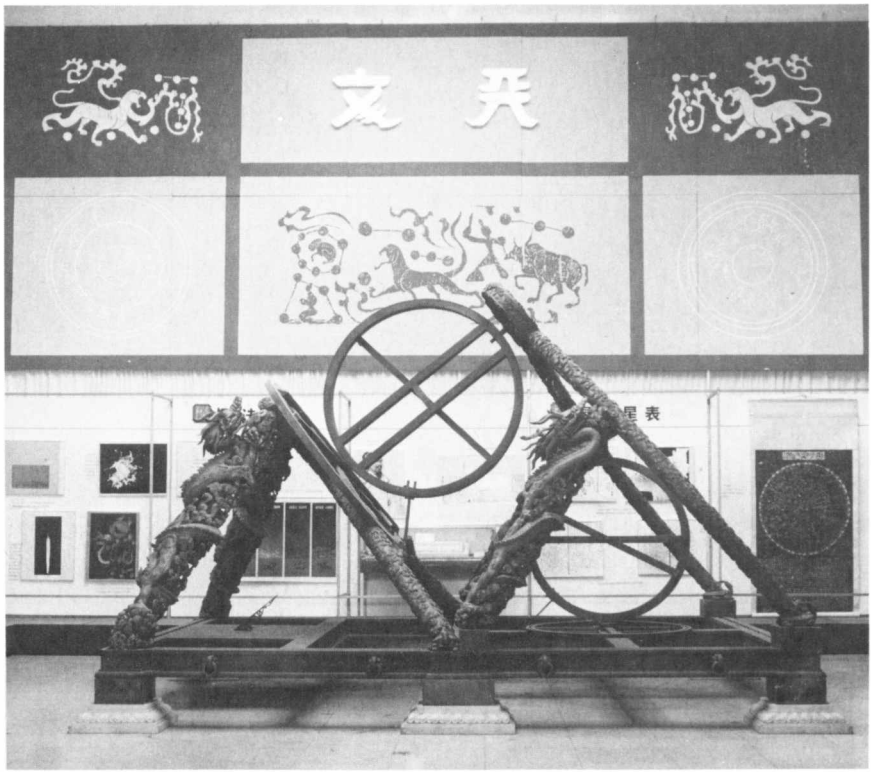
NATIONAL NEWSLETTER

June, 1982

Supplement to the JOURNAL OF THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

Vol. 76, No. 3



This armillary sphere is in the major Chinese exhibition *China:7000 Years of Discovery* on view at the Ontario Science Centre in Toronto from May 1 to October 31, 1982. Over 500 exhibits brought from China describe important innovations of ancient Chinese science including paper making, the magnetic compass, astronomy, medicine, and bronze casting. In addition to the armillary sphere, a model of a "false sky" observatory built 900 years ago, old almanaca, star charts, and sundials will be on display.

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Deadline is six weeks prior to month of issue.

London Centre Celebrates Diamond Anniversary

by Tom Glinos
London Centre

During the lifetime of a Centre there are events that are very auspicious and memorable. The London Centre celebrated such an event on March 19, 1982 when it marked its Diamond Anniversary as a 60 year member in the Society.

The Jubilee Program was held in the new Art Gallery situated on the fork of the Thames. Cocktails were spent in pleasant conversation with the representatives of our seven closest neighbouring Centres.

After a fine dinner, congratulatory messages were received from Dr. Ian Halliday, our National President, Dr. Peter Millman, National Honorary President, and George Connel, President of the University of Western Ontario.

Centre business was quickly taken care of, and followed by a brief but fascinating summary of the Centre. This included comments from our inaugural meeting of 1922. The comments made on that occasion by our founding president, Dr. H. R. Kingston, are as relevant today as they were 60 years ago.

The Centre then had the honour and extreme pleasure of having Dr. Bart Bok deliver the H. R. Kingston Memorial Lecture. He entertained us with anecdotes about the pioneers of Milky Way astronomy like Oort, Shapely, and Hubble, whom he had known during his years at Princeton. He recounted 60 years of progress in astronomy, and the human side of scientists who developed the current knowledge of our galaxy and universe.

All in all it was a truly memorable night in our minds and in the history of our Centre.

The Art Gallery of London, Ontario was the place to be, as participants from seven Centres of the R.A.S.C. gathered to celebrate the London Centre's Diamond Anniversary.

Le théodolite

by Réal Manseau

Mon intérêt pour les appareils anciens n'est pas nouveau. Le tout a commencé par l'étude des principes de fonctionnement du cadran solaire, dans les années 76. J'ai construit un cadran solaire équatorial polaire de 46″ de diamètre installé en face de ma demeure le 4 septembre 1977. Tout en conservant mon intérêt pour les instruments scientifiques des temps passés, j'ai mis deux ans d'études et de recherches de documents et livres sur la sphéropée. J'ai construit en 1980 une sphère armillaire de Ptolémée, qui est maintenant devenue le Prix Méritas de l'A.G.A.A. (Association des Groupes d'Astronomes Amateurs du Québec). Tout en m'intéressant de plus en plus aux livres anciens, j'ai nourri l'idée de me construire un théodolite de style ancien. A maintes reprises dans nos conversations, l'intérêt a mesurer la position d'un astre ou objet céleste me motivait à concrétiser mon rêve dans un avenir prochain.

Historique des ancetres du théodolite

L'arbalète ou arbalestrille aussi appelé Baton de Jacob. L'arbalète décrite pour la première fois en 1342, servait d'abord comme instrument de topographic vers la fin du XV^{e} siècle; puis utilisée par les navigateurs jusqu'au XVIII^{e} siècle pour mesurer la hauteur d'un astre et faire le point en mer. Elle se compose d'une règle à section carrée et de marteaux qui glissent le long de la règle jusqu'à ce qu'une pointe des extrémités coincide avec le ligne d'horizon et l'autre pointe avec l'astre observé. On pouvait lire la hauteur de l'astre sur les graduations de l'arbalète. Fabriquées le plus souvent en bois, elles sont trés rares dans les collections d'instruments scientifiques.

Au XIV^{e} siècle, l'octant était l'appareil de mesure des astrologues. Son rapporteur d'angles était formé d'un huitième de cercle. Au XVI^{e} siècle, le théodolite devint très populaire par sa précision et sa facilité de manipulation. La lecture était prise avec des mires de visée fixées à une règle. Au XVII^{e} siècle, le théodolite, qui était positionné sur le pôle à la boussole, fut amélioré avec l'application du

niveau à bulle installé sur diverses parties du théodolite. L'invention de la lunette astronomique et du réticule, vers 1609, a grandement augmenté la précision des mesures de coordonnées.

L'addition du vernier (appareil servant à lire les dixièmes de partie ou de degrés) a rendu les observations de plus en plus précises. Au XVII^{e} siècle, la perfection des machines à diviser a amélioré la précision des mesures angulaires avec, en plus, le perfectionnement du chronomètre au XVII^{e} siècle. A cette époque, l'addition de diverses techniques connues a grandement amélioré la précision des mesures de coordonnées. Pour en citer quelques exemples: l'invention de la lunette en 1609, le calcul de la réfraction, correction de la mesure du temps par l'équation du temps, l'addition du niveaux à bulle, le calcul de la déviation du pôle magnétique et l'invention du vernier.

Caracteristiques du théodolite

Le théodolite sert à déterminer les coordonnées azimutales (horizontales) et les coordonnees zénithales (ou verticales de hauteur). Les principales parties du théodolite sont:

1 Socle ou base où sont gravées les coordonnées azimutales de 0° à 360° en commençant avec 0° au nord, 90° a l'est, 180° au sud, et 270° a l'ouest.
2 Dans le socle, trois vis d'ajustement servant au nivellement de la base.
3 Le corps du théodolite ou colonne.
4 La lunette de visée avec fil réticule.
5 Le demi-cercle zénithal ou vertical gradé en degrée.

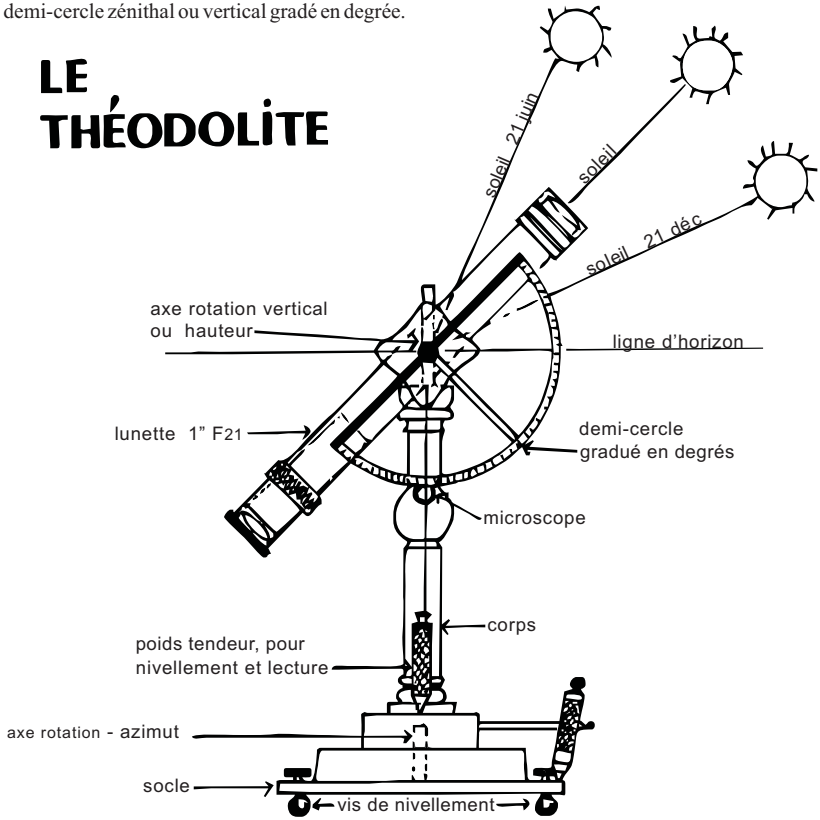

FIG. 1

6 L'axe horizontal et l'axe vertical, les deux seuls mouvements du théodolite.
7 Le microscope pour la lecture des mesures verticales.
8 La pointe pour la lecture des mesures horizontales.
9 Le poids pendu à un fil servant au nivellement nord, sud, est et ouest.
10 La boussole ajustable selon la déviation du pôle magnétique.

La construction a été réalisée avec de vieux matériaux; freins à disques en cuivre rouge pour le socle, le corps du théodolite est en noyer noir américain, le tube de la lunette en ABS de 1¼″ de diamètre extérieur, la lunette se compose de deux lentilles achromatiques 1″ de diamètre et 10.5″ de focale à f/21 grossissement 1X.

Après la construction vient le moment des premiers essais. Mes coordonnées sont: "longitude 72° 27′ 56° ouest" et "latitude 45° 50′ 50° nord".

Après avoir installé mon théodolite sur une table solide vers midi, le 10 juin 1981, j'ai pu constater la précision de cet appareil. J'ai fait la correction sur le pôle avec la boussole, soit 14°30′ qui est la déviation du pôle magnétique par rapport au pôle celeste pour Drummondville; j'ai ajusté le nivellement de l'appareil, trouvé l'heure du passage au méridien = l2h59, calculé l'equation du temps = –1 minute, ajouté la correction par rapport au fuseau horaire de Montebello et de Drummondville qui est de – 10 minutes, cc qui me donnait à ce moment l2h48. A ce moment préci, j'avais le soleil au centre du réticule et le pointeur azimutal marquait 180°, le point sud de l'azimut. L'heure de retard vient du fait de l'heure avancée durant l'été. La lecture azimutale m'a grandement satisfait avec une précision

FIG. 2

d'au moins ¼ de degré. Pour cc qui est de la lecture de hauteur ou verticale, il faut considérer que le soleil est à +23°, 14′ de l'équateur le 10 juin. La hauteur du soleil était alors 90° moins la latitude du lieu d'observation plus la déclinaison du soleil, i.e.: 90° – 45°51′ + 23°14′ =67°23′. La lecture du théodolite m'a donné 67°. La précision dans cc cas est un peu moindre qu'en azimut, mais tout de même inferieure à 0.4°.

C'est une belle experience que de refaire des mesures avec un instrument des temps passés dans ce monde des plus futuriste.

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Note de l'éditeur
Considérant les materiaux et les outils utilisés pour la fabrication de ce théodolite, la precision obtenue est remarquable. A Stellafane, en août 1981 , avec cet instrument, Réal s'est méritéle premier prix dans la catégorie "projets spéciaux."

Light Pollution

by C. E. Spratt
Victoria Centre

The byproducts of our technology degrade many aspects of our environment–air, water and soil–but one of the most visibly damaged is perhaps the least noticed. Artificial illumination of roads, parking lots and buildings severely reduces the visibility and beauty of the celestial objects in the night sky.

However, light pollution differs from other forms of pollution in being easily reversible, at least in theory. If all the lights of your city were suddenly turned off the sky would be dark again instantly. But in practice, nobody wants to turn out the lights!

This interfering luminous veil of urban night contrasts with the almost complete dark of the natural sky. Without light pollution, stars appear close, and the Milky Way starts to illuminate the sky on its own. A century or even 50 years ago, the natural sky was visible to most people. Now it can be seen only far away from population areas. In some places, especially in North America, polluted skies are brightened between 20 and 30 per cent each year, not so much from more people as from advancement of lighting technology and the spread of the automobile. Parking lot lights are still on at 4 am and shopping centres can be seen distinctly on the horizon up to 50km away, even against a background of urban glow.

Amateur astronomers from Toronto decided to study the problem, with very pessimistic results. A literature search showed that even the major observatories in Canada had not measured sky brightness at their own sites.

Robert Pike and Richard Berry, in their article in the February 1978 issue of *Sky and Telescope*, indicate that sky brightness in some parts of the United States, increased 23 per cent each year from 1967 to 1970. Near Toronto this figure was about 30 per cent annually. They state further that all good land-based observing sites will be severely endangered within a decade for southern Ontario, and the situation in New England will be much worse. (See also *J.R.A.S.C.* 70: 97–115, 116–126, 1976.)

Today there are very few cities from whose downtown 1000 stars can be seen, but around 1840 the German astronomer F. W. A. Argelander found that he could see with his naked eye 3268 stars. This from downtown Bonn! He would be lucky to see 300 today.

Amateur astronomers across the United States have been fighting light pollution for several years and have a few victories to their credit. The Canadian record is very dismal–few government agencies wish to listen to a minority, especially one that is of minor importance. For any specific action, the local astronomical club has to arouse the consciousness of its community to the seriousness of light pollution and then propose specific actions and solutions.

The record of the professional astronomers, especially in the United States where federal funds finance the operation of observatories, has been good. There have been some hard-won victories. The

city of Tucson, Arizona, with its complex of professional observatories surrounding the city, has had a light pollution ordinance on record since 1972. Called City Ordinance 3840, this legislation has been a model for similar regulations used by various cities in the United States. To date no Canadian city wishes to approach the problem–or even admit that there is a problem.

In 1980 Winsford, Cheshire, England, at the urging of the local amateur astronomy club, passed an ordinance calling for the installation of canopies (shields) over the street lights. In so doing, it was expected that a saving of 25 per cent in energy costs would be achieved because a lower wattage lamp was required to provide the same illumination.

Since these are energy-conscious times, businesses should be happy to shut off lights at night, saving both money and energy. Smaller bulbs can replace larger ones, and lights can be aimed to illuminate only the intended areas. Curtains pulled can give privacy, save heat loss and discourage burglars, who then cannot see if there is anyone at home alone. Highway lights should all be shielded and low pressure sodium vapour lamps installed, to replace the glaring mercury vapour lamps now being used. Mercury vapour lamps are very inefficient in doing the job intended, but do a marvellous job for any skywalkers.

Studies financed by the lighting industry have always stressed the crime deterrent of high outdoor illumination. A careful study by the US National Institute of Law Enforcement and Criminal Justice has found that there is a strong indication that increased outdoor lighting, or perhaps lighting uniformity, decreases the fear of crime. The personal opinions of law enforcement leaders favour intensified lighting. But rigorously conducted studies of the effectiveness of outdoor illumination have not provided consistent results.

In one study, only 2 per cent of city streets were lit to minimum standards and 90 per cent were underlit. Eighty per cent of crimes occurred in the underlit areas. Conclusion: there was a need for more streetlights. The same data can demonstrate, however, that 20 per cent of the crimes occurred in the 2 per cent of brightly lit streets. So, is the light a deterrent?

Dr. A. Upgren of Van Vleck Observatory at Wesleyan University, Middletown, Conn., has been surveying light pollution around American cities. He comments:

> "If the growth rate of outdoor lighting in this country (USA) over the last two decades continues through the next two, outdoor lighting will account for over half of all electrical power usage, and the night sky will be over 40 times as bright as it is today. Our larger cities will be visible to an observer standing on the moon. If new nuclear power plants become necessary in coming years, outdoor lighting will be the paramount reason for their existence."

Note that Upgren states that any new nuclear power plants will be used for outdoor illumination. Most of this type of illumination is useless now and not cost-efficient. Is that any reason to build nuclear reactors? Wise and efficient use of existing electrical supplies will be better for us all in the long run.

The most compelling thing about low-pollution illumination is that it is compatible with good lighting practice, which is to use the least energy and to reduce glare. The elimination of present or future lighting isn't desirable either, but a reasonable and responsible use of existing technology and supplies is. Light pollution is an insidious disease, and only by lectures, letters to editors, bumper stickers, conservation groups, and petitions to local governments can this affliction be stopped.

"Help keep astronomers in the dark–End light pollution!" reads a bumper sticker. Is that too much to ask? As an amateur astronomer now resident in Victoria, I wish only to be left in the dark. Please help–turn out your lights when you're not using them. You'll save money, and somewhere an unknown neighbour will thank you for it.

(Reprinted from *Skynews Victoria*)

Sketching Hevel

by Maritta Ellis
Toronto Centre

My fascination with astronomy began about a year and a half ago when I took an astronomy course at the University of Toronto. The curriculum included either a project or an essay. I chose to do a project which involved making sketches of a lunar crater at different sunlight angles. The ideal time to do such

sketches is when the terminator is clearly defined, such as at half moon. However, because of clouds and other course commitments, the sketches were done two days before the full moon.

The crater I chose was Hevel, which is named after the Polish selenographer Jan Hevelius (1611 –1687), who published fifty maps of various areas of the lunar disc in 1647. Hevel is 118 km in diameter and has a convex floor from which rises a central mountain with a craterpit at the summit. The western wall of the crater rises over 1 km.

All the equipment needed for this kind of project are a small telescope, sketch pad, pencils, pencil sharpener, eraser, and plenty of clothing. The telescope I used was a 3½-inch Questar, and the only drive it had was me. I had some trouble keeping the moon in view because I always turned the control knob in the wrong direction. Until then I had not realized how rapid the moon's motion actually is.

My observing site was a fifteenth floor balcony, and the date was near the end of February 1980. I read in the paper the next day that at 5:00 a.m. it had been –22°C, the very time when I made my last sketch. The sketches were done every 30 minutes, starting at 22:30 and finishing at 05:00. Sketching the details was easy until the moon began to drop toward the western horizon; then it appeared to speed up and the atmospheric interference made the image waver.

I was surprised at the great change in the crater's appearance. The four sketches clearly show the change. Small hills inside the crater appear only with the sunlight at certain angles. A complicated rill system gives the floor a rough appearance. The rim deposits on the right become more prominent in later sketches due to the lunar libration. The libration enables us to see 50% of the lunar surface over a period of time. In the last sketch, higher-walled formations beyond Hevel can be seen.

The first couple of hours were frustrating because I could not co-ordinate myself with the pencils, the gloves and the telescope. Then the changes in the appearance of the crater began to show up in the sketches and I became better co-ordinated.

The quiet and the beauty began to penetrate. The cold did not seem so bad, and I began to really enjoy observing. I am still observing and the fascination has only deepened.

FIG. 1. 2230 EST. The craterpit of the central mountain is clearly defined, as is the rugged right wall. The terminator is on the right hand margin of the sketch.

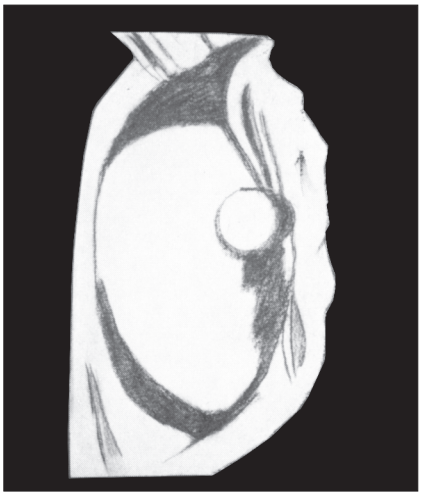

FIG. 2. 0030 EST. The craterpit appears larger and the rim deposits are clearly seen. The crater appears more like a vertical oval.

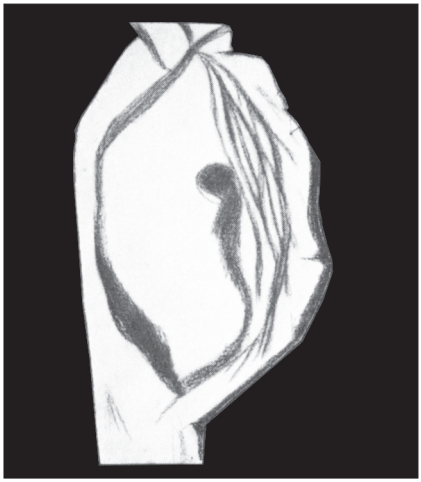

FIG. 3. 0230 EST. The central mountain has lost its clearly defined borders as the sun angle changes. The rim deposits on the right are very prominent. Rotation of the image makes the crater appear vertical.

FIG. 4. 0400 EST. The mountain can only be distinguished from the crater floor by a thin dark shadow. The rim deposits are no longer visible, and the floor is completely illuminated. Another mountain ridge has appeared on the right as a result of the libration.

National Council Report

by Harlan Creighton
National Recorder

The National Council of the Society met at National Headquarters on Saturday, January 31 to consider a wide range of Society business. Here are a few of the items discussed that are of general interest to the members.

The National Office will have a new telephone number effective March 15, 1982: 483–6383. The area code will remain 416. Please note this change in your telephone books.

The 1982 edition of *The Observer's Handbook* won rounds of praise from many councillors. Hearty congratulations to Dr. Roy Bishop for a job well done!

The Membership Certificate is an award given in recognition for service rendered that has significantly contributed to the work of the Society and/or a Centre of the Society, or in recognition of long-standing membership–twenty-five or more consecutive years. National Council approved the following Membership Certificates: Mr. Mario Lapointe and Mr. Giancarlo Taddei, both of Quebec Centre; and Mr. Clinton Constant of the Edmonton Centre. Incidentally, Mr. Constant's award will recognize his status as a charter member of the Edmonton Centre, which this year celebrates its 50th anniversary.

Council also approved a Messier Certificate for Mr. Phil Mozel of Toronto Centre. Our sincere congratulations are extended to all of the above award winners.

Your Council approved an operating budget for 1982. Revenues are estimated to total $129,600 and expenses $131,870, yielding a projected deficit of $2270.

The matter of whether or not the Society should purchase a building for its national headquarters was discussed and it was decided that, at present, the best interests of the Society would be served by staying

in our present office. The Property Committee was therefore directed to give up its active search for a new property, with the understanding that as conditions change, this policy may be reviewed at any time.

An invitation was received from the Winnipeg Centre for National Council to hold a meeting in Winnipeg during 1983, and this matter will be dealt with when the new council takes office in May.

The president, Dr. Halliday, advised Council that an anonymous donation had been received in the amount of $30,000. A special committee of Council, consisting of First Vice-President Franklin Loehde, Treasurer Marie Fidler, and Second Vice-President Dr. Roy Bishop was established to review the overall financial picture of the Society (including special funds) and report to the next meeting of Council.

Council learned that Miss Donna Haley, who had advised the Society on legal matters for many years, has been appointed to the bench of the York County Court in Toronto. Council expressed its sincere thanks to Judge Haley for her many years of faithful service, and extended its congratulations on her appointment.

A letter from Damien Lemay reported that arrangements had been made to hold the 1983 General Assembly at Laval University in Quebec City May 19–23, 1983. Meanwhile, preparations for the 1982 General Assembly are well under way.

Dr. Joseph Pearce

by Chris Aikman
Vlctorla Centre

Recently Murial Enock (Editor of *Skynews Victoria*) and I spent several delightful hours at the home of Dr. Joseph Pearce, the Honorary President of Victoria Centre. As we arrived at his gracious residence we were greeted by his housekeeper and led to the warmth of a cozy fireplace, around which we all arranged ourselves while talking and hearing about the early days of Victoria Centre and of the Society itself. Fortunately, Dr. Pearce has recovered substantially from a stroke of last winter, and was able to recount a host of details on these topics with an enthusiasm that belies his 89 years of age.

His voice is indeed that of history itself, for Dr. Pearce has been very involved with our Centre since his arrival in Victoria in 1924. By the following year, he was the Centre's recorder, then vice-president and president (1928–29). In 1931, as past president, he started the Centre's library with a donation of his own valuable books, and also initiated the "Summer Evenings with the Stars" program which continues to this day. The lectures were pretty thorough in those days, with the participants actually calculating spectroscopic binary star orbits, no small task in the days before electronic computers! By 1932, he was the Centre's honorary president, a role to which he has returned almost half a century later! He also served as national president during 1940, and later as honorary national President.

Although we talked of his early work, which included independent discovery of several novae and the computation of asteroid orbits, and heard anecdotes of life at the DAO, somehow our conversation never reached to the work for which the rewards were most dramatic. It is a story which bears retelling, and I shall attempt to do so now.

The 1920s were an exciting era in astronomical discovery, when the "great debate" raged concerning the size of the Milky Way system and the status of the spiral nebulae. Harlow Shapley, who had just identified the centre of the globular cluster system as the centre of our galaxy, argued that the spiral nebulae were comparatively local objects within our own Milky Way system. Opposing him were Heber Curtis and others who correctly argued (ironically, on mainly erroneous grounds) that the spiral nebulae were themselves galaxies far beyond our own. By the time Joseph Pearce arrived in Victoria from Lick Observatory, Hubble had just identified a cepheid variable star in the Andromeda spiral, which revealed it to be at a distance far beyond the Milky Way.

This almost resolved the debate, but a great conceptual problem still confounded the recognition of spiral nebulae as external galaxies, namely that there was no satisfactory picture of our own Milky Way system. Rather, there was a painful dichotomy between two opposing pictures: counts of stars of diminishing brightness suggested that the Sun lay near the centre of a small system (the "Kapteyn

system") of stars a few thousand light years across, while Shapley's studies of the globular cluster system put the Sun near the edge of a huge system at least 300,000 light years across. Both these studies and distance estimates were flawed by the failure to include the dimming effects of interstellar material on starlight, since interstellar absorption had not yet been recognized.

At Victoria, J. S. Plaskett had been amassing data on the hottest, most luminous stars of the Milky Way since the first night the big reflector had been turned skyward; the pace of the work quickened with Dr. Pearce's arrival. Then came a double breakthrough. Firstly, Plaskett and Pearce, following the work of Lindblad and Oort in Europe, showed decisively, from the motions of these distant stars, that the Galaxy rotates differentially about a centre some 33,000 light years distant from the Sun in Sagittarius; the Sun orbits about this centre in a period of 220 million years. The galactic diameter is 100,000 light years and the total mass of the system including stars and diffuse matter is 1.7×10^{11} times the mass of the Sun. It is worth noting that all these, and other parameters they derived, compare quite favourably with the best modern determinations except for the total mass, which is somewhat higher (by an amount which is still unknown) due to unseen matter in the centre regions of the Galaxy.

Secondly, Plaskett and Pearce showed that interstellar ionized calcium participated in this general galactic rotation at a rate exactly one half that of the stars against which it is observed. This could be explained if a calcium-absorbing cloud lay just half way to the background star in each case, but an alternate and much more realistic interpretation is that the absorbing material is distributed more or less uniformly between the observer and the star. Thus the universal pervasiveness of interstellar material was at last recognized. This did not actually prove that the interstellar medium caused a general absorption of starlight, but it certainly made the case more credible. By 1930, the reality of interstellar absorption was clearly demonstrated by Robert Trumpler at Lick Observatory, and thus the old dilemmas caused by its nonrecognition were swept away.

Plaskett and Pearce's papers from 1927 to 1935 make illuminating reading even today, written as they were in the perspective of those years of exciting discovery. Many of these papers are in the Centre library.

Copernicus, Brahe, Kepler and Galileo each played a vital part in the recognition of Earth's motion about the Sun. In the recognition of the Sun's motion about the centre of the Milky Way, the names of Shapley, Lindblad, Oort, Plaskett and Pearce will be forever linked. They gave us the first accurate picture of the Galaxy in which we live.

As a footnote to the above, one of the exciting aspects of studying our old minutes is that all the above research was reported to our Centre by the researchers as it happened and, furthermore, it was carried the next day in the Daily Colonist and the Times. How privileged we have been!

(Reprinted from *Skynews Victoria*)

Perseid Meteor Shower Alert

by Michael E. Boschat
Halifax Centre

As an amateur meteor observer I am requesting that this year's annual Perseid meteor shower be observed by all amateur astronomers across Canada.

The Perseids appear to come from the direction of the constellation of Perseus and are debris associated with the periodic comet Swift-Tuttle last observed in 1862 and with a period of about 120 years. The *Observer's Handbook* gives a rate of 50 meteors per hour but in recent years the activity has been increasing as indicated by reports from American and Russian amateurs, perhaps signalling the return of the parent comet.

This year the shower peaks on the morning of August 12 but early Perseids can be spotted in late July and activity is high for a few days on either side of the peak.

Anyone interested in participating in a Canadian Meteor Network beginning with this shower is invited to write to Michael E. Boschat at 6363 Liverpool Street, Halifax, Nova Scotia B3L 1Y1.

(*Ed*. Meteor observing can be a very enjoyable activity and does not require any elaborate equipment. Let's support Michael Boschat and report observations from across Canada.)

FIG. 1. Funnel extends from cloud.

FIG. 2. Just before tornado hits ground.

Tornado!

by Harlan Creighton
Assistant Editor

The above photographs were taken by R.A.S.C. student member Joseph Fourre shortly after 8:00 p.m. on Wednesday, 11 July 1979. The pictures are part of a series taken from the Government Wharf at The Pas, Manitoba which show the development of a small tornado that subsequently roared through town, damaging several buildings.

Following Figure 1 the funnel was observed to extend and retract from the base of the cloud several times, although it did not yet reach the ground. Later the base of the cloud near the tornado was observed to be rotating rapidly and shortly after (Figure 2) the twister hit the ground west of town.

The photographs are remarkable not only for their record of the development of the tornado, but also because they were some of the first slides taken by Mr. Fourre with a single-lens reflex camera.

Shortly after snapping the last photograph, Mr. Fourre and I set a new land speed record as we raced for shelter! The tornado missed us by about three blocks.