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STAR SEEKER

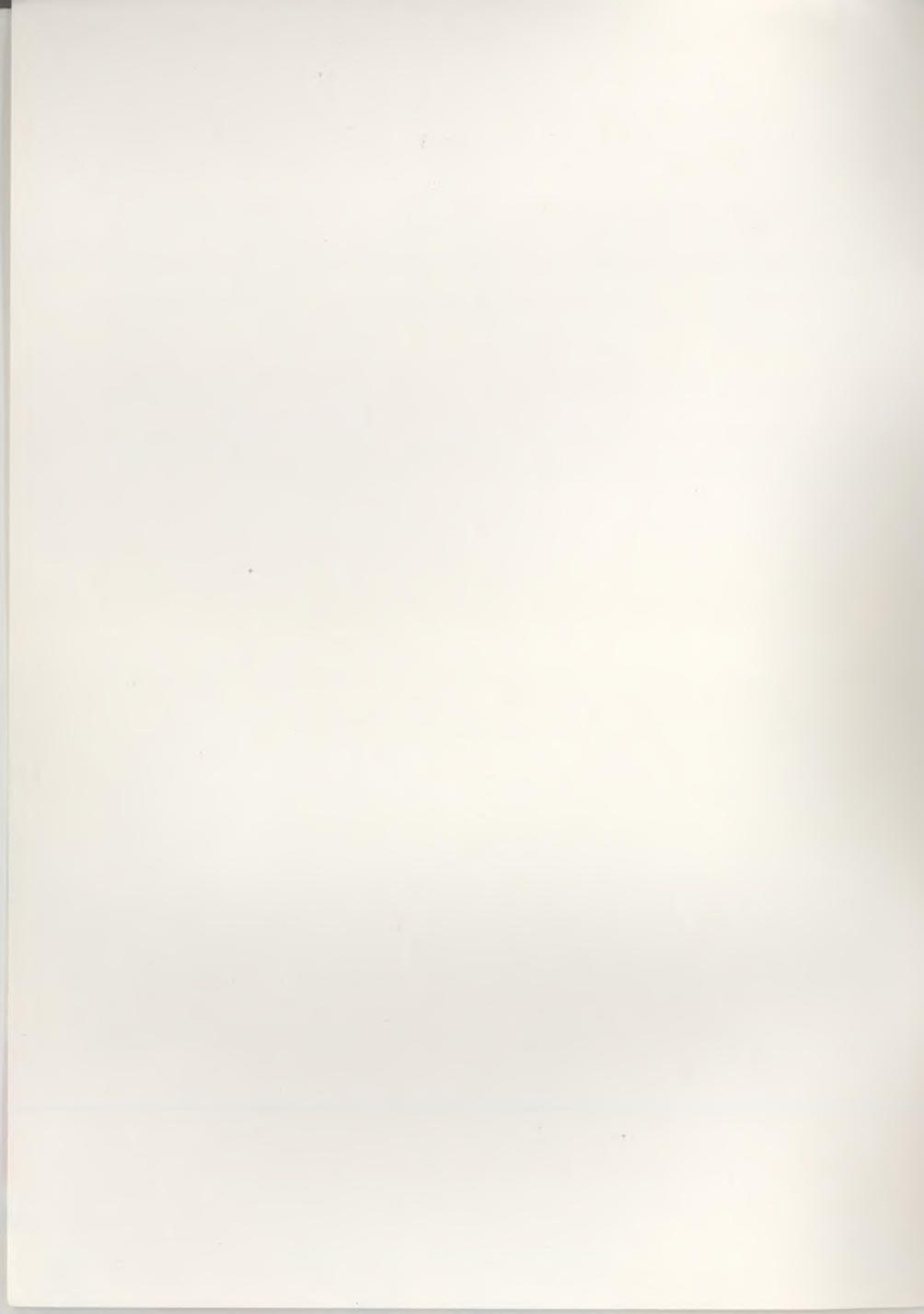
A guide to the night sky
by Paul Phillips, PhD, FRAS
in association with
THE LONDON PLANETARIUM

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STAR SEEKER

by A. P. Phillips, PhD, FRAS

Foreword

"If the stars should appear one night in a thousand years, how would men believe and adore."

Fortunately for those of us who wish to observe them, the stars are visible more often than this! You do not have to be a scientist to enjoy searching for them, and with the aid of STAR SEEKER you can find your way about the sky, learn the names of the constellations and some of the brightest stars, and watch their apparent movement across the sky. It is a program which should have appeal to professionals as an aide-memoire, and to amateurs; together with its companion program, SOLAR SYSTEM, about those 'wandering' stars, the planets. STAR SEEKER provides a most entertaining way to study the skies from the comfort of your own armchair.

In an age when many people live in cities, from where the night sky is just a glare of sodium and neon, the stars seem to be further away than ever. We are very pleased to be associated with a program which will bring them nearer. The gasp of surprise and pleasure which greets the appearance of the stars in our Planetarium shows is proof that their magic still holds.

**The London Planetarium,
Marylebone Road,
London NW1 5LR**

The London Planetarium is open seven days a week from 12.15 pm. (11 am. Saturday and Sunday) to 5 pm.

35 minute star shows are given regularly throughout the day, using music and special effects to create an unique spectacle. A range of programmes for schools is given during term time.

Information from Party Booking Office, The London Planetarium, Marylebone Road, London NW1 5LR.

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CONTENTS

SECTION A: STAR SEEKER

	Page
1.0 INTRODUCTION	4
2.0 RUNNING STAR SEEKER	4
2.1 Specifying location, date and time	4
2.2 Specifying direction of view	5
2.3 Star Map	5
3.0 USING STAR SEEKER	7
3.1 Recognising the constellations and individual stars	7
3.2 Using information on individual stars	9
3.3 Obtaining a close-up of a small region of sky	10
3.4 Watching stars rise or set	11
3.5 Planning observations of the night sky	12
3.6 Southern hemisphere stars	13
3.7 Relevant information from SOLAR SYSTEM	15
4.0 THE STAR DATA	15
SECTION B: SOLAR SYSTEM	17
1.0 INTRODUCTION	17
2.0 RUNNING SOLAR SYSTEM	17
2.1 Specifying location, date and time	17
2.2 The Menu	17
3.0 USING SOLAR SYSTEM	20
3.1 Locating objects in the night sky	20
3.2 Displaying the Solar System	22
3.3 Orbital motion	22
3.4 The return of Halley's Comet	23
3.5 Relevant information from STAR SEEKER	24
APPENDIX 1: Notes on the accuracy of STAR SEEKER and SOLAR SYSTEM	25
APPENDIX 2: Introduction to the Planets	25

SECTION A: STAR SEEKER

1.0 INTRODUCTION

STAR SEEKER has been designed as an interesting introduction to astronomy enabling the user with no previous knowledge of astronomy to learn about the stars visible in the night sky, also as a reference guide and practical tool for the amateur astronomer and as an aide memoire for the professional. The program accurately plots the most prominent stars seen in the night sky from any position on Earth. The information provided will allow the user to easily identify stars by their star name and groups of stars by their constellation name. The program contains information on over 500 stars in 76 different constellations, including the most prominent stars and constellations visible with the naked eye. Information can be obtained on any selected star, the names of the constellations visible can be listed and the shapes of constellations can be outlined. In addition, the rotation of the Earth is simulated, allowing you to watch the stars change their positions in the sky as the night progresses. It is also possible to obtain a print-out of the star chart plotted if your computer is connected to a printer.

The next Section describes how to run the program, and Section 3 provides some illustrations of how to use the facilities available in STAR SEEKER for learning about the night sky.

2.0 RUNNING STAR SEEKER

To load and run the program, see separate instruction sheet.

2.1 Specifying location, date and time

The program will ask you to input the location on Earth from which you wish to view the night sky. This location is specified by the longitude and latitude in degrees. For convenience a list of the longitudes and latitudes for selected cities is given in Table 1. A good atlas can be used to determine these values for any location on Earth. For normal purposes approximate values of the longitude and latitude (within a degree or so) will give acceptably accurate plots of the night sky.

Table 1 Geographical longitudes and latitudes (in degrees) for selected cities

City	Standard hours (+ or - from GMT)*	Longitude (+ = East - = West)	Latitude (+ = North - = South)
ATHENS	+ 2	+ 23.7	+ 38.0
BELFAST	-	- 5.8	+ 54.6
BERLIN	+ 1	+ 13.3	+ 52.5
BIRMINGHAM	-	- 1.9	+ 52.5
BOMBAY	+ 5	+ 72.8	+ 19.0
CAIRO	+ 2	+ 31.3	+ 30.0
CAPE TOWN	+ 1	+ 18.3	- 34.0
CARDIFF	-	- 3.2	+ 51.5
CHICAGO	- 6	- 87.7	+ 41.8
DUBLIN	-	- 6.3	+ 53.3
EDINBURGH	-	- 3.1	+ 55.9
LONDON	-	- 0.1	+ 51.5
MADRID	-	- 3.7	+ 40.4
MANCHESTER	-	- 2.2	+ 53.5
MELBOURNE	+ 10	+ 145.0	- 37.8
MOSCOW	+ 3	+ 37.5	+ 55.8
NEWCASTLE	-	- 1.6	+ 55.0
NEW ORLEANS	- 6	- 90.0	+ 30.0
NEW YORK	- 5	- 74.0	+ 40.8
PARIS	-	+ 2.3	+ 48.8
RIO DE JANEIRO	- 3	- 43.3	- 22.9
ROME	+ 1	+ 12.5	+ 41.9

SAN FRANCISCO	- 8	- 122.4	+ 37.8
SINGAPORE	+ 7	+ 103.8	+ 1.2
SYDNEY	+ 10	+ 151.2	- 33.9
TOKYO	+ 9	+ 139.7	+ 35.7
WELLINGTON	+ 12	+ 174.8	- 41.3

**These times can vary with local standards being set by time of year or by continental standards, e.g. British Summer Time is one hour ahead of GMT.*

Next you input the date on which you wish to view the night sky – specified by the Year, Month and Day of month. The program requires you to specify the date by numbers, e.g. for 31st December, 1984 (31.12.1984), the year is input as 1984, the month as 12 and the day of month as 31. Only the dates in the range indicated on the screen are acceptable. You are then prompted to input the required time of night, specified by the Greenwich Mean Time (GMT) on a 24 hour clock. Hence 11.30 p.m. GMT should be input as 2330, and 01.00 a.m. GMT should be input as 0100. You should determine how many hours in advance or behind GMT your chosen location is at the time of year you are specifying. As a rough guide, each full 15 degrees of longitude East of zero means 1 hour ahead of GMT and each 15 degrees West of zero is 1 hour behind GMT. There can be slight variations from this rule as local standards are applied. For example, British Summer Time is 1 hour ahead of GMT, so in Great Britain while British Summer Time is in force you will have to subtract 1 hour from the clock time to obtain GMT.

2.2 Specifying direction of view

The program will then ask you to choose the direction in which you wish to view the night sky – the options include North [N], East [E], South [S], West [W] and Overhead [O]. For example, if you choose option [N] (North), then the centre of view of the Star Map plotted will be due North, with the horizon towards the bottom of your screen and the overhead position towards the top. The left-hand edge of the Map will be towards North-West and the right-hand edge will be towards North-East.

An additional option [X] is available which allows you to position the centre of your field of view towards any direction in the sky and also to alter the size of the field of view displayed. The centre of your field of view is specified by the number of degrees round the horizon from North (this is called the Azimuth) and by the number of degrees above the horizon (Altitude). The number of degrees round the horizon is measured from North (0 degrees) through East (90 degrees), South (180 degrees) and West (270 degrees). The number of degrees above the horizon is measured from the horizon (0 degrees) towards the overhead position (90 degrees). For example, to select a direction SE the number of degrees from North will be 135, since East has a direction 90 degrees and South has a direction 180 degrees. To position the centre of the Star Map two-thirds of the way from the horizon to the overhead position the number of degrees above the horizon will be 60, since the horizon is at 0 degrees and the overhead position is 90 degrees above the horizon. If the size of the field of view is chosen to be, say, 40 degrees then the Star Map displayed gives a close-up of this small region of the sky. If the size of the field of view is 90 degrees then the Star Map covers a wider area of sky and so more stars will be visible. Should your specified field of view extend below the horizon, then the program will plot stars below the horizon and a horizontal line will appear showing the position of the horizon. After you have entered the direction of view you want, the program will ask you whether you are satisfied with the details you have given it. If you press [Y] in response, the program will construct the appropriate star map. If you press [N], you are given the opportunity to change some or all of the numbers you have entered before going on to the next stage.

2.3 Star Map

Once you have input your required direction of view, the program will plot the requested Star Map. Plotting is complete when the

CALCULATING STARMAP message at the bottom of the screen is replaced by the PRESS L, C, I, U, N, P or M (Menu) message. These letters indicate the options available. The option required is chosen by pressing the appropriate key. On screen information explaining each option is obtained by pressing [M] for Menu.

The options available are as follows:-

[L] – List constellations plotted

The names of the constellations (star groups) visible on the Star Map will be listed. A

constellation will be included in the list if there is at least one star in that constellation within the displayed Star Map. The stars in each constellation will flash on and off briefly while each constellation name is being listed, and the number of stars in that constellation will be given.

[C] – Construct Constellation Map

The constellation shapes will be outlined by lines drawn between the stars of each constellation (to produce a Constellation Map). As each constellation is plotted its name is displayed at the bottom of the Star Map, just above the CONSTRUCTING CONSTELLATION MAP message. An individual constellation shape will only be shown if the displayed Star Map includes all stars defining that shape. This option is particularly useful for learning to recognise the individual constellations and their relative positions in the night sky. Once plotting is completed you may choose the [P] option to obtain a printout of the plotted map.

[I] – Information on a star

This option allows you to obtain information on any plotted star. On pressing [I] a cross-wire cursor appears at the centre of the screen. You must position the cursor over the star on which you require information, then press the [ENTER] (Spectrum) or [RETURN] (MSX) key. To move the cursor in the required direction use the normal cursor control keys (←, →, ↑, ↓). The cursor can be made to jump in large or small steps, selected by pressing the [L] or [S] keys respectively. Initially the cursor will jump in large steps. When the cursor first appears manipulate its position until it is close to the required star, then press [S] and position the cursor carefully over the star, finally press the [ENTER] (Spectrum) or [RETURN] (MSX) key to obtain the information.

Having successfully chosen your star, the information listed includes:-

- (i) **The accurate position of the star in the sky.** The number of degrees round the horizon from North and the number of degrees above the horizon are displayed. This position can be used to locate accurately your star in the sky at the chosen time of night.

The position of your chosen star is also given in terms of its Right Ascension and Declination. These are the celestial longitude and latitude of the star. In the same way that the position of a point on the Earth's surface can be specified by its longitude and latitude, the position of a point in the sky can be specified by its Right Ascension and Declination. Right Ascension is measured around an imaginary circle in the sky known as the Celestial Equator, which represents the projection of the Earth's equator out onto the sky. The main difference between Right Ascension and longitude is that the former is normally expressed in hours, minutes and seconds. Twenty-four hours of Right Ascension correspond to 360 degrees, so one hour corresponds to 15 degrees. Declination is measured from the Celestial Equator northward (positive Declinations) or southward (negative Declinations). So a point in the sky directly above the North Pole will have a Declination of plus 90 degrees. The Right Ascension and Declination of your star can be used to find the star on published star charts since these are normally plotted in terms of Right Ascension and Declination.

- (ii) **The brightness of the star.** Astronomers express the brightness of a star in magnitudes. The brighter a star, the lower its magnitude. The brightest star in the sky is SIRIUS with a magnitude of -1.5 and the faintest stars that can be seen with the naked eye have a magnitude of about +6. A difference of five magnitudes corresponds to a brightness ratio of 100 to 1. For example, a star of magnitude 1 is 100 times brighter than a star of magnitude 6. Some stars vary in their brightness and the program will tell you if the brightness of your chosen star is variable.
- (iii) **The name of the constellation** in which the star is located and whether the star is the brightest star in that constellation.
- (iv) **The times at which the star rises and sets** on the specified day. Alternatively, whether the star is always above the horizon or never rises at the specified latitude.

[U] – Update star positions

This option will automatically update the positions of stars in the sky at one of the intervals specified on screen. The apparent motion of the stars is due to the daily rotation of the Earth about its own axis. This axis runs through the north and south poles so stars appear to rotate about two 'pivots' directly above the poles, making one complete circuit in nearly twenty-four hours. The automatic updating of positions is stopped by pressing the [S] key. Each movement takes a few seconds to plot.

[N] – New observing parameters

To input a new geographical location, date and time of night, line of sight, field of view, or any combination of these.

[P] – Printout Star Map to a printer

This option can be used to obtain a printout of the Star Map plotted if your computer is connected to a printer. This is particularly useful since you can take this printout outside and actually identify the stars in the night sky. (see separate sheet).

3.0 USING STAR SEEKER

This section provides some illustrations of how to make the best use of the facilities available within STAR SEEKER. The emphasis will be upon how STAR SEEKER can be used to learn about the night sky.

For illustrative purposes we will discuss the appearance of the sky at 11.30 p.m. (2330 hours GMT) on 31st December, 1984 (31.12.1984), as seen from London (longitude -0.1 degrees and latitude 51.5 degrees). We recommend that you input these values into STAR SEEKER for a visual reference guide to the following sections.

3.1 Recognising the constellations and individual stars

Figure 1 (a) shows a display of the stars visible in the southern sky. On choosing option **[C]** the Constellation Map will be constructed, as shown in Figure 1 (b). As each constellation is plotted notice its name and shape. After re-plotting the Star Map try to recognise the patterns of the constellations and to check whether you have identified them correctly, plot the Constellation Map again.

You will see that the constellation ORION (the Hunter) is one of the most prominent in the southern sky at this time, containing relatively bright stars. You can use it to find other constellations or stars in the night sky. For example, notice the three stars near the centre of ORION which lie almost in a straight line. These are quite close together and are known as Orion's Belt. Following the line through these stars downwards towards the horizon, you will notice the very bright star called SIRIUS (the Dog Star). You can check this by obtaining information it using option **[I]**. SIRIUS is the brightest star in the sky, its magnitude being -1.5 . It lies in the constellation CANIS MAJOR (the Great Dog), as can be confirmed by using option **[L]**. Alternatively, following the line through Orion's Belt upwards you will come to the constellation of TAURUS (the Bull), within which the brightest star is ALDEBARAN. This procedure illustrates how you can find your way around the night sky by recognising one of the more prominent constellations and then using it to find others, or individual stars. You will find it surprisingly easy.

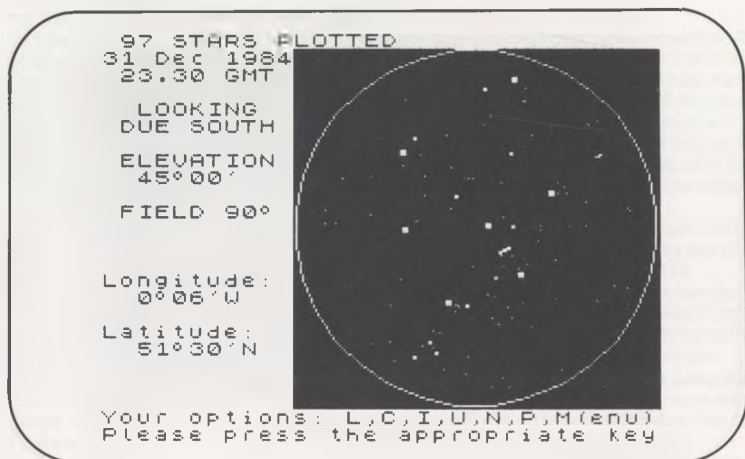


Figure 1 (a)

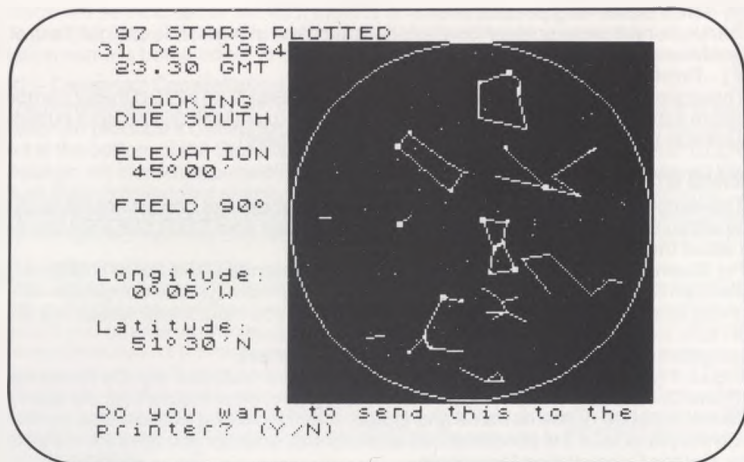


Figure 1 (b)

Figure 2 (a) shows the Star Map of the northern sky and Figure 2 (b) shows the corresponding Constellation Map. Use option [N] to choose the new direction of view. Try going through the sequence of plotting the Star Map and the Constellation Map until you recognise the constellation shapes. In the northern sky at this time URSA MAJOR (the Great Bear) is prominent towards the north-east. Seven of its bright stars are more commonly known as the Plough, and you can use those stars as signposts also. For example, the two stars (known as 'the Pointers') at the top of the Plough's spade, point towards a star near the centre of the map. It is POLARIS, the brightest star in the constellation URSA MINOR (the Small Bear). It is also known as the Pole Star, or North Star since it lies almost directly above the North Pole, near a position known as the North Celestial Pole. As the Earth rotates, the stars

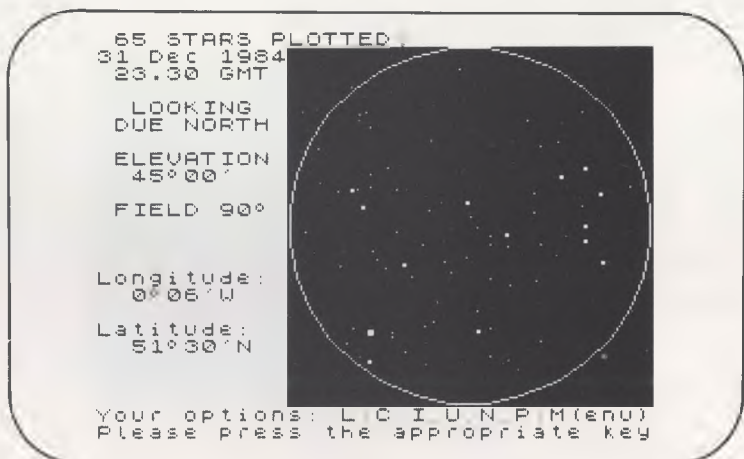


Figure 2 (a)

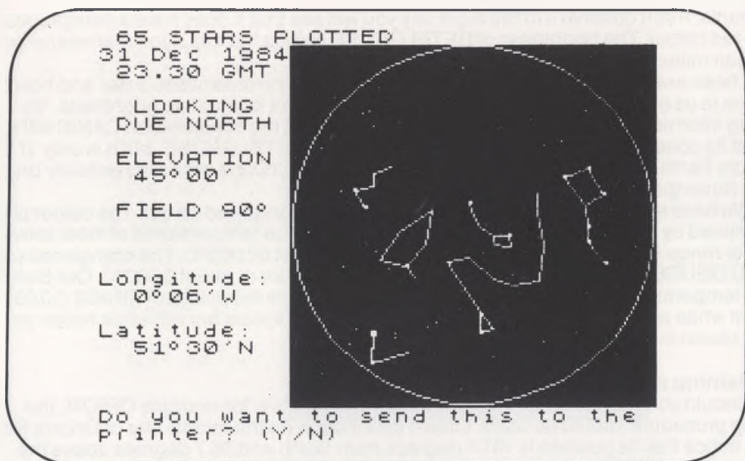


Figure 2 (b)

appear to move in circles around the Pole Star. You can watch this happening by selecting option to update the star positions in hourly intervals.

The ability to recognise POLARIS in the night sky is useful because it indicates the direction of North. In addition, if you obtain information on POLARIS you will notice that its position above the horizon is close to 51.5 degrees—the latitude used for this Star Map. This is the case whatever location is used. For example, at the North Pole with a latitude of 90 degrees, POLARIS will be about 90 degrees above the horizon, i.e. almost directly overhead. Hence by determining the position of POLARIS above your horizon you can determine your latitude.

3.2 Using information on individual stars

It is possible to locate precisely in the night sky any star that you have viewed on the screen. To illustrate this, let's return to our original display of the southern sky at 2330 hours, using option again. Use option to obtain information on SIRIUS, the brightest star displayed. We see that its position is about 172 degrees from north and about 21 degrees above the horizon. Hence it lies 172 degrees from North measured along the horizon in a North-East-South direction. Since South is 180 degrees from North, SIRIUS will lie just to the East of South and will be fairly low in the sky at 21 degrees above the horizon. So with this information you can find the precise location of SIRIUS in the night sky; and all the other stars too, using the same procedure.

The distance to SIRIUS is 9 light years, which means that light emitted from SIRIUS takes 9 years to reach us, so we see it as it was 9 years ago. All the stars in the sky are at different distances from Earth, the nearest one (apart from the Sun) being ALPHA CENTAURI, at a distance of just over 4 light years. The observed brightness of a star depends both on the actual brightness of the star itself and on its distance from Earth. SIRIUS appears particularly bright to us principally because of its relative nearness to us. Returning to the constellation of ORION, option can be used to show that its two brightest stars are BETELGEUSE and RIGEL, at distances of 520 and 900 light years respectively. Despite these huge distances both these stars are among the brightest in the sky; and this is because they are very large. BETELGEUSE has a diameter of some 300 million miles: compare this with the distance between Earth and the Sun of 93 million miles. And the Sun is so small in comparison that if it were placed at the same distance as BETELGEUSE it would be too faint to be seen with the naked eye. BETELGEUSE is one of a class of stars known as Red

Supergiants; if you observe it in the night sky you will see that it does have a conspicuous orange-red colour. The brightness of BETELGEUSE results from its huge diameter of some 300 million miles.

These examples serve to illustrate that if we know the distance to a star and how bright it appears to us on Earth, we can obtain a rough estimate of its intrinsic brightness. Try obtaining information on the brightest star (PROCYON) in the constellation CANIS MINOR. Note that its observed brightness is the same as that of BETELGEUSE, but it is only 11 light years from Earth. From these facts we can see that PROCYON is not as intrinsically bright as the Red Supergiant BETELGEUSE.

We have mentioned that BETELGEUSE has an orange-red colour. The colour of a star is determined by the temperature at its surface. The surface temperatures of most stars lie within the range from a cool 2,500° Centigrade up to about 50,000°C. The orange-red colour of BETELGEUSE results from its relatively cool temperature of about 3,000°C. Our Sun, with a surface temperature of about 6,000°C, is a yellow star, while the colour of SIRIUS (10,000°C.) is a brilliant white with a tinge of blue. Broadly speaking, cool stars are red while hotter stars are white or bluish in colour.

3.3 Obtaining a close-up of a small region of sky

Should you require a close-up of a small region of sky, for example ORION, the following procedure should be used. Obtain information on the middle star of Orion's Belt. You will notice that its position is 191.4 degrees from North and 36.7 degrees above the horizon.

Re-plot the Star Map and choose to plot another direction of view. Select option [X] to specify your own direction and input the position of this star as the centre of your field of view. Choose 30 degrees as the size of your Star Map. You should obtain the Star Map illustrated in Figure 3 (a), giving the required close-up view of ORION. The corresponding Constellation Map is shown in Figure 3 (b), helping you to become more familiar with its shape.

There are some regions of sky which are best seen by taking a close-up view. One such region of sky lies in the constellation of TAURUS. In section 3.1 we saw how ORION can be used as a guide for finding other constellations, or individual stars. Returning again to our original display of the southern sky at 2330 hours GMT, the line through Orion's Belt upwards points approximately to the position of ALDEBARAN, the brightest star in TAURUS. If you

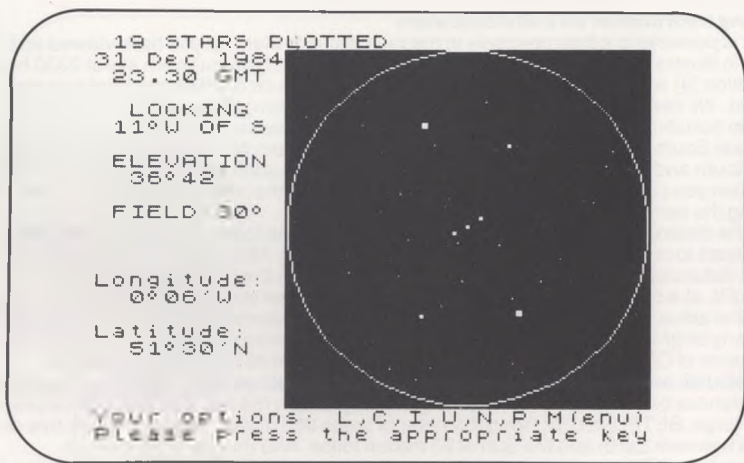


Figure 3(a)

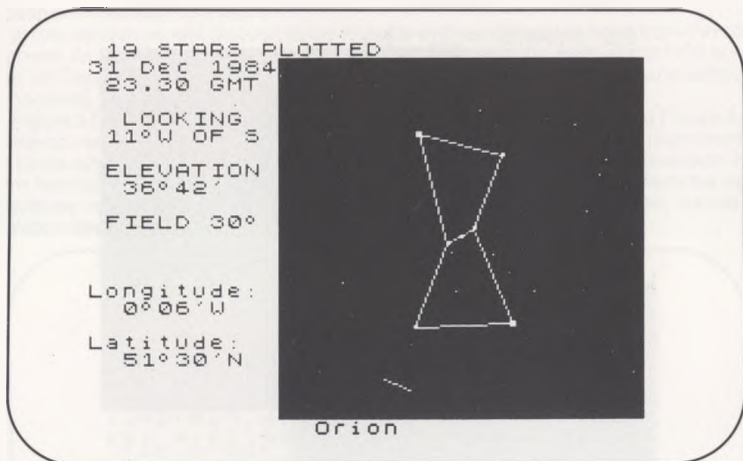


Figure 3 (b)

obtain information on this star you will see that it lies 2178 degrees from North and 50 degrees above the horizon. Obtain a new Star Map using the position of ALDEBARAN as the centre of your Star Map, with a field of view of 35 degrees. The resultant Star Map displays a close-up of the constellation of TAURUS. Request a Constellation Map to confirm this. Returning to the Star Map, notice the small cluster of closely separated stars in TAURUS towards the right-hand side of the display. These are known as the PLEIADES. To obtain a close-up view of this cluster, centre a new Star Map on any of the stars in the cluster, using a small field of view of 5 or 10 degrees. STAR SEEKER shows the six stars in this cluster which are easily visible with the naked eye. The PLEIADES are more commonly known as the Seven Sisters since in Greek mythology seven sisters are mentioned in legends connected with them. It is possible that the seventh star has faded in brightness, although this is uncertain since observers with good eyesight are able to count more than six stars on a clear night. In fact, large telescopes reveal that the number of stars in this cluster runs into hundreds.

3.4 Watching stars rise or set

Owing to the Earth's daily rotation on its own axis, stars appear to rise slowly in the East and set in the West. By hourly updates of star positions the program can be used to show the apparent motions of stars as the night progresses. Leaving our southerly view, obtain a Star Map using option [X] with the centre of your field of view 270 degrees from North (i.e. looking West), and 30 degrees above the horizon. Select 90 degrees as the size of your Star Map. Your Star Map extends below the horizon as indicated by the horizontal line showing the position of the horizon. Then choose option [U] to produce hourly updates of star positions. You will notice them, by now familiar, shape of ORION appears in the South-West (left of your display) 3 hours later than our original time of 2330 hours. As the updates continue ORION falls slowly towards the western horizon, starting to set after about 5 hours, i.e. at about 0430 hours on 1st January, 1985. The display at this time is illustrated in Figure 4. Notice that SIRIUS is just about to set. This example illustrates how the program can be used to follow stars as they slowly set in the West. Should you wish to watch stars rising above the horizon, choose an easterly view of the sky.

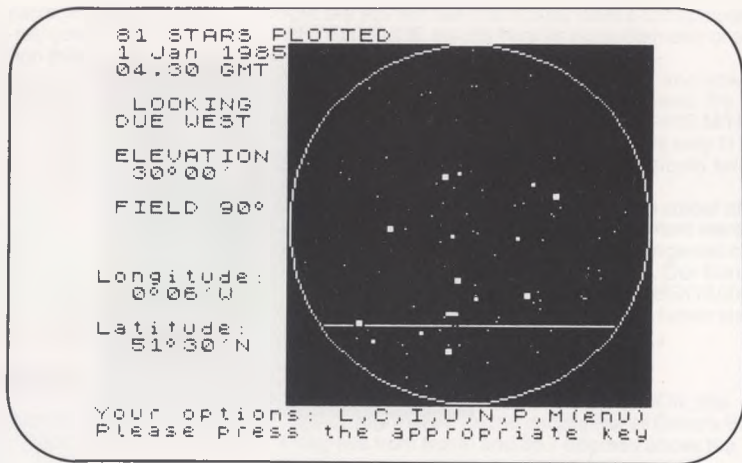


Figure 4

3.5 Planning observations of the night sky

The Star Maps display the most prominent stars visible at the specified time of night, allowing you to identify them in the night sky. Having obtained a Star Map, the information provided on a chosen star includes the times at which it rises and sets. This gives you the range of times when a particular star is above your horizon and hence observable. Alternatively, you might wish to determine the time during a given night when, for example, the southern sky contains particularly prominent stars or constellations. To determine this, display a southerly Star Map at the beginning of the night and update the star positions to view the changing southern sky during the night. Hence you can determine the time when it will be most profitable to start your observations of the night sky.

Since the stars appear to rotate about two 'pivots' directly above the North and South poles, some stars never set. These stars are known as the circumpolar stars. They are always available for observation. From the northern hemisphere the stars rotate about POLARIS, the Pole Star. The particular stars which are circumpolar depend on the latitude of the observer. If the observer is at a latitude of 51.5 degrees then stars within 51.5 degrees of POLARIS will be circumpolar. Stars within 80 degrees of POLARIS will be circumpolar to an observer at a latitude of 80 degrees. Alternatively, a star will be circumpolar if its Declination is greater than 90 degrees minus the latitude. Hence, at the North Pole, where the latitude is 90 degrees, all visible stars are circumpolar. In the other extreme, for locations on the equator (latitude 0 degrees) no stars are circumpolar—all stars rise and set at some time during the day or night.

As we have seen, the apparent motion of the stars through the night is caused by the daily rotation of the Earth. However, the stars do not make one complete circuit of the sky in exactly twenty-four hours, but in a period about four minutes shorter than this. The reason for this is that the Earth is not only spinning on its own axis, but is also orbiting around the Sun. This latter motion causes the observer's outlook on the stars to slowly change during the year. This gradual change causes the change in the constellations visible at a given time of night through the year.

This slow change throughout the year can be studied by using option with a time interval of one day. The sequence of star maps you then see corresponds to a fixed line of sight at a fixed time. The change in successive plots is barely perceptible, but the drift of constellations is evident over longer periods.

3.6 Southern hemisphere stars

In this section we will discuss some aspects of the night sky as seen from the southern hemisphere. As an example, we will look at the appearance of the night sky at 1700 hours GMT on 1st October, 1984, as seen from Sydney (longitude +151.2 degrees and latitude -33.9 degrees).

Figure 5 (a) shows a display of the stars visible in the northern sky and Figure 5 (b) shows the corresponding Constellation Map. The constellation of ORION is prominently placed to the east of North, but note that it is upside-down compared to its orientation in the northern hemisphere. Observers in the southern hemisphere see the stars from the opposite angle to those in the north—it is the observer's orientation which has changed, not the constellation itself.

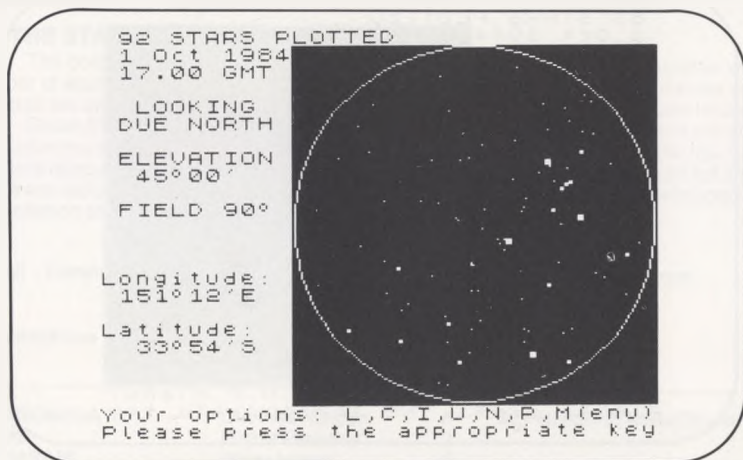


Figure 5 (a)

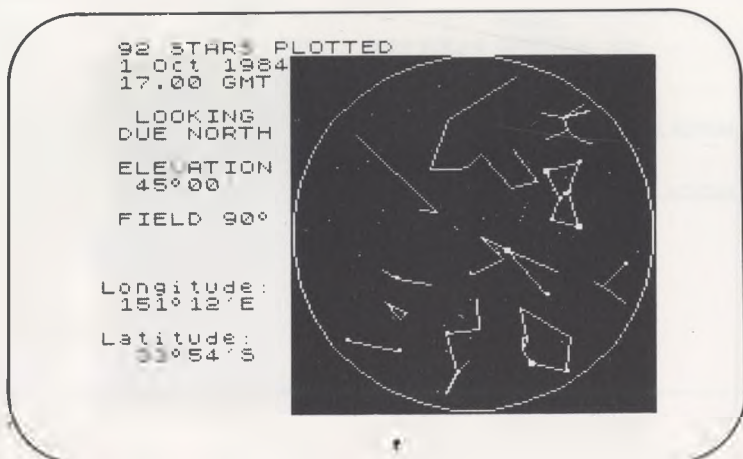


Figure 5 (b)

Figure 6 (a) displays the stars looking South from Sydney and the corresponding Constellation Map is shown in Figure 6 (b). The constellations seen here will be unfamiliar to observers in Britain, remaining below the horizon at all times during the year. Choosing the option [U] to update the star positions you will notice that the stars appear to rotate about a point due South, about a third of the way from the horizon to the overhead position. This point is directly above the South Pole and is known as the South Celestial Pole. Unlike the situation in the northern hemisphere with POLARIS, there is no star to mark conveniently the position of the South Celestial Pole but as an approximate pointer to it, the small, but distinctive, constellation known as CRUX (the Southern Cross) can be used. The longer axis of the cross points roughly in the direction of the South Celestial Pole.

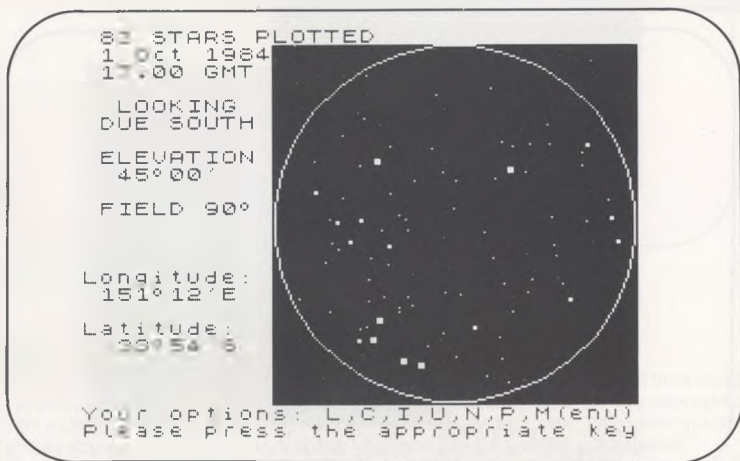


Figure 6(a)

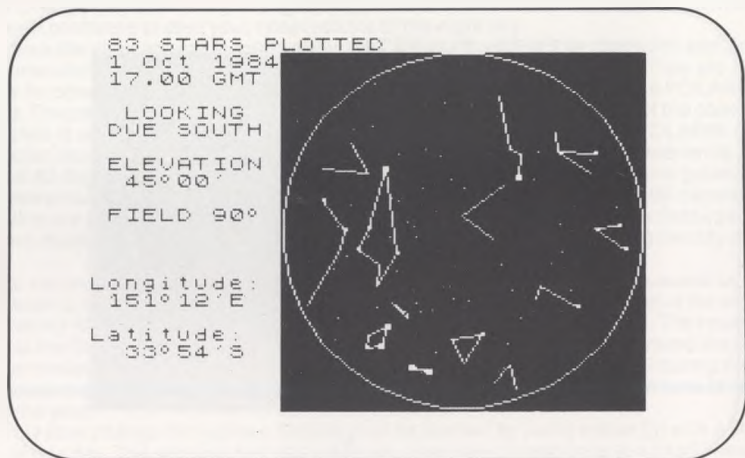


Figure 6(b)

3.7 Relevant Information from SOLAR SYSTEM

The program SOLAR SYSTEM, which is the other program in this package, provides information on the Sun and Moon which will be useful when planning observations of the stars.

The rise and set times of the Sun allow you to determine when the Sun is below your horizon, enabling observations of the stars to be made. Remember that there will be a period of twilight immediately before the Sun rises and immediately after the Sun has set. During twilight the sky is not completely dark.

The rise and set times of the Moon and the Phase of the Moon may also be useful. If it is close to Full Moon and the Moon is above your horizon then the sky will not be completely dark. Stars are best seen against a dark sky, so preferably the Moon should be below the horizon or its Phase should be close to the New Moon.

4.0 THE STAR DATA

The constellations included in STAR SEEKER are listed in Table 2, together with the number of stars within each constellation. The stars for which common star names are included are also given in Table 2, alongside the constellation in which they are located.

Since STAR SEEKER only contains data on the more prominent stars in the night sky, the fainter stars within constellations listed in Table 2 will not be included in the file. Some of the more obscure constellations have insufficient stars available to define their full shape. These are indicated in Table 2 by an asterisk. When a Constellation Map is produced, these constellation shapes will never be displayed.

Table 2 Constellations and star names included in the STAR SEEKER program

Constellation	English Names	Number of stars	Star names
ANDROMEDA	Chained Maiden	8	ALPHERATZ, MIRACH, ALMAAK
* APUS	Bird of Paradise	2	
AQUARIUS	Water bearer	9	
AQUILA	Eagle	8	ALTAIR
ARA	Altar	7	
ARIES	Ram	3	HAMAL
AURIGA	Charioteer	9	CAPELLA
BOOTES	Herdsmen	7	ARCTURUS
CANCER	Crab	2	
* CANES VENATICI	Hunting dogs	1	COR CAROLI
CANIS MAJOR	Great dog	12	SIRIUS (Dog Star), ADHARA
CANIS MINOR	Small dog	2	PROCYON
CAPRICORN	Sea goat	5	
CARINA	Keel	9	CANOPUS, MIAPLACIDUS
CASSIOPEIA	Lady in chair	7	SHEDIR, CAPH
CENTAURUS	Centaur	19	HADAR
CEPHEUS	King Cepheus	8	
CETUS	Whale	9	
* CIRCINUS	Compasses	1	
COLUMBA	Dove	5	
CORONA BOREALIS	Northern crown	5	ALPHEKKA
CORVUS	Crow	4	
* CRATER	Cup	1	
CRUX	Southern cross	5	ACRUX, MIMOSA
CYGNUS	Swan	14	DENEK, ALBIREO
* DELPHINUS	Dolphin	2	
* DORADO	Swordfish	2	
DRACO	Dragon	12	THURBAN

Table 2 Constellations and star names included in the STAR SEEKER program (cont)

Constellation	English Names	Number of stars	Star names
*EQUULEUS	Small horse	1	
ERIDANUS	River Eridanus	15	ACHERNAR
*FORNAX	Furnace	1	
GEMINI	Twins	12	POLLUX, CASTOR, ALHENA
GRUS	Crane	6	ALNAIR
HERCULES	Hercules	15	
*HOROLOGIUM	Clock	1	
HYDRA	Water monster	11	ALPHARD
HYDRUS	Sea-serpent	3	
*INDUS	Indian	2	
*LACERTA	Lizard	1	
LEO	Lion	12	REGULUS, ALGIEBA, DENEbola
*LEO MINOR	Small lion	1	
LEPUS	Hare	8	
LIBRA	Scales	6	
LUPUS	Wolf	11	
LYNX	Lynx	2	
LYRA	Lyre	3	VEGA
*MONOCEROS	Unicorn	2	
MUSCA	Fly	5	
*OCTANS	Octant	1	
OPIUCHUS	Serpent bearer	13	RASALHAGUE
ORION	Hunter	15	RIGEL, BETELGEUSE, BELLATRIX, SAIPH, ALNILAM, ALNITAK, MINTAKE
PAVO	Peacock	6	
PEGASUS	Winged horse	10	MARKAB
PERSEUS	Champion	12	ALGOL, MIRPHAK
PHOENIX	Phoenix	7	
*PICTOR	Painter's easel	2	
*PISCES	Fishes	3	
*PISCIS AUSTRAL	Southern fish	1	FOMALHAUT
PUPPIS	Poop (stern)	8	
*PYXIS	Compass	2	
*RETICULUM	Net	2	
*SAGITTA	Arrow	2	
SAGITTARIUS	Archer	16	
SCORPIUS	Scorpion	19	ANTARES, SHAULA
*SCUTUM	Shield	1	
SERPENS	Serpent	9	
TAURUS	Bull	18	ALDEBARAN, AL NATH, THE PLEIADES, THE NYADES
*TELESCOPIUM	Telescope	1	
TRIANGULUM	Triangle	3	
TRIANGULUM AUSTRAL	Southern triangle	3	
*TUCANA	Toucan	2	
URSA MAJOR	Great bear (or The Plough)	19	DUBHE, ALIOTH, ALKAID, MIZAR, MERAK, PHAD, MEGREZ, ALCOR
URSA MINOR	Small bear	7	POLARIS (Pole or North Star)
VELA	Sails	9	
VIRGO	Virgin	9	SPICA
*VOLANS	Flying fish	4	

SECTION B: SOLAR SYSTEM

1.0 INTRODUCTION

Our Solar System consists of a single star, the Sun, together with nine planets orbiting it. In order of increasing average distance from the Sun, they are Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto. In addition to the Sun and Planets there are various other bodies in the Solar System, for example, comets. The most famous example is Halley's Comet, which spends most of its time in the outer regions of the Solar System where it is not well placed for observation from the Earth. However, every 76 years this comet returns to the inner Solar System where it can be easily seen from Earth. It was last seen in 1910, and will return to grace our skies towards the end of 1985 and early in 1986

The program SOLAR SYSTEM provides information on the Planets and Halley's Comet. The purpose of this program is two-fold. Firstly, SOLAR SYSTEM can be used to locate these bodies in the night sky from any location on Earth, or to determine when they are best placed for observation. Secondly, the program will display the relative positions of bodies within the Solar System at any time and you can follow their motions within the Solar System as they slowly orbit the Sun. This provides an informative and entertaining way of learning about our Solar System.

The next Section describes how to run SOLAR SYSTEM and explains the different types of information available from the program. Section 3 provides some illustrations of how to use the facilities available in SOLAR SYSTEM both for planning observations and for learning about our Solar System. Some of the astronomical terms used have already been explained in Section A. In such cases an explanation of their meanings will not be repeated. In Appendix 2 we include a brief introduction to the Planets to complement the information obtainable from the program.

2.0 RUNNING SOLAR SYSTEM

To load and run the program, see separate instruction sheet.

2.1 Specifying location, date and time

You are first asked to input your longitude and latitude and the date and time on which you require information on the Solar System. These details are entered in exactly the same way as for the program STAR SEEKER. You can refer to page 2 of Section A to obtain a detailed description of how this is done. Having entered these details, the program will enquire whether you are satisfied with the input location, date and time.

Next there is a short delay, indicated by the Computing Orbits message, while the program carries out computations necessary for determining the positions of bodies within the Solar System. The main Menu is then displayed giving the full list of options available to the user.

2.2 THE MENU

The Menu provides the user with a total of 6 options. The options available are as follows:

Option 1

This option allows you to obtain information on any of the Planets and Halley's Comet. A second menu allows you to select one of these bodies. Information available includes:

POSITION IN SOLAR SYSTEM: The distance of your chosen object from the Sun and its distance from the Earth are listed. These distances are given in terms of Astronomical Units (abbreviated A.U.). One Astronomical Unit is equal to the average distance between the Earth and the Sun, which is about 93 million miles. Within the Solar System astronomers often express distances in Astronomical Units since if the mile or the kilometre were used then distances would be quoted in inconveniently large numbers.

POSITION IN SKY: The number of degrees round the horizon from North in the sense NESW and the number of degrees from the horizon are listed. This position can be used to locate your chosen object in the night sky. However, if the number of degrees from the horizon is negative then this means that the object is below the horizon at your chosen time of night. As in the program STAR SEEKER, the position is also given in terms of Right Ascension and Declination.

BRIGHTNESS: The approximate brightness of your object is given. As with stars, this brightness is expressed in magnitudes, with brighter objects having lower magnitudes. The quoted brightness is on the same scale as that used for stars. Recall that the faintest stars

visible with the naked eye have a magnitude of about 6, so if the magnitude of your object is greater than 6 it will be too faint to be seen with the naked eye.

RISE AND SET TIMES: The times at which the object rises and sets on the specified date are displayed. As with STAR SEEKER you will be informed if the object does not rise above your horizon or does not set at your chosen latitude.

Option 2

On choosing this option the times of sunrise and sunset are given. Again you will be informed if the Sun does not rise above the horizon or does not set at the specified latitude. This situation can occur from locations on Earth near the North and South Poles at certain times of the year. If the Sun is above the horizon at the input time of day then a warning will appear. If this is the case then you will obviously not be able to see any other astronomical objects at that time, except possibly the Moon.

Option 3

On choosing this option there will be a short delay, indicated by the message

Computing MOON orbit . . .

During this time the program will be carrying out the calculations needed to determine the position of the Moon in its orbit around the Earth. On completing these calculations SOLAR SYSTEM will list the times at which the Moon rises and sets on the specified date. Alternatively, you will be informed whether the Moon does not rise above the horizon or does not set at the chosen latitude.

The phase of the Moon is displayed on your screen. The Moon does not emit its own light but shines by the reflected light of the Sun. Since the Sun can only illuminate half of the Moon's surface, the other half remains dark. The phase of the Moon depends on the relative positions of the Moon, the Sun and the Earth. When the Moon is approximately between the Earth and the Sun the daylight side of the Moon is turned away from us, so we cannot see it. This is called the New Moon. In the other extreme, when the Moon is on the opposite side of the Earth to the Sun, the daylight side of the Moon is facing us. This is known as the Full Moon since we see a fully illuminated disc. Between these extremes we see some of the daylight side of the Moon.

The age of the Moon is also displayed. The Moon's age is related to its phase, being the number of days since the last New Moon. As the Moon moves in its orbit around the Sun its age increases. Full Moon occurs when the age of the Moon is about 14½ days. The next New Moon occurs after about 29½ days.

Option 4

This option provides a table which summarises the positions and brightnesses of the Planets and Halley's Comet. For each object the position in the sky is displayed in terms of the number of degrees from North and the number of degrees from the horizon. The approximate brightness, expressed in magnitudes, is also listed. If a body is both above the horizon at your chosen time of night and bright enough to be seen with the naked eye then this will be indicated on screen. This option is particularly useful for quickly determining those objects which are observable with the naked eye at the specified time of night.

Option 5

On choosing this option a display of the Solar System will be produced. This display shows the relative positions of the Planets and Halley's Comet on the input date. The Sun is plotted at the centre of the display. At the bottom of the screen the message Press S, I, O, M, P or E (Explanation) will be displayed. This message indicates the options now available to the user. An option is selected by pressing the appropriate key. The individual options are explained by pressing [E] for explanation.

Each of these options is now described:

[M] -To return to MENU

Choose this option to return to the main MENU.

[P] -To obtain PRINTOUT.

Choose this option for a screen dump of the present display to a printer (see separate sheet).

[S] – For another Scale of view

In order to understand fully the effect of this option we shall first mention some characteristics of our Solar System.

The Planets and Halley's Comet move in orbits around the Sun at different distances from it. During this motion the distances between the Sun and the orbiting body will vary since the orbits are elliptical, not circular. For most of the Planets these orbits are only slightly elliptical, making them almost circular. However, the orbit of Halley's Comet is highly elliptical. As a result its distance from the Sun varies greatly, depending on the position of the comet in its orbit. The average distances of the Planets from the Sun are listed in Table 3, being quoted both in terms of Astronomical Units and millions of miles. For Halley's comet the range of distances from the Sun is given, from its closest approach to the Sun to the farthest point in its orbit. Also given in Table 3 are the corresponding orbital periods, in years. The orbital period is the time taken for an object to make one complete orbit of the Sun. As can be seen from the Table, during the period of time taken by Pluto to orbit the Sun the Earth will have completed 248 orbits.

The orbits of these objects do not lie exactly in the same plane in space. The screen display of the Solar System shows the positions of each body projected onto the plane of the Earth's orbit around the Sun (known as the plane of the ecliptic). As you can see from Table 3, the distances of the Planets and Halley's Comet from the Sun vary over a large range. The innermost Planet, Mercury, lies at about 36 million miles from the Sun, while Pluto is about 3664 million miles from the Sun. Hence the average distance of Pluto from the Sun is about a hundred times that of Mercury. As a result it is not possible to conveniently plot all the objects on one screen display.

The program allows you to display the Solar System using different scales of view. When the initial display is shown SCALE 2 is used. Using this scale of view you can see all the objects in the Solar System, although the plotted positions of the innermost Planets are close together near the centre of the display. By pressing [S] you can change the scale of view. Scale factors between 1 and 10 can be input. Entering a larger scale factor than 2 allows you to 'zoom in' to view the inner Planets. Having variable scales of view in this way provides considerable flexibility in allowing you to obtain the most appropriate screen display for your particular purpose.

[I] – For Information on a displayed body

This option allows you to obtain information on any plotted object. On pressing [I] a cross-wire cursor appears at the centre of the screen, directly over the position of the Sun. You must carefully position the cursor over the object about which you require information, then press the [ENTER] (Spectrum) or [RETURN] (MSX) key. This procedure is identical to that used in STAR SEEKER when obtaining information on a plotted star. Having successfully chosen your object, the name of that object is displayed and its distance from the Sun is given, in Astronomical Units.

[O] – To follow Orbital motions

This option allows you to watch the motions of the Planets and Halley's Comet as they orbit the Sun. On pressing [O] you will be asked whether you want to follow the motions of all the bodies plotted, or any one or two. In the latter two cases you are then asked which bodies, you require.

Next you must enter the Time Step required for the motions, in days. This is the interval in time between successive updates of the plotted positions. For example, if you input 10 days then the positions of the plotted points will be updated in steps of 10 days. Care should be taken in choosing your input Time Step. Referring to Table 3, we see that there is a wide variation in the orbital periods of the objects. Whereas Mercury orbits the Sun in slightly less than a quarter of a year, Pluto takes over 248 years to complete one orbit of the Sun: the further an object is from the Sun the slower it moves, objects at greater distance from the Sun move at slower speeds in their orbits. Hence, a Time Step of 10 days will produce a very small change in the position of Pluto, but a significant change in the position of Mercury. As a rough guide, the orbits of the inner planets are best seen using a Time Step of about 10 days, while the motions of the outer planets require Time Steps of about 600 days or so.

Mother's Very Easy Meals Just Satisfy Us Nicely Please

Table 3. Orbits of the Planets and Halley's Comet

Object	Average distance from the Sun in:		Orbital Period in years
	Astronomical Units (A.U.)	millions of miles	
MERCURY	0.39	36	0.24
VENUS	0.72	67	0.62
EARTH	1.0	93	1.0
MARS	1.5	142	1.9
JUPITER	5.2	483	11.9
SATURN	9.5	886	29.5
URANUS	19.2	1782	84.0
NEPTUNE	30.1	2792	164.8
PLUTO	39.4	3664	248.4
HALLEY'S COMET	0.59-35.3	55-3284	76.0

Having input your Time Step the program will automatically update positions, keeping a track of the current display date. The current position of an object on the screen is indicated by a large plotted point. The previous positions will be recorded by small dots, except when successive plotted positions are very close together.

The automatic updating of positions is stopped by pressing [S]. After the motions have stopped, the message Press C (to Continue motions), F (to Finish motions), P (Dump screen) or I (for Information) will appear at the bottom of the screen, indicating the current options available to the user.

On pressing [C] the automatic updating will be continued as before.

On pressing [I] the cross-wire cursor will appear, allowing you to obtain information on the current positions of displayed objects. This is achieved by positioning the cursor over the current position of an object in the normal way, then pressing the [ENTER] (Spectrum) or [RETURN] (MSX) key. The name of the selected object will be displayed, together with its distance from the Sun, in Astronomical Units. Having obtained your required information the display will return to automatic updating from the current positions.

On pressing [P] the program will print a copy of the present updated display to a printer. (See separate sheet). Having obtained your printout the display will return to automatic updating.

On pressing [F] the updating will finish and you will be returned to the main Menu. Note that, having returned to the main Menu, you are also returned to your original input date and time.

Option 6

This allows you to change the date of observation and/or time of night and/or geographical position.

3.0 USING SOLAR SYSTEM

This Section provides some illustrations of how to make the best use of the facilities available within SOLAR SYSTEM.

For illustrative purposes we will initially discuss information on the Solar System at 6.30 p.m. GMT (1830 hours) on 15th January, 1986 (15.1.1986), as seen from London (longitude -0.1 degrees and latitude 51.5 degrees). By this date Halley's Comet will have returned to the inner Solar System and will be bright enough to be seen with the naked eye. We recommend that you input these values into SOLAR SYSTEM for a visual reference guide to the following sections.

3.1 Locating objects in the night sky

From Option 2 of the Menu we find that on 15th January the Sun sets at about 1614 hours GMT, i.e. about 4.14 p.m. Since our input time of day was 1830 hours GMT, the Sun will have set over two hours before this time. Twilight will have effectively ceased and the night sky should be relatively dark.

Figure 7 shows the display obtained on selecting Option 3. We see that there will be a crescent Moon, it being just over 5 days since the last New Moon. Only part of the illuminated side of the Moon is visible to us. Also notice that the Moon will be above the horizon, setting in the West about four hours later than the input time of night.

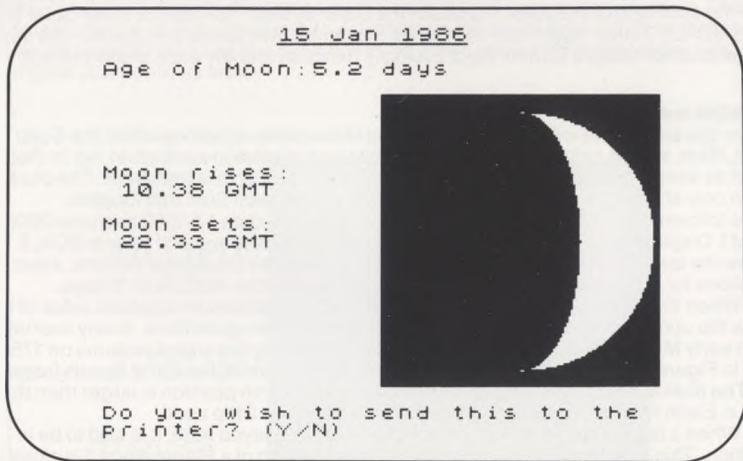


Figure 7

In order to quickly determine which objects are both above the horizon and bright enough to be seen with the naked eye select Option 4. From the displayed table of positions and brightnesses we see that two objects fall within this category: the Planet JUPITER and HALLEY'S COMET. However, JUPITER lies only about one degree above the horizon so it would be very difficult to observe at this time of night. Buildings or hills will probably be in the way! HALLEY'S COMET lies about 10 degrees above the horizon so it may be observable low in the sky. The Comet lies about 247 degrees from North. Since South lies 180 degrees from North and West lies 270 degrees from North, the Comet will lie in a direction between South-West and West. Its brightness at this time is about fourth magnitude, making it bright enough to be seen with the naked eye, although not particularly prominent. Hence, this information can be used to locate the Comet in the night sky. Option 1 can be used to obtain full information on HALLEY'S COMET. From the displayed information we see that the Comet will set a little over one hour later than the input time of 1830 hours GMT.

However, as we have seen, the Moon is above the horizon. If it was a Full Moon, then the light from the Moon would cause the night sky to be relatively bright, making observations of fainter objects more difficult. In this case the phase of the Moon is a crescent so the sky will not be completely dark. Also, since the Moon will set in the West about four hours later than our input time it will be in the same region of sky as the Comet. This situation will not make identification of the Comet an easy task on this occasion. Since on the 15th January, 1986 the age of the Moon is 5.2 days, it might be more profitable to search for the Comet a few days earlier when the phase of the Moon will be close to New, so the sky will be darker. This example shows the types of consideration to be taken into account when using SOLAR SYSTEM to plan observations.

The above illustration does not represent the most favourable time or location to view Halley's Comet on its return in 1986. We will return to this point in Section 3.4.

SOLAR SYSTEM can be used in a similar way to locate the Planets in the night sky. However, the outermost Planets Neptune and Pluto are so far from the illuminating light of the Sun that they always remain too faint to be seen with the naked eye. Uranus is sometimes bright enough to be visible in good observing conditions, but even at its brightest it is not easy to identify.

3.2 Displaying the Solar System

The information obtained using Option 1 shows that on 15th January, 1986 Halley's Comet is 0.8 Astronomical Units from the Sun. On this date the Comet lies in the inner Solar System, being inside the Earth's orbit. On choosing Option 5 to display the Solar System at this time we obtain a view of the whole Solar System. This display (SCALE 2) provides a good view of the positions of the outer Planets in the Solar System. To view the inner Solar System select a SCALE 7 view. Apart from the Sun at the centre, five points are plotted – the innermost four Planets and Halley's Comet. By pressing you can identify each plotted object.

3.3 Orbital motion

In this section we will look at two aspects of the orbits of bodies within the Solar System. Here, we are only interested in their positions relative to each other, not in their position as seen from Earth, so the observer's location on Earth is irrelevant. The observer's location only affects the positions of objects in the sky as seen from that location.

(i) The following procedure should be followed: Input the date 1.8.1983 and time 0000 hours GMT. Display the Solar System (Option 5) and change the scale of view to SCALE 7 to view the inner Planets. Then choose Option to follow the orbital motions, selecting the motions for Earth and Mars only. Enter a Time Step for the motions of 10 days.

When the display first appears Mars and Earth are almost on opposite sides of the Sun. As the updating continues the Earth gradually catches up on Mars, finally overtaking Mars in early May of 1984. The display obtained by stopping the orbital motions on 17.5.1984 is shown in Figure 8. Apart from having a smaller orbit to traverse, the Earth travels faster than Mars. The distance between successive updates of the Earth position is larger than that of Mars, i.e. Earth travels farther than Mars in the 10 day Time Step used.

When a body lies directly opposite the Sun, as displayed here, it is said to be in opposition. This is the most favourable time for observation of a Planet since it is close to Earth and in a direction directly away from the Sun. Since the orbits of Mercury and Venus lie between the Earth and the Sun, they cannot come to opposition. However, you can use the above method for determining when the other Planets are most favourably placed for observation.

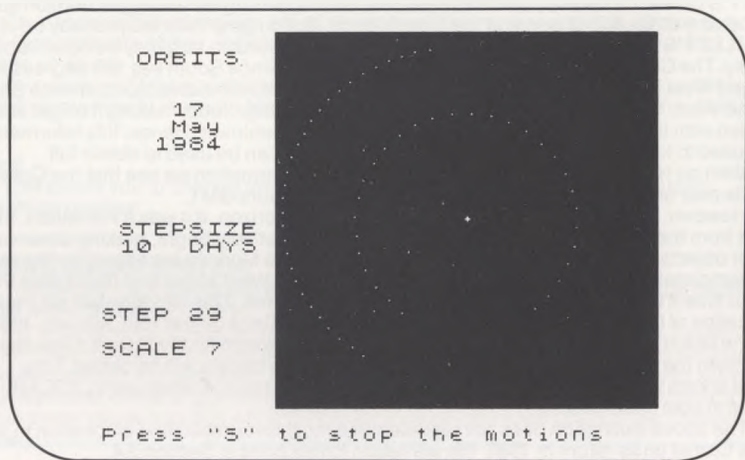


Figure 8

- (ii) Using the same starting date as in Part (i) (1.8.1983), display the Solar System using SCALE 3 and follow the motion of only Halley's Comet with a Time Step of 300 days. The Comet quickly nears the Sun by 1986, and then makes its way into the outer Solar System. Its orbit is highly elliptical. The Comet travels much slower in the outer parts of its orbit, hence spending most of its time far from Earth. This is a characteristic of all orbiting bodies—the orbital velocity decreases as the body moves further from the Sun. This was first established in 1609 by the German astronomer Johannes Kepler. Figure 9 shows the display obtained by stopping the motion in 2056, three years before the Comet returns to the original position in its orbit.

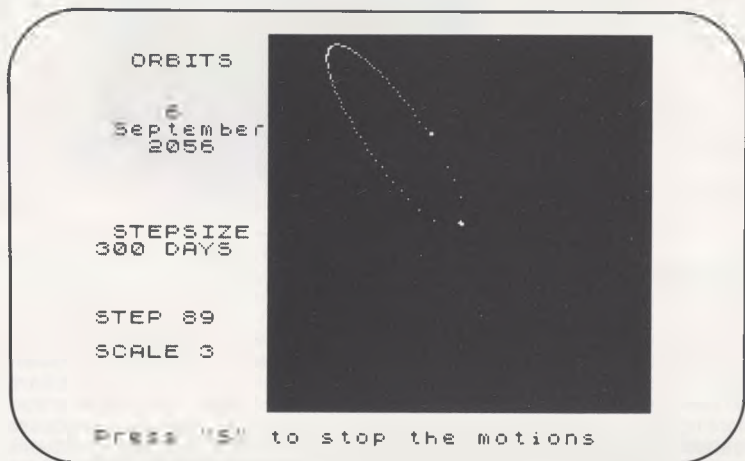


Figure 9

3.4 The return of Halley's Comet

The core of a comet, known as its nucleus, is only a few kilometres in diameter. It is thought to consist of ices and snows of various substances, mainly ordinary water ice, with dust particles of different sizes mixed in. When this "dirty snowball" approaches the Sun it is heated, resulting in some of its material being released from the nucleus in the form of gas and dust. This gas and dust is then driven away from the Sun by the Sun's radiation and by particles constantly streaming away from the Sun (known as the Solar Wind). This creates the glowing tail of the comet which can extend for several tens of millions of kilometres. Since the release of material from the nucleus is greatest when the comet is closest to the Sun, the comet is best seen at this time.

Since Halley's Comet approaches the Sun once every 76 years, most of us will only get one chance to see this most famous of comets during our lifetime. Figure 10 shows a close-up view of the Comet's return in 1986. It was created by entering a starting date of 1.9.1985 (0000 hours GMT), displaying the Solar System using SCALE 7 and following the motions of the Earth and Halley's Comet with a Time Step of five days. The motions were stopped when the current date was 9.5.1986, producing the illustrated display. If you go through this procedure yourself, you will see that the Comet comes closest to the Sun in early February 1986. Unfortunately, as you can see from the screen display, this occurs when the Earth is on the opposite side of the Sun. So when the Comet is at its brightest we will not be able to see it in the night sky.

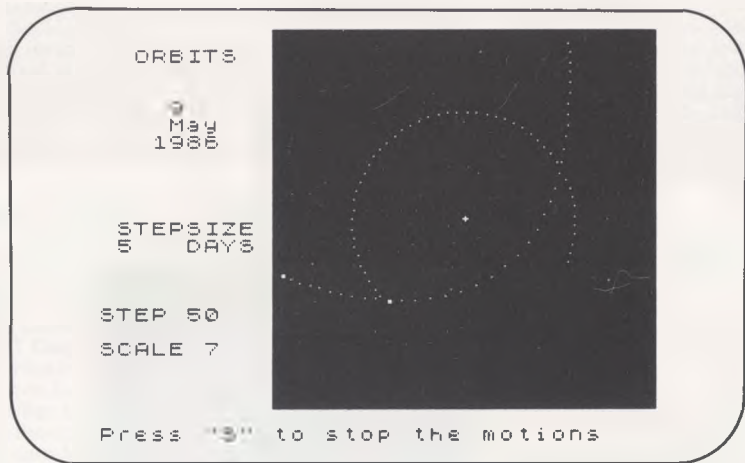


Figure 10

However, as you will see the Comet does pass close to the Earth both before and after its closest approach to the Sun. The program can be used to show that the Comet comes closest to Earth on its second passage, in early April 1986. It will be best seen from Earth at this time. The Comet will be most conveniently seen when it is high in the night sky. Some experimenting with the program will show that in early April 1986, this occurs for observers at latitudes south of the equator. For example, at 1600 hours GMT on 10.4.1986 from Sydney (longitude +151.2 degrees and latitude -33.9 degrees) the Comet is over 70 degrees above the horizon and bright enough to be seen with the naked eye. So, if you live well north of the equator, you might consider planning a holiday to take full advantage of the once-in-a-lifetime opportunity of viewing Halley's Comet. SOLAR SYSTEM can be used to ascertain the position of the Comet from any location on Earth.

3.5 Relevant information from STAR SEEKER

STAR SEEKER can be used to show the position of a Planet or Halley's Comet in relation to the background stars. First use SOLAR SYSTEM to find the position of the object in the sky (i.e. the number of degrees from North and the number of degrees above the horizon) for your chosen location, date and time. Then run STAR SEEKER using the same location, date and time. Obtain a Star Map by specifying your own direction of view (Option [X]), entering the position of your object as the centre of your field of view. The resultant Star Map will display the stars around your object. The position of your object will be at the centre of the Star Map. This position can be shown by pressing [I]. The displayed cross-wire cursor will be in the position of your object. This will help you to locate your chosen object in the night sky.

APPENDIX 1: Notes on the accuracy of STAR SEEKER and SOLAR SYSTEM

STAR SEEKER: The positions and rise and set times for the stars are based on figures which hold exactly for the epoch 1984-5 and are taken from the Yale Catalogue of Bright Stars. No corrections are applied for such phenomena as aberration, precision, nutation, or proper motion, all of which affect these positions slightly with time.

However, over a period of a century or so, their combined effect will not result in a significant change in a star's stated position.

SOLAR SYSTEM: The computational method used provides reasonably accurate results over the period of about 1950 to 2000, with lower accuracy outside this time interval. As a rough guide, for Mercury, Venus, Mars, Jupiter and Saturn the quoted positions in the sky will typically be accurate to within about a half a degree, while for Halley's Comet an accuracy of within about a quarter of a degree is to be expected. Their positions in the Solar System, in terms of their distances from the Earth and from the Sun, will generally be accurate to within about a hundredth of an Astronomical Unit. Estimated brightnesses of the Planets and Halley's Comet will only be accurate to within a magnitude or so. The positions of the Planets and Halley's Comet have been computed under the assumption that their motions are controlled solely by the gravitational field of the Sun. As a result, somewhat lower accuracy is achieved for the outer Planets Uranus, Neptune and Pluto because of the perturbing effect of gravitational interactions between the outer Planets.

The times at which the Sun and Moon rise and set are typically correct to within about five minutes.

APPENDIX 2: Introduction to the Planets

At the centre of our Solar System lies the Sun, a vast globe of hot gas about 864,000 miles in diameter. The Sun is a normal star, its prominence and importance to us on Earth lying in the fact that it is a mere 93 million miles away. When we compare this to the distance of the next nearest star, ALPHA CENTAURI, of about 25 million million miles we see that it is a short distance on the astronomical scale. Apart from providing the energy required for the existence of life on Earth, the gravitational force exerted by the Sun controls the motion of the Planets in their orbits. Unlike the Sun, which emits its own light, the Planets shine by the reflected light of the Sun.

The following notes provide some background information on the nine Planets:

MERCURY: This is the nearest Planet to the Sun, its average distance from the Sun being about 36 million miles. However, compared to the other Planets the orbit of Mercury is markedly elliptical, its distance from the Sun varying from 29 million miles at its closest to 43 million miles at its farthest point. The program SOLAR SYSTEM can be used to illustrate this by obtaining a close-up view of the inner Solar System (using SCALE 9) and then following the orbital motion of Mercury with a Time Step of, say two days. After the Planet has described one complete orbit, the oval shape to its orbit can be clearly seen.

Unfortunately, two factors make Mercury a difficult Planet to observe with the naked eye. Its diameter is only 3,100 miles which makes it a little bigger than our Moon and it is never very far from the Sun in the sky. This latter point means that Mercury can only be observed when low in the twilight sky, making it a difficult object to find.

The Planet's small size has meant that it has been unable to retain any appreciable atmosphere. Without the protective influence of an atmosphere its daytime temperature may reach as high as 450° Centigrade when it is closest to the Sun, while at night the temperature falls to a freezing -180°C, America's Mariner 10 spacecraft transmitted the first close-up pictures of Mercury in 1974 and 1975, revealing a heavily cratered surface not unlike that of our Moon.

VENUS: Venus is our nearest planetary neighbour, at times coming to within 24 million miles of Earth. Its diameter of 7,700 miles makes it almost as large as the Earth. The Planet's surface is hidden by a dense cloud-laden atmosphere, composed almost entirely of carbon dioxide. Its atmosphere is a particularly efficient reflector of sunlight, making Venus a brilliant object in the sky. At maximum brightness the Planet is brighter than every other astronomical body, except the Sun and Moon. In fact, the light from Venus has been known to cast shadows. Since its orbit lies between Earth and the Sun, Venus is never too far from the Sun in the sky, so characteristically it is often seen as a brilliant object in the evening or morning twilight.

The Planet's dense atmosphere allows sunlight through to its surface, but prevents heat from escaping, causing a 'greenhouse effect'. As a result the surface of Venus experiences temperatures of about 470° Centigrade. The surface is also subjected to an atmospheric pressure ninety times that of the Earth.

EARTH AND MOON: Earth is the third Planet from the Sun and the only one known to support life. With a diameter of about 7,900 miles, our Earth is the largest and most massive of the inner four Planets.

It has one natural satellite, the Moon, which orbits the Earth at an average distance of about 250,000 miles. The Moon always presents the same face towards the Earth since it rotates once on its own axis in the same length of time that it takes to orbit the Earth. The darker areas on the moon's surface are known as maria (seas), although we now know that they never contained water, but were probably originally lava flows. Binoculars or a small telescope are sufficient to observe craters on the Moon. Surface features are particularly well seen when they are near the boundary between the illuminated side and the dark side of the Moon (known as the terminator). From this part of the Moon's surface the Sun will be low in the sky, casting the long sharp shadows which highlight details on the surface. Hence, Full Moon is not the best time to observe the Moon.

MARS: This is the next Planet out from the Sun, with a size of about half that of the Earth. It has a thin atmosphere, composed mainly of carbon dioxide and a surface which is pitted with craters. The surface is covered in a fine reddish dust made up of iron oxides, giving Mars its distinctive red colour which can clearly be seen with the naked eye.

Mars is best placed for observation from Earth when it is in opposition, i.e. it is opposite the Sun in the sky. The orbital periods of Earth and Mars are such that this occurs at average intervals of about two years 50 days. Since Mars is a relatively small planet it only presents a particularly bright spectacle in the night sky around times at which it is in opposition.

JUPITER: Moving out further from the Sun we come to Jupiter, the largest Planet in the Solar System with a diameter of nearly 90 thousand miles across its equator. Its large size ensures that it presents a conspicuous sight to the naked eye. It has a mass which is greater than that of the other Planets combined.

The Planet is composed predominantly of the lightest element, hydrogen, so that despite its large mass its density is not much greater than that of water. Jupiter has a deep atmosphere, including gases such as ammonia and methane (compounds of hydrogen), which increases in density until hydrogen becomes liquid at depths of around a thousand kilometres. Hence, unlike the inner Planets, Jupiter is not thought to have a well-defined solid surface.

Unlike Mars, which has only two tiny moons, Jupiter has over a dozen moons in orbit around the Planet. The four largest moons can be seen through binoculars or with a small telescope. They are known as the Galilean satellites after Galileo who observed them in 1610, soon after the invention of the telescope.

SATURN: This planet is slightly smaller than Jupiter, with a diameter of about 75 thousand miles across its equator. It is a similar planet to Jupiter, being composed largely of hydrogen, having a dense atmosphere with no well-defined solid surface. It never reaches the brilliance of Jupiter in the night sky because of its larger distance from Earth and smaller size. However, through a telescope it provides a spectacular sight, being surrounded by a conspicuous system of rings consisting of numerous individual particles each orbiting the Planet independently as minute satellites.

URANUS, NEPTUNE AND PLUTO: Although somewhat smaller Planets, Uranus and Neptune are similar in nature to Jupiter and Saturn. Uranus may just be visible to the naked eye in a clear sky, although it is not easy to identify. Uranus has the distinction of being the second ringed Planet in our Solar System, the existence of the rings being discovered in 1977.

Neptune and Pluto are always too faint to be seen with the naked eye, lying far from the illuminating light of the Sun. Unlike the other outer Planets, Pluto is tiny in comparison. Its diameter is smaller than that of our Moon. Even the largest telescopes show this Planet as a star-like point.

Pluto's orbit is markedly elliptical and at its closest approach to the Sun it comes inside the orbit of Neptune. Indeed at the present time Neptune is the outermost Planet in the Solar System.

STAR SEEKER

A guide to the night sky

48K SPECTRUM

RUNNING STAR SEEKER (SIDE A)

To load and run the program:

1. Type **LOAD** "STAR" or just **LOAD** " " and press **ENTER**
2. Press **PLAY** on your tape recorder.

The program will then load automatically.

RUNNING SOLAR SYSTEM (SIDE B)

To load and run the program:

1. Type **LOAD** "SOLAR" or just **LOAD** " " and press **ENTER**
2. Press **PLAY** on your tape recorder.

The program will then load automatically.

At no point in either the loading or running of the program should **BREAK and **CAPS SHIFT** be pressed simultaneously, as this will cause the program to crash.**

If you have any difficulty with loading, you should:

1. Check the leads between the computer and the tape recorder.
2. Check that the tape is fully rewound.
3. Refer to your computer's manual on the subject.

USING PRINTERS WITH STAR SEEKER AND SOLAR SYSTEM

The programs allow screen dumps to ZX, and other printers provided the Kempston centronics interface is used. If you are not using a ZX printer, you **MUST** load your own printer software before loading STAR SEEKER or SOLAR SYSTEM. The programs will detect whether this software has been loaded and adjust the printing instructions accordingly.

On-screen instructions will show when print options are available and should be followed exactly to obtain the required output.

DISCOVER THE FASCINATION OF THE HEAVENS!

STAR SEEKER by Paul Phillips, PhD, FRAS

The mysteries of the night sky are revealed with STAR SEEKER, an easy to follow introduction to the fascinating science of Astronomy.

STAR SEEKER accurately plots on-screen the position of more than 500 of the most prominent stars in the night sky. It will map the sky seen from any point on Earth at any day and time in this and the next century.

A host of features include options to plot constellations, to simulate the changing night sky as the Earth rotates, to pinpoint individual stars for on-screen information including their accurate positions and to dump screens to a printer.

Also included is a companion program SOLAR SYSTEM which locates the planets in the sky and plots their orbits relative to the sun and each other. Information on the sun and moon is also included. SOLAR SYSTEM also plots the course of Halley's Comet, last seen in 1910 and due in our skies in 1985 and 1986.

An informative instruction book explains how to operate the programs and provides a wealth of astronomical information. Loading and printing instructions are given on a separate sheet.

Star Seeker

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