NATIONAL NEWSLETTER

December 1975

Robert Pike was camped on a small granite island in Lake Weslemkoon, 30 miles NE of Bancroft, Ontario, when he was surprised to notice an extra star in Cygnus. He took this picture of Cygnus and Nova Cygni 1975 using a 28 mm f2.5 lens and TRI-X 35 mm film developed normally (ASA 400). This exposure was hand-guided for five minutes with the camera clamped to a rather crudely mounted equatorial telescope. The exposure was made at 3:30 UT on Sunday August 31, 1975. (Roughly 1/3 of the 35 mm frame is reproduced here.—Ed.)

NATIONAL NEWSLETTER

DECEMBER 1975

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

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.

Editorial

We have always felt that it is best to keep editorial comment in a publication like the *NATIONAL NEWSLETTER* to a minimum. Hence, Editorials, such as this one, have been rare in recent issues. However, there are a number of special aspects of this issue that we feel should be commented on.

First, this is the last issue for 1975. We hope every member has enjoyed reading the *NEWSLETTER* as much as we have enjoyed producing it. To all those many members who have helped in any way with this year's volume, many thanks for your interest and assistance.

This is also the last issue to be published under the capable guidance of Dr. Ian Halliday, as Chairman of the Society's Editing Committee, to which the Editors of the *NEWSLETTER* report. Dr. Halliday has been a member of the Society for about twenty-five years and has served in many capacities at both the local and the National level. He became Assistant Editor of the *JOURNAL* in 1964 and Editor in 1970.

We feel that all members owe Dr. Halliday a hearty note of thanks for the countless number of hours he has spent on our behalf. Thank you, Ian, and best wishes for the future.

With the next issue, Dr. Lloyd Higgs of Ottawa will become the *JOURNAL*'s editor and, as such, the Chairman of the Editing Committee. We wish to extend to Dr. Higgs a warm welcome.

Also with the next issue, we hope to begin introducing a number of changes in your *NEWSLETTER*. Watch for them, and drop us a line if you have any comments. (We might even publish your letter, and reserve the right to reply!)

In closing, the Editorial Committee of the *NEWSLETTER* extends to all members and their families our best wishes for a very Merry Christmas and a happy and prosperous 1976.

Calgary 1976!

The Exhibits Committee for the 1976 General Assembly to be held in Calgary has not been idle during the summer. By the end of August requests for entry forms have been received from four provinces and outside of Canada as well.

We would like to ask those who are planning to participate in the Exhibits Competition to send for their entry forms early, since this would give us a good idea of the volume of projects to expect for the General Assembly. And remember, the entry forms are accompanied by more information on the categories.

At this time the committee is also announcing another award: this one based on Centre participation. To determine this award, the first place in each category will be given a value of five points, second a value of three points, and third a value of one point. A plaque will be suitably inscribed and presented to the Centre with the members who in total receive the largest number of points.

For more information about the contest, refer to the *NATIONAL NEWSLETTER* in the June, 1975 *JOURNAL*.

Keep the entry form requests coming!!!

DUNSTAN PASTERFIELD
ULRICH HAASDYK
Exhibits Committee

Due$ Due

All members are reminded that their 1976 fees were due October 1, 1975. Members of Centres should remit directly to their Centre's Treasurer; unattached members should send their fees to the National Office, 252 College Street, Toronto, Ontario, M5T lR7. Please include your new postal code.

Fees are $12.50 regular and $7.50 for students *under the age of 18 years* as of October 1. As well, some Centres have special fees in addition to the above. Consult your local Treasurer for details.

Treasurers of Centres are reminded that all membership fees received up to December 31 must reach the National Office by January 15 in order to permit membership lists to be updated in time to mail the February *JOURNAL*. It will not be possible to retain membership and receive the publications of the Society unless such fees are received by January 15.

Nominations for RASC Executive, 1975-1976

The By-Laws of the Society provide for a Nominating Committee composed of the three surviving immediate Past Presidents, whose duty it is to prepare a slate of candidates for the offices of the Society.

Next May, we must elect the following officers: President, 1st Vice-President, 2nd Vice-President, Treasurer, Recorder, and Librarian. If any member wishes to make suggestions in this regard, he should contact the Committee Chairman, Dr. J. D. Fernie, c/o The National Office, 252 College Street, Toronto, Ontario, M5T lR7.

As well, the By-Laws provide that "any five members of the Society, in good standing, may nominate additional candidates for any office, provided that such nomination, accompanied by a letter of acceptance from the nominee shall be received by the Secretary of the Society, not less than sixty days before the date of the annual meeting."

It would be appreciated if any such nominations were submitted no later than March 1, 1976, in order to allow for the printing and mailing of ballots.

Full details pertaining to nominations are outlined in By-Law 1, Article 11(a), as published in the June, 1969 *JOURNAL*, pages 155–168.

Computer Ray Tracing for Amateur Telescopes

Using a set of optical ray-tracing algorithms presented in Smith's *Modern Optical Engineering*, the author last spring wrote a computer programme in ALGOL-W for the study of lens and mirror systems. With the financial assistance of the Dynamic Graphics Project at the University of Toronto, a number of representative amateur telescopes were schematically analysed in detail.

Over the summer, this programme's lens-tracing routines were translated into "C" to run on the Dynamic Graphics Projects PDP-11/45 under the UNIX time sharing system. This allowed the use of high resolution "state of the art" graphic display units which provide about a 20-fold increase in resolution over the ALGOL programme's line printer output. The illustrations presented here are photographs of the display.

At present, the ability to trace mirrors and aspherical surfaces is not available in the

TABLE I

OPTICAL PARAMETERS FOR LENS SYSTEMS

	Surface	T	R	N	r
System A:	1	0	773.1	1.5195	100
f/12	2	20	–1159.7	1.623	100
200 mm aperture	3	20	3752.4	1.00	100
System B:	1	0	1159.7	1.5195	100
f/12	2	20	–773.1	1.623	100
200 mm aperture	3	20	–6071.4	1.00	100
System C:	1	0	981.2	1.5153	100
f/12	2	20	–981.2	1.6214	100
200 mm aperture	3	20	∞	1.00	100

T : distance back from the previous surface (mm).
R : radius of curvature (+ in direction of rays).
N : index of refraction behind the surface.
r: aperture radius (D/2).

"C" programme, which somewhat restricts the range of study. However, there still remains an enormous number of possible systems to investigate. The references made here to parabolic mirrors will be taken from results of the ALGOL programme. Due to restrictions of hardware (i.e. insufficient available memory), it is unknown when the "C" version will be able to handle a general optical system.

A series of achromats and parabolic mirrors at focal ratios of 5, 8 and 12 were tested with the programmes. For brevity, and in consideration of what is expected of a doublet lens, we will here be concerned primarily with the f/12 systems. Arbitrarily, the apertures were set at 200mm (approximately 8″) but, as the programme does not consider interference in the images, this has no significant effect upon the results – one must simply look at the calculated images with respect to the theoretical resolution of the aperture.

One immediate problem was to find a lens design which would be well corrected for both colour and spherical aberration and be reasonably simple for an amateur to construct. It was decided to test the three basic achromat designs given in *Amateur Telescope Making, Book One* (Table 1). Unfortunately, as it turned out, the lens best suited for visual work (System C) involves a plane surface which is difficult to fabricate. Of course, for a parabola, both design and construction are straightforward.

These systems were then tested using the programmes. All three lenses had some residual spherical aberration, but in system C the amount was negligible. In interpreting the programme's output, of course, it is assumed that the lens-maker will produce optically perfect surfaces. By "parabola" it is implied that the mirror is *exactly* paraboloidal (that is, after all, what one strives for) and *not* one within ¼ wavelength. The image changes off-axis produced by non-ideal surfaces may be studied in the future.

However, counter to this restriction runs the possibility of aspheric lens surfaces produced by the amateur. This does not imply that the amateur designs his lens with these higher-order corrections, but rather that they come about simply during the figuring process. If the lens is found to be over-corrected in the centre, then the figuring process will flatten out the curve, producing a non-spherical surface. For visual work, this is always desirable but may not be in photographic work (see Figure 2 and the text later on). In the general case, though, this will not deteriorate the off-axis images significantly.

Axial aberrations were absent, of course, in the parabolas (for an excellent discussion on the nature of the parabolic images see W. Weller's article in this issue. The reader should convince himself that results with parabolic mirrors apply equally to classical Cassegrains, but *not* to Dall-Kirkham Cassegrains because of the ellipse-sphere combination of surfaces). The third lens design (System C), involving an equiconvex crown lens and a planoconvex rear flint element, was nearly perfect on axis for spherical aberration and compared favourably with parabolas off axis, as well. System B, intended for photographic work, had fairly poor axial correction but had images comparable to parabolas up to 5° off axis. System A is just bad!

The parabolas are best corrected in all respects, as is to be expected. It is worth noting that catadioptric (lens-mirror) systems such as Schmidt-Cassegrains can outperform parabolas off-axis, producing near-perfect images 5° or more off the optical axis. System C performed just as well as the parabolic mirrors compared to lenses. The lenses have spherical surfaces (in the programme, at least – remember the lens-maker will produce a strange set of curves in figuring the lens) so a bundle of rays approaching at an angle sees a lens which is still essentially a sphere. Parabolas are only symmetric about one axis (the optical axis), so off-axis rays see a very strange shape. The result of this is an abrupt change in the nature of the comatic images about the focus. This change is so striking in my 6″ f/5 Newtonian that it is fine enough to determine the focus using only off-axis images. One feature shows up in these comatic images which is of particular interest. A parabola (the conic section as opposed to the parabolidal figure of revolution) is really a shape only defined by an eccentricity of exactly 1.00. If it is viewed from an angle instead of straight on, it still appears as an ellipse from the side. Because of this, off-axis rays meeting a paraboloidal surface in a plane perpendicular to the angle of rotation (i.e. the off-axis angle) meet a section of the surface which is itself a parabola (this is an approximation which is really true only in the limit of small angles but it is a very good one out to 10° or so). However, this section has a longer focus, by a factor of the secant of the off-axis angle, so that in the comatic image at the plane of best axial focus these rays have not yet focused but instead form a very evident straight line through the "head" of the coma. This line is easily seen in very fast (f/4 or f/3) parabolas about a degree off the optical axis and becomes more evident, due to the secant factor, as the off-axis angle is increased.

The skeptical reader will probably have commented by now that eyepiece fields are very rarely larger than 2°, corresponding to off-axis angles of 1° at the edge, so much of this discussion seems somewhat irrelevant. However, in a parabolic system, the images 1° off-axis are already *twenty times larger than the theoretical limit of resolution at f/12* – independent of the aperture of the system. This result (which is "experimental" in the sense that it comes from the programme), when combined with the observation that the actual size of the comatic image seems independent of focal length, leads to the conclusion that this factor of 20 is proportional to 1/f, the focal length, so that the situation is much worse in fast systems, which also tend to have larger fields. The trend of this tortuous logic is to establish the apparent fact that accuracy of collimation, or the allowable deviation from all optical elements on the same optical axis, becomes more stringent by a factor of $1/\phi^2$ where ϕ is the focal ratio. But Nature has not finished playing cruel tricks. The ease of collimation goes as ϕ, so that one may express the "agony of collimation" as being proportional to $1/\phi^3$. Herein lies what is probably the most directly applicable result of running the programme – *collimation is very critical*. Those who judge the telescopes at Stellafane have commented that they very rarely see a telescope in proper alignment. From my own experiences, it is quite easy to detect a deterioration of the image in an f/8 system only 5 minutes of arc off the optical axis.

Of course, these arguments refer to visual work primarily. For photography, in which the images on the film are typically on the order of 0.1 mm, an f/12 system should perform adequately to about 2½° off axis for a 5° field. At f/5, the maximum field is only about 2°. A pertinent consequence of the constancy of the comatic image size is that, since the image scale in a long system is larger, the coma and other aberrations are smaller relative to the image. This, of course, is why lenses are made around f/10 or longer, and why high resolution telescopes are always made long focus, even though a short focus ideal system should perform just as well.

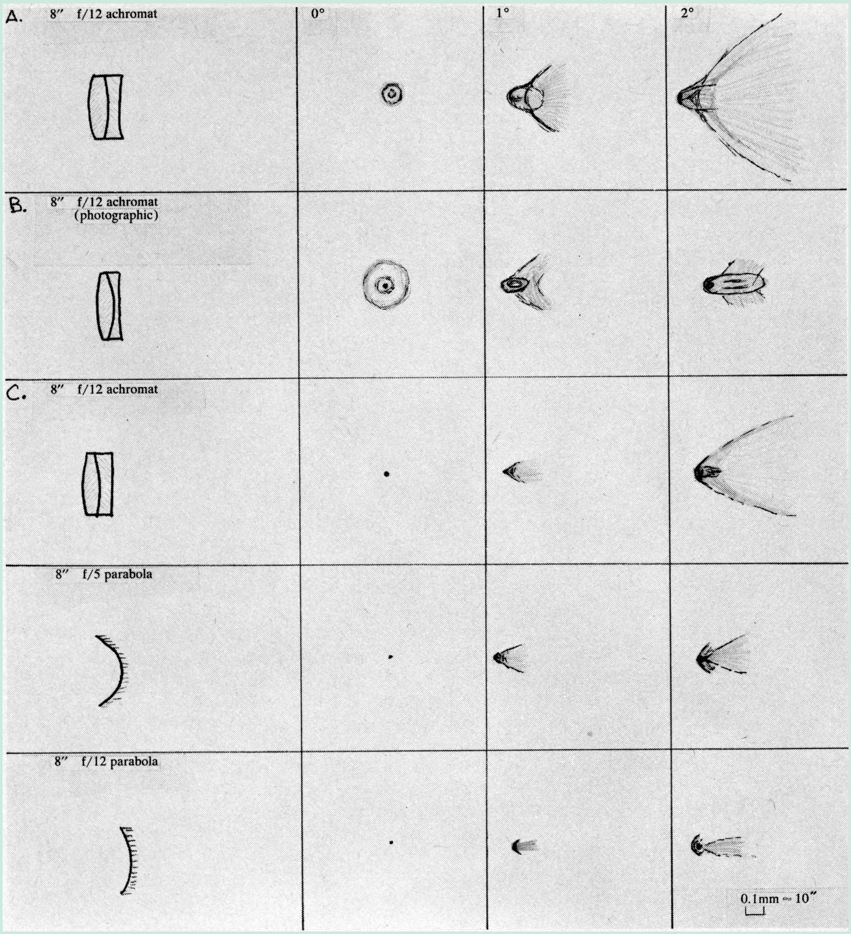


FIG. 1—A comparison of tlae systems tested by the programmes at 0°, 1° and 2° off axis

FIG. 2—A series of traces of System C.

	Distance past focus (mm)	Off-axis angle (°)	Box width scale (mm)
a	–0.5	0	0.1
b	0.0	0	0.1
c	+0.5	0	0.1
d	–0.5	1	0.5
e	–1.0	0.5	0.5
f	–0.5	0.5	0.5
g	0.0	0.5	0.5
h	+0.5	0.5	0.5

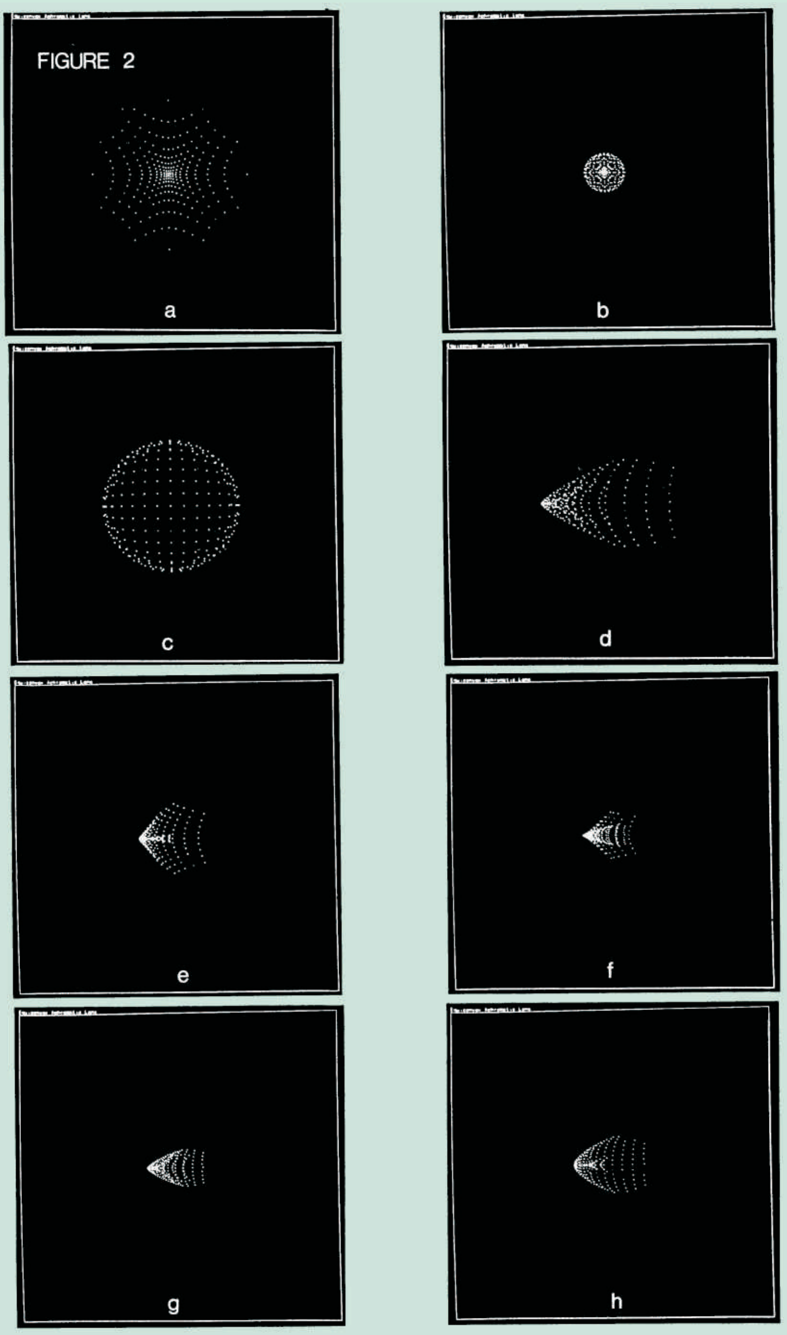


FIGURE 2
a
b
c
d
e
f
g
h

The diagrams should solidify some of these concepts. Figure 1 shows a comparison of the three lenses and an f/12 and f/5 parabola. Note the tremendous difference in the appearance of the images. The parabolas clearly have the cleanest images, but they are still quite poor off-axis. System C is tested much more thoroughly in Figure 2, since it is the best lens of the three. System A is so poor as to be unworthy of discussion. System B is intended for photographic work. The axial images are poor. The off-axis images have strange shapes but manage somehow to be about the same size. Comparison of the 2° image with the rest of the systems should bring this interesting feature out.

Figure 2 is a succession of traces at various off-axis angles and distances from focus. Figures 2a, 2b, and 2c show the appearance of the image from 0.5 mm inside to 0.5 mm outside of the focus. These diagrams (the boxes in which they are drawn) are 0.1 mm on a side. This I will call the "scale" of the picture. The apparent curvature of the images, especially in 2a and 2c, is the appearance of negative spherical aberration. With positive spherical aberration, 2a and 2c would be interchanged. Figure 2d shows the image 1° off-axis 0.5 mm inside the focus at a scale of 0.5 mm. Compared to 2a or 2c the image appears about the same size here but the scale is 5 times as large, thus so is the image. The images 1° off-axis in the focal plane are little better. This is one reason why it is difficult to focus a badly aligned system. Figures 2e to 2h show, at a scale of 0.5 mm, the appearance of the image ½° off-axis from 1 mm inside focus to 0.5 mm outside focus in steps of 0.5 mm. Two degrees off-axis the image appears similar to 2d, but it is roughly twice as large. Five degrees off-axis, the lens has essentially stopped forming an image.

It is perhaps unfair to be overly critical of the image in amateur telescopes – they certainly suit our needs. However, by using sophisticated optical systems, excellent images may be obtained well off axis. This is demonstrated by the spectacular wide angle photographs taken with Schmidt cameras. For amateurs, though, the aspherical surfaces involved are rather difficult to make.

Well, how much of this applies to the amateur observer or ATM? The most obvious fact is that collimation is critical. An f/8 telescope shows noticeable image deterioration only 5 minutes of arc off the axis, and so should be aligned at least that accurately. Very few observers are careful enough about this point. For the maker of telescopes, a mirror cell capable of holding the objective that accurately becomes a necessity – it is not too difficult, but most commercial cells do not perform adequately.

Also of interest is that axial aberrations become magnified off axis – the old ¼ wave rule may be sufficient in the centre of the field but breaks down towards the edges and in telescopes which will be used for photography.

I hope in the near future to update and improve the programme so that I can take a look at some catadioptric telescopes using only second-order curves. Everything in a single element telescope seems so critical that one is led to believe there must be a better way! However, it seems at present beyond the reach of most amateurs and their pocketbooks.

I would like to extend thanks to Ronald Baecker, Thomas Horsley and the other members of the Dynamic Graphics Project for their financial and moral assistance and to Richard Berry who showed me the ray-tracing algorithms.

Those interested in receiving further information about the "C" programme itself should write me at the address below for a copy of the documentation. The source is neither readable nor thoroughly debugged but performs well if you're nice to it.

2515 Merrington Crescent
Mississauga, Ontario L5K 2B8

ROBERT PIKE
Toronto Centre

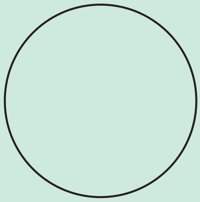
Conic Sections

How often have we heard the term "conic section" in telescope making? How often have we said "conic what?!" That's what I thought.

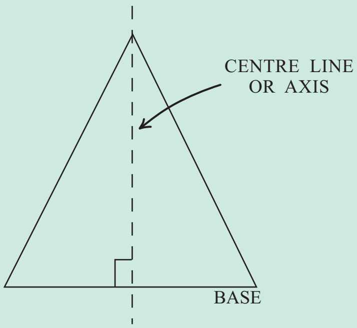
For those of us who are not well versed in mathematics, but who would like to know what people are talking about when they go off on tangents about parabolas, hyperbolas and so forth, I offer this confusing description.

1. The Cone

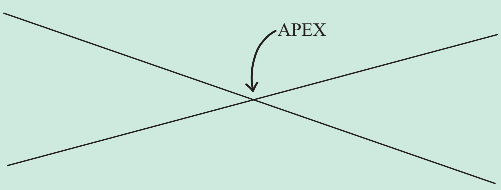
There are many types of cones found in nature (pine, ice cream etc.) , but the cone in which we are interested is the right circular cone. The ice cream cone, in fact, is an example of a right circular cone. If you look at an ice cream cone end on you see a circle, like this:



This is where the “circular” part of the name comes from. When you look at the cone from the side you see this:



The right angle (90°) between the base and the centre line is where the “right” part comes from. When we discuss conic sections we will need two cones joined to point like this:

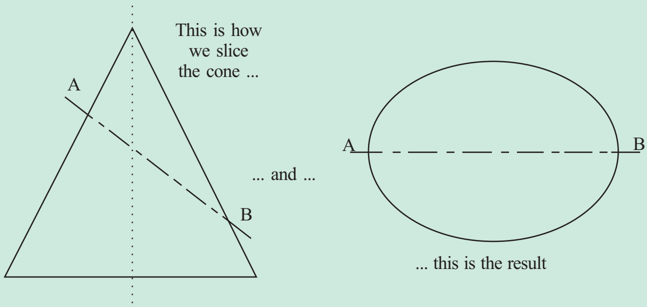


Unlike the lines in the drawing, the lines in the mathematical cone really go on forever in both directions. Each of the two individual cones is called a “nappe”.

2. Sectioning the Cone

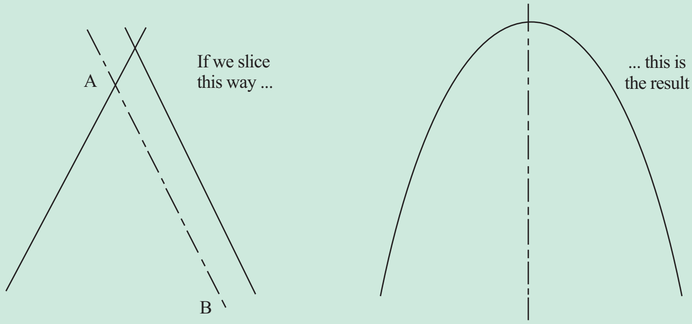
In this context “section” means slice, so conic sections are simply slices of the cone. We have already seen one such section. When we slice the cone with a plane which is perpendicular to the centre line we get a circle. Slicing the cone with a plane which is *not* perpendicular to the axis can give us three different classes of sections.

a) If the plane is tipped slightly we get an ellipse.



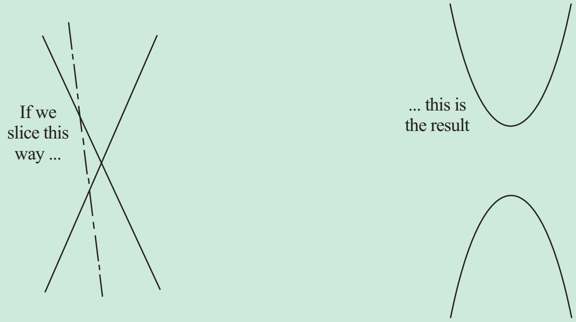
An ellipse is just a flattened circle.

b) If we tip the slicing plane a bit more, so that it is parallel to one of the sides of the cone, we get a parabola.



If you examine the drawing you will notice two things. First, unlike the circle and ellipse, the parabola is open; that is, no matter how far B is extended it will never again meet the cone. Second, if the plane A-B is moved over to meet the apex the result is a straight line. We say that a straight line is a “degenerate” parabola. (This has nothing to do with its morality.)

c) Tipping the plane over still further we get the dreaded hyperbola.



The same remarks hold here as for the parabola, and in addition you can see that the hyperbola comes in two parts, one from each nappe of the cone, this is the only conic section which does so. A degenerate hyperbola is just two straight lines that cross at the apex.

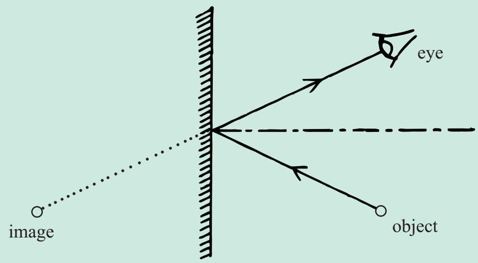
3. The Reflector Properties of the Conic Sections

Now we come to the interesting part. The whole point of the foregoing is to connect up conic sections with the making of telescopes.

Let's examine what happens when we bounce light from reflectors in the shape of conic sections.

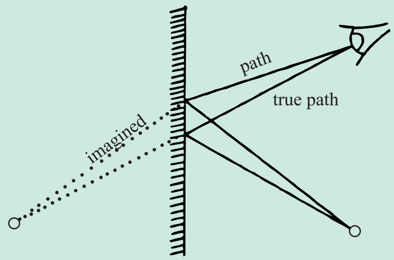
a) A plane mirror.

Before we go into the really hairy stuff, let's think about reflection from an ordinary plane mirror.



If you set up a mirror and look into it, you see an image which is located behind the mirror. If you trace the paths of the light from the object to the eye, and from the image to the eye you will notice two things. First, the apparent path of light from the image to the eye is a straight line. Second, the distance from the image to the mirror, and from the object to the mirror is the same.

Now comes the scary part. In 1657, a mathematician named Fermat set down a principle which says, roughly (among other things), that if a ray of light is given a choice of several paths, it will choose that path which minimizes its time of flight. Since the speed of light is constant (at least in the near vacuum we call air), this simply says that the light goes by the shortest route. (Note that the constance of the speed of light cannot be used for lenses, since the index of refraction of glass is different from that of air.) If we look back to the plane mirror diagram, you can see how this applies.

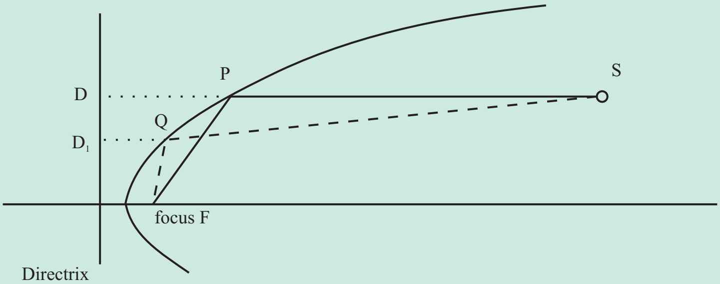


Note that if we imagine any path other than the straight line, it must be longer. That is, a straight line is the shortest distance between two points. This is a verification of Fermat's principle for a plane mirror, and we will use Fermat's principle to look into other mirrors (so to speak).

b) The parabola as a reflector.

To understand what follows, you will need to recall the focus-directrix definition of a parabola as "that set of points which are equidistant from a given line, and a given point" (the directrix and the focus respectively).

On a diagram it looks like this:

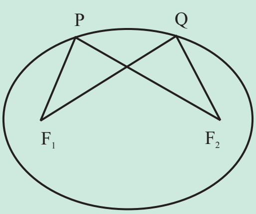


I have also drawn in line SQF which we can imagine to be a path for light in the diagram. The distance the light has to go is the length of the lines SQ plus QF.

From the above definition of the parabola $D_1Q = QF$ so that the length can be written $SQ + D_1Q$. But look at the line $SP + PF$ which is equal to $SP + DP$, it is shorter than the path through Q. Therefore, by Fermat's principle, the true path of the light is from S along a line parallel to the axis, and then to the focus. We can therefore express the reflective property of a parabola as follows: *a parabolic mirror reflects a bundle of light rays travelling parallel to the optical axis through a single point called the focus*.

c) The ellipse as a reflector.

We need, as for the parabola, the focus directrix definition of an ellipse, and we shall use: "a set of points such that the sum of the distances from each point to two given points (the foci) is a constant".

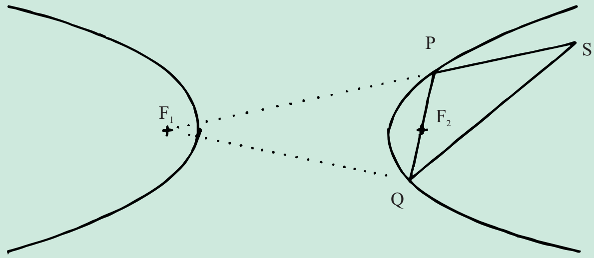


Labelling the foci F_1 and F_2 and imagining two light paths F_1PF_2 and F_1QF_2, where P and Q are any two points on the ellipse, we find by the definition that the two paths have exactly the same length. Therefore Fermat's principle states that it makes no difference which path the light takes since the time of flight is the same in each case. Thus we may state the reflective property of the ellipse as follows: *an elliptical mirror reflects all light emanating from one focus to the other focus*.

As an aside, we can consider a circle to be an ellipse, both foci of which are in the same place. Since this is so, we can see that the reflective property of a sphere is such that all light passing through the centre is returned to the centre. This is why a sphere does not make a satisfactory telescope mirror.

d) The hyperbola as a reflector.

Again we begin with a definition of the hyperbola as "a set of points such that the difference between the distances from each point to two given points (the foci) is a constant". Note how this differs from the definition of the ellipse. A hyperbola is just an inside out ellipse!



Imagine S to be a source of light and SQF_2 to be a possible path of light from S to F_2 via the hyperbolic surface. Imagine also SPF_1 to be a straight line drawn from S to F_1. Since P and Q are both on the hyperbola, we can say that $F_1P - F_2P$ and $F_1Q - F_2Q$ are both equal to the constant for this hyperbola. Now since F1PS is a straight line, the path from F_1 to S via P is shorter than the path via Q, or:

$$F_1Q + QS > F_1P + PS.$$

But applying the two relations we determined above:

$$\text{constant} + F_2Q + QS > \text{constant} + F_2P + PS.$$

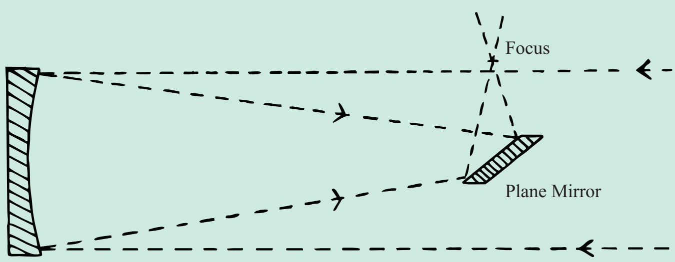
So the distance from F_2 to S via the path through Q is longer than the distance via the path through P. So we can state the reflective property of the hyperbola as: *an hyperbolic mirror reflects light which is converging toward one focus of the hyperbola so it will pass through the other (conjugate) focus*.

4. Application of these Reflectors in Telescopes

a) *The Newtonian*

The simplest of all telescopes is the Newtonian. (I will not include the Herschelian, since it is an off-axis system.) This telescope consists of a parabolic mirror, and a plane mirror arranged like this.

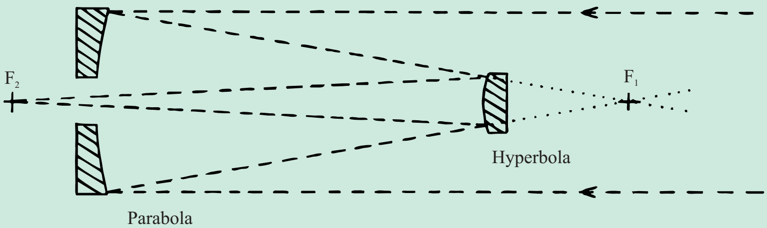
The dotted lines indicate the path of light parallel to the axis in the system.



Parabola

b) *The Cassegrain*

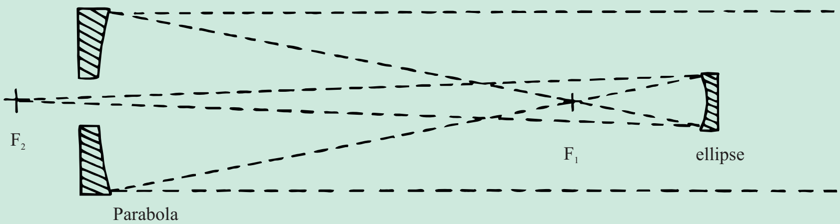
The next most popular amateur-built telescope, and the arrangement used by virtually all observatories, is the Cassegrain. This telescope contains two mirrors, a parabolic primary, and a hyperbolic secondary arranged like this.



The light travels along the optic axis and upon reflection from the parabolic mirror is returned to a focus at F_1; but before it gets there it strikes an hyperbolic mirror. The hyperboloid is placed so that one of its foci is in the same place as the focus of the paraboloid (F_1) . Since in an hyperboloid, light converging on one focus is reflected to the conjugate focus, we can see that the final image is found at F_2 which is the other focus of the hyperboloid.

c) *The Gregorian*

This type of instrument can be thought of as an “inside out Cassegrain”. The primary mirror is the same, a paraboloid, but the secondary is an ellipsoid.



The principle of operation is precisely the same, that is, light from the primary passes through F_1 which is also one of the foci of the ellipsoid, and it is returned by the ellipsoid to the other focus F_2, forming an image.

5. Conclusion

This is by no means an exhaustive description of conics and their use in telescopes, but I hope that it will help those who know nothing at all at least to understand some of the terminology and perhaps pursue the topic further on their own. Anyone wishing to discuss telescopes and designs are invited to drop in to the McLaughlin Planetarium Optical Workshop where several experts will gladly lead you up the garden path.

W. Weller
From the July, 1975 issue of *’SCOPE,*
the Toronto Centre newsletter

Cold Weather Astrophotography

Why would anyone in his/her right mind want to take astrophotos in below-freezing temperatures? For a starter the winter skies in the Northern Hemisphere offer many more interesting areas of constellations and other astro-objects than the summer skies and, in addition, the viewing time available is greatly extended due to the longer periods of darkness and, as anyone who has lived in Canada knows, the weather in the winter is COLD. In addition, “cold-camera” techniques can apply once the temperature has dropped to –20°F with a normal camera which makes color photography possible without the problems inherent with reciprocity failure. Besides, who ever claimed that astrophotographers were considered in their right mind anyway – they don't need reasons.

One of the primary considerations for taking good astrophotos is personal comfort – in winter this means proper warm clothing and a sheltered location. It is possible to bundle up with coats, scarves, mitts, etc., but mobility is also essential. My own personal preference is a good "skidoo-suit", with an attached hood, and felt-lined skidoo boots. This type of dress offers excellent cold weather and wind protection without loss of mobility. (My only complaint is the shortage of pockets.) Thin leather gloves with silk lining keep the hands warm without too much loss of flexibility. Protection of the face itself is a problem. I have tried various masks, but invariably end up fogging the lenses, so I use nothing except shelter and, so far, have not had frost-bite.

All equipment – telescope, oculars, camera, film, etc., should be positioned at the site chosen and allowed to cool down to outside temperature before being used. If a variable frequency drive unit is to be used, this should be operating for at least an hour to reach a stable operating state.

Dewing or frosting of optical surfaces is always a problem in cold weather. Avoid breathing on or close to such surfaces, as the moisture in one's breath will cause instant fogging. All such surfaces should be kept covered during cool-down, and only uncovered during actual use. Long "dew-caps" should be installed on the front of each telescope, including the finder and tracking 'scopes. If possible, some form of low-level dewcap heating, (e.g. resistance wires installed along the inside of the dewcap, coupled to a battery and with rheostat control should be provided). In any case, covers should be provided to fit over each dewcap when the telescopes are not in use. Where mains power is available, a blower-type hair dryer can be used for short periods to clear off any frosting of the objective – in no case should it be used long enough actually to heat the objective above ambient temperature as this can accelerate re-dewing once the objective cools down.

Now to the camera. Some cameras do not operate properly at cold temperatures while others perform quite satisfactorily. If the camera is not cooled to outside temperatures when a picture is taken, heat currents will be set up that can ruin a picture. The primary problems are the shutter and shutter speed setting. To find out the limitations of your camera, cool it down in a freezer (wrap completely in thin plastic to prevent any condensation) , and then try the shutter in the "Bulb" position – see that the shutter opens and closes properly. If there is any delay this should be taken into account when taking pictures. The adjustment of shutter speeds should be done very carefully. Under no circumstances should you "force" a change in shutter speed setting as it is possible to damage the camera mechanism, resulting in a costly repair bill. If there is any trouble experienced, the chances of cold weather photography are not too promising.

Now to film. Film gets quite brittle at very cold temperatures and can break or tear easily. This is especially applicable to 35 mm roll film. In addition, when a cold film is taken inside to warm up, condensation results with consequent water-staining of the negative unless suitable precautions are taken. One good feature, however, is the reduced effect of reciprocity failure, especially below –20°F, so that color film will show a better color-balance, i.e., the same effect as a "cold-camera".

What measures can the amateur astrophotographer take to overcome the condensation and brittleness problems? Load your camera with film, then wrap it tightly in plastic to minimize the amount of air around the camera, and then place in the cooling section of your refrigerator. Leave it there until you are ready to take it outside. Do not let it warm up. Keep the camera wrapped up until ready to mount it on the telescope. If the temperature is above zero, the film should advance in the camera without breaking or tearing the perforations. Below this temperature it is advisable to warm the camera (film) before advancing the film. To do this remove the camera from the telescope, wrap tightly in plastic, and take inside to warm up – keep wrapped all the time. Advance the film as soon as possible (still wrapped up) then take the camera back out to the telescope. Let it cool down again before taking the next picture. The reason for wrapping in plastic is to prevent the warm moist air in the house from condensing on the film surface and camera. This same situation applies when removing the exposed film from the camera. If the temperature is not too cold, rewind the cassette outside, remove it from the camera, wrap it tightly in plastic to exclude all air, then take it inside to warm up to room temperature before unwrapping and developing. If the temperature is really cold, wrap up the entire camera and film, take it inside and allow it to warm up completely before removing the wrapping and film. These measures will prevent condensation forming on the film, and avoid ruining an otherwise good picture. Never try to develop a cold film – always let it warm up to normal inside temperatures.

A word of caution on oiled mechanisms such as motors, focusing units, etc. At cold temperatures normal oil tends to stiffen and congeal, and this places an extra load on the drive motors, and makes focusing difficult. This problem can be avoided by using an oil, one of the silicon-type, that is unaffected by the range of cold temperature that the amateur experiences.

The above summarizes a few of the problems experienced by the author in winter astrophotography, together with the solutions he has found. No doubt other problems will arise, but it is hoped that others can benefit from the suggestions contained in this article.

G. N. Patterson
Saskatoon Centre Newsletter

Astronomy Update

On the basis of their observed rates of expansion and their masses, it is believed that the lifetime of a planetary nebula is of the order of 10^4 years. Since there are about 10^3 planetary nebulae catalogued in the Galaxy, it follows that the formation rate is of order 10^{-1} (i.e. one new planetary nebula formed every 10 years, or so) . At that rate we should expect to observe at least a few stars in the very early stages of ejecting a planetary nebula. Several stars are, indeed, known which show spectroscopic features characteristic of a stellar photosphere and, at the same time, spectral features characteristic of a lower density, highly excited plasma. One such star is V1016 Cygni.

Modern interest in V1016 Cyg began around 1965 following a major photometric outburst. During the past ten years the spectrum has continuously evolved in a way (steady increase in ionization level, strengthening of forbidden lines, etc.) as to suggest that this system – it is also a binary in which intrinsic stellar variability complicates the picture – is in a state of rapid evolutionary change including the development of a compact planetary nebula. (*Astronomy and Astrophysics, 39*, p. 405, 1975)

The Great Red Spot on Jupiter appears not to be a unique structure. A smaller red spot – about one-third the diameter of the Great Red Spot – has been found between the North Tropical Zone and the North Equatorial Belt. (*Icarus*, *25*, p. 1, 1975)

With four exceptions, all known galactic X-ray sources have been identified with Population I objects, i.e., relatively young objects preferentially located in the galactic plane. The four exceptions have now been identified with globular clusters. Although more observations are needed, those presently available suggest that near the centre of each of these globulars there exists a massive Black Hole into whose critical Schwarzschild radius interstellar gas is entering. (Most of the Population I X-ray sources are believed to be binaries in which an evolving and expanding star provides the gaseous material which falls into its Black Hole companion.) For most globulars one does not observe, nor does one expect to find, any interstellar gas or dust. Most globulars are so loosely bound gravitationally that gas left over from their formation billions of years ago will have long since escaped. (*Nature, 256*, p. 23, July 3, 1975)

Dr. D. P. Hube
From Edmonton Centre's 'Stardust'