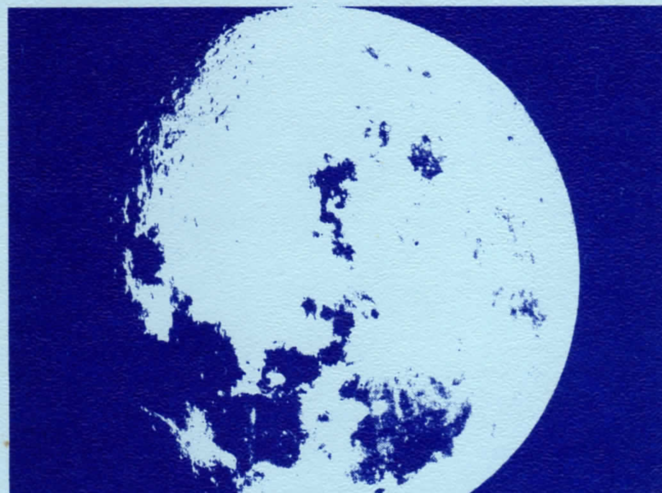

STAR NIGHT '76

STAR NIGHT '76

HOSTED BY

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

(Edmonton Centre)

and

THE QUEEN ELIZABETH PLANETARIUM

STAR NIGHT BROUCHURE

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CITY OF EDMONTON

It is with pleasure that we welcome our visitors to Star Night '76. As you look around the display area do not hesitate to ask questions of any R.A.S.C. members wearing name tags. This year as in the past, Star Night is a joint venture between the Edmonton Centre of the Royal Astronomical Society of Canada and the Queen Elizabeth Planetarium.

The featured subject again is telescope making with a static display of the tools and materials of mirror grinding. The telescope making group now numbers about 20 people and of these, perhaps a third have completed their instruments. Several people are working on their second telescope having survived their first effort. Some examples of their work may be seen and used on the lawn area to the south-west of the Planetarium.

The telescopes set up are intended to give those unfamiliar with such instruments some idea of what may be seen in "amateur" sized telescopes. The moon, star clusters and Jupiter (after 10:00 P.M.) may be seen. The Planetarium runs a special free show for this occasion, part of which is designed as a prelude to your use of the telescopes. The telescopes and Planetarium shows are the most popular items and considerable line-ups occur.

The purpose of Star Night each year is to inform and entertain. We wish the Public to be aware of our existence, aims and efforts. Our aim is to promote an informed interest in astronomy among the general public and to encourage and recognize the efforts of practicing astronomers both amateur and professional. Astronomy is for anyone interested and we hope you will enjoy this edition of Star Night.

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

Anyone who is interested in one of the many facets of astronomy; whether it be star-gazing, telescope making, Astronomical or Space Science Theory, can find an opportunity for sharing and increasing those interests by becoming associated with the Royal Astronomical Society of Canada, Edmonton Centre. Membership in this centre entitles one to full privileges as members of the R.A.S.C., which has its National Headquarters in Toronto, Ontario. The R.A.S.C. includes both professionals and amateurs and has centres in major cities across Canada.

Meetings of the Centre are normally held on the second Monday of each month (from October to June inclusive), at 8:00 P.M., in the Queen Elizabeth Planetarium. These meetings feature a variety of guest speakers whose topics range from practical observational astronomy to theoretical discussions of exotic interstellar objects. In addition to these regular meetings, we organize each year an observing and information session or Starnight, several out-of-town observing sessions, and a banquet held in November. As well, each year an exchange speaker from the Calgary R.A.S.C. and the Saskatoon R.A.S.C. present a talk.

Membership in the R.A.S.C. includes complementary admission to the Queen Elizabeth Planetarium. R.A.S.C. members also receive the annual R.A.S.C. Observer's Handbook; Stardust, the monthly bulletin of the Edmonton Center and the Journal of the National R.A.S.C. published bi-monthly.

QUEEN ELIZABETH PLANETARIUM

The Queen Elizabeth Planetarium was built by the citizens of the City of Edmonton to commemorate the 1959 royal visit of Her Majesty Queen Elizabeth and Prince Philip.

Officially opened in October, 1960 the Planetarium became the first such facility in Canada devoted to the popularization of astronomy. Since that time hundreds of thousands of visitors have attended the Planetarium programmes making the unit an important part of Edmonton Parks and Recreation's Historical and Natural Science Services.

The heart of the Star Theatre is the "Star Projector". Manufactured by the Goto Optical Company of Tokyo the "Venus" projects some 2,800 stars through thirty-two optical systems as well as projecting the Sun, Moon and the five naked-eye planets of our Solar System.

With this incredibly complex instrument the audience may view the evening sky as seen from any point of the surface of the Earth while passing through any time sequence; as small as a minute or as large as an eon. Aided by a battery of 35mm slide projectors, a panorama system and highly specialized effect projectors, the audience can be transported to anywhere in the solar system...and beyond. The entire visual experience is enhanced through the use of the finest of sound systems.

The Planetarium is in essence the ultimate form of Multi-Media Theatre. Each production is a dramatic blend of the astronomer's knowledge and the talents of writers, artists and technicians. The end result is a programme which is not only educational but also entertaining, sometimes serious, sometimes amusing!

TELESCOPIC OBSERVING

Weather permitting, many different telescopes will be set up on the lawn in front of the Planetarium. While there may seem to be a wide variety of telescopes present, there are actually only two types-- reflectors and refractors. Figure 1 illustrates a Newtonian Reflector, in which light is reflected off the main mirror at the base of the tube and aimed out the side by a small secondary mirror. A variation of this -- the Cassegrain Reflector is shown in figure 2. The secondary mirror sends the light rays back down the tube and through a hole cut in the primary mirror. Refracting telescopes use no mirrors. As seen in figure 3, light is bent by a lens placed at the front of a long tube. The light is received by a second lens system, the eye-piece, at the end of the tube. Good refractors can be purchased for as little as $100.00 and hence are quite popular beginner's telescopes. Newtonian reflectors can be made by an amateur at a total cost of less than $200.00 or can be bought for $300.00 and up. The Cassegrain reflectors cost $800.00 and up due to more expensive optical extras.

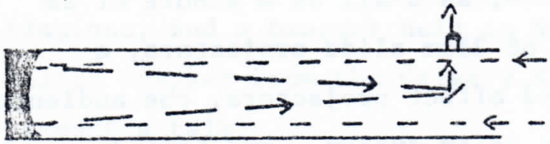
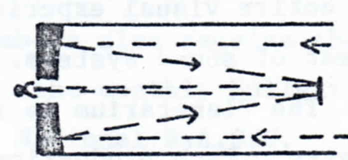


Figure 1 -- Newtonian

Figure 2 -- Cassegrain



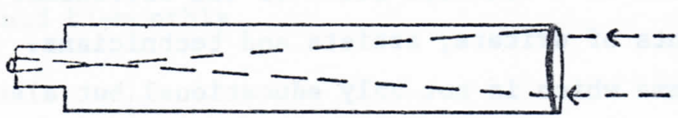


Figure 3 -- Refractor

AN INTRODUCTION TO A CAREER IN ASTRONOMY

Astronomy, the oldest and one of the most rapidly changing sciences, encompasses the widest range of physical phenomena of any science. The research interests of astronomers range from interstellar space, which is a vacuum superior to any produced in a terrestrial laboratory and where temperatures are typically a few degrees above absolute zero, to the recently discovered Pulsars in which the density of matter is measured in billions of tons per cubic centimetre (!) and the temperatures in hundreds of millions of degrees. More classical fields of study are the structure and origin of the Earth and the Solar System, the Sun's place in the Milky Way Galaxy, physical and dynamical properties of stars and galaxies, and so on.

A successful career in Astronomy and Astrophysics requires a thorough education in the physical sciences. The increasing sophistication in methods of analysis, the study of more and more extreme physical conditions, and the increasingly complex picture of the Universe which is emerging,force the students of Astronomy to become especially familiar with advanced mathematical techniques and the use of computers.

Anyone planning to pursue a career in Astronomy is advised to major in Physics and/or Mathematics during his undergraduate years at university. At this stage, one or two courses in introductory Astronomy and Astrophysics are adequate. More advanced training and specialization in a particular field of Astronomy will normally be reserved until the student is in graduate school.

It should be noted that many Radio Astronomers have received their undergraduate training in electrical engineering.

Studies in Physics should include mechanics, heat, optics, (geometrical and physical), electricity and magnetism, thermodynamics, atomic physics, and an introduction to nuclear physics, geophysics and quantum mechanics. Studies in Mathematics will include trigonometry, analytical geometry, calcalus, advanced algebra, some statistics and numerical analysis and computer science. One or two courses in Chemistry and, possibly, Biophysics might be useful.

Most major Canadian universities offer undergraduate and/or graduate programs in Astronomy. For further information, write to the Guidance Centre, Faculty of Education, University of Toronto, 1000 Yonge Street, Toronto, Ontario M4W 2K8, and request a copy of the GC. Occupational Information Monograph entitled, Astronomer.

ASTRONOMY IN CANADA

At the present time over 150 persons are employed full-time as professional astronomers in Canada. Most Canadian universities have either a separate department of astronomy (Toronto, Western Ontario, University of British Columbia) or have one or more astronomers on staff in their departments of physics or mathematics (Alberta, Calgary, Victoria, Brandon, Queen's, St. Mary's etc.).

The largest optical telescope in Canada is the 188 centimeter (74 inch) diameter reflector of the David Dunlap Observatory north of Toronto. There are 183 and 122 centimeter telescopes near Victoria, a 122 centimeter near London Ontario, and many 60, 50, and 40 centimeter telescopes at other locations. A Canadian-owned 60 centimeter telescope is operated on Las Campanas, Chile. The largest Canadian radio telescope is 46 meters (150 feet) in diameter and located in Algonquin Park, Ontario. There is a 26 meter dish near Penticton B.C.

Most of these telescopes are open to public view during restricted visiting hours.

Three years ago an agreement between Canada, France and Hawaii was signed announcing the construction of a 3.6 meter (141 inch diameter) telescope on Mauna Kea, Hawaii (elevation 4,185 meters). When completed in late 1978 (at a cost of more than $20 million) this instrument will be one of the half dozen largest telescopes in the world, and will provide an important stimulus to the further development of Canadian astronomy.

ASTRONOMY AT THE UNIVERSITY OF ALBERTA

The Department of Physics offers several undergraduate courses in astronomy and astrophysics. Some are directed toward students majoring in a physical science: Astro 253, Astro 410, Phys563, Phys 565. Others,are basically survey courses of a descriptive nature and are available to students in other faculties such as Arts and Education: Astro 253, Astro 353.

Research and teaching in astronomy and astrophysics is conducted by members of the academic staff in the Department of Physics, (observational astronomy, theoretical astrophysics, laboratory astrophysics) and in the Department of Electrical Engineering (radio astronomy). Programs leading to undergraduate and graduate degrees are open to qualified students. A graduate program is available in Astronomy and Astrophysics leading to the M.Sc. and Ph. D. degree. Excellent computer and laboratory facilities exist. Observational facilities consist of a 30 centimeter (12 inch)telescope on campus for use by undergraduates and a 50 centimeter research telescope near Devon. Also available for use is one of the largest computers in Canada, and a wide variety of laboratory devices such as spectrographs and linear accelerators. Staff and graduate students make frequent use of telescopes at the David Dunlap Dominion Astrophysical and Kitt Peak National Observatories.

OBSERVING FACILITIES OF THE UNIVERSITY OF ALBERTA

The Devon Observatory 50 centimeter Reflector

History:

The Astrophysics Group of the Department of Physics at the University of Alberta has, for a number of years, operated a small observatory at a site some 5 kilometers north of the town of Devon. The main instrument has been a 30 centimeter Tinsley Cassegrain reflector. This instrument proved to be unsatisfactory for serious astronomical research, and about two years ago the decision was made to construct a larger, research-grade instrument.

The size of the new telescope was dictated by 3 constraints: limited funds, a limit to the size of work that could be done in University machine shops, and the fact that the finished telescope would have to fit into a dome of only 4 meters inside diameter. From a consideration of these constraints, it was decided that the optimum aperture was 50 centimeters. To compensate in part for the limitations imposed by the modest size of the new instrument, emphasis was placed on making it as versatile as possible, both optically and mechanically.

Optical Design:

The telescope is designed so that it can be used in any of three different optical configurations. It will be usable at the prime focus as a Schmidt-quality camera, at an F/8 Cassegrain or Naismyth focus, and at an F/18 Cassegrain or Naismyth focus.

(a) Prime Focus: (figure 1a)

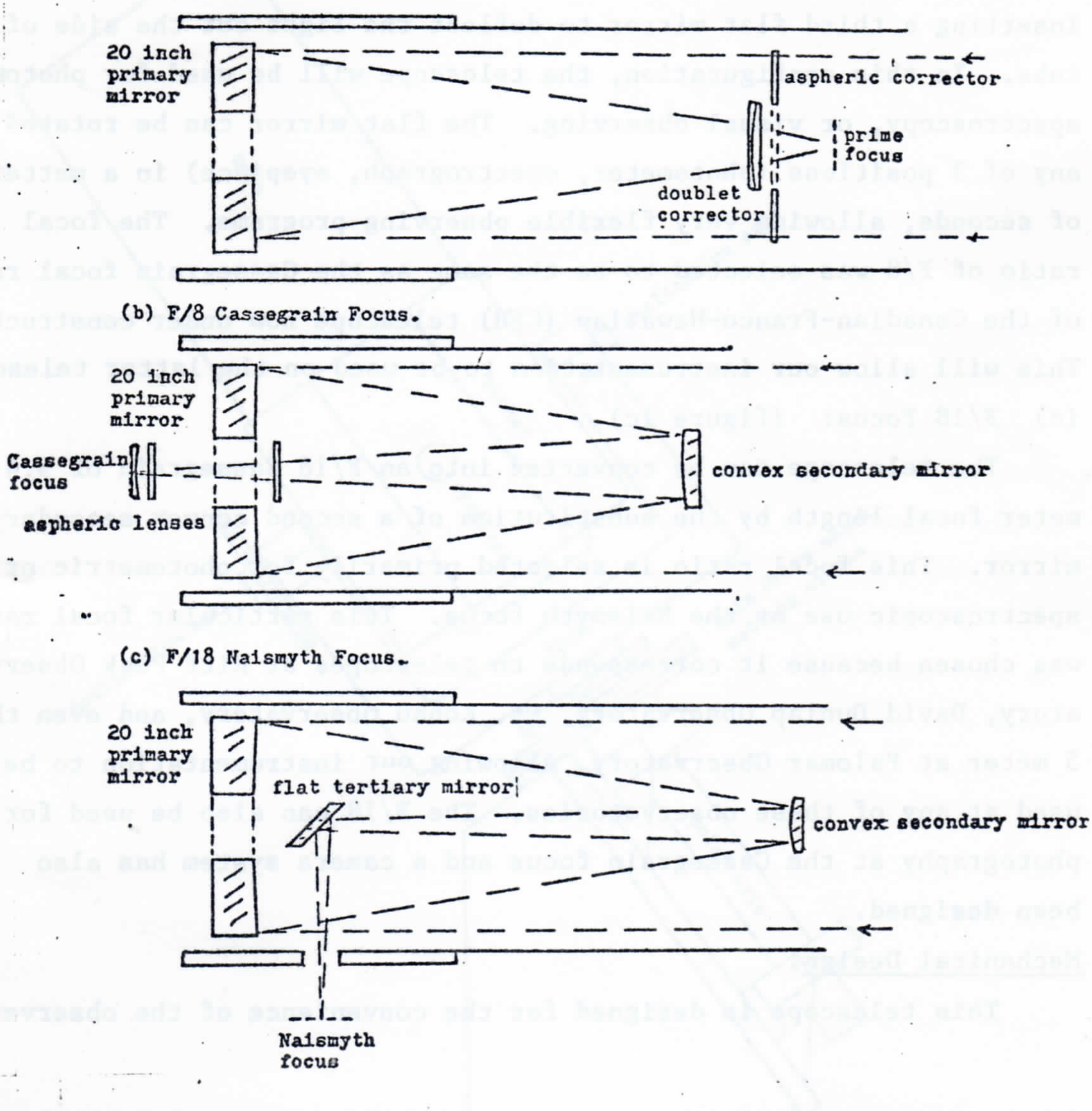
The prime focus will be used exclusively for photographic work. As in any Schmidt system, there is some loss in aperture to minimize vignetting. In the present case, the correcting plate reduces the effective aperture to 43 centimeters. The double correcting lens reduces the

Figure 1. Optical design of the 20-inch telescope.

(a) Reflector-Corrector prime focus camera.

(b) F/8 Cassegrain Focus.

(c) F/18 Naismyth Focus.



effective focal length, hence the final focal ratio is F/2.65.

(b) F/8 Focus: (figure 1b)

The telescope can be converted into an F/8 Cassegrain of 4 meter focal length by replacing the prime focus corrector and camera by a convex secondary mirror. The F/8 focus is designed primarily for photographic use. The limiting magnitude should be fainter than +21 (about the same as the 122 centimeter Schmidt of Palomar Observatory). It is also possible to use the Naismyth focus (folded Cassegrain) by inserting a third flat mirror to deflect the light out the side of the tube. In this configuration, the telescope will be used for photometry, spectroscopy, or visual observing. The flat mirror can be rotated to any of 3 positions (photometer, spectrograph, eyepiece) in a matter of seconds, allowing very flexible observing programs. The focal ratio of F/8 was selected to be the same as the Cassegrain focal ratio of the Canadian-Franco-Hawaiian (CFH) telescope now under construction. This will allow our instrumentation to be used on the latter telescope.

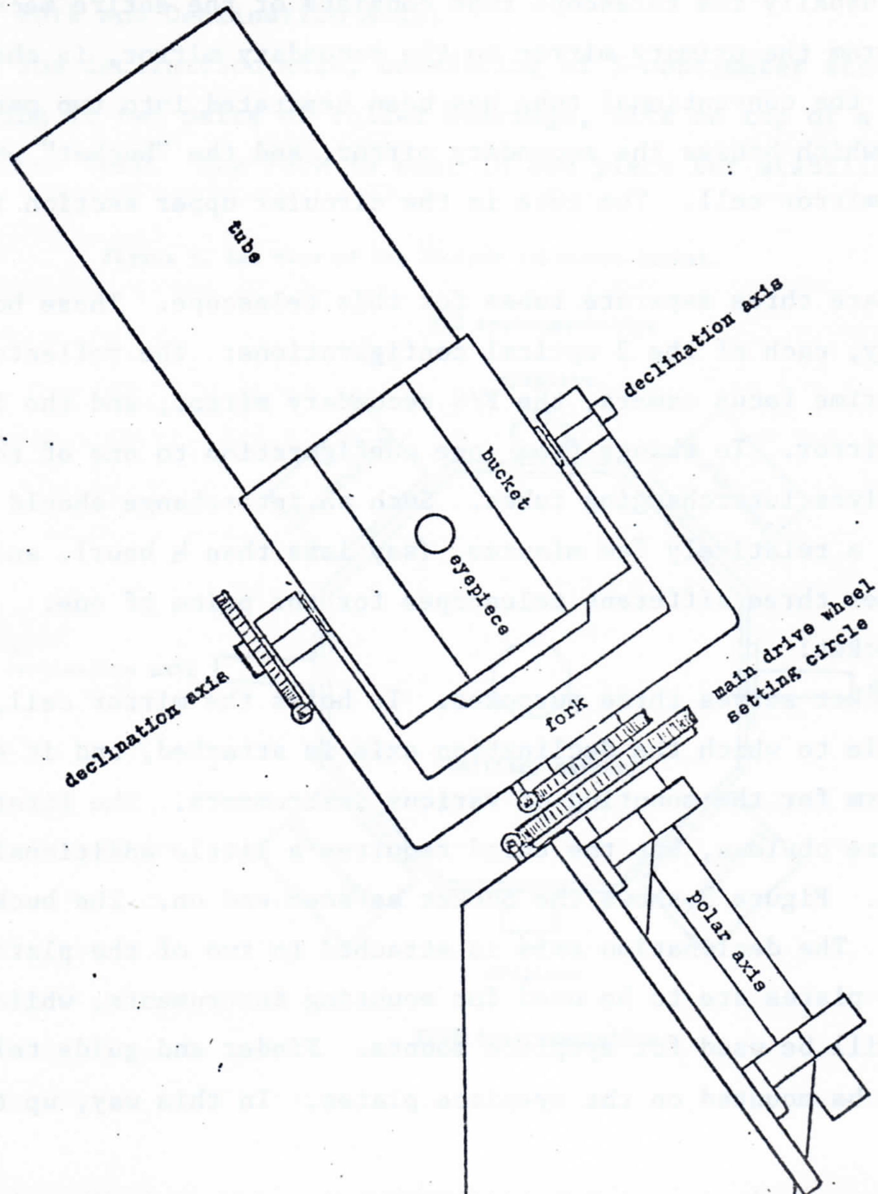
(c) F/18 Focus: (figure 1c)

The telescope can be converted into an F/18 Cassegrain of 9.4 meter focal length by the substitution of a second convex secondary mirror. This focal ratio is selected primarily for photometric or spectroscopic use at the Naismyth focus. This particular focal ratio was chosen because it corresponds to telescopes at Kitt Peak Observatory, David Dunlap Observatory, Mt. Kobau Observatory, and even the 5 meter at Palomar Observatory, allowing our instrumentation to be used at any of these observatories. The F/18 can also be used for photography at the Cassegrain focus and a camera system has also been dasigned.

Mechanical Design:

This telescope is designed for the convenience of the observer, in that the Naismyth focus remains near the same position (about 1.5 meters from the floor and near the center of the dome) regardless of where the telescope is pointing in the sky. Hence the observer will not have to climb ladders in order to reach the eyepiece at odd positions. The finder, guide telescope, and offset guider will also be

Figure 2. Sketch of the 20-inch telescope.



conveniently placed. There will be electric motor drives for both right ascension and declination setting, controlled from a single hand-paddle. Consideration is being given to the possibility of digital readouts and computer control. A sketch of how the finished telescope will appear is shown in figure 2.

(a) The Tube:

While usually the telescope tube consists of the entire mechanical structure from the primary mirror to the secondary mirror, in the present design, the conventional tube has been separated into two parts — the "tube" which houses the secondary mirror, and the "bucket" which houses the mirror cell. The tube is the circular upper section in figure 2.

There are three separate tubes for this telescope. These hold, respectively, each of the 3 optical configurations: the reflector-corrector prime focus camera, the F/8 secondary mirror, and the F/18 secondary mirror. To change from one configuration to one of the others involves interchanging tubes. Such an interchange should be possible in a relatively few minutes, (say less than ½ hour), and in essence gives three different telescopes for the price of one.

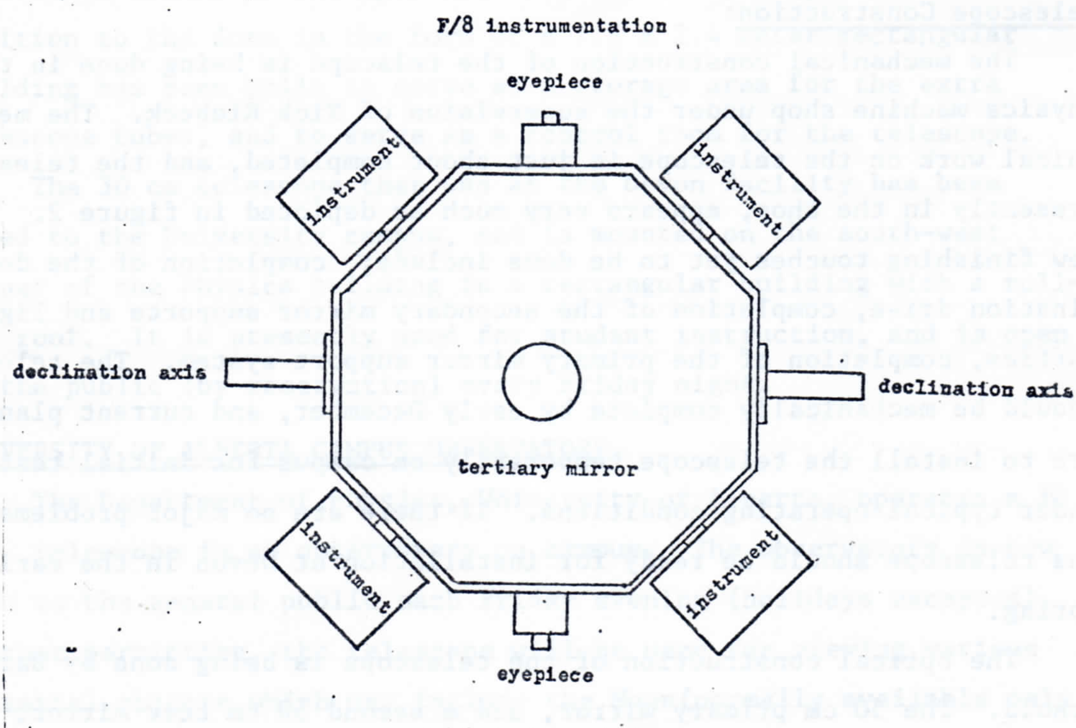
(b) The Bucket:

The bucket serves three purposes. It holds the mirror cell, it is the saddle to which the declination axis is attached, and it serves as a platform for the mounting of various instruments. The first two functions are obvious, but the third requires a little additional explanation. Figure 3 shows the bucket as seen end on. The bucket is an octagon. The declination axis is attached to two of the plates. Four of the plates are to be used for mounting instruments, while the final two will be used for eyepiece mounts. Finder and guide telescopes will be mounted on the eyepiece plates. In this way, up to four separate instruments can be permanently mounted on the telescope. The tertiary mirror (in the center of the bucket) can be rotated to any of the instruments or eyepieces, hence the telescope can be rapidly switched from one piece of instrumentation to another. Alternatively, the tertiary mirror can be removed entirely and replaced by the Cassegrain camera for photography.

(c) Fork and Declination Axis:

The declination axis, consisting of 5-centimeter steel shafts turning in two pairs of roller bearings, sits on top of a heavy cast aluminum fork. The fork is cast in one piece for stability, and

Figure 3. End view of the 20-inch telescope bucket.



weighs approximately 140 kilograms. A motor drive, coupled to the declination axis through a worm and 30-cm diameter wheel is used for setting the telescope in declination, and also serves as a declination clamp.

(d) Polar Axis:

The polar axis, a 10-cm diameter steel shaft, turns in two precision tapered bearings spaced about 61-cm apart. The sidereal drive is coupled to the polar axis through a worm and a 50-cm diameter precision wheel. These gears were purchased from Edward R. Byers. Also attached to this gear is a 50-cm setting circle with gradations every minute of time. A smaller gear, similar to the one on the declination axis, is used for setting the telescope in right ascension.

Telescope Construction:

The mechanical construction of the telscope is being done in the Physics machine shop under the supervision of Nick Riebeek. The mechanical work on the telescope is just about completed, and the telescope, presently in the shop, appears very much as depicted in figure 2. The few finishing touches yet to be done include: completion of the declination drive, completion of the secondary mirror supports and light baffles, completion of the primary mirror support system. The telescope should be mechanically complete by early December, and current plans are to install the telescope temporarily on campus for initial testing under typical operating conditions. If there are no major problems, the telescope should be ready for installation at Devon in the early spring.

The optical construction of the telescope is being done by Barry Arnold. The 50 cm primary mirror, and a second 50 cm test mirror, both purchased from Bourns Optical Company, have been ground and partially polished. The hole in the primary mirror is presently being ground. The F/8 and F/18 convex secondary mirrors have been ground and are ready for polishing. The basic optics (primary mirror, F/8 secondary, F/18 secondary, and flat tertiary mirror) should be completed by early next year. The photographic optics for the three camera systems will not be started until the basic optics are completed, and hence probably will not be completed for over a year.

The Observatory:

A few changes have been made in the observatory at Devon to accomodate the new telescope. A new pier has been installed for the telescope. The floor has been raised by about 46 cm to allow more convenient access to the eyepiece of the new telescope. A small addition to the dome in the form of a 1.8 x 2.4 meter rectangular building has been built to serve as a storage area for the extra telescope tubes, and to serve as a control room for the telescope.

The 30 cm telescope that was at the Devon facility has been moved to the University campus, and is mounted on the south-west corner of the Physics building in a rectangular building with a roll-off roof. It is presently used for student instruction, and is open to the public (by reservation) every Friday night.

UNIVERSITY OF ALBERTA CAMPUS OBSERVATORY

The Department of Physics, University of Alberta, operates a 30 cm. telescope in an observatory on campus. The observatory is now open to the general public each Friday evening (holidays excepted). Weather permitting, the telescope will be used for viewing various celestial objects which may include the Moon(normally available only one evening each month), Jupiter (beginning in December), Saturn (in the spring), double stars, star clusters and gaseous nebulae. In the event of cloudy weather, a slide or film show will be presented.

There is no admission fee, but only a limited number of people can be accomodated each evening. Reservations must be made in advance. For individuals or small groups contact the Public Relations Office at 432 - 4201 during normal working hours.

Large groups only (Scouts, Guides, schools, etc.) may be admitted at other mutually convenient times. Arrangements must be made well in advance by contacting Dr. D.P. Hube (432 - 5410) or Dr. J.E. Winzer (432 - 5033).

NON-TELESCOPIC OBSERVATIONS

So you don't have even $100 to invest towards a telescope. Does this mean that astronomy is not for you? Definitely NOT! Nearly everyone has a reasonably decent pair of eyes, many people also have binoculars and a camera. Properly used, this equipment will give you a fairly good idea as to whether or not astronomy is for you.

The whole key to non-telescopic observing is to LOOK UP WHENEVER POSSIBLE. This seems to be simply stating the obvious, but it certainly can't be over-emphasized. Most people know the beauty of a sunrise or sunset, and many look for a rainbow after a storm, but there are other sights in the heavens that can be just as inspiring. Some are very infrequent, others may occur every night.

Eclipses of the Sun and Moon are rare, but spectacular sights. (October 12, 1977 and February 26, 1979 are days when partial solar eclipses will be visible from Edmonton. The 1979 solar eclipse will total in Winnipeg, and surrounding areas. Lunar eclipses visible from Edmonton include a partial eclipse the evening of April 3, 1977 and a total eclipse September 6, 1979). Even more unreliable is the appearance of a bright comet, but Comet West, visible before sunrise early this year, proved to be an excellent naked eye/binocular comet.

During the night, other events and objects present themselves to view. The changing face of the moon regularly enhances the night sky. A display of the aurora borealis may appear at any time. Every hour 5 or 6 meteors appear for a few brief moments, but on certain evenings up to 50 meteors per hour may stream from a particular region of the sky. (Some of the more intense meteor showers that occur each year are: the Quandrantids - January 4, 40 meteors per hour; Eta Aquarids - May 5, 20 meteors per hour; Delta Aquarids - July 28, 20 meteors per hour; Perseids - August 12, 50 meteors per hour; Orionids - October 21, 20 meteors per hour; Geminids - December 12, 50 meteors per hour).

Acting as a backdrop to all this activity are the bright and faint stars that make up the various constellations. Knowing where these star groups are, their approximate shape, and where the brightest stars are in each is not only of general interest but is useful when describing where various celestial events were seen. Certain constellations and bright stars can be employed as skymarks against which the positions and motions of the various planets can be plotted. (Venus is currently in the west at sunset, Mars is too close to the sun, Jupiter is prominent in the east near the Pleiades, Saturn is visible just before sunrise. Mercury can best be seen in the east before sunrise near October 7 and in the west after sunset near April 10, 1977). The motions of the various planets are easy to see when they pass near a bright star or close to each other. The great speed of the moon also becomes apparent under similar circumstances. (Oct. 11 and Oct. 12 will see the moon west of Jupiter, then east of the planet.

This has been only a quick and incomplete series of ideas as to what can be seen with simple equipment. Many of the events described are fairly simple to capture on film. Watching these celestial events may help you decide whether or not you want to invest further time, effort and money in the subject.

ASTROPHOTOGRAPHY FOR THE AMATEUR

Ever since the 1840's, astronomers have capitalized upon photography's two chief advantages to science:

1. A photographic record of an object or event is more objective than a purely human recording.
2. A photographic plate or film can record objects no human eye can see, since during long time exposure the light hitting a film will build-up an image of an otherwise dimly perceptible object.

Photography is probably the most important research technique available to the professional astronomer. In the hands of the amateur, its stature changes from that of research tool to a means of simply producing very beautiful images of the celestial wonders of nature. To do this successfully, there are basic techniques used by every amateur astrophotographer.

A. The best all-around camera for astrophotography is the 35mm single-lens reflex. This type is compact, versatile and allows you to see in the viewfinder exactly what's going to be "seen" by the film.

B. The question of which film to use is somewhat more difficult to answer. Generally, whether it be color or black and white, a fast film (ASA 100 or higher) is the best. However, slow fine-grained high-resolution films have their place as well. If you're just beginning, stick with black and white film for your initial experiments, provided you're prepared to do your own processing. B & W film processing is very easy — it doesn't require a darkroom and will reduce your film cost considerably. TRI-X film at ASA 400 is the best general-purpose film for astrophotography. Load your camera with this film and shoot every sort of astronomical subject that you can. Make sure that you carefully record all pertinent data on each exposure and note the results. The mistakes are sometimes just as educational as the good photos. Once you're sure of your technique and basic data like exposure time for all the subjects you'll be shooting, then <u>and only then</u> should you move on to color film and more exotic varieties of B & W.

C. With a camera equipped with a normal lens (usually a 50 mm f/1.8 or f/2), a tripod, locking cable release, and some film, you're ready to start doing astrophotography.

Within reach of this basic setup are certain types of astronomical subjects like:

1. Aurora (5 to 30 sec. exposures)
2. Planetary conjunctions (¼ to 10 sec.)
3. Constellations (no longer than 15 to 30 seconds to avoid star trailing)
4. Bright comets (5 to 60 seconds)
5. Star trails (1 min to 1 hour exposures in a dark sky.)
6. Meteors (usually captured while taking star trail pictures.)

Adding a telephoto lens in the focal length range of 135 mm to 400 mm enables you to record solar and lunar eclipses. Unfortunately, these events will not be too common in this part of the world for the next couple of years. A wide-angle lens is also useful for pictures of star trails, aurora and constellations.

D. To graduate to a more advanced brand of astrophotography requires a telescope, one with an equatorial mount (as opposed to the simple altazimuth mount) and preferably with a clock or motor drive unit on the polar axis that drives the telescope at the same speed but in the reverse direction to the earth's motion, preventing the blurring or "trailing" of celestial objects over long exposures.

There are several ways to attach a camera to a telescope.

1. Afocal camera: This is a technique whereby the camera with its own normal lens is mounted so that it's "looking" into the telescope's eyepiece. The camera may be attached to the telescope itself via a special bracket or mounted on a separate tripod and aligned to the eyepiece. Typical subjects for this method are full disk images of the sun and moon, satellite configurations around Jupiter and Saturn, and lunar and planetary details at high magnifications. Exposures for these sorts of subjects are from 1/500 to 30 seconds. Exposures longer than 1/30 second or so require that the telescope be clock driven. This limits owners of non-driven telescopes to photography only of the sun and moon.

DO NOT ATTEMPT ANY SOLAR PHOTOGRAPHY WITHOUT TAKING PROPER PRECAUTIONS TO FILTER THE LIGHT. A solar filter that fits over the front of the telescope and not at the eyepiece end is the best type. Contact the Planetarium or the R.A.S.C. for advice on this.

2. Prime Focus Camera: Here we remove the camera lens and the telescope eyepiece and use the telescope's main mirror or lens as the photographic lens itself. The same sort of subjects listed under the afocal method are applicable here as well but the straight-through prime focus technique yields much better resolution. Some sort of camera-to-telescope adapter is required — something

that will slide into the telescope eyepiece drawtube at one end and screw or bayonet into the camera's lens mount at the other. Several manufacturers sell items like these for all kinds of camera makes. The Planetarium or R.A.S.C. can supply you with addresses of astrophotography accessory suppliers.

With the addition of more elaborate equipment, photographs of deep-sky objects such as star clusters and nebula can be made, but these require exposures of anywhere from 10 minutes to 1 or 2 hours. Over exposure times such as these it is necessary to manually "guide" the telescope to insure that it points to exactly the same spot in the sky throughout the exposure. Even with a motorized clock drive, guiding is still necessary because of factors like atmospheric refraction, machining errors in the motor gears and failure to align the telescope's polar axis directly on the north celestial pole. To perform the guiding exercise you need another telescope, perhaps a small refractor, attached alongside your main telescope on the same mount. The guide scope should be equipped with a special eyepiece that has illuminated cross-hairs. Another guiding method uses a small off-axis prism in the path of the main optics to pick a guide star just off the edge of the film frame.

With this array of apparatus, the photographer selects a fairly bright star in the guide scope that's close to the nebula or star-cluster he's interested in, puts the star on the cross-hairs and keeps it there for the duration of the exposure through a fine manipulation of slow-motion controls on both axes of the telescope. Needless to say, this is one of the most demanding areas of astrophotography, but one that can yield results rivalling that of professional astronomical photos.

3. Eyepiece Projection: For photographs of the planets and close-up areas of the sun and moon, considerably more magnification is required than is available using only the prime focus method. To achieve this sort of magnification, an eyepiece is inserted into the telescope-to-camera adapter in order to project its image directly onto the film. The shorter the focal length eyepiece and the longer the projection distance, the higher the magnification you get. To obtain images of the planets that are large enough to photograph, effective focal lengths of 10,000 to 50,000 mm are used with f/ratios of f/40 to f/300.

   Exposures with reasonably fast film are anywhere from 1 to 10 seconds. To insure sharp images of the planets or small sections of the moon, the atmosphere must be very steady and there must be absolutely no vibration transmitted through the telescope. Jupiter is the easiest planet to photograph, so use it as an initial test object for planetary photography. Lunar close-ups are a little easier since they usually don't require as much magnification.

4. Piggyback Photography: This variation again uses the camera with its own lens but instead of fixing it to a stationary tripod, the camera is attached to the side of the telescope tube with a suitable bracket. The trick here is to point the telescope/camera combination to a sky area of interest, say a particular constellation or section of the Milky Way, select a guide star visible in the telescope eyepiece, open up the camera shutter with the lens at about f/2 or f/2.8 and expose the film for several minutes to an hour or so. During the exposure the telescope is again guided both electrically and manually to prevent unwanted star trailing.

   Very faint objects can be recorded this way. The Milky Way, for example, can show up on a well-guided time exposure photo as a blaze of glowing cloud stretching across the sky. For any long exposure of faint stars, deep-sky objects and the Milky Way, you require a dark observing site well away from the glare of city lights.

For more detailed information on this subject, here are a few recommended sources.

Brown, Sam; <u>All About Telescopes</u>; Edmund Scientific Co., Barrington, New Jersey, 1975. (contains a fairly comprehensive section on adapting your camera and telescope for photography.) This book is available at the Planetarium bookstore for $3.75.

Paul, Henry; <u>Outer Space Photography for the Amateur</u>; Sky Publishing Corp., 49-50-51 Bay State Road, Cambridge, Mass. 02138 Cost: $9.95.

"Astronomy" a colorful monthly magazine featuring a regular department for astrophotography. Available on a yearly subscription basis for $15.00 from Astro Media Corp.; 411 E. Mason St., 6th Floor, Milwaukee, Wisc. 53202.

Plus: The public library has a large section devoted to astronomy containing several titles dealing with astronomical photography.

The monthly R.A.S.C. meetings often deal with the techniques and results of amateur photographers. Several R.A.S.C. members are active in this area and would be glad to assist you as you get started in this challenging pursuit.

VARIABLE STAR OBSERVING

There are many fields of endeavour that an amateur astronomer can pursue. One of the more rewarding of these is the observation of variable stars. While most stars shine with a constant brightness, there are some stars that, because of an instability within the star itself, change in brightness either in a regular (periodic) or irregular manner. The character of the variations provide clues to such quantities as age, mass, radius and structure of the star. The periodic variables, behaving in a predictable manner, have been thoroughly observed by professional astronomers. The irregular variables, howyver, are unpredictable and require frequent monitoring. In most cases systematic observations of these stars are too time consuming to be undertaken by professional astronomers, yet can be productively observed by the amateur.

By watching these irregular or semi-regular variables in an organized manner, amateur astronomers make a significant contribution to astronomy. The observation of these variables is co-ordinated by the American Association of Variable Star Observers (AAVSO). AAVSO provides finding charts of suitable variables, instructions for observing, and serves to compile the observations of many amateurs and make them available to professional astronomers.

To observe variable stars, only a minimum of equipment is necessary. Often a pair of binoculars is sufficient although possession of a telescope greatly adds to the number of variables that can be observed. The techniques for observing a variable star are also simple. First, the star is located and identified using finding charts provided by the AAVSO. The brightness of the variable is estimated by comparing it with several other stars of known brightness (listed on the observing chart).

The time and date of the observations are recorded. This data is then compiled on a report form and sent to the AAVSO headquarters for processing.

To illustrate the need for amateur observations of variable stars, consider the case of the variable star R.U.CAM. This star was, for many years, well known as a periodic variable. Then, in 1965 it was found to have stopped varying...an event totally unprecidented for a periodic variable star. This discovery caused a flurry of excitement among professional astronomers and for several years it was the object of close scrutiny. But, as nothing significant was happening, interest wained. Some two years ago a set of observations in November showed it to be varying almost normally, but when the observations were repeated the following April, it had stopped again. What is it doing now? If you want to find out you'll have to observe it yourself. A finding chart has been provided. This particular star is only one of the many interesting variable stars in the sky.

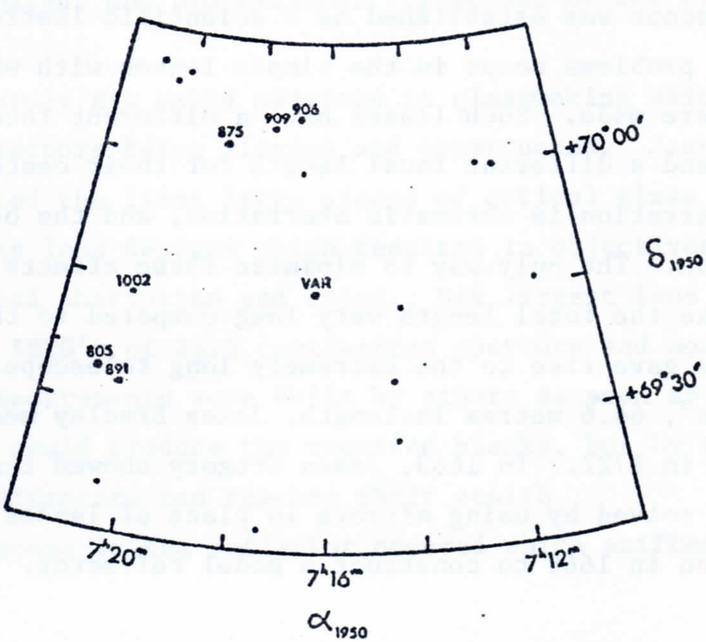


Fig. 1. Finding chart for RU Cam showing stars to

TELESCOPE MAKING

HISTORY AND DEVELOPMENT

The first reference to the properties of lenses and mirrors with specific mention of magnification occurs in the Kitab al-Manazir by the Mohammedan scientist Alhazen (965?-?1039). The work of Roger Bacon about 1250 indicated that he knew enough of the properties of optical components to construct a telescope but he did not construct any model that historians know of.

The first telescope patent recorded was filed on October 2, 1608 by Hans Lippershey of Middleberg, Holland. The extent of official excitement over this new device may be appreciated by noting merely that the patent was denied. However, in 1609 Galileo Galilei, an Italian scientist constructed a rudimentary telescope having a magnifying power of 3 diameters. During the next year he built two more, the best having a 40 millimeter aperture with a magnification of thirty-three diameters. After 600 years of theoretical possibility, the telescope was established as a scientific instrument.

Two problems occur in the simple lenses with which early telescopes were made. Such lenses have a different focal length for each colour, and a different focal length for their center and edge. The first aberration is chromatic aberration, and the other is spherical aberration. The only way to minimize these effects in simple lenses is to make the focal length very long compared to the diameter. This principle gave rise to the extremely long telescope. With an "aerial telescope", 64.6 metres in length, James Bradley measured the diameter of Venus in 1722. In 1663, James Gregory showed that the problems could be solved by using mirrors in place of lenses and it remained for Newton in 1668 to construct a model reflector. The reflecting telescope has no chromatic aberration even when focal lengths are short compared with their diameter because light is reflected at the same angle regardless of its colour. Newton's reflector had a concave mirror which directed star-light in a converging beam back along its axis where it was intercepted by a small flat mirror and sent out to the side of the telescope tube to an eyepiece. Newton made his mirrors of speculum metal which was brittle and subject to tarnish but when freshly polished reflected fairly well.

The optical system of the refractor possessed the great advantage that no metal surfaces were present to tarnish and thus, once properly finished required no attention for years. When John Dolland demonstrated his achromatic lens (1758), a 15 centimetre telescope which a hundred years earlier was necessarily 45 metres long, could be made only 1.8 metres long and the refractor enjoyed a great increase in popularity. The small refractor (8 to 15 centimetres diameter) became the amateurs telescope; indeed no clear distinction exists between amateur and professional telescopes of the 1700-1800 era.

The next century saw rapid advances in glassmaking which resulted in larger refractors being planned and constructed. Joseph von Fraunhofer produced the first large pieces of optical glass of fine quality as well as lens designs which resulted in objectives nearly free from spherical aberration and color. His largest lens was completed in the 1820's of 23.5 centimetres aperture and mounted at Dorpat. Larger instruments were built by others as soon as the glass industries could produce the required blanks, but by the end of the century refractors had reached their zenith.

Two developments in the reflector occured which shifted the advantage back to mirrors after a hundred years of lens supremacy. In 1858, Leon Foucault invented a method of testing telescope mirrors in the shop. The poor reflectivity of speculum metal, especially after tarnishing, was overcome in about 1860 when Liebig invented the process of silvering glass. The new technology of the glass industry was soon applied to casting of large glass discs and by the turn of the century, the modern astronomical telescope took its final form. Professional astronomers today use a variety of instruments, the largest of which are reflectors used in several configurations adapted to specific jobs.

THE AMATEUR'S TELESCOPE:

Present day amateur astronomers use a wide variety of instruments. Small telescopes available today range from 6 cm to 15 cm refractors, reflectors from 10 cm to 40 cm and 9 cm to 35 cm compound models. The larger of these telescopes made commercially costs thousands of dollars. Many amateurs construct their own telescopes and it is entirely practical to do so. As well, only an amateur can afford the time required to obtain the precision necessary for perfect performance. Beginners most often build Newtonian reflectors 15 to 20 cm in diameter as their first effort. Kits which contain everything needed to grind and polish the mirror for such a telescope are available but some prefer to obtain the required materials separately. In any case time is the major investment and no one should expect to finish a telescope quickly. The Royal Astronomical Society of Canada, Edmonton Centre, has an active telescope making group which offers instruction to beginners and encouragement to those already bitten by the telescope bug.

AMATEUR TELESCOPE MAKING (in a non-metric world)

The motives that drive an amateur to build his own telescope are many -- for some it is the cost factor, for others it is the challenge, while for others still it is the desire for some exotic design. But whatever the motive, a very large number of amateurs have undertaken, and have successfully completed, the construction of their own telescope.

This article is intended to present the prospective telescope maker with a brief account of what is involved in making a telescope as an aid in helping him make that all important decision -- whether or not to build a telescope. But please do not consider this as the only source of information on telescope making. There are a number of books on telescope making in the public library, but a word of caution -- while some books are very helpful and informative, there are others that are hopelessly complex. Read several to get a more general view. Highly recommended is the book Making Your Own Telescope by Thompson (Sky Publishing Corp.). Talk to people that you know who have built, or who are building telescopes. Attend the meetings of the local telescope makers group which meets alternate Saturday mornings at the University.

Type of Telescope:

Of the three types of telescopes -- the reflector, the refractor, and the catadioptric -- only the first, the reflector, lends itself to amateur construction. Both the refractor and catadioptric require the polishing and figuring of several optical surfaces, and the spacing and thicknesses of the optical elements are critical. In the reflector, whose optical configuration is shown in figure 1, only one surface must be optically figured (the small flat mirror is usually bought separately), and the spacings and thicknesses of the optical elements are not critical.

Size of Telescope:

Kits for making reflecting telescopes are available in several standard sizes: 4¼-inch, 6-inch, 8-inch, 10-inch, and 12½-inch. The size refers to the diameter of the mirror and will be the aperture of the completed telescope. The optimum size for a first attempt is a 6-inch, and most first telescopes are of this size. However, it is definitely not suggested that you make anything larger than 8 inches as a first telescope. A 12½-inch requires at least 10 times as much work as a 6-inch, and were you to start with such a large telescope, it probably would never get completed.

Focal Ratio of the Telescope:

The focal ratio of a telescope is a measure of the total length of the telescope. The focal length is simply the focal ratio (F/number) times the diameter of the mirror. For example, a 6-inch F/8 has a focal length of 8x6 = 48 inches. The focal ratios (F/number) are similar to those used in photography. A fast telescope (low F/number) is best for photography and for viewing nebuleous objects, but requires considerable work to grind the deep curve on the mirror, and is much more difficult to figure. A slow telescope (high F/number) is best for planetary observations and high magnifications, and is easy to make, but the tube is long and awkward. For example, a 6-inch F/20 will require a 10 foot long tube. The best compromise is in the range of F/5 to F/8 for a 6 or 8-inch telescope.

Materials Needed:

It will be necessary to obtain a mirror kit of the proper diameter. Such a kit contains a mirror blank, grinding tool, abrasives pitch for the polishing lap, and polishing compound. You will have to supply a barrel, stand, or table on which to grind the mirror, and a few miscellaneous items such as newspaper, water and a bottle to hold it, a tin can for melting pitch, scrap pieces of glass, etc. You will also have to make a simple stand for holding the mirror while testing, and simple testing device. With these, you can produce a mirror for a telescope.

However, the mirror is only part of a complete telescope. You will also need components for the tube and mount. Some of these can be made from surplus materials, while others are probably best purchased. Two items that almost definitely will have to be purchased are the flat diagonal mirror, and one or more eyepieces. Items such as a mirror cell, eyepiece holder, diagonal holder, finder telescope can either be made or purchased. The tube and telescope mount will almost definitely have to be constructed, but these can often be built from surplus wood, pipe fittings, car parts, etc.

Cost of the Telescope:

A very important question is just how much is this project going to cost. For discussion purposes, we will consider a 6-inch F/8. A medium quality commercial instrument of this size will cost over $500.00 by the time customs duties and shipping charges are paid. A kit for a 6-inch telescope is only about $30.00. If a flat diagonal mirror is also purchased at a cost of about $20.00, and two eyepieces for about $50.00, and everything else is built from scrap materials or scrounged, a 6-inch telescope could be built for about $100.00, or about 1/5 the commercial price. More likely, other components such as eyepiece adapter, mirror cell, and miscellaneous materials for tube and mount will be purchased, so the cost will probably run closer to \$200.00 by the time the instrument is completed.

Work Involved:

The construction of a telescope is not something that you can start Friday night and have completed by Monday morning (unless that Monday morning is about a year later). Grinding and polishing will take from 50 to 100 hours of spare time (say 3 months). Building the tube and accessories and mount will take at least as long. The work involved is not hard physically, nor does it require particularly great mechanical ability or extensive machine shop facilities. The average person should have no serious problems in building a telescope. The following description will provide some idea of the work involved.

The first step is to grind the mirror. The grinding process generates the curve on the mirror. Typically this curve is only a few hundredths of an inch deep, and is quite easily produced. To initiate the grinding operation, about a teaspoon of the coarsest abrasive is sprinkled on the tool (second blank) along with some water. The mirror is moved back and forth over the tool while applying maximum pressure with both hands. In a few minutes, the abrasive will be exhausted and fresh abrasive must be applied. This process is followed until the desired curve is generated and will take typically 5 to 10 hours of grinding. Once the curve is generated, the deep pits from the rough grinding operation must be eliminated. This requires grinding with successively finer abrasives. When the mirror has been ground with the finest abrasive, it is ready for polishing.

Before the polishing operation is begun, it is necessary to make a pitch lap. This is formed by pouring a layer of pitch on the grinding tool, and serves to carry the polishing compound yet yield slightly to the surface of the mirror. The pitch lap is charged with polishing compound and the mirror is rubbed across the lap, with little or no pressure, until it is free of pits. This operation will take several hours.

The final step is figuring. At the end of polishing, the mirror should be spherical but it is necessary to change this sphere into a parabola. The figuring is actually just a continuation of the polishing operation, but here, instead of trying to polish out the pits of the grinding operation, you are trying to change the shape of the mirror very slightly (a few millionths of an inch). Once the mirror has the correct figure, it is complete, and need only be aluminized before it can be put into operation.

The telescope is still far from completion at this point. The mirror must be mounted in a tube, and the tube mounted such that it can be pointed anywhere in the sky. Tubes can be obtained from various sources. Commercial fiberglass or aluminum tubes are available at prices ranging from $50.00 to $100.00. However, the ingenious telescope builder can usually improvise something far cheaper: a cardboard tube such as is used for concrete forms, a sheet metal tube similar to stove piping, a square tube cut from scrap plywood, etc.

Telescope mounts can be made from surplus pipe fittings, scrap wood, etc. Some arrangement such as shown in figure 2 is necessary. Two axes are necessary: one axis, called the polar axis, is for moving the telescope in an east - west direction, while the other, called the declination axis, is for moving the telescope in a north-south direction. The telescope tube is attached to the declination axis, while the polar axis is attached to some sort of stand or tripod which will support the whole telescope.

The telescope is now completed. One problem, however, with making your own telescope is that it is never <u>entirely</u> complete. You will always be adding to it -- different eyepieces, a clock drive, setting circles, a guide telescope, etc. But this is also an advantage, as a home-made telescope is meant to be a custom instrument and is normally made to suit the builder's observing requirements, and be changed as these requirements change.

Probably the greatest satisfaction from building a telescope comes from actually using it. The observational uses of a 6-inch telescope are virtually unlimited: the sun, planets, Messier objects, variable stars, astrophotography - many of these uses are discussed elsewhere in this publication.

Figure 1. Sketch of the optics of a 6 inch reflector.

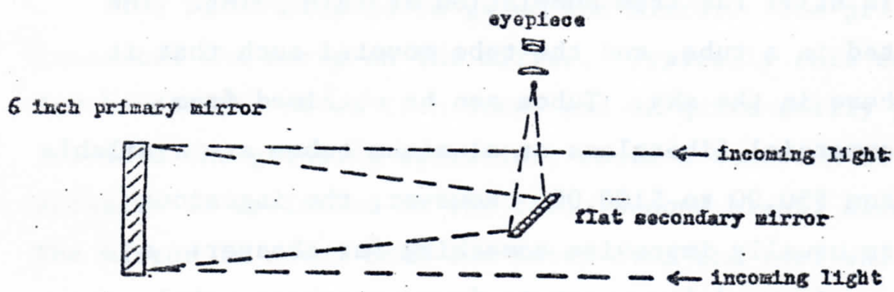
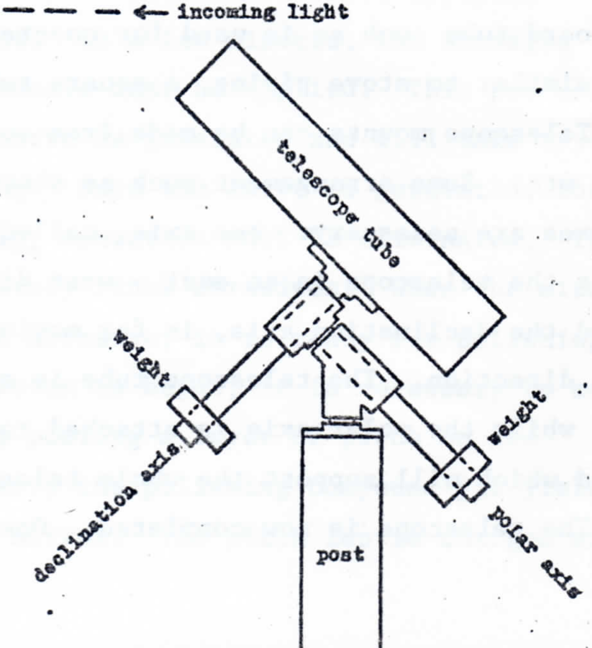


Figure 2. Sketch of a possible mount made from pipe fittings.



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- Journal of the R.A.S.C. (published bi-monthly)
- STARDUST (published 11 times each year by the Edmonton Centre)
- Free admission to Planetarium programs upon presentation of membership card.

For further information, please call the planetarium at 455-0119

or write: TREASURER, Edmonton R.A.S.C.
c/o Queen Elizabeth Planetarium
10th Floor, C.N.Tower
City of Edmonton

The organizing committee of STARNIGHT, the members of the Edmonton Centre of the R.A.S.C. and the staff of the Queen Elizabeth Planetarium hope you have enjoyed STARNIGHT '76. The next regular meeting of the R.A.S.C. will be Monday October 18 at 8:00pm at the Planetarium. Future meetings will be held at the same place and time, but every second Monday of each month. Hope to see you there.

COURSES IN ASTRONOMY

This fall, the Queen Elizabeth Planetarium is offering Public Evening courses in Astronomy starting in the first week of October.

Section	Location	Date	Duration
Adult Intro	11507 74Ave	Oct 5/76	8 weeks
Adult Intro	Nature Centre*	Oct 6/76	8 weeks
Student (6-12)	Nature Centre*	Oct 2/76	6 weeks
Adult Advanced	11507 74Ave	Oct 7/76	6 weeks

*Nature Centre is located in Fort Edmonton Park.

Further information is available at the Planetarium reception desk, or by phoning the Planetarium at 455-0119.

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