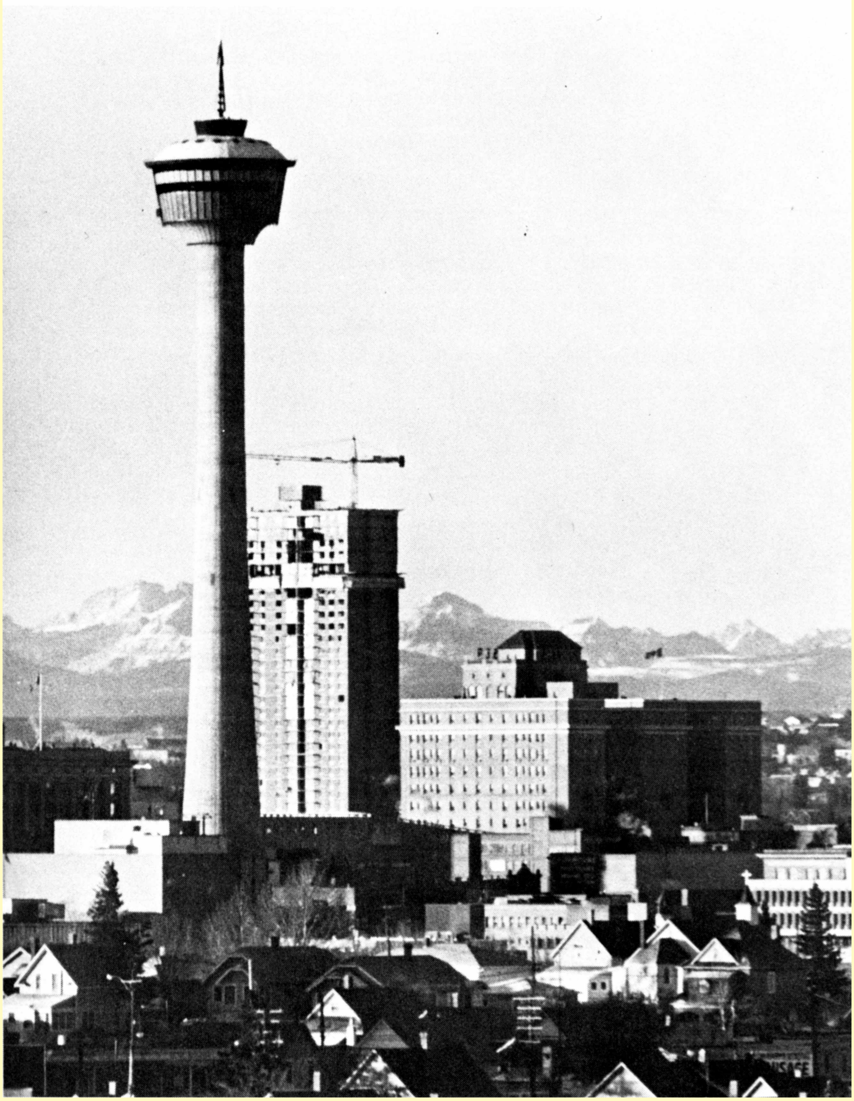
L17

NATIONAL NEWSLETTER

April 1976



Calgary beckons. Striking modern architecture, a foothills landscape and the magnificent mountain backdrop make Calgary an exciting location for this year's General Assembly. See the back page of this *Newsletter* for details. Photo by W. T. Peters.

NATIONAL NEWSLETTER

April 1976

Editor: HARLAN CREIGHTON
Assistant Editors: MARIE FIDLER / NORMAN GREEN / J.F. HEARD / CELESTE PETERS / WILLIAM PETERS. *Artist*: WILLIAM IRELAND

Please submit all material and communications to:

The *National Newsletter*
c/o William T. Peters
McLaughlin Planetarium
100 Queen's Park
Toronto, Ontario
M5S 2C6

Deadline is two months prior to the month of issue.

Editorials

The Yellow Pages

Readers will no doubt have noticed that the *National Newsletter* has a new look this year. We have changed our paper from Planefield Mint to Planefield India in the hope that we can achieve a better reproduction of photographs, as well as a smarter-looking publication. We extend our thanks to Mr. Jan Davidse of University of Toronto Press for assisting with the paper selection. We did consider going to white paper, which would be best for reproducing astrophotos, but some members of National Council pointed out that printing the *Newsletter* on coloured stock makes it easier for readers to locate the *Newsletter*.

We hope that you will "let your fingers do the walking" (Ring a Bell?—Ed.) and enjoy the Yellow Pages.

P.S. Let us know how you like the "new look." We might publish your letter, and reserve the right to reply.—Ed.

Welcome!

We are pleased to introduce to our readers Mr. Bill Ireland, who joins the staff of the *National Newsletter* as our artist. Bill is a member of the Toronto Centre and the artist at the McLaughlin Planetarium. We consider him to be Canada's foremost planetarium artist and astronomical illustrator (Anyone wishing to challenge this statement is welcome to, and should include samples of drawings, cartoons, etc. for publication...).

Welcome aboard, Bill!

RASC Elections, 1976

Just as we are going to press, word has leaked out that there will probably be a run off for at least two of the positions at National level. We urge all members to read carefully the biographical material enclosed with each ballot, and then to VOTE for the candidate of their choice.

National Library Closes Temporarily

In order to prepare for the move to new quarters, the National Library will close on April 30 until further notice. The co-operation of members in promptly returning borrowed materials wlll be greatly apprecIated

The H. R. MacMillan Planetarium

By David A. Rodger

Ed. Note: This article is the first of a series that we hope to publish about the activities of Canadian planetaria. Its author, David Rodger is the current President of the Planetarium Association of Canada and the Director of the MacMillan Planetarium in Vancouver. He is an active member of the Society's Vancouver Centre, which he has served in many capacities, including that of President.

Although we are well into the 1976 production year, at the H. R. MacMillan Planetarium, we are still reflecting back, evaluating the factors which helped to make 1975 our most successful year. Over 272,000 people attended our public and school shows, compared to 210,000 people in 1974, and 244,000 in 1969, our best previous year (and, not coincidentally, our first full year of operation!). There is no simple answer to our ability to draw well last year; instead there are a number of component answers. First, we have a small but dedicated professional staff, who are united in their objectives of producing and presenting first-class shows. Secondly, there is obviously a public eager for new knowledge. Thirdly, there is the selection of topics which can be uniquely presented in a planetarium theatre with the aid of sophisticated visual and sound facilities. In 1975, our shows included *New Images For the Gods*, which was a review of the latest information on the planets Mercury, Venus, Mars, and Jupiter in the light of recent spacecraft investigation; *Black Holes in Time and Space*; *The Flying Saucer Show*, an objective appraisal of a matter of major public (if not scientific) interest; and *Vortex*, an experimental concert of contemporary music and abstract visuals. Our school presentations included *Stars For Little People*, featuring Harold the friendly Zeiss projector; *Journey to the Planets; Sky-Scan; From Babylon to Skylab; and Star of Wonder*, an investigation of the nature of the Star of Bethlehem, a traditional planetarium show everywhere. Also, we continued our popular series of recorded classical music concerts on Monday nights, and presented a highly successful Hallowe'en show featuring music, and scenes from Shakespeare's MacBeth, complete with live witches.

We like to remain flexible; however, at the moment, our 1976 schedule looks like this. The year opened with *Nothing Like A Comet*, a light-hearted but factual history of the "human" side of comets. During the spring, in answer to many requests for such a show, we'll be presenting *An Introduction to the Universe*, which will survey many aspects of our astronomical knowledge, both in terms of the visible sky, and the universe beyond. Our summer show will be entitled, simply, *Mars*. It will describe in vivid detail, from the perspective of that planet, the history of Mars since its formation in the solar nebula, through the shaping of its surface by meteoric bombardment, plate tectonics, dust storms, lava flows, volcanic eruptions, water, and, possibly life, up to the present age of investigation from the earth. The show is being constructed in such a way that it is unlikely to be out-dated by the findings of the Viking spacecraft. However, a special report on Viking will be presented at the show's conclusion, and this will be revised regularly as new information arrives. In the autumn, our attention will turn away from astronomy, as we present a planetarium documentary entitled *In Sound Out*, dealing with the psychology and physiology of sound. Our year will end with a show explaining why Canada and France have decided to build a major observatory in Hawaii.

The production of our theatre shows occupies the majority of our time and attention, but there are other activities in which the planetarium staff are involved. We remain the major source of astronomical information in the Vancouver area and, through the close relationship we have with the Dominion Astrophysical Observatory in Saanich, we help to serve the entire province of British Columbia. Mail and telephone calls are handled daily, and we try to find time to publish popular articles on astronomical subjects. Our beautiful new souvenir booklet, Galaxy, is handed out to all visitors to the museums and planetarium complex, and it contains as much information as we can cram into it about telescopes, astronomy, and related subjects.

The Vancouver Centre of the Royal Astronomical Society of Canada is headquartered here, and our staff includes three past and one present president of the Centre! Jim Wright, Assistant Planetarium Director, is a past president of both the Vancouver and Calgary Centres. Monthly meetings are held in the Centennial Museum Auditorium just two floors below the planetarium.

In future reports to the *National Newsletter*, we'll be providing more detailed information on specific aspects of our facilities and programming. In the meanwhile, we extend a hearty invitation to members from across Canada and beyond to drop us a line if you plan to be in Vancouver, so that we can roll out the red carpet and give you a backstage tour and a show "on the house"!

Vancouver's MacMillan Planetarium, home of some of the most exciting planetarium shows to be found on this continent and headquarters for the RASC's Vancouver Centre. Photo by W. T. Peters.

The Adams-Leverrier Affair II

by Dr. J. D. Fernie, National President

(Continued from the previous issue.)

Urbain Jean Joseph Leverrier was born in 1811, some eight years before John Adams, in a small town in Normandy. His father was a minor civil servant of modest means, who, like Adams' parents, was prepared to sacrifice much for the education of his son. Urbain too showed an early aptitude for mathematics, and at the age of nineteen he graduated at the top of his class from the college at Caen. This spurred him to compete in the difficult entrance exams of the great Ecole Polytechnique in Paris, but to the surprise of all, he failed. Forced to continue his studies elsewhere, and supported financially by the sale of his father's house, Leverrier settled down to the enormously determined effort that was to characterize his entire career. By the end of 1831, not only was he in the Polytechnique, but carrying off some of its highest honours. Never again did Leverrier descend from the first rank of scholars.

But unlike Adams, Leverrier had no burning astronomical ambitions. His interests inclined more to chemistry, and his first professional job was as a chemist in the Tobacco Administration of the government. Here for some years he produced papers on experiments with phosphorus and hydrogen and oxygen (what this did for the quality of French tobacco I'm not sure), until in 1836 he resigned because, having become something of a Parisian sophisticate, he disliked being sent on field trips to the provinces. There was also the matter of a Mlle Choquet in Paris, soon to become Mme Leverrier. For a while he became a teacher in one of the lesser colleges of Paris. At the end of 1837, however, he tried to get back into chemistry by applying for the post of assistant to the famous Gay-Lussac, who was professor of chemistry at the Ecole Polytechnique. Gay-Lussac was nonplussed, for there was also another equally good applicant. And right there, the whole Adams-Leverrier affair would never have erupted if, at that crucial moment, a similar position in astronomy had not fallen vacant in the Polytechnique. Gay-Lussac resolved his dilemma by awarding the chemistry post to Leverrier's competitor, and suggesting to the mathematically gifted Leverrier that he take the astronomy post.

And so "without regret as without effort, without dividing his attention and without looking back, [Leverrier] detached himself from chemistry and, obedient to the decree of chance ... rapidly became an astronomer." The switch in no way diminished his ambition, as he told his father: "I have already begun to mount the ladder [of success], why shouldn't I continue to climb?" And with his great abilities, determination, and capacity for hard work, it wasn't long before he caught the attention of leading astronomers. A series of papers on the stability of the solar system, on the motion of Mercury (those missing 43 seconds of arc were to plague Leverrier all his life), and on comets drew well-deserved praise, and Leverrier was soon regarded as one of the "bright young men" of French astronomy. Thus it was that in the summer of 1845 Francois Arago, dean of French astronomers, suggested to Leverrier that a topic worthy of his talents would be an investigation of the problem of Uranus. The 34-year-old Leverrier had no inkling that its solution was just then being completed by the 26-year-old Adams in England; indeed, neither he nor any other French astronomer was even aware of Adams' existence.

Unlike Adams, who said nothing of his work until it was completed, and then only mentioned it privately to his professor, Leverrier documented the progress of his research in a series of brilliant papers published by the French Academy during the following year. Leverrier too wrote to Airy for the Greenwich data, Airy again put his question about the radius vector of the hypothetical planet (getting an immediate and satisfactory reply this time), but never once did Airy even mention Adams and his work. Even during Airy's numerous travels among Continental astronomers was there so much as a verbal hint given of Adams' solution. Instead, Airy heaped loud and plentiful praise on Leverrier for his work.

The following summer (of 1846), when Leverrier's papers made it clear that he was rapidly homing in on the same solution as Adams, the British group finally began to do something. Airy, presumably out of purely nationalistic motives, wrote to Challis and suggested it was about time to start looking for the new planet. Challis, he thought, had at Cambridge the best available telescope for the purpose. Adams provided Challis with updated predictions of the planet's expected position for the next few months, and Challis lumbered into action by drawing up a ridiculously cumbersome observing program that might have taken forever to complete.

Events began to move rapidly towards a climax. Challis started observing on July 29, laboriously mapping the positions of stars in the region of sky expected to contain the new planet. These maps were repeated on subsequent nights, and after the night of August 12 Challis made a partial comparison to see if his mapping technique was repeatable. He checked the first thirty-nine stars, and finding them all in stable positions, stopped. Had he continued for ten more stars he would have found No. 49 to have moved, for it was Neptune. The planet would have been his. But instead he put the work aside and went back to his routine reductions of comets.

August 31 saw the presentation of Leverrier's final paper, giving orbital elements for Neptune very similar to those derived by Adams. Still knowing nothing of Adams, Leverrier began calling for observers to search for the planet.

By early September Adams could see what was going to happen. He prepared a paper outlining his work to read at a meeting of the British Association for the Advancement of Science. Hurrying down to the meetings in Southampton he arrived to find the section on physical sciences had concluded the previous day and he would be unable to present his paper. It was Tuesday, September 15, 1846.

Meanwhile Leverrier had run into the same block as Adams. The French savants applauded his work enthusiastically, but no observer sped to the telescope. Wherever he turned among French observers there was some reason why they could not undertake the search. Finally, in some desperation, Leverrier recalled an acquaintance of his in Berlin, Johann Gottfried Galle. On September 18 he wrote to Galle and asked him to undertake the search, emphasizing that Galle should scrutinize each star carefully, for the new planet might well have a disk distinguishable from any true star, and so cut down the length of the search considerably. The letter reached Galle on September 23, and he immediately requested permission from his Director, Encke, to begin the search. Overhearing the request, a young assistant Heinrich d'Arrest asked to be allowed to participate. That very night being clear Galle and d'Arrest opened the dome of the Berlin Observatory's 9-inch refractor and turned the telescope on Leverrier's predicted position (RA = $22^h\ 46^m$; Dec. = $-13°24'$) Galle began scanning the nearby stars. After a short while d'Arrest suggested they also use a star map, which by luck had recently been completed at Berlin for that part of the sky. Returning to the telescope Galle continued scanning, calling out coordinates to d'Arrest seated at a desk with the map. Within minutes Galle hesitated over the appearance of a star at $22^h\ 53^m$. "It is not on the map!", exclaimed d'Arrest. Neptune had at long last been discovered.

The news spread swiftly across Europe. Airy heard it in Gotha, Germany, on September 29, and said nothing. The French were ecstatic: one of the greatest triumphs in the history of astronomy had come to France.

But others in England had been hearing about Adams' work, the first public announcement of which came in a letter to the press by Sir John Herschel on October 3. Then Challis took it on himself to write to Arago on October 5 to announce that he himself had been searching for the planet since July, and (now that he had bothered to check his observations) the planet was indeed there. He only later mentioned Adams.

It began to seem as though the British were starting to counterclaim to priority, belittling France's glory. And that was when it all hit the fan. The violent storm, long delayed but inevitable, was about to break.

To say that the French – astronomers and public alike – were totally outraged by claims for Adams' role in discovering Neptune would be to say that Napoleon was mildly disappointed at losing Waterloo. Just how perfidious could Albion be?? The tirade in the French press lasted months. *L'Univers* attacked England for "an odious national jealousy"; *Le National* accused the English of "treating France as a stupid nation, M. Arago as a Humbug, our own writings as discredited articles, everything crowned by the glorious refrain 'Adams and England forever' "; *L'Illustration* published vicious satirical caricatures of Adams.

But that was as nothing compared to the thunder that erupted on the floor of the French Academy. Meetings were stormy to a degree that led one reporter to ask "Are we in the Academy of Sciences or the Chamber of Deputies?" Arago read out translations of letters from Challis and Airy, and then, choking back his anger, launched into an impassioned denunciation dripping with sarcasm and venom:

> Challis so exaggerates the merits of Mr. Adams's clandestine work, that he assigns [him] the right to name the new heavenly body. This claim will not be accepted .... What! ... today we are called upon to share this glory ... with a young man who has communicated nothing to the public, and whose calculations, more or less incomplete, are with only two exceptions totally unknown to the Observatories of Europe! No, no! The friends of science will not permit the perpetration of such a flagrant injustice! ... Mr. Adams has no right to figure in the history of the discovery of the planet Leverrier, neither by a detailed citation, nor by the slightest allusion.

Airy, as usual, succeeded in exacerbating the situation. To Leverrier he wrote

> If in this I give praise to others I beg that you will not consider it as at all

> interfering with my acknowledgment of your claims. You are to be recognized, without doubt, as the real predictor of the planet's place. I may add that the English investigations, as I believe, were not so extensive as yours.

Then, only a short while later, he had the gall to tell someone else "I believe I have done more than any other person to place Adams in his proper position."

But Airy was to be called to account, for the fury of the French was hardly more than that of the British themselves with their Astronomer Royal. On November 13, 1846, there was a meeting of the Royal Astronomical Society at which Airy, Challis, and Adams gave accounts of what had happened. As one Fellow remarked, they were "the three most remarkable communications which the Society can ever expect to receive in one night." Challis, filled with foreboding, wrote to Airy beforehand "I am in difficulties about this report and should be glad to see some means of getting out of it." There was no escape. Adams restricted himself to a detailed account of his researches, and, of course, received a tremendous ovation. With the subsequent publication of this paper his work was at last available for all to judge. The reception accorded Challis and Airy was vastly different. Challis caved in under it all and emerged a sorry figure indeed, scorn and abuse heaped upon him, and viewed thereafter with little more than contempt. But the neurotic Airy had a hide to rival a rhinoceros. Sir David Brewster and Sir James South led a savage and bitter attack on him, and even his closest friend, Adam Sedgwick, wrote to say:

> You were accused, not only of unreasonable incredulity and apathy towards Adams, but also of having ... "snubbed him from the first" and so acting ... prevented him from reaping the honors of a great discovery .... I think the facts speak so loudly that my dull ears cannot help hearing them.

All such attacks were absolutely and entirely disregarded by Airy; as one who knew him well said "He was perfectly satisfied with himself, and what other people thought or said about him influenced him no more than the opinions of the inhabitants of Saturn."

Fresh fuel was now added to the fire over the question of naming the new planet. Arago (at the insistence of Leverrier himself, it later turned out) demanded that it be called Planet Leverrier, citing the fact that Uranus was long known as Planet Herschel, and that such names as Halley's Comet had proved acceptable. The British, of course, would have none of that, quite apart from the implied denigation of Adams. As Piazzi Smythe gloomily remarked "what if the next planet should be discovered by our hirsute friend Boguslawski?" Eventually saner heads, mostly outside of Britain and France, prevailed, and Neptune was agreed to by all.

Through the hard work of John Herschel in England and Jean Biot in France the furor finally calmed down, so that by the following summer it was possible for Leverrier to be welcomed at the British Association meetings in Oxford. And there, finally, John Adams and Urbain Leverrier met for the first time. The two men had not participated in the mud-slinging of the previous winter, and it is one of the few happy aspects of this story that they immediately became firm and respected friends and remained so for the rest of their lives.

Neither, of course, would ever achieve such headlines again. Adams, retiring as always, lived out his life in relative obscurity, declining a knighthood, but eventually succeeding to Challis' position as director of the Cambridge Observatories. He came to the forefront only once more, when in the mid-1850's he again had a run-in with French astronomers over the secular acceleration of the Moon. This had supposedly been settled by the great Laplace, but Adams showed his solution to be incorrect, and Adams' work eventually led in the twentieth century to the discovery of the Earth's irregular rotation. It was in his beloved Cambridge that Adams died in 1892 at the age of 72.

Leverrier, as might be expected, had a far more visible career. His prediction of Neptune resulted in many honours being showered on him by foreign governments and academies, and he was soon appointed director of the Paris Observatory. As such, his dislike of Pierre Janssen led to the founding of the Meudon Observatory and the beginnings of French astrophysics. At the time of his death in 1877 (aged 66) he was the leading figure in the renowned search for the missing planet Vulcan, a story that I must take up here sometime.

It was that old smoothy, Sir John Herschel, who pronounced the final verdict on the Adams-Leverrier affair:

> As genius and destiny have joined the names of Leverrier and Adams, I shall by no means put them asunder; nor will they ever be pronounced apart so long as language shall celebrate the triumphs of science in her sublimest walks.

Neither, it is true, could properly be called a mathematical genius; rather they were superb craftsmen of their trade. But as co-discoverers of Neptune, they occupy a special, undiminished place in the history of astronomy.

Cassegrain Telescope Systems

By Jack Winzer

Although Cassegrain telescopes are seldom constructed by amateurs, for reasons that should become apparent later, this type of telescope is widely used, and is important enough to warrant some consideration. Commercial amateur instruments of Cassegrain optical configuration include both the Questar and Celestron designs, although neither of these are true Cassegrains in the classical sense. Large professional instruments are also of Cassegrain optical configuration. While a few articles in *Sky and Telescope* describe the construction of Cassegrain telescopes, there is a general lack of discussion devoted to this type. In particular, there is almost a complete lack of details on how to design a Cassegrain telescope, or how to produce and test the optics. This present article will hopefully fill these gaps. It is not, however, intended to be a set of instructions for building your own Cassegrain, nor is it intended to imply that a Cassegrain is a suitable project for amateur endeavour.

Design of a Cassegrain telescope

The optical configuration of a typical Cassegrain telescope is shown in Figure 1. There are five dimensions that must be specified in the process of designing the telescope. Three of these can be selected to satisfy various design criteria, while the remaining two must be calculated. It is usual to select the focal length of the primary mirror f_1, the overall focal length f, and the back focal length e. These are considered separately as follows:

(1) The focal length of the primary mirror f_1 should be chosen to optimize two factors. The first is the overall length of the telescope, which can be considered to be approximately equal to f_1. The second is the amount of work involved in producing the primary mirror, which increases for short focal length mirrors.

(2) The overall focal length f determines the magnification and photographic speed of the telescope. Although Cassegrain telescopes can be made with focal ratios of F/8 (focal length 8 times the diameter of the primary mirror), in such cases, Newtonian telescopes can be made far more easily in amateur sizes. Focal ratios greater than F/20 are likewise not recommended as the telescope becomes too slow for anything except planetary observing. The optimum range is probably F/12 to F/15.

(3) The back focal length, e, determines the position of the final focus. This can be anywhere, even in front of the primary mirror. In general however, allowing for the thickness of the mirror and cell, and the focus travel of a conventional eyepiece adapter, a simple approximation to e can be made by setting it equal to the diameter of the primary mirror. Obviously, this can be varied to suit individual demands.

The other two quantities: the separation between the mirrors d, and the focal length of the secondary mirror f_2, must be calculated. The formulae for the calculation of these are:

$$d = \frac{f_1(f - e)}{(f + f_1)}$$

$$f_2 = \frac{f_1(d + e)}{(f - f_1)}$$

It is also wise to substitute these numbers into a third equation to verify that they are the correct values. This equation is:

$$\frac{1}{f} = \frac{1}{f_1} - \frac{1}{f_2} + \frac{d}{f_1 f_2}$$

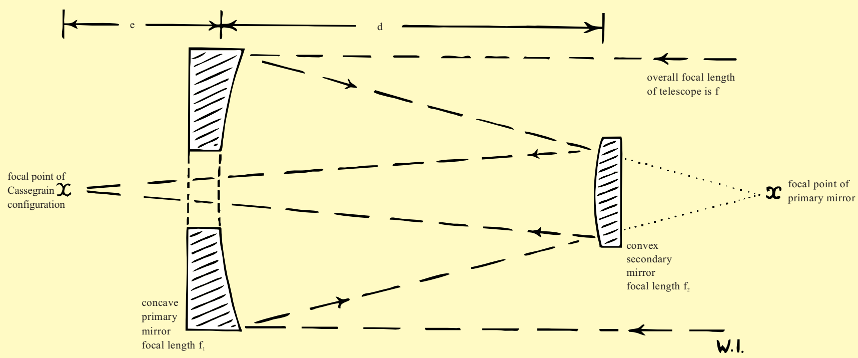
There are two other dimensions that must be calculated; namely the diameter of the secondary mirror D_2 and the diameter of the hole in the primary mirror D_3. For visual observation with ordinary 1¼ inch eyepieces or photography with a 35 mm camera, ϕ can be as small as 1 inch. For wide field Erfle eyepieces or large format photography, ϕ would be somewhat larger. The formulae for calculating these quantities are:

$$D_2 = \frac{(d + e)D_1 + (f - d - e)\phi}{f}$$

$$D_3 = \frac{eD_1 + (f_1 - e)\phi}{f}$$

In both these equations, D_1 is the diameter of the primary mirror, and ϕ is the linear diameter of the field of view. A typical size for the diameter of the secondary mirror is ½ the diameter of the primary mirror, and for the hole in the primary mirror is ¼ the diameter of the primary mirror.

Finally, we must consider the problem of light baffles. Very few amateur Cassegrains are baffled, and in fact very few amateurs constructing Cassegrains even know what baffling is — yet it is one of the most important considerations in a Cassegrain telescope.



The following dimensions must be specified:

f = overall focal length of Cassegrain configuration
f_1 = focal length of primary mirror alone
f_2 = focal length of secondary mirror alone
d = separation between primary and secondary mirror
e = back focal length, distance of final focus behind front of primary mirror.

FIG. 1—Sketch of the optical configuration of a classical Cassegrain telescope.

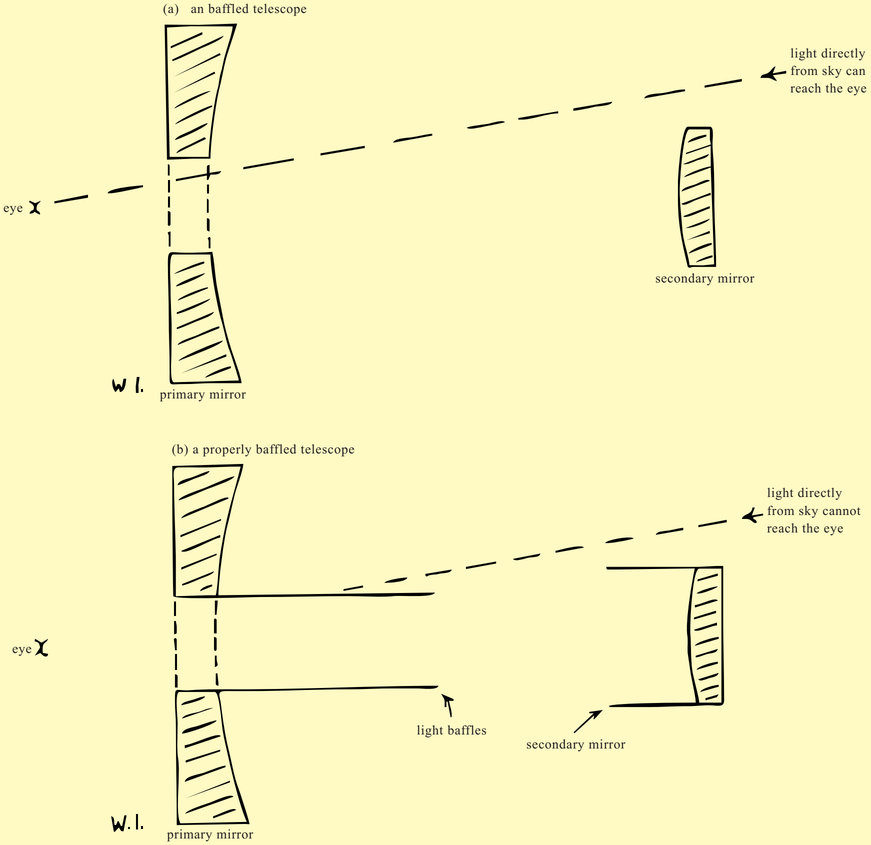


FIG. 2—Light baffles in a Cassegrain telescope.

Light baffles are simply tubes inserted in appropriate places to prevent direct sky light from entering the eye without passing through the optical system. See Figure 2a. The size and configuration of the baffle system is easily determined by making a scaled sketch of the telescope and drawing in shields by trial and error until no light can get to the eye without passing through the optical system. A more complex mathematical analysis can be undertaken if desired. A typical baffle system is shown in Figure 2b.

This completes the design of the telescope in as far as the dimensions of the mirrors, focal lengths, and separations are concerned. In the next section, we will consider the fabrication of the optics to meet these design requirements.

Optics of a Cassegrain Telescope

At the very onset, it is important to stress that the optics of a Cassegrain telescope must be produced to very close tolerances if the finished instrument is to resemble at all the initial design. This means control of the radii of the optical surfaces to a few tenths of an inch. The mirrors should also be centered (constant edge thickness) for ease of alignment of the finished telescope.

The primary mirror should present no outstanding obstacle. It is ground and figured in much the same way as a conventional mirror for a Newtonian. The only difference is that a hole will have to be cut in the center of the mirror. Such a hole is not hard to make, although it is wise to practice cutting a few holes in scrap glass first. A piece of tubing slightly smaller in diameter than the finished hole, and some #80 or #120 abrasive are all that are necessary, although a drill press, if available, will make the job somewhat easier. If a drill press is not available, a wooden framework to hold the tubing perpendicular to the mirror blank will have to be constructed. To drill the hole, place abrasive and water on the glass under the tubing. Rotate the tube (either by hand or electric drill) while pressing it against the glass. The procedure will, after several hours, cut a central plug from the center of the mirror. It is important that the hole be exactly in the center of the mirror, and to ensure this, the mirror should be frequently rotated in a fixed circumference during the drilling operation.

The best time to cut the hole is at the end of fine grinding. If it is done at this time, the hole should be drilled from the back of the blank, and stopped within about ¼ inch from the front surface. The channel around the plug should then be filled with parafin wax, and the mirror polished and corrected in the normal manner.

When the mirror is completed, the central plug is removed by drilling out the remainder of the glass *from the front*, taking great care not to scratch the finished surface. While the method just discussed is the preferred way to drill a hole in a mirror, it is also possible to drill the hole completely through before any work is done on the mirror, although it is then necessary to grind, polish, and figure a mirror with a hole in it. Another alternative is to drill the hole completely through after the mirror has been finished, but with the added risk of distorting the figure or scratching the surface of the finished mirror.

The secondary mirror is easy to grind because of its small size. The same procedures for grinding an ordinary mirror are followed, except that the mirror is the convex blank instead of the concave blank. The only possible difficulty comes in polishing a strongly convex surface. Conventional tools tend to concentrate the polishing action in the center, and sometimes it is impossible to extend the polishing out to the edge. This problem is remedied by removing several facets in the center of the lap. The figuring strokes will have to be determined by trial and error.

The primary mirror can be tested by conventional means. The secondary mirror, however, being convex is an entirely different problem. There are several methods of testing convex surfaces, but all are difficult to perform and/or require auxiliary optics. The main methods are summarized as follows:

(1) Testing the mirror from the back as a concave mirror. By this means the mirror can be tested by a conventional Foucault test, but the back must be ground and polished, and the effects of the light passing through the blank on the knife edge settings calculated. A variant of this method involves an oil solution of the same refractive index as the glass to eliminate effectively the back surface.

(2) Testing the mirror by interference. In this approach, the mirror is tested in the same manner as an optical flat, namely by observing the interference fringes when the mirror is placed against a test surface. This test requires a separate test plate of the same focal length as the mirror, and figured either to a sphere, or to the same hyperbola as is desired for the mirror.

(3) Testing the mirror with a full aperture spherical mirror. The secondary mirror of a classical Cassegrain can be tested by substituting a spherical mirror of the same size as the primary mirror but of half the focal length in place of the parabolic primary, and placing both light source and knife edge at the Cassegrain focus. This is a null test (similar to the Foucault test for a spherical mirror).

(4) Testing with a full aperture flat mirror. By placing a full aperture flat mirror in front of the complete Cassegrain system, and the light source and knife edge at the Cassegrain focus, another null test is achieved.

(5) The Hartmann test. The Hartmann test involves photographing a star image inside of and outside of focus with a special Hartmann screen (a disk with a series of small holes in it) placed over the end of the telescope. This test is slow and complicated, but it is the test performed on large professional telescopes.

To summarize, the testing of the convex secondary mirror is the most difficult step in the production of a Cassegrain telescope. This, plus the close tolerances on the focal lengths, difficulty in aligning, problems of light baffling, etc., accounts for why a Cassegrain is not recommended as a first telescope (or even a second telescope!). After you have been able to produce a good reflector, a refractor (for experience in working with convex surfaces), and possibly an optical flat, then you may be ready to attempt a Cassegrain.

Other Types of Cassegrain Telescopes

In the discussion thus far, the classical Cassegrain (parabolic primary mirror and hyperbolic secondary mirror) has been considered. It is not necessary to adhere to these particular surface figures. It is possible to achieve improved optical performance by the proper selection of asphericities *but* it is also possible to achieve inferior optical performance by the improper selection of asphericities.

(1) Dall-Kirkham Cassegrain: With a spherical primary mirror and an elliptical secondary mirror, this system has the sole advantage of being easier to produce by virtue of the spherical primary mirror. The cost of this advantage is poor off-axis performance, restricting this type of telescope to long focal ratios, typically F/20.

(2) Ritchey-Chretian Cassegrain: The asphericities can be chosen to eliminate coma and reduce astigmatism. Such an optical system has a hyperbolic primary and a hyperbolic secondary. This is the optimum design for a two-mirror Cassegrain.

(3) Flat Field Anastigmatic Cassegrain: By redesigning the Ritchey-Chretian slightly with the addition of an aspheric correcting plate, placed either in front of the entire telescope (as in a Schmidt), or in the converging beam a short distance from the focal point, then a telescope with no secondary aberrations is produced. If the primary and secondary mirrors have the same focal lengths ($f_1 = f_2$) then the telescope also has a flat field. This is the ultimate in Cassegrain telescopes.

(4) Catadioptric Cassegrain: There are two types of Catadioptric designs. One is the Maksutov, most familiar in the Gregory-Maksutov form (constructed by amateurs) or the Questar (commercial product). The other type is the Schmidt Cassegrain such as is produced by Celestron. The Schmidt Cassegrain must not be confused with the Flat Field Anastigmatic Cassegrain, for while they both use an aspheric correcting plate, the former has a spherical primary mirror whereas the latter has a hyperbolic primary mirror and overall superior optical performance.

(Reprinted from Edmonton Centre's *Stardust*)

New Observing Aid

By David L. DuPuy

I have a beautifully clear Friday night; the new moon has just set; my 6-inch mirror has just been realuminized and re-installed, and I finally got the variable drive and slow motions working! But I've looked at M31 and M13 until I'm tired of them. *Sky & Tel's* "Ramblings" are just too rambling, and Walter Scott Houston is just too faint for me. What shall I look at next?

Does the above sound familiar? The best solution to this problem that I've seen is a product called *Astro Cards*, by George R. Kepple.* The subtitle is "Deep-Sky Objects – Set I, The Messier Objects." On 3 × 5 inch index cards, Kepple has assembled all the data you need to observe all 109 Messier objects. The cards are arranged in order of Messier number, and you simply pull out the objects on your list for that evening.

The layout on the cards is convenient. A complete title on each card gives the Messier number, name, position, size, magnitude, month for 9 pm transit, and constellation. Two finder charts are shown on the front of each card: on the left is a wide-field finder chart, showing constellation outlines and bright stars, along with the Messier object. On the right hand half of the card is shown a detailed finder chart with fainter stars; i.e. what you can expect to see through a widefield telescope. Unfortunately, the scale of the finder charts is not given, and Kepple states that it would have been impractical to make all of the finder charts to the same scale (I agree). Nonetheless, the diagrams are clear and easy to read and very convenient to use at the telescope.

In addition to the set of 109 cards, one card gives a handy chart which lists for each month the Messier objects which transit around 9 pm, and around midnight. There is also an explanation of how to use the cards, and hints for observing (which RASCers certainly won't need). An illustration of the cards for M11 and M80 can be seen in back pages of recent *Sky & Tel.* (e.g. page 240, October 1975). All in all, the *Astro Cards* are very useful if you enjoy observing.

*Available from George R. Kepple, 156 Beale Road, Sarver, Pa. 16055 $5.95, + $1 outside U.S.A.

Astronomy Update

By Dr. D. Hube

The local cluster of galaxies (the Local Group) which includes our Galaxy, M31 and the Magellanic Clouds, as well as about twenty other galaxies, is an outlying member of a supercluster of galaxies. The centre of this supercluster is marked by the Virgo Cluster which is dominated by the giant elliptical M87. The supercluster is measureably flattened with a thickness of approximately 30 million light years. Where clearly defined, the planes of symmetry and/or major axes of member clusters are found to be aligned, to within 35°, with the central plane of the supercluster.

(Astrophysical Journal *202*, 610, 1976)

The star AY Muscae, long known as an eclipsing binary, in recent years has shown no brightness variations. lt is suggested that a third star in the system with an orbital period of order one-half year has perturbed the short period pair reducing the inclination of the orbit plane from 83° to less than 73°. The result is that no eclipse can occur at conjunction at the present time.

(Astronomy and Astrophysics Suppl. *22*, 263, 1975)

Following in the tradition of Velikovsky and von Daniken, Gribben and Plagemann have recently published a book of nonsense called *The Jupiter Effect*. It is hypothesized that an alignment of the outer planets in 1982 will lead to a series of disastrous earthquakes. Jean Meeus, well-known Belgian astronomer, has recently published a critical review. The observational and theoretical 'facts' presented in support of the hypothesis are shown to be simply false, non-existent or the result of gross misinterpretations of observational data. Among other things, no planetary alignment will even occur in 1982! Gribben and Plagemann give no numerical data on this planetary conjunction; Meeuss shows that the outer planets when appearing closest to one-another will be spread over a region of the sky more than 60° wide. Gribben and Plagemann need not worry, however, as the gullible and ignorant exist in sufficient numbers to turn the book into a best seller.

(Icarus *26*, 257, 1975)

Is the Sun a pulsating variable star? Using a modified magnetograph, velocities of the solar surface have been measured at the Crimean Astrophysical Observatory. There appears to be a well-defined surface oscillation with a period of 2 hours and 40 minutes. This turns out to be the period one would expect for radial pulsations in a homogeneous sphere of one solar mass.

(Nature *259*, 87, 1976)

Using telescopes in the United States and Germany as a long baseline interferometer, radio astronomers have observed the Seyfert galaxy NGC1275 and achieved a resolution of 0.0003 arc second. At the distance of the galaxy this means that structure as small as 0.1 parsec can be resolved.

(Nature *259*, 9 and 17, 1976)
(From Edmonton Centre's *Stardust*)

The University of Alberta Observatories

By Dr. D. Hube

The on-campus observatory is now in operation. On Saturday, November 15, a 12 × 16 foot steel-framed and steel-clad building with a roll-off roof was lifted by helicopter and placed on the southwest corner of the roof of the Physics Building. Only a few problems were encountered: the roof fell off the truck transporting it to the campus, and then lowered by the helicopter onto the supporting walls, the roof was turned through almost 180° from its intended position! That same afternoon the roof was lifted manually and placed in its proper position. During the following weeks, damage to the roof was repaired and the rails on which it rolls were welded in place, doors and a floor were installed, the telescope was installed, and lights and power provided. The roof area around the building had previously been surfaced with asphalt pads, and the entire area is now enclosed within steel railings. Access to the observatory is via a door, newly installed, at the west end of the seventh floor hall.

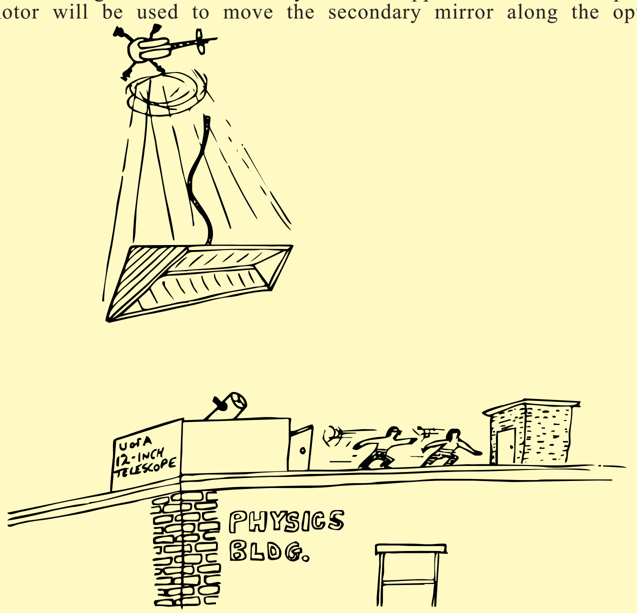
Preliminary observations by John Woolley indicate that neither warm air currents from the main building nor vibrations are great enough to adversely affect seeing conditions.

Decisions regarding keys and building alterations necessary for security are still to be made before the observatory can be opened on a regular basis.

At the same time that work was proceeding on campus, alterations were being made at the Devon site in preparation for installation of the 20-inch telescope. A second concrete pier has been poured and joined to the original with a reinforced concrete slab cap to which the base of the telescope will be anchored. The dome was raised and now rests on an 8-inch high curb. (This 8 inches has also been added to the height of the main door much to the delight of those of us approaching six feet in height!) A wooden floor has been built about 31 inches above the original floor level. On entering the dome, one immediately turns to the right and climbs a small set of stairs to the observing floor. A 6 x 8 foot concrete slab was poured outside on the east side of the dome. This will serve as the base for a small addition to the dome to be built next year to house the upper ends of the telescope tube and the electronics for the photometer. A new door in the east wall of the dome provides access to this storage area.

In the machine shop at the Physics Department, the base of the telescope complete with polar axle bearings has been assembled. The back plate/mirror cell has been completed. The surface of the fork has been machined to a smooth finish with all corners rounded and conduits for wires and cables drilled. On December 5 the declination axles and bearings were attached to the bottom of the tube and the whole then mounted on the fork. As measured from the bottom-centre of the fork, opposite ends of the declination axle are level to within one one-thousandth of an inch – a good indication of the extreme care being taken in the construction of this instrument.

A gear is being cut that will be mounted between the differential gear box and worm supplied by Byers. This will allow the gear box to be mounted inside the base of the telescope. The design for the secondary mirror support has been completed. A small electric motor will be used to move the secondary mirror along the optical axis for



"You never told me he used to be a bomber pilot, Doug!"
Cartoon by Anthony Whyte

focusing, controls for this being located conveniently close to the eyepiece of the main telescope. A temporary polar axle is being machined out of aluminum. The fork and drive assembly will be mounted on this axle and tested before the final axle is machined from steel.

1976 General Assembly

Members of the Calgary Centre will be waiting to welcome YOU to the 1976 General Assembly to be held at the University of Calgary from Friday, May 21 to Monday, May 24. Clip out the form on the back of this page NOW and mail in to receive your registration form.

We hope each Centre, as well as unattached members, will be represented in our "Exhibits" contest, which has been designed both to recognize and to encourage amateur observational astronomy in our Society. We believe this is an exciting innovation and, hopefully, will be continued in future years. The categories and rules were published in the June 1975 issue of the *National Newsletter*. We have been fortunate to receive grants to cover cash prizes and ribbons for each category ... what a way to defray your expenses!

One of the main aspects of Assemblies is the "Session for Papers". As usual, abstracts of approximately 150 words should be submitted. These should be sent to Dr. T.A. Clark, Department of Physics, University of Calgary, Calgary, Alberta – it's not too late to enter – get in touch right away! As in past years, each presentation should take about 10 minutes in order to allow time for discussion.

We are happy to have the retiring Presidential Address by Dr. J.D. Fernie as well as a Ruth Northcott Memorial Lecture by Dr. Jack Locke, Director of the Herzberg Institute of Astrophysics and a Past President of the Society. The former will be held at the Wainwright Hotel in our famous "Heritage Park" – one of the finest examples in Canada of pioneer living. Dr. Locke's address will be held at the University with the banquet being hosted by the Province of Alberta.

The non-technical highlight of the meetings will be the Sunday trip to beautiful and exciting Banff, with the gondola ride to the top of Sulphur Mountain and access to the Cosmic Ray Laboratory. The day will be topped off with an outdoor Barbeque complete with Western entertainment.

For those able to stay on Monday, a visit to the University's Rothney Astrophysical Observatory at Priddis has been arranged.

To condense the program for you, here is an outline:

Friday:	12:30 p.m.	Registration
	7:00 p.m.	Retiring Presidential Address
Saturday:	9:00 am.	Session for Papers
	2:30 p.m.	Annual Meeting
	7:00 p.m.	Ruth Northcott Memorial Lecture
Sunday:	9:00 am.	Trip to Banff and Barbeque

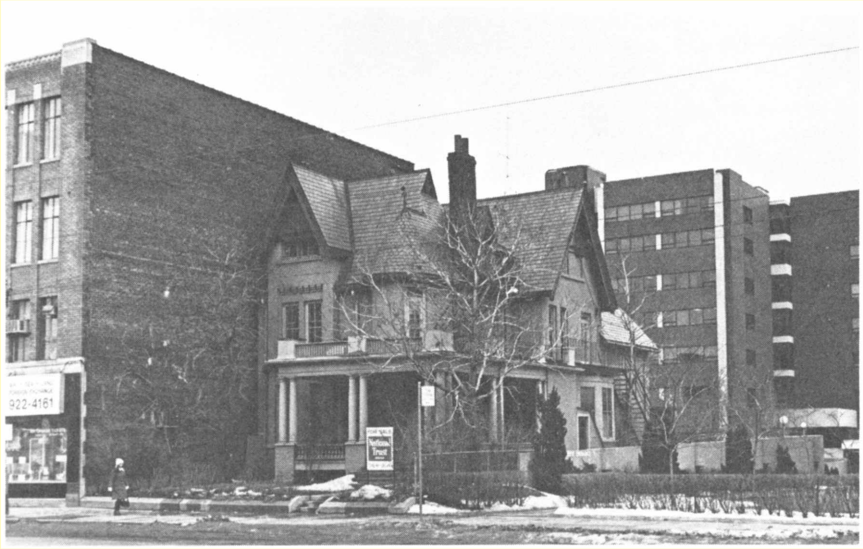
At the time of the Annual Meeting on Saturday, a bus tour of the city will be available for non-members of the Society who do not wish to attend the Annual Meeting.

Inexpensive accommodation will be available at the University of Calgary – and these prices *include* a complete breakfast!

Single – $13.00 per night
Twin – $ 9.25 per night
Youth – $ 7.75 per night (under 18 years of age; proof required)

Come one, come all – ready to learn, participate and enjoy these days in Calgary – the fastest growing city in Canada! We'll be looking for you!

Ulrich Haasdyk, President,
CALGARY CENTRE, R.A.S.C.



The Grand Olde Lady is for sale. "Because of increasing deterioration due to age, the costs of upkeep of the building are becoming exorbitant" reports President J.D. Fernie in his Annual Report for 1974. And so the 'For Sale' sign was posted in front of our National Headquarters in December. (Sniff! Sniff!) Photo by W.T. Peters.

Late news received as we go to press: "252" has been sold.

A warm invitation is extended to you to attend the

1976 GENERAL ASSEMBLY
in
CALGARY, ALBERTA

May 21–22–23–24

to be held at

THE UNIVERSITY OF CALGARY

We hope you are planning to attend. For further information concerning the program, registration form, etc, write to Mr. Cam Fahrner, 115 Coleridge Road N.W., Calgary, Alberta T2K lX5

☐ Yes, I plan to attend ☐ I may attend

Number in my party ....

NAME ....

ADDRESS ....