TRANSACTIONS

OF THE

Astronomical and Physical Society of Toronto,

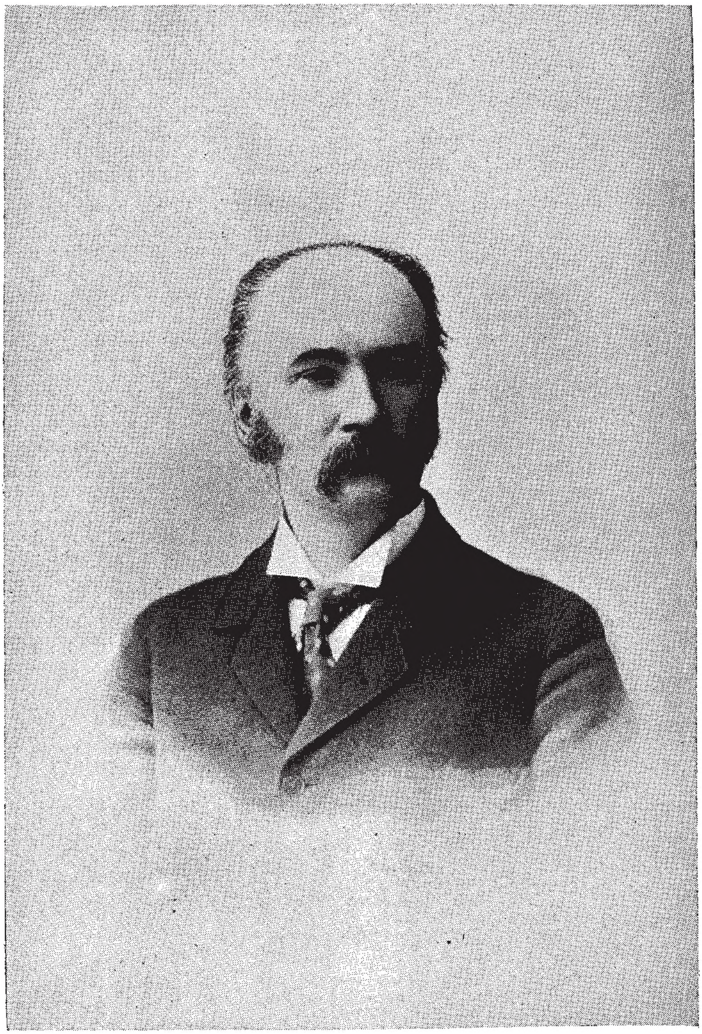
FOR THE YEAR 1897

INCLUDING EIGHTH ANNUAL REPORT.

PRICE ONE DOLLAR.

TORONTO:
ROWSELL & HUTCHISON,
Printers to the Society.

1898.



JOHN A. PATERSON, M.A., (Tor.)

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ERRATA ET CORRIGENDA.

Transactions, 1896.—To the list of Honourary Members, add A. M. W. Downing, LL.D., F.R.S., etc.

" " To the list of Active Members, add Prof. A. C. MacKay, B.A. (Tor.).

" " Page 98. To list of periodical literature (Librarian's Report), add *Popular Astronomy*.

Transactions, 1897.—Page 70, third paragraph from bottom, for "Algal," read "Algol."

" " Page 100, second paragraph, for "Sweedish," read "Swedish."

" " Page 71, third paragraph, sixth line, for "Sun," read "Earth."

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[Authors are alone responsible for views expressed in papers or abstracts of papers published in the *Transactions.*]

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TRANSACTIONS

OF

The Astronomical and Physical Society

OF TORONTO,

DURING THE YEAR 1897.

FIRST MEETING.

January 19th; the President, Mr. John A. Paterson, M.A., occupied the chair. This was a special meeting to which the public had been invited, it having been announced that the President would deliver an address on "The Progress of Astronomy during 1896."

Mr. H. Harrison of the Observatory, Jersey City, N.J., was duly elected an associate member of the Society.

A cordial letter was read from the Hon. G. W. Ross, LL.D., Minister of Education, who was unable to be present.

The Secretary announced that he had received through the Department of Marine and Fisheries a statement of the views of the Admiralty in regard to the proposed Unification of Time. Following is the text:—

DEPARTMENT OF MARINE AND FISHERIES.

Ottawa, 26th December, 1896.

GENTLEMEN,—Referring to your letter of the 9th April last, addressed to the Secretary of His Excellency the Governor-General, in regard to the subject of the unification of astronomical, civil and nautical time, I beg to inform you that a despatch has been received from the Secretary of State for the Colonies, advising that the Lords Commissioners of the Admiralty have found themselves unable to depart from the adverse decision conveyed in the despatch of the 31st December, 1895, in which it was stated that as unanimity in the desire to make this change on the part of other nations that publish ephemerides had not been obtained, their Lordships had no intention of moving in the matter.

I am, gentlemen, your obedient servant,

(Signed) F. GOURDEAU,

Deputy Minister of Marine and Fisheries.

ALLAN MCDOUGALL, ESQ.,

Secretary, Canadian Institute.

G. E. LUMSDEN, ESQ.,

Corresponding Secretary, Astronomical and Physical Society, Toronto.

Discussion of the communication was postponed until a meeting of the Joint-Committee could be held to consider the best method of laying before the Admiralty the views of the master mariners of Great Britain and other nations. These, though entirely favourable to the Unification of Time, had not been considered by their Lordships the Commissioners.

The business of the meeting was then suspended and the Vice-President, Mr. Arthur Harvey, F.R.S.C., requested to take the chair; whereupon the President delivered the annual address, the full text of which was subsequently embodied in the volume of *Transactions* for 1896.

The address was enthusiastically received and the cordial thanks of the meeting presented to the President at the close.

SECOND MEETING.

February 2nd; the President, Mr. John A. Paterson, M.A., occupied the chair.

Mr. A. Elvins drew the attention of the members to the announcement of the death of Mr. T. Gwyn Elger, F.R.A.S., whose work in observational astronomy had been so valuable. Mr. Elger's charming book on the Moon had been read and studied by observers all over the world; as a selenographer we would not easily find his equal. It was a matter of extreme regret that he was lost to the science of astronomy.

The Secretary read a communication received from Dr. Sandford Fleming, writing from London, Eng., and advising of the progress being made in the matter of the Unification of Time. A copy of a letter on the subject communicated by Dr. Fleming to the *Times* was enclosed, and also a copy of the memorial of the Royal Colonial Institute to Her Majesty's Government.

The text follows:—

UNIFICATION OF TIME AT SEA.

To the MOST HONOURABLE THE MARQUESS OF SALISBURY, K.G., *Prime Minister.*

THE MEMORIAL OF THE ROYAL COLONIAL INSTITUTE.

The Council of the Royal Colonial Institute, for themselves and on behalf of about four thousand Fellows of the Institute residing in all parts of Her Majesty's Dominions, desire respectfully to submit to Her Majesty's Government the advisability of taking early steps for the Unification of Time at Sea, a question of world-wide interest which has been brought under the consideration of the Council by the Royal Society of Canada,—an important and influential body which has invited their co-operation in strongly advocating this reform in the interests of navigation and commerce.

Your Memorialists submit that the various points connected with civil, nautical, and astronomical time at sea appear to have been fully gone into during the past twelve years by various societies and authorities in different countries, and to have been eventually resolved into the simple question of the desirability of advancing astronomical time by twelve hours so as to harmonize it with civil time —for nautical time has in general practice long been assimilated to civil time, and is no longer a matter giving rise to difficulty or discussion.

It is believed by your Memorialists that the proposed change can be easily introduced with decided advantage to observers, and that the general principle of the Unification of Time at Sea has now an almost universal consensus of opinion in its favour. This consensus of opinion is especially remarkable in the case of the shipmasters of the mercantile marine, who are deeply interested in the question.

The advancement of astronomical time by twelve hours so as to assimilate it to civil time, in order that both may be in agreement and begin everywhere at midnight, would require the adaptation of the *Nautical Almanac* to the change.

As the *Nautical Almanac* is of necessity prepared some years in advance, it is respectfully submitted by your Memorialists that a decision on this important subject should be arrived at by Her Majesty's Government with as little delay as possible, in order that the change may take effect at the date indicated by astronomers, viz., the first day of the new century.

IN WITNESS WHEREOF the Council have caused the Common Seal of the Royal Colonial Institute to be affixed this first day of January, One thousand eight hundred and ninety-seven, in the presence of—

GEORGE S. MACKENZIE, *Chairman of the Day,* } *Members*
A. H. HOSKINS, Admiral, *Councillor,* } *of the*
FREDERICK YOUNG, *Vice-President,* } *Council.*

J. S. O'HALLORAN, *Secretary.*

Foreign Office, January 4, 1897.

SIR,—I am directed by the Marquess of Salisbury to acknowledge the receipt of your letter of the 1st inst. forwarding a Memorial of the Royal Colonial Institute in reference to steps being taken with a view to the Unification of Time at Sea.

I have the honour to be, Your obedient servant,

SIDNEY GREVILLE.

The Secretary,
Royal Colonial Institute,
Northumberland Avenue, London.

It was thought a matter of very great moment that a body so influential as the Royal Colonial Institute had taken such definite action in the matter of reform in time reckoning, and the hope was freely expressed that success would surely follow the determined efforts of the Institute and others.

Mr. G. G. Pursey presented a detailed report of his sun-spot observations, with diagrams, which had been made on every possible occasion.

Miss A. A. Gray then read by special request the report of Mr. Percival Lowell's observations of Mercury as published in *Popular Astronomy.* Skilful reproductions of the drawings accompanying had been made by Miss Gray on the black-board, thus enabling the members to very clearly follow the text. A lengthy discussion followed the reading of the paper. The members were not unanimous in accepting the conclusion drawn, principally that the planet did not rotate upon its axis in short period. Mr. Harvey thought that more complete evidence should be deduced, for example, an examination of the markings on Mercury when on the west side of the Sun, Mr. Lowell's drawings having been made when the planet was evening star and east of the Sun. Mr. Elvins pointed out that if the planet did not rotate, still the great libration to which it was subject, due to the ellipticity of the orbit, might very easily have given rise to the old conclusion, drawn from displacement of the markings, that there was axial rotation similar to that of the Earth. Mr. Lindsay reviewed an essay written in 1892 by Prof. Coakley of New York, in which a mathematical demonstration was given of the very great probability at least that Mercury did rotate in short period, notwithstanding statements to the contrary which had shortly before been made, and for the first time, by the distinguished Italian astronomer, Schiaparelli.

THIRD MEETING.

February 16th; the President, Mr. John A. Paterson, M.A., occupied the chair.

This was an open meeting (to which the public had been invited) held in the Physical room of the Toronto University by kind permission of Prof. J. Loudon, M.A., LL.D., President of the University. Dr. Loudon had kindly arranged to give a popular lecture on

THE INTERFERENCE OF SOUND,

and had prepared the apparatus of the physical laboratory for experimental illustration.

Dr. Loudon prefaced his remarks by calling attention to the importance of acoustics as a science to be studied if large halls are ever to be perfectly designed for good hearing. The subject, however, was a very wide one, and the lecture of the evening would merely touch upon one branch. The vibratory movements involved in sound waves in air were first described, and diagrams used to show graphically the relation between the rapidity of these movements and the length of the wave. The method of detecting rapid or abrupt changes in air pressure was explained experimentally with perfect success. It was shown that one of the most delicate tests is to allow the sound wave to act upon a small jet of gas, when the changes in pressure are made visible by the dancing image of the jet in a revolving mirror. The apparatus consisted of a tuning fork at the mouth of a great resonator, from the back of which a rubber tube was led to a manometric flame before a revolving mirror. On revolving the mirror in front of the flame, a streak of light only was seen, but on striking the tuning fork this streak became a zigzag curve, easily visible to all in the room. Another apparatus of great delicacy was Marey's drum, to which a stile was attached, which would move to the left or right, according as the drum was agitated by a wave of compression or rarefaction. Dr. Loudon first showed the use of the drum by attaching to it a long tube, into which he simply exhaled air from the lungs in ordinary breathing, when the stile immediately moved to the left; then on inhaling the air, and so producing a wave of rarefaction, the stile turned to the right.

The subject of reflection of sound waves was then taken up, and illustrated by experiments with pistol shots fired into a long conduit.

It was shown by means of the tracing of the stile of a Marey's drum that the compression caused by the shot when reflected from the closed end of the tube gave rise to compression, but when the end was open there was a return wave of rarefaction. In these experiments the projection lantern was used to throw the image of the tracings on the screen, these being made on a piece of smoked glass in front of the lantern by the stile at the instant of the firing of the pistol. The accompanying illustrations, 1 and 2, show the opposite characters of the reflections from the closed and open ends of the pipe respectively :—

These experiments were followed by several others, designed to exhibit the effects of interfering waves. In one of these the resonator and the gas jets were again brought into requisition. A sound wave corresponding to a low note (128 vibrations to the second), was separated into two waves, which took different paths to the flame. On adjusting the lengths of the paths so that they differed by about $2\frac{1}{2}$ metres, the two waves, on again uniting, were shown by the steadiness of the flame to be completely interfering.

The most striking experiment, perhaps, was with the pistol fired into a tube, one end of which was partially open. (Dr. Loudon here explained that sound waves are reflected not only from solid substances, but from the surrounding air. We may, for instance, have an echo from the clouds, as well as from the surrounding hills, in nature.) Two reflected waves or echoes, in opposite phases, were obtained by properly adjusting the size of the opening. The return waves thus completely interfered, the fact being indicated by the absence of the second signal from the drum, as shown by the trace of the stile on the smoked glass and projected on the screen.

The accompanying illustration, No. 3, is a photographic reproduction of the tracing in this case :—

The large audience thoroughly appreciated the efforts which President Loudon had made to render the lecture instructive, as it undoubtedly was, when illustrated by actual experiment at every point. At the conclusion Mr. J. A. Paterson, on behalf of the Astronomical Society, tendered thanks to Dr. Loudon, and to Mr. Plaskett, who had ably assisted in the manipulation of the apparatus.

FOURTH MEETING.

March 2nd; the President, Mr. John A. Paterson, M.A., occupied the chair.

Mr. Napier Denison of Toronto, was duly elected an active member of the Society.

A communication was received from the Secretary of the Royal Society of Canada calling attention to the meeting at Halifax, June 21-26.

A letter was read from Dr. W. T. Harrison of Keene, Ont., who reported having observed a brilliant meteor while driving between Fowler's Corners and the communication road between Peterboro' and Lake Chemong. The light was blue and orange, the rush of the body being accompanied by a hissing sound. It was moving from north to south and appeared to strike somewhere near the town of Peterboro'. An account of the observation was subsequently handed to the press in the hope that the meteor might be looked for in the neighbourhood of where it appeared to strike. There were no results, however.

Mr. Geo. E. Lumsden reported having observed the somewhat rare phenomenon of the

BLACK AURORA.

1897, February 27th, 1 to 1.30 a.m.:—Detected auroral display with some curious features; night very cold, and steady observation unpleasant; aurora low in north and of the ill-defined, hazy kind without streamers and showing no activity except in extreme east where the glow was only more intense. Lying centrally, but low, along the auroral arch was an opaque "something" that might have consisted of a dense cloud, but apparently was not, for the entire sky was perfectly clear and the stars very bright and steady. Gave very careful attention to the dark belt, which was inky black as compared with the sky; the lowest bright stars in Cassiopeia were just above it, with one of them easily visible through the glow; noticed that in half an hour the belt had sensibly shifted its position eastward and that its upper and thinner edge was sufficiently dense to sadly bedim the brilliance of Alpha Cass, though the display was nearly over; cannot dispel the idea that if there are black auroræ, this was one.

Mr. Arthur Harvey read a preliminary note on what were styled

FOCI OF SOLAR ACTIVITY,

treating of the distribution on the Sun's surface of disturbed areas which are seen as protuberances by spectroscopic aid when on the limb. The data for the paper were chiefly the exhaustive reports of the Italian Spectroscopic Society. Day by day, at the observatory of the Roman College, the exact positions of the prominences had been noted, and on plotting these positions there had been detected what was considered good evidence of a distribution more or less regular, resulting generally in a belt formation similar to that on the planet Jupiter. It was presumed that the disturbed areas were practically fixed in position. The evidence deduced in favour of this was the recurrence of the prominences on the limb at regular intervals, a period for the synodic rotation of the Sun having been adopted of $27\frac{1}{4}$ days. In order to make the subject clear Mr. Harvey had prepared a chart of the solar surface on a mercator projection, and showing all the disturbed areas for the year 1895. These ranged themselves distinctly in belts. Certain objections which might be raised as to the ultimate value of a chart of this kind were anticipated; it being admitted that the result from one year's observations was not enough to preclude the element of chance in distribution of disturbed areas. But it was held that there is good reason to expect results of value when magnetic disturbances and the temperature curves on the Earth are studied in connection with solar charts of the kind shown. Mr. Harvey stated his intention of bringing the subject before the Society at a future meeting in greater detail.

FIFTH MEETING.

March 16th; the Vice-President, Mr. Arthur Harvey, F.R.S.C., occupied the chair.

Mr. Neil McLeod, of Toronto, was duly elected an active member of the Society.

Among other visitors at the meeting, was Miss Gertrude Woollfe, of Harvard Observatory, engaged at that centre of astronomical research in the reduction of star plates.

The matter of sending a delegate to the meeting of the Royal Society was discussed, but appointment was deferred. The Secretary was instructed, however, to prepare a synopsis of the Society's work in 1896, and to forward the same to the Halifax meeting.

On motion, Mr. D. J. Howell was placed in charge of the Society's lantern slides and photographs.

Mr. Howell was instructed to forward the slides to the Meaford Astronomical Society to be used at a lecture to be given by Rev. D. J. Caswell.

Mr. J. R. Collins reported some interesting observations of Venus, then evening star, and gave details of some experiments designed to compare its brilliancy with that of Jupiter, then in the south-eastern evening sky.

Mr. G. G. Pursey, reporting his solar observations, called special attention to the large proper motion of a spot which he had closely observed from March 13th to 15th.

The chairman read a short note on his solar researches, following up the theory advanced regarding the rotation period and the effect of solar disturbances on terrestrial magnetism.

Mr. Elvins and Mr. Howell were then called upon to exhibit the Society's lantern slides on the screen, they having kindly made arrangements to do so. Among the slides were the set of photographs of the Moon made at Lick Observatory and several enlargements of special features photographed by Messrs. Henry Bros. of Paris. There were also several reproductions made by Mr. Howell of star clusters and nebulæ, photographs of which had been presented to the Society by Prof. E. C. Pickering of Harvard.

The thanks of the meeting were due to Mr. Elvins and Mr. Howell for the very perfect arrangements they had made for showing the slides.

SIXTH MEETING.

March 30; the President, Mr. John A. Paterson, M.A., occupied the chair.

The Secretary reported having received from the Vice-President, Mr. Arthur Harvey, the necessary apparatus for a seal to be used by the Society on official documents. A Committee had been appointed at a council meeting previously held, to consider the execution of a suitable design.

Among presents received were several volumes of the early Reports of the British Association for the Advancement of Science, donated by Mr. W. B. Musson, to whom the thanks of the Society were due.

During a discussion on some points of general scientific interest Mr. G. G. Pursey asked some questions regarding the theory of sound, particularly as to the explanation of crescendo and dimuendo. He remarked that some tones ordinarily low, could be heard at a much greater distance than other tones stronger and apparently greater in volume. Mr. Pursey hoped that at some future meeting this subject might be taken up.

On motion of Mr. Geo. E. Lumsden, seconded by Mr. Arthur Harvey, it was moved and

Resolved, That the Corresponding Secretary be requested to convey to Prof. Simon Newcomb, LL.D., etc., on the occasion of his retirement from the position of Superintendent of the American Ephemeris and Nautical Almanac Office, a due sense of this Society's obligations to Dr. Newcomb for many acts of courtesy and kindness, and to express the wish that he would long be spared to enjoy a well earned rest from the always important and not infrequently arduous duties of his high position; and to further assure Dr. Newcomb of this Society's high appreciation of the services he had rendered, during a useful life, to the science of mathematical, descriptive, observational and nautical astronomy.

The resolution was supported by addresses from several of the members present and was unanimously adopted.

The Chairman called upon Mr. E. A. Meredith, LL.D., to read a paper which, by special request, he had been asked to prepare on

THE NOVEMBER METEORS OF 1832 AND 1833.

Dr. Meredith prefaced his remarks by referring to the two papers on the subject of meteors read before the Society during the past year, one by the President, Mr. J. A. Paterson, M.A., and the other by the Vice-

President, Mr. Arthur Harvey; also to the special mention at some length of the November meteors in the brilliant inaugural address of the President at the opening of the present session. After the recent delivery of these able and interesting papers the lecturer said that he would have hesitated about reading yet another paper on the same subject were it not that he had been invited to do so by the Society, as one who had been an eye witness of the splendid meteoric display of November, 1832.

Dr. Meredith then proceeded:—I am old enough, I do not say fortunately old enough, to remember distinctly the brilliant display of meteors in Ireland in November, 1832, a sight never to be forgotten. I was then at Castlenock School, a large private school in the neighbourhood of Dublin, just outside the Phœnix Park. The meteors were not then called "November Meteors," for no one at that time dreamt of their being annual visitants, and the name of "Leonids," by which they are now familiarly known, was not given to them until many years later. I should not have been at all certain of the year, much less of the month or day of the wonderful phenomenon, but for the fact that it was at school I witnessed it, and I entered Trinity College, Dublin, in October, 1833, before the November shower of that year. There can, therefore, be no doubt that the display which I saw must have been in the year 1832, and as there was not more than one such display in that year it must be assumed to have been the one that took place in November. Lucky it was for me that we boys had every evening to run across the open from the school room to the supper room, as otherwise I should probably have altogether missed seeing this magnificent spectacle, for it was on the occasion of one of these evening transits, shortly after eight o'clock, that we boys, as we came "bounding out of school," were amazed and awe struck by the extraordinary spectacle which the heavens presented. It was as if all the stars had become suddenly unfixed and were rushing pell mell to the Earth, leaving the firmament an empty void. It looked indeed like a shower of fiery snow flakes, so thickly and yet so gently did the falling stars seem to come down. The author of the noble poem of "Festus" must surely have had in his mind this amazing spectacle, or the still more astonishing display in November, 1833, when he penned the lines,

> "He shook
> The stars from heaven like rain drops from a bough,
> They poured adown Creation's face like tears."

It was indeed a realization of the picture of the Hebrew poet when he wrote: "All the host of heaven shall be dissolved and the heavens shall be rolled together as a scroll, and all their host shall *fall down*, as the leaf falleth off from the vine, and as a falling fig from the fig tree."

I need not remind you that these phenomenal meteoric showers occurred in the Novembers of two successive years, 1832 and 1833. But in the former year the display was more brilliant in Europe and the western part of Asia, whereas in 1833 the New World was the more favoured.

Strange to say while there are abundant authentic records of the great meteoric shower on this continent in November, 1833, there are, so far as I have been able to discover, comparatively few of the meteoric shower of 1832 in the Old World; indeed I have not seen even a single account by an eye witness of the November shower of 1832 in Ireland. A Captain Hammond records a wonderful display of shooting stars at Mocha on the Red Sea on the 13th of November, 1832, and we are told that at Portsmouth, England, "shortly after midnight on the 13th of November in that year the heavens presented a very extraordinary appearance. Thousands of meteors were seen continuously dashing about in every direction, and the whole atmosphere was illuminated. The driver of the London stage coach said the effect was awful, and that it was with the utmost difficulty he could get his horses to face it."

The meteoric shower of November, 1833, which was so much more brilliant on this continent than in Europe, seems to have extended from longitude 61° to 100° in Central America, and from the North American Lakes to the West Indies.

There is, as I have said, no lack of accounts of the latter phenomenon. The American Journal of Science for 1834 contains some sixty or seventy detailed descriptions of the shower of the preceding November, furnished by astronomers, meteorologists and others all over the Union. The astonishment and delight with which the spectacle was beheld by the educated classes was only equalled, it would appear, by the consternation and terror of the ignorant and uneducated, who thought that the terrible spectacle portended some awful disaster if not the end of the world, and in fact seemed to expect

> "To be sent
> With hideous ruin and combustion,
> Down to bottomless perdition."

Similar accounts were given by eye witnesses at the Falls of Niagara, in North Carolina, and the West Indies, and Miss Clerke, the well-known astronomer, thus sums up the account of this meteoric display on this continent.

"On the night of November 12th-13th, 1833, a tempest of falling stars broke on the earth—North America bore the brunt of the pelting. From the Gulf of Mexico to Halifax, until daylight with some difficulty put an end to the display, the sky was scored in every direction with shining tracks, and illuminated with majestic fire balls. At Boston the frequency of the meteors was estimated to be about half that of snow flakes in an average snow storm. Their numbers, while the first fury of their coming lasted, were quite beyond counting; but as it waned a reckoning was attempted, from which it was computed, on the basis of that much diminished rate, that 240,000 must have been visible during the nine hours they continued to fall."

I have dwelt perhaps somewhat too much in detail on the meteoric showers of 1832 and 1833, but besides being the special subject of my paper these showers have a unique scientific importance. They form in fact an epoch in the history of meteoric astronomy—not merely because of their surpassing grandeur, for in this respect they were in the modern phrase "record breakers," as history contains no account of any previous showers approaching them in splendour: But still more because they attracted the attention of astronomers and of scientific men generally to a branch of astronomy hitherto almost wholly neglected, with the satisfactory result that meteoric astronomy has since been for the first time placed on a scientific basis. We can hardly refrain from smiling at the theories as to the origin of meteors which obtained even among scientific men in 1833. There were three leading theories: the *Atmospheric*, the *Volcanic*, and the *Solar*. The *Atmospheric* ascribed the origin of meteors to the combustion of gases in the atmosphere, the *Volcanic* to matter ejected from lunar or terrestrial volcanoes, and the *Solar* to matter projected from the Sun by some tremendous explosion. The investigations following on the displays in 1832 and 1833 showed how absurd and untenable all these theories were, and conclusively established that meteors were a *cosmical* phenomenon outside and independent altogether of our solar system. Strange as it may seem to us (who without any merits of our own enjoy the benefits of the immense advance made in astronomy in the last sixty years)—strange I say as it may seem to us, it required many years of study to establish this fact, now apparently self-evident, as to the *cosmical* origin of meteors.

Here the question naturally suggests itself, if these meteors are of cosmical origin and properly belong to the interstellar spaces, how did they become entangled in our solar system, a mere speck in the universe? This is an interesting and perplexing question. To answer it I must repeat the story of the capture of these meteors and their annexation to the solar system so graphically told by the President in his paper. The interstellar spaces are filled with innumerable bodies apparently wandering about aimlessly at their own sweet will through the universe; some in clusters, others solitary. A very large cluster of these celestial tramps found themselves in their wandering in the year of grace 126 within the influence of the Sun's attraction and obedient to the universal laws of gravitation were hurrying straight to the Sun, intending, no doubt, to serve as stokers and feed her fires with fuel. While yet on the confines of our system they encountered the lonely outlying planet Uranus keeping watch on the borders of the system. Indignant naturally at their "molesting his ancient solitary reign," and unwilling possibly to be pelted with aerolites, Uranus, as they neared him, swung the cluster of meteors angrily over his shoulder into the orbit in which they have ever since continued to revolve like ruly and well conducted planets. This is in brief the story of the capture of the Leonids, our famous November meteors.* But there are a great many other well-known groups of meteors revolving planet-like round the Sun—as the Perseids, the Taurids, the Andromedes, the Lyrids—some hundreds already classified; and named after the constellations in which the radiant or converging point is found. The story of all these groups is probably the same as that of the Leonids. All have at one time been "free lances" in the universe, but coming incautiously within the influence of the Sun, have been captured by one or other of the outlying planets and made obedient vassals of our Sun king. It seems to be the special function of these distant planets to act as "meteor catchers for the solar system." Patient and persevering fishermen they doubtless are, and are

*Dr. Ball tells us that the orbit of the Leonids does not intersect the path of Jupiter, Saturn or Mars, but does intersect the orbit of Uranus. "It must therefore sometimes happen," he adds, "that Uranus will be passing through this point of its path just as the shoal has arrived there. Le Verrier has demonstrated that such an event took place in the year 126, but that it has not happened since."

well content, no doubt, if once in a thousand years they make a haul in their celestial drag nets of such a cluster as Uranus captured in A.D. 126.

The motion of the Leonids is retrograde, *i.e.*, in an opposite direction to the motion of the Earth and the other planetary bodies. Why is this? What is it that determined the motion of the stream, and made it retrograde and not direct? Was it not determined by the position of the planet which captured the meteors and flung them into the orbit in which they now move? Assuming the planet to have been at the time in the neighbourhood of its aphelion (as Uranus is believed to have been in 126, when the meteors were nearing it), would not their resultant motion depend on whether the planet had or had not passed his aphelion at the time? If the meteoric stream came under the attractive influence of the planet when the latter was nearing but had not reached his aphelion, then the planet would necessarily have drawn the meteors towards himself and set them moving as they now are in an opposite direction to himself—in other words, the motion of the meteors would be retrograde. If, on the other hand, the planet had passed his aphelion when the meteoric stream came under his influence, then the stream would have been drawn towards the planet and would have had a direct motion like that of the planets.

When it was clearly established that the period of these meteors was about 33 years, astronomers naturally looked to see if there were historical records of similar displays at the dates corresponding with that period, and it was found that there were authentic accounts of several remarkable star showers just at the dates when on that calculation they should have occurred. The most remarkable November showers recorded were in 902, 931, 934, 1002, 1101, 1202, 1533, 1602, 1698, and 1799, and in this century we have already had brilliant displays in 1832 and 1833 and in 1866 and 1867. It will be noticed that 33 years, or a multiple of 33 years, occurs between these several displays—and it is curious that they occur at the beginning and the end of each century—and we fully expect this nineteenth century to close with a brilliant display of fire works in its penultimate month. It is not wonderful that the common people looked with terror on these wonderful celestial phenomena and regarded them as the signs of wars and pestilences and other terrible and literally *disastrous* events, or that they should have thought that meteors, like comets, "from their horrid hair shook pestilence and war." The earliest shower to which we have referred—that of 902, commonly known as the year of stars—strangely enough occurred on the very night of the capture of Toormina by the Saracens, and that of 1366 just before the death of the king of Portugal, with which it was at once associated by the common people. The November display in 1799 is interesting, from the fact that it was witnessed in South America by Humboldt and his travelling companion, Bonplant, who has left us an admirable description of it. The earliest account, I believe, of a meteoric shower is given by Livy, who frequently when recording some remarkable event in Roman history, writes "*fertur pluisse lapides.*"

There are two interesting meteorological phenomena which have greatly perplexed physicists and which, I think, can only be satisfactorily explained by the action of streams of meteors. One of them is the "dark days" which have occurred at various times in different places; and the other, the recurrence on certain stated days of the year of abnormal depression or fall of temperature. The two periods specially noted in this latter respect are the 12th of February and the 11th, 12th and 13th of May. The first of these dates was pointed out by Brandes about the beginning of the century, and the latter by Mädler in 1834. Mr. Erman, a distinguished German scientist, suggested that these periods of depression of temperature might be explained by the intervention of a stream of meteors between the Earth and the Sun which would necessarily cause such a depression. On the 12th of February it is alleged that the Earth is in conjunction with the meteoric stream of the August meteors, and on the 12th of May it is in conjunction with the meteoric stream of the November meteors, which means that on both occasions there is a stream of meteors intervening between the Earth and the Sun. Chladni had many years before suggested that the intervention of such a meteoric stream was the most probable cause of the other phenomena to which I have referred, namely, the dark days.

There is a graphic account of one of these dark days in Canada given in the Rev. Mr. Abbott's "Life of a Missionary in Quebec." The date, if I recollect, was the 15th of November, 1819. It seems to me that the meteor theory affords the most probable solution of both the phenomena to which I have referred. Humboldt mentions the occurrence of dark days in 1090, 1203, 1547, and on the *12th of May*, 1706. This last date is specially interesting because it is the very day on which the abnormal fall of temperature every year is supposed to take place, and it lends support to the supposition that this fall of temperature is due to the presence of a stream of meteors intervening between the Earth and the Sun on that day.* A stream of meteors which would produce a fall of temperature would, if increased in thickness, cause a dark day.

There is a branch of this subject upon which I had hoped to have said something to-night, and that is the relation of comets to meteors, as to whether meteoric groups are not in fact broken-up and disintegrated comets. It has long been an established fact that the orbits of certain meteoric streams are identical with the orbits of comets, showing how very closely they are connected. But I have not had time to investigate this matter and must therefore leave it for the present.

We speak of these great meteoric displays as if they lasted only for two consecutive years. For example, we say the display of 1832 and 1833 and of 1866 and 1867. But as a matter of fact striking displays occur often two years before and after the maximum display, but only one or two really brilliant consecutive exhibitions are usually seen.

As the periodic time of the meteors is a little over thirty-three years, it is plain, assuming the meteors to move with a uniform velocity in that orbit, that if the stream takes five years to pass a particular point, the length of the stream would be nearly one-sixth of the length of the orbit. But as we know that the meteors when at aphelion, or most distant from the Sun, move at little more than a mile a second, while their velocity when crossing the Earth's track is twenty-six miles a second, the length of the meteoric stream must be very much more than one-sixth of the orbit, probably more than a third.

As the time for the grand exhibition is nearing the interest in this wonderful phenomena is increasing, and astronomers are asking the question will the display in 1899 equal in grandeur those of 1867 and 1833? And the answer (I am sorry to say for those who will witness the display of 1899) is in the negative according to an able authority on the subject (W. F. Denning), who thus writes in October last in *Nature*:—

"Changes" he says, "are doubtless affecting the stream (of meteors), and the effects are cumulative. Thus the circumstances attending their ensuing return will be somewhat different from those which controlled the displays in 1833 and 1866. The meteors are probably lengthening out along the orbit owing to the difference in periodic time amongst

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*The 11th, 12th and 13th of May are known in France as the days of the "Ice Saints" Mamertius, Pancratius and Servatius.

them, and the stream is widening as an effect of planetary perturbation. Thus in future ages the showers will probably return in many consecutive years near the epoch of maximum, while the maximum itself will be less brilliant than in former times, etc. The stream must necessarily be undergoing a gradual process of thinning out since our atmosphere destroys by combustion such of the particles as enter it, and the number so destroyed must amount to many millions whenever a rich shower takes place. Still in comparison with the enormous number of meteors comprised in the whole system the proportion caught and vapourised by the Earth must be insignificant. After a long series of years the Leonid display like that of the Perseids in August, will probably become a rich *annual* shower, and lose much of the grandeur which has attended it at intervals of about thirty-three years in the past."

Although it is unquestionable that millions of the Leonids are consumed whenever they come in contact with the Earth's atmosphere, yet many hundred millions probably still remain, and we may, I think, reasonably expect that these *coelestia damna* (heavenly losses) which the meteoric stream has suffered during this century will not appreciably affect the display to which we look forward in 1899 and 1900.

Those who are on the look out for the Leonids in November must bear in mind that there are several other meteor streams which are visible generally at that date. Among these are the Perseids and the Taurids. In ordinary years the meteors of these groups quite outnumber the Leonids; but in the years of the great Leonid display, the other meteors are relatively so few in number as to be practically almost inappreciable. It is not difficult for even an ordinary observer to distinguish between the Leonids and the other meteors, not only because the others diverge from a different radiant, *i.e.*, from a different quarter of the heavens, but also because the Leonids are so much more rapid in their flight through our atmosphere than the others. As the Leonids and the Earth are moving in opposite directions, the former at the rate of twenty-six miles a second and the latter at the rate of 18 miles a second, it follows that the Leonids "must pass through the Earth's atmosphere," as Prof. Ball says, "with the enormous velocity of nearly forty-four miles a second."

The Leonids, the Taurids and the Perseids are all mid-November meteors. "Apart from these," as Mr. Denning writes, "there is another system, the Andromedes, of considerable strength and many interesting associations, which makes its periodical apparitions in the latter part of the month of November. It has a period of six and a-half years, and presents very close orbitual resemblance to Biela's comet." * * "A brilliant return of these meteors ought to be witnessed next year on November 23, as a similar period will then have lapsed to that which separated the splendid display of these meteors in 1872 and 1885." "Thus in November, 1898," he says, "observers are offered a double prospect. They may see a fine exhibition of swift streak-leaving Leonids on the morning of November 15, and an equally abundant display of train-bearing Andromedes on November 23. The latter shower may even exceed the former in point of numbers, for the showers of Andromedes in 1872 and 1885, as meteoric spectacles, have never perhaps been excelled except by the magnificent display of Leonids in 1799 and 1833."

SEVENTH MEETING.

April 13th; the President, Mr. John A. Paterson, M.A., occupied the chair.

The Assistant-secretary stated that he had received from Mr. Harold B. Lefroy a copy of a photograph of the lightning flash which was of particular beauty and scientific value. It was possible to study the flash in the most minute detail; the great main streak running to Earth, the secondary branches, and offshoots from these again were portrayed with a startling vividness. The members present to whom the picture was shown were unanimously of the opinion that it surpassed any photograph of the lightning which had yet been taken. Mr. Lefroy having signified his willingness to allow the picture to serve as a frontispiece for the *Transactions* then nearly ready for issue, it was decided to commission an engraver to make a reproduction for that purpose.

Observational work had been hindered by considerable bad-seeing weather; it had not been possible to observe the occultation of the Pleiades of April 5th. Mr. Pursey reported briefly his solar observations; faculæ had been noticeable on the solar disc for sometime past while it had been possible to observe. Some discussion arose regarding the peculiar appearance of the snow during a recent storm. Mr. R. F.

Stupart stated that several people had asked if the snow had on that occasion fallen in "snow-balls"; this was explained by the action of the wind on the snow particles; the campus of the University had presented just such an appearance as would have resulted if the snow had fallen in lumps; hence the many enquiries from observers.

Mr. Arthur Harvey having referred to the great utility of seismological observations in connection with meteorological work, Mr. Stupart informed the members that a set of the instruments for recording the minute tremors of the Earth's crust would shortly be added to the equipment of the Toronto Magnetic Observatory.

The Chairman then called upon Mr. A. F. Miller, who had prepared a paper by special request on

MEASUREMENT OF ABSOLUTE WAVE-LENGTH.

Mr. Miller began by stating that a somewhat incorrect idea prevailed as to the smallness of the space occupied in the performance of luminous undulations; in fact, that some people seemed to regard the wave-length of light as something almost inconceivably small. Really, however, we are fairly familiar with much smaller dimensions. For instance, he had found from actual measures made in a manner to be afterwards described, that the wave-length of one of the characteristic lines in the spectrum of sodium vapour was 5,896 tenth-metres, or Angstrom's units, which would equal a length of 1-42,000 of an inch very nearly. The thickness of ordinary gold leaf is given as 1-282,000 of an inch; from which it becomes evident that the wave-length of sodium light, which is nearly an average wave-length for the visible spectrum, is six and a half times as great as the thickness of gold leaf. Such a dimension as 1-42,000 of an inch could readily be measured by a suitable micrometer; but of course the waves of light, as well as the ether particles by which they are transmitted, are entirely invisible, and even were this otherwise the frequency of the undulations is so inconceivably great that the actual phenomena of the movements could never become perceptible. [The formula for computing wave-frequency was briefly stated, and its working explained.] In measuring the absolute wave-length, therefore, we are forced to take the indirect method of observing the results of the undulations in cases where, by a suitable arrangement of the experiment, equal and opposite phases of vibration are made to arrive simultaneously at the same point, so producing phenomena of interference. The meaning of this expression was shown by diagrams, which illustrated the interference of two systems of waves, produced simultaneously on the surface of a liquid, and thus a comprehension of the conditions prevailing in the luminous ether was rendered possible by analogy. The theories advanced to explain the propagation of light by Newton, Descartes, Hooke, and Huyghens, were referred to, and the principle of Huyghens was thus stated :—" When an undulatory movement propagates itself through an elastic medium, every particle imitates the motions of the original vibrating particle, and if free to do so is ready to act as the originating particle of a wave-system." This principle had served Huyghens to explain all optical phenomena known in his day, and has since answered perfectly to explain the complicated phenomena of polarization and diffraction discovered more recently, thus rendering it highly probable that the theory is an actual statement of facts. A model was shown, illustrating the diffraction phenomena produced by a slit illuminated by a very narrow pencil of rays, and the explanation of the alternate dark and luminous striæ was given in accordance with Huyghen's principle.

At this point Mr. Miller closed the first part of his paper, it being arranged to continue the subject at the next meeting.

EIGHTH MEETING.

April 27th ; the Vice-President, Mr. Arthur Harvey, F.R.S.C., occupied the chair.

Copies of the volume of *Transactions* for the year 1896 were distributed among the members ; the lightning photograph formed the frontispiece of the volume.

The Secretary read a most cordial letter from the Director of the Paris Observatory covering the transmission of copies of the first issue of lunar photographs taken with the great equatorial coudé. These were very much admired by the members, the Librarian being instructed to procure a proper portfolio to hold the pictures until the set would be complete ; it could then be decided as to the best method of arranging them for ready inspection. The thanks of the Society were specially due to the donors, MM. Loewy and Puiseux, for this mark of their favour.

The Secretary also reported having received from Mrs. Crawford, of Fergus, Ont., a photograph of the late Dr. J. C. Donaldson, and some astronomical works from the large collection accumulated by the deceased during his many years of active life in the interest of science. The thanks of the Society were due for these.

A communication was received from Sir R. S. Ball, who wrote that he would be unable to accompany the British Association to Toronto during the present year. This was much regretted.

Mr. George Craig reported having observed on the evening of the 16th of April, at about 8.45 or 9 o'clock, a large and brilliant meteor shooting across the heavens from east to west, apparently at an angle of about 45 degrees. Before dying out it exploded into a number of brilliant points, resembling in that respect the explosion of a large sky-rocket, but maintaining a uniform colour similar to that proceeding from an electric light. The duration of the display was about four or five seconds. No noise accompanied the explosion.

Among other observations Mr. Pursey reported that there had been no spots visible on the solar disc since April 21st.

In continuation of the paper read at the previous meeting on the measurement of wave-length, Mr. A. F. Miller showed that by a simple geometrical construction a formula might be deduced applicable to the determination of the wave-length of homogeneous light traversing a narrow slit, the width of which is accurately known. From this followed the improvement introduced by Fraunhofer, who substituted many fine slits for a single one, and thus devised the diffraction grating which, according to the original methods of the inventor, might be used to form spectra either by transmission or reflexion, and could deal with light not necessarily monochromatic. The diffraction grating was described, and the geometrical principles which its use involves were demonstrated diagrammatically. From these the general formula

$$\lambda = \frac{s \sin \delta}{n}$$

was obtained. The corrections to be applied, owing to changes of temperature and other sources of error, were then dealt with, the theory of the spectrometer discussed, and finally, from actual measurements of diffraction angles and grating spaces, the wave-lengths of several lines in the solar spectrum were accurately worked out.

NINTH MEETING.

May 11th; an open meeting held in the Electrical room of the Technical School; the President, Mr. John A. Paterson, M.A., occupied the chair.

Mrs. Balmer, of Toronto, was duly elected an active member of the Society.

A letter was read from Prof. Simon Newcomb, replying cordially to the resolution adopted by the Society on the occasion of his retirement from the more active duties of his office. From Mr. H. Harrison, of Jersey City, was received a copy of an oil painting of the Moon in the first quarter, as seen in the telescope. The picture was unique, reproducing the lunar features with almost photographic accuracy. The thanks of the Society were specially due to Mr. Harrison for the gift of the picture, which was admired by all present. The Secretary reported having received, through the kindness of Prof. E. S. Holden, several copies of the first series of lunar photographs taken with the great 36-inch equatorial of the Lick Observatory. These were considered a magnificent addition to the Society's collection. A portfolio in which they could be conveniently kept was ordered to be procured, and the Secretary was requested to convey to Prof. Holden the thanks of the Society.

Mr. Lindsay reported having made some observations on sun-spots with a telescope by Messrs. Collins of a new construction. He had found the instrument as represented, perfectly achromatic, so far as the tests applied could determine. The definition was excellent. There was no combination of crown and flint as had always been considered necessary for achromatism. The instrument was a combination of reflector and refractor.

The reading of further notes on observations was deferred, in order to afford time to Mr. Napier Denison, of the Meteorological Service, who had prepared an illustrated lecture on

THE AIR BAROMETER.

Mr. J. Keele, of the School of Practical Science, had very kindly brought the large lantern used in his department, and most successfully projected on the screen the various slides illustrative of the subject. A synopsis of the lecture follows :—

A full account of these researches will eventually be published in our *Monthly Weather Review*, but thinking the present observations would be of interest to your Society, Mr. Stupart, Director of the Observatory, has allowed me to present some of the investigations now being carried on. The object of this paper is to bring before you a simple form of instrument many times more sensitive than the ordinary mercurial or aneroid barometers, and by presenting some interesting records from the same, to endeavour to illustrate the wonderful unseen forces at work during disturbed atmospheric conditions. A detailed history of this instrument would be of little interest, suffice it to say several of them are in use in the United States, but none as sensitive as this one; while one designed by Prof. King at the Wisconsin Agricultural Experimental Station is used in conjunction with special instruments for studying that most interesting subject of fluctuations of the level and rate of movement of ground water, which is so closely connected with "soil breathing."

To fully understand the following illustrations let us realize we are living at or near the bottom of a great ocean composed of an elastic gas called air extending upwards about one hundred miles, the weight of which exerts at our level a pressure of 15 pounds to the square inch. This air is never at rest, is continually varying in density, and as these changes are evidently due to great disturbances at different levels above us the ordinary mercurial barometer was invented and is now in common use at numerous points all over the bottom of this ocean for measuring the pressure changes. In later years man, not being satisfied with these eye readings taken so many times a day, and realizing that a constant record would bring to light much more minute undulations, devised the present form of barograph. One of these instruments is set up at the observatory in a specially constructed room 14 feet below the ground in order that the surrounding air may not be affected by great changes in temperature. It consists of a vertical glass tube containing the column of mercury which is connected below with the cistern of mercury whose surface is exposed to the pressure of the air which is normally of sufficient weight to sustain a column of mercury in the glass tube about 30 inches above the surface in the cistern. As the pressure of the air upon the mercury in the cistern varies so does the mercury in the glass tube correspondingly rise and fall. The constant record is obtained by permitting a ray of light to pass through a condensing lens over the top of the mercurial column, then through a special photographic lens and a narrow slit, upon a sheet of sensitized photographic paper which is attached to an upright cylinder revolved by clockwork once every 24 hours. [A slide showing the readings taken at the Toronto Observatory was here projected on the screen.] We now have before us an actual record from this instrument during disturbed atmospheric conditions over this continent; you will note the curve is broken up into numerous forms of undulations or waves. Although this appears to be a most complete record of the existing undulations many of the smaller ones are not discernable which by means of a still more sensitive instrument can clearly be defined.

Before proceeding further let us get a general insight into the atmospheric circulation at our latitude and the cause of these peculiar undulations. We are told by the late Prof. Helmholtz, who made a special study of atmospheric waves from theory and analogy with ocean waves, that as soon as a lighter fluid lies above a denser one with well defined boundary, then evidently the conditions exist at this boundary for the origin and regular propagation of waves such as we are familiar with on the surface of water. Since the moderate winds that occur on the surface of the earth often cause water waves of 3 feet in length, therefore the same winds, acting upon a stratum of air of ten degrees difference in temperature, maintain waves of from 1 to 3 miles in length. Larger ocean waves from 15 to 30 feet long would correspond to atmospheric waves of from 8 to 18 miles which would be more than the whole sky of the observer. He also states that waves of smaller and smallest wave-length are theoretically possible. To-night we shall endeavour to study these most interesting waves of varying extent, as shown upon the air barograph, which are just beginning to be appreciated by the scientific world.

The diagram before us gives a general idea of the disturbed condition of the atmosphere when the lower layers are travelling in an opposite direction to the upper strata. The upper portion of the atmosphere, that is from about 5 miles above us to the extreme limits, is constantly moving from the equator polewards and spiralling around the Earth, being always deflected to the east, due to the Earth revolving upon its axis. Many of you will be astonished to know that during the winter months the average rate of movement of these upper currents is 110 miles per hour and in summer 60 miles; this great difference in the velocity during the summer and winter is due to the far greater difference of temperature, between the equator and the poles, in winter than in summer. The points to be gained from this diagram are that when the surface air is set in motion in an opposite direction to the layers above, waves are set up along its boundary surface which may extend to the bottom of our atmospheric ocean; also when the lower air is moving in the same direction as the upper these undulations are much less marked; and thirdly, it will be well to note that clouds are often formed at the crests of these billows.

Now we come to the air barometer itself which is set up in a small detached underground house which belongs to the observatory. Six feet below the level of the floor is a metallic vessel 2 feet in diameter, from the bottom and centre of which extends upwards a galvanized iron pipe 3½ inches in diameter. This large vessel is air tight with the exception of two small holes into the bottom of the vertical pipe. To complete this barometer water is poured in until it has risen above the tapering part of the large vessel, as shown by the dotted lines. You will note the water in the central pipe stands much higher than that in the larger vessel. This is due to the increased pressure of the confined air exerting a counteracting effect upon the central column of water and external air.

Upon the surface of this central column is placed a float which is connected to the pivoted lever above by a line; upon the other end of this lever is attached an automatic inking pen which lightly rests upon a recording cylinder which revolves once in twenty-four hours; an hour on this cylinder is equal to one inch. As the centre column is depressed or raised by changes of atmospheric pressure a corresponding but magnified movement is transmitted to the arm carrying the pen which minutely records all small pressure changes; this instrument is seventeen times as sensitive as the ordinary form of mercurial barometer. On the right and bottom of the apparatus is a thermometer suspended by a line which gives the temperature of the Earth at the level of the confined air. It is interesting to note that from the month of January to the present time there has only been a rise of 3°, viz., 40° to 43°, while the temperature of the surface air has increased from a monthly average for January of 23° to 43° in April, or a difference of 20°.

Let us now look at some of the traces taken from this instrument; here we have one preceding fair mild weather and two preceding and during storms. In the first case you will observe an almost unbroken line, which according to Helmholtz' theory would indicate that both the upper and lower air were moving in the same direction. To fully understand the atmospheric conditions prevailing at this time let us look at the weather chart for 8 a.m. of this day. As you all are aware these charts are obtained from instantaneous observations taken at many points over the bottom of this atmospheric ocean and telegraphed into the Central Offices at Toronto and Washington. The dark curved lines represent isobars or lines of equal pressure which are drawn to every tenth of an inch, and the arrows fly with the winds. You will observe the pressure is heavy over the lakes and light over the S. W. States; our winds, therefore, are northerly or blowing towards the region of light air. We would naturally expect to find marked undulations upon this trace, for the upper and lower air appear to be moving in opposite directions. The next chart shows us why the trace was quiet. This area of light air did not develop but moved to the west and north of Toronto which has given us fair warmer weather with moderate southerly winds.

Let us now take the case of a decidedly disturbed trace during fine weather; you will note marked undulations throughout, which, in some instances, assume the proportions of enormous billows. As will be seen by this chart, at the commencement of these disturbances the pressure is again heavy over Ontario, while to the south-west of us, a distance of over 1,200 miles, there is seen an area of low pressure or light air not many miles east of the foregoing one when first cited. In this case the area developed into an important storm and moved to the south of the lakes, giving us a strong north-east wind with four inches of snow.

It is hoped the conditions of these barometric traces will throw much light upon the future course of an approaching storm, which is at present one of the difficult problems for weather forecasters to solve.

Let us now pass on to another branch of this most interesting study, namely, barometric disturbances during thunderstorm conditions. As the water level of the lakes is also greatly affected at the same time, we will glance for a moment at the instrument set up at the mouth of the Humber river for recording these rapid changes and then bring before you an actual record during one of these great disturbances. This instrument consists of a recording cylinder placed horizontally, which, by means of clockwork, completes one revolution every 24 hours.

Resting upon this is a self-inking pen attached to an arm, which slides freely upon a horizontal guide. This arm is connected by a line to the float, which is enclosed in a special shaft, so constructed as to admit the water only through several small holes; this prevents any sudden movement of the float being caused by local wave motion. As the float rises and falls, the pen correspondingly moves up and down upon the paper, which is revolving at the rate of one inch per hour. The ratio of movement between pen and float is as 1 to 4, so that a rise of one inch of water level corresponds to a movement of one-quarter of an inch upon the paper. One-quarter inch squared paper is used, the vertical lines marking 15 minute intervals and the horizontal one inch change in water level.

On the 8th of March, 1897, we have a most remarkable record from both lake instrument and air barometer. The barometric trace from noon is of a decidedly undulating type until 2.50 p.m., when abnormal wavelike changes of pressure take place; these are followed shortly afterwards by correspondingly large lake undulations, greatest amplitude 11½ inches in 15 minutes. A similar movement, but to a lesser degree, may be detected upon this instrument during the passage of great cloud masses, as is often the case during clearing weather.

The average decrease of temperature as we ascend is one degree for every 300 feet. In order that you may form some idea of the great cold above us, even during the summer months, permit me to cite two cases of actual temperature records obtained from balloons carrying special automatic thermographs. In one case the height attained was 42,933 feet, when the record showed 81° below zero, and in the other, at an elevation of 50,854 feet the extremely low reading of 94° below zero was registered.

It is interesting to note that during squally weather there is a marked correspondence between the time of greatest wind velocity and the crest of an atmospheric wave.

During the passage of a gale when the wind is blowing with great force and apparent steadiness, as is often experienced in an easterly storm, this instrument clearly demonstrates the constant existence of various forms of intensity of the wind which are recorded as minute waves or ripples upon the cylinder. This affords a simple method of studying the fluctuations of the wind which Prof. Langley of Washington has so graphically brought before us in his "Internal Work of the Wind."

It has been found that each pulsation in the force of the wind when from an easterly direction causes the pen to move downwards below the normal line, while on the other hand when the wind is from the west these movements are all upwards. These are due to the position of the instrument which is placed in a small building quite close to the west wall of the School of Practical Science. When the wind is easterly it first strikes the eastern side of this large building then passes over it, which tends to form an eddy or diminish the atmospheric pressure upon the opposite side of the building, which would immediately cause the barometric pen to fall. On the other hand, a westerly wind would tend to increase the atmospheric pressure against the western side of the large building which would necessarily act upon the air barometer.

In conclusion, may we not venture to predict that the day is not far distant when the present form of mercurial barometer will become an old-fashioned instrument, only used for checking more sensitive forms, and that the latter will come into common use throughout the world, when startling results may be looked for and a much grander field opened to the weather forecaster? If so, we trust Canada may be well in the foreground.

TENTH MEETING.

May 25th; the President, Mr. John A. Paterson, M.A., occupied the chair.

A communication was received from the Hon. G. W. Ross, LL.D., congratulating the Society on the success attained in the general objects of popularizing scientific studies and suggesting that something be done towards affording the Toronto Observatory, already well-known for its magnetic work, increased facilities for astronomical research. Monsgr. Merry del Val, who in the course of his mission from Rome had visited Toronto, wrote a very cordial letter in which he stated that he had forwarded to the Vatican, on behalf of the Society, a request for an exchange of publications.

Mr. D. J. Howell reported that he had finished the work of arranging the Society's lantern slides. These would be so marked that they could be readily placed in the lantern so as to show on the screen the inverted image as seen in the telescope. Mr. Howell stated also that he had had some correspondence with Rev. Mr. Campbell, of Wiarton, a gentleman interested in astronomical work, and had asked Mr. Campbell to endeavour to form a branch of the Society in his locality.

Notes of observations were received from Mr. G. G. Pursey, Mr. A. Elvins and others. In the course of a discussion on the reports from the Lowell Observatory, Mr. Elvins stated he had on several occasions observed what were generally taken to be snow caps on the poles of Venus, but these were not seen by Mr. Lowell. It was stated also that European observers had frequently noted these phenomena.

Dr. E. A. Meredith called attention to the observed agreement of fact and theory regarding the temperature on the 12th, 13th, and 14th of May. He showed by records from Europe that the temperature on those days this year had been lower than that of the days preceding, and that the phenomenon was well-known among the farmers in Germany.

Mr. Mungo Turnbull read a short paper on the phenomena involved in the Earth's rotation, having special reference to the best methods of making clear to the student the geometric significance of an axis fixed in space, but viewed under different aspects. One of Mr. Turnbull's charts was designed to show how the circles of latitude, as seen by an imaginary observer on the Sun, pass from straight lines to ellipses as the Earth presents to the source of light first one-half of each hemisphere and then more and more of one or the other. A celestial globe designed by Mr. Turnbull was also shown and its mechanism explained. The globe and charts were much admired.

ELEVENTH MEETING.

June 8th; the President, Mr. John A. Paterson, M.A., occupied the chair.

Communications were read from Mr. Jas. E. Gore, F.R.A.S., Mr. Garrett P. Serviss, and Dr. M. A. Veeder.

Mr. W. R. Pringle and Dr. Otto Hahn, of Toronto, were duly elected active members of the Society.

The Librarian reported the receipt of presents and exchanges, and read some extracts from current numbers of scientific journals. Among these were some notes on the reformation of the calendar published in the memoirs of the Antonio Alzate Scientific Society of Mexico, with a request that other societies would reply as to what they considered would be an advantageous change. One method proposed was somewhat similar to the change advocated by Dr. A. D. Watson in a paper read during 1896. The matter was referred to the council with instructions to present a formal report on the question to be transmitted to the Antonio Alzate Society.

The weather during the previous fortnight had been very unfavourable for observation. On days when it had been possible to do so, Mr. G. G. Pursey had made his customary solar drawings.

Brief reports of observations were also received from Mr. J. Phillips and Mr. J. H. Weatherbee, the latter presenting a drawing of auroral streamers seen in the north-eastern sky on the evening of May 31st.

The question being always open as to the best method of making the work of the Society valuable, Mr. G. E. Lumsden had been specially requested to bring his views before the members. The following paper had been prepared and was read on

THE NECESSITY FOR INDIVIDUAL EFFORT.

With your permission I will offer, and I do so with some diffidence, a few observations in support of the general proposition that a Society, like ours, cannot reasonably hope to make progress, satisfactory to its members collectively and individually, unless each one assumes and continues to manifest a practical interest in its work and, consequently, in its usefulness and welfare.

Let us make this view of the matter personal to ourselves and apply it for a few moments.

Actuated by this conception of his duty, one can imagine the newly-elected member communing with himself in a manner somewhat after this fashion:—"It will not be enough for me to attend the meetings of this Society with passable regularity. It will not be sufficient that I listen to the papers with attention, varied by the accident that the subject-matter may or may not happen to be of interest for me. I must be a positive, not a negative quantity. Clearly, I have a duty to perform. A duty, too, not only toward the Society, but also toward myself. It is, moreover, a duty that I shall best discharge toward myself when I shall have best discharged it toward the Society. I must not only evince, I must actually take an interest in what is going on around me.

I must make a share of the Society's proceedings something personal to myself. I may not be immediately useful to it, but surely there is something I can do. By being helpful to the Society I must, of necessity, be helpful to myself. At best, my service may be modest, but if the members are animated by that masonry of fellowship and sympathy which are, or should be, found in the ranks of every properly constituted scientific society, my efforts, be they never so humble, will be accepted with cordiality even if they be not greatly appreciated as well. I will select some subject, or some branch of a subject, and will endeavour to become its master. If I cannot do more, at the start, than search books and magazines and newspaper articles for the latest information and views concerning my own branch of work, I will, at least, do that much. I will, therefore, take hold earnestly, and will do my best, so that if my connection with the Society do not prove to be mutually beneficial, it shall not be because of a lack of interest, or of something on my part left undone."

These observations are not by way of chiding. They are rather by way of enabling me to emphasize the thought that the successful working out of its mission by a body like this depends not upon some of its officers, nor upon a few of its members, but upon all; in other words, that there must be individual effort if there is to be individual advantage in being a member. If each individual is at work, then not only himself, as a member, but the entire Society, as a body, must make and share in the general progress. That only can be a hive of industry where each individual is busy.

Now, in a Society which, like ours, takes notice of all of the subjects which comprise the fields of astronomy and of physics more or less nearly associated with astronomy, there must be work for every one. No one, no amateur at least, can hope to master all of these subjects. As in other sciences, so in this, there may be specialists, possessing also a generally accurate knowledge, but there can be no more Admirable Crichtons of astronomy, no more John Herschels. That day has passed.

Let us look about us and see what work lies at hand. Meteorology is included within our field. Let us take it as an illustration, because it is a science in some one or other portion of which we must and do take an interest. Of itself, it is a vast subject. We by no means embrace it, when we allude to it simply as "The Weather," for it is made up of the more or less major branches, alphabetically arranged, of the atmosphere, the aurora, the barometer, the climate, the clouds, the dew, the dust in the air, electricity, evaporation, fog, frost, hail, halos, lightning, magnetism, rain, snow, storms, temperature, winds, and a practical knowledge of the various instruments employed for taking observations.

Meteorology is, therefore, a multi-sided subject. Many of the requisite observations are very simple in character. They are also extremely interesting. With what attention have we listened to papers and items dealing with one or more of the branches which have been enumerated! The history of meteorology is delightful to the student. Like astronomy, meteorology is ancient. But, like that of astronomy also, its material advance is modern. Down to the year 1643, the date of the invention of the barometer, meteorology stood practically still from the time of Aristotle, who collected the current prognostics of weather, as they were understood, and of Theophrastus, one of his pupils, who classified under four heads the opinions commonly received in his day regarding the weather, viz., the prognostics of rain, of wind, of storm, and of fine weather. But the invention by Torricelli, of an instrument to measure the weight of the atmosphere, and by Fahrenheit, of a portable thermometer to take temperatures with some precision, gave the science a new birth, as it were, and during two hundred and fifty years its progress has been rapid and assured. Yet our knowledge is by no means perfect. The associated phenomena to be observed and discussed are highly complex, and their first causes often obscure and difficult of perception. Cause must precede effect. There must be a cause for every change, whether that change be normal or abnormal. We are at this moment experiencing weather that is far from normal, if the average Canadian summer be the standard. Why is this so? What is the cause? Is it terrestrial? Is it solar? Is it cosmical? Is a stream of meteoric matter steadily passing between us and the Sun, and cutting off a portion of his heat? Why have we so much cold? So much cloud? So much rain? Possibly, the unusual conditions will induce Dr. Meredith to examine still further the evidence in support of the meteoric theory which has been propounded. It may be that such years as this occur at regular intervals, and can, therefore, be predicted. The meteorological records may be able to throw some light upon the subject. Then, too, is this peculiar weather general and wide-spread, or limited and local? As we know, there are intervals when special and local conditions prevail, in spite of general and wide-spread conditions. Several years ago, we had a bitterly cold winter. At the same time the heat in the southern hemisphere was abnormally great. Why? In another winter while the weather was so mild that there was no ice in this country, and even not in Iceland until the end of January, the cold was intense and abnormal in the Southern States, the harbour at Norfolk, Va., being ice-locked for some time, and persons as far south as Texas having been frozen to death during a "norther."

Tromholt tells us of a couple of interesting incidents, possibly more local, as to area, than those mentioned. In 1880-81 the winter in Iceland was very cold, probably colder than during any previous winter within one hundred years. Yet, at the same time, in West Greenland the weather was very mild. In the following winter exactly opposite conditions prevailed, for the winter was mild in Iceland, and so cold in West Greenland and the spring so late, that the first vessels which arrived from Denmark could not reach the harbours on account of land-ice. Why was this? In some years we have many storms. In other years, not so many. Reasons are given, but are they really the true reasons? This is the 8th of June, and we have not had one real summer day, or one electrical storm worthy of note. This is not usually so. Why? Amateur, as well as professional observers, are interested in these and a multitude of other matters. They are accumulating observations which, some day, will, collectively, disclose causes now more or less obscure. Every amateur who is at work deserves encouragement. No one knows how valuable his contributions to Science may become. When Schwabe began his record of sun-spots he little knew to what result his patient observation, which was continued thirty years, would lead. His discovery of solar maxima and minima explained much not previously understood. But much remains to be explained. Amateurs have done well. Professional men have accomplished much, but the highest examples have been professional men who, at least, really remained enthusiastic amateurs. Indeed, the successful professional man has always been an amateur first. And the amateur has been successful largely because he put forth individual effort and depended upon his own exertions.

I beg to be excused for this digression, but my object was to elaborate, in some degree, the idea of the necessity for individual effort. I have taken, as an illustration, one of the branches of Science which fall within our purview. That which has been said in respect of meteorology, may be said of astronomy. This science, too, has many sides. No one of us can hope to master all of them. What we had best do, therefore, is to select some one of the branches. There is, in the order in which I would place them, first, the Moon ; second, the Sun ; third, the planets ; fourth, the stars of the naked eye magnitudes ; fifth, telescopic objects such as the other stars and the nebulæ, and sixth, comets. Under each of these main heads there are other heads, and these subheads, have, in turn, other sub-heads, all interesting to the amateur and some certain to be so in a very particular degree. Now, which of us will elect to make choice of one or more of these ? Who will lead us ? From our President we have no right to expect more than he now does for us, but we shall be glad if he can help us here. Who will be our chief planetary observer ? Will it be Mr. Harvey ? and, if so, will he continue to inform us of the many scientific matters upon which he keeps a vigilant eye ? Who will be our chief meteorological adviser ? Will it be Mr. Stupart, assisted by Mr. Denison, representing the professional side, and shall it be Mr. Pringle, representing the amateur side ? Who will be our chief solar observer ? Will it be Mr. Blake, or Mr. Pursey, or will both act, there being plenty to do ? Who will be our chief lunarian ? Will it be our veteran, Mr. Elvins, with Dr. Wadsworth to assist ? Will Dr. Meredith make of meteors a still further study ? Who will form a rallying point for those of us who are anxious to know more of auroras —a very delightful subject ? Are there black auroras ? Professor Abbe, says that black auroras and black lightning seem to be "paradoxical." Possibly, but are there such auroras ?* Is there black lightning ? If there be not, how do you explain the peculiar phenomena caught by the photographic plate ? And speaking of photographs, who will take photographs for us, who make our lantern-slides, who manipulate the lantern and thus assist materially in the delivery and intelligent appreciation of papers ? Surely this is a circle of absorbing subjects forming a wheel so large that we may apply all of our shoulders to it. Then there are the constellations and eclipses, and minima of Algol and other stars, the predictions of phenomena, the collection from the newspaper press of items of scientific news in which we all take an interest.

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* In reply to an inquiry at a later date, Dr. F. Nansen stated that, during his arctic voyages, he had "never seen anything resembling 'black auroras'; the only thing at all like it has been dark clouds, which is no unusual occurrence."

Then may not we have a scrap-book for these items? Who will keep that? Who will reduce to crisp paragraphs articles found in the magazines and like periodicals, and thus greatly enable the Editor to compilation of annual reports which shall, within a reasonable degree, be works of ready reference? Much of the work outlined should have and has a charm for the feminine mind, and if undertaken by ladies will be found to afford entertainment as well as useful information. Indeed, there are some branches of work in which they might take even a leading part.

And now for a closing word. Who will come forward and take his place in making this Society a hive of scientific industry; or rather an industrious hive of scientific individuals? The summer is upon us and is, or ought to be, if Dr. Meredith will only persuade his meteoric stream to "move on," the best season for out-of-door work of all kinds. Let it be remembered that one observation is better than a page of description. Very often the clearest page of written description remains obscure to the student until he is able to take the observation necessary to make it lucid, probably in an instant. Those who have had the pleasure and advantage of looking into Mr. Miller's spectroscopes must know how this is in so far as spectroscopy is concerned.

Individual effort is what is wanted. These remarks have been a sort of plea for it. A poor plea truly. But such as it is, the writer trusts it will be accepted as some evidence of willingness to comply with a duty to prepare a note on this subject, imposed upon him at the last meeting, and really only performed at the last minute. As he takes his seat, he once again begs each and all to make the success of this Society a personal matter, and this can best, possibly only, be done by putting forth individual effort.

The paper was received with enthusiasm and discussed by several members. In connection therewith it was decided to keep the text of Mr. Lumsden's remarks constantly before the Society.

As the date for the next regular meeting fell on June 22nd, the day set apart for the celebration of Her Majesty's jubilee, it was decided to hold the meeting on June 24th as the members would, with the other citizens of Toronto, wish to take part in the festivities of the day.

TWELFTH MEETING.

June 24th; the President, Mr. John A. Paterson, occupied the chair.

Mr. R. S. Gibson, of Toronto, was duly elected an active member of the Society.

Cordial letters were read from Mr. W. D. Barbour, of the Leeds Astronomical Society; Prof. Holden, of the Lick Observatory, and M. Paul Henry, of Paris.

Mr. Lindsay stated that he was greatly indebted to, and desired to publicly thank Prof. Pickering, of Harvard Observatory, for some valuable information required for the continuation of the History of the Greenwich Nautical Almanac.

An important communication was received from Sir Sandford Fleming, C.M.G., relating to the work of the Joint-Committee on the Unification of Time. It appeared that several high officials in the United States were thoroughly in accord with the change proposed and would advocate the continuing of the campaign vigorously. It was proposed by Sir Sandford that a paper on the general subject be prepared and presented to the British Association at the Toronto meeting. After some discussion the President was requested to prepare the text of the paper and Mr. G. E. Lumsden was requested to present the side of the question dealing more particularly with the necessity for the change from the standpoint of the navigator.

Mr. D. J. Howell reported having sent the lantern slides of the Society to Meaford, where they had been used by Rev. D. J. Caswell in course of a popular lecture on astronomy. Much pleasure was expressed by the members at being able to assist the Meaford Society in its work. A brief report of the Stellar-section meeting was made by the President. It had been held at Walmer road on June 15th, and after spending an hour in observation, the members had listened with much pleasure to short addresses by Dr. J. J. Wadsworth and Mr. G. E. Lumsden on work for amateurs.

Observations were reported by Mr. Pursey and Mr. Lindsay. The latter stated that he had been unable to detect the difference in colour between Alpha Ursæ Majoris and its distant companion, using a $2\frac{1}{4}$-inch telescope. The faint star was undoubtedly coloured but considerable aperture, he thought, was necessary to enable the observer to name the colour.

Mr. A. F. Miller read the following notes on

DR. ZEEMAN'S DISCOVERIES

communicated by Mr. C. A. Chant, B.A. :—

I wish to bring to the notice of the Society a new relation which has been discovered between light and magnetism.

In recent years we have witnessed the growth of the electromagnetic theory of light in which it is shown that there is a grand fundamental connection between electricity and optics ; but quite apart from this, several connecting links between these two branches of science have been discovered—methods of obtaining an optical effect by purely electrical or magnetic means. At present I have not time to enumerate these, my desire being to give a short account of one which has been very recently discovered by Dr. P. Zeeman, Professor of Physics in the University of Amsterdam, and published by him in the *Philosophical Magazine* for March.

Some years ago Zeeman examined the spectrum of a sodium flame which was between the poles of a strong electromagnet. Upon making and unmaking the magnet he hoped to see some alteration in the yellow lines, but no effect whatever was observed. Some time afterwards, upon reading Maxwell's sketch of Faraday (written for the *Encyclopedia Britannica*) he found that Faraday had made the very same experiment in 1862—that, indeed, it was the very latest research of the great experimenter. Though the result in Faraday's case also was negative, Zeeman determined to make another attempt, and, on using the best means at his disposal, success was attained.

Between the poles of a Ruhmkorff electromagnet he placed a Bunsen flame in which common salt was vaporized. A very narrow slit was placed near this, and a concave grating with 14,000 lines to the inch and a radius of 10 feet produced the spectrum which was observed by an eyepiece. The D lines were first obtained with the magnet unmade ; then on turning on a strong current a very intense field was excited where the flame was, and *the lines were seen to broaden.* Lithium gave a quite similar result.

Then the absorption spectrum of sodium vapour was used. For this purpose a porcelain tube with glass ends, containing a salt of sodium, was placed between the magnet poles and heated either by a Bunsen or an oxy-coal-gas flame. Light was now projected from an arc lamp through this tube, and upon analysis by the grating the dark lines were obtained. Upon exciting the magnet these lines also broadened out.

Zeeman now sought for a theoretical explanation of the new phenomenon. An attempt had been made to connect all the phenomena of light and electricity upon the electromagnetic theory by Prof. Lorentz, of Leyden, and to him Zeeman communicated his results. Lorentz at once informed Zeeman that if the theory which he had proposed was correct the light from the edges of the widened spectrum lines should be circularly polarized, and Zeeman, upon trying the experiment, found that such was actually the case.

The explanation of the widening of the lines is somewhat as follows: It is assumed that in all bodies there are present small electrically-charged particles of definite mass. These are called "ions," and upon the charge, configuration and motion of these ions all electrical phenomena depend. These ions also have an oscillatory motion, in straight lines, circles, ellipses, or some other curves, by which the ether is agitated, and the disturbance thus produced travels out as light, heat or other ether radiance.

Now it is quite generally accepted, as the result of Faraday's experiments and Kelvin and Maxwell's researches, that in a magnetic field there are rotations going on about the lines of magnetic force—possibly the molecules are the rotating bodies. It is the combination of this magnetic rotation with the above mentioned oscillations of the ions which gives rise to the widened lines.

If in a source of light, waves of all lengths are present, we have the continuous spectrum, but if waves of only one length, then the spectrum will be a narrow line. In the sodium flame there are waves of two distinct lengths, and so its spectrum consists of two narrow lines.

Suppose now the observer is looking along the positive direction of a line of magnetic force, that is from the N. pole to the S. pole. Then the rotations which produce the magnetic effect will take place about this and the parallel lines of force, the rotations being right-handed, *i.e.*, in the same direction as the hands of a watch when we look at its face. Suppose the oscillations of the ions to be in circles or ellipses, and in various planes. To the observer some of these will appear right-handed, others left-handed.

We should naturally expect, then, that the right-handed magnetic rotations would assist the right-handed oscillating ions, and thus make their periods *shorter* and therefore the ether waves excited by them *shorter*. On the other hand, the left-handed oscillations will be retarded in their motion, the period *increased* and the emitted ether waves *lengthened*. By this means there will be produced ether waves, some greater and some less than the original one, and thus the spectrum line will be widened.

Upon learning of the discovery I determined to try the experiment, and about two weeks ago arranged apparatus for the purpose. The sodium was vaporized between the poles of a large Ruhmkorff electro-magnet, and the spectrum was produced by a flat grating with 7,000 lines to the inch, placed at the centre of a divided circle with collimating tube and telescope. I observed the effect myself, and on Tuesday evening of last week Mr. Miller and I spent some time in experimenting. We found the strongest effect with the third and fourth spectra on one side. Upon making the magnet the lines brightened up and widened.

We have not yet tried the absorption spectrum or the test for the circularly-polarized edges, but hope to do so at a more convenient time.

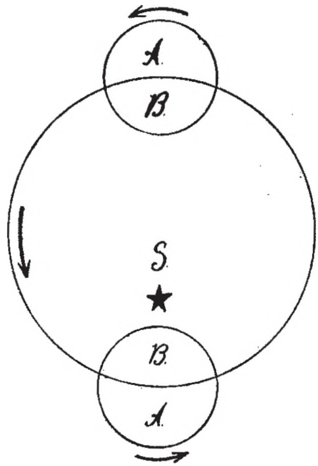
[NOTE :—Mr. Chant subsequently stated that a further consideration of Lorentz's theory led Zeeman to believe that with a sufficiently strong magnetic field the spectral line would be broken into a doublet or a triplet according as the light was emitted along the lines of force or at right angles to them. With sodium these could not be observed, but with the blue line of cadmium they were both seen.]

Mr. A. Elvins then read the following paper, taking up a subject which had been discussed with much interest at several meetings of the Society in past years, on

PLANETARY ROTATION.

Before entering upon the question to which I ask your attention, I wish to refer to the laws of motion (which are not questioned by students of physics or mechanics).

1st. Law.—Bodies must continue in a state of rest, or of uniform motion in a straight line, if not acted on by an external force. *Mass* is the quantity of matter in a body. *Momentum* is the product of the *mass* into its *velocity*. If two equal masses move at the same rate, their momentum is equal. A moves one mile per hour, B moves at the same rate. A force which would stop either of these bodies, would stop the other, if applied in the same manner, but if A moved faster than B, its momentum would be greatest and its motion only retarded. As I wish to apply this law to planetary rotation, I wish these well-known facts to be remembered.



If a disc or globe moves around a centre S on a rod to which it is firmly fixed, it will rotate once in each revolution, and as A is more distant from the centre around which it revolves than B, the outer half will pass over a large space in a given time than the inner half will, and hence the outer half will move with greater velocity than the inner half. As the masses outside and inside of the centre of gravity are equal—and the outer half moves at a greater speed than the inner, the outer half's momentum must be greatest.

The planets are material bodies, spherical in shape, revolving in orbits around the Sun. Two forces act on each planet, the one attractive (centripetal), the other tangential (centrifugal). This latter is the result of the tendency of matter to move in a straight line. The density of a planet is probably about the same in any part on or near the surface, and if so, equal volumes at the points, nearest to and furthest from the Sun, would have the same momentum if each portion of the mass moved at the same rate in the orbit. But two such portions of the mass could never move at the same rate; A must of necessity move faster than B in its orbit, for it goes over a greater space around S in the same time; and as the mass into its velocity is its momentum, A's momentum must be greater than B's at any given moment of time.

If the body rotated only once in a revolution, these opposing forces would elongate the planet, the resulting shape would be a prolate spheroid, the centre of gravity resting on the orbit, the inner half being stretched sunward, the outer half stretched out backward, and a section cut lengthwise would be an oval or ellipse.

Now, such a shaped planet would keep the same side always turned sunward, for the plus attraction of S at B, would keep it pointing sunward, whilst the more distant centre of gravity would move onward in the Earth's orbit. If the planets were solids, rigid and unyielding, such would not be the result of these opposing forces, but masses are not thus unyielding; the most rigid substances we know of would yield under such a strain.

Now, if planets moved in perfect circles, and at a uniform rate, they would make but one rotation on their axes in each revolution; but their orbits are not circles, nor is their rate uniform; let us see how they must act when they move in ellipses, and as a consequence, with changing velocity. The planet moves slowly when passing aphelion, but its velocity increases as it moves towards its perihelion, and when it is passing perihelion it is moving at its greatest speed. At this point acceleration of the mass ceases, and retardation of the mass begins, the speed decreasing until aphelion is reached again. At each perihelion passage, as at other times, the centre of gravity of the planet is on the orbit; and when passing perihelion the half of the planet most distant from the Sun will have greater momentum than the less rapid nearer half; this plus (the momentum resulting from greater motion), would turn the rigid planet around on its centre of gravity, which would be *rotation,* in the same direction as its orbital motion.

I have embodied the above reasoning in a mechanical form in this model, and the result of the revolution of the globe, at varying rates of speed, is always rotation of the globe in the same direction as the revolution.

In the model introduced by Mr. Elvins a small globe was delicately balanced on a pivot and made to revolve at varying rates of speed, about a centre. As it revolved it took up rotation.

THIRTEENTH MEETING.

July 6th; the President, Mr. John A. Paterson, M.A., occupied the chair.

Mr. F. J. Campbell, of Toronto, was duly elected an active member of the Society.

Reports of observations were received from several members. Mr. J. R. Collins reported having observed a meteor in the northern sky on the evening of June 24th, which left a luminous track of about 30 degrees in extent, the duration of the light being about half a minute. Mr. H. Charlesworth had also noted this meteor. Mr. G. G. Pursey in reporting his solar observations again emphasized what he thought was the explanation of the faculæ, that is, that they were crests in the fiery envelope of the Sun akin to the crests of storm-tossed waves on the sea. Mrs. Savigny presented two sketches of the lunar disc made without the aid of the telescope. From Mr. Collins were received some photographs of terrestrial objects taken with a 10-inch reflector. Among these were several portraits which it was thought were the first that had been taken in this way.

Much regret was expressed on learning of the death of Mr. Alvan G. Clark, the world-renowned maker of telescopes. Mr. Lumsden stated that a visit would probably be made to Toronto by Dr. J. A. Brashear, of Allegheny, who was now on his way to Muskoka.

Some discussion arose regarding the effect which a network of electric wires around a city might have upon terrestrial magnetism at near points. Mr. Elvins thought that this was a question of great importance to meteorology and casually stated there was frequently noticed at Toronto a very clear sky overhead but banks of clouds all round the horizon.

A paper on the "Planet Mars" was read by Mrs. A. G. Savigny. The first part of the paper dealt with the early observations of the seventeenth century, when telescopes were very inferior, compared with those now used. It was shown, however, that some of the more noticeable markings on the disc of Mars were well seen even in those days. The marking known as the Hour-glass sea was very perfectly delineated by the celebrated Huyghens, in honour of whom it was thought the sea should be named. The general conditions of the Martian surface were very lucidly sketched, drawings being shown in illustration, and in each particular references were given to the work of competent authorities on the telescopic appearance of the planet. It was arranged that Mrs. Savigny should continue and read the second part of the paper at a future meeting.

FOURTEENTH MEETING.

July 20th; the President, Mr. John A. Paterson, M.A., occupied the chair.

Mr. A. Boyd, of Rosedale, and Mr. J. Colby, of Toronto, were duly elected active members of the Society.

The weather had for some time past been particularly fine for observational work and every advantage had been taken of it. Mr. Lumsden had placed his 10-inch reflector at the service of any friends who could arrange to meet at his residence during the July evenings, and much pleasure had been afforded those who took the opportunity of seeing what a large reflector can do. Mr. Harvey had seen in this telescope five of the moons of Saturn; on occasions very favourable Mr. Lumsden had himself seen seven satellites, the eighth being probably beyond the light gathering power of any telescope yet mounted in Canada. Mr. Lumsden reported having seen two of the satellites of Uranus, and especially remarked that the greenish colour of the planet was well observed. The Sun had been as usual closely observed by Mr. Pursey, but the period of minimum of sun-spot activity being now in progress, there were few of these objects to be seen. Among reports of another kind, from correspondents, were two interesting accounts of waterspouts, one seen on Lake Erie, July 13th, and the other on Lake Ontario, July 14th.

The Librarian reported the receipt of exchanges and among other items of interest it was noted that Mr. G. F. Hull, B.A., formerly of Toronto University, had been appointed to the chair of physics in Colby University in Maine. Mr. Hull had the best wishes of the Society for his success in his new field.

A paper was read by Mr. Lindsay on the subject of the solar eclipse to be visible in Canada as a partial obscuration, on the morning of July

29th. The Moon would be in contact with the west limb of the Sun at 8h. 46m. 12sec., and would cover about one-third of the disc at middle eclipse. The last contact was calculated to occur at 10h. 56m. 10sec. These were the results of the computations by Mr. F. L. Blake, Chief Observer at the Toronto Observatory. It was hoped that all who could observe would do so.

Mr. Lindsay concluded by calling attention to

THE TOTAL ECLIPSE OF MAY, 1900.

Now these partial solar eclipses are very interesting phenomena in their way, but we would be better pleased to hear that within a reasonably short time we would have a total eclipse and have an opportunity right here at home to see that object of wondrous beauty, the solar corona. Well, I do not know when such an eclipse will occur. There is a list of these phenomena, dates and localities, to be found in a valuable work by an English astronomer, a clergyman of very great mathematical talent and a genuine love for hard work, but I have never had access to the book and do not know whether Toronto is to be favoured during the next century or not. However, the next best thing to having an eclipse at your front door is to have one across the street. What do you think of the Southern states: Louisiana, Mississippi, Alabama, Georgia, the Carolinas, Virginia, and off at Cape Henry? Say a matter of 800 miles from home, $25 return fare, excursion rates. How does that sound for an expedition scientific? The Toronto Eclipse Expedition, how does that look? And the date, May, 1900. A May morning in the Southern States, May of all months in the years. What ought we to do in view of the fact that three years from now there will be the chance of a life-time to stand in the path of the Moon's shadow as it sweeps across the Earth? Why organize of course; and commence right now. We are not a body of gentlemen of leisure trying to kill time in recreative studies. We are all busy people, and can only at stated times meet for discussion. It will take us a pretty long time to arrange all the details for a scientific expedition, had we not better commence early? It will do no harm to commence to-night. We need not do much at present, just give our expedition a name, that will be enough. Of course there will be several committees to be appointed. We must have for instance a committee on computation; we will want to know just exactly where the line of totality passes; I think we had better put Mr. Blake at the head of that committee with instructions to get all the mathematical work down to the finest. Then we will want a topographical committee, to select from the points on the line places where we will be most comfortable. We will require a good man for that, one who will fearlessly keep us clear of all prohibition towns, temperance hotels and such like menaces to the well-being and peace of the expedition. I think we might put Mr. Musson at the head of that committee. He has the topography of the country at his fingers' ends though I am not so sure about his other qualifications. Then we will want a photograph department, we can run Mr. Howell in for charge of that; and publication committees, and so on; in fact, any amount of work for everybody. We can see about a leader of the whole expedition when the date draws a little nearer. But we want a financial leader right now, to keep note of the sums to be subscribed presently. We will appoint him to-night. Mr. Todhunter will please consider himself treasurer of the expedition; *ex officio* in fact, as he is Treasurer of the Society. There will be a good deal of solid work to be done and I need not remind you that labour when most highly concentrated takes the form of current coin of the realm.

Now, we cannot all be heads of committees, we cannot all be important elements in the work of the day; some of us will simply want—to be there. You can place me on that list if you please. It will satisfy me to be able to say by-and-by, "I have seen the most beautiful work of creation, the Sun's corona."

Some of our number are young enough to expect many opportunities to observe total eclipses, if money for travelling is no obstacle; but others of us, who will be hovering around the half century mark when the new century dawns, will find that this is an opportunity which should not be lost; and there are others already become full of years and honours, who, revelling to the very last in the love of nature, will say that this is an opportunity which must not be lost. Whatever may be the span allotted to these dear friends, we will reverently trust that it will extend beyond the year 1900 and we will hope that they will live to remember that year as of the past, and bright with pleasant recollections. We can in fancy see one of these honoured friends explaining a solar eclipse to a little one two or three generations younger, and can hear him say: "Yes, my boy, I have seen a total eclipse of the Sun. It was during the last year of the last century and we had formed a grand expedition in Toronto to go down to the cotton fields of Carolina, right in the track of the Moon's shadow. How I had looked forward to that event! I had seen and remembered celestial phenomena early in the century, long before the new astronomy began, before the stars gave up the secret of their constitution; I had seen the great meteor shower of 1832; the splendid comet of 1843 I had never forgotten; I remembered the brilliant work of Adams and Leverrier in the discovery of Neptune; I had seen many transits of Mercury and the century's pair of transits of Venus; partial eclipses of the Sun, such as they had been, I had observed many times, but a total eclipse, that I had never dreamed of seeing for the only reasonably possible one seemed so far ahead. But it pleased Heaven to spare me a little and I only wish now I could describe to you the feelings that possessed me on the 28th of May in the year 1900. There we were, instruments all ready; telescopes, spectroscopes, cameras, everything. There we were on a beautiful morning, under the clearest sky that ever delighted the student of the stars. There we were, gazing up into the heavens and watching a black velvet disc eating its way into the glorious orb of day; then looking anxiously, nay fearfully, to the south-west, looking for the great blue-black shadow cone that we know must soon envelop us. Smaller and smaller grew the rim of light, and an indescribable sense of awe possessed us; tick, tick, tick went the timepiece that was to mark the instant of totality; tick, once again, a sharp signal announcing that the exact computed moment had arrived—and the shadow was upon us! A feeling of nameless dread possessed me, in such utter blackness it seemed as if for me the whole universe was blotted out. Then I looked up and in that instant there flashed out as a halo around an inky black disc—the Sun's corona, that object which neither camera nor pencil can delineate, which the language of poetry can only feebly describe. For two short minutes I drank in the beauty of the spectacle feeling indeed that I was in the presence of the Creator—then it was gone, as quickly as it came—but, though I did nothing but look, awe-stricken, some there were who employed every second in interrogating nature, and you know, my boy, it is recorded in your book that the Toronto expedition finally solved the mystery of the Sun's corona."

Some such a picture, friends, look forward to and let me ask you to-night, who will join the expedition?

FIFTEENTH MEETING.

August 3rd; the Vice-President, Mr. Arthur Harvey, F.R.S.C., occupied the chair.

On taking the chair Mr. Harvey stated that since the previous meeting the President had met with a very painful accident which would necessitate his remaining under a surgeon's care for some time. Serious results were, fortunately, not anticipated; he was sure the members would join him in wishing Mr. Paterson a speedy recovery and an early return to the duties of his office in which he had always taken such pronounced interest. Mr. Harvey read a letter from the President in which it was said that the work of preparing the paper on the Unification of Time for the British Association would be proceeded with notwithstanding the inconveniences to which the accident had subjected him. A letter on this subject was also received from Sir Sandford Fleming, C.M.G.

Reports were then received of observations of

THE SOLAR ECLIPSE OF JULY 29TH.

The day in Toronto had been one of disappointment. Mr. Harvey said:—The morning was so cloudy that I had no opportunity of seeing the first contact. The Sun appeared faintly through the clouds at about 10.30, and I could see the disc fairly well, as may be understood when I say the two spots on it were plainly visible. The Moon was then cutting off a small portion of the disc only. I used a low power of about 80, with a non-inverting eye-piece. The clouds soon blotted out all vision, but another rift in them appearing, I was able to observe the last contact. I had a view for three or four minutes before it, when I was a little surprised to note how rapidly the Moon was moving off the disc. I timed the disappearance at 11.57, one of my daughters holding a watch, which I at once carried to the observatory, finding it half a minute slow by the standard time. This is as close to the true time as the weather and the bad seeing permitted me to arrive. It would have been useless to have calculated upon seconds.

Several other members reported similar experiences. Mr. A. F. Miller had timed the last contact to a very close agreement with the computed time, so far as under the conditions he could judge. Mrs. Savigny handed in a little sketch of the solar disc showing the position of the Moon when about passing off and also the position of spots on the surface of the Sun. This had been made at the observatory where the large telescope had been prepared for observation. Mr. G. G. Pursey and Mr. T. Lindsay also reported their non-success. From correspondents the reports were more encouraging.

Mr. J. R. Connon, of Elora, had seen the eclipse fairly well and had taken a photograph at 9h. 40m., a copy of which was forwarded to the Society. Mr. Connon remarked that the air was full of moisture and that the photo revealed this defect.

Dr. J. J. Wadsworth, of Simcoe, wrote :—

The eclipse of the Sun was observed here on 29th ult. Clouds obscured the phenomenon until 9.45, but from that time until 10.40 we caught glimpses through rifts in the vapour. The sky was clear the last ten minutes, and we had fine views through the reflector, aperture reduced to 6 inches, power 120, dark screen glass. Also I had the solar image thrown on a screen of cardboard, using my 3-inch refractor attached to the large telescope; so that the whole party watched the eclipse to the close—Rev. Canon Hicks, Rev. J. W. Dey and W. F. Steinhoff (the builder of my new equatorial stand) and others. They allowed me the privilege of seeing the final disappearance of the Moon, which I watched with much satisfaction in the reflector, direct vision of course. Time (railway, E. S. T.) 10h. 52m. 30s. (But our watches are to be allowed for !) The group of spots and the large single spot near the western limit were well seen both by direct vision and on the screen—even the latter showing the penumbra clearly.

The following was received from Mr. D. E. Hadden, writing from Alta, Iowa, Lat. N. 40° 41′; Long. W. 6h. 21m. :—

The partial eclipse of the Sun which occurred on July 29th, 1897, was observed in Alta, Iowa, under favourable conditions, the sky being cloudless and of a deep blue colour. First contact was noted at 7h. 33m. 2s.; the disc was a little unsteady and this time may be a few seconds in error. The last contact was quite accurately observed at 9h. 35m. 47s.

At 7h. 47m. 20s. the limb of the advancing Moon occulted the larger sun-spot nearest the west limb, the spot being exactly bisected at the time mentioned, and its reappearance was noted at 8h. 20m. 55s.

An interesting phenomenon was the apparent blackening of the umbra of this sun-spot, as the edge of the Moon appeared to touch it (the umbra before appearing a shade lighter than the Moon). I also noticed a peculiar lengthening of the umbra towards the Moon's limb as it reached its edge, a sort of "black drop" or "bead" so to speak. I do not think this was due to the inequalities of the Moon's edge as the same appearance was observed during the spot's reappearance.

About 4 digits of the disc were obscured, the sunlight was quite perceptibly changed about the time of mid-eclipse and the temperature of the air fell 4° in the shade as recorded by a self-registering minimum thermometer.

All observations are in Central standard time, a 4-inch telescope with Herschelian eye-piece magnifying 78, was used.

Among reports of other phenomena Mr. J. F. Maybee said that he had observed a very brilliant meteor on the evening of August 2nd about 10 o'clock, while out on the lake. It passed from Ursa Major through Leo Minor to the horizon, leaving a luminous track of a distinctly greenish tint. Some discussion arising regarding the colour of meteor tracks the Chairman stated that the green tint might possibly be due to nickel vapourized as the body passed through the atmosphere.

Mr. W. B. Musson then read the text of a paper which had appeared in *Popular Astronomy*, dealing with the value of the work done in stellar astronomy.

SIXTEENTH MEETING.

August 17th; Mr. G. G. Pursey, occupied the chair.

This was a meeting held at the Toronto Observatory by permission of the Director, Mr. R. F. Stupart, to which a general invitation to attend had been extended to any of the members of the British Association interested in astronomical work. The large telescope of the observatory had been placed at the service of the Society, under the direction of Mr. F. L. Blake, the astronomer of the observatory. Several portable telescopes were also placed on the lawn by members. Among these were a 3-inch Vion Frères telescope, brought by Mr. S. Michael; another of the same instruments was brought by Mr. C. T. Gilbert. Mr. J. Todhunter brought his 2-inch, a telescope of very superior excellence, and Mr. Stupart had also placed on the lawn a 3-inch Dollond telescope which had for many years been the observing instrument for the service at Toronto.

The evening was spent in observation; the position of Saturn was favourable, while there were many stellar objects of interest above the horizon. The thanks of the Society were due to the Director for the pains taken to make the meeting an enjoyable one as it undoubtedly was.

SEVENTEENTH MEETING.

August 31st; the President, Mr. John A. Paterson, M.A., occupied the chair.

Mr. G. G. Pursey rose to express the pleasure which he was sure all the members felt at seeing Mr. Paterson recovered from the effects of the accident which had recently happened to him. All were very glad to learn that serious results had been averted.

A letter was read from Dr. M. A. Veeder covering the transmission of a copy of his paper on "Ice Jams," read, at Detroit, before the American Society for the Advancement of Science.

Dr. A. D. Watson read a letter received from the Secretary of the Antonio Alzate Society of Mexico, conveying his entire agreement with the views in Dr. Watson's paper on the "Reformation of the Calendar."

The Librarian reported the receipt of four volumes of the publications of the Observatory of the Vatican, which Monsgr. Merry del Val had undertaken to have forwarded to the Society from Rome. The thanks of the Society were due to the authorities at the Observatory for this mark of favour.

During the fortnight preceding this meeting, Toronto had been the scene of the meetings of

THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Many of the members had availed themselves of the opportunity to hear the papers read by the distinguished men of science who had taken part in the work of the Association, and these freely expressed the great pleasure derived from attendance at the sectional meetings, etc., which had been held.

The President spoke in review of the circumstances attending the reading of his paper on the Unification of Time before Section A, in compliance with the previously expressed wish of the Society. He said that the section had paid him the compliment of placing his paper first on the list for the first day, and that he had had the pleasure of reading it before a large audience which listened to it with apparent attention. He added that he had intended following up his paper with a motion, but that Prof. A. R. Forsyth, F.R.S., President of the section, had suggested that the proper plan would be to submit a resolution to the Committee of the section which would meet next day. The reading of the paper was followed by some observations made by Prof. Simon Newcomb, who stated that astronomers were not in accord with the plan, and also by Prof. Arthur W. Rücker, F.R.S., General Treasurer of the Association, who explained that, by reason of a request received by the Royal Society of London from the Royal Society of Canada, the subject of the Unification of Time had been under the consideration of the Council of the Royal Society last year, and had been by it referred to a Special Committee, of whom the Astronomer Royal was a member. Prof. Rücker further said that he apprehended the present was not an opportune time to deal with the subject-matter of the paper in the manner that so grave a matter required as but few astronomers were present at the meeting of the Association. He felt, however, that it might be revived with advantage at a meeting of the Council of the British Association, which, he intimated, would be held, towards the close of the year, in England. Mr. Paterson further intimated that the only really unfavourable criticism of his paper, in respect of the proposed change of time reckoning, consisted of the remarks made by Prof. Newcomb, and added that in the course of the discussion which had followed, Mr. Arthur Harvey pointed out that Prof. Newcomb could not have made himself acquainted with the views of those really interested, for it was an undoubted fact that the great majority of those, whether astronomers or mariners, who had been asked for their opinions had declared in favour of the change. Hence the action of The Astronomical and Physical Society of Toronto, which recognized that the views of a few astronomers, even of such eminence as Dr. Newcomb, should not be allowed to bar the way to a change desired by those whom, in large part, the astronomers were working to serve, namely, the great body of master-mariners throughout the empire.

Mr. Paterson further mentioned that in view of the attitude of hesitancy on the part of several of the leading members of the British

Association to take action, it had been deemed proper to appoint a small delegation to wait upon the Council, and that Prof. Rücker very kindly arranged for the reception of a deputation, which, consisting of himself (Mr. Paterson), Sir Sandford Fleming, Mr. Arthur Harvey, and Mr. G. E. Lumsden, was received on the 23rd day of August, by Sir John Evans, F.R.S., President of the British Association, Prof. Rücker, Prof. Forsyth, and Prof. Foster, F.R.S., who attentively listened to the members of the deputation, who, in turn, addressed them. As a result of the interview, it was decided, on the suggestion of Prof. Forsyth, that the following resolution should be moved in Sections A and E, Prof. Rücker, speaking on behalf of that body, undertaking to see that the matter should be brought forward at a meeting of the Council, to be held in England :—

THAT, in view of the facts (1) that a Committee of astronomers appointed by the Royal Society of London, in consequence of a communication from the Royal Society of Canada, has recently considered the matter and has arrived at the conclusion that no change can now be introduced in the Nautical Almanac for 1901, and (2) that few English astronomers are attending the Toronto meeting of the Association, RESOLVED, that the Committee of this section are not in a position to arrive at any definite conclusion with respect to the Unification of Time ; but they think it desirable to call the attention of the Council to the subject, in which the interests of mariners are deeply involved, with the view of their taking such action in the matter as may seem to them to be desirable.

Mr. Paterson said that, upon his motion, the resolution was adopted by the Committee of Section A, and concluded his statement by calling upon Mr. Lumsden to report to the Society the action which, on its part, had been taken by Section E, the Geographical section of the British Association.

Mr. Lumsden said that as the result of an arrangement, kindly suggested by one of the Secretaries of the Association, and, with the readily given assistance of the President and Recorder of Section E, effected on the 21st, he read, on the 23rd, a somewhat hurriedly prepared paper on the subject of the Unification of Time at Sea, which he treated from a standpoint different from that occupied by Mr. Paterson. On the 24th, at the meeting of the Committee of Section E, seconded by the Rev. Dr. Burwash, Chancellor of Victoria University, he moved the resolution agreed upon, the day before, when the deputation met the Council of the British Association. The resolution was carried and directed to be reported to the Council. This appeared to have been done in due course, for, on the day succeeding the close of the meeting of the Association, he had found in the newspaper-press report the following paragraph under the head of "Resolutions":—

> "Prof. Roberts-Austen, F.R.S., moved the adoption of the report of the Committee of Section E, which set forth that they were not in a position to arrive at any definite conclusion with respect to the proposed Unification of Time, and thought it desirable to call the attention of the Council to a subject in which the interests of mariners are so deeply involved, with a view to the Council taking such action as it may deem desirable. In support of his motion, Prof. Roberts-Austen pointed out the difficulty in coming to a decision on the subject owing to the absence of so many English astronomers. The motion was adopted unanimously."

Mr. Lumsden went on to say that it was noteworthy that the deputation from the Society had been met with a cut and dried draft resolution of the most non-committal description, and that it was only when some heat, as to the attitude of the representatives of a body of British scientific men, had been manifested, that Prof. Forsyth consented to amend his draft by inserting the words, "in which the interests of mariners are deeply involved." Here, as elsewhere, had been found the fixed impression that the reformation of Time is matter for astronomers only, and that every other interest must be subservient to their personal convenience. It was pointed out that it was quite unnecessary to have astronomical as well as civil time at sea, involving two distinct dates with the risk of errors, and, further, that though to change a date in his note-book at midnight may somewhat incommode the safely and comfortably housed official astronomer, his convenience is as nothing compared with the convenience and interests of mariners, who, preoccupied by a thousand anxieties and obliged to use time-observations to decide upon their course, are greatly more exposed to error than the astronomer, error, too, which may be attended by grave consequences to life and property. The most painful incident associated with the interview was the impression, amounting to a disillusion, that the British Association is in all matters not an independent body. This Society, which has for years been working to advance the movement for the adoption of a common day, rightfully expected the co-operation and assistance of an Association understood to be, in a particular degree and in the best sense, representative of the material interests of a great commercial Empire, but found that even in a matter so vital to commerce, the Association must take its cue from a few astronomers, who are members of another body, and are prejudiced against the movement, and who, the servants and not the masters of mariners, should not be consulted at all. This Society must not be discouraged. The reform is bound to come. If it does not come at the change of the century, a time-epoch which would most suit astronomers, we believe it will not be long delayed, and if the change is made at another period less suitable, astronomers will only have such Associations as the British Association to blame. They will probably then discern that they have adopted a short-sighted policy in opposing the reform.

From Mr. A. F. Hunter, M.A., of Barrie, who had been present at the meetings of the Association and taken much interest in the work, the following notes were read:—

What impressed me most at the British Association meeting was their vigorous way of promoting scientific research apart from government action, when contrasted with the purely socialistic way in the commonwealths of this continent. This was conspicuous in the grants of money, aggregating $6,570, made to thirty-six special committees for scientific purposes, all doing excellent work under the auspices of the Association. These special committees do much work that lies beyond the reach of government bureaus. They indicate in advance, as it were, how government effort should be directed, and they add life and spirit to the whole scientific movement.

On this continent scientific research is undertaken by the governments to an even greater extent than in Great Britain. We may cite a few examples: the Geological Survey, the Weather Service, the Quarantine and Board of Health Services, Archæological work, Horticultural and Farm experiments. I feel satisfied that we have laid even broader foundations than they have; but the building does not go on with the same vigour. The work under the government systems is less efficient in many ways than it should be. The bureaus are exposed to political evils, and there is a lack of expedition in the work actually accomplished.

A great problem before us is to increase the efficiency of our government scientific bureaus. This very question is agitating the minds of scientific people in the United States. Within the past year or two a proposal has been made to organize the sixteen scientific bureaus in connection with the Agricultural Department at Washington under a Director-in-chief. Whether this would attain the desired end, it is impossible for me to say; but their object is the same, viz., to improve and expedite the work done. The government bureaus are the chief factors in the advancement of science on this continent, but it seems to me that scientific opinion should be vigorously organized and expressed apart from them, and in this respect we may copy the British Association. It sounded strange to our ears when we heard that they have a rule forbidding them to accept any government aid—a rule that was violated at the Toronto meeting, fortunately or unfortunately as the case may be. In this country the usual clamour is for more government aid. Let us cultivate some opinion on scientific matters independently of government bureaus, and exercise a healthy influence on their growth and on the advancement of science in general.

Mr. Harvey gave an interesting account of some interviews had with authorities on magnetology who were among the visitors at the Association meeting. He had found the impression very general that the splendid record of Toronto Observatory as a centre for the study of magnetic phenomena was in danger of being terminated unless something were done to meet the disadvantage of having to battle with a system of trolley wires surrounding the place of observation. It was very satisfactory to know that the Director of the observatory had foreseen the danger and was now arranging for the removal of the instruments to a locality free from electric systems. Mr. Harvey had read before Section A, a paper on "Magnetic Phenomena." The interest taken by the members of the Society had not been confined to the department of physics. Rev. C. H. Shortt, M.A., briefly reviewed the interesting meetings of the Geographical and Anthropological sections; Dr. A. D. Watson had given considerable time to the meetings of the Physiological section. Mr. J. R. Collins stated that he had had the pleasure of meeting several prominent scientific men from the United States, to whom he had been introduced by Dr. J. A. Brashear. It had been hoped that Dr. Brashear would have been able to have attended the present meeting of this Society, but his arrangements did not so allow. Mr. Collins was desirous of publicly thanking the Doctor for many valuable hints given in connection with optical work.

Mr. Miller had taken much interest in the papers read before the Chemical section, and stated that he had been allowed to use his spectroscope in the laboratory to show the spectrum of argon, some tubes of which Prof. Ramsay had been exhibiting. The model made by Mr. Elvins to illustrate planetary rotation had been placed among the exhibit of apparatus. Dr. E. A. Meredith had been an attendant at sectional meetings as often as possible. He voiced the opinion of many members of the Society when he said that "he felt the inconvenience of not being able to divide himself into a number of parts and attend all."

Mr. Lindsay called attention to a valuable paper on "Measuring the Intensity of Sound," read by Prof. A. G. Webster. In the course of the discussion a gentleman in the audience had asked whether there was any explanation for what is known as the "carrying power" of the violin, which is much more noticeable than the same quality in the grand piano of the orchestra. Prof. Webster had treated the question as if there were nothing to be explained, as if this and other similar phenomena were purely subjective. Mr. Lindsay recalled the fact that at a previous meeting of the Society, Mr. G. G. Pursey had asked the same question. He was sorry to have been disappointed in getting an answer; the moment the gentleman referred to asked the question he had thought, "here is an opportunity to learn."

Mr. R. F. Stupart had read a paper before the Meteorological section, and had contributed the paper on "The Climate of Canada," which was embodied in the Association Guide-book. Mr. Stupart was requested to prepare a paper for the Society on the general subject, and kindly consented to do so at the earliest opportunity. Mr. Napier Denison had read a paper on "The Great Lakes as a Sensitive Barometer," and following up a subject which had been presented to this Society on "The Air-barometer."

Dr. Otto Hahn had read before the Physical section a carefully prepared paper on "Meteorites," illustrated by microscopic exhibition of specimens, which were on view during the meeting in the apparatus room.

The members were unanimous in the opinion that the meeting of the British Association had been a pronounced success, and an event to be long remembered.

EIGHTEENTH MEETING.

September 14th; the President, Mr. John A. Paterson, M.A., occupied the chair.

Mr. C. Currelley, of Toronto, and Dr. Geo. Sexton, of St. Catharines, were duly elected active members of the Society.

It was moved by Mr. G. E. Lumsden, seconded by Mr. Arthur Harvey, that this Society apply for affiliation with the British Association for the Advancement of Science, so that it may have, if deemed convenient, a delegate at the meeting at Bristol in 1898. This was carried.

It was announced by Mr. Lumsden that an offer had been made by a friend of the Society to donate a full set of the *Scientific American* to the Society's library. It was moved by Mr. Harvey, seconded by Mr. Lindsay, that the offer be accepted, and the thanks of the Society conveyed to the donor through Mr. Lumsden.

Rev. D. J. Caswell, Ph. B., President of the Meaford Astronomical Society, was present, and addressed the meeting briefly on the line of work pursued at Meaford. Mr. Caswell gave a most encouraging account of the progress of astronomical study in his location.

Mrs. Savigny reported observation of two meteors seen on the evening of September 11th. The first was seen at 21h. 30m., passing to the north from a point about 30 degrees south-east of the zenith, a brilliant flash of bright yellow light. The second was from an exactly opposite direction, passing northwards at 22hrs.; the trail a vivid golden, visible for three seconds.

Mr. A. Elvins was requested to read some notes of lunar observation which he had prepared for the Lunar section of the Society. These were chiefly on Aristarchus and Herodotus. Mr. Elvins said:—

Since I last reported to the section I have had two opportunities of observing Aristarchus and Herodotus under very favourable conditions. The first was on the 10th of August, 1897, the latter on September 8th. My attention was chiefly directed to the great valley which curves northward from Herodotus, and more especially to determine whether it is or is not connected with that depression, and on both these occasions the atmosphere was so perfect that seeing was excellent. Close to, or at any rate, quite near the wall of Herodotus, there exists a knoll which seems to block the valley as if it had been a later formation than the valley and had filled it up; but a rill is now seen as if it is a connecting canyon or cutting through a hill, and this connects the valley with the crater. The wall of the crater itself is broken down, or has a gap in it, just where the rill enters the northern part of the wall; there is no difficulty in tracing this connection, as the Sun throws a shadow into it and shows it as a dark line across the knoll. The observation of August 10th was satisfactory, and it was, if possible, better seen on September 8th. Mr. Lumsden's statement that the valley connects with the crater is perfectly borne out by these observations. I cannot but refer to the similarity of this formation to what might be expected if it were the result of the action of a liquid flowing out of Herodotus. Had it been a lake, and this valley an outflow from it, the stream would widen as it passed onward, and it would enter the ocean and spread itself amongst its waters. But possibly it (Herodotus) might not have been a lake which discharged its waters outward from itself; it might have received its waters from without like the Caspian, the Dead Sea, Salt Lake in Utah, and many other terrestrial examples. The valley and all its surroundings are so much like the result of water action or of some other liquid, that I cannot but refer it to aqueous agency in the past. I ought to have noticed the fact that the valley and its neighbourhood are only well seen before the Moon is full. My observations show every thing so changed at and after full Moon, that the scenery, so conspicuous a few days earlier, can scarcely be recognized.

Mrs. Savigny was then called upon to read the second part of her paper on "Mars":—

This dealt with the observations reported by Mr. Percival Lowell at Flagstaff, Arizona, and was illustrated by reproductions of many of the drawings which were made at the Flagstaff telescope. Mrs. Savigny accepted the conclusions of Mr. Lowell, and sustained many of his arguments with much skill. The paper was of particular interest in view of the fact that at the meeting of the British Association, Mr. Lowell had been heard in his own defence as against those who claimed that his views were erroneous. He had shown how perfect the atmosphere around his observatory was, and held to the point that if other observatories were similarly situated, the great telescopes would reveal markings on planetary discs as he sees them. Several of the members had heard Mr. Lowell and had been much pleased with his admirable paper. Mrs. Savigny had met Mr. Lowell when the latter was in Toronto and had discussed his observations of Mars especially. The present paper was, therefore, exceedingly opportune and was much appreciated.

At the close the hope was freely expressed that other lady members of the Society would assist in the presentation of these subjects in a popular way, a work for which ladies seemed especially fitted.

NINETEENTH MEETING.

September 28th; the President, Mr. John A. Paterson, M. A., occupied the chair.

A letter was read from Dr. M. A. Veeder, of Lyons, N.Y., intimating that he would shortly be in Toronto, and would be pleased to meet the Society in a discussion of Auroral phenomena. The Secretary was requested to arrange for a special meeting at a date suitable for Dr. Veeder.

A communication was received from Miss Brown, President of the Solar section of the British Astronomical Association, calling attention to the total solar eclipse of January, 1898, and to the arrangements that were being made for a trip to India where the phenomenon would be visible.

Reports of observation were received from Mr. Harvey and Mr. Pursey. The former illustrated, by request, the method of determining the radiant point of a meteor stream. Among predictions of phenomena it was noted that on the evening of October 13th, there would be an occultation of the Pleiades. Mr. R. F. Stupart very kindly offered to place the large telescope of the observatory at the service of the members on that occasion.

Mr. A. Elvins stated that the Society had lost a corresponding member by the death of Mr. S. E. Peal, of Sibsagar, India. Mr. Peal had, on several occasions, favoured the Society with communications on subjects of scientific interest and had always been interested in its welfare.

Some discussion arose regarding a problem which had formed the subject of an interesting article in *Popular Astronomy*. This was, the absolute direction taken by a body falling from a great height. The President reviewed the problem at some length, and showed how the deflection to the east was explained.

The President then called upon Mr. G. E. Lumsden to read a paper, a portion of the latter part of which had been communicated to the Geographical section of the British Association, on

THE NAUTICAL DAY.

The Phœnicians, or the inhabitants of Tyre and Sidon, are said to have been the inventors of the science of sailing, as well as of that of Astronomy, a knowledge of the latter being necessary to a practical use of the former. Some of the ancient poets ascribe to Jason the credit of having been the first to navigate the open sea, but he and the Argonauts, who sailed from Greece to Colchis in quest of the Golden Fleece, that is, of Commerce, flourished long after the Phœnicians were a powerful maritime nation.

In early antiquity, whether impelled by sails or oars, a vessel hugged the shore if she could, and never ventured into the open main save to reach an island or to cross a channel of moderate width. Navigation was wholly suspended during winter. A ship now carries water and provisions for the entire voyage, and stands boldly out to sea, steering by the compass and astronomical observations along a charted course. An ancient vessel advanced from one port or landing-place to another, took in food and water at successive stations, was drawn up on shore during a storm or at night, and made an average day's sail of about thirty-five miles. The ship's company was dependent on its communications with the coast, and the essential progress of the vessel could be ensured only under one of two conditions : either the country must be friendly or the crew must be of sufficient strength to overawe the natives. The first of these was the ordinary state of navigation in the Mediterranean, either when Phœnicians sailed along the northern shores of Africa, or when the Greeks made their way along the coasts of Greece or Italy. The second was exemplified by the early voyages of the Phocæans, made in ships of war, which, for the purposes of being readily handled, were not unseldom constructed with two prows and two rudders. The officer in command of a vessel wore a sort of distinctive uniform, and took charge of the steering, it being his duty, from his high perch at the stern, to give orders about such matters as the making or the taking in of sail, and the plying or checking of the oars. It was the business of this pilot, styled the gubernator, magister or rector, to be acquainted with shores and ports, to know the signs of the weather, to observe the positions of the stars, and to change the watches.

The connexion between Navigation and Astronomy was considered to be intimate. Virgil supposes that sailors were the first to give names to the stars. A treatise on Astronomy has been attributed to Thales, and the works of Endoxus and Aratus on the stars are stated to have been intended for the use of mariners. Long before the time of these writers, the nautical skill of the Phœnicians was accepted as evidence of their astronomical knowledge. Navigators, steering their barks by night along trackless seas, travellers passing through wild and sparsely settled countries, and even camel-drivers, journeying across deserts, are known to have shaped their courses by some northern constellation commonly supposed to have been the Great Bear, or, more probably, its most striking feature, the Seven Stars forming the so-called Great Dipper. It is related that the Greeks preferred the Great Bear, which, at best, afforded but a rough northern direction, and that the Phœnicians chose the Little Bear, the superior advantages of which were by Thales impressed upon his fellow-countrymen. It is not difficult to credit the statement that the Seven Stars were the first to be associated by man with his material interests. The Dipper has long been a conspicuous group ; for many centuries, even more so than now. Four thousand odd years ago, Thuban, a faint star in the tail of the Dragon, was the North Star, and marked a point now twenty-five degrees distant from Polaris and the present North Star. Mizar, the well-known splendid double in the handle of the Dipper, and a much more notable star than Thuban, was then only ten degrees from the celestial pole, and not nearly thirty, as now. So that the Dipper revolved around the pole at no great distance, and in the latitude of the Mediterranean, was always high above the horizon. The north pole of the celestial sphere is gradually shifting farther and farther from the Dipper. Five thousand years hence, when Alpha Cephei is the pole-star, the Great Dipper and the Great Bear will have been displaced to that degree that they shall have disappeared entirely from our circle of perpetual apparition, and will be farther from the pole than are now Lyra and Cygnus, which themselves will then revolve about the polar-point at a distance not much greater than that which separates the Guardians of the Pole from Polaris itself. Thus, in the days of incipient navigation, the Dipper, resplendent in stars of the second magnitude, formed a much more striking north-point and was, therefore, more beloved by sailors than any other stellar-group in the north, or the inconspicuous Thuban, a star of low magnitude. The Seven Stars, otherwise the Septentriones, revolved within a circle which might be compared to a celestial clock-dial, of noble proportions, around whose face, like a vast hand, they moved night after night, season after season, their position at nightfall, referred to the pole, being significant of change of time and the approach of spring or of autumn, as the case might be.

The Great Bear has strong rivals in other senses, but is unique in this, that for long ages, antedating almanacs and time-pieces, it was the calendar of myriads of human beings. Perhaps, for those who have attentively studied them all, and have examined their chief beauties, no other stellar group has the charm possessed by Ursa Major. For, apart from its systems of splendid double, triple and multiple suns of many hues; apart from its red and variable stars, and apart from its abounding nebulæ, is it not the one constellation around which hoary tradition clusters most? And is not this true, in a particular degree, of the Great Dipper?

These Septentrional stars revolve every day about a common centre and never set. During the long winter nights their motion can be observed through nearly three parts of their revolution about the pole. In former times, to the mariner afloat, to the soldier in the field, or on the march, or to the traveller overtaken in lonely places, their presence and motion during the long night hours must have been inspiriting. Ancient writings, descriptive of the sea, the camp, the stage, or the domestic life of the people, allude to the practical uses to which the stars were put. As one of many instances, it may be mentioned that Homer makes Ulysses, on leaving Calypso's island, sail boldly across the main for seventeen days, during which he contemplated the various constellations, by which he laid his course until they were hidden from him by cloud and storm raised against him by his wrathful enemy, Neptune.

Originally, the stars were not associated with the religion and the mythology of the ancients, who regarded the heavenly bodies not as something to be adored, but as something useful in the walks of daily life. Socrates took this view when defending himself from the indictment that he had transgressed the bounds of legitimate knowledge in investigating things under the Earth and things in heaven. This accusation was due to a lasting popular prejudice formed against him as a result of the sarcasms of Aristophanes, who, represented the pupils of Socrates poring over geometrical diagrams inscribed on the floor, while he himself was suspended in a basket withdrawing his mind from Earth and intent only upon celestial phenomena. This extravagant scene in the comedy of The Clouds may have formed the hint upon which Dean Swift worked when he set Europe laughing at the astronomers and mathematicians of the Flying Island of Laputa, aiming, as he is supposed to have done, his shafts of ridicule at Newton, who was reported to become so absorbed in his calculations and investigations that he was oblivious of all else. In his own defence, Socrates took a practical view of the value of astronomy, which he professed to respect, but not to have taught. In his opinion, that science was desirable to the extent of determining the day of the year or month, and the hour of the night, for journeys by land and sea and for military guards. He held that the marks of time for these purposes could easily be learned from night-watchers, pilots and others whose business it was to know them, but he denied and decried the usefulness of speculation upon such matters as the distances of the stars which were of no material benefit.

The day, or rather the interval between sunrise and sunset, was divided by the Greeks into twelve equal parts, or hours, but the day, or the period of time divided, varied with the season of the year, being longer in summer and shorter in winter. Time was imperfectly measured, first by the gnomon, and next by the dial, when the Sun shone, and, when it did not, by the clepsydra, or the sand-clock. Notwithstanding the employment of these crude instruments, the stars were preferred at night, and certain persons were appointed to observe their risings and settings and to call out the hours. Among the Romans the day was either natural or civil. The civil day was from midnight to midnight and was divided into sixteen parts designated by names suitable to the respective periods of time. The natural day was from the rising to the setting of the sun and was divided into twelve parts. The night was divided into four watches each consisting of three hours, which varied with the season. In camp the guards or sentries, and, among the ships drawn up on shore, the guards or watches were changed at the end of each period of three hours determined by hour-glasses, or clepsydra, which, it is said, came to be used at sea on cloudy nights. The practice of setting watches for the safety of the ship and its cargo, when drawn on shore, was succeeded by the custom of dividing the ship's crew into two or more watches whose business it was to propel the oars or otherwise work the ship when overtaken by night, or caught out in a storm. And thus, with little change, matters appear to have gone on for centuries and until the introduction of the use of the compass and later of clocks keeping more or less accurate time. It is difficult to fix the date upon which the so-called nautical or sailor's day came into vogue, and to explain why it was first reckoned from noon instead of from midnight, though it is highly probable that it was, in a measure, due to the importance given to the mode of measuring the day adopted by Ptolemy and to the invention of instruments, no doubt rude, for taking solar observations at sea. At one time, the nautical day seems to have been the only day recognized on ship-board, at least, at sea, but as almanacs were prepared by the astronomers who preferred astronomical time, and as there was ever a tendency, when in port, to use the local or civil time, because more accurate than that kept at sea, the nautical day began to fall into disuse. There are those who contend that practically there is now no nautical day, but this assertion is not borne out by the inquiries recently made with a view to the preparation by members of this Society of papers to be read before two of the sections of the British Association. Those inquiries were voluntarily made by the Director of the Toronto Observatory, who received from a number of the masters of ocean-going vessels and others, letters and extracts from the logs of ships, which plainly show that the nautical day has not entirely disappeared. Thus we have three, or parts of three, days—the nautical, the civil and the astronomical—of which navigators have to take note.

In a communication, under date of the 13th of August, 1897, the captain of the *Milwaukee*, one of the largest ocean steamships lying at the port of Montreal, said : "A few years ago, before steamers became so common, many, if not most of the ships' logs were kept by astronomical time, that is, the day began (on paper) and ended at noon, but, nowa days, civil time has become universal, and the only difference between the time on board ship and that on shore is that on board of well-regulated steamers the time is kept as nearly as possible at apparent time for the ship's longitude, whereas time on shore is generally the mean time of some recognized meridian." The captain supplied a copy of the "deck," or "scrap," log of his ship while at sea on Wednesday, August

4th. The entries are made in two 12-hour series, headed "A.M." and "P.M." These entries show the hours, knots, course, winds, and the readings of the barometer and thermometer for the day. But it is noteworthy that at noon of the 4th, and between the two series of A.M. and P.M. entries, there occurs, as a matter of special importance, a noon-entry ruled off by itself. This entry is in respect of the latitude and longitude of the ship's position as shown by dead-reckoning, checked by observation, and also the course and distance sailed over; these items are not for the twelve hours preceding noon of the 4th, *but for the twenty-four hours from noon of the 3rd.* So that, whether he intends it or not, the captain really states his latitude, longitude, course and distance for the nautical day of the 3rd of August. Appended to this interesting log is the following memorandum: "This is just a rough abstract from our scrap-log as kept by the officers of the watch, and is, I imagine, an average style for this class of ship. Of course, the clock goes back an estimated amount each watch to balance the longitude made, so as to have the approximate apparent time for observations, and this is always checked by the second officer after the usual A.M. sights. The noon-position shows course, distance, and run generally *from noon of the 3rd.*" Several other masters of ocean vessels lying at Montreal and Quebec, confirmed this statement in these words: "The ship's position is kept from noon to noon." Norrie says that the merchant-ship's log is usually kept in civil time while lying in port, and in nautical time when at sea, and that if a ship leaves port in the forenoon of the 17th, civil time, the day ends at noon, and is noted in the log as containing only twelve hours, when the 18th, sea-time, begins; and, further, that while ships in the Royal Navy, and some merchantmen date their logs in civil time, they "make up the day's work as usual from noon to noon, or at the middle of the civil day." So that upon this and plenty of other evidence, it may be safely claimed, that whether recognized or not, the nautical day has not departed altogether from the annals of navigation. As to errors, Commodore Franklin, U.S.N., in a general report upon the subject, said: "It is an undeniable fact that the educated navigator finds the conversion of time a simple matter, yet experience has demonstrated that to the mariner who is not possessed of a mathematical education, there is a decided liability to the confusion which is so greatly deprecated by all who are interested in this subject." The force of this remark will be admitted when it is borne in mind that the nautical and the civil days are measured in two series of twelve hours each, and the astronomical day in one series of twenty-four hours, so that the nautical day is twelve hours in advance of the civil day, and twenty-four hours in advance of the astronomical day of the same date. Hence, No Hours, August 18th, astronomical time; Noon, August 18th, civil time, and Noon, August 19th, nautical time, occur at one and the same instant. Thus, five hours, August 18th, astronomically, is 5 p.m., August 18th, civilly, and 5 p.m., August 19th, nautically. Consequently, an event at sea occurring on the afternoon of Monday, the 21st, civilly, is entered under date of Tuesday, the 22nd, nautically.

Now, apart from the general public, which may not yet be prepared for the change which is bound to come, there are two classes of individuals who are deeply interested in the proposed Time reform, astronomers and mariners,—the former largely in an official way, the latter wholly in a practical way. In the Encyclopœdia Britannica, 1888, Dr. Dreyer, in his article on Time, makes the following observation: "The International Conference which met in the autumn of 1884, at Washington, to consider the question of introducing a universal day, has recommended that the astronomical day should commence at midnight to make it coincide with the civil day. The great majority of American and continental astronomers have, however, expressed themselves very strongly against this change, and even if it should be made in the *British Nautical Almanac*, it appears very doubtful whether the other great ephemerides will adopt it, the more so, as astronomers have hitherto felt no inconvenience from the difference between the astronomical and the civil day." Dr. Dreyer, who, it will be noticed, makes no mention of the interest of mariners, by the way, the paramount interest, does not give the evidence on which he bases his assertion as to American and continental astronomers, but, with due deference to him, it may be said that if the facts were with him in 1888, they are against him now. The conference to which Dr. Dreyer alludes was composed of the representatives of twenty-five nations, invited to Washington by the President and Congress of the United States, to consider various suggestions as to reforming the methods of reckoning time. All the propositions of the Congress, save one, have been carried into effect. The exception is known as the Sixth Resolution, which, in a word, expresses the hope that the day will soon arrive when the astronomical and nautical day will everywhere begin at mean midnight;

and it is in promotion of an endeavour to bring about the general adoption of this resolution that, since 1890, the Astronomical and Physical Society of Toronto, the Canadian Institute, and more latterly, the Royal Society of Canada, have become actively interested, as the records of the three societies will conclusively prove.

Several years later, the Astronomical and Physical Society, which had, in the meantime, received the active co-operation of Captain W. Nelson Greenwood, of Lancaster, England, addressed its attention to mariners. Captain Greenwood caused to be distributed in some eight or nine of the chief British ports, a circular on the subject and containing four questions dealing with the advisability of adopting a prime meridian, a universal day and the method of counting the astronomical day from mean midnight. In a short time, answers were received from four hundred and fifty-eight shipmasters, active and retired. Of these, the answers of four hundred and forty-six, or ninety-seven per centum of the whole, were in the affirmative. Those in active employment consisted of four hundred and twelve master-mariners, representing five hundred and twenty-two thousand and eighty-two shipping tons of the carrying steam and sailing tonnage of the British, colonial and foreign mercantile marine. Curiously enough, all of the foreign ship captains, in number seventy-four, and representing eighty-four thousand three hundred tons, answered "yes" to all four questions, including the one suggesting that of Greenwich as the prime meridian. The percentages of answers in the negative varied from one-half of one per cent. to six per cent., and are, therefore, not significant. In his last communication, Captain Greenwood says:—"You will see amongst them (the captains) a fair proportion of colonial shipmasters, also foreign masters, but the bulk are captains of our large 'tramp' steamers, and their opinions are, I think, most valuable. A hard-working class of men, they know what it is to economize time and the practical necessity of minimizing the chances of mistakes, particularly in time nautically applied to longitude." On this very point, Prof. Johnston, of McGill University, very truly says:—"The omission of even a single step in an oft-repeated process of calculation has an obvious advantage; when the simplification removes at the same time that most dangerous source of error, an ambiguous expression, it becomes a great gain."

Now, having pointed out the fact of the existence of confusion and of a liability to error at sea owing to diverse systems of reckoning time, it may be asked "What can be done to remedy all this?" The answer, and the only answer, seems to be one in favour of the introduction, at a proper time-epoch, of a day which shall be common to astronomical, civil and nautical purposes. In other words, a day which might be styled a "common day," commencing at mean midnight and extending throughout one series of twenty-four hours. The best time-epoch is, no doubt, the 1st of January, 1901. This would give all mariners, indeed, the whole world, as well, reasonable notice. That date is still far off, except for nautical ephemerides which are published (by no means necessarily, however, in these days of rapid transit by water) three or four years in advance, when, really, one year would answer perfectly. Be that as it may, it should not be greatly difficult for a nautical almanac office to issue the amended ephemerides for 1901, seeing that there is yet a period of nearly three years within which to compile the volume, which, after all, so it is alleged, would require little more than the changing of the headings of certain columns. It is best probably to wait for such a time-epoch, but it is really not absolutely necessary, if we may rely upon the opinions of the Astronomer Royal and various officers connected with the United States' Navy.

Great Britain stands in this enviable position. If she make the necessary change in the *Nautical Almanac*, other nations must, almost of necessity, follow her lead. That, subject to one condition, she is willing to make this change has been conclusively shown on more than one occasion by Imperial despatches received in this country. The sole condition mentioned was the desirability of securing unanimity on the part of ephemerides publishing nations. An effort to secure this unanimity was made by the Imperial Government, with the result that, with three exceptions, all the nations gave their consent. The exceptions were Germany and Portugal, not heard from, and the United States, the Government of which transmitted, without comment, a somewhat adverse report representing the views of three officials. The omission of the Government to approve of, or in any other way to take any responsibility for the report, has been thought not to be without significance. While, naturally, every Englishman and every Canadian would prefer to see the Imperial Government take the lead, it may be said, without fear of contradiction, that no Englishman and no Canadian would regard with the slightest jealousy the taking of the lead, as it might well and most properly be taken, by the United States, which has achieved renown and glory in the matter of time reform. Indeed, one can scarcely conceive of a happier consummation than would be afforded by that great country itself announcing that it had decided to bring to a perfect fruition the labours of the Congress of 1884, because, while it would be doing justice to itself as a great and enlightened nation, it would be paying the highest compliment to the scientific men who formed that distinguished conference, and to the countries who sent them to Washington.

TWENTIETH MEETING.

October 12th ; the President, Mr. John A. Paterson, M.A., occupied the chair.

A communication was received from Rev. T. E. Espin, of the Wolsingham Observatory, announcing that the variability of star 867 D. M. had been definitely ascertained.

A cordial letter was also read from Mr. Joseph Pope, under-Secretary of State, Ottawa, with reference to the most expeditious method of effecting interchange of publications with the European observatories and scientific institutions.

The Chairman called the attention of observers to the expected meteor showers of October. These were the Orionids, having their radiant point in the constellation Orion, due between October 15th and 27th ; and the Geminids, radiant point in Germini, observable generally throughout October.

Some notes on minima of Algal were read by Mr. G. E. Lumsden, who hoped that the members generally would endeavour to observe these phenomena. In this connection, Mr. W. B. Musson was asked to prepare a paper dealing specially with the system of Algal. It was arranged that this subject would be brought before the Society at an early date.

A series of drawings, illustrating observations of the Sun, made during the past three months, was presented by Mr. G. G. Pursey, who had on all possible occasions continued the work of regularly noting the phenomena of sun-spots and faculæ.

The Chairman then called upon Mr. Arthur Harvey to read the full text of the paper, on which he had been for some time engaged, on the subject of

PERIODICITY OF MAGNETIC DISTURBANCES.

The Society is aware of the interest I have felt in Mr. Pursey's regular reports of his solar observations, and that soon after he commenced them I began an enquiry into the periodicity of sun-spots; not as to their maximum and minimum frequency, but as to whether, at more or less regular intervals, spots would break out in the same solar regions.

To come to a conclusion on this subject, the first thing to be determined is, of course, the rate of solar rotation, and, following my favourite method of making an investigation for myself without reference to the studies of others, and of referring to authorities only after having gone as far as possible independently, I set to work to ascertain what the time was in which the Sun turned upon his axis.

Astronomers, as all members of the Society know, arrive at this rate of rotation from the passage of spots across the Sun's disc. Most of my hearers will remember that Galileo was among the first to observe these spots with the telescope. It was his "Dissertation on Sun-spots," which, published in 1613, drew on him the censure and warning of the Church, which declared it was contrary to Scripture to say the Sun moved. The words, "and nevertheless it does move," attributed to that immortal physicist upon very doubtful authority need not be faintly muttered now, as it is said they were by him, and, curiously enough, it is to an ecclesiastic, the Jesuit Scheiner, we owe the first fairly accurate determination of the time it takes for the spots to traverse the disc. He stated in 1675, after a long life devoted to observations, that the rotation period was 25·33 days.

It does not seem to have occurred to the early astronomers to go beyond the simple question of the average time of sun-spot rotation, and successive observers occupied themselves with the correct determination of that period only. Nor is this so easy as it may seem, for changes in form are always taking place, no spot having the same contour for so much as a single day, some, moreover, having a proper motion of their own, which is more or less confusing. It has lately been recognized, too, that the rate of rotation varies in different solar latitudes. Still, the idea of a nucleus to the Sun, surrounded by an atmosphere, this nucleus rotating at a steady rate while parts of the atmosphere have a different rate, has not met with general acceptance, nor is it yet spoken of in any of the standard books I have consulted.

Such, however, was the idea which, as you know, occurred to me, and if I can trace it to any other person's suggestion, it is to the late T. Sterry Hunt; not, indeed, in connection with the Sun, but in that essay where he speaks of the deposition of the limestone strata on the Earth. He pictures our planet as having had at one time an atmosphere charged with calcium vapour, as we know that of the Sun to be at present, and he tells of acid rains during the cooling process, to which our enormously thick deposits of carbonate of lime are due. I derive from him the conception of such a rain originating from condensation in the upper regions of our air and descending on the still intensely hot equatorial regions. Their heat would again vaporise that rain and disengage the fixed carbonic acid as gas. In its explosive ascent it would burst through the envelope of self-luminous cloud-laden air. An extra terrestrial observer might then have seen the bright vapours dispersed in those regions where the action was violent, and beheld a comparatively dark spot, with irregular edges, changing like the spots we now see upon the Sun.

But the conditions upon the Sun cannot be the same as those upon the Earth were, even at its incandescent period. There cannot be seasons resembling those which from the earliest time in the Earth's history there must have been here. Some different cause for a diminished temperature at the solar poles, if it exist, must be found. Therefore no argument can be strong which is based on such hypothetical analogy alone. I began then with a simple supposition based upon one series of observations, that upon the surface of the solar nucleus there are regions where chemical action is from some cause more violent than in others; such action being sometimes forceful enough to dispel the upper photospheric cloud layer, and I proceeded to enquire how far other observed facts would justify this theory.

Pardon me if I digress to define synodical and sidereal rotation. Imagine a line drawn from the centre of a rotating Sun through its equator to a Star. It would pass through a certain point on the solar surface, and, taking Scheiner's period, that point would in 25·33 days have been turned around the solar axis and again be on the imaginary line. That is the time of sidereal rotation. But if when we first drew the line, the Earth were passing across it, the point on the solar surface central on the Sun's disc, as seen from the part of the Earth just on that line, would not be central when the point had again come round to its place with respect to the star, for the Earth would have gone a long way forward in its orbit. A longer period is therefore required for the given point on the Sun to become a second time central on his disc as viewed from the Earth. That difference, added to the sidereal rotation, gives us the synodical rotation of the Sun. Knowing the length of our year, the one is easily reducible to the other.

Now, my first examination of Mr. Pursey's diagrams was of this nature. Taking any large spot, central on the disc on a given day, at what date was it again central by rotation? Even though not traceable by rotation more than once or twice, then, assuming the rate of rotation thus ascertained, would the spot reappear as central after quiescence? Let me mention here one of the spots I thus followed. In this case I have ascertained from Mr. Maunder, the President of the British Astronomical Association, through Miss E. Brown, the President of its Solar Section, the heliographic latitude and longitude of the spot. Mr. Maunder writes that he once himself suggested the outbreak of spots in a "disturbed region" after temporary quiescence. He also states that this particular spot belonged to a "disturbed area." It seems a pity that with the facilities Greenwich Observatory possesses, the "suggestion" should not have been thoroughly examined.

1896.	Date of Centrality.	Heliographic Lat.	Long.	Character of Spot.	Intervals in Days.
	Feb. 24	—16°	220°	Fine	—
	Mar. 23	—13°	215°	Large	28
	Apr. 20	—18°	215°	Fine	28
	———	———	———	———	—
	June 14	—18°	215°	Enormous	55
	July 12	—14°	217°	Fine	28
	———	———	———	———	—
	Sept. 5	—18°	212°	Group	55
	———	———	———	———	—
	Oct. 30	—18°	203°	Noteworthy	55
	Nov. 26	—19°	148°	A spotted region	26
	Dec. 23	....	....	Fine	27
1897.	Jan. 21	—18°	210°	....	29
	Feb. 18	....	....	Fine	26

But the rotation of spots is an imperfect means of determining that of the Sun proper, for, as Mr. Maunder puts it, "the synodic period varies for every latitude." As it is not possible to suppose that the whole body of the Sun is contorted and that each frustum of the whole sphere revolves at a different rate, the spots must be connected with some kind of atmosphere, within which there is a nucleus. At what rate does the nucleus rotate, and how are we to get behind the veil of photospheric clouds to find the answer to this enquiry? It is a question of importance, for if the spots are merely symptomatic of great disturbances on the nucleus, caused by volcanic eruptions from a region in which intense chemical action is going on, and are seen whenever in such a region an outbreak occurs of sufficient violence to affect the solar atmosphere through all its layers, then, if we knew the exact rate of rotation of the nucleus, we could trace the history of spots for many long years—identify with each other spots whose appearances are separated by considerable intervals of time—learn the relative activity of particular regions—and know where and perhaps when to look for great spots again. It also follows that the non-reappearance of spots over particular regions would show the phenomenon to be merely atmospheric and unconnected with the nucleus.

As the breaking out of spots is said to cause the radiation of much heat, the temperature of the Earth must be hottest when the spot is turned towards us. The solar rotation period ought, therefore, to be noticeable by means of the thermometer. In examining the curves of temperature I found strong indications of a periodicity of between 27 and 28 days, but the irregularities were very baffling. Noticing next that the curves of temperature seemed to be very closely connected with magnetic curves, I thought I might find a safe guide in the latter, and began the enquiry, of which I have finished one stage only, which I shall not be able to complete in my lifetime, but which I have found so deeply interesting that I shall have to continue it as long and as far as possible. A non-professional physicist need not fear to walk in such a path as this, for the *maxima* and *minima* of sun-spots—their increasing and diminishing frequency towards *maximum* and *minimum*, and the assertion of periodicity in these *maxima* and *minima* is due to Schwabe, a simple counsellor, of Dessau, who happened to have a 3-inch telescope, and for his amusement began solar observations which, continued for forty years, led him to announce these remarkable discoveries.

I claim to be the first to endeavour to deduce from magnetic records the rate of rotation of the nucleus of the Sun. In the course of my enquiries I have found several whose paths of investigation approach and cross mine, but so far I have not found any who before me announced that magnetic disturbances could be made use of with absolute exactitude, for the determination of this important point.

I was almost frightened from my proposed course by Maxwell. He dismisses terrestrial phenomena in one chapter of his work on magnetism. He says that a member of the Royal Society of London found, after close examination, three different periods for magnetic disturbances; one that of the rotation of the Sun, and the other two those of the synodical and tropical revolutions of the Moon. The whole question, he adds, is full of intricacy and presents unusual difficulty. It, therefore, seemed prudent to attack the subject step by step.

The first question to consider was the exact date to be assigned to any given magnetic disturbance. I offer here a scale-diagram of the record of Horizontal Force for July, August and September of this year, where a dip begins on September 2nd and lasts for ten days. Which day shall we take for our reckoning? I have adopted the method of taking the lowest marking. Moreover, this chart shows the mean reading for the day. I take the lowest hour of that day, but only do not fail to note any very low reading during the progress of the depression. In this case it is on the 11th, which is a repetend of the dips on July 17th and August 14th.

I take the Toronto records alone, because disturbances are so synchronous all over the Northern Hemisphere that it is only a multiplication of tedious work to resort to others. In proof I give the comparative mean daily curve for the observations at Toronto and at Tiflis (Caucasus, Russia), for the months of January, February and March, 1895. The difference in the gradients, which is but slight, and of no importance for my enquiry, would probably disappear if corrections were made for the different magnetisation of the respective bifilars.

I take Horizontal Force, because I do not wish to resort to averages. A magnetic storm affects dip and declination too, but in somewhat different ways. I hope, as soon as the Toronto observations are printed, which they have not been since 1848, fifty years ago, to examine the disturbances in these records too.

Prof. Frank H. Bigelow, now of the Weather Bureau, Washington, D.C., whose work is near in character to mine, published a paper in the American Journal of Science for December, 1895, in which he proved that the curve of temperature followed that of magnetic disturbance very closely, and assigned 26.68 days as the period. He concluded that paper by saying that from all his tables he gathered the underlying suspicion that there was a nucleus to the Sun, which rotated at the same rate as the solar equatorial belt. At the recent meeting of the British

Association, Prof. Bigelow showed me his tables, and he has favoured me with a letter, in which he says they are "the results of a very extensive computation of European observations for the years 1878-1889, and the period can be seen readily by even a hasty glance at the sheets." Prof. Bigelow means by this, that he has underlined the principal disturbed periods of each calendar month, and can readily see that the belt of disturbance thus indicated, which covers several days, occurs from three to four days earlier each month. I had seen this in all the tables, but found it much more satisfactory to reduce them to graphic curves. By these I was confirmed in my view that this method, which I had considered before Prof. Bigelow's admirable paper was brought to my attention, was not sufficiently exact. The disturbed period of the month did indeed recur, but the disturbance was of different duration each month and its intensity was differently concentrated, a disturbance of one or two days' duration tending to lengthen and to divide into two parts, the following of which led to uncertainty and confusion. In proof I ask you to consider the Tiflis and Toronto curves just given.... The lines drawn perpendicularly across them answer to periods of solar rotation, and you will easily trace the variation to which I allude.

In Maxwell's work it is stated that most of the variations are due to terrestrial causes, but that some of the most violent disturbances are believed to be connected with solar phenomena. The result of my study is to connect the disturbances chiefly, if not altogether, with the Sun, the ruler of his system in magnetic as in other particulars. There is doubtless a daily and an annual change in magnetic conditions, as well as a secular one, dependent on terrestrial causes, such as changes in temperature, but the great irregularities are all periodic, and if any of them are solar in their origin, so then are they all.

The interferences of one disturbance with another are, as I believe, the causes of the seeming confusion. An outburst of activity on the northern hemisphere of the Sun will probably mask the effect of another on the southern hemisphere. An eruption on the side of the disc turned from us may interfere with the needle in a very different way from one on the side facing us. The Sun is always in a state of the most intense activity, many regions being disturbed at the same time. Faculæ and protuberances, especially the latter, are, I think, as symptomatic of those solar conditions which produce magnetic effects as sun-spots are. It has puzzled many to disentangle the numerous interfering waves of pulsation, but I think I see how it is to be done.

With your leave I will enter briefly into some details of the investigation.

I commenced with a remarkable storm on January 10th, 1895. There is a corresponding storm on February 7th, twenty-eight days thereafter. Meantime another important disturbance occurred on January 19th, duly followed at an interval of twenty-eight days on February 16th. These two disturbances continue their record on the photographic traces throughout the year, and a third wave appears at the end of September. Of sixty-five periods for recurrence I can identify fifty-one, and the average period is a little over $27\frac{1}{4}$ days. Please to note, on my charts, for yourselves, these numerous recurrent dips. (The charts were here exhibited and examined.)

I have, however, given most study to the disturbance of 13th January, 1888. The mean of this day was the lowest of the month, and the reading at 10 o'clock was the lowest of the day as well as of the month. Having the key to the mystery furnished by the approximate period of $27\frac{1}{4}$ days, I traced this dip both forward and backward, and I present the following table of sixty-three periods for its occurrence :—

No.	1887. (Interval 27·25 days.) Month.	Calculated date for the lowest reading of the depression. Day. Hour.	Actual date of the lowest reading. Day. Hour.	NOTES AND REMARKS. The first six observations show merely the preliminary indications of a noteworthy disturbance, like the first mutterings of a terrestrial storm. The series properly begins with the depression of July 7th. Intervals calculated from January 13th, 1888, as a datum.
1	Jan.	24·4	23·19	The absolutely lowest reading of this small decided dip is on the 22nd, at 22h.
2	Feb.	20·10	21·	Of small importance.
3	Mar.	19·16	20·	First decided "pull" of a dip which lasts until 24th.
4	April	15·22	......	Nothing noticeable.
5	May	13·4	13·	This and the 14th are days of moderate depression.
6	June	9·10	......	Very slight dip.
7	July	6·16	7·4	The lowest reading of the month.
8	Aug.	2·22	3·11	Again the lowest reading of the month.
9	Aug.	30·4	30·16	The lowest mean daily reading of the month.
10	Sept.	26·10	26·22	A great storm, the lowest reading of the year.
11	Oct.	23·16	24·4	Very perceptible, but the violence of the periodical storm is moderating.
12	Nov.	19·22	20·10	Still moderating, but the mean reading is still the lowest of the month.
13	Dec.	17·4	17·16	Still a considerable dip, though a temporary subsidence.
	1888			
14	Jan.	13·10	13·10	The mean reading and the lowest reading also, are the lowest of the month.
15	Feb.	9·16	......	Nothing shown in the mean reading. A decided dip at 11 hours.
16	Mar.	7·22	7·19	This is a decided dip ; lowest reading since 1st and until 16th, though the 8th and 9th have lower means.
17	April	4·4	......	The 4th and 5th are the lowest means of the month until the 11th.
18	May	1·10	1 10	This day has the lowest mean until 7th ; the reading is lowest until 20th.
19	May	28 16	......	No indication of repeating. One should not forget that this is an autumn storm. [anniversary.
20	June	24·22	......	Still no indications. It broke out in July of the last year. Wait for the

No.	1887. (Interval 27·25 days.) Month.	Calculated date for the lowest reading of the depression. Day. Hour.	Actual date of the lowest reading. Day. Hour.	NOTES AND REMARKS.
				The first six observations show merely the preliminary indications of a noteworthy disturbance, like the first mutterings of a terrestrial storm. The series properly begins with the depression of July 7th. Intervals calculated from January 13th, 1888, as a datum.
21	July	22·4	22·11	Mean of this day is the lowest of the month. Decided reappearance of the storm. [probably active. The disturbance continues to the 18th.
22	**Aug.**	**18·10**	**18·6**	**The 18th is the lowest of the month. Some other centre of disturbance is**
23	Sept.	14·16	13·	The lowest mean and the lowest reading of the month.
24	Oct	11·22	11·20	Absolute lowest reading of the month; lowest mean until 20th.
25	Nov.	8·4	......	The lowest means of the month were on the 5th and 8th; the next lowest
26	Dec.	5·10	......	Nothing noticeable. [this day.
	1889.			
27	Jan.	1·16	1·11	This is only the fourth lowest mean of the month, but the readings at 11 and 12 are low, and that at 1h. of 2nd is lowest of month.
28	Jan.	28·22	......	Nothing worth remarking upon.
29	Feb.	25·4	......	The 25th, 26th, and 27th are disturbed, but give high readings.
30	**Mar.**	**24·10**	......	**Distinctly high. Rising for the solstice. Is this Prof. Bigelow's "inver-**
31	April	20·16	......	Nothing noticeable. [sion of the solar curve"?
32	May	17·22	......	Same observation. As quiet as at this time in 1887.
33	June	14·4	14·9	Much the lowest reading of the month. Curve of same form as in Janu-
34	July	11·10	11·10	Storm repeats, continuing 11th and 12th. [ary, 1888.
35	**Aug.**	7·16	......	No disturbance. **[is the lowest since 27th ult., and until 11th.**
36	Sept.	3·22	4·8	Slight depression in the means of 3rd and 4th; the reading at hour named
37	Oct.	1·4	1·14	Depression begins. The reading at hour given is lowest since 28th ult.,
38	Oct.	28·10	28·16	Lowest mean since 23rd and until 1st prox. [and until 5th.
39	Nov.	24·16	24·20	Only three readings this day. That noted is lowest of month so far.
40	Dec.	21·22	21·4	Lowest reading since 3rd and until 26th at midnight.
	1890.			
41	Jan.	18·4	17·10	This depression is three-fourths of a day early.
42	Feb.	14·10	14·24	Lowest reading; the mean being lower on 15th, a day late.
43	Mar.	13·16	15·	An important depression, but increasingly late. An interference by another disturbance probable, which will retard this one, while it continues Storm seems to be widening and dividing.
44	April	9·22	9·24	The reading is the lowest since the 5th.
45	May	7·4	5·22	This day—one and a quarter days before time (see No. 41 also) has the lowest reading of the month, though the mean of the 18th is lower.
46	June	3·10	3·	An important depression this day and the next.
47	**June**	**30·16**	30·	**Also an important depression. Disturbed period lasts several days.**
48	July	27·22	27·	A noteworthy dip.
49	Aug.	24·4	24·	Slight dip.
50	Sept.	20·10	19 & 21	Decided dips. Some interference on the 20th.
51	Oct.	17·16	17 & 18	An important dip
52	**Nov.**	**13·22**	**13·**	**A decided depression**
53	Dec.	11·4	12	Same remark
	1891.			
54	Jan.	7·10	......	Nothing of moment to remark. Tiflis Obs. give a somewhat disturbed
55	Feb.	3·16	3·	A very slight depression. [curve on 6th and 7th.
56	**Mar.**	2·22	3·	**An important dip Tiflis Obs. give the minimum for the month at 22 hours on 2nd.**
57	Mar.	30·4	30·	The dip begins now and lasts over 1st and 2nd April. Tiflis minimum is
58	April	26·10	......	Nothing of special moment to record. [at 12h. on 1st.
59	May	23·16	......	Same remark. The disturbance of the previous week marks this, which should reappear in a month or two.
60	**June**	**19·22**	20·	Slight depression and disturbance. Storm of the week before is less violent than during the May term thereof.
61	July	17·4	17·9	This is the most important depression of the month, the mean reading being the lowest, also the reading at the hour named.
62	Aug.	13·10	......	The depression seems to have been neutralised by the remains of that which preceded it in April and May. That was a spring storm and should not longer affect this.
63	Sept.	9·16	10·3	The most important disturbance of the month and the lowest dip. A very low reading. So, too, is the reading at Tiflis on the 9th at 18h., which may be the date we should regard most.

Here the outbreak ends as an important storm. On these sixty-three dates, eight give the lowest reading of the respective months, and seven others are very close to it. Only fourteen show nothing noticeable, so that in forty-nine cases indications of repetition are traceable. If we reject the first mutterings of the storm and commence with the important and clearly recurrent disturbance of July, 7 days 4 hours, 1887, we have 57 occurrences, or 56 periodical opportunities for return in the 1525 days 23 hours between that time and September 10 days 3 hours, 1891, which gives us 27·249 days for the period. Going back into pre-photographic times, we can connect this storm with that of 8th October, 1886, prefaced by an equally severe storm of 10th September. We see it on 29th March, 5th February, 9th January of that year, and, by following the series of principal outbreaks still further back, I can identify it with the dip of January, 15 days 6 hours, 1841—the first year of our Toronto observations—which was the most important of its month, and recurred 2nd and 29th June, 23rd to 25th July, 15th October, 11th November and 8th December of that initial year. From that beginning to the end of the series as given in my table, there are 679 rotations in 18·499 days 21 hours, which gives 27·24575 .... days as the average interval between the magnetic disturbances which arise from this more or less permanently active area on the inner body of the Sun as it is turned around into the position in which it most strongly affects the magnetic conditions of the terrestrial field. In other words, this is the synodical rotation period of the Sun, where sidereal rotation, therefore, occupies 25·35447 days or 25 days, 8 hours, 30 minutes, 26·2 seconds.

I cross with a line, at the proper intervals, the curves drawn from the daily magnetic observations for all the intervening and subsequent years, and we are thus enabled to follow with ease the history of the storm. After September, 1891, it was interfered with by other disturbances, notably by one of November 20th, which itself recurred markedly on January 29th, 1892, still more violently on May 18th, and broke the magnetic record on July 13th and 14th. During suppression, our storm appears by faint traces to be struggling to reassert itself, and on February 25th, 1894, it seems to coalesce with another eruption, forming a grand series of magnetic waves. It reappears on January 19th, 1895, repeating vigorously on February 16th, March 14th and 15th, April 11th and 12th, but only to subside into insignificance again, which continued to the time I prepared a paper for the British Association. I said in that paper that it might at any time be renewed, and on July 31st it broke out again; it is in evidence also on the 23rd September. In discussing my paper, I said we might look for traces of it on August 27th, September 23rd, October 20th and 21st, etc., and this was reported in the city papers. The present is a very quiet magnetic year, and great disturbances are not to be expected, but on August 27th we had a low reading (33·2) at 21 o'clock, with a still lower one (32·4) on the 28th at 10 o'clock, while on September 23rd at 10 o'clock, we had the absolutely lowest reading since recovery from a preceding dip on the 11th. I think this is the first attempt at predicting a magnetic phenomenon, and it was successful.*

In the *Century* magazine, for the present October, in a very interesting article on auroras, the following paragraph occurs :—

"In 1872, Prof. Young noticed a disturbance in the chromosphere in the neighbourhood of a sun-spot, and upon asking the astronomers at Greenwich and Stonyhurst to examine their magnetic records, it was found that great disturbance had occurred about that time. Ten years later, the astronomer at Greenwich sent out a message that read something like this : 'Remarkable sun-spot now visible.... area of whole spot 247—100,000 of the Sun's visible surface.' Try to imagine what this means, and fancy yourself on the Sun while that tremendous storm was in progress. We know that here on Earth there was a magnetic storm with auroral displays that beggar description. Beginning a little before daylight on November 17th, 1882, not a wire of the Western Union Telegraph Company could be used for three hours. * * It so happened that about the pole, that year, were clustered representatives from twelve nations. * * November 14th to 19th, 1882, was a period never to be forgotten by these Arctic prisoners. While we at home saw the display of a decade, the observers of the frozen north * * saw visions glorious by day as well as by night, and felt, perhaps, some recompense for their isolation and peril."

I have brought my diagrams to this meeting that you may see the identification of this storm with that of which we have been following the history, and see for yourselves the long continued violence of it, as

* In October the disturbance began towards the close of the 18th, a day and a-half before time, but lasted until the 20th. In November an important disturbance covered the 16th, 17th and 18th, the lowest reading of the month being on the 17th, at 9h. 53m. The December disturbance has not at this writing been investigated.—AUTHOR'S NOTE.

well as the intensity which at one time drove the recording pen clean off the paper.

The *Century* article contains the following illustrations :—

1. West end of an auroral band, photographed February 1st, 1892. My curves show a noticeable dip on February 2nd.
2. Photograph of sun-spot, August 8th, 1893.

   These are important spots. The article does not say they were central at that date. Here, however, is an important magnetic storm, August 6th and 7th, 1893.
3. Aurora of December 21st, 1882.

   Observe the important magnetic dip at that date.

Sun-spots cannot yet be said to be coincident, either on first appearance or when centrality occurs, with magnetic outbursts, nor can we yet say that all magnetic storms cause auroras. I simply show the magnetic curves, along with the *Century's* article and illustrations, to illustrate the advantage and convenience of having them in this shape and to indicate the possibility of a future co-ordination of these allied phenomena.

In Nansen's *Farthest North* eleven auroræ are specially referred to. Two are co-incident with remarkable magnetic dips, three with slighter ones. The rest were evidently strictly local phenomena, and produced no effect on the daily means.

The chief difficulty I have thus far encountered in establishing to my satisfaction the theory of permanently active areas on the Sun is an unexpected one. You are aware that, having determined the rate of solar rotation, I mapped on a chart of the Sun the localities of the protuberances recorded by the Italian spectroscopists. This I did for each of the years 1894, 1895 and 1896. The results I have heretofore shown you ; the charts resemble the belts of Jupiter, having marked areas of disturbance and of quiescence. But in one year, the polar belts are further north and south than in the next. The inference is *primâ facie* adverse to my contention. Much more has to be done, then, before the theory can be established. Meantime it is something to have arrived at a definite idea of the rotation of the Sun's nucleus, from magnetic data.

I am indebted to Prof. Bigelow for a reference to some other calculations of the Sun's rotation period from terrestrial phenomena, given in the *Repertorium des Physik* for 1866. We have no copy of the work in Toronto, and I cannot say what means have been used, but the table given me by Prof. Bigelow is as follows, our two figures being added to those in the *Repertorium* :—

Deductions of Sun's Synodic Rotation from Terrestrial Phenomena.		From Magnetic do.	From Sun-spots.
Days.		26·68....Bigelow.	27·51
27·05	25·87	27·2457..Harvey.	27·32
26·69	25·86		27·27
26·39	25·86		27·23
26·32	25·83		27·22
26·24	25·82		27·10
26·05	25·79		26·85
26·03	25·66		
25·96	25·47		
25·92			

The mean of all these is 26·43, but Prof. Bigelow very justly says that "this is a question not to be settled by a majority." He remarks on the curious fact that the results from terrestrial phenomena tend persistently to be much lower than those from sun-spots and other visible solar phenomena. This is, however, not the case with my results, which agree closely with them.

So also do those of Dr. M. A. Veeder, of Lyons, N.Y., a corresponding member of ours, who has tabulated auroral displays, and finds that a period of $27\frac{1}{4}$ days will fit the principal recorded occurrences of noteworthy brilliancy.

I ought not to conclude this paper without referring to the work of Mr. Carlos Honoré, of Montevideo. By investigating the late Prof. Gould's thermometrical observations at Cordoba, Argentine Republic, he finds that there is a periodicity of hot and cold waves which he places at 27·241326 days. He has published his views in a work called the Law of Solar Radiation (*Loi du Rayonnement Solaire, Montevideo*, 1896). He adopts as the commencement of his periods January 1st, 1894, at mean noon, in the longitude of the Villa Colon Observatory.

If I were rearranging my work, I should take the 6th of March and the 6th September as the dates for commencement, or the 4th of June and the 6th of December, the dates at which the Earth's orbit crosses the plane of the solar equator. Thus I should divide the tables and the corresponding curves into periods influenced chiefly by disturbances on the northern and southern solar hemispheres, respectively.

Mr. Honoré considers that solar vibration proceeds on lines parallel to the plane of the solar equator, and thus explains the disappearance after several rotations of the maxima and minima of magnetic disturbances at the calculated periods. Prof. Bigelow has noted what he calls the inversion of the solar magnetic curve, and thinks magnetic force proceeds from the Sun in great curves, from one of his poles to the other, like those of an ordinary spherical magnetic field here, which Mr. J. R. Collins has shown this Society by means of photographs of iron filings. These curves embrace the Earth, nay every planet in the system. I have not gone further than to observe that the principal disturbances of the early months of our year are not identical with those of the fall months ; their period is the same, but the periods of one are not continued with anything like the same intensity throughout our year. Many things will have to be explained before I can give credence to the view that magnetic currents can be emitted from an intensely hot sphere, and I am forced to favour a theory of some form of radiation or vibration which acts inductively and indirectly upon this and other planets.

Mr. Honoré coincides with me in referring his disturbance period to the effect of the rotation of the Sun's nucleus, but both he and Prof. Bigelow have taken a much shorter range of observations than I have. To this I attribute the slight difference between Mr. Honoré's period and mine. Prof. Bigelow, however, differs so much from both that either his method is faulty or those of Mr. Honoré and myself are erroneous.

Lastly, I wish to express my obligation to Mr. R. F. Stupart, the Director of the Magnetic and Meteorological Observatory here, for allowing me free access to the records, and for many kind answers to enquiries.

TWENTY-FIRST MEETING.

October 28th; the Vice-President, Mr. Arthur Harvey, F.R.S.C., occupied the chair.

During the preceding fortnight the members had had the pleasure of hearing a most interesting lecture by Dr. M. A. Veeder on "Auroræ." Invitations to all friends of the Society had been sent out, and the Electrical room of the Technical School had been kindly placed at the service of the meeting. It was the unanimous voice of the members that Dr. Veeder's lecture had been most enjoyable; the method of treating the subject had been a particularly happy one, so that the lecture had been a popular one in the best sense of the term. Dr. Veeder had emphasized the statement that he had no theories to offer, nothing but facts; these would have to be sifted and arranged—he would be content with having been in some small measure instrumental in accumulating these. The Doctor also spoke on a subject interesting to Canadians, "Ice-action in the Lake Region." This was of very general interest, and was treated as popularly as the subject of auroræ. It was hoped that Dr. Veeder would issue both lectures in pamphlet form.

Referring to the benefits derived from popular lectures of this kind, Mr. Lumsden stated that Prof. A. C. Mackay, of McMaster University, had recently addressed the students on astronomy, illustrating his subject with many beautiful lantern slides. It was decided to specially invite Prof. Mackay to address the Society on some special subject in connection with astronomical work.

A letter was read from Mr. Joseph Wallace, sr., of Orillia, who had for many years been devoted to observational astronomy. Mr. Wallace was the possessor of a very excellent 4½-inch refractor, which he used to great advantage, frequently gathering together small parties of friends who were desirous of viewing the beauties of the heavens. The Secretary was asked to invite Mr. Wallace to contribute a paper to the Society, descriptive of his general work.

Observations were reported by Mr. Pursey, Mr. Elvins, and others; arrangements were also made for systematic observations of the November meteors.

Mr. J. R. Collins then read the following paper on

THE RETROGRADE MOTION OF THE MOONS OF URANUS.

It is hardly necessary to point out that the distinguishing feature of the physical astronomy of to-day consists in the application of the laws of terrestrial chemistry and physics generally, as well as mechanical principles, in the endeavour to determine step by step the past, present, and probable future physical condition of the celestial bodies,—as well as to observe their relative positions, differentiate their proper from their apparent motions, map out their orbits correctly, and be able to indicate with precision any given point upon their orbits where they may be at any given time; and that the spectroscope is the instrument that has shown these bodies, strewn throughout the immensities of space, to be all akin; with atoms and molecules vibrating with like periodicity, communicating shocks, stresses, strains and twists to the continuous ether in like manner as the same elements do or can be made to do here upon the Earth, justifying the contention that if the nature and condition of the substance be known, results can reasonably be predicated. In this way as a great authority has said "with the appliances modern science has placed at the command of the investigator, it is possible to know more about the physical nature of the Sun than we can possibly know about the Earth we live on." The application of these results (because of their being unknown until within a comparatively recent date), was formerly impossible, to that class of astronomers who wished to delve into the mysteries of things, and they were forced to be content with mere speculation upon the subject of physical condition, or else regard the question as belonging to that class of impractical transcendental speculation that might serve only as a pastime for poets to indulge in.

In view of these facts it could hardly be expected that those bold spirits who possessed assurance enough to undertake to outline a system pretending to account for the origin of the cosmos or of that little part of it contained in the solar system, could be able to indicate a process of development that would fully meet the various physical requirements that a fuller knowledge only could foresee. When the facts are numerous enough, and are classified, some theory becomes a necessity if an intelligent understanding of them is to be desired. The nebular theory of La Place, it is needless to say, has generally been accepted by astronomers as the most probable process of development of the solar system that has yet been suggested ; in fact this theory has explained and grouped the facts so successfully and harmoniously that most astronomers have come to regard it no longer as theory but as an established order of nature in general outline at least. But of late years the retrograde orbital motions of the satellites of Neptune and Uranus have been established and emphasized, and the inner moon of Mars has been located in a position uncalled for by the nebular theory as generally interpreted, and it is claimed, in a condition impossible of satisfactory explanation on the nebular basis. Believing the difficulty not to exist, many of its strongest advocates have averred that the existence of such a difficulty would be fatal to the theory. Their words are now made to witness against themselves. This is the uncovered heel or joint in the harness that has given Mr. Lockyer an opportunity to draw a bow at a venture and launch forth the meteoric hypothesis as the Parthian arrow that was to deal death to the nebular theory, but its friends still aver, that though the wound is serious it is not necessarily fatal and confidently anticipate a satisfactory solution of the difficulty if such it be.

The existence of the apparent paradox referred to has, says a jubilant critic, " caused many of its friends to rush forward with explanations of an imaginary collision with, or influence of, a comet, but any such explanation of the phenomenon is now generally viewed as unsatisfactory and extremely improbable, if not impossible."

Prof. Newcomb says (*Wash. Ob.*, appendix to '75) in a full analysis of the system of Uranus, that with the 26-inch Naval Observatory telescope, satellites 3 and 4, Titania and Oberon, are of the brightness of a fourth magnitude star, but that 1 and 2, Ariel and Umbriel, are difficult objects ; with a 12-inch ach., with good seeing, the latter two were quite invisible, and Dr. Vogel saw with difficulty 3 and 4 with that aperture at Bothkamp ; satellite 1, Ariel, appears as a variable. The period of Uranus' axial rotation, has been supposed to be from 10 to 12 hours. From actual markings seen on its surface this period has been uncertain, though the polar flattening and equatorial bulge would indicate a short rotary period. Buffham noticed markings from which he deduced a period of twelve hours, but the plane of rotation did not coincide with the plane of the satellite's orbit. Young, in 1883, Henry Bros., Lockyer, Penotin and Thallon, made out a non-coincidence of from 15° to 40° out of plane of satellite's orbit. Prof. Holden and Schaeberle, in 1890, at the Lick Observatory, with the 36-inch, saw two faint belts resembling those of Jupiter or Saturn upon the surface of the planet near its equator, making an angle with the plane of the ecliptic of about 90°, showing the plane of the planet's rotation to be somewhere near the plane of its satellite's orbit (Astron. Soc., Pacific, 1890). Prof. Young, Dr. Brockett, M. McNeil, and M. Tisserand, have all seen the markings on the planet's surface as belts. According to Proctor and Ranyard the two outer satellites have been seen by Ward, of Belfast, with a $4\frac{3}{10}$-inch refractor, and by Dr. Huggins with an 8-inch, and by Sadler with a $6\frac{1}{2}$-inch reflector. Webb could only see one with a $9\frac{1}{3}$-inch reflector, and in May and June of last year C. Roberts, F.R.S., saw belts on Uranus with a $6\frac{1}{2}$-inch Herschelian reflector with a power of 200. *Journal* B. A. A., 1895-6, contains a note to the effect that during 1894-5 Prof. Barnard observed Uranus with 36-inch Lick telescope and noticed great polar compression, much greater than Saturn, indicating a rapid rotation. He also made out that the plane of the orbit of the satellites, though coinciding with each other, deviates 20° or 30° from plane of major axis of the disc. The plane of the orbit of Neptune's satellite he noticed to be somewhere about 34° inclined to the plane of the ecliptic, also in retrograde motion.

The distinguished Frenchman, M. Faye, has been able to show (*Sur l'origine du Monde*, 1885) that it is not impossible, at any rate, that a condensing original nebulous mass, as La Place supposed, may have condensed and separated into rings and local masses midway between its centre and exterior surface simultaneously, and that the regions near the terrestrial sphere would be the first to form, and the Sun as well as the outer planets would be the last to form into definite surfaced bodies, and, furthermore, retrograde would be the initial direction of axial rotation of such bodies thus formed. The most complete and satisfactory treatment this feature of the subject seems to have received, will be found in a series of articles by Prof. William H. Pickering, appearing in *Astronomy and Astro Physics* of 1893. After noting the retrograde axial rotation of Jupiter's first satellite, and certain irregularities in figure and behaviour of the others, he goes on to show clearly that a more important factor than tidal action in modifying the condition of a body in its formative stage is brought into play as a result of the physical condition.

Owing to viscosity, the component particles of rotating gaseous rings formed from a condensing rotating nebula, will tend all to rotate in the same time as if it were a solid. In doing this the outer particles must move with greater velocity than the inner portions, and if in this condition the ring be broken by whatsoever cause, (owing to their excess of velocity,) the outer particles of the ring will rush forward and inward, curling in upon themselves, and form a spherical body rotating upon its axis in the same direction in which the body is moving in its orbit.

Now, if the temperature of such a nebulous ring were to be reduced below the critical point before breaking up, then the inflated gaseous mass would collapse into a shower of liquid or semi-liquid particles, scattered throughout the space they formerly completely occupied when in the gaseous condition. Viscosity would not now interfere with the gravitational pull of the attracting central body, and the inner particles of this shower ring would move faster in their orbits than the outer ones, and upon breaking up the inner particles would rush forward and outward, curling backward upon themselves, producing a retrograde axial rotation in the resulting planet. If the plane of rotation and the plane of the orbit coincided, then a condition of unstable equilibrium would be established, but if the equilibrium were to be disturbed by tidal action or perturbation of a neighbouring body, so that the planes no longer coincided, then the action of gravity emanating from the primary upon the revolving particles of the body would be to cause the planet to slowly invert its poles, in the endeavour to twist back again until its axial and orbital planes coincided; by the time this was accomplished the secondary would be rotating directly in a condition tending to stable equilibrium.

Prof. Pickering supposes the members of solar system to have at one time all rotated in a retrograde direction. To the Earth and other planets at one time the Sun rose in the west and set in the east, but they, with their systems of satellites, have been swung round to their present positions by precisely the same combination of forces that act upon the revolving wheel of a gyroscope, and which tend to continually twist the wheel out of its plane of rotation. Uranus and Neptune are, however, so far away from the Sun, and their orbital periods so comparatively long, that their poles have not yet been completely inverted. Uranus and its system is now about half way over, and Neptune is not that far yet.

W. F. Stanley gives in *Nebular Theory*, 1895, a table of theoretical rotation periods of planets formed under purely nebular conditions as follows :—

	Calculated Period.	Observed Period.
Jupiter	11·126	9·868
Saturn......................	10·27	10·16
Uranus......................	12·34	

"A nebula extending from the Sun to orbit of Neptune, would be 1/166,800,000 times less dense than ordinary atmospheric air."

We have now seen how the retrograde motion existing in the solar system may be reasonably accounted for without doing violence to the nebular theory in the main, and, further, that the initial factor in determining retrograde motion, namely, precipitation of a floating gaseous surfaced mass, into discrete liquid or solid particles, will also explain the possibility of formation of a satellite much closer to the surface of its primary than could possibly be the case if no precipitation took place until after the satellite's orbit had been determined.

Taking into account the possibility of precipitation consequent on the temperature falling below the critical temperature, the orbital velocity depends solely upon distance from the attracting centre and has not necessarily any connection with its orbital period, and the period of axial rotation of its primary. Take for instance the case of the planet Mars, when the planet rotates upon its axis once every 24h. 46m. 37s·227, while its inner satellite revolves in an orbit around it more than three times during the same period. It is quite evident that the planet with its present rotary motion, could not have thrown off a ring in the present position of this satellite, having a velocity three times its own. But when we consider a slowly rotating gaseous body distended enormously in size until its rarity is less than 1/166,800,000 of an atmosphere and remember that the gaseous particles cannot approach nearer the centre of the mass, but float upon its surface or in the several strata, though gravity continually acts upon them, the mutual repulsion of the particles restrains their approach. But if the critical temperature has been reached and reduced below that point, the elements affected would simultaneously collapse into a shower of liquid or solid minute bodies scattered through the immense space they formerly occupied; they would then be free to answer to the pull of gravity and would fall in towards the central mass or body, until the centripetal and tangential velocities determined the position of the orbit about the surface of the central mass without regard to whether the central mass were rotating at all or not. The satellite's orbit point would depend solely upon the distance from which the particles fell, and the amount of tangential motion they originally possessed before precipitation; such orbital velocity need not have any direct connection with the equatorial rotary velocity of the central attracting mass. If the original tangential velocity of the particles, before precipitation, were slight, they would form an orbit comparatively near to the primary's surface; or if the original tangential velocity were considerable, the orbit would be found further away. In either case the satellites would obey Kepler's 3rd law, the squares of the periods being as the cubes of their mean distances from the primary. If the conditions hold good, the explanation seems satisfactory, though it must be admitted that this is a feature of the problem that La Place did not take into account in the development of the general theory of his nebular hypothesis.

TWENTY-SECOND MEETING.

November 11th; the President, Mr. John A. Paterson, M.A., occupied the chair.

Communications were received and read from Prof. James E. Keeler, of Allegheny Observatory, and from Prof. W. H. Pickering, of Harvard Observatory, bearing upon points raised in Mr. J. R. Collins' paper on the "Moons of Uranus," read at the previous meeting. Prof. Keeler had kindly forwarded a photograph of the spectrum of Jupiter, showing the displacement of the lines due to the velocity of rotation of the planet.

A cordial letter was also read from Mr. T. S. H. Shearmen, in which was promised at an early date a detailed account of the astronomical work in which he had been recently engaged at Woodstock and Brantford.

The Corresponding Secretary then addressed the meeting at some length on the very important subject of assisting in the organization of branch societies throughout Canada. He had been much pleased at the encouraging tone of letters received from Mr. Joseph Wallace, sr., of Orillia, and was sure that a Society could be established there full of healthy life. The last letter received from Mr. Wallace had been of particular interest; extracts from it were read, and it was decided to embody these in the minutes of the Society as the first

REPORT FROM ORILLIA.

Situated as we are upon the margin of a lovely lake, so suitable for boating and yachting purposes, it is, perhaps, not to be wondered at, that aquatic and athletic games should be extensively pursued by the young, to the neglect of the cultivation of those higher powers with which we are endowed and which form the crowning glory of man. I thought, might it not be possible to interest some of the more intellectual in the study of objects of infinitely more consequence than the propulsion of a boat a second or two faster than anybody else, after a laborious system of training and effort? And I came to the conclusion that I would endeavour to effect this, by setting apart every evening of this summer, except the Sabbath, solely for this purpose.

The three newspapers were quite willing to insert my short notices, headed "Astronomical" to catch the eye; and these notices I put in every alternate week. I mentioned the objects which would be shown, and I was particular that it should be understood, that the poor man or boy would be as welcome as those in better circumstances, and lest any should think they were intruding when they were inclined to come again, I was careful to let them know that I appreciated repeated visits far more than first ones, and that I expected at least five hundred to come and see the wonders of the heavens during the summer; my sole aim being to lead some into the pleasant paths of science, who might otherwise by unwise associations fall into the snares so ruinous to the young. Every evening, while it was still light, the stand was made ready for the telescope, and everything seen to be in good working order. After tea I was on the outlook for the first glimpse of Jupiter, when the telescope was placed in the holder, and I took a peep to see how many moons would be visible to my visitors.

The first night after the notices came out, on the 15th of May, I had five, the next fourteen, then nine, five, seven, nine, and so on; the weather during the latter part of May was rather windy for good observations. In June it was more favourable, and the numbers rose from ten to thirty; even on Jubilee night I had two. During July it was very good, except one or two nights; one especially was very windy, and I had twenty-five visitors. It was very disappointing; a star would swing like a pendulum out at both sides, so that I could scarcely tell when I had it in the field. I particularly requested them all to come again. The two nights following were both good and the numbers were thirty and fifty. August was generally fine, the figures rose to thirty, fifty, seventy and eighty. These were principally to see the Moon. On the night of the highest number, I did not count them, but some said there were between one and two hundred, so I put it down as eighty. I used a low power, as there was a general desire to see the whole of the Moon at once, and as the motion across was slower, it was more pleasant and more easily managed ; the lawn was pretty well filled with visitors. The latter part of August was colder, although sometimes fine for observing, but the numbers began to decrease, and by the eleventh of September I had numbered eleven hundred, and the washerwoman coming up that Saturday night I got her to look through to make one more for luck.

After this date I gave no more general invitations, but intimated through the papers that any one wishing to see through the telescope could do so any clear night by communicating the wish to me some little time beforehand. Two weeks ago I had a visit from Mrs. Manley, of the Meaford Astronomical Society, and spent a very pleasant evening among the double stars.

A question was often asked me about the price of telescopes. To that I could give no definite answer, but I was sure that a small instrument could be purchased, which would show Jupiter's moons, Saturn's rings, and a good many double stars for what many a young man pays for his bicycle. "I know which I would rather have," said our lady telephone operator. "I think I will sell my bicycle," said one young gentleman stranger.

Fully fifty per cent. of the visitors were ladies, over twenty-five per cent. young persons, the others were men. Most were from the town, a few from the country, and some visitors from the United States. To myself it has been of great importance, I know much more about the heavens than I did when these outdoor meetings commenced ; besides, it acted as a spur to read up on the subject in order to be able to answer queries and also find out new objects to present to my audience. It has been to me purely a labour of love, and I have realized the truth of the saying, which to many is paradoxical, "It is more blessed to give than to receive."

After the reading of Mr. Wallace's report the President gave a brief review of the history of the Leonid meteors, and showed by diagrams the relative positions of the Earth and the stream in November. The night of the 14th would be the best for observing, but the bright moonlight would greatly interfere with the visibility of the meteors. The year 1898 would be better, as there would be no moon on the night when the Earth would be in the best position. The year 1899 would be unfavourable on account of the moonlight, though the Earth would then be in the thickest of the stream.

Mr. Thos. Lindsay then read the following paper, being a continuation of his

HISTORICAL SKETCH OF THE GREENWICH NAUTICAL ALMANAC.

IV. *The First Issues.—The Solar and Planetary Ephemeris.*

We are concerned now with the subject-matter of the early issues of the Almanac, and the data used in its compilation. We might imagine the whole structure of an ephemeris to proceed from one such establishment as the Greenwich Observatory; but in reality there has never yet been a centre of learning and research claiming to know everything. And so Nevil Maskelyne, while leading in his preface to the inference that he alone was responsible for the accuracy of the tabular work, took very little credit to himself, generally not nearly what was due him, for the correctness of the fundamental tables. One great astronomer to whom Maskelyne and all other computers were indebted for data concerning the Sun was Tobias Mayer, whom we have already mentioned. Mayer was a German, a brilliant mathematician, the first to deal with "equations of condition," which enter so largely into astronomical calculations. The world of science was fortunate when he was appointed to a chair in the University of Gottingen. Grant says that his department was that of political economy. We do not know whether Mayer received this appointment because he was an astronomer, or whether he was simply given the chair for the purpose of bringing him into the roll of the staff; at all events our authority says that he appears not to have delivered any lectures on the subject, and so did not earn his salary in that line of work. Perhaps this was to the disadvantage of the students; it is just possible that if some one were to carry into the study of political economy the same firm resolve to search for absolute truth and to deal with first principles, that marks astronomy, there would be fewer schools of finance to bother the life out of the inquirer, wishing to know why there is not enough for everybody in a world that teems with the gifts of a loving Providence. However, if Mayer did not lecture on this much abused subject, he worked nobly for astronomy and is now classed among the greatest.

England had something to do with the equipment of the Observatory of Gottingen, George II. having furnished the instruments constructed by the great artist, Bird, of London. The chief of these instruments was a mural quadrant of six feet radius reading to 30 seconds by the vernier, and these again sub-divided by the micrometer screw to single seconds. It is worthy of note here that John Bird published his method of graduating instruments of this kind in the same year that saw the issue of the *Nautical Almanac*, 1767, and received a substantial bonus from the Admiralty Board for instructing apprentices. The reader in the history of astronomy knows well how much all great observers have been indebted to their predecessors and contemporaries. While Mayer was labouring at Gottingen our own Bradley was engaged in making thousands of observations at the Greenwich Observatory, observations of all kinds, and with noble instruments also constructed by Bird. Here we may note the marvellous accuracy with which Bradley determined the latitude of his observing point. For information on this point I am indebted to Mr. A. C. D. Crommelin, F.R.A.S., who writes me :

"Bradley's zenith sector was mounted in two different positions : one east of the Transit, the other in the Brass Quadrant room. The instrument was reversed in the two positions so as to get rid of error of graduation. The latitude in each case was the same, and within two or three feet of that of the present Transit Circle, which only means a difference of 0″·02 or 0″·03 in arc, which you will probably consider negligible."

Mayer's tables were published as soon as completed, in 1753, were compared by Bradley with the Greenwich observations in 1755, pronounced as near perfection as could be attained, and formed, as stated, the basis of the solar ephemeris for all computers of that day. The work of both these enthusiasts ran in similar lines, and we may rest assured that Bradley would not have endorsed Mayer unless he had been satisfied that all the discoveries of past centuries had been laid under tribute as they ought. Another contemporary of Mayer was Nicholas Louis de Lacaille, a lustrous name in the long roll of the great mathematicians of France. He also was engaged in the construction of solar tables, and when he published these, in 1758, they were found to contain some at least of those minute corrections due to the perturbations of the planets. These three illustrious men, Bradley, Mayer, and Lacaille, the greatest of their time in their respective countries, died in the same year, 1762, so that, and this is to be specially noted, Maskelyne stood practically alone, at their decease, among astronomers who combined great mathematical talent with keen observational powers. A short period did intervene between Bradley's death and the appointment of Maskelyne. The immediate successor of the former was Dr. Bliss, Professor of Astronomy at Oxford, and a man fully competent to take up the onerous duties of the office. But Dr. Bliss lived only three years after appointment, and his work does not enter particularly into astronomical history.

Maskelyne had taken his M.A. degree at Trinity College, Cambridge, in 1757, at the age of twenty-five, and in the following year had been elected to fellowship in the Royal Society. In 1761 he had taken an active part in the transit of Venus expedition to St. Helena. He was designed for the Church, and this must have suited his own tastes, for in due course of time he qualified himself for taking holy orders. When he commenced the *Mariner's Guide*, however, he was still a curate, and he did not take his D.D. degree until he had been some years in office as Astronomer Royal. Although this office had been originally created that there might be some competent astronomer always ready to assist the navigator, for English commerce was growing, it was not the duty of the incumbent to prepare an almanac. The *Mariner's Guide* had been a perfect success commercially, and no doubt Maskelyne derived some profit from its publication. But in the *Nautical Almanac* he could have had no commercial interest. This was clearly a labour of love. We have him then as a minister of the Gospel, the superintendent of an observatory, and the compiler of an ephemeris.

In the first issue of the *Nautical Almanac* the ephemeris proper begins with the familiar "explanation of characters used." These are ancient enough, but since the day of which we are speaking some one has sought to improve upon the symbol for the Earth by putting a criss-cross within the little circle in place of the single horizontal line. Uranus was, of course, unknown. (Without being specially interested in the origin of these symbols, I would like some one to tell me how the one used for Venus came to be a looking glass, if indeed that is intended. I am sure the goddess used nothing but nature's mirror.) In the table of eclipses which follows we note, and will note for many years of the Almanac, that the conjunction of the Sun and Moon refers to conjunction in celestial longitude, and the difference between the centres is the difference in latitude. If we turn directly now to an almanac of the present day we find the co-ordinates given in this connection are those of R. A. and Dec. The obliquity of the ecliptic is then given for five dates throughout the year. The three great astronomers named above found the mean obliquity about 1750 to be 23° 28′ 18″. Euler had already shown that the action of Jupiter on the Earth caused a diminution of the obliquity, but the demonstration that the angle varies only within certain limits had not yet been given to the world.

Page 1 of the tables for each month gives the calendar, the Moon's phases, and a few phenomena. Here we have references to close approaches of the planets to the brighter stars, and the times of conjunctions of the Moon with such stars as would be occulted to observers in some part of the world. The times are given to the nearest minute only, and the conjunctions refer to longitude.

Page 2 gives us the ephemeris of the Sun, the first column for longitude. Here we note that the old astrological method of dividing the ecliptic was still in use, so that 280° are expressed as 9 signs 10°. The positions are given to seconds of arc. No more than this could be expected. If the elements of the Earth's orbit were determined from observations by instruments reading to seconds of arc, could the ephemeris be computed to name smaller arcs?. It appears to me that Maskelyne wished to be quite honest and dropped the decimals on the verge of uncertainty. I have already referred to the fact that other almanacs of the time gave the position of the Sun daily, and tried to show the importance of Kepler's problem dealing with the division of an ellipse into equal areas. While Maskelyne may not have had any advantage over other computers in the matter of being able to apply analytical geometry to the solution of Kepler's equations, I still think he was favoured in point of fundamental tables dealing with the corrections to be applied before a result was ready for publication to the world. He states in his preface to the early issues that "all the Calculations of the *EPHEMERIS* relating to the Sun were made from Mr. Mayer's last Manuscript Tables, received by the Board of Longitude after his Decease, which have been printed under my Inspection, and published in 1770." Now if Mayer's last corrected tables were the best, it is clear, seeing that until 1770 they were not accessible to the public, that Maskelyne was able to give a more correct ephemeris than any other computer. I have already mentioned a little peculiarity of the Admiralty in regard to exclusiveness, and we may readily believe that the penalty for surreptitiously making use of the precious manuscript would have been—to be hanged, drawn and quartered. The first edition of Mayer's tables and those published by Lacaille would still, however, have been at the service of outsiders. The next column of page 2 gives the Sun's R. A. to the nearest tenth of a second of time, and following is the column giving the Sun's declination to seconds of arc. We note that these columns are headed H, M, S, and D, M, S; the symbols for degrees, etc., are not used in the body of the work. Then we have a column giving the equation of time, and next the daily differences. The tables had not yet been brought to a degree of perfection which would admit of giving hourly differences in this quantity. We turn a moment now to the explanation of the tables, and we learn that these positions of the Sun are given for apparent noon at Greenwich, that is sun dial noon. It appears that Maskelyne was not in the early years of his official life very hopeful of the art of making time-keepers, and as throughout England sun dials were no doubt more common than good watches we need not be surprised that he brought his computations to the moment of the true transit of the Sun over his meridian. After explaining the column equation of time, and indicating its use, he says, "but if time-keepers should be brought into use at sea," and so on, from which we may infer that Harrison's chronometer had not yet become a common instrument with navigators. No doubt Maskelyne would rise in his grave if he knew that mariners now often enough sail round and round the world, relying solely upon their time-keepers.

One very important word is left out in the headings of the columns. We are not told that these are the *apparent* positions of the Sun, but of course they were, and who knew better than Maskelyne, in that day, how to deal with those minute corrections to be applied to the place of the Sun's physical centre? Just forty years before the Almanac, Bradley commenced those observations which resulted in the immortal discovery of the aberration of light. The famous artificer, George Graham, predecessor of Bird, had made the zenith sector with which the work was done; on English soil had the instrument been erected, and so in using Mayer's tables Maskelyne was yet raising a monument to the brilliant discoveries of a countryman and predecessor in office.

There is nothing said, however, in these early issues about aberration, although the value of this constant had been announced, and was well known to astronomers. Again, it was Bradley who fixed the value of that little bewildering displacement of the Earth's axis known as the nutation, after the eighteen years of observation between 1727 and 1745. I need hardly say that the work of such masters in astronomy has always been most methodical, and the labour of looking through and investigating 18 years' observations would be consequently brought to a minimum. The printing of such things, however, was not done so expeditiously then as now. Maskelyne was himself specially interested in the determination of the co-efficient of nutation, and from his own observations deduced a value, agreeing very closely with Bradley's, and which he probably used in the construction of the ephemeris. There is, however, very little said in the early issues about nutation or even about the constant of precession, though a value for the latter of 50″·1 had been arrived at independently by the three great masters who had just died, and like the other small corrections was of course well known. We should note in passing that this correction was no doubt taken into account in all the modern almanacs long before the last century. The Arabian astronomers gave 54″, and Tycho Brahé still closer, 51″. We shall see that the Almanac was not intended to be so much of a veritable text book as in our own time it has become. There is, however, a short table which does show that Maskelyne wished at least to hint at the preliminary work in the construction of the ephemeris. Opposite the five dates giving the obliquity of the ecliptic we have the "Equation of Equinoctial Points." Probably the Admiralty did not wish to encumber the Almanac, for we must admit that pages of explanation on such points as aberration and nutation would not be likely to be read by mariners for whom, after all, the ephemeris was principally intended. The omission evidently did not reduce the labours of Maskelyne, for within a few years after his appointment he was engaged in giving all this kind of matter to the world in the shape of a large folio of observations, which was published by the Royal Society. The value of Maskelyne's work in this respect cannot be too highly estimated. In an admirable sketch of the astronomer's life, written by Mrs. Story-Maskelyne, of Basset Down, Wilts., for the *Wiltshire Magazine*, there are given the exact words used by the celebrated Delambre, in his *éloge* on Dr. Maskelyne, before the Imperial Institute of France, 4th January, 1813.

"He has left the most complete set of observations with which the world was ever presented, corrected in the most careful manner, which has served during thirty years as the basis of all astronomical investigations. In short it may be said of the four volumes of observations which he has published, that if by any great revolution the work of all other astronomers were lost, and this collection preserved, it would contain sufficient materials to raise again, nearly entire, the edifice of modern astronomy, which cannot be said of any other collection."

Then there was the volume of *Requisite Tables* to be used with the ephemeris. This I have not seen. It no doubt served admirably as a companion work. It seems to have sold rapidly, the first edition of 10,000 copies lasting only a short time. The annual issue of the Almanac was somewhat less than this, so that we may presume that every one who had an ephemeris had also a volume of the *Tables* We have to note here that in the matter of printing Maskelyne was more expeditious than Bradley. The latter did not print his observations at all, and some difficulty arose after his death about getting possession of them for the purpose of publication. It seems that the Admiralty demanded the manuscripts from Bradley's heirs, regarding them as public property. Hardly anybody likes to be addressed in that way, even by Lords Commissioners, and of course there was trouble at once. The Government finally relinquished its demands, and then of course the precious papers were freely given up, presented to the University of Oxford. But the final result was that printing was delayed until 1798. I mention this in passing because I think we may see that a gradual change was taking place in public sentiment with regard to science. Maskelyne, no doubt, observed this and wished to foster it in every way possible; consequently he kept a printing press before his mental vision continually.

Proceeding with description, we have on page 3 of each month a little column giving the Sun's semi-diameter for five dates throughout the month; for the angle at mean distance, 16′ 2″ ·8, credit is given to Mayer. Maskelyne says that this quantity was deduced from 130 observations with the mural quadrant at Gottingen. Then follows the time of Sun's semi-diameter passing the meridian, the hourly motion in longitude, the logarithm of the Sun's distance, and the place of the Moon's node. Probably the words, "Sun's distance" were used for simplicity, instead of "radius vector," as we have it now. In the explanations referring to these columns we find a brief reference to some of the more intricate problems in astronomy. Maskelyne says there, that the place of the Moon's node is necessary for finding the equation of the equinoctial points, the equation of the obliquity and the deviations of the fixed stars in R. A. and Dec. All this of course was intended for astronomers; it must have been somewhat beyond the great majority of mariners. These columns took up only a part of the 3rd page, and the rest of the space was used for phenomena of Jupiter's satellites. Here only the eclipses are given, transits over the disc or occultations by the disc seem not to have been calculated for publication.

The astronomer to whom in that day all computers were indebted for fundamental data concerning the Jovian system was Wargentin, a Swede, Secretary of the Royal Society of Stockholm, who devoted his whole life to researches on this subject. It is worth repeating what Grant says of him: "The success which attended his labours affords an encouraging illustration of the valuable results which may be achieved by a mind, even though gifted with no extraordinary powers, when its whole energies are perseveringly directed to any specific object." Maskelyne, in his prefaces, gives due credit to Wargentin, and a few years after the institution of the Almanac he slipped the Sweedish astronomer's table into print, with his usual foresightedness.

If there were no satellite phenomena observable the half of page 3 was left blank, except that it bore the familiar legend stating the fact. While we are at Jupiter we may finish him. The last page of each month was reserved for the configurations of the satellites, or if not observable the page was blank. This page was arranged pretty much in the same way as now. The symbol for Jupiter used here was the same as for the Sun, and the satellites were little dots with the numbers close to. When two of them were close enough to be in conjunction the symbol for this configuration was placed between them. There was one difference, however, in the heading which, by the way, shows there is nothing new under the Sun. If we turn to an almanac of the present day we find that the table of configurations is selected for a stated hour each day; always for an hour when the planet will be in a favourable position. But we read now, "at 14 hrs.; 16 hrs., 30 mins.; or it may be 9 hrs.," reckoning, of course, from the noon of the astronomical day. But Maskelyne, so that there might be no misunderstanding, so that he who ran might read, puts it "at 6 o' th' clock in the evening; half-an-hour after 2 o' th' clock in the morning," and so on. After all these years we are trying to reform the method of time-reckoning, but you see we are doing what Maskelyne seems to have done when he wanted to make a date clear for everybody; he made astronomical time give way to civil.

Referring to the use of the table of eclipses, Maskelyne says that "they are well-known to afford the readiest and, for general practice, the best method of settling the longitudes of places at land," and he gives four pages to the discussion of the problem. In the table the times of disappearance in the shadow or of reappearance out of it, as the case might be, are given to seconds, and certainly by observing the local time the longitude could be had very nicely. But a 3-inch telescope cannot be used satisfactorily at sea; a common spy-glass is better on board ship, so that mariners could not make much use of the eclipses while sailing. Maskelyne says that on his voyage to Barbadoes in 1763 he tried what was called a marine chair, for observing at sea; but he found it useless. This voyage, by the way, was the one undertaken for the purpose of testing Harrison's chronometer.

With regard to the instruments supposed to be used in observing the eclipses of the satellites, I quote from the explanations: "The Telescopes proper for observing the Eclipses of Jupiter's Satellites are common refracting Telescopes from 15 to 20 Feet, reflecting telescopes of 18 Inches or Two Feet focal Length, and Telescopes of Mr. Dollond's Construction with Two Object Glasses from 5 to 10 Feet; or, which are still more convenient, those of 46 Inches focal Length, constructed with Three Object Glasses, which are as manageable as reflecting Telescopes, and perform as much as those which he makes of 10 Feet, with Two Object Glasses." The Mr. Dollond, I think, must have been Mr. Peter Dollond.

We are thus brought into the private observatory of the amateur astronomer of 130 years ago. We gather from these words that the observer interested in watching celestial phenomena had four kinds of instruments to choose from. The first named has quite disappeared, that is the single lens telescope of very long focus; the second still survives, there will always be work for the reflector; the third we may say has disappeared, this was the first style of achromatic, ratio of focal length to aperture very great; the last named is our achromatic telescope of to-day, say 3-inch aperture, except that the three object glasses have given way to the pair, flint and crown. There is nothing said about aperture, though of course upon this depends entirely the successful observation of eclipses of the satellites. We know, however, that refractors of large apertures were not made until long after the institution of the Almanac, and although James Short, the Edinburgh optician, had constructed two or three reflectors of 12 and 18-inch aperture, these were out of the ordinary. Gregorian reflectors of 3 and 4-inch aperture were luxuries, and we may therefore look back 130 years and in fancy see some young or old enthusiast watching the motions of Jupiter's moons with an instrument like this, or with this very instrument itself. This is a 4-inch Gregorian, and bears the name of the great maker J. Bird, London. We have here a specimen of his skill.

The telescope which Maskelyne himself used is still, I believe, in the Royal Observatory at Greenwich. It is one of those he refers to in the explanations, a 46-inch triple objective, $3\frac{3}{4}$-inch aperture.

One of Dollond's instruments we have seen at the Toronto Observatory on several occasions when Mr. Stupart has kindly placed it on the lawn for our use. It is smaller, however, than the one above mentioned.

The prices of these instruments were of course very high, and they remained expensive articles until well on in the present century. Mr. Elvins tells a story of about sixty years ago bearing on this point. It appears that he and some other youngsters in the little village of Sticker, in Cornwall, besought their old schoolmaster to get them a telescope, on the co-operative plan of course. The old gentleman was as anxious as the boys to have a first-class instrument, an achromatic of $2\frac{1}{2}$-inch or so, and enquired the price from London. He was told twenty-five guineas. We fancy we see the good man, ready perhaps to accept the alternative for himself, but trembling for the dark future before the boys, as he imparted the sorrowful information in a short sentence which spoke volumes: "My dear lads, there will never be a telescope in Sticker."

For this old Gregorian I must confess to a certain fondness. It belongs to a lady of this city who cannot, however, give me its whole history. But we have only to look at it, and it seems to carry us so easily into the past. Observe how nicely it is adjusted. We can clamp in altitude and azimuth, give slow or quick motion, use our two hands in moving the screws, while our eye is at the eye piece; and carry the whole affair about without any trouble. We fancy we see it fitted up in some quiet corner of England where Science has gained a foot-hold. Who the observer? Perhaps an old man, one who had in his youth heard the living voice of Newton, and caught his inspiration from the immortal philosopher. For him this is a gigantic instrument, these screws the perfection of the instrument maker's art; he is supremely happy in possession. He delights to gaze upon this or that object of beauty in the heavens, to dream of what those markings mean that he sees upon the disc of Jupiter, to speculate on the nature of that great cloudy mass in the swordbelt of Orion, but fully convinced that he has seen all that ever man can see. Or, perhaps, it is a young man, fired with ambition; rumours have reached him of the great telescope which Herchel is constructing; he dreams of what the nineteenth century will bring; perhaps he may live to see the mystery of that nebula solved, and may yet know what mean those beautiful rings encircling Saturn. If the telescope could only speak! But no, it is a silent witness and an old-fashioned one, so we must put it away in the garret. Clean it? Not I, not if it lay for a hundred years in the lumber room. Let the brass be tarnished, I want to look upon it just that way. But now and again I would wander up amongst the old lumber, often, then less often, till perhaps I could only creep up, as age came upon me, and I would see that one part was kept bright and new; this part, I clean it now, and there stands out the bold legend J. BIRD, LONDON.

But we must proceed with our description: Page 4 of each month is devoted to the planets, the old familiar disposers of events, as the first star gazers used to call them. We have the positions for each fifth day in the month. The data given are, heliocentric longitude and latitude, geocentric longitude and latitude, the declination and the time of passage over the meridian, all to minutes only, of arc or time. The R.A. was not given; this had to be calculated from the other co-ordinates.

As the meridan passages were only given for stated days throughout the month, it was necessary to show how the time for any day might be calculated. This Maskelyne does in the explanations. He takes the Moon for an example, and shows how the time given in the columns is derived. In passing we note that the example was given for July 1st, 1767, and this matter probably was kept in type by the printer right along. The same example appears in the explanation twenty years later. Of course the day chosen was quite immaterial. I take this to show

Maskelyne's talent for doing the most work with the least expenditure of energy. There was no special necessity for changing the example.

We must now see what the astronomers of that day knew about the planets. Mercury was then, as now, the most troublesome. Our own Edmund Halley, and on the continent, Lalande, were the two astronomers who had been most assiduous in work upon fundamental tables for this planet. But these were not considered satisfactory at the time of the institution of the Almanac, and it was not safe to predict Mercury's position for any length of time in advance. We read that as late as 1786 a transit of Mercury, predicted by both the astronomers named, occurred forty-five minutes later than Lalande's time and forty-five minutes earlier than the prediction which Halley had made. However, good or bad, Halley's tables for Mercury were the only data to be relied upon at all in 1767. The same may be said of Venus and the other planets; Halley was the authority. It is to be borne in mind that we are speaking of a time prior to the satisfactory discussion of the perturbation of the planets among themselves. Those astronomers who brought the planetary theory to something like perfection were living in 1767, but were still young men.

Regarding the unit of the celestial scale, there is nothing said in the early issues. The transit of Venus of 1761 had been observed, but the discussion of the data seems not to have been satisfactory. In the volume for 1769 Maskelyne gave directions for observing the transit of Venus of that year, and subsequently was deeply interested in the calculation of the parallax from the data thence derived. I have here a volume on astronomy, by Dr. Vince, of Cambridge (about whom we shall have more to say as our sketch goes on), containing a chapter by Maskelyne, giving the details of the calculation to determine the parallax from the transit of 1769. The result given is 8″·723. Regarding the unit actually adopted in the construction of the ephemeris, Dr. Downing has kindly written me:

> "So far as I can ascertain 9″ appears to have been the value of the Hor. Par. adopted for the Sun. This is the value in both the first and second editions of the 'Requisite Tables.' In the 'Explanations' of the tables in the second edition (1781) it states * * * when the Sun is in the horizon where it (*i.e.*, the parallax) is about 9″."

Now, you will remember that in the introductory chapter I said we would learn something of Maskelyne's personality as we proceeded.

Well, I think we have already learned that he had a wonderful capacity for work. He was not the first or the last English clergyman who laboured hard in the cause of the advancement of astronomical knowledge. Of all people in the world a clergyman is the one who need never be idle a moment, and by merely turning over the pages of the Almanac we readily gather that Maskelyne must have employed just about all the time he had that he did not need for sleep, and probably he encroached upon that. But the labour of computing the ephemeris was not all his own. One assistant he always had at the Observatory to aid in the work of, to use the words of the original warrant of 1674, "rectifying the tables of the motions of the heavens." In his preface Maskelyne speaks of one person, and another person ; he was one of course, who was the other ? We have no difficulty now in learning the names of the gentlemen who assist Dr. Downing in the construction of the ephemeris ; it would be a pity if we could not put on record the names of those who aided Dr. Maskelyne, and so I will promise right now to devote one chapter entirely to them before taking up that part of the Almanac dealing with the ephemeris of the Moon, and the lunar distances, and reviewing the lunar theory generally as understood in Maskelyne's day.

[SUPPLEMENTARY NOTE.]

At a subsequent meeting Mr. Lindsay said :

It will be remembered that in the initial chapter, dealing with this subject, I stated that I had little hope of finding material for more than a mere sketch of the history of the *Nautical Almanac.* Since that time I have received much encouragement and assistance, a mass of material hitherto unpublished, and many kind promises to supply original notes of the work done in the early days of the great monument to astronomy. Indeed, so far from making these papers a mere sketch, it would be possible to give you a minute history, to call up almost the very daily life of Dr. Maskelyne, to present a panorama of the labours of his assistants, among whom was—I do not wish to anticipate the next chapter, but I cannot help saying this—among whom was a relative of our own Dr. E. A. Meredith, one who was a tower of strength in the scientific world in days gone by, the Rev. John Brinkley, D.D. But this for a stronger hand. My work will not be more than the sketch intended, though I trust it will be of more interest than at first undertaking seemed possible. To myself it is of absorbing interest to read anything connected with the history of the Almanac ; the pages of the work have to me been always things of beauty ; the columns of figures are not merely the language of mathematics, they are the expression of the everlasting hymn of praise which the true student of nature sings to the Creator ; they are the evidence of the goodness of the Infinite in bestowing upon man the power to read aright the lessons of the stars, and every scholar, young or old, who from the first days till now, has had to do with the construction of the ephemeris, is for me an interesting personality.

You will then understand something of my feelings when I received from Nevil Story-Maskelyne, F.R.S., etc., of Basset Down, autograph letters of Dr. Maskelyne, written in the last century, and was privileged to hold in my hand the paper on which the genial Astronomer-Royal had impressed the evidence of his kindly interest in one who was his life-long assistant, the Rev. Malachy Hitchins, now slumbering peacefully in St. Hilary's, Cornwall :—

WRIGHT'S HOTEL, SOHO SQUARE, March 4, 1785.

Dr. Maskelyne presents his compliments to Sir Joseph Banks, and should be much obliged to him if he would be so good as to favour the Rev. Malachy Hitchins (a very deserving servant of the Board of Longitude as comparer of the *Nautical Almanac*), with his interest with some British peer for a chaplainship, which is a circumstance requisite to enable him to avail himself of the gift of a second small living from the Bishop of Exeter, in addition to his former one. There are some lay-Lords who have a right also to make chaplains, a list of whom will beg leave to present to Sir Joseph to-morrow, at the Board of Longitude.

And with not less pleasure did I read, in another letter addressed to Sir Joseph Banks, the evidence that Dr. Maskelyne, while deeply engaged in the special work of his life, had visions of the future of the Empire, and was fully alive to the requirements of a great colonizing nation.

GREENWICH, February 24, 1791.

SIR,—In addition to the instruments and books which I had the pleasure of sending you a list of as proper for the use of the astronomer proposed to be sent to the north-west coast of America : now there is more time allowed to procure any new instruments that may require time, I think it would be useful to provide a marine dipping needle similar to those which were used in the voyages round the world by the astronomers sent out by the Board of Longitude, and to have a portable tent observatory made. I am of opinion that an allowance at the rate of £400 per annum, the same as was allowed to the astronomers sent out by the

Board of Longitude, besides being paid for the expense of carriage and setting up the instruments, building an observatory and such like expenses, would not be too great, but proper and reasonable.

I am, Sir,

Your most Obedient Servant
Nevil Maskelyne

These are relics of the past; I touch them reverently; they will be returned in due course, and with them sincere thanks to Mr. Story-Maskelyne for having allowed the members of this Society to look upon the handwriting of the great founder of the *Nautical Almanac.*

TWENTY-THIRD MEETING.

November 25th; Mr. G. G. Pursey occupied the chair.

The attendance at this meeting was much smaller than usual, on account of the day being Thanksgiving and a public holiday. In consequence of this a paper by Mr. W. B. Musson was postponed until the next regular meeting.

Mr. A. Elvins referred to the recent announcement of the death of Mr. D. K. Winder, of Detroit, an associate member of the Society, and long engaged in scientific pursuits. Mr. Elvins said: "Friend after friend departs. Of those who were active in the formation of this Society many have already left us. Carpmael, Roberts, Wilson, Kirkwood, Peal, are gone, and now Daniel K. Winder, a personal and dear friend of mine is no more. About thirty years ago I became acquainted with Mr. Winder, and found him always a diligent and enthusiastic student of Nature; my life has been to a considerable extent moulded by contact with him. In 1868 we constructed a spectroscope, the first seen by either of us; it was a rude instrument compared with the elaborate ones of the present day, but it was useful, and with it we examined the light of the aurora, lightning and the fire-fly. Schellen, in his *Spectrum Analysis,* quotes some observations made by Mr.

Winder at that time. Our departed friend thought and wrote on many physical questions and on points in natural history. A little book on 'Canadian Mushrooms' is, I am told, much prized by collectors of that delicacy. But it was his loving disposition and kind spirit which caused me to prize him as a personal friend. Possessing a sanguine temperament, like myself, he sometimes allowed himself to be led on rapidly when he should have moved slowly; but his persevering search for truth, his loving disposition and his taste for scientific studies caused an attachment which has been only deepened by time."

The Chairman also addressed the meeting, recalling pleasant associations of past years when Mr. Winder had been among them in Toronto. The Secretary was requested to convey to the surviving relatives of the deceased the sympathy of the Society and an expression of the high regard with which Mr. Winder had been held among the members who had had the pleasure of knowing him.

Among other observations Mr. Lindsay reported having made good use of the Gregorian reflector, by Bird, shown at the previous meeting. He had observed specially the nebula in Orion and had been much pleased with the performance of the telescope. The night of the 14th of November had been so cloudy that observations of the Leonid meteors had been impossible. This had been much regretted, as preparations had been made for extensive observations.

The Librarian announced having received from Lick Observatory the second series of lunar photographs made with the great telescope. These were laid on the table and the remainder of the evening was very enjoyably spent in discussing them.

TWENTY-FOURTH MEETING.

December 9th; the President, Mr. John A. Paterson, M.A., occupied the chair.

Correspondence was read from Dr. Copeland, of the Royal Observatory, Edinburgh; the Secretary of the Chamber of Commerce, Edinburgh; Mr. D. Brown, of Port Elgin, Ont.

Mr. Brown was duly elected an associate member of the Society.

Dr. J. J. Wadsworth, of Simcoe, Ont., who was present, handed in, as additions to the Society's collection of drawings, several lunar sketches made at his $12\frac{1}{2}$-inch reflector, by two ladies, Miss Stennett and Miss Beemer. These comprised drawings of the walled plain Clavius, and the Bay of Rainbows, and had been made under different phases of illumination. Miss Stennett had also made a sketch of the remarkable feature known as the "straight wall." Dr. Wadsworth was requested to convey to the ladies the thanks of the Society for these drawings. It was thought to be a most encouraging sign of the growing popularity of astronomical work when ladies were willing to devote their time to the interesting work of sketching at the telescope. Reference was made to a former gift to the Society by a lady of Simcoe who had made a drawing of Saturn at Dr. Wadsworth's large reflector.

Observations of the Sun were reported by Mr. Elvins and Mr. Pursey. Mr. Harvey called attention to the coincidence of marked depression in horizontal force with auroral observations as recorded by Dr. Nansen during his expedition to the north. After some further discussion on matters of general interest the Chairman called upon Mr. W. B. Musson to read the paper, postponed from the previous meeting, on

THE VARIABLE STAR ALGOL.

Of all fields of astronomical research, there is perhaps, none that offers greater opportunities to the amateur than the study of the variable stars. Many of the observations are of a comparatively simple character, the optical power required is low (much being possible even to the unaided eye), and the work, if carefully and systematically carried on, is of real practical value in adding to the knowledge already possessed of these objects. In addition to this, the study is of a highly interesting character. The phenomena exhibited are of the most diverse, and complex nature, comprising every conceivable variety in period, light curve and spectrum. The differences in periods already observed range from 1 to 700 days, and in light changes, from 1 to 8 magnitudes.

Prof. Pickering classifies variable stars in five groups, the chief points of difference being: 1st, Length of period; 2nd, Amount of variation; 3rd, Character of light curve. The usual colour of these stars is white, yellow, orange, or red. Nearly all variables of long period are red, and have spectra of the third type—that is, showing dark bands in place of lines. They are of greater amplitude and less regular periodicity than those of short period, and show changes in spectra leading to the conclusion that atmospheric ignition occurs during the outbursts of brightness. There also appears to be a distinct association between the length of period and degree of redness.

Dr. Chandler has expressed this peculiarity in an interesting table, in which he represents white by 0, and the maximum of redness by 10.

Days.	Stars.	Redness.
150—200	9	2·3
200—250	13	2·6
250—300	24	3·4
300—350	25	3·8
350—400	23	4·6
400—450	11	6·1
450—500	4	8·1

It will be seen from the above table that the longer the period the redder the colour. This fact has been considered of interest when taken in connection with others, as tending to confirm the impression of the greater age of these bodies, or systems.

Short period variables are white or yellowish in colour, and have spectra of the Sirian or solar type. There is, among these latter, a group of some 9 or 10 stars (No. 5 in Pickering's list) presenting such marked peculiarities as to form a class by itself. The characteristic features are, an apparent continuance at a constant magnitude, great loss of light at minimum, and a remarkable regularity in period. The most famous of these, which forms the subject of the present notes, has given its name to the type, and is known as Beta Persei, variable No. 1090, or more commonly, Algol. This star is peculiarly interesting, not only on account of its remarkable variation in brightness, but as being one of the first objects, to the examination of which, the new spectrographic method was applied, and also the first star whose mass was determined.

It may be remarked in explanation of the number 1090 that the system now adopted for designating the variable stars is to take the R. A. for the year 1900, reduce it to seconds, and divide the result by 10. Thus the R. A. of Algol is 3h. 1m. 40s. or 10900 sec. $\frac{1}{10}$ of which is 1090.

Algol is now known as a white star, but it is an interesting fact that it was seen by a Persian astronomer of the tenth century as red. So far as known to the writer all recorded changes in the colour of stars are from red to white or blue. On the assumption that red indicates age, this is the reverse of what would be expected, but it is probable that such a generalization must be received with extreme caution. Colour in all probability depends more upon atmospheric absorption than upon the actual character of the light radiated. Lockyer thought that a star's history might be traced through the stages represented by red and white on the ascending, and yellow and red on the descending scale. It will thus be seen that colour alone would be no criterion of age. It has been suggested in explanation of a change from red to white that condensation generates more heat than is lost by radiation, until a certain degree of density is reached, when the process is reversed and the period of decline begins.

The spectrum of Algol is of the Sirian type, and the dark lines shift backwards and forwards during the progress of the period of minimum, in such a manner as to lead to the conclusion that more than one body is represented. The Arabic name of Algol signifies the Demon, and suggests that his "mysterious winking" was observed long before the dawn of modern astronomy.

The first authentic record of the star's variability, however, is contained in a short treatise by Montanari, supposed to have been published between 1669-1672. He says, "If you look at the dreadful head of Medusa you will perceive that the brightest star that shines there passes through surprising changes, and only at alternate seasons does it possess its greatest light." Marildi confirmed this discovery in 1694, but it was not until 1782 that the regularity of its period was discovered by Goodricke. Kirch has left some records that would indicate that he had observed a minimum in 1733, but he attributed the change in light to careless observation, and evidently failed to realize the significance of what he had seen. General interest was now awakened in this remarkable object, and careful observations were made by Wurm, Pigott, Herschel, Lalande and others.

The most important of these were by Wurm, who is said to have determined its period as 2d. 20h. 48m. 58·69sec. He subsequently corrected this to 58·50sec. from a series of minima observed between 1783-1818, but did not say whether he considered the period to have actually changed. Argelander, however, subsequently decided this question beyond a doubt. From 1800 to 1840 observations were fewer, but the work was again energetically taken up by Heis, Schmidt, Argelander, and other observers, and from that time until the present, Algol has been so closely watched, that it is now the best known of all the variables. Schonfeld was the first to give the star's light curve particular attention. His paper on this subject was published in 1870, the deductions being based upon over 600 observations made by himself, and covering the period from 1864 to 1870. In 1882 Scheiner published a full discussion of Schonfeld's observations with a view of determining the constancy of Algol's normal light. This series contained 1600 observations and Scheiner's concluded "that the full light of Algol may be regarded as entirely constant." On the other hand M. Plassman (a pupil of Schonfeld's) comes to the conclusion, after a comparison of his own observations (made in 1890-91) with Scheiner's, that "it may be regarded as proved that Algol during the time of its full light, *undergoes certain variations.*"

Evidently this question is one for further observation. M. Plassman suggests in explanation of these alleged changes, atmospheric tides in the principal star, in addition to a faint light emitted by the satellite. It has been suspected of late that changes are taking place in the light curve, but although this is very probable, the evidence appears to be as yet inconclusive.

Algol is sensibly constant at 2·3 magnitude for 2½ days, when it begins to decrease, at first gradually, but with increasing rapidity until it reaches a magnitude of 3·5, loosing about two-thirds of its light in 4½ hours; near the time of minimum the rate of decrease appears to again become slower; then without a pause the increase commences, and the maximum is reached after a similar manner in about 9 hours from the first diminution. The total time from minimum to minimum being 2d.20h.48m.59sec.

Regarding this period Schonfeld remained satisfied that it was practically constant, basing his conclusion upon the series of observations already referred to, but Chandler states that shortly after 1870 the period, which had been nearly constant for fifteen years, began to diminish rapidly, and has again become sensibly constant. Prof. Chandler in 1888 undertook a discussion of the star's elements based upon a comparison of some 700 observed minima, which he published in the *Astronomical Journal* of that year. The result of this exhaustive work forms probably, the present standard measurement of the star's period. His conclusion was that the irregularity comprised two inequalities, the first having a period of about 140 years, and the second of 37·7 years. A third period of seventeen years was also suspected, but this awaits confirmation. These changes Prof. Chandler represented by the following data :—

	D.	H.	M.	Sec.
1782	2	20	48	58·0
1798				59·8
1808				57·2
1830				59·2
1843				54·0
1858				52·8
1866				54·4
1877				51·1

Argelander of Bonn, who is also an authority upon this point constructed a table which differs somewhat from Chandler's.

	D.	H.	M.	Sec.
1784	2	20	48	59·42
1788				58·74
1793				58·39
1805				58·45
1818				58·19
1830				57·97
1842				55·18
1848				53·37

Since 1877 the period has remained nearly constant, and we should now be close to the end of the general decrease, and may in a few years expect the increase to commence.

Various theories had been advanced to account for these variations, but up to the year 1888 the question was one of pure hypothesis.

Goodricke suggested that they might be due to the eclipse of light by some interposing body, but there was at that time no evidence to substantiate the theory. Herschel was of the opinion that spots similar to those seen on the Sun might, when considered in connection with axial rotation, account for the phenomenon.

Pickering also entertained this suggestion to some extent. It is interesting to note here, that in 1852 M. Rudolf Wolf drew attention to a similarity in the curves representing sun-spot frequency, and those indicating stellar light changes.

Another writer thought that variable stars might be flattened spheroids, and the variability explained by a nutation of the axes of revolution, and as is well-known, Mr. Lockyer advanced his meteoritic hypothesis as a probable explanation.

In 1888-1889, however, observations were made at Potsdam which threw a flood of light upon the question. Vogel decided to apply his spectrographic method to the solution of the problem, and his experiment was rewarded by the most gratifying success.

The first observation disclosed the fact that Algol was retreating from the Earth at the rate of 24·4 miles per second, but upon repeating the observation the still more remarkable discovery was made, that the star was *approaching* the Earth at a speed of 28·5 miles, and further, that this motion was not only periodic, but was directly associated with the variability in brightness. To Prof. Pickering is due, I believe, the credit for having suggested these observations.

There could be, according to the laws of motion, but one explanation of such a phenomenon—namely, that Algol was moving in an orbit, and as a corollary, that there existed a large attracting body, and that these bodies revolved one about the other. To quote the words of Sir Robert Ball: "The essential point to be noted is that the spectroscopic evidence admits of no other interpretation, save that there must be another mighty body in the immediate vicinity of Algol. There cannot be any longer a doubt that the mystery has been solved. We have such a remarkable concurrence between the facts of observation and the laws of dynamics that it is impossible to doubt the explanation they provide of the variability of this famous star." It may therefore be accepted that Goodricke was correct and that the eclipse theory rests upon a solid basis of demonstration. Such being the case, we would naturally expect a similar explanation to apply to other stars of the same type. Such confirmatory evidence will be awaited with interest.

As the spectrum of Algol indicates no such physical change in the light emitting body, during minimum, as is observed in the long period variables, we are justified in looking for a different explanation in regard to the latter. There is yet to be considered the question of the long period variation shown in the tables of Chandler and Argelander.

When making observations to determine alterations in terrestrial latitude, Prof. Chandler, among other stars, made use of Algol. During the course of these investigations the suspicion was aroused that this star was subject to a change in position not to be accounted for by any variation in latitude on the Earth, and a closer examination convinced him that not only was this suspicion correct, but that Algol's change of place among the stars was closely related to its period of variation in brightness. He was further led to the conclusion that Algol and its companion revolved together about a third body in an orbit nearly equal to that of Uranus. This orbit is supposed to be almost circular, and to lie in a plane inclined about 20° to our line of sight. Consequently when traversing that portion of the orbit nearest to, or farthest from us, Algol will be nearly constant in the line of sight, but when receding or approaching on the opposite sides, the motion in the line of sight will be increased or reduced accordingly. The effect of this would be that when approaching, the light from the star would reach us a little sooner, and when receding, a little later, than if the source of emission were constant. Hence the variation in the period of light change.

Taking into consideration the differences in the period of variable brightness, together with the known velocity of light, Chandler computed the size of the orbit, and, comparing this with the observed size of orbit, determined the distance of Agol from the Earth to be about 46 light years. Tisserand doubted the truth of this explanation, thinking rather that the long inequality might be accounted for by a progression of the line of the apsides. According to Chandler's explanation a maximum of acceleration should take place when Algol reaches the point of its orbit nearest the Earth, which is expected to be about the year 1900; after this the intervals between the eclipses should begin to lengthen until 1934. It will therefore be seen that observations made at the present time, and for the next few years, will be of especial interest.

Prof. Boss, of Dudley Observatory, has published a list of observed positions of Algol for the year 1895, with a view of testing Chandler's theory.

We now approach the consideration of a most interesting problem—the determination of the dimensions of the system in question, and of the masses of its components. Knowing the amount of light lost from the eclipse of the satellite, the relative sizes of the two bodies may be deduced, and taking into consideration the known velocity of Algol, the period of eclipse, and total length of the cycle (the density being assumed to be equal), these have been approximately determined as follows:—

Diameter of A	150,000	miles.
" " Companion	825,000	"
Distance apart	3,000,000	"
Velocity of Companion per second	55	"
(Mean velocity of A.) per second	26	"
Mass of A	$\frac{4}{9}$	Solar Mass.
" " Satellite	$\frac{2}{9}$	" "

It will be seen from the above that the volume of Algol is nearly twice, and that of his dark companion about equal to, the Sun's volume, although of much less density. This very low density would lead to the belief that the bodies are in a highly gaseous state.

There is another feature in which this system is—so far as known—unique—namely, the extraordinary proximity of the satellite to its primary. Some idea of this may be obtained if we consider that the proportion would be fairly well represented by a 25c. piece and a 10c. piece placed two inches apart. The tidal action in such a system must be on a magnitude of which we have little conception, and should Darwin's theory of the evolution of binary systems be correct, it may be that we see here an example of a satellite but recently separated from its parent, and just commencing its long spiral journey towards the point of greatest eccentricity.

It seems not too much to hope that the close study now being applied to such systems will result in vastly extending our, as yet meagre, knowledge of the constitution of the stellar universe.

TWENTY-FIFTH MEETING.

December 23rd; the President, Mr. John A. Paterson, M.A., occupied the chair.

Letters were read from Mr. Joseph Wallace, sr., of Orillia, in reference to the formation of a branch of the Society at Orillia; from Mr. A. C. D. Crommelin, F.R.A.S., of Greenwich, Eng., and from Mr. Anthony Story-Maskelyne, of London, Eng.; both of whom had kindly forwarded valuable information of historical interest.

This being the closing meeting of the year, nominations for officers for the year 1898 were called for. The Hon. G. W. Ross, LL.D., etc., was nominated for Honourary President; Mr. John A. Paterson, M.A., was nominated for President. At this point Mr. Paterson addressed the meeting briefly, thanking the members for the honour paid him but declining re-election and citing the well-known principle in this connection. Mr. Arthur Harvey, F.R.S.C., was then nominated for the office of President, the Chairman sustaining the motion by calling the attention of the members to the many services rendered by Mr. Harvey, the high standing which he now occupied as a cultured man of science, and the eminent fitness which he possessed for the office.

A letter was read from Mr. J. Todhunter, who wished to be relieved from the office of Treasurer. Much regret was expressed at losing the efficient services of Mr. Todhunter, who had for so long occupied the office. Mr. Chas. P. Sparling was nominated as his successor. Mr. E. A. Meredith, LL.D., was nominated for the office of Vice-President, filling the vacancy occasioned by the nomination of Mr. Harvey for the Presidency; Mr. R. F. Stupart was nominated jointly with Dr. Meredith. The other nominations were then proceeded with.

This item of business being concluded, the Librarian reported having received from the Paris Observatory the second set of lunar photographs taken in the great equatorial coudé by MM. Loewy and Puiseux. These were shown to the members and much admired. The special thanks of the Society were due to the Directors of the Observatory for this mark of favour. In the series there were photographs of features which had been drawn at the telescope by ladies at Simcoe, Ont., and shown at a previous meeting. It was very interesting to note the great fidelity of the drawings when placed by the side of the photographs.

Mr. Harvey, in reporting observations, called attention to the fact that during the previous month no astronomers had reported having seen any marked display of the Leonid meteors. The facts, as they stood, seemed to point out that the swarm is not so lengthened out as has been supposed.

Mrs. J. Fletcher read some notes on Prof. Corrigan's theory of solar disturbances, which gave rise to some discussion. The Chairman pointed out that the original article by Prof. Corrigan, as published in *Popular Astronomy*, had been so changed in so-called reproduction for the daily press as to be hardly recognizable. It was apparently the aim of many journals to make astronomical news as sensational as possible, if they inserted such at all.

Mrs. Savigny then read some notes contributed by Rev. W. H. Withrow, D.D., descriptive of the Berlin institution known as *Urania*. It was shown how admirably the management had succeeded in making popular astronomical facts and in representing by models whatever, belonging to the solar system, could be so represented. Some time was spent in discussing the possibilities for Canada if a similar institution could be established in Toronto. In this connection it was announced that Mrs. Craig had prepared some notes on popular astronomical work and would present these at the next meeting.

EIGHTH ANNUAL MEETING.

January 6th, 1898; the Vice-President, Mr. Arthur Harvey, F.R.S.C., occupied the chair.

After the reading of the minutes of the previous meeting, the election of officers for the year 1898 was proceeded with, resulting as follows :—Honourary President, Hon. G. W. Ross, LL.D., etc. ; President, Arthur Harvey, F.R.S.C. ; Vice-Presidents, E. A. Meredith, LL.D., and R. F. Stupart ; Corresponding Secretary, Geo. E. Lumsden ; Treasurer, Chas. P. Sparling ; Librarian, W. B. Musson ; Photographer, D. J. Howell ; Recording Secretary and Editor, Thos. Lindsay ; Members of Council, C. A. Chant, B.A., J. R. Collins, A. F. Miller, G. G. Pursey, Rev. C. H. Shortt, M.A.

The Treasurer's report for 1897 was then read, as follows:

Receipts:

Balance on hand January 1, 1897	$294 23
Government Grant	200 00
Fees from Members	84 00
Interest	8 17
	$586 40

Disbursements:

Publication Account..	$168 90
Sundry Expenses	96 16
Balance on hand	321 34
	$586 40

On motion the report was adopted.

It was then moved by Mr. Lumsden, seconded by Mr. Lindsay, and

Resolved, That the cordial thanks of this Society are due, and are hereby tendered, to John Andrew Paterson, Esq., M.A., for indefatigable personal exertions on its behalf, for the careful attention with which he, whether as private member or officer, has watched over and safeguarded its best interests, and especially for the ability with which, during the last two years, he has discharged the duties of President. This Society recognizes that it owes its satisfactory position, in a large degree, to such exertions, attention and ability, and hopes Mr. Paterson will long be spared, and will continue to be its warm friend and zealous supporter.

Resolved, That an engrossed copy of the above resolution be presented to Mr. Paterson as a slight memento from his fellow-members.

The resolution was carried unanimously.

The President then gave notice that at the next regular meeting of the Society he would move that the Council be asked to consider such amendment to the constitution as would enable the Society to confer the title of Fellow on certain of its members.

Mr. Lumsden gave notice that at the next regular meeting he would move that the Council be asked to consider the terms on which other societies in Canada might become affiliated with this Society.

It was then moved by Mr. Lindsay, seconded by Mr. Lumsden, and

Resolved, That the thanks of this Society are due, and are hereby tendered, to the press of Toronto for the valuable assistance given in aid of the Society's work of popularizing scientific studies.

The Librarian then reported the receipt of exchanges and presents. Among the latter was a copy of *Observational Astronomy*, by Arthur Mee, F.R.A.S., to whom the thanks of the Society were due.

Among reports of observations, Mr. Pursey stated that during the past fortnight he had noted one case in which his prediction of spots from the appearance of faculæ did not agree with results. He also reported his observations generally. A letter was read from Mr. R. S. Muir, of Belleville, reporting an unusual observation of midday rainbow between the Sun and the zenith. This, the Chairman stated, had no doubt been a sun-dog, but not common at this time of the year.

A letter was read from Dr. J. J. Wadsworth, giving particulars of his observations, and accompanied by a sketch of Ptolemy as his share of this special work in connection with lunar study.

The Chairman then called upon Mrs. Geo. Craig to read the paper announced at the previous meeting, on "Popularizing Astronomy." Mrs. Craig dealt specially with the necessity for the establishment of an observatory which would be under certain regulations, open to the public, intended to be used for general observation of the beauties of the heavens rather than for special study of particular objects. Touching the very important question of the providing of funds for this purpose, it was said :—"I believe there are hundreds of intelligent people who, if properly approached, would respond to an appeal for funds for the very worthy object indicated in this paper. Indeed, I would not be surprised to find that many such would subscribe in the interests of Science generally who are not, perhaps, specially interested in astronomy. I can conceive of no more pleasing task than that of presenting the case for the observatory. The personal element would be eliminated, and the matter could be more strongly urged on that account. However, as it is a fact that it is only human nature to expect something for something given, we could, in return for a subscription of a fixed amount, to be determined later, present a card of invitation, or of membership, so that subscribers would feel that they were welcome guests at our observatory, not timid visitors, uncertain of their reception. Let us send an envoy through the Province, some enthusiastic person (for enthusiasm is contagious), some one thoroughly qualified to speak on the subject, and armed with the authority of the Society ; let us interview the clergy, the learned professions, the teachers, and such others in the business world as we deem expedient, not forgetting our friends of the press, who will, no doubt, notice and second our efforts."

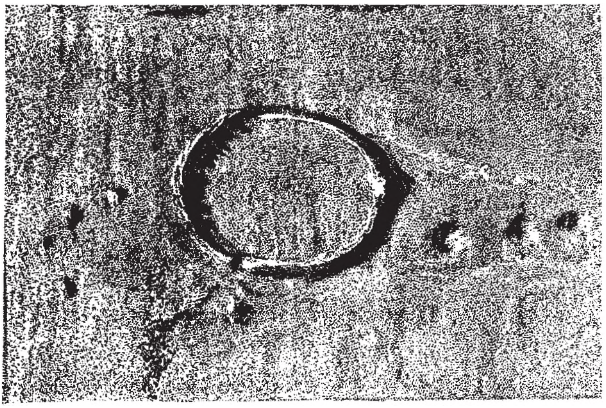
An interesting discussion followed the reading of Mrs. Craig's paper, which was considered decidedly opportune. The want of a popular observatory had been long felt, and was continually before the Society. It was decided to take up this matter during 1898 and make a special effort to accomplish something towards the much desired end.

From Mr. T. S. H. Shearmen a brief report was received of work done at Woodstock and Galt. The $4\frac{1}{2}$-inch equatorial at the latter place, in the observatory of the late Mr. John Goldie, had been in almost constant use for several months past. Observations had been made of coloured, variable and double stars, as also in the examination of planetary detail, and also of occultations by the Moon on all favourable occasions. Mr. Shearmen had made an observation of a partial division in the inner bright ring of Saturn, in July. The original notes in reference to this would be forwarded on completion of some correspondence on the subject with another observatory. In August, Mr. Shearmen and Mr. Alex. McDonald, of Galt, had noted a brilliant meteor, the disappearance of which had been accompanied by a distinctly audible report.

At Woodstock, arrangements had been made for photometric observations of the outer satellite of Uranus. It was finally decided, however, that the 8-inch refractor had not sufficient light-gathering power for delicate work of this kind. Mr. Shearmen had, therefore, commenced the construction of an 18-inch reflector, which was now well on the way to completion. Part of each week had been spent at Brantford, so that the interest in observational work had been maintained at the three different places. Mr. Shearmen was warmly congratulated on his success, and was requested to prepare a paper for the Society on the details of his observations.

Mr. A. Elvins presented, as a part report of the work of the Lunar section, a series of crayon sketches, of which the accompanying engravings are reproductions. The first showed Plato, special attention being called to the break in the northern wall. Mr. Elvins thought this break, and the apparently broken ground leading up to it, should be carefully observed. The appearance suggested to him the question: Does it indicate a passage through which a liquid once flowed?

S.

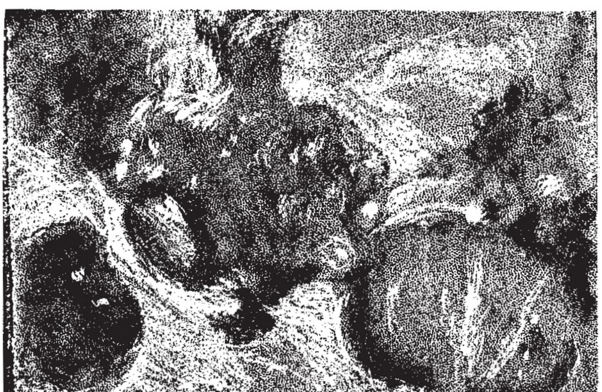


N.

PLATO.

The next drawing was of the Maria, Serenitatis and Tranquillitatis. Special attention was called to the darkening on the margin of the seas, which is very noticeable under certain phases of illumination. Mr. Elvins remarked that the engraving showed this margin somewhat too dark.

S.

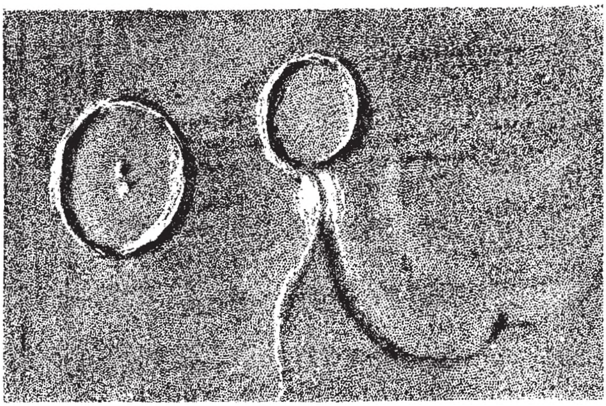


N.

MARE TRANQUILLITATIS AND MARE SERENITATIS.

The sketch of Herodotus, then shown, was of particular interest to members of the Lunar section, Mr. Elvins having frequently made drawings at different ages of the Moon, and presented short papers in description. The drawing accompanying shows the great valley sweeping round the north-east of Herodotus, the entrance to the crater to be particularly noted. A knoll seems to block its path just north of the wall, but Mr. Elvins stated that on August 10th, 1897, and again on September 8th, he could see the valley as a narrow dark line right into the crater.

S.

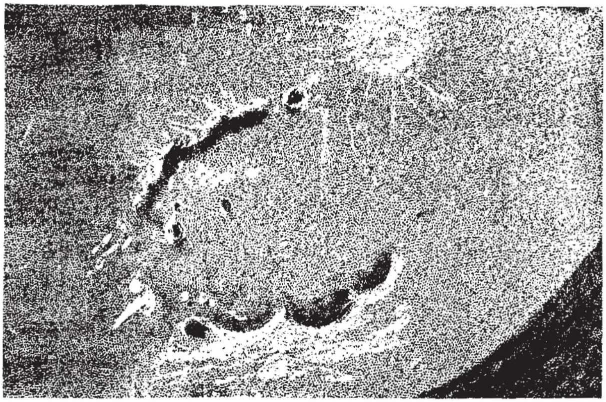


N.

HERODOTUS.

The next drawing shown was a sketch of the Mare Imbrium, for the purpose of calling the attention of observers to the dark shading on the north border of the sea. (The engraving shows this still too dark.) This was a feature selected by the ladies at Simcoe for drawing at Dr. Wadsworth's reflector, as reported at a previous meeting. The thanks of the members were specially due to Mr. Elvins for many valuable hints relative to lunar study, and the ever popular and valuable work of drawing at the telescope. The drawings presented were but a few of the many made by Mr. Elvins, several of which, made on a large scale, and on a specially prepared paper, he had presented to the Society.

S.



N.

MARE IMBRIUM.

Mr. J. R. Collins then read the following paper on

SCHÆBERLE ABERRATION IN THE TELESCOPE.

Prof. Schæberle has lately shown that the optical image of a celestial object, formed in the focus of a reflecting telescope of *great angular aperture*, is possessed of errors of definition which arise from a cause hitherto unrecognized by mathematical and practical opticians.

The matter stated briefly is: 1st. The focus plane of a curved reflecting surface, for parallel rays impinging thereon, is situated upon the axis, half way between the centre of curvature and the reflecting surface itself. That is to say, a parabolized concave reflecting surface whose radius of curvature is 12 feet, will bring parallel rays to a focus, at a distance of 6 feet from the mirror. Fig. 1.* If an arc be described having its radii centering upon the focal plane and situate on the mirror's axis—the centre of the arc touching the centre of the reflecting surface—it will be seen that as the extreme of aperture is approached, the converging rays are of different lengths.

We are all aware that an image formed by a pinhole increases in size to the eye of the observer as he recedes from the pinhole, and

* The parabola departs so little from a true spherical curve, as to appear inappreciable in the diagram.

decreases in size as he approaches it, in proportion to the distance; and so of every optical image formed, the longer the focus the larger the image, and the shorter the focus the smaller the image will be.

The standard of unity of measurement for magnitude is generally taken as 10 inches. A pinhole, a lens or a mirror, having a focus of 10 inches, will produce an image of magnitude 1. 20-inch focus will produce an image having a magnitude in diameters of 2. 30-inch focus = magnitude in diameters 3, and so on. Every 10 inch increase of the focal length adds 1 to the magnitude, and any fraction of 10 inches, no matter how minute it may be, added to or taken from the focal length, will consequently produce a larger or smaller image—as the case might be—in direct proportion as the fraction is contained in this unit of length—10 inches. A focus of 11 inches for instance produces an image having a magnitude of $1\frac{1}{10}$ diameter; $10\frac{1}{2}$-inch focus will give a value of $1\frac{1}{20}$ diameter, and a focal length of $10\frac{1}{10}$ inches = $1\frac{1}{100}$ diameter, and so on until the fraction above or below unity becomes so small a quantity as to be inappreciable under a high power eye-piece, though this fractional amount must be exceedingly minute to escape observation. To find its comparative value the fraction may also be divided into the total focal length and then reduced to minutes or seconds of arc.

Now when we remember that each particular little patch of the mirror produces a complete image of the object itself, and that these numerous images are superimposed upon each other in the common focus plane of the telescope and produce one bright image to be examined with the eye-piece; the importance of having all parts of the converging surface of equal focal length becomes at once apparent, for if they differ in focal length, as we have just seen, the superimposed series of images will differ in diameter and will produce a more or less confused compound image instead of a clearly defined one that would result if all parts were of equal focal length.

2nd. The plane of the image formed by each small patch of the converging surface tends to lie at right angles to the path of the focussed rays as arrows at p in Fig. 1, so that the images formed from every minute portion of the reflecting surface, while their centres may coincide on the axis of the telescope, all tilt from the focus plane directly as the extreme of aperture is approached or as the focus point is shifted from the axis; this with a planet would cause oval and irregularly formed superimposed discs producing another blurring effect as well as that due to a series of unequally sized images, focussed for examination before the eye-piece of the telescope. These are defects, however, which Prof. Schæberle has shown are not appreciable when the aperture is less than $\frac{1}{14}$ the focal length.

These defects Prof. Schæberle seems to suppose cannot be corrected in a reflecting telescope, and also that they do not exist in the refracting telescope, for, he says, in *Popular Astronomy*, October, 1897: "The reader will doubtless be amazed that errors of such magnitude should have escaped the attention of astronomers from the days of Newton to the present time, especially so, as the comparison between visual observation made with refracting and reflecting telescopes have indicated that there was something wrong in the images formed by the latter instrument. For the examination of nebulous objects having no sharp boundaries, the reflector of large angular aperture will continue to be of invaluable service, both visually and photographically." But if we examine the optical principals involved in the construction of the Gregorian form of reflecting telescopes, where the image is formed by the large reflector in front of the small concave mirror, and the light impinging on the latter is thrown back to a focus on the axis through an opening in the centre of the large reflector to the eye-piece, Fig. 2, we will see that it is possible to so proportion the curvatures of the reflecting surfaces of this form of telescope to each other, as to completely correct the tilt and want of uniformity of dimensions of the components of the compound image that it may be delivered in front of the eye-piece entirely freed from these defects.

This correction may be brought about by pitting the negative aberrations of this character in the small mirror against the positive aberrations of like kind in the large mirror. As the small mirror deals with diverging rays, Fig. 2, its resultant focus F, is pushed back beyond its centre of curvature *c* in proportion as the mirror itself is drawn towards the focus plane *p* of the large reflector,* so that when the curvatures of the combination are in proper proportion to each other, and the negative and positive aberrations are of equal amount, the defects of both are obliterated, even when a large angular aperture is used.

* By a reference to the dotted lines in Fig. 2, describing an arc from the focus of each mirror, it will be seen that while the rays proceeding from the central portions of the large reflector are shorter than the marginal rays, the reverse is the case with the small one, the central rays being the longest and the marginal rays the shortest.

Figure 3 shows that the result of the Cassegrainian form is to correct the tilt of the combined images, while it aggravates the defect of non-uniformity of size.

The science of optics is indebted to Descartes for the discovery of the fact that when the refracting surface of a lens is of an elliptical curve, whose major axis is to the distance between its foci x F, as the index of refraction of the lens is to unity, then parallel incident light will be brought to a single focus at F, Fig. 4. Now if we describe a circle R, whose centre is on F, we will see that the marginal rays, although coinciding on the same focus plane, are shorter than the central ones, and consequently will produce smaller images than those passing through the central portion of the lens. Of course such a lens is not achromatic, and in the ordinary achromatic objective the difference of the refractive indices of the crown and flint respectively, in the combination, are so manipulated as to approximately bring all the corrected rays to a common focus plane by the employment of spherical curves only. The image formed by the ordinary two lens achromatic is equivalent, however, to that formed by a single elliptically curved refracting surface, and possesses the same defect of definition as that now under discussion, namely, a difference of focal length for different parts of the glass, which must necessarily produce unequally sized superimposed images in the common focus plane of the telescope. The tilting of the image, depending upon the angular aperture, is the same for the refractor as for the Newtonian reflector of equal focal length, whilst the defect of unequally sized images must theoretically be twice as great in the refractor when the focal length of both are the same. (With a three lens combination, similar to Cooke & Sons' new objective, the extra curves would modify this result.)

If we compare the results of an analysis of the theory of the formation of images in the refractor with the Newtonian reflector we will find that this is the case.

Let us take the 36-inch objective of the Lick telescope (Prof. Schæberle's own telescope at present) and see what the result will give us. In vol. 1, *Publications of the Lick Observatory*, we find the curvatures of the 3-foot objective to be as follows :

The crown lens	1st	rad.	=	+ 259·52	inches.
" "	" 2nd	"	=	+ 259·52	"
" flint	" 1st	"	=	− 239·59	"
" "	" 2nd	"	=	− 40,000	"

The crown and flint being 8 inches apart, the combination gives a resultant focus of 56·2 feet, or 674 inches, aperture 36 inches.

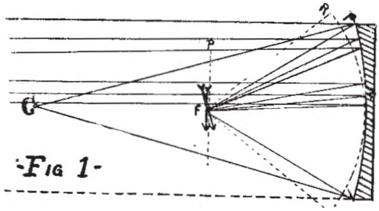
Figure 5 shows the result of this combination for incident parallel light, *r* represents the equivalent refractive curve situate in the lens from which the focus point must be measured, and having its radii centred at C, approximately half way to the focus point F. As in the other figures, an arc R, drawn from the focus F, will have all the lines drawn from it to F of equal length, but they proceed from *r* to F, and as this is a deeper curve the lines differ in length gradually as the curves R and *r* separate, until the extreme of the aperture is reached where they are the shortest.

The actual amount of difference in focal length of the marginal from the central rays is approximately $-\frac{1}{4}$ inch.

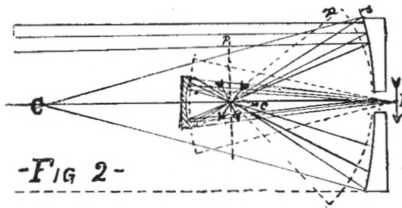
The difference of focal length of marginal from the central rays in a Newtonian reflector of equal aperture and focal length is $+\frac{1}{8}$ inch, and consequently the resultant defect is twice as great in the former instrument, so that a Newtonian reflector 20 feet shorter should, as far as this defect is concerned, other things being equal, define equally as well as the 56-foot Lick refractor, with equivalent magnification.

If a Barlow amplifying lens were used in front of the eye-piece of the Newtonian, a still shorter focal length should theoretically equal the longer refractor, so that it will appear, from a comparison of the two instruments, that the reflector is as yet far from being so completely pushed to the background as the casual reader of Prof. Schœberle's able article might be led to suppose.

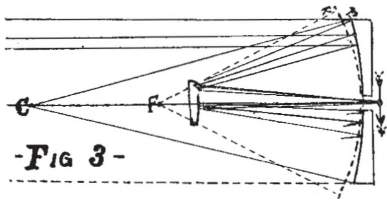
In closing, it might be pointed out that an analysis of the problem will show that the Schœberle aberration is a defect that does or may exist in all forms of lenses or combinations of lenses; in the microscope as well as camera; and is a point that must be taken into account if maximum definition is to be secured.



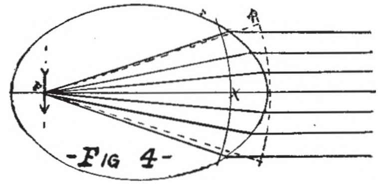
-Fig 1-



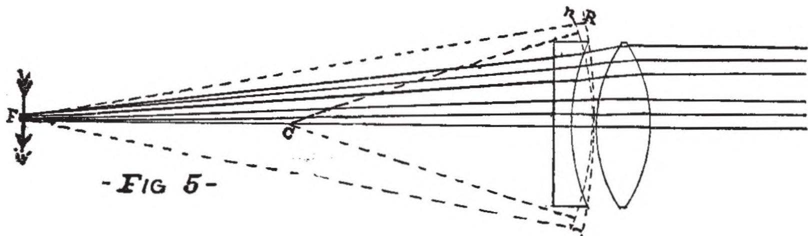
-Fig 2-



-Fig 3-



-Fig 4-



-Fig 5-

THE ASTRONOMY OF 1897—A POPULAR REVIEW.

[*Address delivered before the Astronomical and Physical Society of Toronto in the Theatre of the Normal School, February 3rd, 1898, by the retiring President, Mr. John A. Paterson, M.A. The President, Mr. Arthur Harvey, F.R.S.C., occupied the chair.*]

MR. CHAIRMAN, LADIES AND GENTLEMEN, MEMBERS OF THE SOCIETY,—

One year ago it was my great privilege to return thanks for the distinction conferred upon me by this Society in electing me to the highest office in their gift: it is now equally my privilege to congratulate you, sir, our unanimous choice, in so fitly and worthily wearing the mantle of the Presidential office, and to wish you and the Society God-speed while the year is yet young, looking as I do for a ripe fruitage of good and useful work yet to be done. I stand not to-night on the Bridge of Sighs—contentment, and not contention, is the spirit of every loyal member and of every good officer. If it is true with you, Mr. President, that "uneasy lies the head that wears a crown," then, indeed, it is true with me that easy lies the head that has doffed the coronet, and so with Sancho Panza I say that "having my will I should be contented, and when one is contented there is no more to be desired, and when there is no more to be desired there is an end of it." Are the years far distant when the Presidency will mark certain epochs in the annals of our Society? when the term "*Praeside*," coupled with the name of some distinguished member, will signalize events in our history as a Society, and have the same significance in our ear and recall to all memories as dear as the term "*Consulibus*" did to the ancient in the palmy days of the republic, when the seven-hilled city stood, or the "*Archon Eponymus*" to the old Greek dwelling in the city of the Violet Crown among his temples and his statues: and circumstances of interest will be recalled, not as belonging to the year 19— but as having happened in the distinguished Presidency of such a one.

Our hand is almost on the latch of the door to a new century and we stand upon its threshold waiting to see what new triumph Science is about to reveal. The Sun of the nineteenth century is now nearing its western limit and its glories brighten as it sinks. Already we may hear the murmuring welcome of the children of Science to the new era whose jocund morn comes in the white wake of a multitude of sparkling scientific glories, the product of the era now almost at its close—many of which it has been our privilege during the past few years to chronicle. When we contemplate the orb of scientific truth which is now past its crescent promise we are reminded that eagles nestling on cliffs under the dazzling full tropical moon have been known to ruffle their pinions and prepare to launch themselves into space thinking it was the light of day. But we know that however brightly the glories of scientific truth radiate the firmament of the searchable yet, after all, aggregated discovery is yet little more than a crescent: and we students will, therefore, yet humbly wait and not think that Science has her orb fully rounded. And we yet wonder when, if ever, that will be, and the Sun will rise. One of the tales that to each one of us is very dear is that of the Crusader King who was imprisoned by his enemies and was lost to his subjects, spirited away to some unknown dungeon or castle tower. And then it was that his faithful friend dressed in minstrel-garb spent toilsome days and weary nights, and before many a frowning battlement smote his harp, drawing out those sweet strains his monarch loved. Miles were travelled and months were spent and no recognition, until at length from one castled steep, as the musician's notes floated upwards, there came fluttering downwards a token of recognition that brought together the King of the Lion-heart and the friend of the True-heart. We should all be Blondels going up and down looking for Truth where she may be hid. We cannot get behind the castle walls—they are barred—and after all Truth may not be there. We are poor musicians, singing a strain that travellers on the highway know not of, but when Truth hears it then she recognizes its sweetness and reveals herself. And so the great orchestra of Truth-searchers have sung these "rhymes of the universe" through the centuries, and their harp of a thousand strings ever keeps in tune, and thus Truth hearing them comes to light. The growth of Science has been a growth from dark and mysterious beginnings. The astrologer on his tower top with his horoscopes, conjunctions, ascendants and descendants and his polished jargon, once dominated the field of astronomical Science, or rather indeed with his murky superstitions made the beautiful face of Urania terrible, and struck terror into the minds of many who would have been her truest lovers. Homer tells us when Hector clad in all the terrors of battle-mail sought to clasp to his paternal breast the young Astyanax, the hope of Troy, that the boy shrank back in terror from the nodding crest of the dazzling helm fluttering in the breeze, and it was only when the warrior

> The glittering terrors from his brow unbound
> And placed the beaming helmet on the ground

that the child recognized the father and sprang to his arms. And so it was too that when Urania put off from her the garb of terror wherein the priest, and the astrologer, and the mediæval comet-prophet had clothed her, that her children, the true votaries of Science, shook off their superstitious fears and hailed her as a goddess to be loved and to be worshipped. This is the lesson taught by modern astronomy. The comet no longer

> "There with long bloody hairs, a blazing star,
> Threatens the world with Famine, Plague and War.'

And the new astronomy, that "daughter more beautiful than her beautiful mother," teaches us lessons more wondrous yet. Astronomy is now no longer a mere pastime for the geometrician, a trick of the calculus, a mere seance of the magicians of algebra who predict eclipses to a second of time and tabulate the place of a planet or satellite, or even of Sirius cycles of time hence. We now stand on a loftier height and take a grander sweep, the *dolce far niente* magazine reader of the boudoir knows to-day more of physical astronomy than Kepler knew or Newton dreamed of. Before the spectroscope, and the revelations shown by Fraunhofer, Kirschoff, Huggins, Miller and Young, astronomers called the stars by names, wrote of the mechanism of the heavens, and wisely prated of the "whereabouts" of the orbs scattered through space. The universe was dead, inert, a magnificently grand and wondrously accurate machine, and a world-chorus of admirers said "O wondrous wise!" But the prism unravelled the beam of white light, and has shown us the wonders of the dark lines and the bright lines, with their countless variations and combinations, forming a strange cryptography. And then arose teachers, those veritable high priests of Science, who translated for us the code of signals, and gave us the interpretation of these beams that the Sun had been telegraphing to the Earth for myriads of years past, and all these years uninterpreted. And now the problem of "whereabouts" is nothing, and we are past that primer, and studying the grander problems of the "*How*," and the "*What*" and the "*Why*."

These are no longer hidden from us. That new philosophy has hung her silver lamp in the charnel house of innumerable uncertainties and mysteries. The universe is no longer dark and dreadful, and demoniacal—no longer mechanical and monstrous—it is filled with *life* and *light* and meaning—it is the house of our great Father. To the trembling children of men it has lost more than somewhat of its dark mystery—they see the face of the Father unhelmeted and smiling.

A single instance of the wonderful analysis of the new astronomy may be given. Every student of Science is more or less familiar with that wonderful generalization of La Place, known as the nebular theory, which briefly is that this solar system and other systems were evolved out of *nebulæ* operated under those well ascertained cosmic laws of gravitation and thermal physics, which form a sort of Statute Book of Nature. The life of man is but a span, and the lives of men since observations began to be made, are but a few spans added together, and thousands of these would be as nothing to the æons of time in which such an evolution must work, and so no system has been seen to have been so evolved from a nebula to a well-ordered system moving round the nucleus of its parent nebula as a central sun. When the theory was first promulgated, nebulæ were pointed out in the heavens as examples of the fiery mist—the stuff that worlds were made of. But the revelations of the giant telescopes showed that many so-called nebulæ were resolved into myriads of stars, and were not, therefore, aggregations of a shining fluid. And it was argued that if telescopes could be constructed of greater light-gathering and magnifying power, and used under better atmospheric conditions, all nebulæ could be resolved into stars, and so the nebular theory was sorely pressed. Herbert Spencer came to its aid, and showed that notwithstanding the revelations of the Lord Rosse telescope, then the largest in the world, the evidence was in favour of nebulæ being the germs of universes and stages in evolutionary progression. It was left to Huggins, however, to settle that controversy. On the 29th August, 1864, he examined for the first time a planetary nebula in Draco. I tell the story in his own words: "The reader may now be able to picture to himself, to some extent, the feeling of excited suspense, mingled with a degree of awe, with which after a few moments of hesitation I put my eye to the spectroscope. Was I not about to look into a secret place of creation? I looked into the spectroscope. No spectrum such as I expected! A single bright line only! At first, I suspected some displacement of the prism, and that I was looking at a reflection of the illuminated slit from one of its faces. This thought was scarcely more than momentary: then the true interpretation flashed upon me. The light of the nebula was monochromatic and so, unlike any other light I had as yet subjected to prismatic examination, could not be extended out to form a complete spectrum. The riddle of the nebulæ was solved. The answer which had come to us in the light itself read: Not an aggregation of stars, but a luminous gas. Stars after the order of our own Sun, and of the brighter stars, would give a different spectrum, the light of this nebula had clearly been emitted by a luminous gas." Every true student of astronomy must participate in the reverence described by Huggins when he looked at the spectrum of the nebula. Here was God's own finger writing down in cryptograph the nature of the chaos that whirled in fiery tumultuous cloud away in the bosom of space, in the very suburbs of creation, at a distance counted only in the arithmetic of heaven. The Holy Spirit indited to the Jewish lawgiver the words, "In the beginning," wherewith he commenced his history of creation: and so, the Eternal writes in that single bright line in the nebula's spectrum the same words, "In the beginning." Here was the ground plan of the creation of a new system that in milleniums may be the dwelling-place of sentient and immortal creatures, laid down by the Great Architect for us to see—the same ground plan, too, which unnumbered cycles ago was wrought out for our little system of planets by Him, with whom it is a universal Here as well as an everlasting Now. There seems little room for doubt, but that our spectroscopes reveal to us the genesis of our astral systems, the passage of the Almighty's shuttle weaving the garment of world-stuff, and that the language of Fraunhofer's lines, when wisely read, teaches us the "How," and the "What," and the "Whence" of the universe—whether it be from the whirling nebula of La Place, or from that modification of it by tidal effects taught by the younger Darwin and Poincaré. But we need not go so far afield to grope about and seek to grasp the mysteries of life and creation—down lower we may look at the turf, and struggle with the same problem.

> "Flower in the crannied wall,
> I pluck you out of the crannies,
> I hold you here, root and all in my hand
> Little flower—but if I could understand
> What you are, root and all, and all in all,
> I should know what God and man is."

The "everspeaking Yea," the "universal Here," the "everlasting Now," is ever and everywhere with us.

Year by year busy, high-reaching man seeks to conquer more and more of Nature's problems, and to read more and more of the sacred writing of Science, but there are foundations which have not been gauged, and there are heights which have not been scaled. The Chelsea philosopher writes: "To the minnow every cranny and pebble and quality and accident of its little native creek may have become familiar. But does the minnow understand the ocean tides, and periodic currents, the trade winds and monsoons, and heaven's eclipses, by all which the condition of its little creek is regulated, and may from time to time (unmiraculously enough) be quite overset and reversed? Such a minnow is man: his creek, this planet Earth; his ocean, the immeasurable All; his monsoons and periodic currents, the mysterious course of Nature through œons of œons." Truly enough, we know partially the course of Nature's phases, but we know not yet, if ever indeed we shall, the higher courses which lie beyond. Our reach is farther than our grasp. Ajax fought for victory in the dark cloud that descended from Jove's sable shield, and could not achieve victory till at his prayer the Sun burst through, and the blaze of armour flashed against the day. The contest for truth goes on yet in the gloom, and it is only after faithful struggle that the light is at last seen by the Ajaces of Science. Let us make an effort to-night to see what progress, since the last year dawned, the minnow man has made in the study of this ocean—the "immeasurable All," what new principles has he discovered, or, what application of old principles has he invented? What new triumph in astronomical Science has some Ajax with weapons of the brain achieved? I have ventured to gather into my cabinet from the works of the scientific toilers of the last year some gems, and I wish to let you see them, and if you please, to like them. For mind you, I am simply a traveller, and a humble gatherer, and all I do is to arrange the crystals, and I would have you say to me as Proteus says to his friend in the "Two Gentlemen of Verona":—

> "When thou, haply, seest
> Some rare noteworthy object in thy travel:
> Make me partaker of thy happiness,
> When thou dost meet good hap."

Well I have met "good hap" and would fain make thee, my hearer, a partaker in my happiness. Before showing what has been gathered from abroad let me show you some rudely fashioned material found nearer home. We will not use our telescopes at first, we will simply look around us and discover what we can.

This Society meets fortnightly—it comprehends among its members both ladies and gentlemen, no test of scholarship or mathematical attainment is required. Pythagoras wrote over his portals "Here enter not all ye who know not geometry." We are not so forbidding, our only passport is a sincere love of Urania and an earnest desire first to know her and then to know her better. I have read a story of some disciples of the rosy god who arranged for a feast and agreed that each should bring a share of wine which was intended to be all poured into one large bowl and then divided. One of the would-be-revellers of economical instinct filled an empty wine bottle with water thinking that the pouring into the bowl of his *quota* would not be noticed and he would get the same credit as he who brought a choice Falernian vintage. But lo! when all assembled and the pouring in was called for no one would make a beginning, and it was discovered that all had been thrifty and had their bottles filled with water, each trusting that the others would supply the feast. This practice does not prevail in our Society. We all make an honest effort to contribute to the feast of Science and if it happen that one or two have not brought their share to pour into the general reservoir, yet enough is brought to make the general joy complete and the fountain of instruction and useful discussion is perennial. Two of our most earnest members, the Collins' Bros., are still developing their new Monoplane Achromatic Telescope. It is one of 8-inches aperture, having a new form of objective of one kind of glass. Mounted equatorially it delivers an image of a celestial object in front of the eyepiece in dimensions equivalent to a focal length of forty feet—although the extreme length of the instrument complete is but four feet. It is able to correct for spherical aberration as well as chromatism and also for the "Schæberle" aberration that must necessarily exist in the ordinary refractor of great angular aperture. Dr. H. C. Vogel, of the Astro-physical Observatory, Potsdam, after a mathematical analysis of the correction for achromatism says "a workable objective is now shown which, as the reasoning proves, unites in an excellent manner the rays from red to violet better indeed than is the case with an objective of the usual construction." It may be added that the same principle may be applied to the microscope. Mr. George Pursey still continues with great assiduity and success his daily recording of the solar spots on charts which become, through his kindness, the property of the Society.

Six of our members had the privilege of being admitted to the roll of those whose papers were accepted and read at the last meeting of the British Association for the Advancement of Science at Toronto. Mr. G. E. Lumsden, your able Corresponding Secretary, and your ex-President, presented papers upon the "Unification of Time," which were the occasion of a most earnest discussion led by the eminent astronomer, Prof. Simon Newcomb, one of our own honourary members, in opposition. The question involves bringing into unison three different day-reckonings, viz. : Astronomical Day, Civil Day, and Nautical Day. Our distinguished fellow-countryman, Sir Sandford Fleming, has given the project a very great deal of investigation and reflection. It has been strongly advocated by most eminent authority, by most of the world's astronomers, and by nearly all the navigators who have been consulted. It engaged the most earnest attention of this Society and that of the Canadian Institute, represented on Committee by yourself, Mr. Chairman, as the then President. Out of a multitudinous authority hear Sir John Herschel : "Uniformity in nomenclature and modes of reckoning in all matters relating to time, place, weight, measure, etc., is of such vast and paramount importance in every relation of life as to outweigh every consideration of technical convenience and custom." This reform could only be accomplished by all the nations of the world publishing ephemerides agreeing, and as they have not, it is an example of what often happens in advancing reforms that a small minority holds the key of the situation and governs. To some astronomers and computers no doubt it would be inconvenient—perhaps at first a little troublesome—but that weighs but a feather against the necessities of the navigator. The *Nautical Almanac* was made for the navigator and the *Nautical Astronomer* was made for the almanac—the ship masters were not made for him—and so let the world's marine govern. But the Governments of the United States and England did not consult their navigators. In the time of Charles II. it was not so. In his reign a discussion arose as to the difficulties of determining longitude from lunar distances, and one John Flamstead wrote that the places of the fixed stars according to the Tychonic Catalogues were not true. Whereupon the king swore a mighty oath, and stamped his royal foot and said, "I must have them anew, observed, examined and corrected, for the use of my seamen. I must have it done," and on being asked who should do it, the king answered "The person who informs you of them." And straightway, in 1674, "our trusty and well-beloved John Flamstead, Master of Arts," was made by Royal Patent, Astronomer Royal, and in 1675, King Charles signed the warrant for the building of the Royal Observatory at Greenwich. And thereby and from other precedents hangs the tale of England's proud navies with her "far-flung battle line," and her wide-reaching colonization enterprise that gave us Canadians our newer Cis-Atlantic Britain with all our noble heritage of Empire. I also record that our President, Mr. Arthur Harvey, presented to that same British Association a paper upon "Periodicity of Magnetic Phenomena," involving erudition and a vast amount of original research into one of the most recondite problems of our solar system. One of our Vice-Presidents, Mr. R. F. Stupart, Director of the Meteorological Service of Canada, read a paper showing extensive research and accurate knowledge upon "The Climate of Canada," before the Meteorological section of the British Association; the same gentleman had before that written a most valuable contribution upon the same subject which found a place in the Association Guide-book. Mr. Napier Denison also read a paper on "The Great Lakes as a Sensitive Barometer," which was characterized by great originality. In this he further pursued a subject which he had presented to our Society in a paper on "The Air Barometer." Another of our members, Dr. Otto Hahn, also read before the Physical section a paper on "Meteorites," illustrated by a microscopic exhibition of specimens. But let us leave our own humble efforts, as an honest historian I narrate them as facts, they are referred to with diffidence. We remember that "they also serve, who only stand and wait."

Let us look farther and upwards. Ossian addressed the Sun in this wise: "Whence are thy beams, O Sun! thy everlasting light? Thou comest forth in thy awful beauty: the stars hide themselves in the sky; the moon cold and pale sinks in the western wave; but thou thyself movest alone." And that same wandering, wondering cry, "Whence are thy beams, O Sun?" has been repeated in all ages from the earliest days of man's clouted savagery glaring fiercely from under his fleece of hair down to these latest days of mighty intellectual conquests and palatial observatories with their batteries of magnificent instruments of precision. And yet after all we are only at the margin of the problem. Last year has, however, added its quota to solar physics. Sir William and Lady Huggins, or perhaps I should rather say Lady Huggins and Sir William, have been conducting experiments which help to read the riddle of the Sun, to pluck out the heart of his mystery. The Sun is enveloped by very tenuous surroundings. The chromosphere, the corona and the vast equatorial streamers are hardly kept down by gravity. The element calcium was represented in the spectrum of these surroundings by only two lines the dark H and K situated close to the limit of ultra-violet visibility. In the general solar spectrum seventy-five of the Fraunhofer lines are due to calcium—and the problem for the solar physicist was to reduce calcium to a "two-line" condition. This is what Lady Huggins and Sir William have accomplished. Before the Royal Society last June they showed conclusively that calcium vapour sufficiently attenuated and under electrical stimulation radiates H and K alone. In other words they can produce in their laboratory calcium in the same condition as it exists in the raging tornado of the corona. The Sun, the great source of electricity as well as of light and heat, is pouring electrical discharges through its chromosphere and thus modifying the usual calcium vapour. Thus the philosopher cuts up so to speak the orb of the Sun and checks off its various peculiarities as a botanist would cut up and explain the peculiarities of the various parts of an orange. And all this by the subtle analysis of the chemistry of sunlight.

The Wilsonian theory of sun-spots was not long ago considered as demonstrated beyond a peradventure, it was declared to be inexpugnable, and put away and labelled "hands off" among the most sacred achievements of astronomy. It is in our school books, and copied from text book to text book, and so impregnable that if any fact were quoted against it, then so much the worse for the fact. According to it the Sun was built up, like an onion, of concentric shells, which were most luminous on the outside, and less luminous as they approached the centre, then a breach in the outer crust would give the appearance of a dark spot. The deepest portion of the cavity would be the darkest, and might represent the umbra; less deep portions would be less dark, and would form the penumbra. So that, in fact, a spot was a rift in the outside fiery envelope, and we saw the dark, cooler substance thousands of miles deep down. And then we might speculate with Sir Wm. Herschel as to what lay below the lowest shell which we could see, and having got so far the newspaper astronomer then took up the tale and drew his dark trail across the path of honest investigation, and cooler and darker shells were constructed, until at last we had a cool, habitable globe at the centre of the Sun. Rev. F. Hewlett attacked this theory in 1886, and since then it has been limping. Messrs. Maunder, Eversted, and Jenkinson, and others, have been at it in 1897, and the place that once knew it knows it no more. A dark spot is, after all, only an appearance—the very blackest nucleus is intensely bright. The darkness of a sun-spot is only relative, it may be as bright in itself as 10,000 full Moons. A sun-spot may be compared to the flame of an ordinary gas fish-tail burner. The flame has three zones: the outer one is the brighest, then a region of diminished luminosity, and lastly the nucleus which hardly gives any light at all. Suppose now the Sun, covered by such flames in a horizontal plane, the appearance would be a bright, flat surface, diversified by dark spots, and all on a level. A dark spot could be created by the increase of temperature in the region of the spot, so that the precipitation of carbon no longer took place, but it remained in the gaseous state—this would give a great falling off in brightness. In connection with this part of the review may be chronicled a remarkable spot of January, 1897, having a length of 130,000 miles.

Extensive preparations were made in England by the "Joint Permanent Eclipse Committee of the Royal Society and Royal Astronomical Society," and in the United States by the Lick Observatory, to observe the total eclipse in India, which took place on the 22nd January, 1898. The observations made by E. W. Maunders and C. T. Waites, of the English expedition, at Talni, were highly successful. The sky was perfectly clear, and the light during the middle of the totality is reported to have been equal to that given by a full Moon. The corona was well marked, and stretched over two diameters from the Sun. The last recorded solar eclipse at the Varanger Fiord, in Lapland, on 9th August, 1896, was not successfully observed, the cloudland and fogland there veiled one of Nature's most wonderful mysteries. But under the clear, bright sky of India a different result was confidently looked forward to, which, so far as accounts by telegraph have yet reached us, has been abundantly realized. On this continent an opportunity will be afforded all lovers of astronomy, on 28th May, 1900, when a total solar eclipse can be observed in the Southern States. In the meantime, observations have been going on, and will be continued, as to the most favourable positions meteorologically. Central Georgia and Alabama are mentioned as the least likely to be affected at that time of the year by cloud or fog. But those who set themselves in array, and project solar eclipse expeditions, had better take to heart the grim advice a certain King of Israel gave on a memorable occasion to Benhadad, him of Syria—"Let not him that girdeth on his harness boast himself as he that putteth it off." Which, indeed, is a parallelism to that more modern and bucolic advice: "Count not your chickens before they are hatched,"—the hen may not even be on!

To one who is apathetic to these matters it seems strange that governments and societies and private individuals should go to such expense and labour only in quest of a shadow. Looking for a shadow is generally considered as an embodiment of folly: but in this phenomenon, the shadow is the substance of things hoped for and the evidence of things not seen. In the few moments of totality, when the awful weird blackness overwhelms all visible nature, and the Sun's coronal glory and these mysterious hydrogen flames, that have been observed to shoot out 11,000,000 miles from the Sun's centre, may be studied and photographed, there is wrapped up much of the Sun's problem that the master minds of Science have struggled to grapple with. No method has yet been invented to construct an artificial eclipse and so study the Sun's corona. It has only been done hitherto at long intervals of time in remote parts of the earth, at great expense, when and where total solar eclipses happen, and only then when the sky is cloudless, and only then for a few fleeting seconds, when the steady metallic beats of the clock keep time with the pulsating nervous anxiety of the observer. And that is all the chance Dame Nature, niggard as she is, gives to the sons of Science who "scorn delights and live laborious days"—and nights too. The corona has her history, it is no modern discovery—the old Chaldeans, those oldest readers of the scriptures of the skies, had often studied it. It is doubtful if, after all, we know very much more than they did about its mystery and nature. Mr. E. W. Maunder has been studying its annals. On old Assyrian monuments, he tells us, appears a ring with wings and the Egyptian priests, before the pyramids, had carved a winged disc. No doubt here was the circle of light with the streamers and bright red prominences as they appear at solar eclipses. And thus these old devotees read that wonderful hieroglyph of Nature. The circle symbolized the eternity of their deity and the spreading wings his power and protection. The Baal worshippers no doubt saw their great Fire-God in this wonderful manifestation of Presence and Power; the refined Greek there saw him of the silver bow, the far darting Apollo the far-worker, stretching out from behind his blackened shield a bright benediction of peace; and thus, having no science to guide, it was all merged into their superstition, or, if you like it, into their religion. Their deity spoke to them then out of a "horror of great darkness." It has been suggested that Lumiere's invention of the cinematograph (which we have seen in Toronto) could be applied to the study of solar phenomena. Take for an illustration what Prof. Young, the eminent spectroscopist, witnessed on 7th September, 1871: a large hydrogen cloud 100,000 miles long, floating above the Sun, its upper surface 50,000 miles and the lower surface 15,000 miles above the Sun's surface. The whole appeared supported on pillars of fire, these pillars being really hydrogen jets. He turned away from the telescope, and in about half an hour returned, and then he found the whole mass had literally been blown to shreds by some inconceivable uprush from beneath, and the whole air, if one might so speak, was filled with flying debris from 5,000 to 14,000 miles long, by 1,000 or 1,400 miles wide, forming one of the most wonderful sights ever seen by human eye. Now, if this could have been caught on a rapidly moving photographic film, and reproduced as animated pictures, what a feast for the eye and delight for the mind. And so, also, if the coronal streamers and other phenomena seen in a telescope could be so reproduced; accurately as the camera does its work, which has no nerves, and neither exaggerates nor extenuates, what value would such an aid be to the astronomer, and what a charm to the multitude who are not astronomers! Let me again refer to the practical usefulness of these weary globe-wanderings after a shadow. I have read of a certain one to whom knowledge, but not wisdom, had come, saying in a very agony of scientific spirit: "I thank God that this noble science will never be prostituted to any useful purpose!" That out-herods Herod. Doubtless the pursuit of truth is the noblest occupation of man, and its publication a duty. Doubtless, Urania is fair to see, and those who kneel at her shrine would kiss her golden tresses and be content—but though golden they may not always be auriferous, and so make a banker's heart rejoice. True, it may be, that noble thought is always linked with reverence, and if not it loses somewhat of its nobility. Wonder is the daughter of Ignorance, and as Science plants her foot further forward she destroys Wonder, although Reverence always walks in front, and so the advance of Science advances humanity. But yet there remains the question for what commercial purpose do scientists struggle with the Moon's shadow on the Sun, and strive to read its lessons? Know then ye dividend-seeker that the Sun is the great electric dynamo of our system, he is the great force-generator and parent of all energy, and that if the corona will give up her secret we will more fully harness nature, and persuade her to do our bidding more easily and more fully! And so, ye stockholders may reap larger gains, and what is better, ye countless numbers who do not by engines and shafts, and wheels and bands, store up energy and sell it out, but who would fain save nerve and brain and sinew, drawing from the storehouses of Nature's energy more fully and more cheaply, ye, I say, will rejoice and rest. Do not then, ye bargain-fighter, or machine-controller, or machine-user, or whatever ye be, whether in sooth ye command with the sceptre of capital, or wield the sledge-hammer of labour, turn lightly away from the astronomer gazing at shadows through his spectroscope, or dolefully ask whereunto it all tends? The astronomer and the electrical engineer are together joined in a holy quest for the betterment of humanity. From the darkness we reach the light, from the shadow we are led to the substance. Aurora with rosy finger still points out her secret in the spectrum, if we could but read it truly. The birth-song of discovery is ever being chanted, and is ever silencing the swan-song of many a dying fallacy and bygone theory that once masqueraded in the guise of truth. Quite *apropos* to this let me tell you what the Belgian Government has done for astronomy in 1897. It has offered prizes amounting to 300,000 francs (say $50,000) for the following objects :—

1. Construct an apparatus by which relative measures of the value of the force of gravity on shipboard may be made.

2. Construct an apparatus to shew the effects similar to that of the gemination of the canals on Mars and which may explain the actually observed phenomena.

3. Invent a method by which planetary details may be photographed as clearly as they can be observed.

4. Find a method by which the Sun can be obscured at any time as if it were totally elipsed.

5. Indicate a method of determining the amount and direction of movement of the solar system through space.

The kingdom of Belgium occupies an area as large as that part of our Province of Ontario lying from Toronto to Kingston from west to east and bounded on the north by a line running from Orillia parallel thereto. In Belgium only about 70 per cent. of its population can read and write, and this is what it does for some of the abstruse problems of astronomical science. Where is our Canada, our greater Cis-Atlantic Britain, in her encouragement of scientific progress? It would be interesting to read the proceedings of the Parliamentary Committee on public accounts when dealing with such an expenditure as just proposed by the Belgian Government. It would tend at least to dignify these proceedings.

Before leaving the Sun I must note that at the instance of Dr. Gill, Her Majesty's astronomer at the Cape of Good Hope, a series of most elaborate observations of the minor planets Iris, Victoria and Sappho commenced nine years ago, for the purpose of re-determining with greater precision than ever that old constant, the solar parallax. Twenty-two observatories took part in these observations; the labour has been almost inconceivable. The results were published in 1897, and the parallax is put at 8·802″. This puts the Sun's distance at 92,874,000 miles, being, therefore, somewhat nearer the Earth than it was formerly supposed to be. It is gratifying to know that we are not yet running away from him. By the most exact instruments yet possible a thousand miles is neither here nor there when dealing with such a problem. And what exactitude is still possible we cannot yet postulate; we may get it down yet, not only to the miles, but to the odd feet and inches. This measurement is of the very highest importance, because it is the unit of measurement of every other astronomical distance; it is in fact the foot-rule of the universe, and if our foot-rule is too long or too short then everything else which thereon depends will run riot and our conceptions of the universe will be erroneous. In this "globe we groan in" a man who uses a false foot-rule will find himself thrust into an enforced retirement. Astronomers had better beware and not trifle too long with the solemnities of an erroneous space measurement. Bacon said in his Essay on Truth, "the mixture of a lie doth ever add pleasure," but it is not so in astronomy, it may be so in politics.

When I commence to speak of Mars I do so with humble voice and bated breath. I know not whereunto I may reach, for facts and fancies as to Mars have become so inextricably interwoven that it has become impossible to say whether the romancer of newspaperdom, with his fervid imaginings and sweep of rhetoric, has not all but obliterated the quiet and callous mathematician working at the eye-piece of the telescope. Macbeth exclaimed, "the time has been that when the brains were out the man would die," but that was in prosaic matter-of-fact Scotland. But now when we read of Martian engineers digging huge acqueducts, and sitting round the oases in solemn bands, and preparing plans for yet larger canals to catch the downpour in the spring from the melting polar ice-caps, and then flashing signals to their brethren of the genus "acqueducter" on Earth, we see that now the time is when the brains are out and the man really lives and draws, not only his breath, but his salary, as an enterprising if not a veracious reporter. Were I writing a treatise on moral philosophy I would divide falsehoods into three degrees, (1) the lie ordinary or white lie, (2) the lie extraordinary or black lie, and (3) the statements printed about Mars in the Sunday editions of some American newspapers and not emanating from any astronomer. This latter class marks the deepest moral turpitude. We have on previous occasions spoken of Schiaparelli's discovery of the *Canalli* and their mysterious gemination, and of the features of planetary detail which Percival Lowell has discovered and depicted. These discoveries rest on the bed rock of scientific evidence. Last year has not added much to our Martian Encyclopædia. Herr Brenner, at the Manora Observatory reports having seen thirty-one canals not seen before. The fact that certain canals vary enormously in appearance from time to time has received further confirmation. The double canals have increased in number, but not in such quantity as to necessarily support the theory that the gemination of the canals is essentially a seasonal change. There has also been observed a duplication of the dark spots or lakes. That acute astronomer Antoniadi has succeeded in visually duplicating certain geometrical figures and thus showing that the gemination of the Martian canals is an optical illusion. The mathematically straight lines of the canals puzzle observers, and now it is suggested by Dr. Joly that they are ridges raised by the attractions of meteors or small satellites that rotated round Mars and close to his surface when its crust was in a plastic condition, and that these satellites have been drawn in and have been combined with the planet's mass. Prof. Keeler has been diligently photographing the spectra of the Moon and Mars on the same plate, in order if possible to detect the existence of water vapour in the atmosphere of Mars. The result is that no difference whatever could be found between the spectra of the Moon and Mars, when both bodies were at a high altitude, on any of the plates. It is considered well settled that the Moon has no atmosphere to speak of and therefore no vapour floating above her surface, and therefore it must be that Mars has little or none at all. There still remains the problem of the polar ice-cap, and the white crest of snow so plainly seen and melting under heat as the pole shifts towards the Sun, and the lines of vegetation that are supposed to mark the margin of the "canals." Is it possible that all these may be consistent with no vapour floating above the surface? It is not sound philosophy to conclude that the condition of things on our own little world guages the possibilities and relations that exist on our sister worlds. Dame Nature does not turn out all her products from one pattern.

The controversy as to the rotation period of Venus still rages. Such keen-sighted observers as Schiaparelli of Milan and Lowell and See of Flagstaff, declare it to be beyond doubt that Venus turns round her axis in the same time that she wheels round the Sun, that is, in 225 days, and consequently keeps the same face constantly turned towards the Sun, just as the Moon does towards our Earth. This is due, they say, to immense tidal action that has during long ages acted as a brake and slowed down Venus, who, in her youthful days, swiftly circled round herself as she at the same time whirled round the Sun. Now, it seems, that Venus in her old age is less nimble, and makes with the Sun a sort of rigid system, keeping one face fixedly turned sunwards. But, according to equally learned and acute astronomers, such as Leo Brenner, Antoniadi, Trouvelot, and Holden of the Lick Observatory, Venus has as much of her juvenile freshness as ever, and while moving round the Sun in 225 days, pirouets round herself in a period variously estimated from 24 hours to $33\frac{3}{4}$ hours. Mr. F. W. Stanley suggests a series of photographs of the edge or terminator of Venus be taken at about five minute intervals. The images could be examined under a microscope for irregularities; if the surface be very uneven, shadows would then come and go according to the rate of rotation, which might by this method be computed. The difficulty seems to be that Venus, like an Eastern houri, keeps herself so closely and thickly veiled with a heavy atmosphere that her real disc cannot be clearly seen, and the details on her surface, upon which any valuable rotation theory depends, cannot be discovered. If the Venus of the astronomer could be persuaded to do as the Venus of the sculptor has done, and throw off more of her cloudy covering, this vexed question would settle itself, and astronomers would not scold each other in Homeric language. And we would also know whether Venus is, according to Percival Lowell, a desert without water, vegetation or clouds, or a beautiful flower-spangled world shrouded in fleecy clouds tempering the fierce heat of a too blazing Sun. Well, let the astronomers fight it out—peace at any price is a poor thing. Let us have truth first and peace next. Bayonets are better than chains.

The study of planetary detail is now occupying several good telescopes and energetic observers; the soil is not yet cultivated, and great possibilities of a ripe fruition lie before us. The problem is not to draw maps of the surface, but to investigate the changes made by the active forces of nature, rain, frost, heat, or by vegetable or even by animal agencies. Schiaparelli commenced with Mars in 1877, and he has been followed by indefatigable observers. New volumes in astronomical research have been opened by the stimulus of such investigation.

The great red spot of Jupiter still puzzles astronomers. It may be a protuberance of the solid mass, or it may be a floating incandescent cloud in Jupiter's wonderful atmosphere. It is certain, however, that it is gradually fading from view. Dark vapours may be heaping over it, or the forces that generated it may be dying out. So far as we know, Jupiter is a world in a chaotic, perhaps vapourous, condition; 1,400 times the size of our Earth; it has not yet cooled down, it is larger, and therefore younger, or less advanced from its nebulous genesis. Much could be said about Jupiter, but not very much that can be built upon the rock. And as Prof. Howe says: "It is better not to know so much, than to know many things that are not so."

The shower of Leonids that was expected on the 13th and 14th November last disappointed us. The thickest battalions of this great meteor swarm are expected in November, 1899, but the *avants couriers* were due in 1897, and more of them will be in 1898. Last 14th of November we had a gibbous Moon, and, here in Toronto, cloudy weather, and if the swarm crossed our path the clouds must have been too low, and the gods in the upper ether were most favoured. Next November there will be no moonlight when the meteors are due, and the Earth will cross nearer the "gem of the ring," but in 1899, when we will be plunged into the very storm centre of this world stuff, then the Moon, unfortunately, will be at the full, and so the fiery trains of that grand army of wanderers from beyond Uranus, from almost the outpost of the solar system, will be hidden by the greater splendor of the chaste Queen of Night.

Down to the end of the year 1896 the roll-call of the asteroids reached 425—since then five more have been discovered. Supplying these little pellets of worlds with names has become an exhausting task. The wonders of the heavens are as nothing to the wonders of those 430 different names. The list of them sounds like the class lists of several ladies' colleges, and suggests the ransacking of volumes of ancient and modern, foreign and domestic dictionaries. One would think it would be easy for the men who made the names for these planetoids to make names for themselves—but there is no sequence of that sort.

The year 1897 was not fruitful in comets. One little wanderer was discovered on 16th October, at the Lick Observatory, by Mr. Perrine, who casts his net for comets and seldom misses. This one was very unobtrusive, had a very small tail, and in less than two weeks had shrank away apologetically into the obscurity of space whence it had sprung.

The study of binaries, these immense systems of double suns revolving round their centre of gravity, still progresses. It is well-known that Sirius (the dog-star), the mightiest sun in our firmament, has a darker companion, which was discovered by Alvan G. Clark, one of the firm of telescope-makers of Cambridge, in 1862, and only lately deceased. That system has a period of about fifty years. That has been calculated although Sirius is nine light-years from us, that is, it takes nine years for light to travel from the star to the Earth at the velocity of 200,000 miles a second. Burnham, at the Lick Observatory, saw this companion last, before its disappearance, 23rd April, 1890. It has since reappeared, and Dr. T. J. See, of the Lowell Observatory, has lately detected it moving out from the overpowering radiance of the beams of the dog-star. The same keen-sighted observer has achieved another triumph in double star astronomy. The system β 883 is one which has a period of five and a half years and is visible, and is therefore the first of such short period systems that has been actually seen, measured and tabulated. A link is thus formed with the spectroscopic binaries which have been investigated only by the spectrum, and some of which have periods of a few days or months. This brings me to speak of a chapter in astronomy which may be called the "Astronomy of the Invisible." The spectroscope can record the flight of a luminous object directly in the line of vision. If the luminous body approaches swiftly the Fraunhofer lines in its spectrum are shifted from their normal position towards the violet end of the spectrum, if it recedes the lines shift the opposite way. The actual motion of stars whose distances are unknown may be measured in this way. In certain cases these wonderful lines in the spectrum oscillate backwards and forwards at regular intervals, the star is therefore sometimes approaching and sometimes receding and therefore moving round an invisible companion—this companion is also in motion. By tests of this sort the mass and speed of revolution of invisible bodies may be determined. Furthermore, the most powerful telescope may be turned upon some star and it may appear as one, not the slightest division to show it is a double; but the spectroscope shows a confused spectrum, that in fact the origin of light is double and the faint and bright lines shift and overlap in a peculiar way, proving that there are two bodies, not one. The spectroscope in the hands of the astronomer is a most wonderful cross-examiner. What secrets can the stars conceal when questioned by such an instrument? No evasion nor duplicity is possible, the absolute truth and nothing but the truth comes to a mathematical certainty. Some day mayhap we will get the whole truth. The stars cannot finally escape this relentless analysis, they are writing their own records in the lines of the coloured band of light. Both ether and atmosphere are filled with their story, if we could but catch it and read their hieroglyph in the pulsating waves. The photographic film is another weapon in the arsenal of the astronomy of the invisible. What little the eye sees it sees at once, but does not retain it; the camera sees slowly and retains its perceptions for future reference and fuller study. Light of very distant stars is so faint that it makes no impression on the retina of the eye, but when caught by a photographic plate exposed for perhaps hours invisible stars make their record thereon by a miraculous chemistry. And now Bernard has invented a device to photograph unseen or faintly seen moving bodies, such as comets, asteroids or meteors. We know of the X rays applied to lay bare the secrets of terrestrial objects, but here we bring invisible worlds into the astronomical laboratory and read their riddle. Prof. Silvanus Thompson says, "There is no finality in Science. The universe around us is not only not empty, is not only not dark, but is, on the contrary, absolutely palpitating with light, though there be light which our eyes may never see, and sounds which our ears may never hear. But Science has not yet pronounced its last word on the hearing of that which is inaudible and the seeing of that which is invisible."

The year 1897 has added to the world's equipment the largest spectroscope and the largest photographic telescope. The first is made by Brashear for Hanswaldt, of Magdeburg. Its "grating" is 6-inches aperture, and ruled with 110,000 lines. At the Royal Observatory, Greenwich, is erected the giant photographic telescope—a 26-inch refractor, the gift of Sir Henry Thompson.

One of the most notable events of the year was the opening and dedication of the great Yerkes Observatory, at Lake Geneva, near Chicago. Its objective is the largest in the world, having 40-inches aperture. The cost of the rough block of glass, made by Mantois, of Paris, was $20,000, and when Alvan G. Clark finished his work, the lens was worth $70,000. Its test proves most wonderful resolving power, as it separates double stars about one-tenth of a second of arc apart. We must not, however, expect too much. It will not certainly enable us to say whether the Moon is inhabited by gill-breathing creatures or not, or give us incontestably the altitude of the Martian inhabitant, or the size of the shovel with which the canals are dug, but it ought to reveal the existence of other planets or satellites (if any there be), and settle the question of the rotation period of the planets Mercury and Venus, so that the white-winged dove of peace may settle down at Lick and Lowell and Manora, and "grim-visaged war may smooth his wrinkled front." Last May the Flower Observatory, near Philadelphia, was formally dedicated. Twenty years ago Reese Wall Flower died, leaving his whole property of about $200,000 to the University of Pennsylvania for the erection of an observatory, and the endowment of a Chair of Astronomy. Why the testator did this no man could fathom. In his lifetime he had not the slightest interest in the stars, nor did he know any one that had, so the heirs promptly proceeded to contest the will on the ground of insanity, the fact of any one man devoting his estate to astronomical science presenting an irrebutable presumption of lunacy. The result was a compromise, the university took 100 acres of land adjacent to Philadelphia and the heirs the rest. The project lay quiescent until 1895, when the building of an observatory was begun, and in 1897 another engine of attack on the problem of the skies was completed and ready for action. Down to date, no man, sane or insane, has done thus for Ontario. The field of observatory-endowment here is a desert, it is absolutely without a Flower.

MM. Loewy and Puiseux, of Paris, have produced the most wonderful photographs of the Moon with the aid of the great equatorial coudé at Paris. They are the highest results of photographic lunar work, and our Society is the happy possessor of a set of these matchless productions. These observers have evolved a new theory, as to the lunar markings, it is a modified form of the volcanic theory.

The Jubilee year was productive of royal honours granted to distinguished men in every department where celebrity could be achieved. Astronomy was honoured in three of its representatives. The astronomer royal has been created a Companion of the Bath, while Dr. Huggins and Prof. Lockyer are Knights Commanders of the same order. Navigational astronomy has also been similarly honoured in the creation of Admiral Wharton, Hydrographer to the Admiralty, a Knight Commander of the Bath. The order of knighthood sits easily on a man who is great without it. We will think of plain Huggins and Lockyer more frequently than of Sir William and Sir Norman. The heart of all students of Science says that the wreath of royal honour fitly graces these heads on which it has been so graciously bestowed.

The record of the 1897 astronomy is one of progress of an evolution, a growing from more to more, and it has been so with individual astronomers. This life no longer contains some famous men who, when last year opened, had busy hand and pulsating brain, and they have also grown from more to more. Death, that black camel that kneels at the gates of all, has stooped before many whose names are written on the deathless roll of Fame. Two of our own corresponding members, T. Gwyn Elger, of Bedford, England, who was *facile princeps* among selenographers, and S. E. Peal, of Asam, India, the author of a curious theory of lunar surfacing, have gone before. Time permits me only to mention other famous men such as Rev. Alex. Freeman, foremost among English amateurs; Dr. Wilhelm Döllen, of the Poulkowa Observatory; Prof. Van Haerdte, of Innsbruck; Edward James Stone, the Radcliffe Observer at Oxford, famous for his Cape Catalogue of 12,441 stars; Adam Hilger, a maker of precise instruments; Albert Marth, the chief astronomical computer in England; Prof. Nobile, of the Royal Neapolitan Observatory; and Alvan G. Clark, the artificer of the mighty 36-inch objective of the Lick telescope and the still mightier 40-inch one now in position at the Yerkes Observatory. All these names will go down as valiant fighters for the cause of Truth, and who knew that astronomical science is but a link in an endless chain from which no single link can be detached without destroying the perfection of the whole harmony of human knowledge. The longevity of astronomers is remarkable. It may be that the quietness of an astronomer's life, occupied as he is with abstruse problems which do not fret or worry him, conduces to a long life. Astronomers are not responsible for results, they deal with facts and causes; if anything disappoints in an expected result it is not their fault but simply calls for a closer scrutiny into their premises and a new search for some disturbing elements. Out of a list of twenty-seven famous astronomers I find the average age to be eighty-seven years. This list comprehends Caroline Herschel, who, it will not be ungallant to remark, died at ninety-eight; Mary Somerville, at ninety-two; Sir Geo. Airy, at ninety; Cassini and Messier, each at eighty-seven; Halley and Schwabé, each at eighty-five; Newton and William Herschel, each at eighty-four; Olbers and Legendre, each at eighty-two, and Maedler at eighty. And these men did not rust out, they wore out. The mill never grinds with the water that is past, but though men both good and great have passed on and the wheel of scientific progress will not be by them further turned, yet there is a fresh flow of water coming behind that wheel, and a great self-controlled enthusiasm presses forward, animated by men having that Knowledge that is proud of having learned so much, and possessing that Wisdom that is humble in knowing so little. Popular interest in astronomy grows. The British Astronomical Association has reached a membership of 1,180 and feeds that older and more important body the Royal Astronomical Society. In our own humble Province of Ontario we have to express our thanks to the Government for a provincial grant which we trust is an evidence of better things yet to come—for like Oliver Twist we are guilty of a chronic hunger and the little but eloquent word "More" is written across our Library which contains books but few instruments, save the reflector so generously donated to our Society by Lady Wilson. We have four branches: at

Meaford, under the Presidency of Rev. D. J. Caswell; at Orillia, under Mr. Joseph Wallace; at Tavistock, under Dr. M. Steele; and at Simcoe, under Dr. J. J. Wadsworth, one of the most enthusiastic and successful amateurs in the Province.

I have thus sought very imperfectly to place before you, ladies and gentlemen, some of the pebbles that have been in the last year added to the ever increasing pyramid of astronomical discoveries and conquests. I have also made some references to the new astronomy. I would rather say much and not many things, and one cannot say too much about this great and new evolution of the oldest of the sciences. The new astronomy is no longer a nursling, it is in the vigorous beauty of youth, and has already in true Horatian style "erected a monument more lasting than brass and more sublime than the regal elevation of pyramids which neither the wasting shower, the unavailing north wind, nor an innumerable succession of years nor the flight of seasons shall be able to demolish." And withal comes Lockyer's meteoric hypothesis, which explains cosmic phenomena as due to the gravitational impact of meteoric particles. And so all the bodies that range through the universe are after all of one species nebulæ, comets, stars, planets, satellites, and meteors, are but varying stages of development. From the eddying whirls of fiery nebula the sun-stars are wrought that in their turn "wheeling cast their planets." The white sun-star which then by long gradations descends through all its changes of temperature and colour; yellow, red, purple, and then dark—a cold and burned out cinder-world. But this is not the last of it, for the dark star in its ceaseless flight through space, must, as Dr. Croll suggests, collide with some other similarly dark body, and thus both colliding worlds are shattered into vapour or vapour mingled with a universe of meteoric fragments, and so a new nebula is created, the matrix of new worlds that will be generated through ages to come. And so the dark star at the end of one evolution becomes the new nebula at the beginning of a new evolution. Forest leaves bud and bloom and fade and fall, and by their decay chemical elements are released to unite with and form new forest leaves, and thus the world of forest life is constantly renewed. So, too, the orbs of heavens bud and bloom and fade and fall, and in the icy darkness of their death bring into being new worlds, and so Nature ages but never grows aged.

"Say at what point of space Jehovah dropped
His slackened line, and laid his balance by;
Weighed worlds, and measured infinite no more?
Where rears His terminating pillar high
Its extra-mundane head? and says to gods
In characters illustrious as the Sun:
'I stand the plan's proud period: I pronounce
The work accomplished: the creation closed.'"

The work of the Creator is ever doing but is never done, creature man is ever learning but is never learned; mankind is ever advancing but is never advanced.

"Were man to live coeval with the Sun
The patriarch-pupil would be learning still:
Yet dying leave his lesson half unlearned."

We students of astronomy can but snatch a few minutes now and again from otherwise too busy lives to strike a note here and there in that concord that lures Truth from her hiding place. The Eternal will not give unto us unless we ask, He will not reveal unto us unless we search, He will not vouchsafe victory unto us unless we strike.

"'Tis God gives skill,
But not without men's hands. He could not make
Antonio Stradivari's violins
Without Antonio."

Let us therefore work while it is day, read and think before it is late and dark, put out our hands and He will give us skill, apply our minds and He will give us that success that fits us best.

THE MEAFORD ASTRONOMICAL SOCIETY.

(INSTITUTED 1898.)

Affiliated with The Astronomical and Physical Society of Toronto.

Officers:

President .... Rev. D. J. Caswell, B.D., Ph.D.
Vice-President .... Mrs. Henry Manley.
Corresponding Secretary .... Mr. Geo. G. Albery.
Recording Secretary .... Mrs. S. Huff.
Assistant Secretary and Editor .... Mrs. D. S. White.
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Mrs. J. C. Saunders .... Ottawa.

The Meaford Astronomical Society.

Transactions of 1897.

During the year twenty meetings of the Society were held, eight at the office of the Society, and twelve at the residences of the members.

The seventy-first meeting of the Society was held at the residence of Mrs. H. Manley on January 7th. Mr. Albery, the Corresponding Secretary, reported having received Bulletin No. 1 of the Yerkes Observatory. Miss Foster read a selection which was well received. The President read an account of Mr. R. F. Stupart's description of his European trip.

On January 21st at the Society's rooms on Sykes street after the usual routine, a communication from the Astronomical Society of Wales was received and read, accompanied by a copy of the monthly *Journal* of the Society, and inviting co-operation.

The President read an article on "Orion."

On February 4th the Society met at the residence of Miss Paul. The Corresponding Secretary announced that he had sent for and received ten copies of the new text book, Gillet and Rolfe's "Astronomy for the use of Schools and Academies." The Corresponding Secretary read an address to the President (Rev. D. J. Caswell), thanking him on behalf of the Society for the great interest he had always given to the work of this Society; also presenting him with a copy of Gillet and Rolfe's Astronomy, and constituting him a life member. The President exhibited a drawing he had made of sun-spots, which was highly appreciated and led to an interesting discussion. Mrs. Huff read an article by Sir Robert Ball on the "Sun's Light." An interesting discussion then followed during which the subject of Electric Lighting was discussed at considerable length.

The seventy-fourth meeting of the Society was held at the rectory on February 25th. The President showed a drawing of sun-spots (especially of the great sun-spot mentioned by Prof. Holden of the Lick Observatory), as having on the 10th of February returned to almost the same position it occupied on January 14th, thus showing that the Sun's period of revolution to be about 27 days—a rough calculation. A section of the new text book was then read, and list of members revised.

On March 11th the Society met at its rooms in Mr. G. G. Albery's office, Sykes street. Under the head of observations, Mr. Albery mentioned having noticed a sun-dog, which gave rise to a discussion as to the probable cause. A newspaper clipping was read accompanied by a diagram of a mirage, and explaining the cause of its appearance.

On March 25th the meeting was held at the residence of Mrs. H. Manley, Trowbridge street.

A portion of the text book was read, and much of the evening was spent in hearing reports of observations by various members. Miss Layton stated that she had received a letter from her sister in Manitoba giving a description of a mock sun with lines of light crossed and intersected by six circles. The thermometer stood at 40° below zero during the appearance of this phenomena.

On April 8th the Society held their meeting at their rooms in Mr. Albery's office, Sykes street. The President spoke of the observation of a beautiful meteor in the north-western sky about 20·45 on March 31st, which took a course toward the north-east. The Vice-President (Mrs. Manley) then read an interesting lecture by Sir Robert Ball on Meteors, which was greatly appreciated, and was followed by discussion.

The Society met at Miss Paul's on April 22nd. One hundred copies of the Annual Report were laid on the table, and each member took several copies for distribution. The subscription for *Popular Astronomy* was renewed. Mrs. Manley (Vice-President) read an original poem entitled "Thoughts on the Midnight Sky," which, by request of the Society, she allowed to be published in the local papers.

Miss McRae read an interesting paper on the planet Mars.

The seventy-ninth meeting of the Society was held at the Society's rooms, Sykes street, on May 6th. Mr. Albery, assisted by Mr. Clarke, had ingeniously made a planisphere and mounted it. A vote of thanks was tendered them by the Society for the time and trouble taken. The President read a paper by Mr. Napier Denison on "Tidal Waves," and a portion of the textbook was also read and discussed.

The next meeting of the Society was held May 27th at the residence of the Vice-President, Mrs. Manley.

After the usual routine of business Miss Paul read an extract from the Toronto *Globe*, entitled "Sixty Years of Astronomy," showing the progress of the science during that time.

On June 10th the Society met at their rooms on Sykes street. After the usual routine the President, by means of his excellent steri-opticon, proceeded to exhibit the astronomical slides kindly loaned by the Toronto Society. The views were highly appreciated by the members and a vote of thanks was unanimously passed to the Toronto Society for the loan. Mr. Wilson then rose and congratulated the President on the distinguished honour of having the degree of Doctor of Philosophy lately conferred upon him, and moved that this Astronomical Society should testify to their satisfaction at this degree being conferred. This being seconded by Mr. Huff, was enthusiastically carried.

The Society held their next meeting at the residence of Mr. Huff, Lombard street, July 2nd. When the business part of the meeting was over, the remainder of the evening was spent outside making observations by the aid of the Society's telescope. The attendance was unusually large and the atmosphere exceedingly favourable, thus affording those present a very pleasant and profitable evening.

The eighty-third meeting of the Society was held at the residence of Mrs. White, Boucher street. Mention was made of the beautiful aurora seen July 21st, which had presented the appearance of a band of light from the eastern to the western horizon, passing many degrees to the south of the zenith, whilst numerous streamers, beautifully fringed, extended along the northern sky.

On August 26th the Society met at the residence of Mrs. Kirton, Trowbridge street. A communication was read from Mr. S. D. Caswell, speaking of the occultation of the Pleiades which occurred between 3 and 4 o'clock of the morning of the 20th. On the 19th a brilliant meteor had been observed by one of the members, and this announcement was followed by a conversation on "Meteors." Miss Layton gave an account of two mock suns she had seen during her recent visit to Manitoba one evening between 8 and 9 o'clock.

The next meeting of the Society was held at the residence of Mrs. Manley, September 23rd. After the usual routine the President gave an account of his recent visit to Toronto. He stated that he had attended a meeting of the Toronto Society, and also spent several interesting evenings with various members of the Society. The Recording Secretary, Mrs. Kirton, being about to remove from our town, was presented with an inkstand and a gold pen, accompanied by a suitable address in appreciation of valuable services. The President read a farewell poem to Mrs. Kirton, which had been composed by Mrs. Manley.

The eighty-sixth meeting was held at the Society's rooms, Sykes street, October 7th. After routine, it was moved by Miss Paul, seconded by Mrs. Manley, that Mrs. Kirton's name be placed on the list of corresponding members. Miss Paul read an article entitled the "October Skies," which was very interesting. The President read a paper regarding the total eclipse of the Sun to be seen in the Southern States in the year 1900.

On October 28th the Society met at the residence of Mr. J. S. Wilson, M.A., Cook street. The President read a couple of articles, one on "Sensational Astronomy," and the other a description of the Yerkes Observatory. Mrs. Manley then gave an account of her visit to Mr. Wallace, an astronomer of Orillia.

Officers for the ensuing year were then elected by ballot.

On November 11th the Society met at the rectory. Under the head of observations, several members reported having seen the large circles around the Moon, one on October 31st, the other on November 2nd. An interesting discussion followed concerning them. A portion of the text book was read describing the size, form and motion of the Earth, causes of day and night, seasons, etc. The gyratory motion of the Earth was illustrated by Dr. Caswell and Mr. Huff by means of the gyroscope.

On December 2nd the Society met at the residence of Captain McRae, Collins street. The President read a newspaper clipping giving an account of a recent measurement of the Earth from elevated stations. A portion of the text book was read dealing with the seasons, causes of the seasons, tides, etc., and an interesting discussion followed, dwelling particularly on the tides.

The nintieth meeting of the Society was held at the Society's rooms, Sykes street, December 16th. Mrs. White read a lengthy article on the "History of Astronomy," much appreciated by those present. Miss Paul also read an interesting selected article by Miss Proctor on "Christmas Skies, and the Star of Bethlehem." A portion of the text book was then read dealing with day and time, also a portion on Sun time and clock time, which, with discussion, occupied the remainder of the evening. The Society then adjourned to meet again after the Christmas holidays.