GNOMON

Newsletter of the Association for Astronomy Education

Vol. 11 No. 1 **ISSN 0952-326X** **AUTUMN 1991**

This issue of 'Gnomon' has been sponsored by The Royal Astronomical Society

This enables the newsletter of the Astronomical Society of the Pacific, 'The Universe in the Classroom', to be included as pages 5–8 of this issue.

EDITORIAL COMMENT

About one-third of the membership responded to the Questionnaire sent to members, asking for their views on a wide range of matters. There was a variety of views and ideas.What did emerge strongly was (a) a desire for more meetings at regional level, and (b) the need for more 'classroom' activities in the newsletter, *Gnomon*.

Council will be looking into more regional meetings – there are problems with the wide geographical distribution of members but, with a will, these could be overcome.

As far as the second point goes, we hope that *this* issue of *Gnomon* goes some way to meeting the request for more classroom material. We now have 12 pages instead of 8, and about 3 of these are devoted entirely to classroom activities, under the heading 'Curriculum Corner'. But we would like *your* cooperation – please send in *any* material which might interest your colleagues.

Another point concerns the *level* of the various articles – the AAE is a 'broad church', so if you find something which is *either* well above, *or* well below, your level of understanding, please exercise your reader's inalienable right of selection, and skim through the offending sections.

★ ★ ★

Gnomon now has a cartoonist, 'Fiz'. His first cartoon is in the article on spectral types.

Do you think *Gnomon* should have an (astronomical) crossword puzzle? Your views on this are welcome. If so, who would like to volunteer to produce one?

★ ★ ★

GNOBLEM is taking a rest. It is being replaced by a new feature 'For the Newcomer', which should be of interest to those meeting the subject for the first time.

ANNUAL MEETING 1992

I am currently looking for a venue for the Association annual meeting next year.

Somewhere in the South of England or the London area would be ideal.

If you know of a suitable venue which is accessible and not too expensive, please contact me.

Bob Kibble, Secretary, AAE

The National Curriculum for Science

The DES has published draft proposals for a revised National Curriculum for science. The AAE has discussed the proposals at Council and has responded to the DES as requested. The main feature of the new draft is the reduction in the number of attainment targets from 17 to 5. Astronomy still has a place in the new attainment target number 3, NAT3. It appears with Earth Sciences. It is likely that future curriculum developments will try to synthesise the components of NAT3 and hence build bridges between Earth Science and Astronomy. I have arranged for a meeting to be held between Julian Ravest, myself and members of the Earth Sciences Teachers Association, ESTA, in October to explore cross-curricular developments. Watch this space for NAT3 news.

If members have already done some work in this field perhaps they would like to contact me with a view to extending their efforts towards a publication or towards a joint AAE/ESTA initiative.

Bob Kibble, Secretary, AAE

Subscription Rates:

Individual members	£7.50
Retired Members	5.00
Corporate Members (e.g. schools, colleges, etc.)	15.00

Corporate members will receive two copies of *Gnomon*.

Extra Copies:

0 – 11	£1.00 per copy
11 – 50	0.75 per copy
51 –	0.50 per copy

Back numbers, not less than one year old, half these prices.

There will generally be a 10% discount to AAE members on all publications and advertising rates.

Practising teachers may claim their subscriptions as an allowance against income tax, thereby effectively reducing their contributions.

Addresses for Correspondence

Secretary: Bob Kibble, 34 Acland Crescent, Denmark Hill, London SE5 8EQ – for all general enquiries. (Tel: 071–274 0530)

Treasurer: Nik Steggall, 38 Victoria Crescent, Birkdale Road, Dewsbury, West Yorkshire WF13 4HJ – for all financial and subscription enquiries. (Tel: 0924–454718)

Editor: Eric Zucker, 35 Gundreda Road, Lewes, East Sussex BN7 1PT – for all enquiries concerning the Newsletter. (Tel: 0273–474347).

Advertising Charges

Whole page	£120
Half page	£60
Quarter page	£30
Inserts	£75 *

* These may be of any size which may conveniently be inserted into the newsletter. There may also be an additional charge for posting if the inserts are heavy.

The prices are for *one* issue.
A 25% reduction is made for advertising in all four issues.

REVIEWS

Astrology: The Evidence of Science by Dr Percy Seymour, Arkana (Penguin Publishing Group). Price: £5.99.

This book was first published in 1988 by Lennard Publishing and was issued as a paperback at the end of 1990.

Throughout history there has been resistance to new ideas and new theories, whether scientific, philosophical or political. Sometimes the resistance has been justified in the light of subsequent discovery or experiment, and sometimes the resistance has dwindled following the establishment of the validity of the ideas or theories. Meteorites were once considered to be merely hallucinations until evidence proved otherwise.

What, then, is one to say about astrology? This has been around for a very long time, and the very word is enough to arouse hostility in various quarters. So when Percy Seymour entitled his new book 'Astrology: the Evidence of Science' he could expect trouble, and it is clear from remarks he makes in this new edition of his work that he has had many critics.

But it is clear that he is not using the term 'astrology' in quite the same way as many people use it – in the 'What the Stars Foretell' sort of way.

He states: "My theory does not propose any forces. It is a synthesis of known scientific facts and the known forces of physics. Although it challenges the normal attitude of science to astrology, it does not step outside the current framework of accepted science."

He is extremely interested in magnetism, and indeed his PhD thesis was on the magnetic field of the Milky Way. Some readers may know his book on Cosmic Magnetism published in 1986.

Basically, his theory maintains that the Sun, Moon and the planets play a complicated 'symphony' on the magnetic field of earth; and that different themes from this symphony are received by different developing foetuses because of genetic tuning so that personality types, with the alleged astrological characteristics, owe their variation to the magnetic influence exerted by the bodies in the solar system. He believes that, based on what he calls scientific evidence, his theory is able to show why the positions of the Sun, Moon and planets at birth can be used to identify some genetically inherited characteristics of an individual.

Dr Seymour refers to the work of Michael Gauquelin, the French psychologist and statistician, who claimed that there was a link between the position of the Moon in the sky at birth and the professions taken up by ordinary people, described in his book 'Cosmic Influence on Human Behaviour'. He also quotes Professor Eysenck who maintains that the work of Gauquelin stands up to careful scrutiny.

It is not clear, however, how or why Jupiter, Saturn and other bodies became associated with certain characteristics nor how lasting these may be. Most of us recognise, for instance, that during our lives our personalities may change in response to our experience, environmental influences, and the effect of other people on our development. There is no indication as to who or what group of people decided that certain personality characteristics were associated with the influence of Jupiter, Saturn and other bodies.

This book is interesting to read but there is a large gap between the existence and possible influence of magnetic fields and resonances upon living forms on the one hand, and linking this to actual differences in human personality on the other. There are, indeed, many questions which remain to be answered.

There is a quotation from Carl Sagan: "That we can think of no mechanism for astrology is relevant but unconvincing. No mechanism was known, for example, for continental drift when it was proposed by Wegener. Nevertheless, we see that Wegener was right, and those who objected on the grounds of unavailable mechanism were wrong".

Donald Gold

Sundials and Timedials by Gerald Jenkins and Magdalen Bear, Tarquin Publications. ISBN 0 90621 2596. Price: around £5.00.

I first came across this booklet in the National Maritime Museum bookshop in 1988. It retailed then at £3.95 and represented excellent value for money. It would still be a snip at twice the price.Sundials and Timedials is a cut-out and paste book printed on A4 card pages. Altogether there are nine models to be made. They include equatorial, horizontal and polar sundials, a solar compass and time cylinder. I have assembled four of these to-date and they fit perfectly. They tend to be a bit fiddly and delicate and so would be unsuitable for primary school children. As an aid to understanding sundials, time and shadows they provide a good hands-on introduction, especially for the teacher.

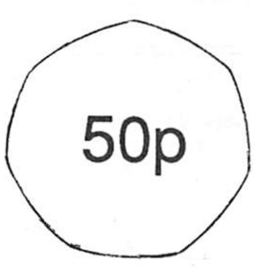
Within the booklet is a background information 'minibook' which also needs to be cut out. It is aimed at the adult or able secondary school reader and introduces a little trigonometry as well as outlining the functions of the cut-out models.

There are few competitors to Sundials and Timedials on the market, certainly none to match its value for money. The only problem with this book is finding a copy. Keep searching, it will be worth it. If you have no luck you might try the publishers at: Tarquin Publications, Stradbroke, Diss, Norfolk IP21 5JP.

Bob Kibble

GNOBLEM 14 – SOLUTION

No need for any maths, although it can be proved. The diagram showing the orbits of the Moon and Earth intertwining is, deliberately, misleading! To have two minima linked by another minimum is obviously impossible, but if we superimpose the intertwining on the *circular* motion of the Earth/Moon system around the Sun, this is another matter. All we need to do is to note the outline of a 50p coin.



This represents the path taken by the Moon (except that this is a seven-sided figure, not twelve as required (very nearly) by the Moon). The Earth's motion is a similar shape interlocking with the path of the Moon.

SUBSCRIPTION RENEWAL

Annual subscriptions to the AAE are now due (£7.50 for individual members, £15.00 for corporate members i.e. schools, colleges, institutions). Retired members pay only £5.00. Income Tax relief is given on subscriptions paid by practising teachers.

In order to avoid costly postage on reminders sent to members in arrears, it would be appreciated if members would send in their subscriptions as soon as possible.

A renewal form is included in this issue of *Gnomon*.

LETTER

Dear Editor,

As the newly elected representative of the British Association of Planetaria, I attended an International Planetarium Society meeting in Atlanta in June. The most interesting item to report on is the next IPS Conference in Salt Lake City in June–July 1992. If any planetarium has not received a letter from me about this, please let me know, as I feel the IPS needs to become more International, and therefore as many Europeans as can attend, should! A new IPS Directory should be published next year.

Yours sincerely,
Undine Concannon,
Planetarium Administrator,
The London Planetarium.

Have you Heard of the AAE?

No, not the Association for Astronomy Education (UK based), but the Association of Astronomy Educators, whose editor is Chaz E. Hayley from Richmond, Virginia, USA. The aims of the Association, which is affiliated to the National Science Teachers' Association, are similar to those of our own AAE, namely 'the sharing of Astronomy and Aerospace ideas and information that can be used in the classroom as well as other educational settings'.

The two AAEs have agreed to exchange newsletters. The American association was represented at our AGM at South Shields by Katherine Becker, from Omaha, who gave an interesting talk on the activities of the US AAE.

Any member who would like to receive a copy of the newsletter, which runs to 24 pages, should apply to the editor of *Gnomon* and enclose a remittance of £2.70 to cover the cost of photocopying and postage. Please make out cheques to the AAE.

For the Newcomer
CLASSIFICATION OF STARS

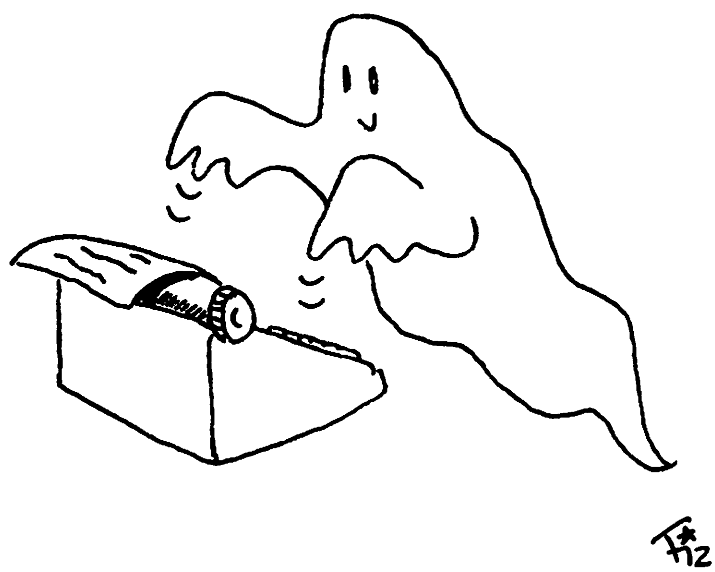
Stars differ from each other in *brightness* and *colour.* Brightness differences may be due to the stars being at different distances, but they may also differ in their *temperatures* (surface temperatures). One would expect hot stars to shine more brightly than their cooler brethren.

One way of classifying stars is through their *spectra.* If a beam of white light is directed through a glass prism, the emergent light is split up into a continuous band of colour, the continuous spectrum. This is the well-known 'colours of the rainbow'. Various transparent materials may be placed in the light-path, e.g. a piece of coloured glass. This will have the effect of removing certain colours from the spectrum, and give rise to a spectrum crossed by dark bands. The dark bands become narrow *lines* when the *absorbing* material is made up of certain molecules – these are *absorption spectra.*

Similar processes take place at the surfaces of stars – the cooler outer layers of the stars absorb certain colours (wavelengths) from the white light coming from the interiors. It is possible to classify stars in order of increasing complexity of the absorption spectra. Over the last 130 years various schemes were proposed for this classification. For historical reasons, the alphabetic classification A,B,C etc has been shuffled around a bit and we now have the classification O,B,A,F,G,K,M which ranges from hot O stars to cool M stars. These are called *spectral types.* Our Sun is a G-type star.

A mnemonic for remembering the order of these letters has recently been criticised as being *sexist,* so will not be given here (readers may like to invent other mnemonics).

Simplicimus



SPECTRAL TYPE

NEWS FROM THE LONDON PLANETARIUM

From Undine Concannon, Planetarium Administrator, The London Planetarium

The London Planetarium's Space Trail exhibition was officially opened by Cosmonaut Georgi Grechko, who gave two most entertaining and enlightening lectures about his experiences as a Soviet astronaut, and on the way forward in Space. An advocate of the British design Hotol, he thought it possible that one of his youngest listeners might be among the first people to visit Mars. Space Trail is a hi-tech area in which interactive video is associated with models of satellites and planets in a colourful and exciting display. It is already proving very popular with children and adults alike. Copernicus, Halley and Einstein preside over the selling of tickets, while Galileo has been given a new setting at a more accessible level than in the old Astronomers Gallery. Combined video and computer technology allow immediate updating of information when necessary.

There is a gravity well (which is unexpectedly proving a useful source of money for charity!). A model of Orion complements the Planetarium's star-studded sky by showing clearly the 3-dimensionality of the constellations.

The two-level area at the Planetarium features a giant revolving Earth, circled by four satellites, live transmissions from the weather satellite, Meteosat, and pictures from the Hubble Space Telescope; communications and mapping satellites provide a comprehensive picture of the varied work being done by these artificial 'eyes'.

Large-scale models of the planets of the Solar System are set against a velvety blue background, accompanied by video monitors and teletext giving up-to-date information in words and pictures.

In addition, visitors are able to see the stars of Orion in 3D, enhanced by ultra violet lighting, conveying fascinating information about space.

A large screen shows dramatic scenes of space exploration and entertains visitors waiting to see the Star Show 'Solar Swoop'. The stairway is adorned with figures of astronauts Neil Armstrong and Buzz Aldrin, beneath the fiery thrusters of an ascending rocket.

The London Planetarium is open every day except Christmas Day.

For further information contact:

Juliet Simpkin – Head of Press & Publicity; Sasa Assari – Press Officer – Tel: 071–486 1121. Direct: 071–465 0875.

WORK WITH THE H–R DIAGRAM

by Merlin Ellis

INTRODUCTION
This article details some work that I did with my group of adult evening class astronomy students. It was my aim to introduce the Hertzsprung-Russell diagram in a participatory way, and to have information concerning the positions of the stars on the diagram come from the students' observations rather than from myself. Although the work was done with a group of enthusiastic adults who rated their previous astronomical knowledge from 'none' to 'fair', I feel that this activity could also be usefully performed with small classes at secondary level.

THE H–R DIAGRAM
This was arrived at independently by Enjar Hertzsprung, a Danish astronomer, in 1911; and Henry Russell, an American, in 1913.The diagram is used to plot individual stars according to two characteristics. Along the x-axis is plotted decreasing surface temperature or some equivalent, such as the star's colour or spectral type. Increasing luminosity, or an equivalent, such as absolute magnitude, is plotted up the y-axis. This diagrammatic representation of stars has proved very useful and is now one of the mainstays of astronomy.

PREPARATION OF MATERIALS
Before the lesson, I consulted the 'Guinness Book of Astronomy Facts and Feats' to come up with two lists.The first gave the spectral types and absolute magnitudes for the 25 stars that appear brightest from Earth.The second gave the same data for the 25 nearest stars. Next, I drew identical axes on two sheets of A2 graph paper, going from Spectral type 00 to M9 and from Absolute Magnitude +18 to -8. Onto these I taped two sheets of A2 acetate.

PREPARATION OF STUDENTS
None of the students was familiar with the H–R diagram before we started, so it was necessary to lay some groundwork.

The colours of stars can be difficult to see with the naked eye, but show up well photographically. Photographs of the night sky taken by me and one of the students enabled the class to pick out reddish, yellowish and bluish stars. The way in which stellar colours relate to their surface temperatures can be compared with the elements of an electric heater warming up. When it starts to glow, it will be dark red.The glow brightens to orange and then yellow, although it will probably not reach white.

We then moved on to the classification of stars according to their *spectral type*, which describes their surface temperatures and hence colour. Originally intended to be alphabetical, the sequence now runs from type 0 (hot and blue) through types B,A,F,G,K to type M (cool and red). (There are other types in the classification, but they are rare and confuse the issue somewhat.) Each spectral type has ten further subdivisions from 0 to 9, type A5, for instance, being half way between A0 and F0.

The luminosity of a star represents its total power output. We considered the factors that could influence a star's luminosity, and decided that it depends mainly on two things: surface temperature and size. Hence a cold red star might put out more energy than a hot blue one if it were a great deal larger.

Luminosity is often measured in absolute magnitudes.The students were already familiar with the magnitude scale of stellar brightness. Therefore, they could appreciate that the absolute magnitude of a star represents the apparent magnitude it would have if viewed from a certain distance (10 parsecs or 23.6 light years). Measuring stellar distances is, of course, another story!

An important thing to ascertain was whether all students were familiar with plotting points on two axes (probably not an issue with a secondary school group). This was accomplished by drawing the axes on the chalk board and practising with a few stars. I had prepared a list of stars that were not on any of the students' lists to this end.

THE ACTIVITY
Having determined that the students knew what the axes on the H–R diagram represent, and that they were happy with plotting points, I split the class into two groups.Each group was presented with one of the 'empty' H–R diagrams that I had prepared earlier, and a marker pen for writing on film. One group had the list of nearest stars and a red pen, the other had the list of brightest stars and a blue pen.

I asked the groups to plot the stars on their lists onto their H–R diagrams.They were also asked to consider whether there was any pattern to the stars once plotted, where the stars were on the diagram compared to the Sun (which both groups plotted), and whether there was any significance to the colour of pen I had given them!

When the groups had plotted the stars, the class came together and discussed its findings.The nearest stars group had found that most of its stars fell on the bottom right hand corner of the diagram. Thus most of our near neighbours in space are dim red stars and this was why they had had the red pen.The other group had seen an upturned curve (smile shape) towards the top of the diagram, with a cluster at the top left. They had deduced that the brightest stars we see were luminous stars of all colours, but with slight predominance of bright blue stars, hence the pen colour.

I had given the students the names of the stars and asked the groups to compare them.The brightest stars group had proper names for almost all their stars, while the nearest stars group found that their list contained mainly catalogue designations. I had not given the apparent magnitudes of either group of stars, but the names showed that most nearby stars were too dim to be considered worth giving proper names.

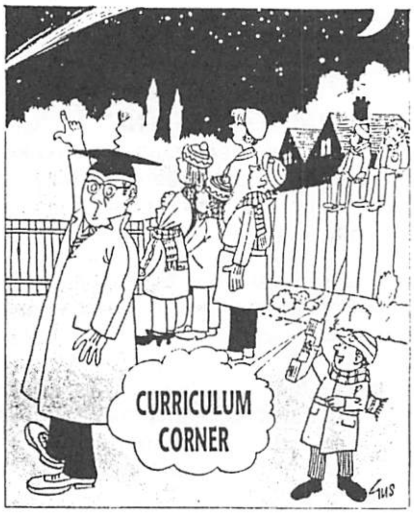
Given that most nearby stars are small and dim, I asked whether this told us anything about how many stars there are of each type. The students could not see why our particular region of the galaxy should be unusual,and so concluded that most stars were, in fact, small and dim. I gave them some statistics on the relative numbers of small and large stars and explained that this was because smaller stars live far longer. The students immediately deduced that this gives the lie to the often-repeated assertion that our Sun is a very average star. True, it lies somewhere to the middle of the H–R diagram, but it is actually bigger than the vast majority of stars.

Next, we removed the graph paper from behind one of the sheets and stapled it over the other. This allowed us to see how many stars appeared on both plots and what type of stars these were. I asked the students whether they could see any pattern to the combined plot and, much to my relief, the Main Sequence was immediately spotted. This was marked on the diagram and labelled.We then discussed the stars that were not part of the main sequence and deduced their properties from their position on the diagram.This led to labelling the white dwarfs and red giants. The completed and annotated diagram was then put up on the classroom wall and used as a resource for future teaching.

CONCLUSION
I felt that this exercise gave the students a much better familiarity with the H–R diagram than a less participatory method might have done. It was important that the students had this familiarity, as I intended to use the diagram extensively in further work. The activity stimulated wide discussion and paved the way for a lot of good work, but perhaps most importantly, the students enjoyed it!

IN THE NEXT ISSUE

1. Review of a new versatile drawing instrument produced by Wellgate Drawing Instruments.
2. Review of the Astrocompass Polascope and Paperclip Stellaplate.
3. Article by Robert Mills on a very cheap gadget called a 'Naked Eye Windowsill Observing Device' – acronym NEWOD?
4. News of a new student-run organisation called 'The United Kingdom Students for the Exploration and Development of Space', or UKSEDS for short.
5. Review of a periodical called 'Satellite News'.



Curriculum Corner is a new, regular feature, to which members and other readers are invited to contribute articles, drawings, photographs, ideas – in fact, anything of a practical nature concerned with teaching the astronomical content of the National Curriculum. *Everything* submitted will be considered for publication: please do not think that your contribution is too trivial (or too advanced). Our experience indicates that there is a considerable body of teachers, many from primary schools, who would welcome reading about these topics. Our *letters* columns are also open to those who would like to comment on the articles in Curriculum Corner.

Articles for this feature will be collated by

Dr David Mannion at
15 Newcombe Rise
Yiewsley
West Drayton
Middlesex UB7 8QE

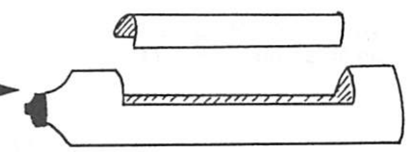
and contributors should contact him directly.

As part of this feature, a sky diary produced by Dr Mannion and Eva Hans (South Tyneside College) will be included.

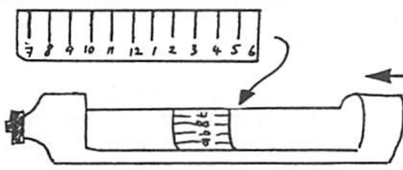
A simple sundial – *from Bob Kibble*

A long knitting needle, an old washing up liquid bottle and a simple support are all you need. Use an atlas to find your latitude (London is 51 degrees, Edinburgh is 56 degrees).

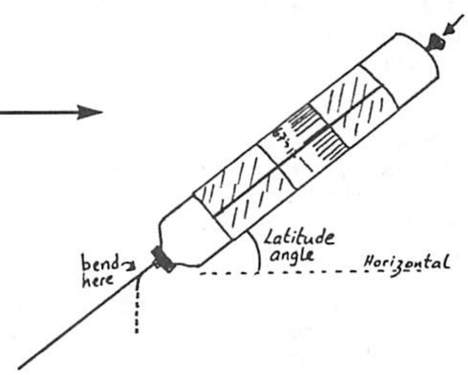
Cut a window from the plastic bottle. The window should extended to half the circumference of the bottle.



Measure the half circumference and cut a piece of paper this length. Mark on the paper twelve equally spaced hour lines and then stick the piece of paper to the inside of the bottle.



Now push the knitting needle through the top of the bottle and force it through a hole made in the bottom.
Bend the protruding end of the needle so that the bottle points up towards the pole star; this is your latitude angle.



Finally find a base to hold the dial. I have used a block of wood drilled to make the needle. It might stand in soil in a garden.

Although the time measured by this dial will disagree with 'clock' time by as much as twenty minutes, you can apply a summertime correction by simply rotating the bottle by one hour!

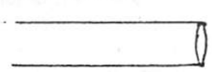
Make your own Cardboard Telescope – *from Anne Cohen*

This can be done as a class activity or at home. The lenses are sizes often found in a school science lab or can be ordered very cheaply from an educational supplier such as Griffin and George. The telescope is low power and suffers from chromatic aberration but it is a good introduction to the way lenses work and to the basic principles behind an astronomical refractor.

INGREDIENTS: Two sizes of cardboard tubing (e.g. kitchen foil tube). • One 50mm diameter, f=40cm converging lens (+2.5D) • One 25mm diameter, f=5cm plano-convex lens (+20D) • Some bubble-wrap • Sticky-tape • Plasticine or Blu-tack.

(If you have any lenses that differ slightly from the above, then go ahead and give it a try anyway.)

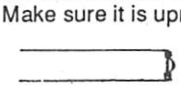
STEP 1: Fix the 50mm lens firmly into one end of the wider tube. Use sticky-tape or blu-tack to hold it.



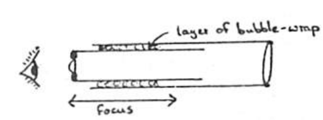
make sure the lens is upright

Cut tube to approx 30cm long

STEP 2: Fix the smaller lens into the end of the smaller tube with the curved face outwards. Make sure it is upright.



Trim the tube to approx 25cm long.



STEP 3: Slide the smaller tube inside the large tuber. Use bubble wrap or a thin collar of plastic foam to ensure a snug fit. Slide in and out to focus.

DO NOT LOOK DIRECTLY AT THE SUN THROUGH YOUR TELESCOPE! YOU COULD SERIOUSLY DAMAGE YOUR EYE.

OBSERVATIONS: The telescope is low power and will not show a great deal of detail in the night sky. Use it to have a look at the Moon (NOT a Full Moon), the Orion Nebula, the Pleiades and the double star ε-Lyrae.
During the day you can study the distant trees and chimney pots – upside-down of course!

Practical Investigation: Hypothesis Testing (Small Group)

from Bernard Abrams

The familiar 'Why is the sky blue?' demonstration provides an opportunity for hypothesis testing (NAT 1) related to NAT 3 Strand 4 (OAT 16) of the National Curriculum. The procedure will need working through beforehand to optimise performance within local provisions. It can be adapted for use with students in late junior/early secondary age ranges (5–7 years) or thereabouts, but much will depend on how much work a particular group of students has done with colour (rainbows etc.) and other associated matters. The precise wording and framework is best left for the professional judgement of those intending to use it.

A suitable quantity of milk/milk powder should be added to one fish tank (or similar container) of water so that a high torch beam shining through it appears distinctly yellow viewed from the opposite side (face-on) with a distinctly blue hue visible in the light scattered from the beam as seen at 90°.

A second tank or similar container containing the same amount of water is made to look pale blue under torchlight by the addition of a suitable quantity of water soluble ink.

The whole set-up needs to be placed in an area with black-out facility.

The two hypotheses to be tested are:

a) The sky appears blue because there is something in the atmosphere which itself is coloured blue and which gives the sky its blue colour.
b) The sky appears blue because something in the air removes the blue light from the Sun's rays and spreads it out (scatters it) over the sky.

A worksheet can be constructed which begins by asking students to draw upon their own experiences of viewing the sky, and the Sun, *but only at sunset* (the important reminder of the grave consequences which follow directly gazing at the Sun should be given). Most students will be aware that the Sun appears deep yellow/orange/red at sunset, while the sky is still blue.

They can then be given two (above) possible explanations for their recalled observations, and asked to perform the setting-up of the apparatus, and repeat the observations.

Finally, a decision should be elicited as to which hypothesis is more worthy of rejection, with reasons. Ideas concerning follow-up experiments which might help them to confirm their suspicions could be sought from the students (e.g. the predicted effect of an increase in the amount of milk/powder and/or ink).

Self-Study Exercise – *from Bernard Abrams*

The paper exercise described below uses the Titius-Bode 'law' to explore the nature of science (OAT 17, NAT 1) in relation to laws and theories. Students need a book or database with information on the solar system if the use of I.T. is to be incorporated in the exercise. It is more appropriate for the latter years of the secondary age range (9/10/11 years). The students' text might read something like this:

TEXT

A formula known as Bode's law can be used to give a reasonably good prediction of the distance of some of the planets from the Sun.The law can be expressed as a series of numbers, which are changed according to the rules of the law, as shown below:

1. Start with the numbers 0 and 3, then keep multiplying by 2 to obtain the next number in the series (0,3,6...)
2. Add 4 to each number.
3. Divide each number by 10.

It is interesting to compare the resulting series of numbers with the distances of the planets from the Sun, measured in astronomical units (multiples of the Earth–Sun distance).

QUESTIONS

a) Follow the rules of Bode's law to obtain the first 10 numbers in the series.
b) Find the distances from the Sun, in order, of the planets (including the asteroid belt) using a book/database, and write them out using the astronomical unit as the unit of distance. (1 astronomical unit is the mean distance of the Earth from the Sun.)
c) Describe how well the distances predicted by Bode's law match up to the actual distances of the planets from the Sun.
d) Write down one reason why somebody might believe that Bode's law is a valid, physical law.
e) Give two points which could be used to argue that Bode's law is no more than a coincidence.
f) Explain the difference between a law and a theory.

FIREBALLS

by Alastair McBeath, Director of the Meteor Section, Junior Astronomical Society

Anyone engaged in nocturnal astronomy is quite likely to encounter the fleeting track of a meteor or two crossing the sky from time to time.There is a continuous background flux of sporadic meteors visible throughout the year, augmented at certain times by members of meteor showers, and both sources can on occasion give rise to bright events liable to captivate the attention of observers whether seasoned veterans or complete novices. Such bright meteors or *fireballs* are of particular interest and importance for a number of reasons, and can perhaps provide the inspiration for an unexpected project when one is spotted by a group of astronomically-minded witnesses.

The standard definition of a fireball-class meteor as proposed by the International Meteor Organization is any meteor which attains or exceeds a visual magnitude of -3. This is roughly equal to the brightness of the planet Jupiter at its best (magnitude -2.6).

As all meteors occur at essentially random intervals from one another, it is impossible to predict when, or indeed where, any given meteor will appear, and as fireballs are quite rare in any case – for sporadics about one meteor in 150 attains magnitude -3, while roughly one in 2000 events reaches magnitude -8 for instance – spotting one is largely a matter of chance. Many fireball witnesses are often not even amateur astronomers, let alone meteor observers. However, fireballs are more prevalent during some of the major meteor showers such as the Perseids in August or the Geminids in December, while sporadic fireball appearances seem to especially favour the spring (particularly April) from Britain and the early evening hours between approximately 18^h to 20^h UT each day.

Fireball observations are important for two main reasons. Firstly, because meteor brightness roughly correlates to the actual size of particle producing the meteor (generally speaking, larger particles give rise to brighter meteors), when we examine these objects we are looking at the larger end of the size-range of meteor-producing material which bridges the gap between meteoric dust and the smallest asteroidal or cometary bodies. The second reason follows on from this, as some of these larger particles may be able to survive their atmospheric flight at least partially intact, to arrive at the Earth's surface as *meteorites*. With enough detailed reports, it may be possible to recover these meteorites, and even to reconstruct their orbits in the solar system prior to encountering the Earth.

The most important items to record on sighting a fireball are the date and time of occurrence (always use Universal Time, UT, to the nearest few seconds if possible), the geographical latitude and longitude of the observing location and its height above sea-level, and the celestial coordinates of the start and end of the meteor's path with respect to the stars using Right Ascension and Declination. Of lesser regard, though still of some importance, are details of the object's apparent velocity (using the scale: 0 = stationary, 1 = very slow, 2 = slow, 3 = medium speed, 4 = fast, 5 = very fast), any persistent glowing ionization train left after the meteor vanished (the duration of this should be noted) and any sounds heard either simultaneously with the sighting (due to very low frequency radio waves) or a few minutes afterwards (caused by sound waves). Both the nature of the noises and the time delay should be taken down. Other items include the meteor's colour, any fragmentation or sparkling along the trail and the meteor's apparent magnitude.This latter point is often not easily determined with certainty, as comparison objects (Venus or the Moon primarily) are usually not usefully nearby. If in doubt, give a possible range of values, e.g. magnitude -8 to -12, rather than trying to guess at a specific number. To assist with brightness estimates, use the following list as a guide:

Venus (brightness)	– about magnitude -5
Crescent Moon	– about magnitude -8
Quarter Moon	– about magnitude -10
Gibbous Moon	– about magnitude -11/-12
Full Moon	– about magnitude -13

Finally, append the names of the observers and a contact address for further correspondence.

No doubt several possible projects will have already suggested themselves should a group be fortunate enough to see a fireball. Using OS maps to obtain the position of the observing site could be an entire sub-project in itself for example, while even simple sketches of the meteor's path shown with respect to some nearby star patterns made by individuals within the group could be used to show up the errors involved in such attempts. The most experienced of meteor astronomers can be relied upon to make positional errors of this sort. Basic observations such as noting that the meteor was brighter than all the surrounding stars could also provide material for further discussion. If data is available for the same meteor as seen at different sites some tens of kilometres apart, a more ambitious project would be to use triangulation to calculate the meteor's start and end heights above the surface. An accurate photographic velocity determination would then allow a computation of the pre-atmospheric orbit, though this is not easy to obtain.

Any observation secured should be sent to the International Meteor Organization's Fireball Data Center: FIDAC, Anton-Fischer-Ring 96, D-0-1580 Potsdam, Germany. Copies of reports from UK sites should also be forwarded to the BAA or JAS Meteor Sections.

Although fireball sightings cannot be pre-planned, their very unexpectedness lends an excitement to them when they do take place. Several leading astronomers today have put their initial enthusiasm down to seeing bright meteors when they were starting to take an interest in the subject. Let us hope the coming generations will be able to find similar inspiration from such events!

THE AZIMUTH DIAL, exemplified by the School Playground dial

from Robert Mills

THIS ARTICLE IS AT SECONDARY LEVEL

This particular horizontal dial has a vertical style, but it can be derived from the equatorial dial formula tan h = tan H sin Ø where h is the shadow angle, H is the hour angle of the Sun and Ø is the latitude of the place.

It is well known that a vertical style set up at the centre of a horizontal circle cannot properly show the Sun's hour angles or show the time throughout the year because of the Sun's change in declination. A horizontal dial with a style pointing to a celestial pole (that is, inclined at an angle CBA = Ø) is shown in Fig.1. The shadow of the style, when the Sun has an hour angle H, passes from C, the centre of the equatorial dial, to the point E on the edge of the dial so that ACE = H.

The shadow of the style cast on the horizontal plane passes through the point D, so that the shadow angle h is ABD, and BAD is 90°, with tan h = AD/AB and tan H = AD/AC. By division, tan h = tan H AC/AB. But AC/AB = sin Ø so tan h = tan H sin Ø. Hour angle lines can be spaced correctly at 15° intervals for each hour only if marked round an equatorial circle. So in order to form the horizontal base for an azimuth dial, a circle of radius 'a' is divided into 24 hour lines spaced at intervals of 15°. This circle held in the equatorial plane is then projected on to the horizontal plane to form an ellipse with a major axis 2a and minor axis 2b = 2a sin Ø where Ø is the latitude of the place (see Fig.2). The minor axis should be in the meridian. It will be seen that the projected positions of the hour lines drawn from the centre of the ellipse are not equally spaced as they were on the equatorial circle. The sundial angle or shadow angle h measured from the North point is given by tan h = tan H sin Ø as derived below. These angles are shown in Fig.2. The construction and marking of this ellipse provides a useful project for the calculator and for understanding the properties of the ellipse. The marking out of the dial on a playground or in a garden can be an enjoyable exercise, and requires some twine, a tape measure, a few pegs, and a small pot of white emulsion paint. It can be accomplished satisfactorily in an hour or so by three or four helpers working as a team following the dimensions and directions given in Fig.3. It can thus occupy a junior form with some practical and instructive activity, and a senior form with some mathematics.

The great attraction of this playground dial is that a young person or slim adult can stand at the appropriate spot determined by the time of year and tell the time by the position indicated by his or her shadow, as it falls on the periphery of the ellipse.

We now use Fig.4 to derive the formula for the familiar horizontal dial with its style pointing to the celestial pole, but now add to the figure the vertical style TCR which passes through the centre of the equatorial circle and meets the base meridian line AB at the point R.

The following angles can now be seen (Fig.1):

The hour angle of the Sun which is ACD; thus tan H = AD/AC

The shadow angle h (ABD) formed by the polar style PB cast on the horizontal plane.

The shadow angle γ (ARD) formed on the horizontal plane by the vertical style.

This gives tan γ = AD/AR and by division

$$\frac{\tan\gamma}{\tan H} = \frac{AC}{AR} = \frac{1}{\sin Ø}$$

Thus tan γ = tan H/sin Ø.

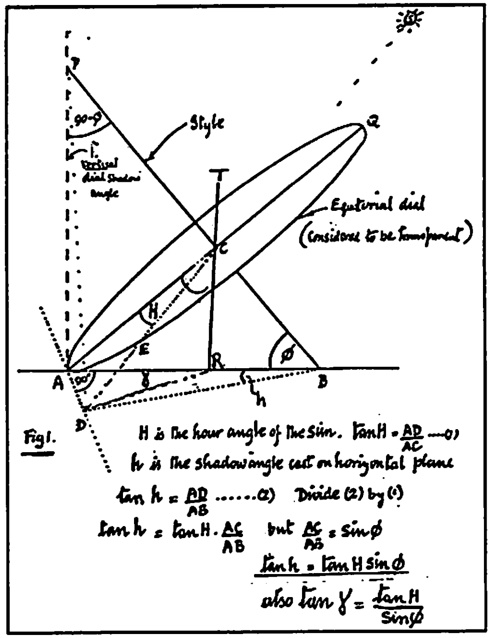
Values of γ are tabulated in Table 1, column 4, but these are valid only when the Sun's declination is 0°, i.e. when the Sun is on the celestial equator. In Fig.3, the vertical style TR crosses the inclined style at the centre C, which is at the segment of the style PB that makes a shadow at E on the equatorial rim only when the Sun's declination is 0°. The angle CEJ is the Sun's declination, the Sun being in the direction JE. Consequently, for the vertical style RT to cast the correct shadow, it must be moved along the meridian a distance d (CF) which equals CJ cos Ø. Also CJ = a tan δ so d = a tan δ cos Ø, which gives the necessary displacement of the vertical style for *any* declination.

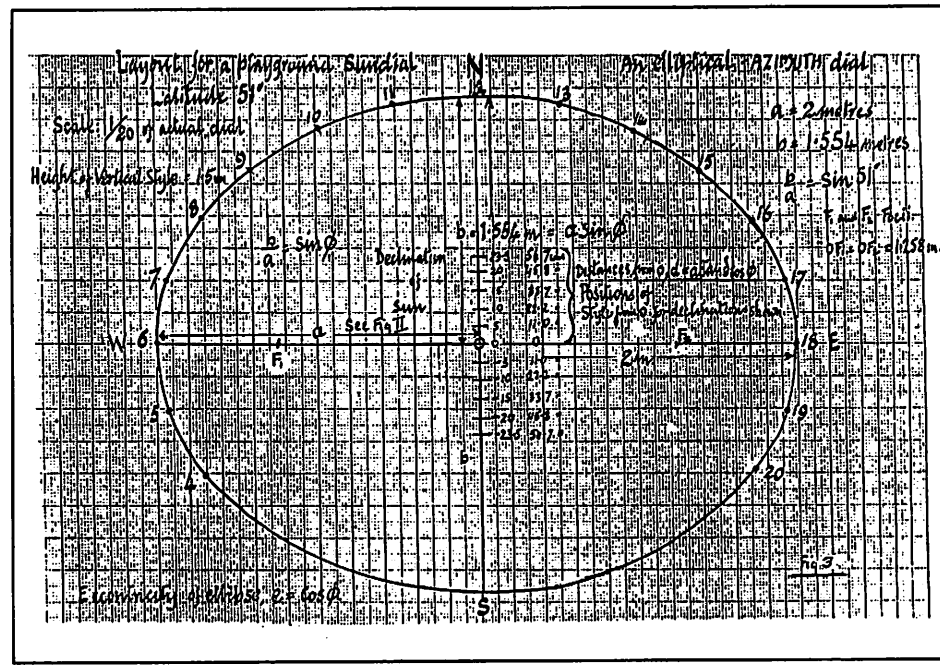
Table 1 shows the calculated times and angles for the Playground Dial. Column (1) Sun Time. Column (2) The Sun's Hour angle H, measured from the meridian. Column (3) The shadow angle h formed by the style inclined at the angle Ø, and cast on the horizontal dial, but only for the Sun when at declination 0°, when tan h = tan H sin Ø. Column (4) shows the shadow angle γ cast by the vertical dial CR when the Sun is at declination 0°, and tan γ = tan H/sin Ø.

▶

Table 1

(1) Sun Time	(2) H in degrees	(3) h (tan h = tan H sin Ø	(4) γ tan γ = tan H sin Ø
11/13	15	11.75	19.02
10/14	30	24.17	36.6
9/15	45	37.85	52.15
8/16	60	53.3	65.83
7/17	754	70.98	78.24
6/18	90	90	90
7/19	105	109.02	101.76
8/20	120	126.6	114.6





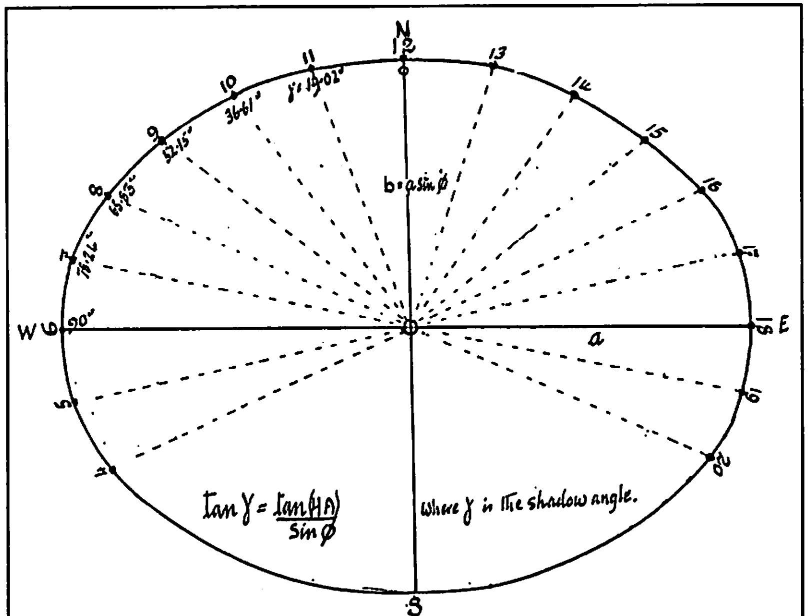


Fig.2: Showing the azimuth angles drawn for the Sun when at declination 0°. The points at which these shadow angles cross the ellipse mark the hours of the dial. For other declinatiokns the vertical style is to positions shown in Fig.1.

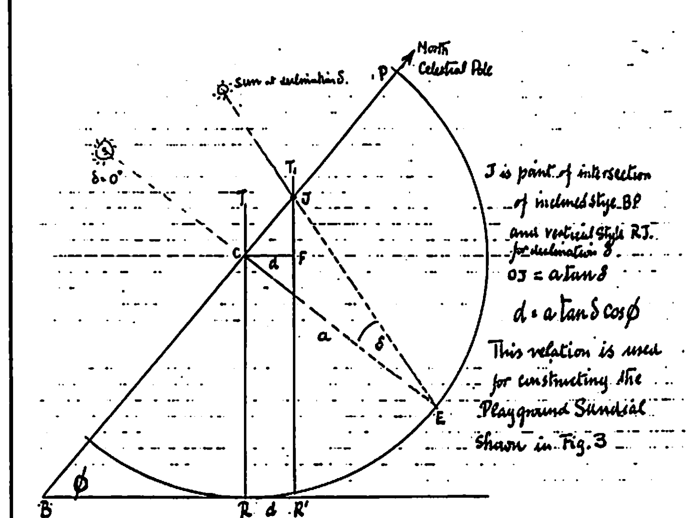


Fig.4: It will be seen that a small cursor, such as a piece of 'blu-tack' stuck on the equatorial style at J so that CJ = a tan δ will then trace out on the horizontal dial, curves representative of the time of year or the position of the Sun in the Zodiac.