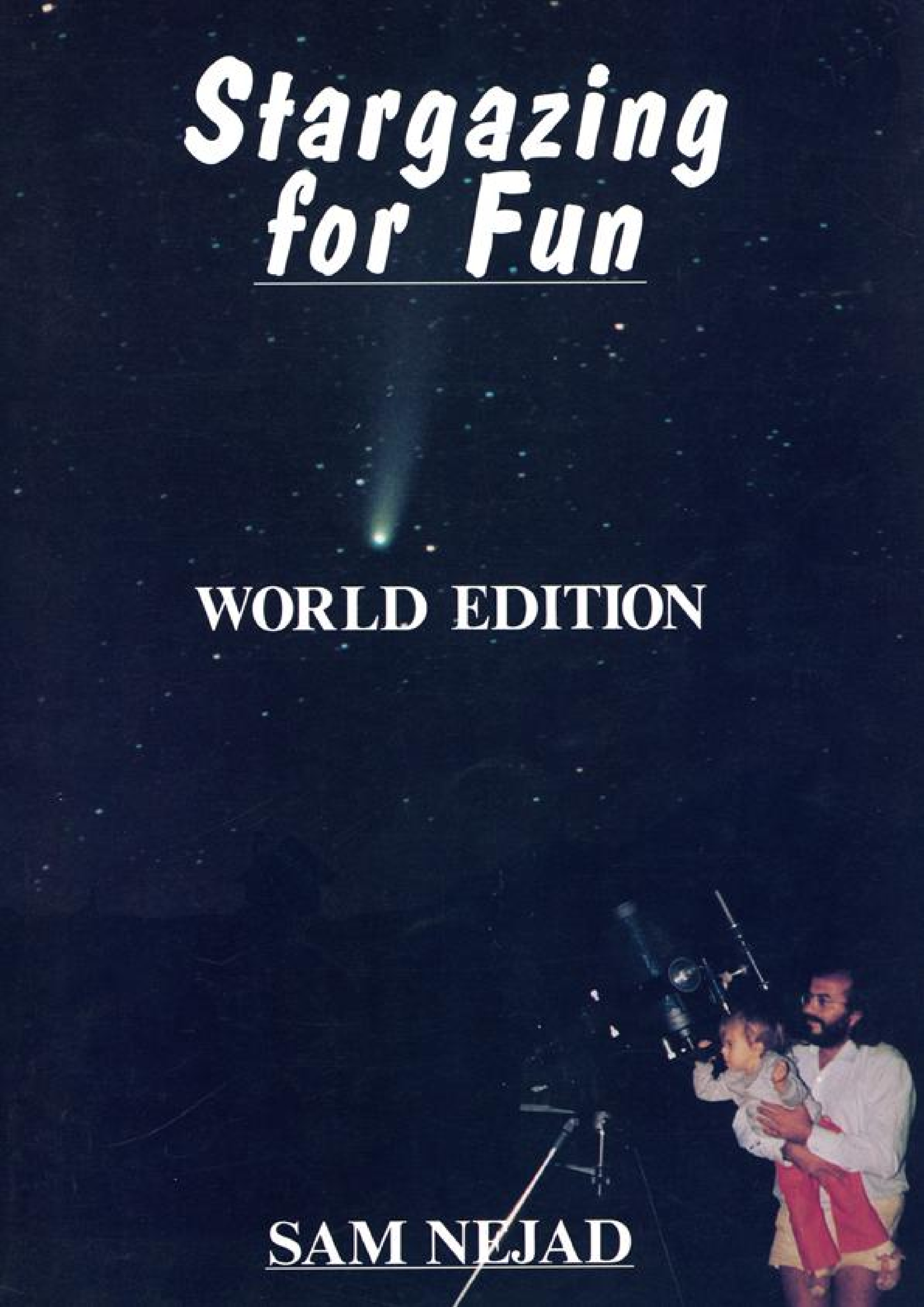
Stargazing for Fun



WORLD EDITION

SAM NEJAD

STARGAZING FOR FUN

World Edition

Sam Nejad

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The Perth Observatory Volunteer Group Inc (POVG) Board and Volunteers express their profound gratitude and appreciation to Mr Sam Nejad for generously consenting POVG republish his book "Stargazing for Fun" in digital format.

Originally published in 1990, "Stargazing for Fun" has proven over many years to be a valuable contribution to the fun and science of astronomy encouraging the acquisition of knowledge that may be found by simply gazing into our night sky and stirring an inquisitive mind of any age.

On behalf of the Perth Observatory Volunteer Group Inc (POVG) Board and Volunteers, Thank You Sam.

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Front Cover: Author & son, Tegan, admiring Halley's Comet.

Back Cover: Eta Carinae Nebula & open cluster NGC 3532.

FOREWORD

By Michael Candy,
Director of Perth Observatory, Western Australia.

I have read the manuscript of this book with great enjoyment. I wish that it had been available when, as an eight year old, I first became interested in astronomy. It is written with such an infectious enthusiasm that any person, young or adult, would find it hard to resist. The outstanding feature is that, for the first time, here is a book that can be used by an observer anywhere on the Earth. Another innovation is the inclusion of “Graphical Orreries”, which will provide an understanding of movements in the Solar System, and the wherewithal to find the bright planets at any time.

The illustrations are provided by the author, using amateur equipment, and give the reader an honest impression of what is achievable with modest means.

It is rare to find such an original book it is not simply aimed at the amateur astronomer but will capture any intelligent audience. It would be an excellent school text.

In summary, the book is recommended without reservation and would provide its readers with the impetus to pursue astronomy as a career or hobby.

Michael Candy
M Sc. B Sc. Hon., FRAS

INTRODUCTION

You have just opened the first page of a tourist brochure, but one with many unexpected surprises which will excite and thrill you as no ordinary brochure can.

For one thing, this invitation includes a guide and “road map” showing you where the tastiest treats are and how to find them. For another, this will be among the cheapest of holidays you have ever taken, yet the most fulfilling. Furthermore it is a vacation of majestic proportions, covering vast distances instantly and without passports and regulations. Finally, you can return and take this tour as often as you like, for just a few minutes or for hours at a time.

Yes, we are about to take a trip to the stars and planets, and to every wonder of the Universe within our grasp and we will do it just for fun. No experience is assumed, no great physical fitness is required; only the desire to know, which you already have.

Like any tourist you can simply remember the sights or you can also take pictures to show those back home when you return from traversing these billions of miles we are about to travel together.

If by now you are impatient to begin, I cannot blame you, so let us proceed

Chapter One:

THE GIGANTIC STAGE

Bend down, if you will, and pick up from some unvacuumed corner of the room a tiny grain of sand about one millimetre across, or the size of the full stop at the end of this sentence Look at it closely, roll it in the palm of your hand, for this is an important grain; for our purposes it is the Earth. Take care not to drop the Earth, it is highly unlikely you would ever find it again. Or if you did find another bit of dust, are you sure it is the same one?

So we have established a scale: The planet we live on, some 12,700 kilometers in diameter is now well within our grasp and only 1 mm across. Lets see how large and far away typical heavenly objects are using this microscopic measurement.

The Moon, our only natural satellite, is only a quarter the grain of sand that we hold, barely visible and fully 31 mm away. That is our closest neighbor, and so far a few Apollo astronauts have walked briefly on its surface. The Sun, that other great bright object, is 109 mm across, an orange nearly 12 metres away.

Lets go further afield. Jupiter, the largest of the planets in the family which orbits the Sun, is just over 11 mm across and on average some 60 metres distant Saturn, the famous ringed planet, is 9 mm in size, another small grape, and 114 metres away There are other planets, some closer some further away, as you see in appendix 2, but what is the greatest extent of the Sun's empire? Pluto is the furthest planet that we know of, it too is only a quarter the size of the grain of sand we hold, and is 480 metres or nearly half a kilometre away!

Imagine that you are a creature living on this grain You are seven million times smaller than the speck you hold in your palm, and yet you know of and have examined the planet Pluto, on this scale, half a kilometre away, a distance over 3,000,000,000,000 (three million million) times your own height! But you have done more

In consort with the rest of humanity you have launched space craft which are now further out than Pluto (Pioneers & Voyagers). If we are wise, inevitably one day our descendants will step upon that world. But how much further before we reach the planets circling those myriad other suns the stars?

A number of the closest stars to us are also. reasonably enough, very bright in the sky. Lets examine the distance of two of these using our scale.
The closest star to us is Alpha Centauri, in reality three stars or a triple system, but to the naked eye only one is seen. Alpha Centauri lies some 3,200 kilometers away from our speck of dust the Earth! And yet it is the closest to us. The brightest star in our skies (apart from the Sun of course) is Sirius and it is 6,500 Km away and the size of a rock melon

It is evident that we need a new way of measuring these vast distances without recourse to a scale using a 1 mm Earth. But before we move on to how astronomers refer to astronomically large distances lets push our model to its limits

Our own galaxy, the Milky Way, contains about 200,000,000,000 (two hundred billion) stars Di suns, many more planets, and is nearly 250 million kilometers in diameter using our scale. The nearest proper spiral galaxy to us (the Andromeda) is 1½ thousand million kilometers away, and there are billions more galaxies all further away than that. Finally, the furthest objects we have so far seen from our grain of sand are the quasars or primordial galaxies, up to about 10 billion light years away! (A light year, l.y, is how far light travels in a year, at almost 300,000 km per second).

By now you see that the Universe is a truly gigantic stage, even using this extremely small ruler. You also notice that the number of suns and planets is literally as numerous as the particles of sand on the beach. But there is another thing we must appreciate, the extreme loneliness of each stellar system. On a beach all the grains and rocks and boulders are touching each other. but in Space they are totally and utterly isolated from each other. Now it is time to return to the real world and the actual size of things. We will do away with miniature models and tackle the enormity of the situation head on.

If these immense numbers and distances intimidate or frighten you, do not worry. Night after night as you look at the stars and galaxies you will little by little come to comprehend the distances involved in the same way that you can visualize how far it is to the local shopping centre. You will feel comfortable with the hugeness of our galaxy and the infinity beyond, and even consider being aboard a spaceship set adrift into the void. Indeed you have no choice about this last proposal, since you already are on a minuscule spaceship of sorts wandering from one nowhere to another.

Suppose someone asks you the distance to the next town, you can reply that it is (for example) one hundred Km away or, seeing they are in a car, say "one hour. So you have replied using either true distance or an equivalent time to reach that town.

Likewise in astronomy. There are three different ways of referring to how far an object is. The first is true distance; miles or kilometers. The second is light years which we will discuss. The third is 'parsecs" which is of only marginal interest to us and explained only in the glossary at the end of this book.

You now have a very fast rocket at your disposal, one so fast that against all known laws of physics it actually travels at the speed of light the fastest known velocity Well, light travels at nearly 300 thousand kilometers per second in the vacuum of Space. You certainly have a most remarkable spaceship Leaving aside the effects of Einstein's Relativity predictions, having an independent observer doing the timing, how long would it take you to reach the objects we have talked about?

The Moon is just one second away. The Sun 8 minutes and 20 seconds. Jupiter takes 42 minutes to reach. Saturn, and its beautiful rings and moons, takes one hour and 19 minutes to get to... still comfortable there and back before lunch. So, on to Pluto; on average 5½ hours. And that is the extent of our solar system. One long weekend, and we take in Mercury, Venus, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto; do a bit of sightseeing and be back on Earth with hardly a hair out of place.

But the situation is different when we come to tackle the distance to other stars. Even at 30,000 Km/ second it will take us some 4 years and 4 months to reach Alpha Centauri, our nearest neighbor! Sirius will take B years and 8 months. It would take us 150,000 years to go directly across our galaxy the Milky Way. The Andromeda Galaxy is a leisurely 2 million years away - we would arrive well and truly fossilized. And the limits. of what we have so far seen, the quasars, well, we can keep going for up to ten thousand milion, or 10 billion years.

All this raises a very interesting situation. When the light leaves all these stars it takes years to reach us. For example, when we look up at the sky and see bright Sirius, the light we see left that star nearly 9 years ago. That is, the star we see is in fact Sirius as it was nearly 9 years ago. Sirius could have blown up last week, and we will not know that or see the explosion for nearly another 9 years!

So every time you look up at the night sky you are aware that you are looking back in time, at how those objects were tens, hundreds, thousands and millions of years ago. The distance of the object in light years tells you how far back in time you are looking. Furthermore, none of the things we see are actually there! Think about this for a moment.

Every object in Space is moving, sometimes at hundreds or thousands of kilometers per second. So, when we see a star, it has actually moved somewhere. else (typically, relatively close to its former position) what we are looking at is not only how that star appeared all those years ago, but also where it used to be. The situation is almost analogous to that of a sharpshooter aiming a rifle at a moving object, one cannot aim simply at the last observed position, but must take the speed of the target into account.

Similarly, were you to head off towards Sirius, you must take into account that Sirius is actually 8 years and 8 months further along in its journey than where you are seeing it. Also that, by the time you get there in another 8 years and 8 months the star would have moved even further. So at the time of leaving the Earth you must actually aim your spaceship at a point in the sky where Sirius is some 17 years and 4 months ahead of where you actually observe it now.

But, as yet, we don't have spaceships which travel as fast as light. Certainly in the foreseeable future we won't have anything that will go even at a reasonable fraction of that velocity

Were anyone to attempt the journey to even the nearest star using the most sophisticated present technology, it would take them tens of thousands of years to reach Alpha Centauri, the closest star.

So what is left to us? We can only approach the stars and planets by looking at them. If we use a telescope we are fortunate and can get closer. At a magnification of 100 times we are 100 times closer to whatever object we look at. For example, the moon is no longer 384 000 Km away, it is only 3840 Km away. At a magnification of 400 we are as close as 960 Km; almost as close as the Apollo astronauts.

Unless we have large telescope set high on a mountain, 400 is about the highest useful magnification we can use, due mainly to the turbulence of our atmosphere. Even at this enlargement though we can glimpse features the size of a football stadium on the Moon. The planets Mars, Jupiter and Saturn also benefit from use of a telescope, and surface features. become visible.

For you without telescopes do not despair. Even a pair of binoculars is a great aid to observing the Universe. The second purpose of a telescope is not magnification, but increased light grasp for our eyes, and here good binoculars are superb, especially if you can mount them on a simple tripod so they don't shake about. But all this is covered fully in chapters 5 and 6.

Enough then to note that for people of our generation, looking at celestial objects with whatever means at our disposal is the only way we can get close and see them for ourselves as opposed to looking at photographs other people have taken of them.

In subsequent chapters other indications of the largeness, massiveness and extreme conditions in our Universe will be given, some of these will be in the month by month coverage of chapter 3, whenever a prime example of some particular quality is high in the sky.

Chapter Two:

SOME BASIC ESSENTIALS

In chapters 3, 4 and 5, I will be using some words which you may not be familiar with, at least the way they are used in relation to astronomical objects. These words replace a whole paragraph of explanation which would have to be used instead of them, so it is better that we tackle them now and refer back to this chapter if we forget their meaning

RISING AND SETTING

Everyone has some idea that the Sun, Moon, planeta and stars rise and set, but most people's idea of the where, when and how of this process is rather woolly.

Suppose a couple of hundred years ago you were the officer on night watch aboard a ship plying the South Pacific routes. You would have undoubtedly noticed, night after night, that there was (and is) a certain pattern to the movement of the stars and planets.

Firstly, you would notice that there was an area of the sky where the stars hardly move at all Indeed the centre of this area called the South Celestial Pole is fixed. Night and day, for every month of the year it remains exactly in the same place. All the heavenly bodies, including the Sun and Moon, seem to orbit around it

Suppose your ship was at latitude 30 degrees south of the equator (one third of the way to the South Pole). You would see the South Celestial Pole 30 degrees up in the sky exactly due South. Any star less than 30 degrees away from this fixed point in the sky would never set. It would just go round and round getting closer and then further from the southern horizon (see fig 1 & photo).

The northern hemisphere has the North Celestial Pole serving the same purpose, but there they are lucky and have a fairly bright star. "Polaris" or the North Star to mark its approximate position.

Furthermore, while you are on watch, you would notice that the so called "fixed Stars" ie, not the Sun, Moon, planets and comets the ordinary real stars always rise at a specific angular distance from the true nouth (or north). Then they each follow their unique particular path across the sky, always an arc. Then they set at exactly the same angle away from the south (or north), but this time on your other side. These stars rise on the eastern side of a line drawn from north to south, and set on the western side of that same line.

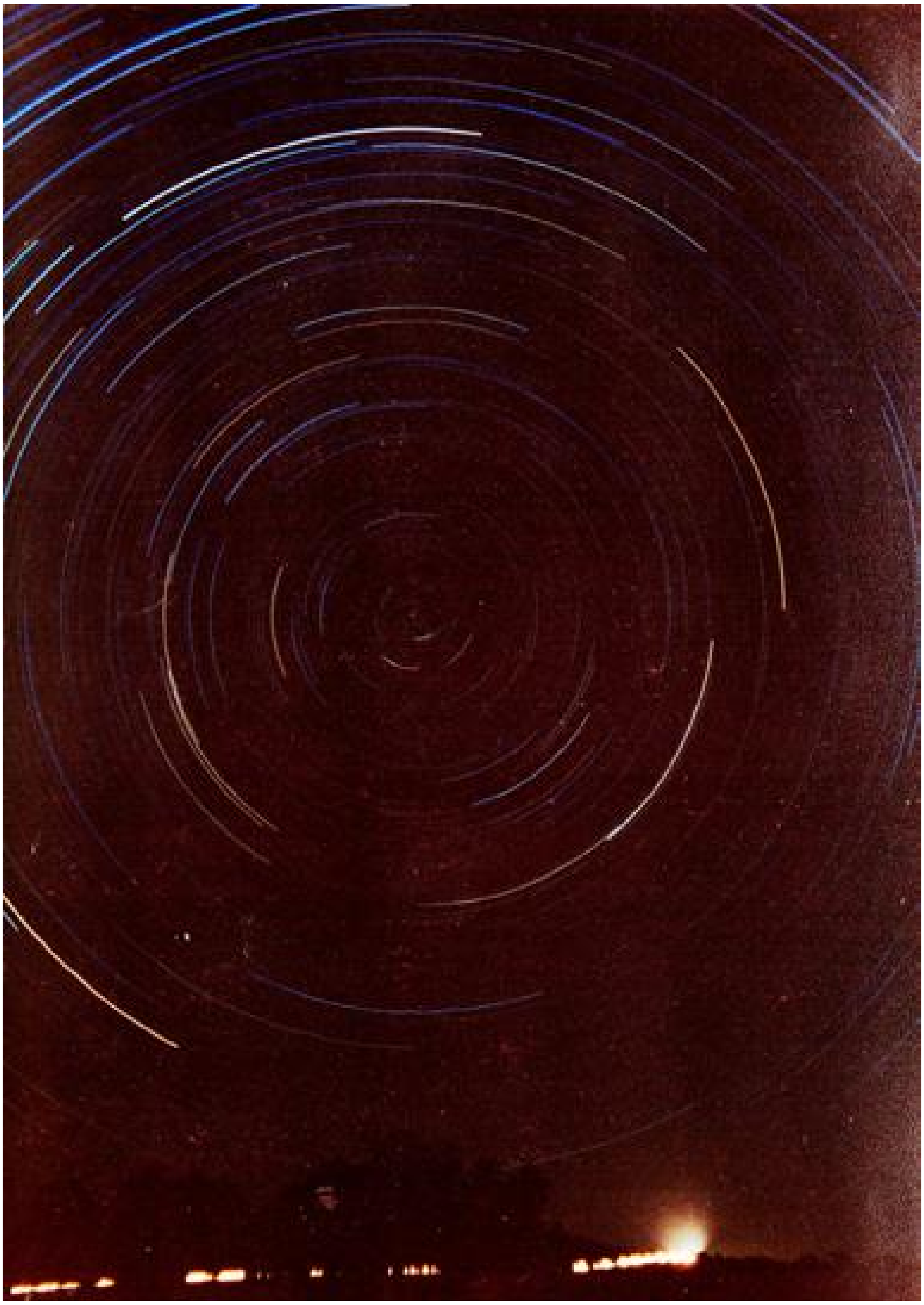
MERIDIAN

The line drawn from north to south straight across the sky and over your head is called the meridian. Generally speaking all things in the sky rise east of this line and set to the west of it. The only things which do not rise and set are the circumpolar stars, ie. what we have already referred to as those stars closer to the celestial pole than your latitude.

When any celestial body is at its highest in the sky it can possibly be (for that night) it lies somewhere on the meridian. (See figure 1)

NORTH AND SOUTH

The Earth is like a ball with an axis la stick right through the middle) about which it spins. So, relative to points of light (stars) practically an infinite distance away, all parts of it move except the poles (tips of the axis) themselves. North is the direction the North tip of the axis points to, and South the direction the South tip



Looking towards the South Celestial Pole we see, in this three hour exposure, the stars circling the Pole, which is fixed. Notice that stars which are closer to the pole than your angle of latitude never set, but just go around and around, without dipping below the horizon. In this photo the trails are 45 degrees long, because the three hour exposure is one eighth of 24 hours, and 45 degrees is one eighth of 360 degrees.

of the axis points to.

Remember, this axis points constantly in the same directions. It never wavers on the scale of an individual lifetime to the naked eye. As the Earth orbits around the Sun, this axis keeps pointing at the same exact point in the depths of Space.

EAST AND WEST

East is the direction the Earth's spin is taking you towards. When you face North, East is to your right and West is directly opposite; to your left.

ZENITH

The point of the sky directly above your head. It lies on the Meridian and is exactly 90 degrees up from a level horizon in any direction.

ECLIPTIC

The plane of the Earth's orbit around the Sun. In the sky this translates into an imaginary line circling the Earth, along which the Sun seems to move during a full. year. All the signs or constellations of the Zodiac (from the Greek circle of animals") lie along the Ecliptic. The Sun moves exactly along it, but also the Moon and planets move approximately along it, since they are roughly in the same plane as the Earth as they circle the Sun.

CELESTIAL EQUATOR

The plane of the Earth's equator extended into infinite Space. It too is seen as an imaginary line set some 23% degrees off the Ecliptic, and intersecting it about March 21st and September 21st, or in the constellations of Pisces and Virgo respectively. See figure 2.

ANGLES

A circle is divided into 360 parts called degrees. From one horizon directly across to the opposite horizon is half a circle (e.g, North to South) and is 180 degrees. A quarter circle is called a right angle and is 90 degrees. If you hold out your hand at arms length, the angle you see across your four fingers is about 10 degrees.

In astronomy, angles are sometimes also measured in hours. Since there are 24 hours in one day, the same part of the sky is seen in the same place every 24 hours or 360 degrees. Thus 360 divided by 24 gives 15. That is, each hour angle is equal to 15 degrees, so every star moves by 15 degrees around the Celestial pole every hour.

OPPOSITION

The closest that any planet is to us is when it is exactly on the same side of the Sun as we are, this is called opposition, and is generally the best time for observing the planet, since it appears largest in any particular telescope.

CONJUNCTION

When a planet is in about the same line as a star of the Sun or anything else, it is said to be in conjunction with that body. New Moon, for example, is in conjunction with the Sun, since they both lie in the same direction.

MAGNITUDE

Traditionally star brightnesses have been referred to in steps called magnitudes. Visually, stars of magnitude O appear about twice as bright as those of magnitude 1, which appear twice as bright as magnitude 2 stars and so on. There are objects brighter than magnitude 0. These go the other way with minus signs. So magnitude 1 is twice as bright as 0. Magnitude -2 is twice as bright as -1 etc

Today, with sensitive and accurate light meters, the exact definition is that each step of magnitude is 2.512 times brighter or fainter than the next (depending whether you are going up or down the scale). Why 2.512? This happens to be the fifth root of 100, and so every 5 magnitudes is a difference of 100 in brightness.

Under dark skies, the typical naked eye detects stars down to magnitude 6 of which about one and half thousand can be seen in the night sky at any one time. Binoculars take you down to as faint as magnitude 9 of which 50,000 are visible at night. The six inch 'scope project (chapter 7) takes you down to magnitude 12 nearly half a million times fainter than the brightest star in the sky Sirius.

Fig: 1

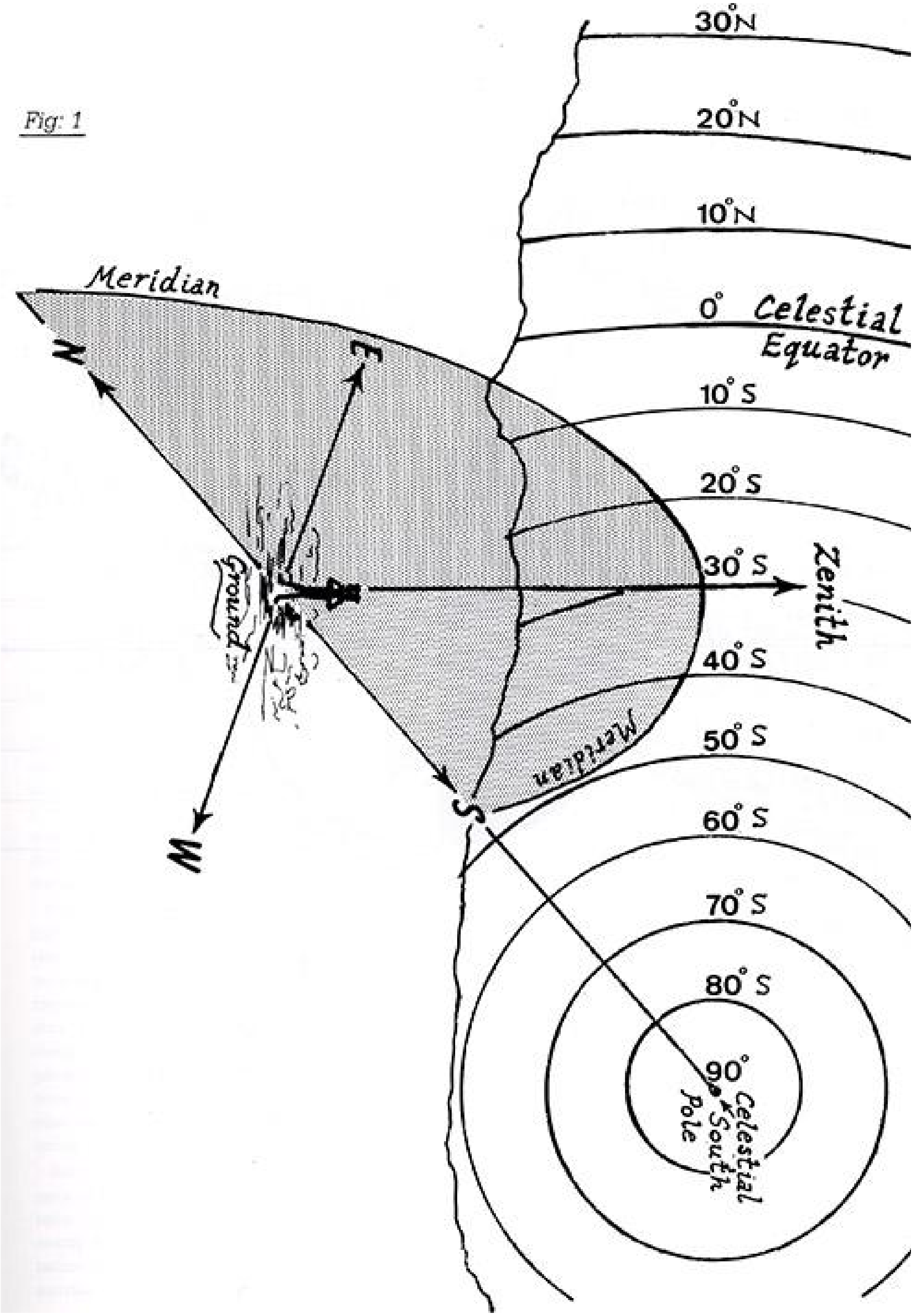
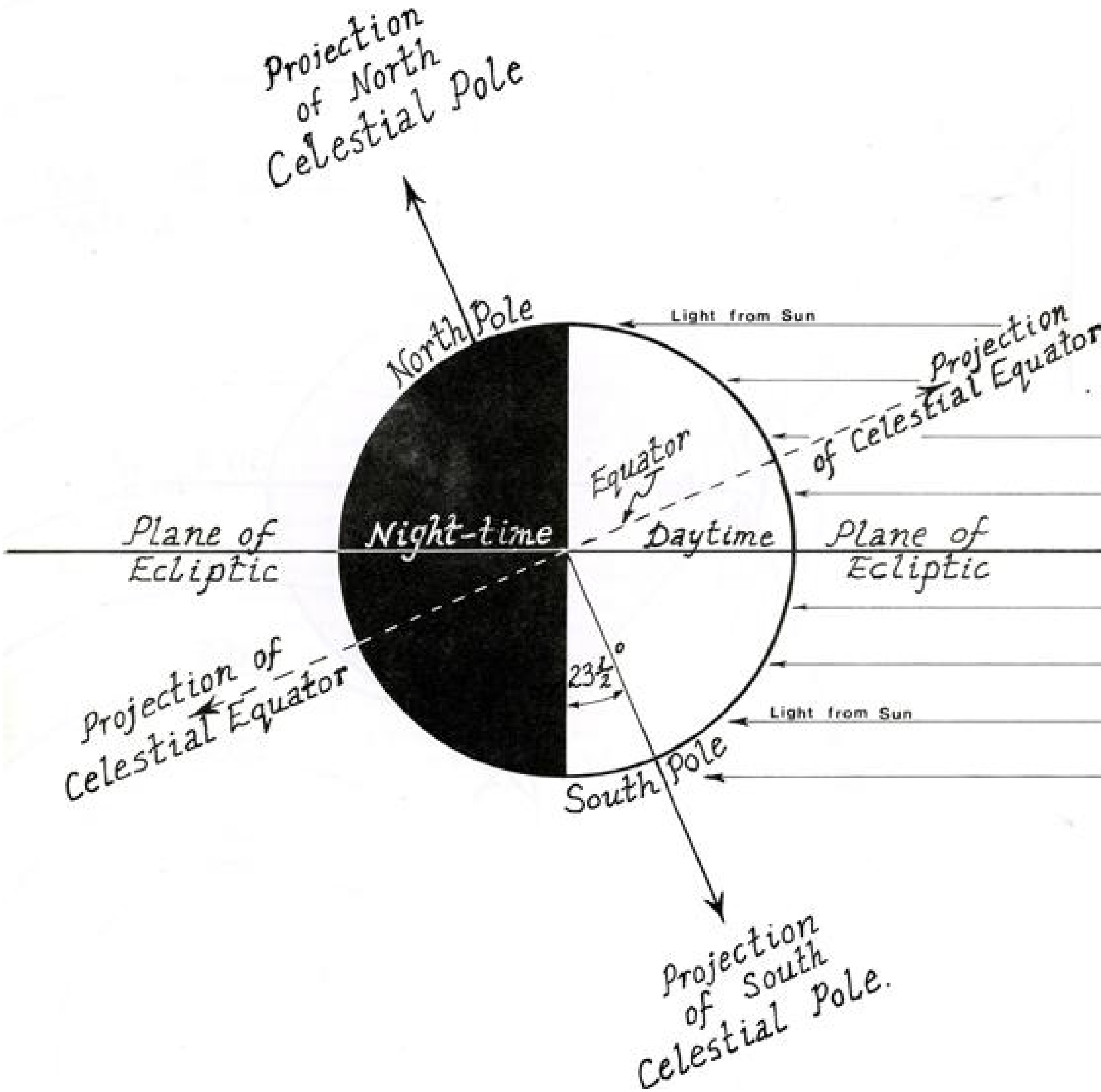

30° N
20° N
10° N
Meridian
0° Celestial Equator
10° S
20° S
30° S
Zenith
Ground
40° S
50° S
Meridian
60° S
70° S
80° S
90° Celestial South Pole
N
E
W
S

Fig: 2


Projection of North Celestial Pole
North Pole
Light from Sun
Projection of Celestial Equator
Equator
Plane of Ecliptic
Night-time
Daytime
Plane of Ecliptic
Projection of Celestial Equator
23½°
Light from Sun
South Pole
Projection of South Celestial Pole.

Chapter Three:

MERIDIAN OBJECTS MONTH BY MONTH

We are now ready to actually go out and observe the Universe around us. For every month of the year some objects are easier to find and examine than others, depending at what time of the night you venture out. I have assumed a time when all the family no matter where they are in the world can enjoy the sights together.

An ideal time is from about 8 pm to 10 pm, and these charts have been drawn with this in mind. Also, for each month only the most interesting objects and the brightest stars are tackled. After all there are literally thousands of nebulae and galaxies within reach of a small telescope, and hundreds of thousands of stars, so the more spectacular sights are more than enough to start with

The easiest way to find anything in the unfamiliar night sky is if it is rising or setting, or on the meridian (see chapter 2). But rising and setting objects are invariably hampered by atmospheric haze and turbulence. The meridian ones are visible in all their glory, and so only these are discussed. Hence all the charts you are about to examine show the stars, galaxies, and nebulae, on the meridian. These star maps can be used ANYWHERE IN THE WORLD, unlike other star charts or planispheres you may have come across

Before explaining how simply you use the maps, a quick recap. If you stand facing North, the meridian starts directly in front of you, rises vertically, passes exactly over your head (zenith), and goes down directly behind you due South. Similarly if you face South, the meridian nses in front, passes directly overhead, and sets behind you due North.

If you live in the northern hemisphere the North Celestial Pole (marked by the Pole Star, Polaris) is visible at your angle of latitude (found on any map) above the northern horizon. Similarly, if you lived in the southern hemisphere, the South Celestial Pole is above the southern horizon at your angle of latitude, but no bight star marks this site.

The width of the charts, running down the page, is a little over 60 degrees This width is centered on the meridian at about 8 pm at the beginning of the month, 9 pm around the middle, and 10 pm at the end of the month. If your locality is using an adjusted summer or winter time you must take that into account, otherwise this meridian strip will be a little to the right or left of the actual meridian.

But you should have no trouble relating the stars as you see them to the meridian strip in this chapter, even if they are a little to one side. Only stars down to 5th magnitude have been plotted, because these are the most easily visible, the size of the stars shows how bright they are, the largest is zero magnitude, and the smallest fifth

The use of the charts is simplicity itself Cut out the transparent overlay (Northern Horizon written at its top) beside this chapter in the middle of that overlay is an arrow marked “YOUR LATITUDE AND ZENITH Place the overlay on top of the star chart of interest. Move it up or down, so that the arrow points to your latitude on the star chart. Press the overlay into the crease of the book, hard against the spine, so that it does not slide about. Every star visible from your area will be seen between the top and bottom limits of the transparent overlay.

The strip of sky you see is 60 degrees wide and centered on the Meridian, from the North to the South.

If you lose the transparency, you can photo-copy another from the one in Appendix 3. If you prefer to use a cardboard stencil, photo-copy onto light card, and cut out the center. If you travel to another country, take this book with you, since you can use it anywhere from the top of Greenland to the tip of South America, for any month of any year for the next thousand years.

One last point. If some nebula or galaxy cannot be seen from your location even though you are looking in the right place with binoculars or telescope, consider this: is there too much light pollution (street lights etc) where you are? Is there a high altitude haze? Is the Moon above the horizon, lighting up the sky?

For many faint celestial sights you need a perfectly dark, transparent sky. The simplest test is this; the faintest (5^{th} magnitude) stars shown on the chart should be easily visible, after you have allowed fifteen minutes for your eyes to get used to the darkness.

Remember, as with anything else, observing the night sky takes a little patience and practice. You may get terrific results on your first night out, but don't despair and give up if you don't. Go out again and again, when you are not tired, especially with some friends who are similarly interested, and the beauty and recognition of the stars and planets will captivate you. Good observing!

PERSONAL NOTES, DRAWINGS & PHOTOS:

JANUARY

By far the most interesting constellation this month is Orion The Great Hunter. This majestic collection of stars is one of the easiest to memorize All its main stars are bright and it contains the most famous nebula in the sky. The Great Orion Nebula; M42, can just be seen with the naked eye. Even in binoculars its character is apparent.

With a telescope of 6 inches (15 cm) or more in aperture, the Orion Nebula begins to show very faint coloration of pink, blue, and yellow. Compare what you see with the photograph in this book, and I think. you will agree that the visual sight is better and more detailed than the photo This is because the aye can pick up details over a wide brightness range, but photographs over-expose the highlights when the shutter is opened long enough for faint details to be recorded.

The main reason for this nebula's brightness is its closeness to us. It is only 1 500 light years away, yet even at this small distance, if you had the means to drive towards it at the legal speed limit, it would take you 15 billion years to get there. That is about as long as this Universe has existed!

Many nebulae, such as the one in Orion, are regions of star formation. But if you transfer your gaze to the bright orange star on the right shoulder of this constellation you will see Betelgeuse, a red giant nearing the end of its life. Soon, no one can predict the date exactly, this star will explode as a nova or super nova, thus destroying any planets and civilizations orbiting it.

Betelgeuse (from the Arabic, armpit of the giant') is truly a giant star, being some 980 million Km in diameter. This is 700 times the size of our Sun! But this value is not fixed, since the brightness and diameter of Betelgeuse fluctuate significantly. This remarkable star is so close (520 Ly away). that it was the first star whose disk was 'seen' and 'sunspots on its surface identified. It was only through recent tremendous advances in micro-electronics that such a feat was made possible.

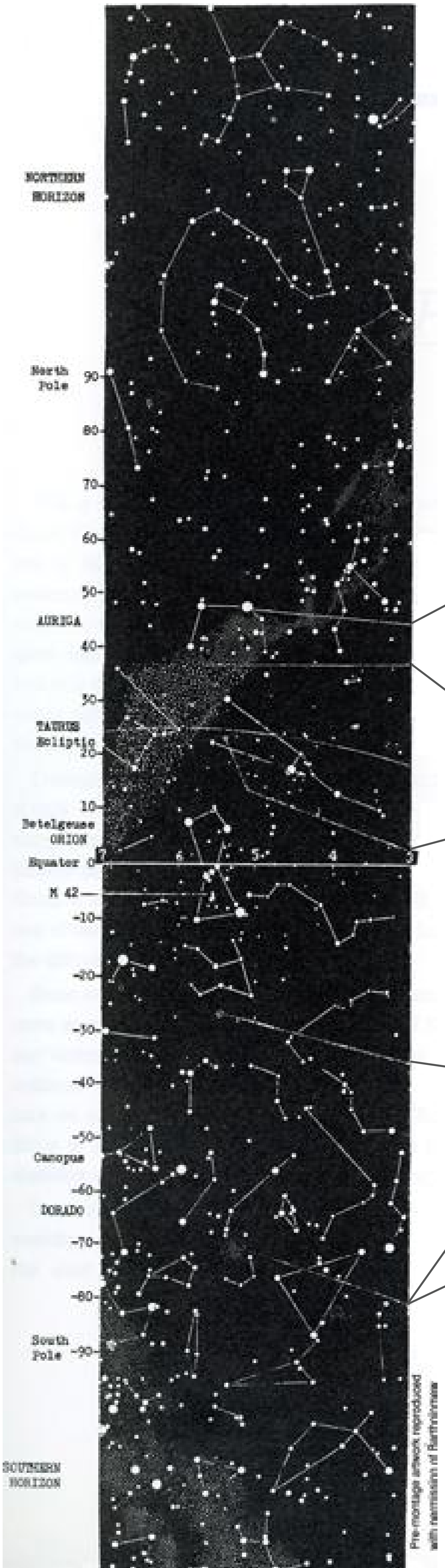
Orion's other bright star is Rigel (Arabic: giant's left leg'). This is the 7th brightest in our skies at magnitude 0.34, about the same as Betelgeuse, Notice how it is a brilliant white color, this signifies a very high surface temperature (about 12 000 degrees Celsius or Centigrade). The difference in the colors of stars come out very well in photographs which you can easily take (see chapter 5).

Rigel is also a giant star, being about 50 times the diameter of our Sun. Even more astonishing though is its brilliance, nearly 60,000 times that of our Sun Put into perspective, if our Sun was at the same distance of 900 light years, it would be totally invisible even in binoculars. Conversely, if Rigel was as close as the nearest star to us (Alpha Centauri, see JUNE) it would be as bright as the full moon.

If you have a telescope you will see Rigel as a double star. Its companion is at magnitude 6.7 and is 9 seconds of arc away (each second is 1/3600 of a degree) so this pair afford a good test for your optical equipment

Other superlative sights are noted beside the relevant chart Since they are not near the equator, and so visible to all people everywhere, they may never be visible from your location a good reason to travel the world.

The Great Orion Nebula (M 42) as it appears in a six to twelve inch telescope at about 50 magnification. More detail is seen visually, but less color, because the color sensing nerves of the eye do not work under low light levels. The Great Orion Nebula (M 42) as it appears in a six to twelve inch telescope at about 50 magnification. More detail is seen visually, but less color, because the color sensing nerves of the eye do not work under low light levels.



On this and subsequent charts you will notice that only objects between the North and South Poles are discussed. This is because they are at their highest in the sky. Objects above the North and below the South Pole are covered six months later, when they are better placed for observation.

Most celestial sights have catalogue numbers to identify them. If the number is preceded by M. for example M42, it was first catalogued by Charles Messier. Nowadays another code is often used: NGC (New General Catalogue). In every case I have shown the most popular designation, and the common name, if any

Only the most important constellation names are given. These are written on the left of the charts, adjacent to where that constellation is The lines connecting bright stars are not necessarily constellation lines. They are mainly used as guides from one star to the next.

Note that these maps are fully 60 degrees wide, and so overlap from month to month, especially near the poles. The Right Ascension hour angle (R.A.) for each map is noted on page 45. The maps are four hours (of R.A.) wide, increasing from the right hand side to the left hand side The hour angle is true only for the central area of the charts, and is used to locate the position of a planet on the ecliptic (after using the graphical orreries in chapter 5).

The very bright star at about 46 degrees North is Capella (Latin: The Goat Star). This is the sixth brightest in our skies at magnitude 0.66. It is 45 light years away, and fully 160 times brighter than our Sun. From a dark observing site you will notice how Capella marks one boundary of the Milky Way. Using binoculars, follow the Milky Way south frorn Capella, and you will be greeted by M38, M36, and M37, in that order.

These three are open clusters, ie. closely associated stars born from the same original nebula. In our galaxy (the Milky Way) you can see many such groups using binoculars or telescope. These three are about 4,000 Ly away.

The Crab Nebula (M1) is an easy object for an average telescope, but not detailed. It is the remnants of a super-nova which was seen in 1054 AD. But it is 6,300 Ly away, and would have exploded that much earlier

Straddling the Equator you can see Orion which is described in the main text. Notice the Hyades Cluster to its north west. The Hyades is some 140 Ly away. The bright orange stat is Aldebaran (Arabic: The Follower). This is not a Hyades member, and is just 68 Ly distant. Aldebaran is 40 times bigger than our sun, and 125 times brighter. In the same binocular field of view you may also see NGC 1647, typical of many average chusters. This is much more distant and also not a member

M79 is a nice though not impressive globular cluster. It is about 50,000 Ly away, and contains up to 100,000 stars Globular clusters are different from open clusters in that they contain many tens of thousands of stars, and are tightly packed; a sort of mini galaxy.

A true small galaxy is the Large Magellanic Cloud (LMC) which together with the Small Magellanic Cloud (SMC) is our closest neighbor at 190,000 Ly away. Both are gravitationally bound with the Milky Way (our own galaxy) and obit slowly around it.

The Large Magellanic Cloud is some 20,000 Ly across and contains about 30 billion stars. Here we find the Tarantula Nebula, an impressive sight in moderate telescopes, and the largest we know of anywhere in the Universe. The famous supernova of 1987 was in the LMC near the Tarantula Nebula (see next photo). To the naked eye the LMC appears like a little bit of the Milky Way, but a telescope will separate many of its brightest stars, and present a glorious sight at low powers. This is also an easy object for fixed tripod photography. Using a very fast film, wide open aperture, and 45 second exposure

PERSONAL NOTES, DRAWINGS & PHOTOS:

FEBRUARY

This is the month when Sirius reigns supreme. Sirius (Greek: the sparkling one) is the brightest star in the whole sky (unless one wants to be pedantic and include our own Sun as a star). It shines in the constellation Canis Major (Latin, the great dog) at magnitude -1.42, and if you were to look at it through the world's largest telescope you would suffer burns to the part of the retina where the image fell

Through amateur scopes it is a beautiful sight; a single resplendent diamond bearing no comparison. When you gaze at it ponder what planets and life forms might be in orbit about it. Sirius is so close at 8.7 light years that it will be one of the first stellar systems we will reach (it is the fifth closest to us).

Sirius will continue to get brighter for thousands more years, since it is moving towards us at 7 Km per second. There is, however, no danger of collision, we will merely pass by each other like cars on a highway. In comparison to our Sun, Sirius is 23 times brighter and nearly twice the diameter, so in this respect it is not outstanding

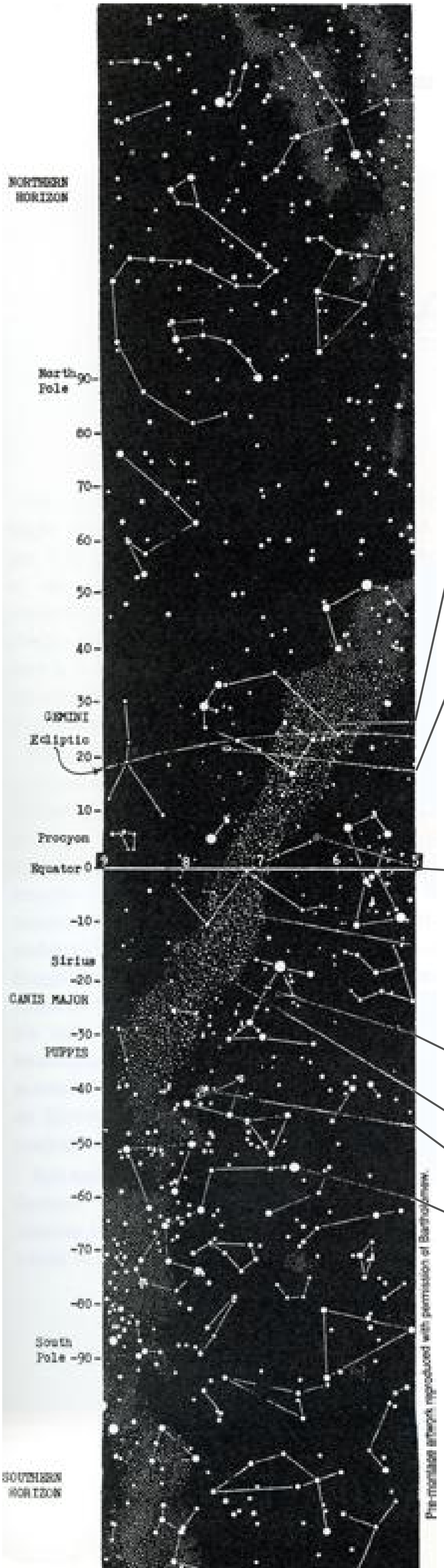
Two other bright stars grace the evening meridian during February. Procyon (Greek, before the dog) is just above the equator in the constellation Canis Minor (the little dog). Procyon is a little further than Sirius at 11.3 Ly and is the 8^{th} brightest star at magnitude 0.35, and it too is gradually getting brighter as it approaches us at nearly 3 Km per second.

Like most of the bright stars in the heavens, Procyon too is more luminous (6 times) and larger (nearly twice) than our Sun. This is not to say that our own Sun is inferior to the average. Remember, we are only noting the most prominent stars; these are bound to be very close, or distinguished in some other way. In comparison to most stars, our Sun turns out to be fairly average in all respects. Like most stars Procyon is a multiple system (a double star in this case) but its companion is too faint for most amateur scopes.

The other bright star to look out for is Canopus (named after a town in ancient Egypt). We will deal with this star by the chart. Apart from these bright stars, this month you can see the Milky Way passing right across the equator in the constellation Monoceros. Even in binoculars the millions of stars of the Milky Way begin to resolve themselves into individual points of light. In fact binoculars, or low powers with a telescope, are the best way to view our own galaxy. Apart from the clusters and nebulae mentioned by the chart, you should be able to see dozens of others.

Here we see the Tarantula Nebula as it appears in a 6 to 12 inch telescope at 50 x magnification. This whole region is part of the Large Magellanic Cloud, and most of the stars seen here do not belong to our galaxy, but are 190,000 light years away. To the bottom right, and the brightest star in the photo is the famous super nova of 1987. Here the super-nova is ten months old and cooling down, hence its orange colour.

On the left of the picture we see a cluster of giant stars in the Large Magellanic Cloud, this is NGC 1910, and its brightness is an indication of the enormous luminosity of the suns it contains. This photo, as all the other you see in this book, was taken with an 8 inch telescope. At the distance of the Large Magellanic Cloud our own Sun would barely be visible only in the largest telescopes in the world. Appreciation of this fact tells us our true place in the scheme of things.



Most of the best open clusters of stars are found along the Milky Way. This is only to be expected, since the Milky Way is our own galaxy, with its billions of stars, seen edge on Go out on any clear night and, even with star maps, you can pick out dozens of clusters and nebulae using only binoculars. The easiest place to find all these objects is in or near the Milky Way

Only the main clusters have been marked on these charts, so be prepared to 'discover' many more. For example, this month you can see an impressive group of stars in the constellation Gemini. This one is M 35. But can you notice right next to it a tiny, more distant cluster (NGC 215B)?

M35 is about 2,200 bght years away, and 30 across But NGC 2158 is not any smaller, it is nearly eight times further away, and that is why it locks so much smaller and dimmer. In fant, since these two clusters are roughly comparable, we find that the distant one appears as one eighth the size of M 35 and one-sixty-fourth (that is; ons eighth squared) the brightness.

The ratios that you observe, for M35 and NGC 2158, are in keeping with the law that apparent size is inversely proportional to distance, and brightness is inversely proportional to the square of distance

A totally different object in Gemini is the Eskimo Nebula (NGC 2352), one of the best planetary nebulae in the sky. planetary nebulae are expanding shells of gas which are the remains of mild novae. They ate lit up by the central star, which is the much altered core of the former star The Eskimo Nebula locks like a faint fuzzy patch about the size of Jupiter, with the central star visible. It gets its name from its facial appearance in photographs

Many people find it easier to spot planetary nebulae by using a 'nebula filter'. This is a filter available from most good astronomy suppliers. You look at the region where the nebula is expected to be, and you fick the filter in and out of your view. Because the filter passes the light of the nebula more easily than other wavelengths, the nebula blinks on and off. These filters are also useful for light polluted skies. around towns and cities

NGC 2244 is an open cluster surrounded by the famous Rosette Nebula. The cluster can be seen, but the nebula only comes out well in long exposure photographs, which you can take with some practice (sae page 78). The Rosette Nebula is about 2600 light years I y) away.

M50 is a better open cluster, about 2900 ly away. It is older than 2244 as evidenced by the lack of nebulosity. The gas and dust (nebula) surrounding many clusters (eg. M42, see January) is the remnant of what they were made from. As they develop, this material is blown away.

Sirius is our guide toward another beautiful cluster, M 41. This belongs to our galaxy, but is not in the mainstream of stars, hence its position to one side of the Milky Way 1 is 2,300 ly away Nearby we can find M46 and M93. These are open clusters, situated 5% and 3½ thousand light years away respectively.

NGC 2477 is yet another cluster some 4,000 Ly away. All the above three are in the constellation Puppis.

Canopus (see main text) is the second brightest star in the sky after Sinus But unlike Sirius it cannot be seen from much of the northern hemisphere. This brilliant sun has magnitude 0.72 which makes it some 1400 times brighter than our Sun. It is also 30 times the diameter of our Sun, 120 light years away, and receding from us at 19 Km pet second.

The Large Magellanic Cloud is still well placed this month. If you observe it with a telescope (for example the 6 inch in chapter seven), you can make out some globular and open clusters in the LMC Compare the appearance of those at. 190,000 Ly distant with our local ones which are much closer.

PERSONAL NOTES, DRAWINGS & PHOTOS:

MARCH

During this month there are no superlatively bright stars on the meridian between 8 and 10 pm. This gives us a chance to capture other types of objects in our telescopes. For northern observers the ecliptic is high in the sky, and if any planets are visible along this part of the ecliptic, now is the time to observe them. Likewise, the Moon placed on the meridian this month would be an inviting spectacle.

For looking at the Moon and planets even a small telescope is adequate, since these are bright objects and do not need large apertures to collect as much light as possible. If you have a tiny refractor, for example the 2½ inch (60 mm) ones brought cheaply at many department stores and camera shops, don't be dismayed by their performance. Early observers, such as Galileo and Huygens, would have given anything to possess a scope as fine as yours. The performance of your 2½ inch is many times better than the best telescopes of their day. The only thing to remember is to always use an instrument within its limitations. A 2½ inch refractor has a top magnification of about 100 times.

Just north of the equator you will find M44, the Beehive Cluster. Even a small scope easily resolves (separates the stars) this into scores of points of light. So why would anyone go to the expense and trouble of buying a very large device, when a small one shows lots of clusters, planets, etc, almost as well?

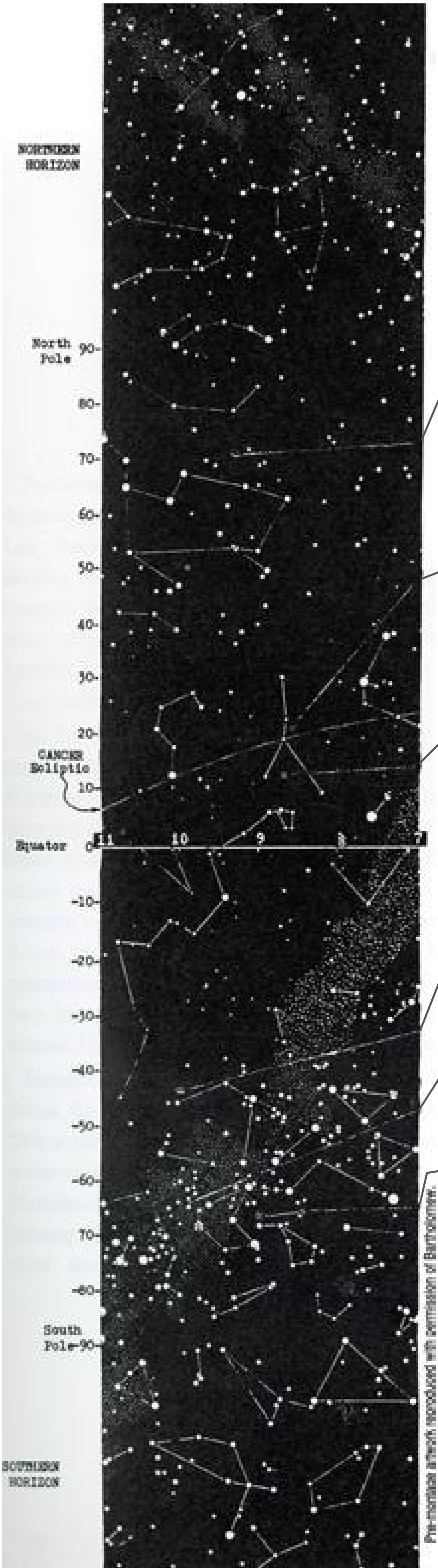
The answer is light gathering power. The surface area of the objective (main mirror or lens) determines how much light is collected. For example a 5 inch scope gathers four times more light than the 2½ inch. A 10 inch scope gathers sixteen times more light. So, at a magnification of 100, the apparent size of a heavenly body is the same in all these telescopes, but the 10 inch shows you an image which is sixteen times brighter than the 2½ inch. For faint galaxies, nebulae and clusters, this can make the difference between seeing something or nothing at all! For things which are visible in the small telescope, the large one is still the winner, because it makes them spectacular, not merely a blotch of hazy light.

If you ever get the chance try this out on galaxies and globular clusters. Many communities have an astronomical society, where members have telescopes featuring various advantages. It is always a good idea to go along to (and even join) an astronomy club, most members are only too pleased to share their experience and telescopes with you.

The Eta Carinae Nebula is seen here as it appears in a 6 to 12 inch telescope. This whole expanse cannot be taken in one field of view unless you use a wide angle eyepiece and magnification of less that 20 x. On the right hand side you can see the beautiful open cluster NGC 3532.

On the bottom left corner is a small, compact, cluster IC 2581. This whole region is comparable to the best that the heavens can offer. Apart from the clusters and nebulae, we have a continuous backdrop of thousands of Milky Way stars. Bear in mind that a star and sun are exactly the same thing. Our Sun is a star. All the stars you see in the night sky are suns, they are, on average, as big or bigger than our local star the Sun. Most of these stars you see have their own planetary systems. Many of the planets circling these stars/suns have their own life forms. Some even have their own advanced civilisations, more advanced than what we can imagine.

MARCH MERIDIAN & 11 TO 7 Hours Right Ascension



Galaxies which are external to our own local group, (Small and Large Magellanic Cloud, Andromeda Galaxy etc) are so far away that they are quite faint in small telescopes. But some of these are still worth tracking down because they are prominent members of neighboring groups and, though faint, their form can just be seen.

Two such galaxies, visible even in binoculars, are. M81 and M82. In a telescope you see the first as a perfect spiral, perhaps similar to our own galaxy. The second is very unusual It is viewed almost edge-on, and shows evidence of some cataclysmic event only a few million years ago, Its center seems to have exploded violently, possibly due to some incredible super-nova explosion. Both of these are 7 milion light-years away.

Sometimes people ask ‘How far can you see with your telescope? Of course there is no straight forward answer to this. It depends on how good your eyesight is, how much you persevere the darkness and clarity of the sky, the brightness of what you are looking at and so on. A rough answer for 6 to 12 inch telescopes (15 to 30 mm) is large galaxies about 40 million Ly.

About 20 degrees above the equator easily visible is M 44, often called the Beehive Cluster. This is one of the most beautiful clusters, and can be seen this month from most parts of the world. The distance is just over 500 Ly, which makes it one of the closer clusters to us. A few others are closer, so they lose the visual impact of their stars seemingly huddling together.

M67 is another cluster, less impressive, but very old. It is unusual in that is stars have not drifted apart. With must open clusters the stars go their separate ways after they have been born, so that clustering effects disappears within a few tens of millions of years. M67 is 2500 Ly away, and that is the main reason why it appears so much smaller and dimmer than M44.

In the constelation Vela (Latin: Sailel you can see NGC 3132, a very fine planetary nebula looking somewhat larger than Jupiter. It has a fairly bright central star, but this is not the remains of the nova which caused this nebula. The actual remains, which is the illuminating source for this planetary is a faint blue-white dwarf, invisible in all but the largest amateur instruments. NGC 3132 is 2800 light years away and would have exploded in Stone Age times.

The most spectacular sight this month must be the Eta Carinae Nebulae This magnificent acene is a worthy match for the Great Orion Nebula and is a better sight in binoculars, since it is over one degree across, lies in a dense region of the Milky Way, and has for companionship the equally bright and pretty cluster NGC 3532 which is 1,400 Ly away (see photo). You can photograph all this with any fast color film, such as Konica SR V 3200 and a normal lens at full open aperture and about 30 to 60 seconds exposure on a firm tripod.

Finally, just west of this part of the Milky Way, NGC 2516 and NGC 2808 can be seen. NGC 2516 is an open cluster 1,200 Ly away, and is similar to the Beehive Cluster to the naked eye. While NGC 2808 is an average globular cluster (tightly packed), and really needs moderate apertures and magnification to make it a satisfying sight, though binoculars show its fuzziness.

March, together with its adjacent months (February and April), offers the best chance for northerners to see the Zodiacal band in the evening twilight, and for southerners to see it in the morning twilight, Similarly, if the planet. Mercury is an evening object at this time of the year, be sure to look for it if you live north of the Equator. If Mercury is a morning object, look for it if you live south of the equator. For those almost exactly on the equator, you are pretty lucky all year round.

PERSONAL NOTES, DRAWINGS & PHOTOS:

APRIL

The brightest star on the meridian this month is Regulus (latin: the little king), in the constellation Leo. Regulus is not superlatively luminous, ranking only 21st on the celestial sphere. It is at magnitude 1.36 and lies 85 light years away. Like most other prominent stars it is intrinsically brighter than the Sun some 160 times so. In other respects it is not remarkable.

All the main stars which we see have a great deal of folklore attached to them. Only the European and Middle Eastern mythologies have been compiled adequately by various authors, and there is scope for some enterprising writer to collect the myths and legends from all remaining cultures of the world before they are lost forever. Since this book is a practical guide, and mentioning the myths we do know of would be very lop sided, as well as requiring a whole volume, I have left out all such stories altogether.

Regulus is, with Spica, Antares, Aldeberan, and Pollux, the only bright star lying near the ecliptic. This is useful to us, because the Moon and planets occasionally pass in front of such stars (Occultation). Occultations are used mainly for refining our knowledge about the exact orbits of Solar System bodies (which today is very important for space travel), and for determining the diameter of the planets.

When looking for the major visual planets (Venus, Mars, Jupiter, Saturn), use the graphical orreries of chapter 5 to find their positions. Then find the constellation the planet is in on these star charts. The planet will ALWAYS be on or near the ecliptic. The planet will also be as bright or brighter than Regulus.

So, if the orrery shows that for a certain year Jupiter is in the constellation Leo, then you see that Leo is mostly seen on the chart for April (a little of each constellation may overlap into adjacent maps). Now you go outside, preferably in April in the evening, and on the meridian you will see the stars as depicted on the April chart. When you see a bright “star” which is not on the ecliptic of the April star chart, then you know that it is Jupiter.

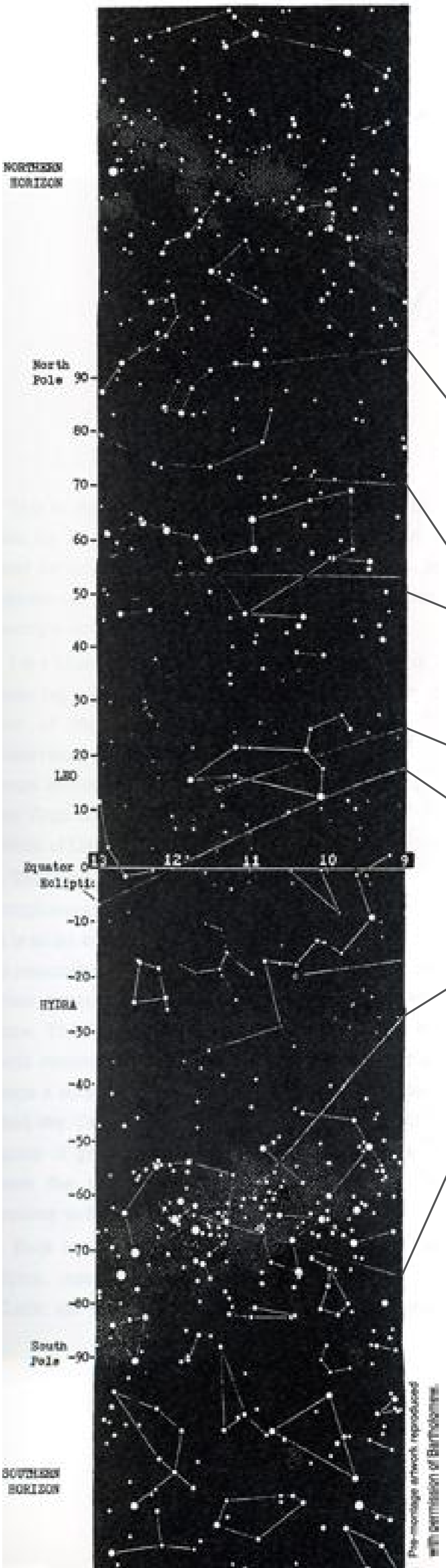
The main ecliptic constellation for each month is as follows:
JANUARY: TAURUS MARCH: CANCER VIRGO FEBRUARY: GEMINI APRIL: LEO MAY JUNE: LIBRA JULY: SCORPIUS AUGUST:SAGITTARIUS CAPRICORNUS NOVEMBER: PISCES SEPTEMBER: OCTOBER: AQUARIUS DECEMBER: ARIES.

The Southern Cross can be seen to the top right of the Coal Sack (center of photo) in this panorama of one of the richest parts of the Milky Way. This is a picture which most people can take with a 35 to 70 mm lens and an exposure of 15 to 30 seconds. You need to use a fast, fine grained film, I prefer Konica SR V 3200.

Notice the Eta Carina Nebula on the right. This nebula glows bright pink due to the illuminating star in the center. Just 150 years ago this nebula did not exist. The Coal Sack is a dark nebula. It is made up mainly of dust which blocks out the light of the stars behind it, like a cloud.

How many star clusters can you see in this picture? There are about 6 visible here. You can verify this by scanning this area with binoculars. What you see here is the naked eye view from a dark location. This is the sort of spectacle which is denied to us if we live in an urban area with street and display lighting.

APRIL MERIDIAN & 13 TO 9 Hours Right Ascension



As mentioned before, objects closer to the pole than the observer's latitude never set, but simply circle around the celestial pole. So, for example, a stargazer at 50 degrees north will see that any star closer to Polaris (the north star) than 50 degrees will not set. It will only appear higher or lower according to the seasons and time of night.

Polaris is in fact slightly removed from exact celestial north pole, but close enough not to make much difference for casual use. It will remain within one degree of the pole for the next 400 hundred years. Polaris ranks as 49th brightest star at magnitude 1.99. It is well over 300 light years away, and appears so bright because it is 1600 times more radiant than our Sun. It is a double star, with a faint blue partner visible in small telescopes.

M81 and M82 are still near the meridian at 9 pm this month see last month). you can, observe these galaxies, then (straight away compare the sight with M106 just south of the Big Dipper, then go to M 65 and M 66 in Leo. How do they compare? Bear in mind that M81 and M82 are only about 7 million Ly away, compared with the 30 million or so of the other three.

M65 and M66 are right next to each other and should be seen in the same field of good binoculars or low power telescopes. Both these galaxies are about half as large as ours with diameters of 55,000 Ly.

Regulus is the bright star on the ecliptic. It is discussed the main text. A notable planetary nebula, NGC 3242 in the constellation Hydra like some other planetaries, looks about the size of Jupiter, but is much fainter. In 15 cm or larger telescopes the central star may be seen. It is about 2,500 Ly away, and would have blown up in prehistoric times,

Beautiful Eta Carinae and her admirer, the cluster NGC 3532 are still meridian objects during April. The Southern Cross, Jewel Box Cluster, and Coal Sack (dark) Nebula can all be seen next to each other in this part of the Milky Way

The Southern Cross, known astronomically as Crux, is the best known southern constellation. Its brightest star, Acrux, is a magnificent double, a good test for your optics. It is 340 Ly away. The Jewel Box is a compact multi-colored cluster some 7,700 ly away. The Coal Sack is the best known dark. nebula anywhere. It is an obscuring cloud of dust only 500 Ly away. This whole area is magnificent to observe and photograph

When you want to enjoy such marvelous sights as the Carina and Crux area of the Milky Way, try to make the condition relaxing and uplifting. Make sure you won't be disturbed by interruptions. Perhaps you can set out a comfortable deck chair, put on your favorite music and so on.

I find that observing companions can increases my appreciation of what I see, because they remind me of the thrill I felt when first looking at the night sky. But even on the nights when you don't want to go out, if a clear sky beckons you, give it a try, you'll be glad you listened. The

Coal Sack is not the only dark nebula in the Milky Way. Can you notice all the other pockets and tendrils of dust, blocking out the stars behind them? Photographs show these particularly well.

PERSONAL NOTES, DRAWINGS & PHOTOS:

MAY

This is one of the most interesting months of the year for deep sky' observing. Deep sky is a term used for anything not in our solar system. So the planets are not 'deep sky', they are far too close, merely a stone throw away.

For a change I'll address anyone with access to a really big telescope. This could be you, if you go to one of the public observing nights at an observatory, or have a friend with a 12 inch or larger scope. Be sure to use the large telescope on the Virgo Galaxy Cluster, sometimes known as the Realm of Galaxies.

The Virgo Cluster of Galaxies is the most notable conglomeration of galaxies in the sky, and because it is so far away at 45 million light years, the group is reasonably compact. In a wide angle low power view, several galaxies may be seen at the same time. They are faint, it is no use chasing them with binoculars or a six inch. You really need as large a scope as possible, and of course a perfect dark sky. On the chart only the central area of this group of galaxies is marked, so you will have to scan the whole area between M64 and the equator to find the many tiny patches of light.

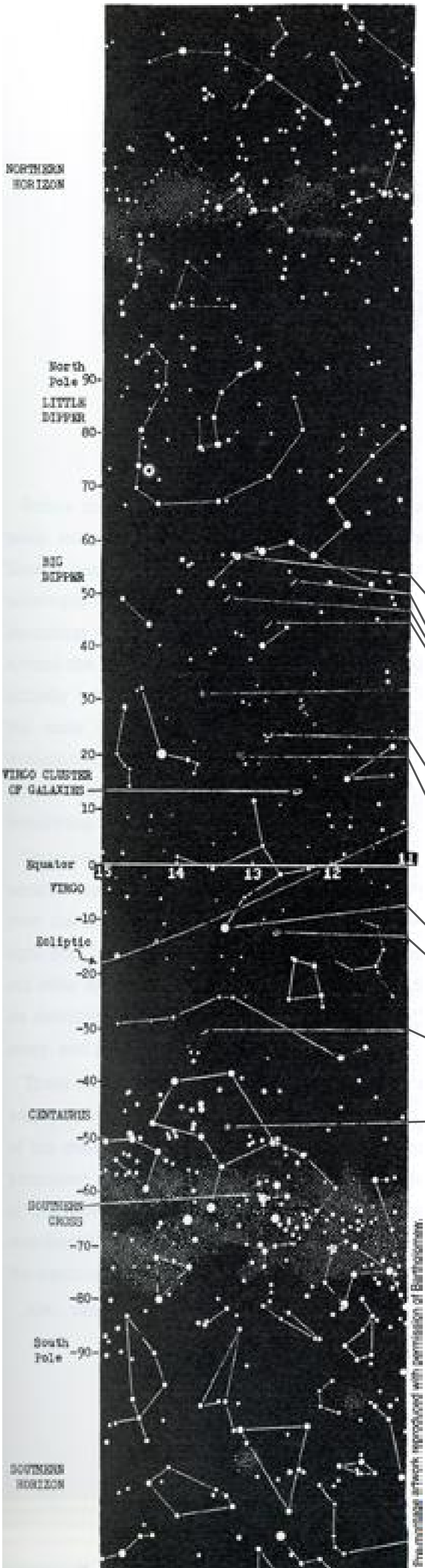
Back to the naked eye, we see the bright star Spica, again in the constellation Virgo. Spica (Latin: ear of wheat) is the sixteenth brightest star at magnitude exactly 1. It is 2,300 times brighter than our Sun, and would be truly dazzling if it was closer that its 275 Ly. If it was as close as Sirius, it would be at magnitude minus 6, casting shadows and bright enough to read by.

This month you also notice that the ecliptic begins to move south of the equator. When you become a dedicated planetary or lunar observer, this is very important. What it amounts to is that from May to October those in the southern hemisphere get a better view of the planets. because these ecliptic objects are higher up in the sky, and so less hampered by atmospheric turbulence. But from November to April, northern hemisphere people get the better view (for the same reasons).

This is not to say that the planets are out of bounds during the unfavorable months, but merely that when we can we try for the really high magnification views when the ecliptic is high in our sky, and the planets near the meridian. Notice that for each hemisphere the best ecliptic times coincide with winter. This is no coincidence. In summer the Sun is high in the sky during daylight, and the planets conversely low at night. The opposite is so during winter. Of course this is strictly true for midday, and midnight, not early evening.

The magnificent Omega Centauri as it appears in a 6 to 12 inch telescope at a magnification of 50 times. Visually this globular cluster is more impressive, due to the fact that the eye can separate many more stars, and so the whole field is like diamond dust scattered on black velvet, Similar, but a little smaller, is 47 Tucanae. These are the sights that you come back to again and again, all the time wishing that a spaceship would land nearby and whisk you away from Earth, towards the infinite wonders of the limitless void.

MAY MERIDIAN & 13 TO 9 Hours Right Ascension



This is the month during which the whole of the Big Dipper straddles the evening meridian. The Big Dippers not a true constellation, but only the hind quarters of Ursa Major (Latin: Great Bear). The tail of the bear is what people see as the handle of the dipper or saucepan.

Many people assume that constellations have a physical significance (or even a mystical one!) but this is not so. The constellations are merely accidental, they are patterns which imaginative shepherds and sailors imposed on the random scattering of stars hundreds of years ago. Often, these patterns were as an aid to memory, in order to help them find stars which had some seasonal significance. That is, certain stars are seen to rise in the evening in spring, so they remind you that now is the time to sow. Another mav rise about the same time when the prevailing winds are due to change (important for square rigged sailing ships).

Our ancestors also supposed the stars to be lights fixed on a crystal sphere, and related to various gods and demons, and sol mythologies were created around them

Mizar (Arabic: Waistband) is the best known star in the Big Dipper. It is a double star in small telescopes, with an orbital periodi of ten thousand years. But in fact there are two more stars involved. which are too faint for small instruments,

M106 is still near the meridian. Now compere it to M51 the famous Whirlpool Galaxy, 35 million light years away. Now, turn your binoculars to yet another galaxy: M94, easily mistaken for a planetary nebula, it is much smaller than our Milky Way. To its south-east you'll see M3. This cluster at 35,000 Ly contains 200,000 stars.

A famous galaxy is the Black Eye Galaxy, M64. Binoculars can detect it. The immense dust clouds of M64 can just be seen in 6 inch plus scopes. This, like M94, is some twenty million Ly away.

Nearby you can find a reasonable globular. M53, beside which is a faint cluster, both of them are 55,000 Ly away.

Spica has a few degrees to its west the distant Sombrero Galaxy M104; this galaxy, with its edge on dust cloud, is fully forty million Ly away.

M83 is a magnificent face on spital galaxy, well defined and only ten million Ly away

Omega Centauri is the premier object this month if you live south of 30 degrees north (the further south the better). This is the most superlative globular cluster in the heavens, comprising some half million stars in an apparent area the size of the Moon The magnificent. Omega Centauri is rivaled only by 47 Tucanee (see October). It is easily seen by the naked eye as a hazy 'star". Binoculars show it as a 'nebula and even the smallest of telescopes begin to resolve it into of myriad tiny diamonds thrown onto black velvet. No first time observer suspecta what she/he is about to see, a sight as glorious as the rings of Saturn or the Lunar Craters.

Omega Centauri is one of the closer globulars at about 17,000 Ly, and is more than 200 Ly across. At its center stars are only one-tenth of a light year apart Compare this to our closest neighbors, all beyond 4 Ly away. Imagine what the view is like from the middle of this cluster.

PERSONAL NOTES, DRAWINGS & PHOTOS:

JUNE

Before the invention of the telescope there was really nothing to distinguish stars from planets. Shortly before Galileo (who made the first serious telescopic observations beginning in 1610), it was becoming clear that the Earth and planets went around the Sun, but no one knew what the planets actually were. It was in these ancient times that the stars were referred to as ‘fixed stars, to distinguish them from the ‘planets’ which in Greek literally meant ‘wanderer’, that is: wandering star.

Once telescopes became a tool of astronomy it became clear that the planets were totally different from the stars. The former shone only by reflected light from the Sun, and were cold, solid spheres in our solar system. The stars were now realized to be shinning by their own light, and much further away, and probably similar to our own sun.

There was another thing that the telescope did very quickly. It dispelled once and for all the notion of the stars being fixed. The movement of some prominent stars had been known before, but most of this movement was due to the Earth itself (e.g. wandering of the poles, known as precession of the equinoxes).

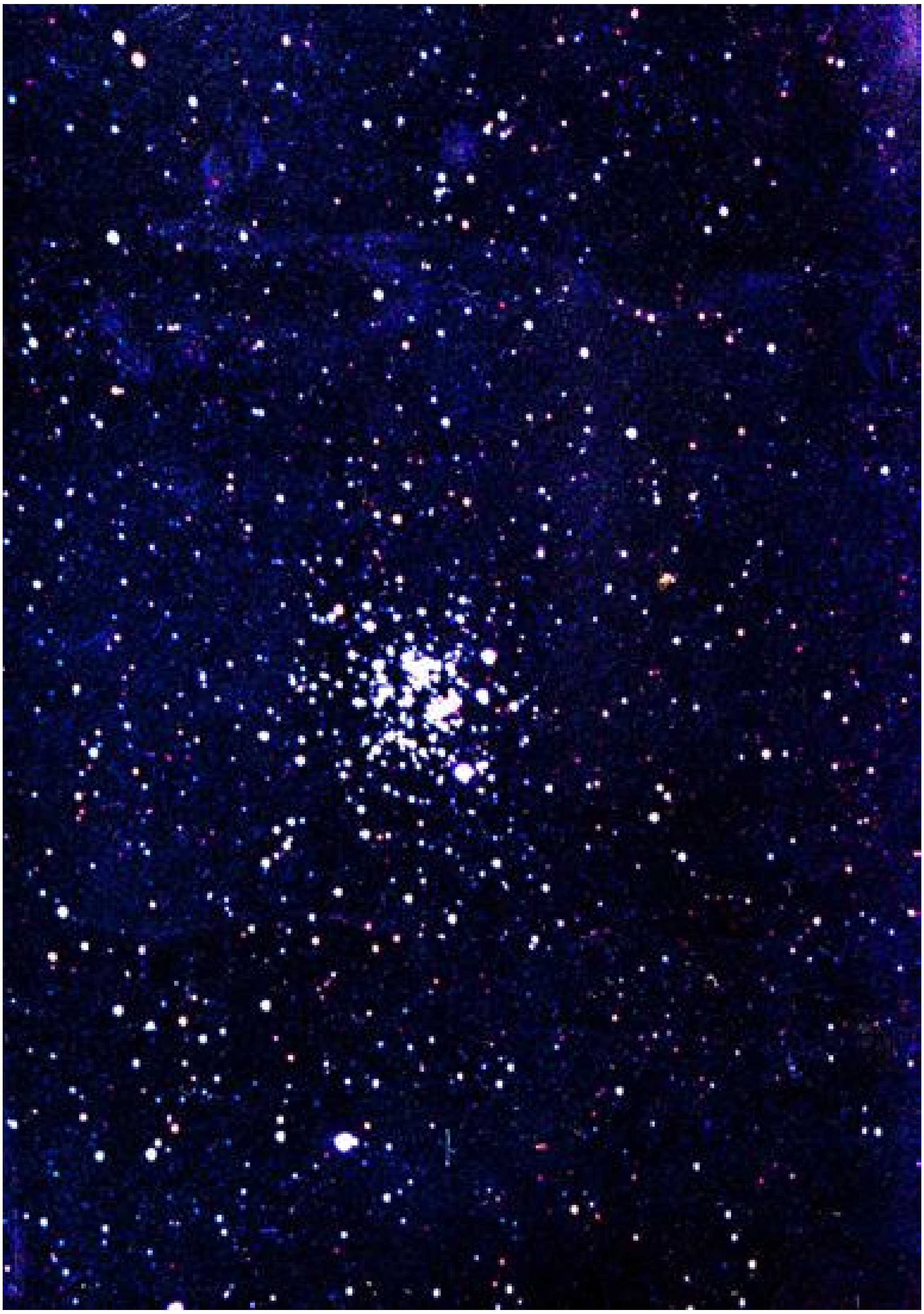
Also observing precession or even the realmotion of some stars was a tedious task spanning generations of observers.

The telescope allowed sensitive measurements of star positions which for some close stars showed real movement year by year. These sensitive measurements also made it possible to calculate the distance to many stars (using parallax due to Earth’s orbit).

You too can measure the movement of some of the closest stars, using just a small telescope. If you live in the southern hemisphere the best choice would be Alpha Centauri. If you live in the northern hemisphere, you’re not so lucky, but Arcturus may be used, or 61 Cygni (refer to detailed star map)

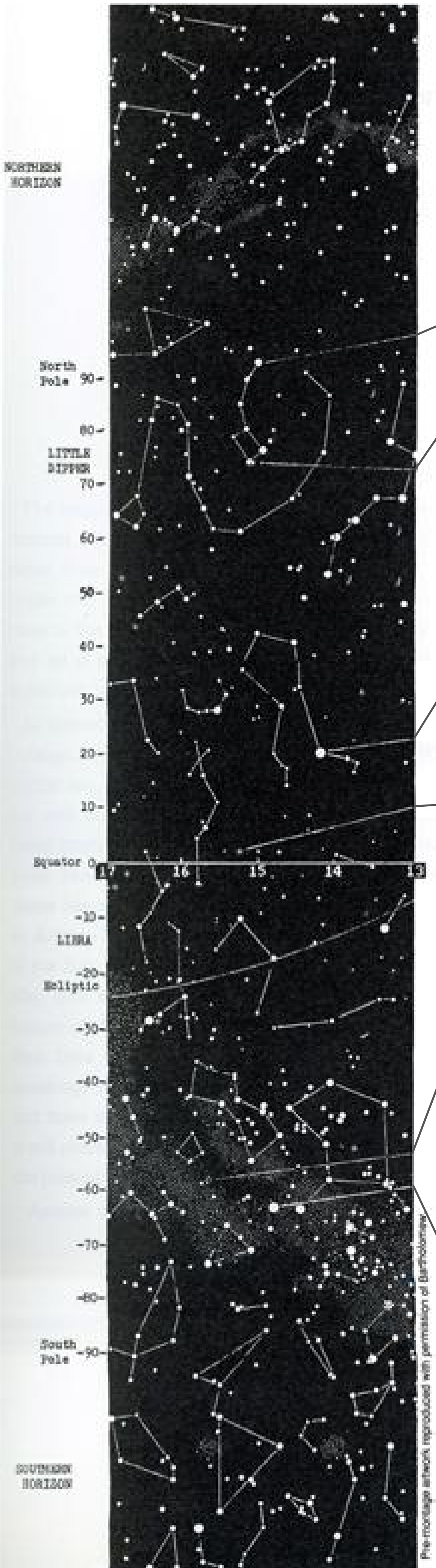
Alpha Centauri (first letter of Greek alphabet. denotes brightest star in constellation Centaurus) is the third brightest star from Earth, this is not surprising, since it is the closest to us at only 4 light years (did I hear someone say: the invisible companion, Proxima Centauri is a few kilometers closer?).

Through a telescope Alpha Centauri is seen as a beautiful double separated by 18 seconds of arc in 1990. The pair orbit each other every 50 years, and this is the first movement you can detect, every few years, by measuring their separation using a graticuled eyepiece, and their angle of tilt (of line joining the two stars). Other features will be dealt with beside the chart.



June is the last chance for those near, or south of the equator, to see the Jewel Box Cluster, right next to the Southern Cross (Crux). Here it is seen as in a small scope at about 100 x. Visually it is more colourful, because individual stars in the Jewel Box range in hue from blue to green, to red. In this long exposure photo the colors have been over-exposed, and so most stars appear pure white.

JUNE MERIDIAN & 17 TO 13 Hours Right Ascension



This month the constellation surrounding the Pole Star, Polaris, is at its highest in the sky (for northern hemisphere observers). It is called Ursa Minor (Latin: The Little Bear), and, like most of the other constellations bears little resemblance to the form it is called after.

Polaris, its main star, was discussed in the April section. If you scan Ursa Minor with any optical aid, you will see that its third star, Pherkad (Arabic: The Dimmer Calf), looks like a widely spaced double. In fact, Pherkad is not a double star, but a chance. Super-position, with one star being much further away than the other. Notice too, the difference in colour. Pherkad is white, and the companion (11 Ursa Minoris) is orange, which signifies that it is cooler.

The colour differences of stars are usually quite subtle to the eye Astronomers though can analyse starlight accurately using a spectroscope (e.g. a prism). For casual assessment, we can say bluish stars are the hottest, with surface temperatures above 25 000 degrees Celsius. White stars: about 11,000 degrees Celsius Yellow stars. 6,000 degrees Celsius. Orange stars 4,000 degrees Celsius

Arcturus (Greek Guardian of the Bear) is the fourth brightest star at magnitude minus 0.06, but just half a million years ago it was so far away that it was invisible. It is now almost at its closest to us at 37 light years, and is swiftly passing us at 144 Km per second If you make a diary and observe it with a graticuled eyepiece every few years (or photograph it you may note the distance of Arcturus from other stars in the field of view, and so actually see it move Every year it moves 2.29 seconds of arc Another half million years hence Arcturus will again be invisible (except in telescopes of course),

M5 is a fine globular cluster near the equator and well resolved in moderate aperture scopes. This wonderful apparition is 26,000 Ly away and contains some 500,000 stars. If our Sun was there, we would not be able to see it except with the largest professional instruments (it would be a very faint 19th magnitude star).

NGC 6067 is a nice open cluster you can see at low magnifications beside the southern Milky Way. It is just a prelude to the magnificent. Scorpius and Sagittarius star clouds which are on the meridian in the next two months.

Following on from the main text, the double star Alpha Centauri may be seen (nearby is Beta Centauri). The real motion of Alpha Centauri across the sky can be measured by you every year Compare it with its surrounding stars in a high magnification eyepiece, and you will see that every year it moves 3.68 seconds of arc in a roughly westerly direction.

When I say that you can detect the movement of Arcturus and Alpha Centauri from year to year, remember that you need lots of dedication and careful observing. Also, the accuracy of your observation is limited to just one significant figure, i.e. Alpha Centauri will seem to move 4 seconds of arc in my telescope, 4 seconds of arc is one division on a 160-magnification eyepiece ruler.

So even we can notice that the stars gradually change their patterns in our sky. In another 28,000 years from now Alpha Centauri light will pass us at 33 Km per second at a distance of just 3 years. For our descendants, it will be almost as bright as Both stars of Sirius.

Both stars of the Alpha Centauri system are similar to our Sun in size and other parameters, so our Sun looks similarly bright to any inhabitants of their planets who could well be looking at us through their telescopes.

PERSONAL NOTES, DRAWINGS & PHOTOS:

JULY

The brightest star on the meridian this month is Antares (Greek: rival of Mars) Antares gets its name from its appearance, which is almost as bright and as orange as the planet Mars. It is so close to the ecliptic that Mars passes it frequently and so a direct comparison (and confusion for some) can be made.

In almost every respect Antares is a twin of Betelgeuse (see January). It has a diameter of 960 million km, which is some 700 times greater than our own Sun! This remarkable star is also 9,000 times brighter than ours and lies 520 light-years away. However, these red giant stars are not very dense (amount of material in a given volume), and so Antares has a mass of only about 12 times that of the Sun. Like Betelgeuse, Antares is a variable star, both in brightness and diameter. This is a feature of all red giants, which are near the end of their lives. Sometime fairly soon (astronomically speaking) Antares will explode as a supernova, and there will be little left to see afterwards since it will probably turn into a black hole (according to the present state of knowledge).

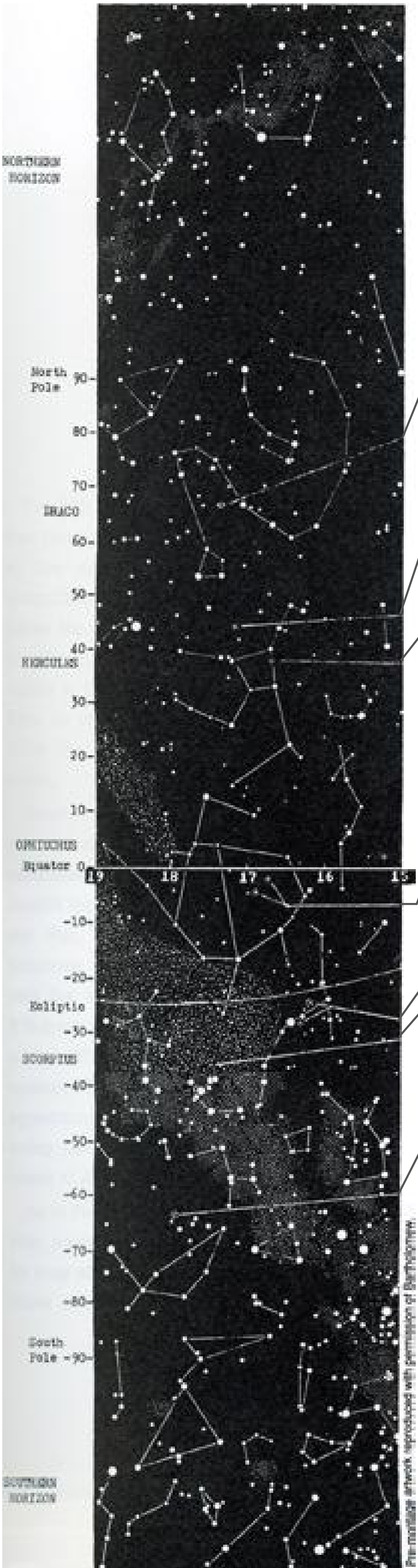
Antares is in the constellation Scorpius, which lies on the ecliptic. This is one of the most interesting constellations in the heavens. The Scorpius, Ophiuchus, and Sagittarius star clouds are the best in the Milky Way and mark the region around the centre of our galaxy. A cursory scan with binoculars will reveal to you the magnitude of what is available in this part of the Milky Way

There are so many stars in this part of the sky that when the Moon and planets pass this region they occult (cover up) dozens of them during their passage. With the Moon, it is easier to see the star blinking off or on (as the case may be, depending on whether the Moon is waxing or waning) on the dark (rather than lit) lunar horizon.

Two beautiful nebulae in this area are the Lagoon and Trifid Nebulae (M8 and M 20). In binoculars and wide-angle eyepieces, both may be seen just 1 ½ degrees apart. The form of these nebulae is seen well in telescopes, but if you are bitten by the astrophotography bug, you will probably be able to take colour photos of them even more attractive than their visual appearance.

Like the Great Orion Nebula (see January) both the Lagoon and Trifid are nurseries for star formation, especially in their dark, dusty portions.

Like two infants huddled together for comfort, the Lagoon and Trifid Nebulae defy the encroaching stars of the Milky Way. The pair are close enough to the ecliptic for the outer planets to sometimes drop by for a visit, and pose for a photo session (though not in this picture, but the next). Notice that the stars in the nebulae are young and whitish, compared with many reddish and old stars in the background. This is the view as seen in a rich field telescope (very wide angle of view), at about 20 x.



One of the brighter planetary nebulae may be seen this month in the constellation Draco (Greek: Dragon). This object, at a distance of some 3,200 light years, is NGC 6543. Like other planetaries, this nebula has a central star (the remains of the nova) which makes it shine a soft blush colour.

In Hercules, the constellation south of Draco, we see a really good globular cluster, this is M92. and is often ignored due to a better cluster being nearby. M92 contains several hundred thousand stars and would be as impressive as Omega Centauri (see May) if it was were closer than its 35,000 Ly. However, it is approaching us at 117 km per second, and so will brighten over the next few million years.

When we talk of objects approaching us at various speeds, the reader should not assume that we are fixed, and everything else. moves, but rather that the velocity of objects relative to us in combination of our movements and theirs.

M13, the Hercules Cluster, is the best globular cluster of the northern hemisphere, containing up to a million stars, this cluster is 25,000 Ly away and is a superlative sight in a telescope. Like M92, we are approaching M13 very quickly at 240 km per second. This is not surprising, since just twenty degrees to the south-west is the galactic area towards which our solar system is heading.

A comparison of globular clusters may be made by observing M10 and M12, both 22,000 Ly away. M10 is fairly compact; its M12 is much looser. Can you see which is which?

Opposite this paragraph, you will find, in the Milky Way, the collection of M8, M20 (Lagoon and Trifid Nebula), and the clusters M19 and M23.

Two more fine globular clusters we can compare are M4 and M80. M4 is the closest globular to us at only 6,500 Ly It is easy to find beside the orange star Antares. In the Milky Way directly across we can see M6 and M7, beautiful open clusters at 800 and 1,300 Ly away respectively.

This whole region of the Milky Way has no competitors. You may find it useful to use the July and August charts together since there is a whole unbroken chain of objects to wonder at.

Lastly, we have one more special globular cluster. NGC 6752 is distinguished (together with M 4) by being the closest to us at 6,500 Ly or so. All the distances of very far objects (beyond a hundred light years) have an uncertainty of usually 15%. So, no one is certain whether M 4 or NGC 6752 is closer. Further observations should establish that.

The subject of measuring distances and movement in astronomy (astrometry) is incredibly interesting, and perhaps too mathematical for many people. But the general principles are easily grasped, and there are many fine books that explain how this is done.

Very briefly, different methods are employed, depending on the distance involved For Solar System objects we can use anything from radar (Moon and Venus) to timing occultations of the planets by the Moon, and occultations of the stars by the planets. Then for the nearer stars (up to 500 Ly) we can measure their parallax as the Earth moves in its orbit. Beyond that, we can compare the brightness of stars with nearer stars of similar spectroscopic qualities.

For other galaxies, variable stars within them are used of known characteristics, as well as comparing distant galaxies with closer ones that are similar, Finally, the redshift of the most distant objects is an indication of their approximate distance. Each level overlaps the adjacent ones and allows checking of the accuracy of all the methods.

PERSONAL NOTES, DRAWINGS & PHOTOS:

AUGUST

The fifth brightest star, Vega, is on the meridian this month. Vega (Arabic: the swooping eagle) is in the constellation Lyra (Greek: lyre). This magnificent star is 27 Ly away, and three times the diameter of our Sun. Our separation is closing at nearly 14 km per second, which will cause it to brighten for the next 300,000 years from its present magnitude of 0.04 to almost -1. After that, it will pass us about 19 Ly away.

Another very bright star, just north of the equator, is Altair (Latin: high one). This is in the constellation Aquila (Latin: Eagle) and is the twelfth most radiant in the sky. Similar in size to our Sun, it is nevertheless nine times more luminous since it is nearly twice as hot. It has a very fast rotation period, turning on its axis every 6 ½ hours compared to our sun's rotation which is a slow 25.4 days. This rapid turning causes the equator of Altair to bulge out, giving it a flattened appearance. Altair is one of our closest neighbours, being just 16 Ly away. It too is getting closer at 26 km per second.

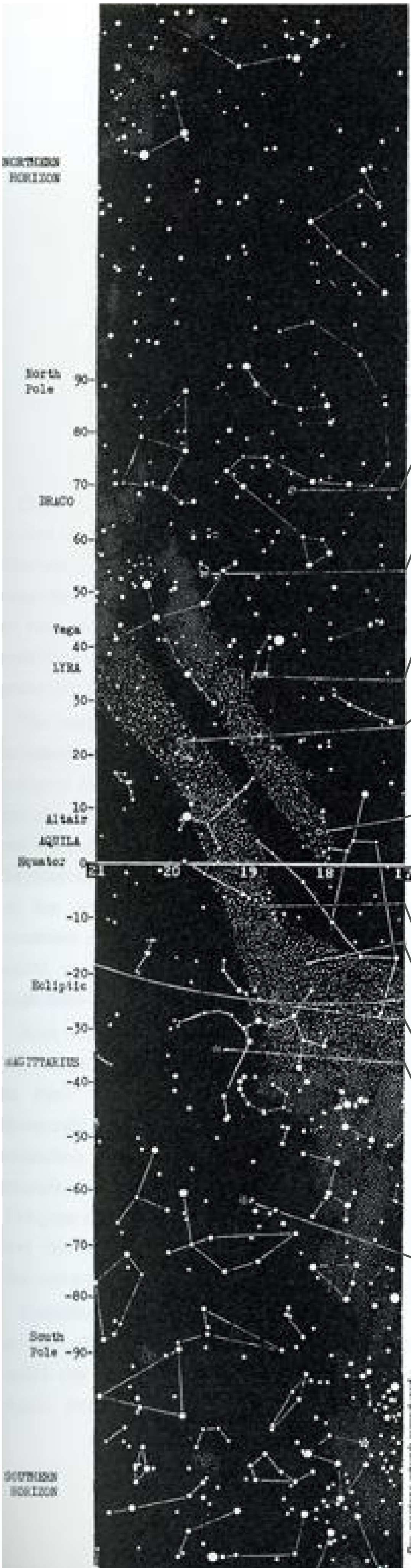
As in February, this month our galaxy, the Milky Way, again runs right through the equator making for long and interesting star gazing, especially for those of us who live south of about 30 degrees north. It is from these areas that the southern Milky Way, containing the centre of our galaxy, is visible. But let us not dismiss the North too hastily, for this is the month of the Perseid meteor shower, a true northern spectacle.

The Perseid meteor shower is spread over a few days, with its maximum of about the 10th of August. This splendid shower shows, on average, about 70 bright meteors every hour at its peak. It ranks a close second to the Geminid shower of December 13th and can only be seen from north of 20 degrees south of the equator, so northern hemisphere citizens have it almost all to themselves.

There is one catch. During August the constellation Perseus is not well above the horizon till after midnight and does not reach the meridian till 4 am.

The Perseid meteor shower radiates from Perseus (all meteor showers are named after the constellation from which the meteors seem to emanate), so to see it you must be outside at a dark location after midnight around August 10th. If you can manage this you could be amazed by how the stars seem to fall out of the sky, shooting in all directions. You may see many more than 70 per hour and can take a photo by opening the shutter for 1 to 2 hours, at f 5.6 on 200 ASA film.

Notice how many clusters and nebulae there are in this part of the Milky Way (in Sagittarius). You can clearly see how our galaxy widens from left to right, as we look towards its middle area. If this photo had carried on further, you would have seen the Milky Way (our galaxy) become narrower again as we moved again towards its edge. The bright and dark nebulae are very obvious here. On the far right we have the Lagoon and Trifid Nebulae (as in photo on page 33A). The very bright 'star' beside them is in fact the planet Saturn, which was loitering here in 1988.



Pre-montage artwork reproduced with permission of Bartholomew.

Hovering around the meridian, we can still see NGC 6543, the bright planetary nebula from last month. About 20 degrees away we can see another; NGC 6826 with a disc about the size of Saturn. Then we have perhaps the best-known planetary nebula; M57, the Ring Nebula in Lyra.

The Ring Nebula is not quite as bright as some of the other planetaries but has a perfect doughnut shape which can be detected with 6-inch and larger telescopes. It has the usual central illuminating star, which in this case is very faint and may be seen only with very large amateur telescopes. However, the central star, like other faint stars and nebulae, can be photographed with a small telescope, since long exposure photos show details up to four magnitudes or 40 times fainter than what the eye can see.

The Ring Nebula is 1,500 light years away, and half a light year in diameter. Its original star would have blown up about 20,000 years ago. Luckily, on this month's meridian, we have another planetary almost as well known. This one is M27.

M27, the Dumbbell Nebula is very large at one-sixth the diameter of the Moon, and so even low magnifications show it up well. It shows its dumbbell shape well, and under good conditions, two very faint 'ears' of nebulosity will test your telescope and eyesight to their limits. It is 2½ Ly across and 900 Ly away. It would have exploded about 50,000 years ago.

Compare the Ring and Dumbbell Nebulae with NGC 6572, which is much smaller, and in one night you will see a good cross-section of the appearance of these intriguing objects.

Planetary nebulae are caused by a mild nova explosion of an old, large, star. Only the central core is then left, which remains as a white dwarf. The white dwarf is the source of the ultraviolet light which causes the cloud of gas to glow. Although the white dwarf will continue to live for many millions of years, the expanding shell of gas becomes too dim for us to see after only a few thousand years, as in the Crab Nebula (see January) which has dimmed significantly since its discovery two hundred years ago.

Often there are two strong streams of radiation (due to the magnetic axis, and spin of the star) which give the two-lobed appearance, as in the Dumbbell Nebula. So, we are witnessing magnetic and nuclear reactions at work without needing a visitor's security clearance!

Opposite this paragraph, you will find the continuation of the richest part of the Milky Way from last month. In sequence, we have an open cluster M11, looking almost like a globular. Then we see M16 and M17, the Star Queen and Swan Nebulae, within three degrees of each other. To top it off, M22, one of the best globular clusters, lies in an already rich starfield. M11 and M17 are both about 6, 000 Ly away. M16 is 8,000 Ly away, and M22 is about 10,000 Ly away.

M55, a loose globular, will show in binoculars as a large hazy star, a telescope will resolve it into its thousands of stars Similar to M55 is NGC 6752, another globular. Both are 20,000 Ly away.

When you look at parts of the night sky as rich as what we have this month, try to imagine what an infinite variety of creatures and civilisations there must be there. This would put into perspective the daily problems we and the Earth endure, and the futility of wars.

PERSONAL NOTES, DRAWINGS & PHOTOS:

SEPTEMBER

Our Sun, like many other stars, is surrounded by a disc of dust extending out to many millions of kilometres The dust grains are extremely fine, typically about one ten-thousandth of a millimetre in size. But there are so many of them that by reflecting sunlight, they appear as a faint glow in particular parts of the night sky, along the ecliptic.

The main glow due to the dust around the Sun is called the Zodiacal Light. September and its adjacent months (August and October) are good months for people in the southern hemisphere to see the Zodiacal light in the evening twilight, and fox observers in the northern hemisphere to see it in the morning twilight. You must have a moonless evening (or morning), away from city lights, in a very clear atmosphere (deserts and high altitudes are quite good)

After sunset (or before sunrise for northerners) look towards where the Sun has just set (or is due to rise). Keep looking every five minutes. Eventually, you may see a faint triangular light extending up from the horizon. The base of the triangle is on the horizon, and the apex in the sky. The glow is in the general direction of the ecliptic and can be photographed quite easily with fast film and a minute or so of exposure.

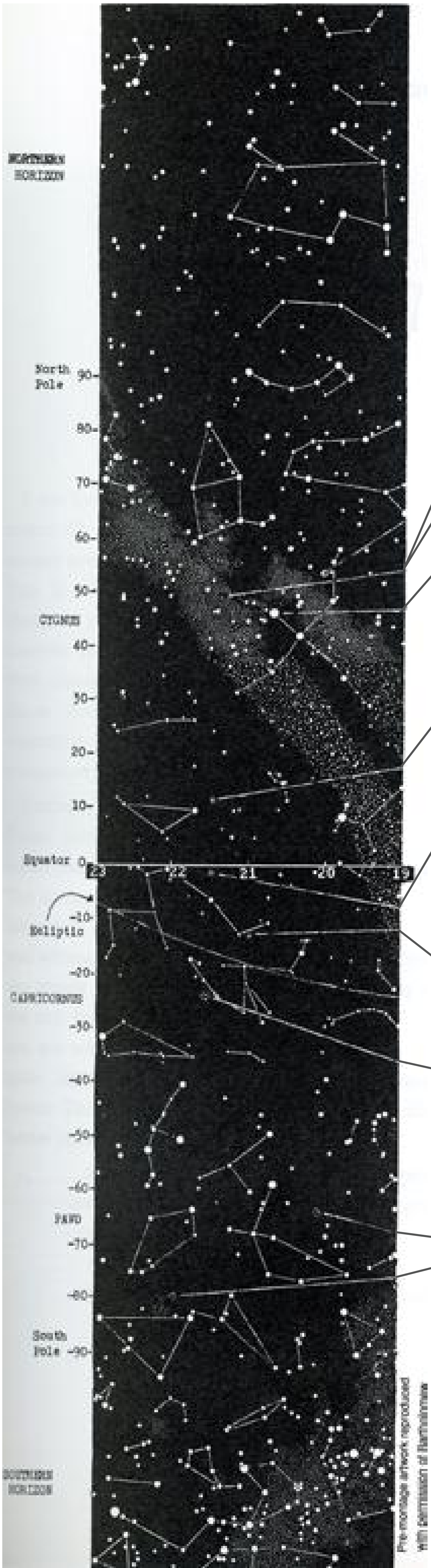
Surprisingly enough, this dusty light can very occasionally be seen about midnight. Then it is called the Gegenschein (German: Counterglow). Again, you must have perfect conditions. If you are determined you may also photograph this but need exposures of several minutes.

To stop the stars trailing you will need some sort of tracking device. Usually, the camera is mounted (with its normal 35 to 50 mm lens) on top of a telescope (called piggyback). The telescope is used for guiding on one particular star, and hence the whole area being photographed. For this, you need an equatorial mount (see Chapter Six). This piggyback' photography is also used for capturing large star areas and extended nebulae. It is the first, and often the most rewarding, astrophotography that amateur astronomers try.

The Gegenschein may best be seen in the northern hemisphere during September, October, February and March. These months correspond with long, dark nights, and the Milky Way away from the ecliptic on the midnight meridian, For the southern hemisphere, the Gegenschein can be hunted during April, August and September, where the seasons are reversed.

The brightest star on the meridian this month is Deneb, ideally observed from the northern hemisphere. Deneb (Arabic: Hen's Tail) ranks 19th most radiant in the sky. It is in the constellation Cygnus (Latin: Swan) and marks the tail of that group of stars. Deneb is an enormous star, twenty-five times more massive than the Sun, 60 times the diameter, and 60,000 times more brilliant! It is 1,600 light years away, and approaching us at 5 km per second.

The Zodiacal Light is clearly visible in this photograph taken one hour before sunrise. Notice that the sky is dark enough for stars down to the sixth magnitude to be visible almost to the horizon. The glow we see is only in the centre of the picture and extends some 20 degrees upwards. It is whitish and quite distinct from the dawn or dusk glow, which runs a long way along the horizon and is red. This photo is a 20-second exposure at F1.7 on 200 ASA film. Perhaps you too can take one.



During early September compare the planetary nebula NGC 6826 which is still near the meridian with nearby M39, a large and loose open cluster in the Milky Way, somewhat like the Pleiades (M45, December).

M39 is just visible to the naked eye as a hazy patch, but is resolved in binoculars and low power in a telescope into a couple of dozen bright stars set against the many other fainter points of light comprising this portion of our galaxy. It is about 800 Ly away.

Next, we have Deneb, the 1.26 magnitude star in Cygnus, set mid-stream in the Milky Way. Remember that the Milky Way is important not just for the many wonderful sights it contains, but also for checking on visibility and light pollution. If you are at a good dark location, you should have no trouble seeing the Milky Way without optical aid, once it is more than 10 degrees above the horizon

M15, one of the better globular clusters, can be seen a little north of the equator. This one is 130 Ly across, and 40,000 Ly away. A similar cluster is found just south of the equator, and so the two may be compared.

M2 is some 50,000 Ly away. There are clusters more distant than this, but obviously not so spectacular. You would have noticed by now that globular clusters are in the general area of our galaxy (ones suitable for amateur scopes), this is because they are a general galactic feature, none are 'independent' galaxies of their own. Their mode of evolution, like many other wonders of the Universe, has not yet been satisfactorily worked out.

This search for knowledge is part of the thrill of astronomy. The discoveries are not necessarily Earth-shattering, they may be personal discoveries that you make for yourself. Also, new developments in astronomy are not always strictly observational, they may be breakthroughs in concepts (e.g. relativity) or calculations (e.g. life cycle of Black Holes).

NGC 7009, the Saturn Nebula, is a planetary shining a brilliant green about the apparent size of Saturn. Its central star may be seen in moderate aperture telescopes. It is 3,900 Ly away.

M 30 is not a good globular cluster and is included to signify about where the really obvious objects end, and the difficult ones begin.

There are many amateur astronomers, who, when they have seen the really grand sights, steadily begin looking for the really difficult ones barely visible in their telescopes. They are not silly, but have instead reached that state of awareness that sees splendour in the minutest details of existence, even a glimpse suffices them.

NGC 6752 (last month) is still visible, as well as 47 Tucanae which is dealt with next month

September 23rd is of course the Autumnal Equinox. That is when the Sun seems to cross the equator and head back South (due to the tilt of the Earth's axis). This is the end of northern summer, and good news for planet watches in the North, because from September onwards the ecliptic moves higher in the sky at night. Any planets visible at night during these cold months will be high in the sky. So brave the cold and give it a go.

PERSONAL NOTES, DRAWINGS & PHOTOS:

OCTOBER

If you live north of about 50 degrees or south of minus 50 degrees, there is one astronomically caused event which you may see quite regularly. This is the Aurora. The aurora is caused by charged particles from the Sun being deflected towards the Earth's Magnetic Poles. There, as they interact with the upper atmosphere, they cause the rarefied air to glow due to the absorption of energy from the particles and its translation into visible light.

Northern Aurora are called Aurora Borealis (Latin: northern dawn), and Southern Aurora are called Aurora Australis (Latin: southem dawn). The aurora is in fact at a height of 100 to 300 kilometres and have nothing to do with dawn. If you witness an aurora from a dark site you may see simply a pale white sheet of light hanging in the sky, but if you see a prominent display you can see whole curtains of coloured light billowing quite rapidly, as if stirred by some heavenly breeze. They can be so bright as to drown out the fainter stars.

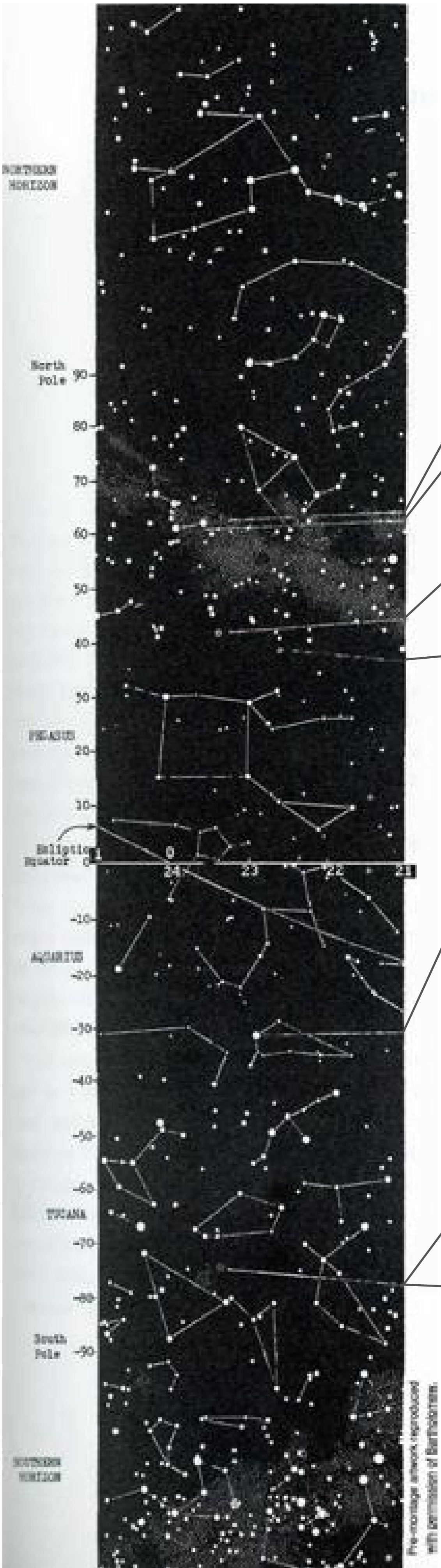
Occasionally aurora is seen from temperate and tropical latitudes, but this is very rare. If you travel to northern latitudes especially to see them, the best area would be northern Canada because the North Magnetic Pole is situated at Bathurst Island at about 76 degrees north, in far northern Canada.

You would also see more aurora if you made the trip during northern late autumn to early spring, from October to March, because the nights are longer. Periods around sunspot maximum are also better, e.g. the first half of the 1990s and every 11 years thereafter. There are no convenient places in the extreme southern latitudes for seeing aurorae. You would need to go to the tip of South America or the continent of Antarctica during southern winter.

During October we have our third most Impressive (on average) meteor shower of the year. This is the Orionids, visible from both hemispheres. The Orionids emanate from the constellation Orion which is well placed above the eastern horizon from 11 pm. On average a maximum bright meteor rate of 40 per hour can be expected. One advantage of the Orionid shower is that it is followed by the Taurid meteor stream and the two overlap. Orion and Taurus are adjacent constellations, and so if you are looking in this direction you should see meteors belonging to both, that is, the moderate number of trails from Orion add up with the ones from Taurus, and so you see more meteors in the one area than otherwise. Observe this region from October 19th to 31st.

The famous aurora of March 1989, one of the few photographed in colour from Australia. This picture was taken just 28 degrees south of the Equator at Geraldton, on the west coast. Normally you must be much closer to the North or South Pole to see auroras.

An exceptional prominence (eruption) on the Sun was the cause of this one so far in the tropics. Best times for aurora spotting are the winter months with long dark nights, preferably at latitudes 60 to 90 degrees North or South.



Two open clusters may be seen in the constellation of Cassiopeia (Name of a woman in Greek mythology). These are M 52 which is compact, and a more scattered variety NGC 7789.

M 52 contains some 200 stars mostly only 20 to 30 million years old. It is about 4,000 light-years away. The other cluster, NGC 7789, is harder to resolve.

NGC 7789 contains about a thousand members. It is much older, perhaps one billion years old, and 6,000 Ly away. This assemblage runs counter to the general observation that open cluster stars tend to drift apart after being born. It may be that this cluster has stayed together because it is so large, and so has a significant aggregate gravitational field holding the members together.

Situated some 4,000 Ly away, the planetary nebula NGC 7662 a # Slant 3 waits for our attention. This is visible in all telescopes as a small green disc. Moderate and larger scopes will show some detail as well as the faint variable central star. The central star, as with many other planetaries, is a very hot blue to white dwarf with surface temperatures above 50,000 degrees Celsius.

NGC 7331 is a beautiful spiral galaxy. It is very similar to the Andromeda (see next month) and our own galaxy. Some idea of the size of such a galaxy may be gained when we consider that it is nearly 50 million ly away, and yet in our sky, its length is still one-third the diameter of the Moon!

Fomalhaut (Arabic: Mouth of the Fish) is so called because it is at the mouth of the constellation “Piscis Australis” (Latin: Southern Fish). Fomalhaut is the 18^{th} brightest star in the sky but tends to stand out in evening October skies because there are no similarly bright stars near it. It is 23 light years away, twice as massive as our Sun, but 14 times brighter. This disproportion between its size and brightness shows that it is hotter than our Sun.

A strange thing happened to me involving Fomalhaut. Someone rang up late one night convinced there was a U.F.O. near the horizon. It had been in the same place for half an hour (1), changing colour very rapidly. A quick glance outside confirmed my suspicion. It was only a bright star as seen through the thickness of the Earth’s turbulent atmosphere. All fairly bright stars twinkle and show colours of the rainbow near the horizon. This is due to diffraction caused by pockets of air at different densities (due to temperature variation).

This month sees one of the splendours of the southern sky on the meridian. This is the justly famous 47 Tucanae, a globular cluster that, in my opinion, ranks first with Omega Centauri (see May). 47 Tucanae is easily visible to the naked eye just beside the Small Magellanic Cloud, as a hazy 4 2 magnitude ‘star’. Thousands of its half a billion stars become visible in moderate and large scopes, and even a small telescope resolves the brighter members.

47 Tucanae is one of the superlative celestial sights, and at southern star parties (when a group of people get together at night to look at many objects through telescopes) this globular captures peoples’ attention as strongly as the Moon, major planets, Orion Nebula, etc. It is one of the visions which prompts us towards buying a larger telescope. It is 16,000 ly away and has a diameter of 210 light years. In the eyepiece, it is nearly as large as the Moon.

PERSONAL NOTES, DRAWINGS & PHOTOS:

NOVEMBER

Up to this point, we have looked at many different objects in deep space, ranging from various types of nebulae to collections of stars in our own galaxy, the open and globular clusters, and finally external galaxies. The nearest external galaxies to ours are the Large and Small Magellanic Clouds, but these are rather small and almost connected to our own galaxy. We have seen the truly giant spiral galaxies set millions of light years away and may have wondered how they would look at close quarters.

Luckily, there is a large proper spiral galaxy. much like our own, not too far away. This is the Great Andromeda Galaxy, M31, which at just over 2 million light years is the closest such object (so far as we know, because our Milky Way may be obscuring any others on the other side of our own galaxy).

You can see M31 quite easily with the naked eye as a hazy patch some 2½ degrees long and over half a degree wide. Compare this with the Moon or Sun, which are just half a degree across in the sky. So M31 looks five times larger than the Moon, but don't rush out expecting to be overwhelmed. Like other deep sky objects, you need dark, transparent skies.

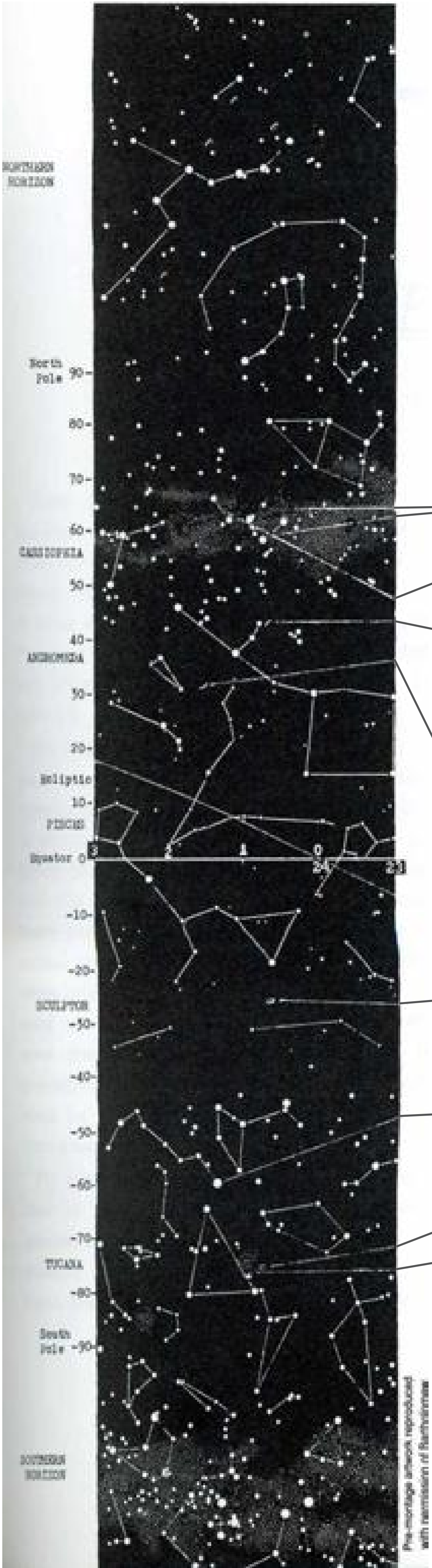
Some years ago, I was looking for the Andromeda Galaxy from a suburban site in California. The sky looked reasonably dark, but 'reasonably' is not good enough; the galaxy was not at all visible! From a rural site in Western Australia, I have no trouble seeing M31 at a glance, even though it is less than 20 degrees above my horizon.

The best instruments for seeing M31 are binoculars. The following types are particularly suitable: 10 x 50, 10 x 60, 12 x 60, 15 x 80, 25 x 150. Photographs may be taken quite easily with any lens of 50 to 500 mm focal length, Konica SR V 3200 film or similar, and quite a few minutes of exposure at full aperture (you need to mount the camera on a motor-driven telescope).

Until the turn of this century, no one knew for sure that there were galaxies outside our own. It was popularly believed that our Milky Way was the Universe! It is thanks to photography that we now have images of distant galaxies that show the brightest stars within them. Spectroscopy has helped establish the distance to the remotest parts of the known Universe and shown us (once again) that we, our planet, the Solar System, and the Milky Way, are not the centre of all things.

Apart from the Magellanic Clouds, M31 was the first galaxy to be resolved into its compo-nent stars, and only a fraction of its 300 billion at that.

The Andromeda Galaxy, M31, as it appears in good binoculars or rich field telescope under clear, dark skies. At first sight the galaxy looks like a nebula, and for many years in the past was called a nebula. But it is in fact a collection of some 300 billion suns at a distance of about 2 million light years. It is the easiest spiral galaxy to observe. If you are showing the Universe to newcomers, a good program is to start with the closest objects at only a few light minutes, and have the finale with the Andromeda Galaxy at 2 million Ly. (Preferably Moonless nights).



About November 3rd is the maximum for the Taurids meteor shower. This radiates from the constellation Taurus (see January chart), which is on the meridian around midnight. Also about the 18th of the month we have the Leonids meteor shower (in Leo) But Leo is not high in the sky till the small hours (see April chart).

On page 45 we can see which chart to use for any hour of any month. In general each constellation is well above the horizon from 4 hours before to 4 hours after the time it crossed the meridian (moving East to West!)

Still well placed for observation during November M52 and NGC 7789 are west of the constellation of Cassiopeia.

To the east of Cassiopeia the small, open cluster M103 can be spotted. This is over 8,000 light years away, and is quite typical of the many insignificant clusters you come across when sweeping the Milky Way with binoculars or low power telescope

M31 (see main text) is undoubtedly the highlight for the northern hemisphere, and down to about 30 degrees south. When you look at it using very low powers, you will notice M32 and a couple of smaller attendant galaxies right next to the main spiral M31. These small companions are the equivalent of our Magellanic Clouds, and many spiral galaxies have such little friends.

In a 15 cm or larger aperture scope you would notice that M31 is seen by us as almost edge on. But close by M33 is, in contrast, an almost face on galaxy. Remember that whatever size telescope you are using, try for low magnifications with a wide angle eyepiece, because these objects are all quite large and faint

M33, known also as the Great Pinwheel galaxy, is about half the size of M31 and a little further away at 2 million light years. It can be seen unaided as a dim patch a little larger than the Moon. In a 12 inch (30 cm) or larger soope you can distinguish the spiral arms.

NGC 253 is another fine galaxy about 7 milion Ly away. It is just visible to the naked eye, and in binoculars extends to almost the size of the Moon. Like many other galaxies, NGC 253 belongs to a congregation of galaxies, known here as the Sculptor Group, after the constellation.

Achernar (Greek: Star at the End of the River), is the 9th brightest sun in the sky. This star is a brilliant blue-white giant, about seven times the diameter of our Sun, 650 times brighter, and 120 Ly away.

You can still see the superlative globular cluster 47 Tucanae, adjacent to our companion galaxy, the Small Magellanic Cloud. The Small Cloud is about the same distance as the Large Magellanic Cloud, some 200,000 Ly away. You cannot miss it, since it is a prominent glowing mass very similar to our Milky Way.

In a good 6 inch or larger telescope the small Magellanic Cloud begins to resolve into thousands of stars. These are only the brightest members, since the whole of this galaxy contains several billion stars. Consider that our Sun viewed from this distance would only be visible in the largest professional telescopes, as a very dim 24th magnitude point of light.

PERSONAL NOTES, DRAWINGS & PHOTOS:

DECEMBER

Those of us who have never looked through a telescope at an open cluster may get an idea of what one looks like in December. The Pleiades cluster, sometimes known as the Seven Sisters, is so close that we can see several members with the naked eye. But in binoculars or a wide field low magnification eyepiece they look truly splendid

The Pleiades also provide us with a test for our own visual acuity. At first glance the group appears as a hazy patch. If you concentrate (and as always you need a dark, clear night sky), you should make out at least six stars. If you see less than five stars, consider a visit to your optician Many people who do not need spectacles for normal daytime use find that at night, especially when looking at the stars, their eyesight is not as good as it should be. Others, like myself, who wear glasses all the time, may find that the prescription they use for daytime is a little too weak for astronomical use. They should ideally have a second pair of glasses.

For many years I could not get a really crisp view of the stars, even though the optician assured me that my glasses were of the right stength. Finally the reason became apparent. At night, aftet a few moments in pitch darkness (as ideal sites must be), the pupils of our eyes open to their maximum diameter, about 6 mm. If the spectacles are even slightly under-corrected their deficiency becomes obvious, since stars are the ultimate test for good optics.

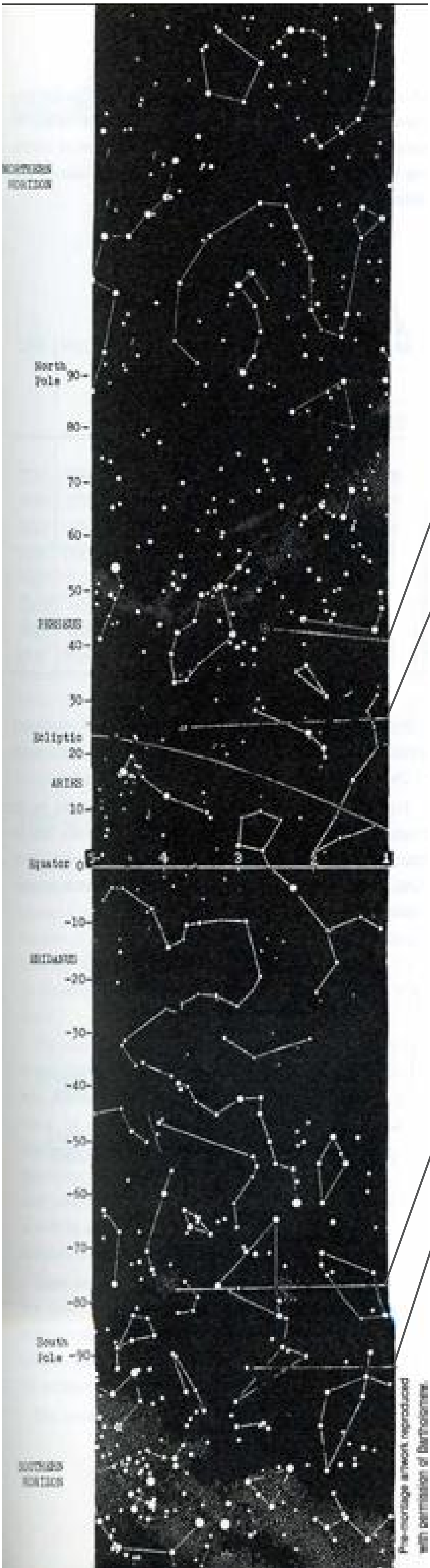
My optician lent me three lenses to take home. These lenses of ½, %, and 1 diopter correction went on my next observing session. After half an hour of dark adaptation, I looked up at the stars, and placed each lens in turn over the glasses I was wearing (one eye at a time). The results were dramatic. Every star became a perfect pinpoint of light. Where, before, only the brightest stars were seen, and those a little bit blurred, now I could see thousands. The Pleiades showed ten stars.

Of course I immediately ordered my special 'star gazing glasses, the lenses now perfectly right for use on the darkest night, but a little too strong for daytime wearing. I can now see stars down to 7th magnitude under the best sky conditions. So, if you feel that this may be a problem you have, don't delay, find a friendly optician who trusts you to return his/her lenses, and by placing them over your glasses see if you also need fractional diopter corrections.

The Pleiades (Greek: to sail) is one of the closest and most recent of open clusters. It is 20 million years old, 400 light years away, and is composed of above 300 stars.

The Pleiades or Seven Sisters is the best known open cluster. To see the wisps of nebulosity (as in this photo) you need very good conditions and set your magnification for an exit pupil diameter of 6 to 7 mm, as explained in chapter six. This is similar to what the Orion Nebula will look like in several million years, when the stars there have all been formed, and blown off the excess gas. Most cultures around the world have stories about the Pleiades and other prominent objects, and the reader may find books about some of them, or even write books about the ones not yet published!

DECEMBER MERIDIAN & 5 to 1 Hours Right Ascension



On the edge of the constellation Perseus and the Milky Way, we can see a pretty open cluster best viewed with binoculars or a small telescope. This is called M 34 and is one of those groups of stars for which a large scope is neither necessary nor desirable. It contains some 80 stars and is 1 400 light years. away.

Another cluster that shuns large scopes is M. 45, the Pleiades or Seven Sisters (see main text). I have obtained my best views of this group with 15 x 80 binoculars.

If you use low powers on the Pleiades and look closely, you will think that your eyepiece is dirty and needs cleaning. When you clean the eyepiece, the brighter stars will still look smeared. This effect is not due to the scope but is in fact nebulosity surrounding the cluster.

Since the Pleiades is just twenty million years old, the stars have not yet cleared all the gas and dust which enveloped them at their birth, and from which they originated. On the best nights, you can see wisps of radiance extending from one star to another. Photographs capture this feature very well.

This month shows us the best meteor shower of the year. This is the Geminids of 7 to 15th December. The shower emanates from the constellation Gemini (Latin: twins) and reaches an average peak rate of 80 per hour, about the 13th of December

During December, Gemini is not well placed for observation till after 10 pm. It reaches the meridian at about 2 am Gemini appears on the meridian chart for February, so if you wish to see the star patterns in that area refer to the February chart. But even without any charts there will be no doubt about the position of Gemini, all you will have to do is notice where all the many meteors are shooting from.

The Large and Small Magellanic Clouds are both near the meridian this month, they are covered in the January and November sections respectively.

In the southern hemisphere, there is no bright star marking out the pole, as Polaris (see April) does for the northern hemisphere. There is a dim 5 ½ magnitude star which is one degree away from the southern celestial pole, but the field has so many such stars that this particular one, Sigma Octans, is hard to distinguish. Binoculars make the job even more frustrating since a group of 7th and 8th-magnitude stars near the pole confuse the pattern

If you are curious or need to roughly align a telescope mounting, an easy way to find the pole is to find the Southern Cross (see May) and extend its long axis, from the sharper end, towards the south by 4½ times the length of the long axis. That is the south pole.

Extremely accurate polar alignment of the telescope mounting is needed when we want to take long-exposure photographs. If alignment is not good enough, the central stars in the photo will be sharp, but the stars near the edge will leave trails, refer to chapter seven for how to accurately align the polar axis. If you intend to do photography, regularly consider having your telescope (or its mounting) set up permanently, perhaps under a dome or slide-off roof. Mine is portable, but I have three metal markers set into the lawn where the tripod feet stand. This allows me to instantly set up the telescope aligned accurately.

PERSONAL NOTES, DRAWINGS & PHOTOS:

If you wish to observe the stars and planets at a time of the night other than between 8 and 10 pm, the meridian strip charts are still accurate. All you need to remember is that the star patterns advance by 2 hours per month. For this purpose, I have included a simple table below. This will enable you to know at a glance which map to use for any hour of darkness. The top row shows the month in which you actually wish to observe. The leftmost column shows the time at which you want to observe. The body of the table shows you which chart to use in the foregoing chapter

Month you are actually observing in → / Hour of night you want am/pm ↓	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	THE CHART YOU MUST USE IS BELOW THIS LINE.											
4 pm to 6 pm	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
6 pm to 8 pm	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
8 pm to 10 pm	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
10 pm to 12 pm	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	NOV
0 pm to 2 am	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB
2 am to 4 am	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR
4 am to 6 am	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR
6 am to 8 am	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY

Note that the angles of longitude on the celestial sphere are called hours of right ascension. This should not worry you, since very few people need to use right ascension information regularly. At the end of the next chapter, there are charts (graphical orrery) for finding the positions of the bright planets for every week of any year. Those charts give the position of the planets both in hours of right ascension and more easily, the constellations of the ecliptic where the planets can be found

If you want to translate from hours of right ascension to/from constellations to/from the meridian strip maps of the previous pages, then use the following list.

The particular meridian strip map is named by its month title. On the left of the month is the left limit in hours of right ascension, and on the right is the right limit Also, below the month is written the main ecliptic constellation for that map.

7 Jan 3 TAURUS	9 Feb 5 GEMINI	11 Mar 7 CANCER	13 Apr 9 LEO	15 May 11 VIRGO	17 June 13 LIBRA
19 Jul 15 SCORPIUS	21 Aug 17 SAGITTARIUS	23 Sept 19 CAPRICORNUS	1 Oct 21 AQUARIUS	3 Nov 23 PISCES	5 Dec 1 ARIES

Chapter Four:

THE WANDERERS

In the last chapter, you would have noticed that no reference was made to the Sun, Moon, and planets etc, in the monthly summary of what to look for in the sky. This is because all objects which are relatively close to us, that is those within our Solar System, move rapidly against the background stars, which are much further away. So, this chapter is devoted to those spectacles which do not stay fixed on a star map, and so do not cross the meridian at about 9 pm in one particular month every year.

THE SUN

The most prominent 'wanderer' is our Sun. We make one orbit of the Sun every 365 ¼ days, and so it moves against the background stars exactly on the ecliptic, at the rate of a little less than one degree per day, until it is at any designated starting point one year later. This by the way, is the probable origin of 360 degrees in one circle

The most important rule to remember about the Sun this: NEVER look at it directly, either with the naked eyes or binoculars or telescope. It will damage your vision to some extent, even to the point of total blindness. For this reason, if your children borrow your binoculars or telescope during the daylight, or have their own, you must make sure they realise the danger of looking at the Sun and are mature enough not to be tempted to 'experiment'.

There are a number of safe ways to observe the Sun. let's deal with these in turn a) If you have no instruments, and you hear of a partial (and very rarely total) eclipse of the Sun for your general locality, look at the eclipse only through a dark filter.

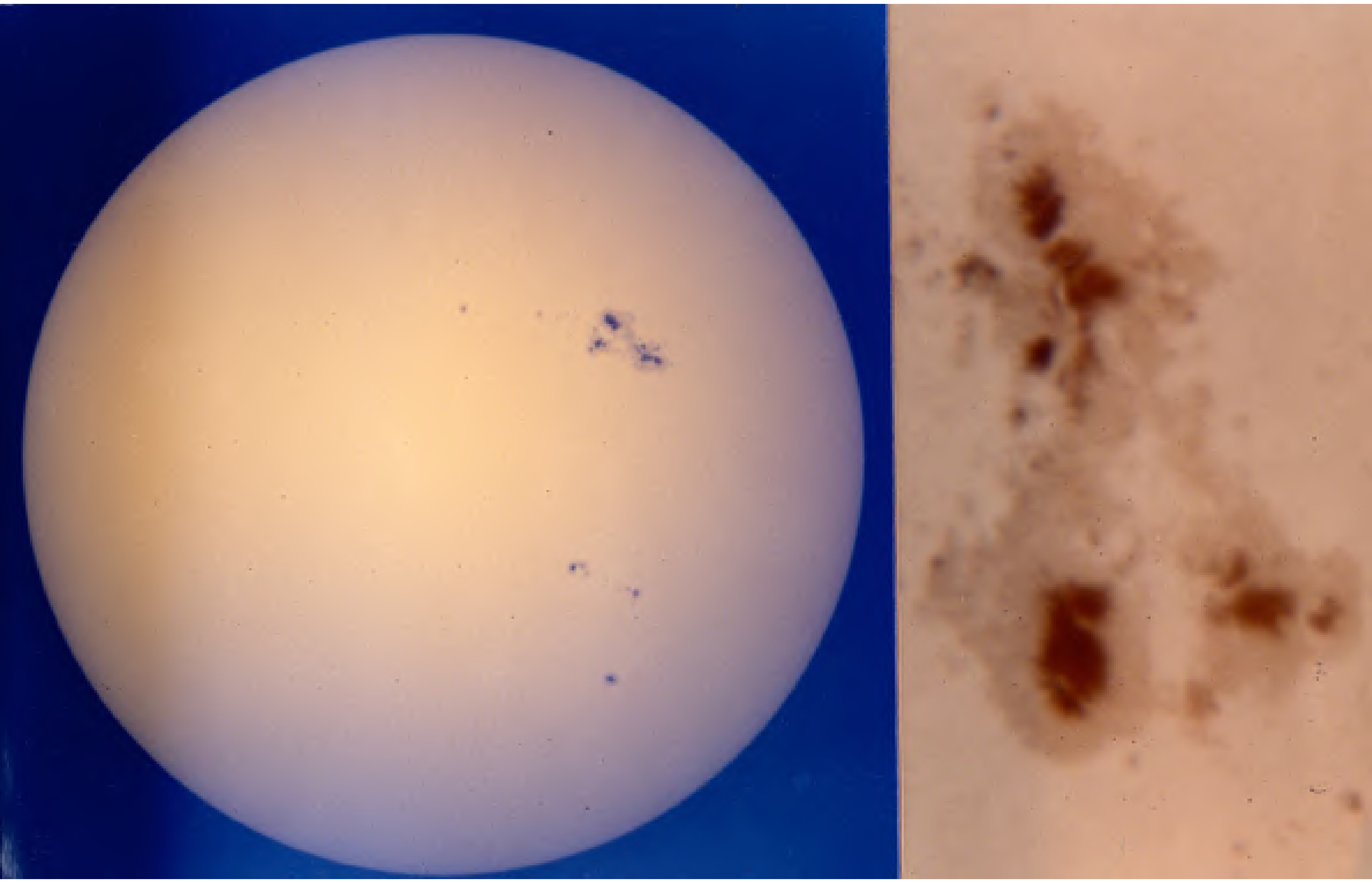
The best filters to use are arc welding glasses. You can get these from a good hardware store and should ask for the darkest available. Do NOT use under-exposed film, smoked glass, or tinted plastics, as these often let through the ultra-violet and infra-red rays of the Sun, without you realizing that your eyes are being hurt

The reason why arc welding filters are safe is that they have been designed to absorb not only visible light but also harmful ultraviolet and infrared. But even so, do not put these at the focus of a telescope, only use them for unaided solar viewing.

Alternatively, you may decide to project an image of the Sun, rather than look at it directly. If you make a pinhole or nail hole in a piece of opaque card (use a large piece so that a big shadow falls behind it) the light of the Sun will pass only through the pinhole, and project a fairly sharp image on the ground or white paper held a few feet or meters away. You have in effect a pinhole camera.

This method can also be used to see large Sunspot groups. b) If you have a telescope of less than 3 inches (75 mm) aperture, put it on a tripod, and project the image of the Sun onto a sheet of white paper or cardboard. This also works with binoculars. You can pick out even small Sunspots quite easily by this method.

If your telescope is larger than 3 inches you will have to 'stop down' to that diameter. That is, you cut a 3-inch hole in cardboard or thin plywood, and tape this over the entrance aperture of your scope. If you do not do this, you run the risk of generating too much heat inside your instrument, particularly at the eyepiece and damaging it beyond repair. Even with a small telescope, however, project the image only a few minutes at a

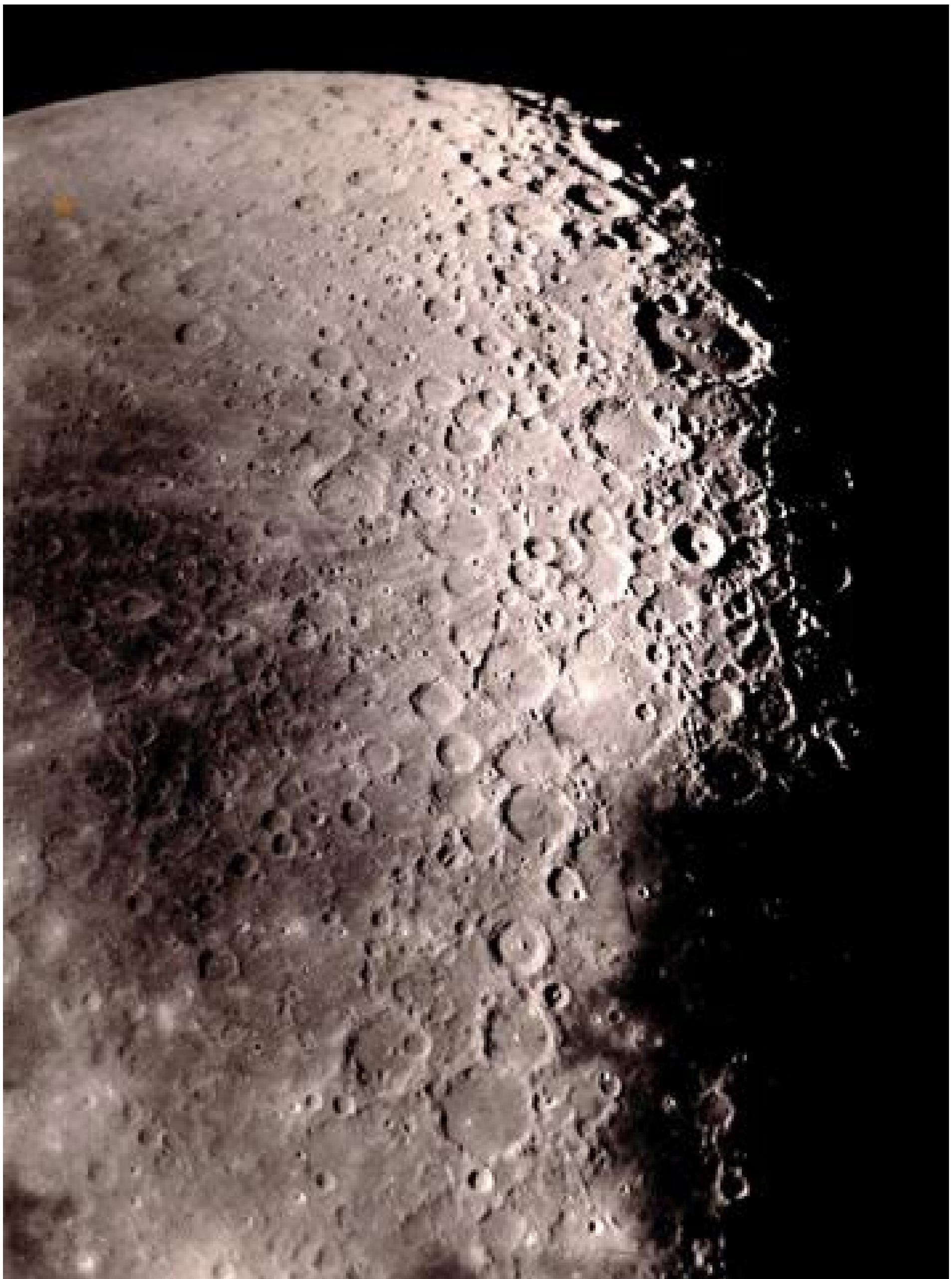


The famous sunspot group of July 1988 was one of the largest ever seen. This group was so large that one could see it with the naked eye USING PROPER DARK FILTERS (see main text). The photo shows the full disc at a magnification of 50 times. The close-up is at about 450 times.

You will notice that the spots have a central black area, surrounded by a grey boundary. A combination of convection currents and magnetic fields is at work in these places, giving us the various shapes that we witness.

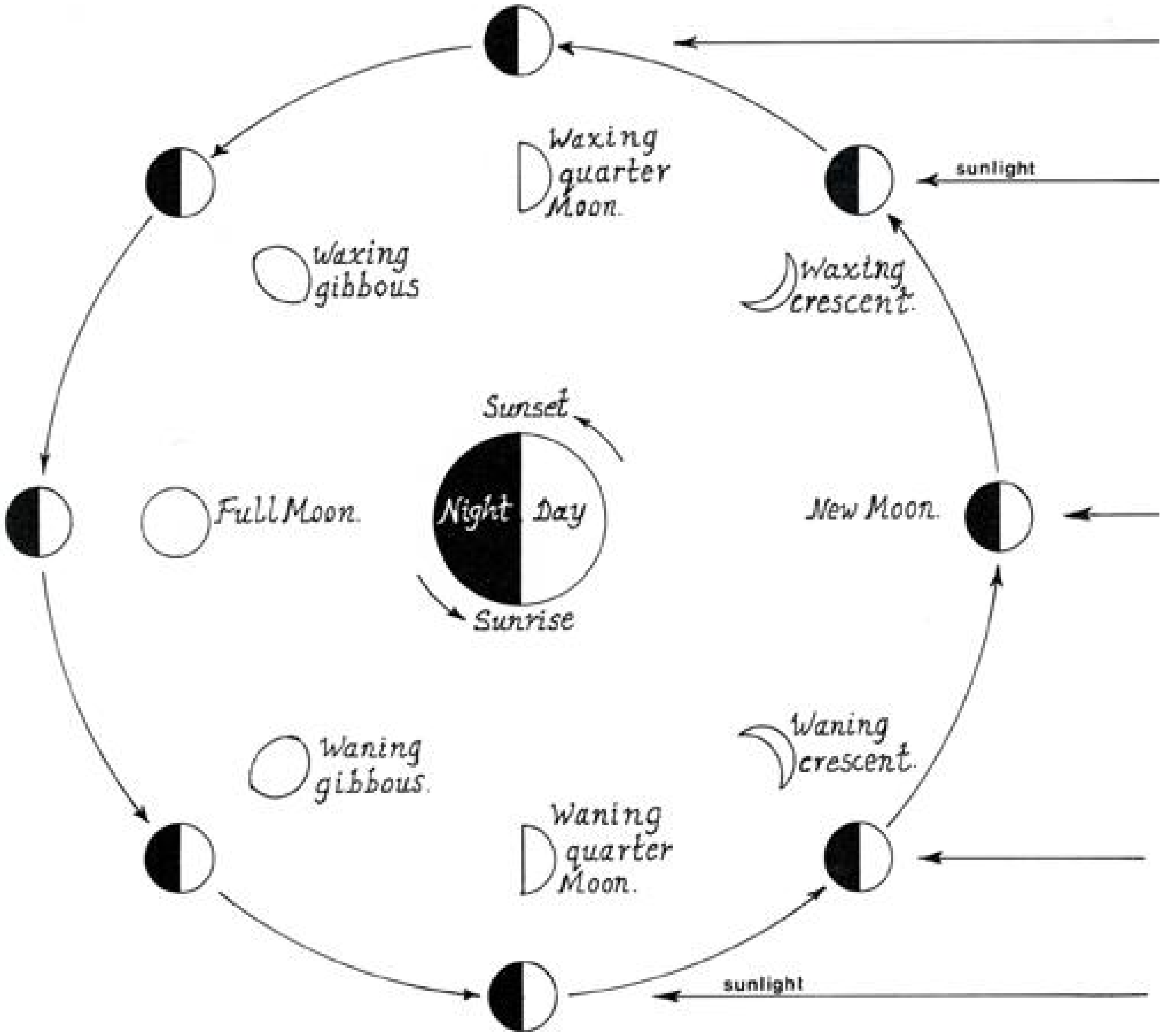
Sunspots are not cold; they are quite luminous and hot. It is only in comparison with the much hotter areas that we get the illusion the spots are black. The markings take about ten days to cross the face of the Sun, and even tiny ones are accessible using small telescopes from urban areas. The largest one here is 100,000 miles across, a very rare event!

In this photo you see the Moon entering a total eclipse. On the left is the Earth's shadow, and the Moon is travelling right to left. The left-hand side is already deeply immersed in shadow, umbra. The far right appears brightly lit but is in fact already in partial shadow, penumbra. The colours you see are real and are mainly caused by the refraction and absorption of light by our atmosphere.



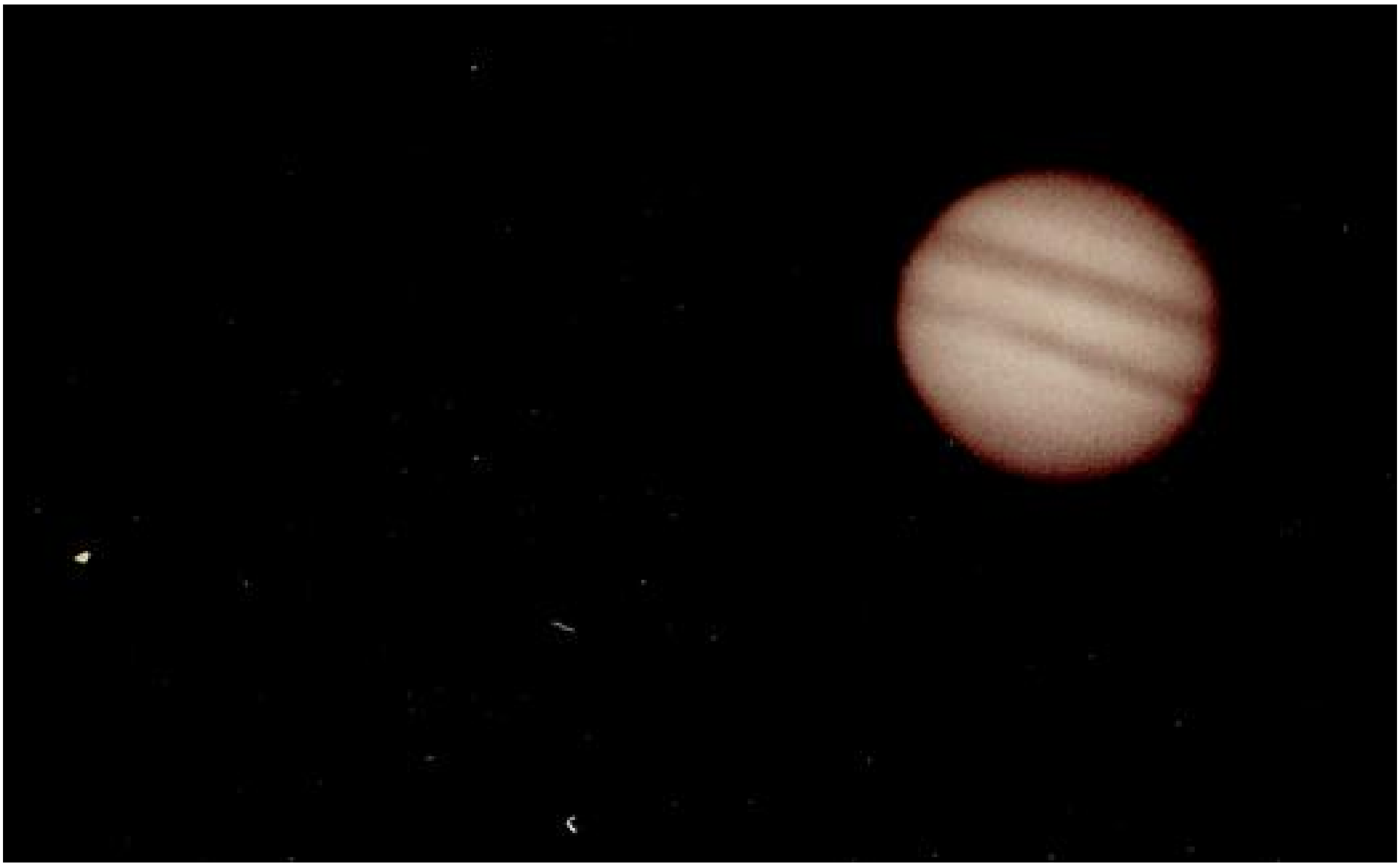
The Moon as it appears in a 4-to-8-inch telescope at a magnification of about 150 x. This photo shows a wide area extending left from the terminator (night/day boundary). Notice how the craters near the terminator are well defined, because of the shadows and highlights, but the fully lit craters have very little shadow, and so appear ‘washed out. Note also the smooth lunar ‘sea’ near the lower right. Of course, there are no actual seas or rivers on the Moon.

REASON FOR THE PHASES OF THE MOON



The diagram is not to scale. We are looking down from a location above the North side of the Earth. The rotation of the Earth is anticlockwise, as is the orbit of the Moon. The Sun is 150 million Km to the right.

This is Venus just a couple of weeks before inferior conjunction with the Sun (when it passes between us and the Sun). Notice the thin crescent, because, like a crescent Moon, we are looking at Venus almost fully from 'behind', and so see only a tiny bit of the lit hemisphere. The blue and red colours are not due to the telescope or Venus but are caused by the Earth's atmosphere breaking up the image like a prism. This happens with all objects near the horizon.



The planet Jupiter as seen in a 3-to-6-inch telescope. The four bright moons of Jupiter cannot be photographed at the same time as the planet, because if the exposure is long enough to show the moons, then the planet itself is grossly over-exposed.

Planetary observation is one area of astronomy where the eye can capture far more detail than pictures. This is due to our eyes having a greater range in light level detection than film emulsions. Also, visually, we can take advantage of momentary good visibility which may last fractions of a second at a time and pick out transient details.

However, this visual advantage may end soon with the greater availability of charge-coupled devices (CCD detectors) wired directly to a fast computer. The computer can analyse several thousand pictures per hour, and using image enhancement programs can merge the best elements of each picture to provide one with superlative resolution. By this method, both faint and bright objects may be shown in one photo.

Halley's Comet as it appeared to the naked eye around the middle of March 1986. Here it is rising about 3 am. Contrary to popular belief, the head and tail of a comet have nothing to do with the direction it is travelling in. When this photo was taken, the comet was travelling tail first. Many bright comets look as good, or better than this to the naked eye.

time and allow the scope to cool down every so often.

Solar eyepieces are available for small telescopes, sometimes they are supplied in the same package. These are eyepieces with very dark lenses which greatly reduce the light intensity to your eye. Personally, I do not recommend using them, because they necessarily ab-sorb a great deal of energy, and become very hot. So, there is some risk of the lens shattering, thus throwing splinters into your eye, and allowing the full light of the Sun to shine through until your reflexes cause you to look away. If you insist on using these eyepieces, then at least do so for only a moment or two at a time, and give them a while to cool down before observing again.

The best way to look at the Sun through a telescope of any aperture is by using a full aperture aluminised filter. This is a thin flat sheet of glass or mylar plastic that has a coating of aluminium and looks just like a mirror. It does however allow a tiny fraction of the light to pass through, thus forming a comfortably dim image at the eyepiece, and preventing the telescope from overheating.

My personal recommendation is to use the mylar plastic front aperture filter, be-cause the glass one may accidentally be broken by a careless observing companion while you are looking through the telescope, but the mylar plastic is immune to this. Mylar filters are also much cheaper. These filters are also available for binoculars.

The power of our Sun can be appreciated when we realise that (on average) every square meter of the Earth's daylight side receives about 1.36 KW of radiant power from the Sun, (a single element bar heater is rated about 1 KW). The total power over the entire day side of our planet is 174 million million kilowatts, and this is just one part in 2 billion radiated by our star! The actual power output of the Sun amounts to near-ly 35 billion billion billion watts. Put into perspective, the Sun releases as much energy in one 30 thousandths of a second as all humanity has used in the last 2000 years!

Where does the Sun get so much energy? During this century we have found that it obtains it by converting matter into energy. At the core of the Sun, hydrogen atoms are fused to-gether to make helium, but every time this is done, some matter is lost. The missing matter has in fact been converted to pure energy (similar principle to the hydrogen bomb). The Sun actually converts nearly 400 million tons of matter into energy every second! This it simply radiates into the depths of Space.

If you become a regular solar observer, there are a number of things you will notice, and which you can adopt as projects. For example, notice how sunspots grow and which you can adopt as projects. For example, notice how sunspots grow and diminish in size, on which side of the disc they first appear, and how long it takes them to migrate to the other side (use this to work out the rotation period of the Sun).

You will also observe that there is a periodic rise and fall in the number of spots; this is known as the 11-year cycle. You can keep a diary of drawings or photos which will improve in quality as you gain more experience.

If you ever got the chance to travel to a total eclipse location don't let it slip away. During a total eclipse, you will get as good a view as possible of the solar atmosphere. You will see prominences and flares, literally tongues of fire extending tens of thousands of kilometres into space. You will see the continuous ejection of hot ionised gases from the Sun, this is the co-rona, and you can easily photograph all this with a telephoto lens and frame it to remember for the rest of your life.

THE MOON

For most people, the Moon is the most spectacular object when they first look through a telescope. Even in binoculars, you can see the largest craters and mountains. Like the Sun, the Moon is also very easy to photograph (see next chapter) and shows a wealth of detail that changes from night to night.

Like the Sun, we need not go into how to find the Moon, you either see it or you don't. Suffice it to say that it revolves around the Earth (relative to the stars) once every 27 ½ days, this is called the sidereal period. But from one full moon to the next takes about 29 days, this is the synodic period and is the reason why an average month is given 30 days, hence 12 months in a year.

Together, the Sun and Moon are the reason for the tides and the main influ-ences on our weather. At times of full and new moon (Le. when the Moon is in line with the Sun, and so cannot be seen at all) we experience very high and low tides. When the Moon is at quarter phase (or more correctly half phase since half of it seems lit by the Sun, but it is never referred to as half phase) we have moderate high and low tides. In any event, we have almost two high and low tides per day.

The seasons have nothing to do with the Moon but are caused by the tilt of the Earth's axis relative to the ecliptic. This causes the Sun to rise higher in the sky during summer than winter and is the reason why at the poles we have 6-month periods of alternate night and day.

Apart from the dwarf planet Pluto and its moon Charon, our Moon has the largest size relative to its mother planet of any other satellite in our Solar System. With a diameter of 3,476 Km, the Moon is more than a quarter the diameter of the Earth. But we must remember that volume is a func-tion of the cube of diameter, and so the Earth is 4 cubed or nearly 64 times the volume of the Moon, it also contains more of the heavier elements (particularly iron) which makes the Earth 81 times more massive or 'heavier' than the Moon.

When observing the Moon, try at first to choose phases around the quarter moon. It is at these times that the mountains and craters stand out in bold relief. You will no-tice that the Moon always keeps the same face towards us. This is not a complete tidal lock (as it is called) since the Moon actually wobbles a bit (libration) and so we see some 59% of its surface.

After a while try to take photos or do drawings of the Moon at every phase, from the waxing crescent to the waning crescent, you will soon develop a keen eye for details you had missed earlier and might even detect unusual events such as the volcanic eruptions which were re-ported during the 1960's from a few craters.

THE PLANETS

Let's start from the inner planets and work outwards. First, we have Mercury. This is a very small planet with a diameter of 4,880 Km. Its size coupled to the fact that it nev-er appears further than about 21 degrees from the Sun makes it pretty difficult to observe. Perhaps if you become a determined amateur astronomer you can try for Mercury, simply to tick it off as something you have seen, but for now, we can ignore it.

Venus is a much better prospect. Most people have already seen Venus with-out realising it. It is the most brilliant planet and can be seen before sunrise or after sunset above the eastern and western horizons respectively

You can find the position of all the major planets by referring to the orrery at the end of this chapter. In just a few seconds this ingenious system will tell you where Venus, Mars, Jupiter and Saturn are, in their orbits and in your sky, for your whole lifetime.

In a telescope, Venus is an easy object, and shows phases similar to the Moon, but devoid of any features, since the whole planet is shrouded in a thick veil of clouds. This is part of the reason for its brightness; it reflects most of the sunlight from the top of its clouds. Venus is almost the same size and mass as Earth.

Mars is also a very interesting planet, just over half the diameter of Earth and with a clear, thin atmosphere. It is Mars which held out hope for advanced life forms in our solar system (apart from Earth of course).

For many years around the turn of this century, some astronomers claimed to see distinct, straight and interconnecting canals on Mars. These they ascribed to highly intelligent be-ings who had constructed an irrigation network girdling the whole planet.

Today, with better equipment and space probes, we know that the canals do not exist but are due to discrete features merging into lines. This happens whenever a telescope is used at the limits of its performance beneath the Earth's turbulent atmosphere, and the desire of the human brain to see patterns where there is none.

Once you have been observing for a few months. identifying the planets will pose no problems. All the ones we deal with are brighter than most stars and do not twinkle nearly as much, due to their apparent size.

Mars reaches opposition nearly every two years and is only worth observing at these times when its disc in a telescope is big enough to resolve some detail. You can spot it easi-ly at these times, because of its brightness and light orange colour. Around the time of opposition, like all the outer planets, Mars rises around sunset and crosses the meridian around midnight.

For observing any of the planets in a telescope we should try to use magnifications of between 100 and 300 times. The lower limit is imposed by the small size of the object, and the upper limit by the atmosphere and the size of the average telescope (say 6 to 12 inches). Of course, if you have a large, fine telescope on a mountain top you can use even higher magnifica-tions.

The first thing you notice when looking at Mars is the polar ice caps. Next, you will make out vague large-scale features, these are due to differing reflectivity from geological and topographic features. Finally, if all observing conditions are right, you can just see small-scale features such as the larger craters and volcanoes, but it will not be obvious that you are looking at such things (as it is on the Moon). It is for this reason that the craters, mountains and volcanoes of Mars have been seen for many years but have never been widely recognized for what they were.

After Mars we have Jupiter. This is the largest planet in our solar system, and 'weighs' 2½ times more than all the other planets combined. In a telescope, Jupiter never fails to please, since of all the planets it appears the largest (Venus is about the same apparent size when a thin crescent). Jupiter also shows the most detail.

The most striking thing which draws your attention is the four main moons of this giant planet. In a low-power eyepiece you can follow their dance about

In a low-power eyepiece you can follow their dance about Jupiter from hour to hour, and if dedi-cated enough can work out their orbital period.

The four main moons of Jupiter are so bright that some people can just see them with the naked eye, can you? I cannot see the moons except with binoculars or a telescope, but I can see the disc of Jupiter unaided, especially at opposition.

The famous belts (bands of clouds) of Jupiter can be seen at a magnification of 40 times or greater. At high magnifications, with suitable instruments and weather conditions, you can see details in the belts that remind you of the Voyager space probe photos.

At high magnifications the disc of the four main satellites also becomes visible, and you see their shadows crossing the parent. Depending on your eyesight and the quality of your telescope you can notice another four moons, but it is not easy to differentiate these from back-ground stars.

The last planet worth looking at is Saturn, arguably the most beautiful planet in our solar system. Everyone has heard of the rings of Saturn, and in a telescope at magnifications of 40 upwards these are clearly visible. Also easily seen is the main moon Titan.

In my 8-inch reflector, I can easily see the main gap in the rings; Cassini's Division. On good nights I can also spot a smaller gap further out, Encke's Division, as well as the Crepe Ring, two belts, the shadow of the planet on the rings, and the shadow of the rings on the planet, and a few more moons. Try to identify these features in your scope. The 6-inch reflector, described later on, may let you appreciate all the items I've listed

After Saturn, we have Uranus, Neptune, and Pluto. Uranus can be seen as a tiny pale green disc, but none of these three outermost planets provide a satisfying sight. You may however wish to add them to your list of challenges so that you can claim to have viewed every planet we know of. For Pluto, you will require superb dark skies and at least an 8-inch scope.

THE ASTEROIDS

Between the orbits of Mars and Jupiter, there are thousands of rocky masses rang-ing in size from a boulder to a 955 Km planetesimal (Ceres). These are specialist items for those of us who have run out of other things to observe.

Even the largest asteroids are quite a challenge and require excellent star maps and the patience to spend hours looking for their location and return-ing the following night to detect any movement of a suspect. Asteroids are still being discovered photographically. but are no longer an exciting area of research for astronomers.

THE COMETS

The situation is totally different with comets. These are still objects of intense investigation. Comets are believed to originate from a 'shell' of debris which is about one light year from our sun. This area that surrounds our solar system is known as the Oort Cloud, and is extremely tenuous, which is why it cannot be seen.

The Oort Cloud probably contains several millions or even billions of small lumps composed of ice and dust. Recently, organic molecules have been identified in some comets. For our purposes, comets are of most interest when they are near the sun. During an average year about a dozen comets are well seen in amateur telescopes. Every few years however a large comet. becomes a truly spectacular sight, even with the naked eye. It is the dust and frozen gases that give comets this characteristic,

As a comet approaches the Sun, the surface melts, releasing gas, dust and va-pour which is light enough for the solar wind (continuous discharge of atomic particles from the Sun) to blow it away. This is seen as the gas and dust tail of the comet, and it extends mil-lions of kilometres into space.

The comets that approach the Sun for the first time are influenced by the gravi-ty of the planets (mainly Jupiter and Saturn) so that their orbits may be changed. Depending on that change, the comet will become periodic, i.e. go into a confined orbit and so return over and over again. Or the comet may simply carry on and leave our system altogether.

The most famous periodic comet is Halley's which returns every 76 years, its path takes it out as far as Neptune, at which point it begins its return journey. I wonder how many readers will be looking for Halley at its next return using the meridian strip maps of this book!

Comet hunting is one area where amateurs excel. To discover a comet, and so have it named after you, all you need is a pair of binoculars and lots of dedication. You simply make an organized sweep of the early evening and morning skies (towards West and East re-spectively). If you do this often enough you will know all fuzzy objects intimately, and so when you see one that was not there before, you have found a comet. You note its position and report it immediately to the Central Bureau for Astronomical Telegrams, in Cambridge, Massachusetts, USA. They, in turn, flash the discovery to various observatories for verification. Of course, you have to be care-ful not to re-discover an already known periodic comet.

METEORS

As comets discharge their cargo of dust and gas, they also leave behind debris composed of sand and gravel-sized pieces of rock. The Earth sweeps up any of this rubbish in its path, and as they enter our atmosphere, at several thousand kilometres per hour, they are heated to incandescence and burn up, leav-ing a brief trail of ionised gases behind them.

Some larger meteors survive down to ground level and are then called meteor-ites. The best time to see meteors is normally in the eastern sky after midnight. Meteor show-ers are particularly good times for seeing hundreds of meteors. They are named after the con-stellation from which the shower seems to emerge. Meteor showers begin and end a few days on each side of the dates given in the August, October, November and December meridian star chart notes, of Chapter 3.

Chapter Five:

FINDING THE PLANETS

There are a number of methods for finding the positions of the main visual plan-ets. Many people simply refer to an almanac or newspaper astronomy column, or even phone their local observatory. But this method is not available to all of us. Almanacs are expensive, and few public libraries have a current copy. Most newspapers do not publish astronomical infor-mation. Most of us do not live within cheap phoning distance of a helpful observatory. Some star-gazers resort to buying computer programs. This is excellent if you also can afford the computer and peripherals. So, what is left?

In this section, you now have the best graphical planet locator published in any book (to the best of my knowledge). A couple of hundred years ago a similar clockwork mecha-nism was in vogue amongst the wealthy aristocracy, it was known as the Orrery. That is what I have called the charts and clear plastic overlays you are about to use: 'Graphical Orrery'.

This graphical ornery shows you the positions of Venus, Earth, Mars, Jupiter, and Saturn, at any month, for any year. You can project the position up to a hundred years into the past or future, beyond that you may experience too many accumulated errors, but may retrieve the situation by plotting a single computed position for that century. This will act as the starting point for a further hundred years of use, and so on.

To locate Venus and Mars look at the first chart. You see the Sun at the centre, then the orbit of Venus, the Earth, then Mars. The orbit of Earth has the months written anticlock-wise around this chart, that is, we are looking down onto the Solar System from several hundred million miles above its North side.

Earth is located for any year at the date on its orbit For Venus, only the year is written on the orbit, from 1989 to 2004. No other years are noted, for reasons of clarity. For the years before 1989, and after 2004, simply use the plastic overlay to mark off additional years.

Now, Venus moves very rapidly in its orbit. So, place the round plastic overlay onto the orrery chart, with the centre on the Sun. Tum it round, so that the beginning of January (marked 'every year begins here") is directly on top of the year you are interested in. Look at the months written on the orbit of Venus, and the planet is at that place at that very same date.

For example, suppose you want to see Venus during 1990 Place the circular overlay with the centre on the Sun, and the orbit of Venus overlapping that on the chart. The beginning of January, marked on the overlay "every year begins here is put on 1990, and stays there. Week by week Venus's position is on the same date as you read for that part of the orbit. You notice that it turns once and two-thirds times around the Sun from January to the end of December. You notice too that at the end of December, the year has become 1991. So that is the place of Venus all through 1990.

But where is Venus in the sky? Take the large page sized clear overly, the one with the constellation names around it. Without moving the circular overlay, place the con-stellation overlay over the whole chart. The centre of the constellation overlay is Earth.

Decide what date you are observing and place the centre of the large overlay on that date, on the orbit of the Earth. Making sure that the length of the overlay is parallel to the length of the page, and the breadth parallel to the breadth of the page, i.e. Virgo is always on the right, and Pisces on the left. Look at the date of Venus which is the same as the date of Earth which is the centre of the constellation overlay. You will see Venus in one of the constella-tions of the topmost overlay. That is where Venus is in your sky!

Go back to the last chapter and find the meridian star chart which has that con-stellation on the ecliptic. Whenever that constellation is above the horizon (during darkness of course) about the date in which you are interested, Venus should be visible in it, or near the ecliptic.

Turning to the above example of 1990. We find that in mid-January Venus is at its nearest to us, between us and the Sun, and is therefore invisible. By early February it is visible as a crescent in Sagittarius, at right ascension 19 hours. It is thus a pre-sunrise object.

Going on through the months, Venus reaches furthest away from the Sun (greatest elongation) by end of April, when it is still a morning object, in Aquarius, at 23% hours right ascension. It is then half-lit, like a waxing quarter Moon. It gradually draws closer to the Sun, until around mid-November it is again in conjunction and invisible. All of this has taken us just one minute to find out!

Suppose you don't get up that early and want to see Venus after sunset, then 1990 is not the year for you. You know, by following the trend of the planet, that in 1991 Venus becomes an evening object. Now you place the circular overlay with its start point over 1991 (on the orbit of Venus). Put the large overlay with its centre on the various dates on the orbit of Earth. You see immediately that. Venus should be a full, small, disc at 19 hours right ascension in Sagittarius, during dusk.

By early May Venus is at greatest elongation after sunset, in Taurus at 5½ hours right ascension. It is, of course, on or near the ecliptic, and a waning quarter phase. It then gradu-ally nears the Sun and is gone during August. Again, all this and more takes just a minute or two to find out.

Apart from noting the position of Venus, look at the patterns it makes in its orbit. Each successive year is found turn clockwise from the previous year. After 8 years Venus is al-most at a previous starting point. This can be used to extend the cycle into the future. For exam-ple, notice the year 2004 is one millimetre anticlockwise from 1996. Likewise, you too can mark 2005 one millimetre anticlockwise from 1997, 2006 one mm from 1998 etc, etc.

Now to Mars. Place the centre of the circular plastic disc on the small cross (x) beside the Sun. Arrange the clear overlay for the orbit of Mars to overlap its orbit on the chart. The process is now exactly the same as with Venus.

Line up the beginning of the year: “Every year begins here”, on the year of your choice. Now, without moving the circular clear disc, put the constellation overlay on top of everything. Line up its centre on the date of interest on the orbit of Earth. Look from that date on Earth's orbit towards the same date on Mars's orbit, and that is where Mars is found in your sky.

For example, if you want to see Mars during 1990 place the starting point of the round clear plastic (every year begins here) on the orbit of Mars 1990. You have immediately the orbital place of Mars for every week and month of that year! Now place the rectangular constellation overlay on Earth's orbit, its centre on your desired date.

At the beginning of January Mars is almost on the opposite side of its orbit from Earth, and not worth observing, because it would appear tiny. By June things are much better, Mars is in Pisces at 1-hour right ascension, visible from 2 am onwards, and steadily getting bigger. By the end of November, everything is ideal, we have opposition, I.e. Mars is directly on the opposite side of Earth from the Sun. This means, as you can clearly see on the orrery, that it is at its closest to us for that year and crosses the meridian at midnight. Now would be the best time to watch it through a good telescope.

Notice that at opposition the month on Earth's orbit is the same as the month on Mars's orbit. This feature is true of all the planets. When the months coincide and are oppo-site each other, we have opposition during that month. For example, in 1990, November and December of our orbit and that of Mars are facing each other, which means that at the end of November or the beginning of December, we have opposition.

To get more accuracy (within a few days) make very small adjustments around that date, taking a straight line from the Sun to the date on Earth's orbit and on towards the same date on Mars's orbit, when all three lie on the one straight line you have the exact date (within a few days, due to the limitations of graphical accuracy).

You see that the orbit of Mars has the years from 1989 to 2007. To extend the years beyond these limits. use the circular overlay. Place it on the preceding year, and at the end of December for that year you have the beginning of the next year.

At this point, you may have experienced some difficulty in keeping the circular overlay still while moving the constellation overlay over it. The best way to keep everything lined up and steady is to use a drawing pin through the centre of the circular overlay. This enables you to turn it to any year without fear of losing the orbit of Venus or Mars. A small bit of chewing gum or 'Blue Tack' may also be used.

Jupiter and Saturn are so far out from the Sun that a separate chart is used, drawn to a new scale. At the centre is the Sun, then the Earth, then Jupiter, and lastly Saturn. Each month is marked by only its first letter on Earth's orbit.

Notice that Jupiter and Saturn have no plastic. overlay. This is because they take many years to complete one orbit, and so do not move significantly during a few months. If you wish, you can divide the years of the orbit of Jupiter and Saturn into tiny divisions of a few milli-metres to denote each month, but I do not advise it. This would clutter up the diagram. It's better to simply estimate each quarter-year period by eye, this gives perfectly adequate accuracy

For example, in three months Jupiter has moved about 6 mm (4-inch) anticlock-wise in its orbit from the January 1st position which is the one marked. Saturn moves about 5 mm anticlockwise per quarter year.

Let's find Jupiter during 1991. As before, place the centre of the constellation over-lay on Earth's orbit, corresponding to the month you wish to observe. On January 1st, Jupiter is in Cancer at nearly 9 hours right ascension. By the end of January, it is at opposition, still at the same hour angle.

From February onwards we race ahead of it. Notice how Jupiter has dropped back to 8 hours right ascension during March. By August the Sun intervenes, and Jupiter is invisible. During November we now see Jupiter in Leo at nearly 11 hours right ascension, rising about mid-night, and steadily approaching opposition again at the end of February 1992.

If we make careful notes of the hour angle of Jupiter over at least one year, we no-tice that it advances through one constellation, 2 hours of right ascension, every year, but around opposition Jupiter seems to go backwards as seen against the background stars. This is called the retrograde motion and is because we are racing ahead of it like one car overtaking another. The retrograde motion of Mars, Jupiter, and Saturn is easily visible using this orrery and can be seen in duplicate in the real sky.

Now let us trace Saturn's path for 1991. Again, we place the centre of the constel-lation overlay on the required month on the orbit of Earth. At the end of January 1991 Saturn is on the other side of the Sun from us, and so is invisible. By early March it rises about midnight and is at 20 ½ hours right ascension in Capricornus, almost on the ecliptic as all the planets at all times.

If you go back to the meridian star charts in the last chapter, you can actually plot Saturn's position from this information and see it against the stars of the constellation of Cancer on the ecliptic. Near the end of July 1991. Saturn reaches opposition, in Capricornus Its pale cream brilliance cannot be mistaken in the constellation of Cancer for anything other than a planet, and its rings are still very open, as noted on the chart...

This graphical orrery is very easy to operate. It can give you lots of useful and prac-tical information in just a few seconds. Like anything else you need to persist in understanding how it works so that you can use it without frustration and mistakes.

To extend the orbit of Jupiter into the distant future, notice that the year 2001 is 4 mm anticlockwise from 1989. Similarly, 2002 will be 4 mm anticlockwise from 1990, 2003 will be 4 mm from 1991 etc, etc. For Saturn notice that 2018 is 9 mm clockwise from 1989. Similarly, 2020 will be 9 mm clockwise from 1990. The year 2021 will be 9 mm from 1991 etc, etc, I wish you many useful, happy, years with this graphical orrery!

CHART FOR FINDING VENUS & MARS

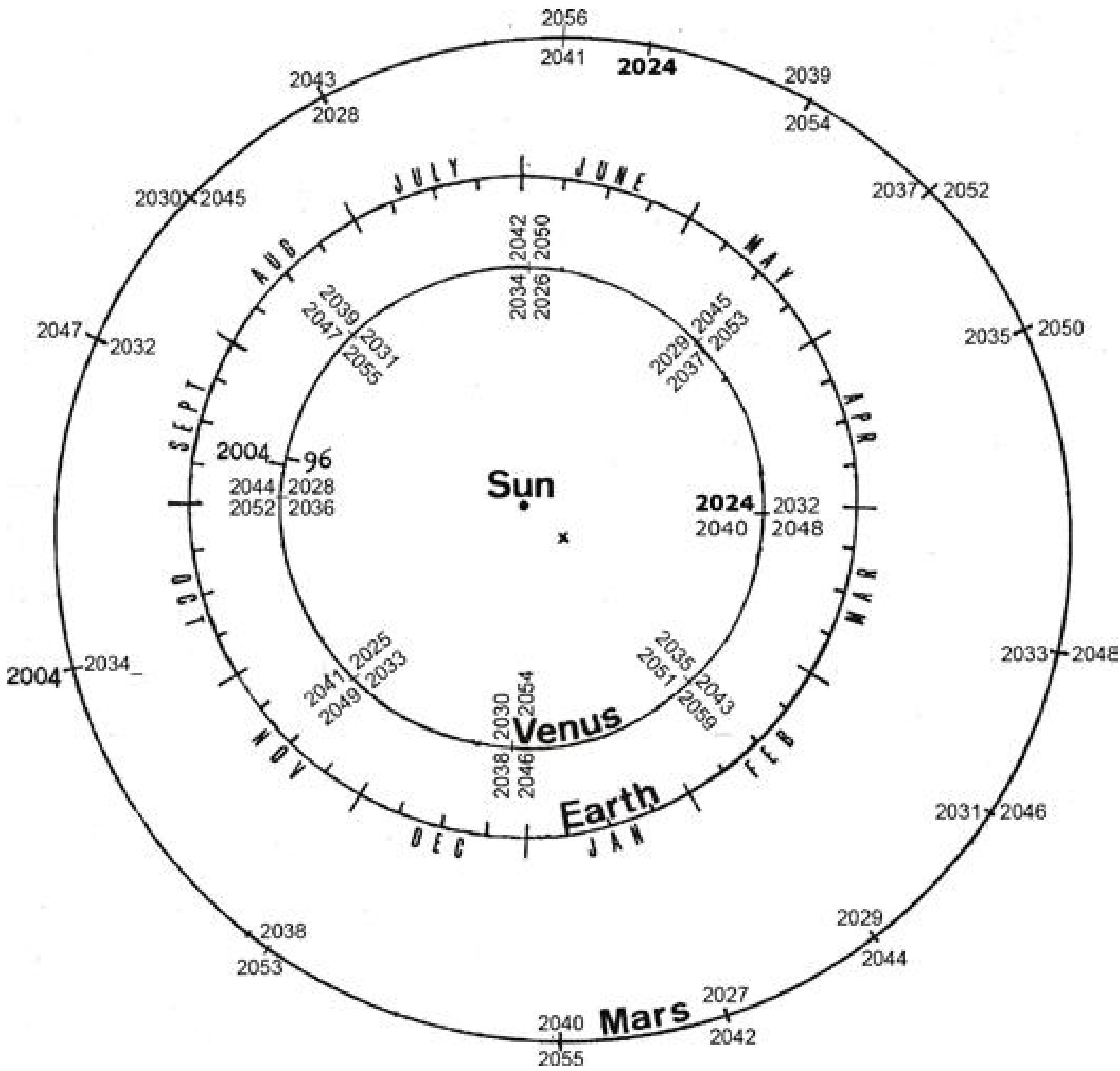
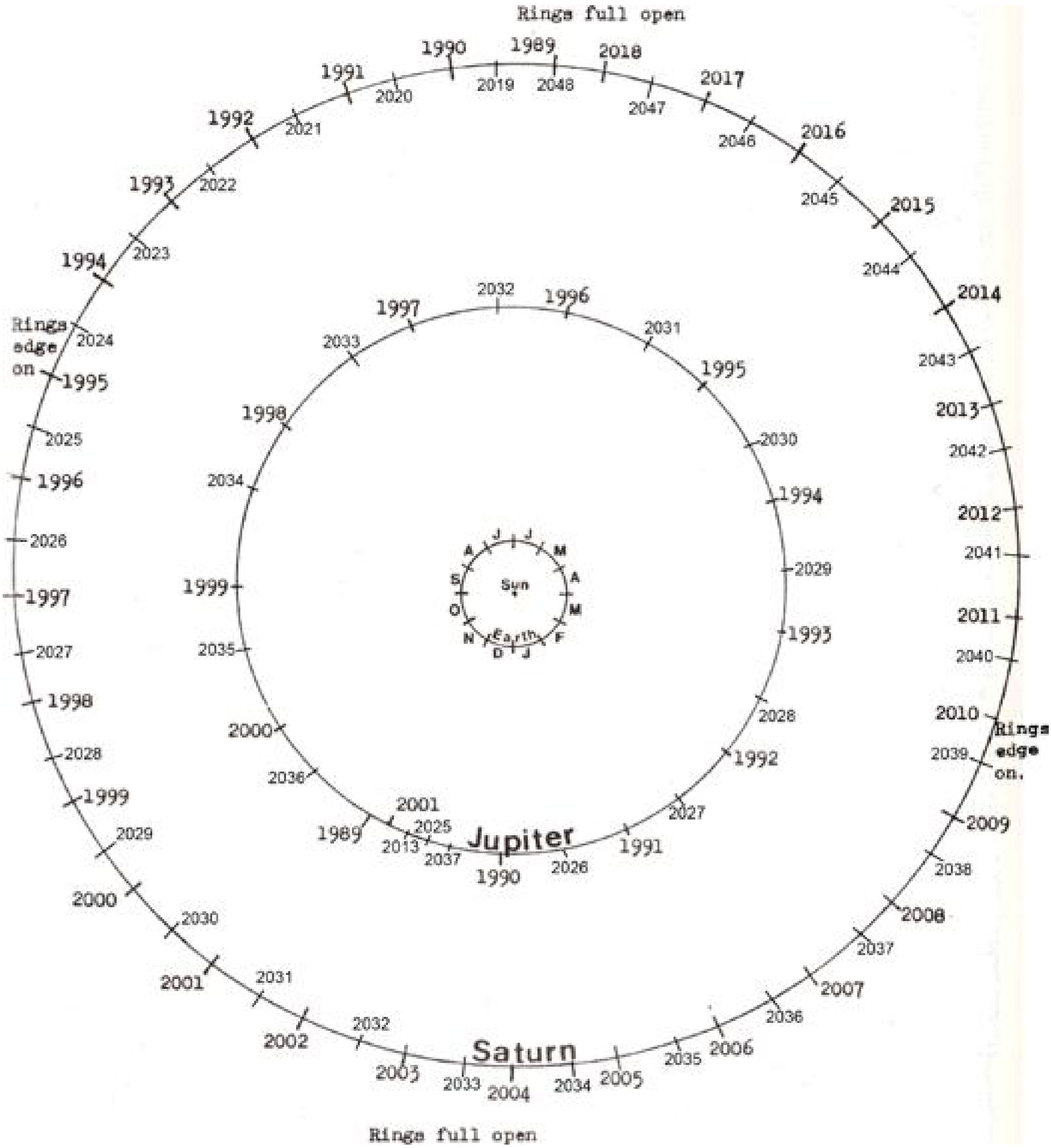


CHART FOR FINDING JUPITER & SATURN



Chapter Six:

GETTING CLOSER TO IT ALL

I hope that by now many of you are about to rush out and get a clear look at the heavenly bodies you've been reading about. Much can be achieved with the naked eye, but all of us want, at some time or other, to get a closer look at the planets and stars. For this you will need optical aid.

If you already have a telescope or binoculars do not skip this chapter, because you may want something better in the future, and there are many tips about how to get the best from your instrument. If you do not have any optics already, pay special attention because there is lots of temptation to buy inferior equipment that you will soon tire of. Price is not a good guide in this area, only knowledge, comparisons (shopping around), and a 'test drive

First some easy arithmetic. The resolution of a telescope (the finest detail visible) is related directly to its aperture (diameter of the main lens for refractors, or the main mirror for reflectors). So, a 4 inch telescope can resolve two stars 1.2 seconds of arc apart (assuming perfect optics and sky conditions), but an 8 inch can separate stars only half that distance or 0.6. seconds apart. "Great' I hear you say, "I will get something as big as possible, and see fantastic detail!" But remember, under good sky conditions you are lucky to even get 1 second resolution from any telescope, по matter how large. That is why there are plans to launch telescopes into Space.

But you want a telescope for more than resolution. You want to gather as much light from faint objects as possible. The light gathering ability of a lens or mirror is related to its surface area, which is a function of the square of diameter. So, a 4 inch scope has a gathering area of about 12 ½ square inches (depending on whether there is a secondary mirror which blocks out a little light), but an 8 inch has an area four times more (not twice as much), and a 16 inch has fully sixteen times more area.

So we see that the 8 inch can show you stars four times fainter than the 4 inch. But nebulae and planets are seen brightest at the lowest magnification needed to resolve them into an extended image, i.e. not a point source of light like a star. So, for example, the Orion Nebula is barely discernible with the naked eye, binoculars make it more easily visible, not because they gather more light, but because they have made it large enough for the eyes to use many light receptors on the retina (cones and rods) to sense the image.

In a 16 inch telescope the Orion Nebula is no brighter than in binoculars which have a typical diameter of just 2 inches hence only 1/64 th the area per eye! But a 16 inch at minimum power fills the whole field of view with the nebula, and so gives you brightness together with resolution, and that is why it is preferred.

So what is 'minimum magnification'? If you stand half a meter from the eyepiece of a telescope (binoculars are simply two low power scopes joined together) you will see a small circle of light in the lens of the eyepiece. This is the exit pupil and can be measured with a ruler.

You will find that the diameter of the exit pupil is; the aperture of the telescope divided by the magnification. Your eye has a maximum aperture at night of typically 6 mm. If the magnification is too low, the exit pupil will be larger than 6 mm, and so the outer fringe of light is wasted, it cannot enter your eye, and in effect you have 'stopped down' your telescope to a smaller diameter than it is.

Let's do some examples. A 4 inch or 100 mm scope has minimum magnification of 100 divided by 6, which is nearly 17 times magnification, or 17 times bigge: than the object appears to the naked eye. An 8 inch or 20cm has minimum magnification of just over 33. So you must choose, for the widest field of view, an eyepiece which will not go below this minimum magnification. We will get to that in a moment.

How about maximum magnification? It has been learned from experience that if the diameter of the exit pupil is less than 3 rd of a millimetre, you suffer great loss of definition. So, a 100mm scope has maximum magnification of 100 divided by ½, which is 150 times. A 200mm, or 8 inch, has maximum magnification of 300 times and so on.

Magnification is worked out thus: the focal length of the objective (main lens or mirror) divided by the focal length of the eyepiece. For example a 100mm f 10. scope has focal length of 100 x 10 1000 mm. A 100mm f 12 has focal length 100 x 12 1200 mm, etc. Taking the 1000mm focal length and (say) a 25mm eyepiece, you have 1000 divided by 25 which equals 40 times magnification.

Normally we have at least three eyepieces for an astronomical telescope. A low power wide angle for nebulae and star clusters, a medium power for general use, and a high power for the Moon and planets. So for a telescope of about 100 mm. like the Maksutov-Cassegrain below. you buy eyepieces of these focal lengths: low power; 58mm. Medium power; 12½ mm. High power, 7mm. The closest values to these will do.

Now we have enough information to go out and buy, new or second hand, the kind of binoculars or telescope to suit our budget. There are points regarding quality and stability of mounting which we must bear in mind.

You may ask about the cost. Here you should buy the best you can afford, and be reconciled by the fact that a telescope is one of the cheapest iterns you will ever purchase. Consider this; what other item will last several hundred years (at least) no matter how often you use it, if cared for properly? What else will show you the Universe as your descendants will see it from a spaceship many generations from now? What else will enable you and your children to appreciate the larger scale of existence and put your daily problems into their true perspective?

If you do not already have them, the first thing to buy is a pair of binoculars. With these you will get a good, bright, wide angle view of the sky. You will see the largest craters and mountains of the Moon, disc and four main moons of Jupiter, clusters and nebulae and the best sights of the Milky Way and Magellanic Clouds. Further more, you can use them at all outdoor pursuits, and so they are rarely lying idle.

The magnification of most binoculars is fixed. Binoculars are also normally hand held, and for sailing and astronomy you will need the brightest image you can get. All this points to the purchase of an instrument with low magnification and large exit pupils. The best value for money are 50mm binoculars. Smaller ones cost just as much, and larger ones cost several times more.

To get a 6mm pupil diameter from your 50mm aperture binocular you do the sums, 50 divided by 6 equals 8⅓. So you need a magnification of just over 8. Well, 8 x 50 (magnification 8, aperture 50mm) machines are fairly rare. So you choose the next highest common ones. 10. 10 x 50, which gives you an exit pupil of 5mm, so you get bright views even at dusk and dawn.

Next comes the telescope. I won't beat about the bush like some writers, and tell you to buy whatever suits you. Unless you are already a fully dedicated amateur astronomer or have lots of money to waste you need a telescope which is versatile and can be used for anything, e.g; taking to the beach, bird watching. photography with a single lens reflex camera, as well as astronomy. So this instrument must be compact, light and robust. It must never lie idle. It must encourage you to use it. It must be able to expand with your needs, and must have a good re-sale value.

I mentioned earlier that on a good night you are lucky to get 1 arc second resolution Well, a scope of about 4 inches will almost reach this. Also, for terrestrial use, magnifications above 100 are usually useless, because you are looking horizontally through the 'boiling' air just above ground level. You never use more that 150 x on nebulae and galaxies, and can see most of the interesting items on the Moon, Sun, and planets at that magnification. You also already have binoculars to handle the wide, low power views.

So, which selescope fits the bill completely? Luckily only one. This is the MAKSUTOV-CASSEGRAIN, one of the new catadioptric telescopes. These are made by such companies as Meade (model 97 E) and Celestron (model C 90) in a package which includes camera adapter, eyepiece, and inverter or star diagonal for upright images (a telescope normally shows everything upside down and wrong way round).

Look in any popular astronomy magazine, and you will see adverts for 90 mm (3½ inch) spotting scopes for very low cost. These scopes are both less than 10 inches (250mm) long, weigh less than 2 kg, and come in little travel boxes Always try your local shop first, because they can give you better after-sales service. But if your local shop does not have it for an acceptable price, the mail order companies are normally very reliable, and accept credit cards over the phone, even inter-nationally, and post the item air-mail to any country.

Some people may ask what is wrong with other kinds of telescopes? Nothing is actually wrong with them, they are just not versatile enough. Let me briefly cover the problems you would encounter in buying a different type of telescope.

SCHMIDT-CASSEGRAIN:

These are almost as compact and light as the Maksutovs, and are just as versatile, but they are not so robust, and their secondary reflector needs occasional collimation (re-alignment) which most people cannot be bothered with. But if you find a bargain and are willing to do collimation, consider buying it.

NEWTONIAN REFLECTORS:

These are no good for terrestrial use, because the eyepiece is always at an odd angle and you will see the landscape tilted sideways. They are also too bulky, so you cannot carry them in a hand-bag and set them up on a camera tripod. They also pose an obstacle for any photography, because with most models the focuser draw tube doesn't have enough travel.

REFRACTORS:

A 3 or 4 inch refractor is usually about a meter or three feet long. How are you going to pocket that conveniently? They also have a different focus for photography than for visual use, unless you buy a very expensive apochromat, so you must use filters for really sharp pictures. Whatever you do, do NOT buy the toy 50 mm refractors you see on flimsy tripods. Every person I have met who has one is bitterly disappointed they didn't spend a little more on a 90 mm Maksutov spotting scope.

Many cheaper refractors also do not have enough draw tube travel for photographic use. If you buy a short focus refractor, in order to have it more compact, you still have a longer telescope than the Maksutov, and you also have exaggerated color and focusing problems.

So we are stuck with the Maksutov-Cassegrain of 90 to 125mm aperture. There is one last point. If possible, get it with 14 inch eyepieces, not the 0.96 inch eyepieces which are cheaper substitutes. If you are given a choice of eyepieces get Orthoscopic, Plossl, Erfle, Nagler, or Super Wide angle designs from the actual scope manufacturer or other well known company. Also make sure your telescope has a camera adapter for your single lens reflex (SLR) camera.

Once you have been using such a telescope for a few years, and if you find that astronomy has become a passionate all consuming hobby, then you could consider going for a larger instrument, say 8 inches or larger, preferably in a dark sky location and permanently mounted.

But most people live in or near cities which have considerable light pollution problems. In that case you would get as portable a large telescope as you can, and there you have a choice of catadioptrics (the Maksutovs and Schmidts already mentioned), refractors, or reflectors. But these larger scopes will be for astronomy only, and will fill the back seat or trunk of most cars.

When you decide to buy this equipment try to get as much as you can in one go, so that you can haggle for a better price, you could make considerable savings. Also do not forget the 'for Sale' adverts in newspapers and your local astronomical society, whose members sometimes have instruments for sale.

If you do decide to purchase second hand gear, examine it carefully Look for chips, cracks and deep scratches on lenses or mirrors. Look for crazing (hundreds of tiny scratches) on these components, this shows bad cleaning practice, and will affect the contrast of whatever you look at. Mechanical problems are not so bad, because they can be fixed by most handymen/women, but optical ones are to be avoided.

Finally, take your time before making any purchase, and be sure you have looked through several different. scopes at various day and night objects, so that you are not overwhelmed by mediocre performance which you think is fantastic, because you've had nothing better to compare it with. Again, the members of a local astronomy club will help you with this.

Chapter Seven:

AN IDEAL HOME-MADE TELESCOPE

As I stressed in the last chapter I strongly suggest that you buy a 90 mm Maksutov spotting scope because, apart from being excellent for astronomy, it is a fantastic all round instrument suitable for nature study, photography and much else. So you never feel that you've wasted your money on perhaps a passing hobby.

If you are determined to buy or make a large aperture astronomical telescope because you already have several years of experience with smaller telescopes, then the best thing to do is to consider seriously a Dobsonian mounted machine, such as the 10.1 inch reflector made by Coulter Optical and others (see magazine adverts). These factory direct telescopes cost the same price as buying only the mirror from a local dealer! You can mount such a telescope on an equatorial mount later.

Some people go as far as making their own mirrors and lenses, but this takes a great deal of enthusiasm and can lead to unsatisfactory results. Nowadays ready made mirrors are almost as cheap as making your own, and are guaranteed to perform well.

I suggest that if you refuse to buy a complete telescope, for example the Maksutov or Dobsonian, or enjoy constructing a fine astronomical telescope then you begin by building a 6 inch reflector. This is a good size for most objects, and can be transported to dark sites.

Those of us who already have, or will buy a complete scope will find the second half of this chapter useful. because it deals with equatorial mounting, and how to clean all optical components without scratching them.

When you buy your mirrors and eyepieces, make sure their quality is guaranteed. These are the only components you need to purchase. The rest can be built by anyone with a modicum of practical ability and basic tools.

The project is so easy that I will only outline the main requirements, the details you can fill in yourself, as a design exercise, to personalize the telescope. If it is built well and has a high standard of finish, this scope should have a resale value of twice what it cost you.

You will need to buy: 6 inch F8 to F10 parabolic mirror of tenth wave accuracy, 32mm major axis and about 22mm minor axis elliptical mirror, 40 or 50mm focal length eyepiece and 6 or 7mm eyepiece, both of 1 ½ inch tube size, and of a design mentioned in the last chapter. Later on you may wish to get another eyepiece of about 20mm focal length..

When assembling the telescope make sure you do not touch the mirror surface. Begin by building a square tube of skeleton construction (as shown). The inside width of the square is 8 inches. Use fast setting epoxy-resin or PVA wood glue with clamps, or better still also use countersunk nails or wood screws for better rigidity. You may decide to have a welded hollow pipe framework, this is fine, but will be heavier, and not so versatile.

Cut out the cross shaped main mirror holder. Use a strong contact adhesive (such as 'Gel Fix') to glue on a layer of rubber about 1 or 2mm thick, you can cut this from an old inner tube which a garage may give you. Once this is dry, center the mirror onto it and mark out the perimeter.

Again, using contact adhesive on the back of the mirror and rubber, finally glue the mirror to its mounting. Drill four 4 mm holes near the tips of the cross so that four 4mm self tapping screws will hold it to the back of the square telescope tube. You must take care that the mirror is centered in the square tube. The screws should be about 25 or 30mm long.

An F8 mirror has focal length of 48 inches. An F 10 has focal length of 60 inches. 42 inches in front of the F8 mirror, or 54 inches in front of the F10, you must place the elliptical flat diagonal. Use a 3mm steel rod about 10 ½ inches long, and ideally threaded at both ends to take tightening nuts.

In the middle of this use epoxy resin to glue two 3 or 4 mm elliptical plywood backing sheets together. Use a small round file to make a small recess in both, so that they meet accurately. Use the elliptical mirror to draw the size of the diagonal holder onto the plywood. Again. use the contact adhesive to glue the mirror onto the backing sheet. Use great care not to dirty the mirror, and to have it centered very accurately in the tube.

As far as the tube is concerned, all you need to do is to cover the open framework with light-weight black cotton fabric, this is to stop stray light reducing contrast. The diagonal is tilted 45 degrees towards the hole where the eyepiece is to be.

Exactly opposite the diagonal, in the side of the tube, cut a 1½ inch hole. Find a plastic, copper or steel tube into which the eyepiece will fit snugly (32mm internal diameter). If need be, get a slightly larger size, and glue in a thin layer of plastic or cork or felt so that the eyepiece does not wobble. The eyepiece tube should slide easily but firmly in and out of the side of the telescope. Since the side of the scope has only a ½ inch plywood cover, you will probably have to glue on another 20 or 30mm of wood with matching hole.

If you have taken adequate care to center all the optical components, only minor adjustments will be needed. Place the telescope tube onto its base (main mirror down) and pointing straight up at clear sky. Look through the eyepiece hole (without eyepiece), you should see the image of the main mirror almost filling the secondary diagonal. If the image of the primary mirror is significantly to one side or other of the diagonal, turn the diagonal slightly to correct this. If the image is too low or high, adjust the nuts at each end of the 3mm steel diagonal rod to center it.

Now, looking at the image of the main mirror, notice if the image of the diagonal, in the reflection, is well centered. If it is too far to any side, use packing washer at relevant arms of the main mirror holder (the cross) to adjust the tilt of the main mirror. You can check which arms of the cross to move by loosening each screw in turn and prizing that arm away. This will make the centering worse; hence wrong arm, or better, hence correct arm for a packing washer.

Make two covers for the mirrors, so that dust and grime does not settle on them during storage and transport. For the primary use a biscuit tin lid lined with plenty of felt or soft cork. For the secondary mirror a thick soft pouch made of chamois leather, brushed denim, or similar material.

Finally, lay a broom handle on the ground, place the telescope tube across it, (have the eyepiece and draw-tube in place) and find the centre of gravity, or balance point. Mark this out, since it is where one axis of the mounting will meet the tube. Four 25mm long bolts about 6mm in diameter must be evenly spaced about the balance point. They are glued into the plywood and will meet four matching holes on the tripod.

Once all the above is done, you can give all the inside faces of the telescope tube a coat of flat black paint to stop sway light. The outside exposed wood may be varnished to stop it changing shape with variations in humidity. Make sure the mirror covers are on while you paint the telescope tube.

All that remains is to build the tripod and equatorial mount. The legs of the tripod are steel tube of about 30 mm (1 ½ inch) diameter, and ¼ meter (three feet) long. At the top they are hinged together, and half way down they have 1 ½ foot lengths of light chain stopping them from collapsing flat on the ground. I suggest that the equatorial head be fixed permanently to the tripod, since it does not take up much room.

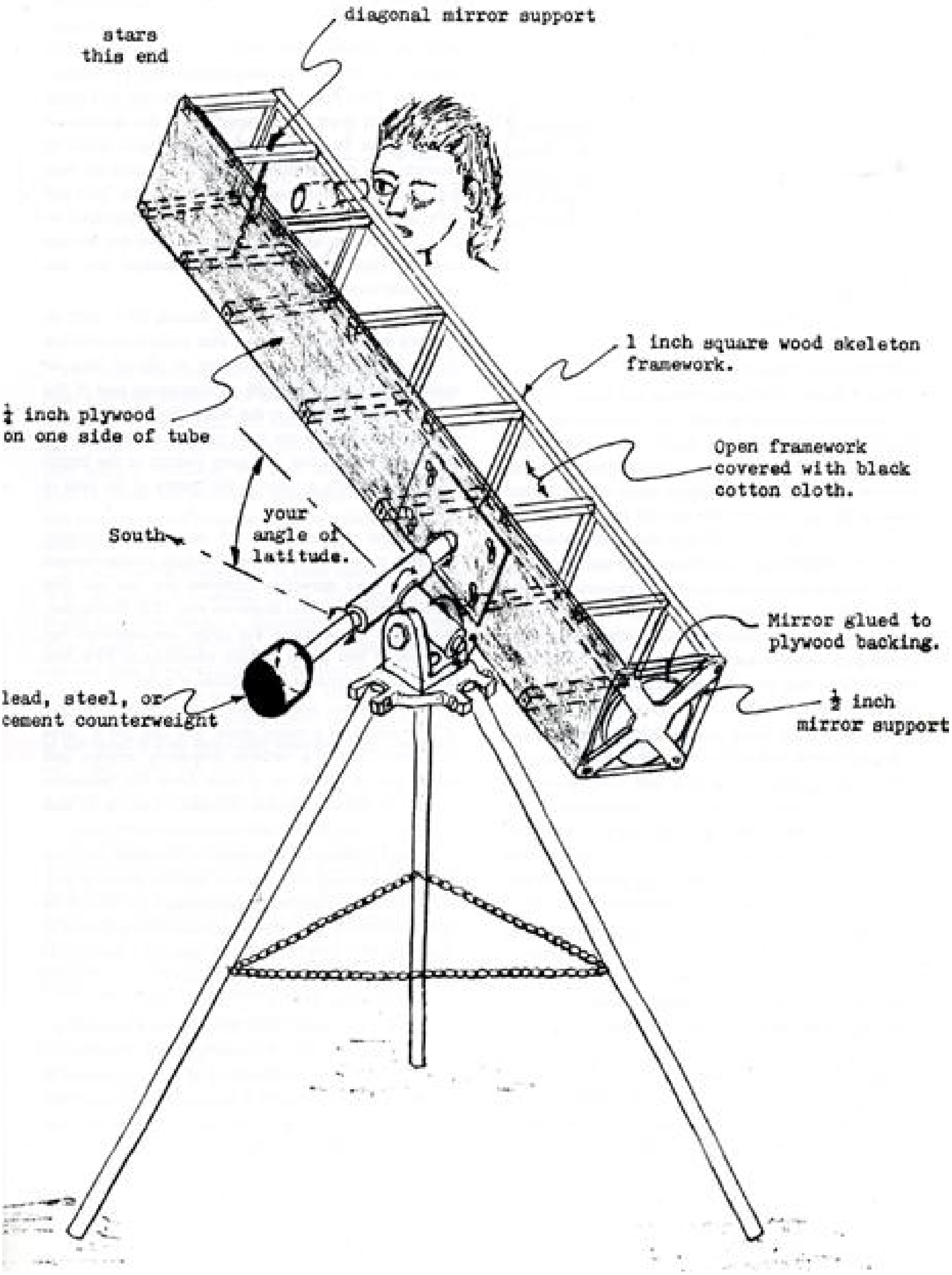
The equatorial head has two axes of rotation. These are achieved by having 1 inch steel tubing inside 1 inch tubing. There should be no slack, but as firm a grip as allows rotation. Use rubber or plastic 'O' rings if necessary to stop any wobbling.

You may use PVC piping for easier construction, in that case use slightly larger diameters otherwise the mounting will shake too much. You may eventually add a motor drive to the polar axis. If you do make sure it is a synchronous motor, and geared so that it turns your scope once in 24 hours. It can be a small one rated about 10 to 20 watts of power.

If you are making a tripod and mount for the 90 mm Maksutov, you can use tubing of 6 mm (4 inch) less diameter. If you are mounting a 10 inch reflector use tubing 6 mm wider diameter.

If you follow the diagrams carefully on the next page, and have reasonable ability at making or repairing household items, you should manage the telescope and tripod in just a couple of weekends. You will know the ins and outs of your instrument perfectly, and will be able to

SKETCH OF THE HOME-MADE 6 INCH TELESCOPE



improve and modify it in future.

From time to time you will need to clean various optical components. If, while not in use, you keep eyepieces and mirrors covered, they will rarely need cleaning. A little dust does not seriously impair performance, and should be left alone. Fingerprints and heavy layers of dirt should be cleaned fairly quickly. For all optics (even camera lenses) use the following method.

Fill a small cup 4 full with surgical alcohol or methylated spirits. Add ½ cup of distilled water. Add one drop of dish-washing detergent. Stir with clean teaspoon. Now get a ball of cotton wool and lightly, and with a flicking action, brush off any dust and sand.

Take a sheet of the softest tissue you know of (try a few expensive brands to find out). Wet the issue in your alcohol mixture and gently wipe the optical surface. Use as many tissues as required, and clean the surface with the solution about three times. Finally soak up any wetness on the mirror or lens with a fresh piece of tissue.If there are any light smears visible when you reflect a light from the glass or mirror surface, then breathe some mist onto the smear and gently wipe with a fresh tissue. This method never fails to work. If you have difficulty with it check that your hands and utensils are scrupulously clean, and your alcohol and water uncontaminated, and the cotton and tissue the softest available.

Remember that using this telescope, like anything else, requires practice. Take every opportunity to set it up and make use of it. The polar axis must be pointed at the South or North Celestial Pole. You incline the axis at the same angle as your latitude, and turn it towards South/North. This will give you a good enough approximation. If the scope is set up permanently you may wish a more accurate aim to the pole.

Find a bright star near the eastern horizon and follow it by rotating about the polar axis only. If the star drifts away from the centre of field of view, adjust the elevation of the polar axis to bring it back to centre. Now, find a star near the zenith and follow it. If the star drifts away from the centre, adjust the azimuth (the horizontal direction of the polar axis, e.g. by tuming the whole tripod). Repeat the whole procedure several times until no star anywhere in the sky drifts out of the field of view when only followed by turning the polar axis.

You can do basic photography of the Moon and planets by buying an eyepiece camera adapter for your single lens reflex camera. Use Ilford XP 1 film and begin with the quarter moon with an exposure of 1/125 second and 50 second using prime focus, i.e. with no eyepiece. Then put in each eyepiece, in turn, and using a large black piece of cardboard, cover the aperture of the telescope. Open the camera shutter, count about 10 seconds, and quickly flick the cardboard out of the way and back again, and close the camera shutter. This will give you exposures of ½ to 1 second, depending on how fast you are with the cardboard. For the planets use only the eyepiece projection method and the cardboard manual “shutter.

For pictures of the stars, use Konica SR V 3200 or similarly fast color film. Mount your camera on the tube of the scope (piggy-back). Use a 50mm lens at apertures of about 2.8. Find an interesting part of the sky, for example Orion or the Milky Way. Find a bright star and centre it in the high magnification eyepiece. Now open the shutter and keep looking at the bright star, making sure it stays in the centre of the field of view

Keep the shutter open for at least 2 minutes. Needless to say you must use a locking shutter release cable. As your expertise improves you can use this method with telephoto lenses on your SLR. Remember, the smaller the aperture, the longer the exposure. For example, if you use a 200mm telephoto at F3.5, you could use an exposure of 5 minutes or more.

Later on, if you add a motor drive to your telescope, or buy one with a motor drive, you can get a ‘drive corrector This is a variable frequency inverter and allows you to speed up or slow down the telescope while it is tracking a particular star. You would also need an off axis guider’ and illuminated cross hairs.

As your reading of astronomical literature expands these will become common and familiar terms to you. With sufficient practice and enthusiasm you should be able to duplicate and improve on the photos shown in this book. But it can be tedious, holding a faint guide star onto cross hairs at a magnification of nearly 500 x for around half an hour!

Magazines such as Southern Astronomy’. ‘Astronomy Now’, ‘Sky & Telescope’ and ‘Astronomy’, are filled with useful adverts, and superb articles & event calendars. If there is a local astronomical society it is a good idea to join it. If there isn’t one why not start one yourself?

Chapter Eight:

CONTROVERSIAL TOPICS

You must have been to many parties where, some how, a furious debate arose about life on other planets. flying saucers, astrology, and such. Maybe you noticed that many of the arguments were based on little more than emotion Probably, the most ardent views were held by those not otherwise interested in astronomy, and who had never looked at celestial objects through a telescope.

In controversial matters, as in most subjects, belief is an irrelevant and useless guide. For example, one would not dare design a sky-scraper or bridge from ideas based on belief. Truth and knowledge should be our only goal. If something is not proven, then one does not have the right to hold opinions. Since opinions, if held strongly enough, will only hinder your appreciation of the facts, if they eventually emerge. Let us examine very briefly some 'hot topics'.

LIFE ON OTHER PLANETS:

I've already mentioned that our own galaxy, the 'Milky Way' contains about 200 billion suns. It has been established that our own Sun is a fairly average star about two thirds of the way out from the center of our galaxy. We know of nine planets in our solar system. At least one of these (Earth) harbors life, and on this planet life has developed to a very high level.

There is no reason, taking into account the laws of celestial mechanics, why other stars should not have some planets. If we assume that half the stars in our galaxy have a few planets circling them, then there would be some 500 billion planets in our galaxy

Most stars with several planets would have these at varying distances, ranging from very close to very far from the mother sun. One or more planets at an inter-mediate distance from that sun would have surface conditions and atmosphere suitable for the creation and sustenance of life. Once life has come into exist-ence there is nothing, except perhaps a very severe environment, to stop it from evolving into more and more complex and intelligent forms.

Even if only one percent of the planets has a habitat admirably suited for life, then we have 5 billion with plants and creatures on them. Given the proclivity with which this life would evolve into complex and intelli-gent forms, it seems fairly reasonable to suppose that most of these 5 billion planets, perhaps 3 or 4 billion have intelligent beings on them. That is; one sun in fifty may have some sort of civilization in orbit around it.

What I have said is not a dogmatic statement, after all we have not detected life on other worlds as yet, except the complex organic molecules which are very prevalent on comets and interstellar gases (identified spectroscopically, i.e. by analysis of their light). But the probability of intelligent life elsewhere in the Universe is extremely high, given the millions upon millions of galaxies, each with billions of stars and planets.

In fact, our failure to detect extra-terrestrial life is a reflection of our own terribly primitive technology; re-member, we have not even left our own solar system in a space ship, and it will be many generations before we do.

FLYING SAUCERS:

Often referred to as U.F.O's (unidentified flying ob ject), there have not been any confirmed sightings. Several people have even approached me with stories of flying saucers' they have seen. Upon investigation it turned out that the objects they sawwere anything from the planets

Venus and Jupiter near conjunction to a sea gull flying over a brightly lit area at night.

I myself was almost caught out once. I looked up at a flock of cockatoos passing just 10 meters above my head, and, when they had gone, I was astonished to see a tiny white object a couple of miles up in the sky. This oval shaped UFO stood still for a few seconds, then flew North very fast, stopped again very suddenly, flew South East, stopped, went West etc. It continued. this amazing zig zagging motion for several minutes. I was totally entranced and had never seen any plane do the rapid, sudden and aimless gyrations I was witness-ing.

Finally the curious object flew very quickly towards the horizon, and was gone in a few seconds. Luckily, just before it made its final departure, I had discerned its identity: It was a small down feather from a cocka-too, and the light gusty breeze was playing with it, and it was only perhaps 15 meters above me!

Have there been visits from aliens to our planet? Yes, very likely there have been in the past, there may be in the future, and we may be under surveillance right now. Are all the flying saucer stories true then? No. they show no signs of intelligence. If you were captain (or whatever they have) of an alien spaceship visiting Earth, you would have a specific mission. If that mis-sion were secret, then no one would see you land and take off. If, on the other hand, you wanted to make contact, then you would land in New York, or London or Sydney. You wouldn't waste time playing peek-a-boo with one of two isolated people on a country road at night... that is stupid!

There have been a few best selling books by charla-tans regarding so called evidence of contact with 'space men' during past Earth civilizations. These au-thors conveniently twist the facts into unrecognizable half truths and outright lies, all for the sake of money or some dubious fame. They pay scant attention to many years of anthropological and archaeological work done quietly by hard working scientists. Denunciations, such as this, are taken as narrow mindedness, and when challenged, instead of venturing into open and rational debate, they claim persecution and thus seck even greater publicity and sales.

You have probably seen some of the fantastic pseudo-scientific books which interpret a painting of a pillar as a rocket, or a rock engraving of a ceremonial head-dress as a space helmet, and so on. Read such literature with a great deal of skepticism.

ASTROLOGY:

The pervasiveness of this pernicious doctrine is so great that it is nearly always confused with the science of astronomy. Try it for yourself go into any newsa-gents and ask where the astronomy magazines are kept. Almost invariably you will be led to some alte: bearing the latest offerings of the fortune tellers, the astrology magazines.

Astrology is a religion whose roots and prophets are mostly lost to us. As a logical systern it has grave flaws. Each culture had its own astrological beliefs. In one country a man or woman born in January was sup posed to have one kind of character, whereas in an other country the high priests of their cult claimed a totally different personality. Neither one had been based on a painstaking, rational observation of a statis tically significant sample. None of the many systems have a logical and demonstrable theory upon which they are based. They simply assert, like a prophet, a catalogue of beliefs' and 'opinions

There are only two celestial bodies which exert any significant influence upon the Earth; these are the Sun and Moon (in that order). Yet the astrologers claim, without any reasons whatsoever, that all the planets, and the random patterns of the stars (constellations) juxtaposed with the time and place of your birth, deter mine your personality and your future.

There are no research papers, no calculations, no mathematics, absolutely no rigorous scientific analyti cal or experimental method by which astrologers have made these spurious statements for several thousand years.

I write an astronomy column for a certain newspaper. Had I been less honest, I think I would have written an astrology or horoscope column and made far more mon-ey. After all, no references would have to be checked. and no thought put into my articles. In just five minutes I could type out be careful when choosing your friends. Pay special attention to your love life this week Don't be tempted to over-spend". What garbage!

NEMESIS:

This is the name of the Greek goddess of retribution, and is a name now used for the 'Death Star'. Paleontol ogists have known for some time that at certain times in the past (eg 65 million years ago) there seem to have been mass extinctions of many species on our planet. Some astronomers have speculated that per-haps there is a black or brown dwarf star which is a companion to our Sun (after all, most stars have one of more companions).

If this 'Death Star' has a distant and highly elliptical orbit around our Sun, it is possible that every few million years it approaches and dislodges comets from the extreme edge of our Solar System. These comets could then fall towards the Sun in a long period orbit, some of them would hit the Earth causing vast destruction

But why can't we see it? If the star is a brown dwarf, it is fairly small and faint, and that would explain why it has not yet been discovered, indeed, the planet Pluto was not detected until 1931. From time to time some astronomers look for such a very distant planet or dim star. The most recent attempts have been to look for any alteration in the expected paths of the Pioneer and Voyager spacecraft, (caused by the gravitational attrac tion of any sizeable object) as a clue to the where-abouts of Nemesis

Nemesis, is however only a hypothesis. We do not actually need our own companion to pass very close to us. Every few million years other stars, not normally associated with our solar system, zoom through the outer fringes of our system, and they could fulfill this same destructive scenario. Eventually, the day may even come when one such star, pursuing its own inno-cent course, as ours is, will make a head on collision. But don't worry, it won't he in our or our children's lifetimes.

WARP DRIVE:

In the same way as Mach 1 is the speed attained by a plane when it reaches the speed of sound, in science fiction books and films Warp 1 is supposed to be the speed attained by a space ship when it travels as fast as light. Warp 2 is twice the speed of light etc.

According to Einstein's Theory of Relativity (which has not been disproved), no material thing can go as fast as light. Light, and other electromagnetic radiation such as radio waves and X rays, travels in Space at nearly 300 000 Km per second. Some subatomic parti-cles may be accelerated to near this speed. But calcula-tions, and experimental work show that neither they nor anything else with mass (substance or 'body') can travel at the speed of light.

If oven a tiny mass is pushed to the velocity of light, it will weigh as much as the entire Universe, and it would take all the energy in the Universe to accelerate it to 300 000 Km per second! This rules out sending even a pellet to Alpha Centauri in 4 years let alone a whole space ship.

There are theoretical predictions for particles called tachyons, which are supposed to travel faster than light, but not slower. How these amazing things can be detected (if they exit) is beyond present scientific possibilities. It seems then that faster than light travel is. definitely ruled out. But this is a hasty conclusion to come to. In the past jet travel was ruled out, and rock-ets to the Moon, but these are now commonplace.

One thing is certain though, if faster than light travel becomes possible, it will be nothing like what we imag ine it to be For example, there are the time dilation. problems to contend with, where an astronaut experi ences the passage of time at a vastly different rate to those left back on Earth. Then there are the collision problems. Space is not a perfect vacuum, but contains dust and gas at many atoms per cubic meter. All these atoms would hit the space craft with such velocity that they would in effect be lethal radiation, and dust and sand particles would be as deadly as bullets.

All this is yet another reason why you should enjoy seeing the heavens through a fine telescope, such as the one in the last chapter, because that is as close as we will ever get to them. Perhaps in several thousand years...

Chapter Nine:

THE LIMITS OF KNOWLEDGE

If you watch any science program on television, eventually you will be confronted with some challeng-ing and esoteric concepts in modern astronomy. Ideas. such as the Big Bang Theory, Black Holes, Gravitational Lenses, etc. will crop up, and often leave you fairly con-fused, as they do many people.

Often these subjects are presented, by the media, from two extreme positions, one is, that there is total confusion amongst scientists; your point of view is merely a matter of taste. The other presentation as-sumes that the whole matter is already decided and fully accepted by everyone concerned, and there is ab-solutely no uncertainty.

In reality it is true that there is continuing debate, calculations, and research projects in the astronomical community about the limits of knowledge, but it does. not mean that all astronomical findings (or discoveries in any other scientific area) are mere speculation. It does not mean that maybe the Universe is just 6 000 years old after all, and finishes just beyond the Moon, as many lay-people still believe. The disagreements among scientists concern mainly the frontiers of knowl edge. Scientific proposals or theories are supported or demolished using a great deal of mathematics, experi mental data, and observational proofs. They are not ar ticles of faith or belief, proclaimed by one scientist and meekly followed by the rest.

Recently I read about surveys done to find the level of public awareness of common facts, in Geography, Spelling, Astronomy, and so on. The results were so de-pressing that I decided to check the claims made in the astronomy survey for myself. You may get an idea of my results from just one finding, almost half of those questioned still thought that the Sun revolved around the Earth! This is 400 years after complete and irrefutable evidence showed that the Sun is the center of our solar system. So you can see how long it takes for a scientific revolution to permeate through society.

Quite often a scientific hypothesis is made by some-one long before we have the means to investigate it. For example Black Holes were proposed some two hun-dred years ago. A hypothesis made ahead of its time. may be disproved, but this is no reflection on the com-petence of the scientist.

It is in the nature of scientific inquiry, to throw various ideas into the arena of debate. The ideas themselves guide researchers in new directions. Even a failed idea or experiment, when done well, tells us some-thing about the Universe we live in. If, by the time you read the following information, it is already our of date. don't be surprised. It is at the very frontiers of discov ery, where change is most rapid

OLBER'S PARADOX:

If the Universe is infinite, and contains an infinite number of stars, then why isn't the whole night sky. brightly lit? True, the stars are mere pinpoints of light, but if in any direction there in an infinite number of them, then surely we should see them, as it were, shoulder to shoulder. This is the gist of Olber's Paradox. which has been asked, by various scientists, for some hundreds of years.

Most astronomers are agreed that there are two ef fects causing the darkness of the night sky. The first is that our Universe is not infinite (according to the big bang theory). It is very old, some 15 billion years old, but not infinite. There are trillions of stars, but not enough to cover the whole of the night sky. Also the most distant stars, which are several billion light years away, have not existed long enough for their light to reach us yet.

The second effect is less important. It involves the red shift. This is the effect which causes the light of a receding object to lengthen in wavelength, but travel at the same speed (300 000 Km per second). For example, blue light would be shifted to yellow, yellow to red, red to infra red, infra red to radio frequencies and so forth.

The most distant stars have the greatest red shift. Since most stars have their greatest outpouring of en-ergy at around visible frequencies (light), the light of the most distant stars tends towards the invisible bands of infra-red, micro-wave and radio-waves. To us they appear almost invisible and with less energy (lower frequencies have lower energy).

THE BIG BANG AND STEADY STATE THEORIES:

There are various theories about the origin of the Universe. The two main ones are the Steady State The-ory, and the Big Bang Theory. The mathematical formu lation of these ideas has only occurred during the 20th century.

The Steady State Theory proposes that the Universe is much as it ever was, and ever will be. In other words that we have an infinite Universe which is constantly being replenished with new galaxies, as old ones die out. It was fairly popular a few decades ago, and still has a few supporters.

The Big Bang Theory proposes that the Universe started roughly 15 billion years ago from the 'explosion' of a primordial nucleus. This has most support amongst astronomers at the moment. because it best explains a number of observations, foremost amongst which is the uniform background energy.

cDuring the 1960's it was discovered that in every direction in which we look, there is a uniform micro-wave radiation, corresponding to about 3 degrees Kelvin (above absolute zero, the lowest temperature is minus 273 degrees Celsius or Centigrade, at which at-oms stop vibrating completely). This 3 degree effect. was a prediction of the Big Bang Theory.

Both theories have a number of problems. Common to both is the non explanation of where the matter comes from in the first place. Neither theory denies the possible existence of other Universes, since we cannot look beyond the horizon of our own Universe.

To be frank, in the opinion of this writer, the whole area of the origins and fate of the Universe (known as Cosmology) is still too speculative, and must be treated. with caution. However as new and more sensitive instruments are built and launched into Space, where they can operate above our atmosphere and radio noise, the new discoveries might clarify cosmological problems.

As already mentioned, the reader must not assume that since there is no consensus among scientists in cosmology, we therefore have a free-for- all, where any old mythology is equally valid. Rather the reverse is true, we need more skepticism and factual information from detailed sky surveys backed by larger public and private grants.

BLACK HOLES:

Apart from cosmological problems there are a num-ber of other areas of astronomy desperate for larger and better telescopes, set in orbit or on the Moon Black Holes are such objects. There are some candidate radio sources which seem to fit the black hole model, but to be sure we really need more information.

Predictions indicate two possible births for black holes. The primordial black holes are those left over from the Big Bang, and many of these would be very small. The second type are Stellar Black Holes which are caused when a very large star has used up all its hydrogen, gone through the whole series of nuclear fu-sions up to the level of iron, and has no more fuel left. It then collapses very suddenly. If the star is smaller than about one and a half times the mass of our Sun, it blows off its outer layers as a super-nova. The core is com-pressed during this process, and becomes a white dwarf. For stars between 1.5 and 3 Solar masses we end up with a Neutron Star or Pulsar (if it is spinning rapid-ly).

Stars greater than 3 or 4 times the mass of our Sun collapse without shedding too much material, because the gravitational attraction is too great. As the collapse continues, internal forces are not enough to keep even subatomic particles separate, and so the compaction increases to the point that the material is compressed into a single perfect point.

Within a particular distance from the center the es-cape velocity (to get off the surface into Space) ex-ceeds the speed of light. That boundary is called the event horizon, and nothing (not even light) can get out from behind this horizon by normal means. That is why the object is called a Black Hole, because we cannot see it. It is perfectly black, except for radiation given off by infalling material, before it crosses the event horizon.

At the center of the black hole we have the singularity, where there is zero volume and infinite density. The radius of the black hole is the distance of the event horizon from the singularity, and is determined by the total mass of the black hole. In general black holes spin about an axis, and are fairly spherical.

Black holes, especially those in multiple star systems, would be detected by the radiation given off by matter as it is sucked in by the tremendous gravity. As this material spirals in towards the event horizon it gives off radistion. So the search for black holes is mainly di rected towards finding likely binary or triple stars which show an excess energy of the right signature.

Recent calculations suggest that by some compli cated processes (involving Quantum Mechanics) black holes can shed energy (hence matter, since the two are interchangeable). When the black hole radiates energy. it loses mass, and eventually disappears, hence the scarcity of primordial black holes. There is speculation that many galaxies may have black/white holes at their center. But then again, none have been identified for sure.

QUASARS:

In the early 1950's, as radio astronomy became a ma jor contributor to the exploration of the Cosmos, maps were made of the sky at radio frequencies. When the positions of radio signals were being compared with objects already seen through optical telescopes, two of them could not be identified (30 48 & 3C 273).

In the early 1960's an intense search of the direction of the radio signals uncovered the suspects. They were faint star-like objects, but with strange spectra (the components of the light when broken up using prisms or gratings). The objects were called Quasi Stellar Radio Sources hence Quasars. It was then realized that the cause of the strange spectra was the fact that they were highly red shifted. So highly red shifted that the Quasars must be moving away from us at a tremendous rate, and so must lie at an enormous distance. They must also be very bright to be seen from so far away.

A few quasars are discovered every year. The fur-thest ones are well over 10 billion light years away, and moving away at 90% of the speed of light. They are hundreds of times brighter than typical galaxies, and their light varies over short periods of time. This varia-tion of the light over a matter of days indicates that quasars cannot be more than a few light days in diameter. Compare this to galaxies which are often one or two hundred thousand light years in diameter. We see then that quasars are very small and extremely bright and the furthest objects we know of.

Naturally there is lots of doubt over what quasars are. Recently very remote galaxies have been identified, as well as galaxies which show some quasar-like features. So this might indicate that quasars are proto-galaxies, and evolved into the galaxies we now see around us.

Then again, some quasars are seen near galaxies and apparently connected to them. The red-shifts of the two objects are vastly different, so this may indicate a cause for red shifts other than the speed of recession Light escaping from a gravity well is red-shifted, but not to such an extent. Perhaps a connection may be found between quasars and the theorized white holes, who knows?

One thing is clear; astronomy is entering a dynamic new age with the recent development of charge cou-pled devices (C.C.D., digital light receptors of remark-able sensitivity, well suited to computer applications). This, together with the new giant telescopes and space telescopes, the super-fast computers and image en-hancing techniques and so forth, will shed new light on old problems. So quasars may not keep their mystery. for much longer.

GRAVITATIONAL LENSES :

One of the predictions made by the Theory of Relativ-ity is that the path of light is influenced by gravitational fields. A massive body, such as cur Sun bends the light enough for us to notice the effect, and during solar eclipses this effect has been verified. This was one means for proving Relativity Theory

The effect is much greater when light passes really massive bodies, such as galaxies and large black holes. So if there is an obscured light source behind a galaxy. the light is bent around the intervening galaxy. De-pending on the exact situation, we could see a dis placed image of the hidden body, or an are of its light. Recently, photographs have been taken of faint arcs of light near a couple of distant galaxies, and it seems probable that the arc of light is due to the gravitational lens effect.

At least one quasar has also been seen showing a double image (quasar 0957+561 A & B). Using image subtraction, a distant galaxy has been identified in our line of sight to the quasar. So there is little doubt that the galaxy is acting as a gravity lens, so that we see the direct and the 'refracted image of the quasar.

Chapter Ten:

EPILOGUE

We have now reached the end of our 'holiday brochure'. I hope that this brief introduction has whetted your appetite and kindled a desire to know more and to see more. There are many simply written astronomy books and magazines readily available. These will be your guide in pursuing your journey in whatever direction most interests you. But do not tarry, do not leave it all for later, perhaps when you retire, or when the children have grown up. You may not have long. No, I do not mean that you may meet with a fatal accident, though that is possible. Rather, the stars may be taken away from you!

As the world population increases, and people demand their 'comforts', nature, and our contact with it, is being pushed into oblivion. We are all familiar with the vast ecological problems we have created, but few of us know of the increasing light pollution which is pervading the Earth.

It is already bad enough that towns and cities are installing more and more night lighting, thus ruining the night sky for their citizens and those unfortunate enough to live within 50 Km of their outer boundaries. The problem of light pollution is now taking on new and sinister dimensions

The celebrations for the centenary of the building of the Eiffel Tower were to be marked by sending aloft a ring of highly reflective mirrors, or one huge mirror which would bathe the night skies around the world with many times the luminosity of the full Moon. Never mind about star gazers, after all it is a 'democratic society, what titillates the majority is law. Only by sheer luck, perhaps helped a little by outrage from the astronomical community, was this fiasco abandoned.

A company in America has been trying to get approval for its plans to launch into orbit a highly reflective cemetery! The ashes of several thousand deceased would be placed in a polished canister and sent into orbit for a fee.

One can already dread the bizarre advertisements; "Yes, you too can have a loved one to look up to as they circle high in the heavens in harmony with the Cosmos. All it takes is a phone call, just dial this toll-free number.... This grotesque and pornographic symbol of human-kinds self-centred ideology would circle unceasingly, ruining one unmolested night after another.

And how long before more advertising satellites and more reflective cemeteries are cast into orbit, until the night sky is crammed with them, and governments use this new opportunity for even more revenue? Once one is approved it sets the precedent, it is the toe in the door' which will herald a flood of space and night sky pollution.

But this is not even the greatest threat. Governments themselves are planning to do the greatest harm. People demand all night lighting for their ever-growing cities. Lighting costs money, but governments cannot ignore the demand because it will cost them votes. So, they will provide as cheap a lighting as possible.

We now are at the threshold of the big streetlamp in the sky. The plan is simple, send into orbit a giant aluminium sail, of several square kilometres area. This sail reflects the light of the Sun towards any particular large city, lighting it and all the surrounding countryside with a mini sun. There are now at least fifty large urban areas, and the number is growing all the time. So, send fifty large sails to orbit, no, double that as will out of commission or pointing in the wrong direction at a certain time.

So, how far away is this tragedy? Well, it was supposed to have started by the end of this century, but large organizations being what they are, these plans have been delayed by maybe ten to twen-ty years. Can it be averted? It is highly unlikely, when we remember that humanity doesn't even show interest in controlling its population explosion or its destruction of forests and wildlife world-wide

Within most of our lifetimes we should see advertising satellites, cemeteries, and reflective streetlights in orbit, ruining the previously dark, star-studded skies of Earth for ever. No more will scores of meteors be seen trailing through the sky every night No more will the band of the Milky Way or its bright and dark nebulae be visible. All telescopes will be virtually useless except for the four bright planets, the Moon and the Sun.

Future generations will have even less of a concept of our place on the gigantic stage than we do. Where before you could see for trillions upon trillions of miles with the naked eye, you will just see a dusky twilight glowing with the mini suns and commercial signs of human folly.

So, go out now, and take your children with you Memorize the general appearance of a truly dark sky walk, if you have to, into the wilderness and taste what It is like to utterly lose yourself in the beautiful and limitless void which surrounds our grain of sand, the planet Earth.

APPENDIX 1

This section will enable you to make a model of the neighbourhood of our Sun. Only the nearest known dozen star systems are shown, there may be some not yet discovered. If you want to venture further out, there are many references which will show you the nearest 20 or 30 systems. Beyond this distance many red or brown dwarfs would be missed out of the distance table, because they are very dim and easily overlooked.

Try to make the stars true to size relative to the Sun. A good scale to choose is one where our Sun is 10 mm in diameter (size of a marble). The distances cannot be true to the same scale as the size, otherwise the stars will be many kilometres away. So, bearing in mind that the distances are to a different scale altogether, a good scale would be 5 cm (2 inches) to each light year. The colours of the stars are also given for the model to have true colours.

The directions of the stars are also given. Treat these just like co-ordinates on a globe of the Earth, with the Sun at the centre. Remember that right ascension is equivalent to longitude, and declination is equivalent to latitude. See how you can improve on this model, by, for example putting in the plane of the Solar System, the direction of our travel relative to these nearly stars and so on.

STAR	DISTANCE light year	DIAMETER Sun = 1	BRIGHTNESS Sun = 4.8	REMARKS AND DIRECTION RA hrs. Dec deg
Alpha Centauri A, B & C	4.3	1.1, 1.2,0.05	4.4,5.8,15.1	14.3,S 62.3 yellow,orange, red
Barnards Star	6.0	0.2	13.2	17.6, N 4.2 red. Fastest apparant speed.
Wolf 359	8.1	0.1	16.5	10.5, N 7.2, red
Lalande 21185	8.2	0.4	10.5	11.0, N 36.2 red
Sirius A & B	8.7	1.8, 0.02	1.4, 11.4	6.4, S 16.4 both white. B is dwarf
UV Ceti A & B	9.0	0.1, 0.1	15.3, 15.8	1.4, S 18.1 both red
Ross 154	9.3	0.2	13.3	18.5, S 23.5 red
Ross 248	10.3	0.2	14.7	23.4, N 43.6 red
Epsilon Eridani	10.8	0.9	6.1	3.3,S 9.4 orange
L 789-6	11.1	0.2	14.6	22.4, S 15.4 red
Ross 128	11.1	0.2	13.5	11.5, N 1.1 red
61 Cygni A&B	11.2	0.5, 0.4	7.5, 8.4	21.0, N 38. both orange stars

APPENDIX 2

Just as in appendix 1 we had the basic information for making a model of the solar region of the Milky Way, here we will have the essential data for building a model of our solar system. This model will be so big as to need a garden setting. It would be a good school exercise. You can keep it for table-top display by restricting it only as far as the planet Saturn. As in the last appendix, the values are rounded off.

You may find the graphical orreries on pages 81 and 82 useful for this project, be-cause they are to scale. As in the star model note that the scale used for the planet size will be different to the scale used for distances. I suggest you use 1 mm for the diameter of Earth, 109 mm for the Sun and so on.

The distance scale is tricky. The main problem is that the Sun interferes with the orbit of Mercury. So at minimum try 200 mm as the distance of the Earth from the Sun, this will let Mercury be 78 mm from the centre of the Sun. which is just 24 mm off its surface. But Pluto will be nearly 8 meters away! Hence the need to put it in the garden.

PLANET	DIAMETER kilometres	DISTANCE Astronomical Units	MASS kg x 10^{24}	ORBITAL PERIOD	NUMBER OF MOONS Large & Small
MERCURY	4 878	0.387	0.330	88 days	none
VENUS	12 104	0.723	4.869	225 days	none
EARTH	12 756	1	5.974	365 days	1 large
MARS	6 787	1.524	0.642	687 days	2 small
JUPITER	142 796	5.203	1899	11.9 yrs	5 L,11 S
SATURN	120 000	9.539	568.5	29.5 yrs	10 L,7 S
URANUS	50 800	19.18	86.63	84 years	5 L,10 S
NEPTUNE	48 600	30.06	102.8	164.8 yr	2 L,3 S
PLUTO	3 000	39.44	0.015	247.7 yr	1 large

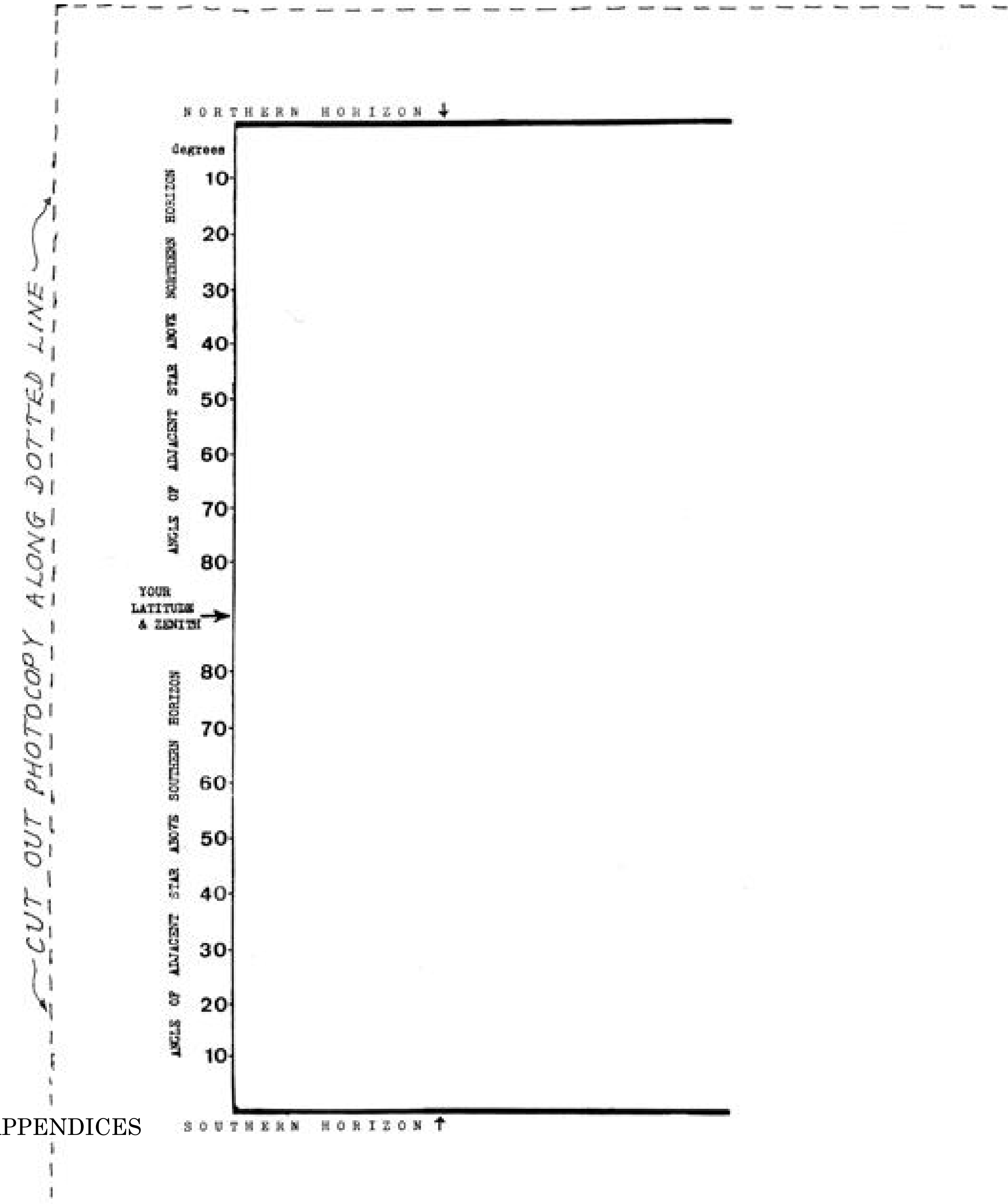
The positions of the main visual planets relative to each other and the stars is found from the graphical orreries in chapter 5. For Mercury, Uranus, Neptune & Pluto, please extrapolate from the following 1989 information: Mercury was closest to us (inferior conjunc-tion) on 24th January 1989. Uranus was at opposition on 24th June. Neptune on 2nd July, and Pluto on 4th May 1989.

Any moons less than about 200 km diameter have been marked as small. You will find that enough information has been given so that, in addition to the model, those so in-clined can do some basic calculations regarding the planets School classes may be particu-larly interested to work out things like the gravitational attraction, surface area, apparent size in telescope, and so forth, for the various planets. Refer to a physics book for these formulae.

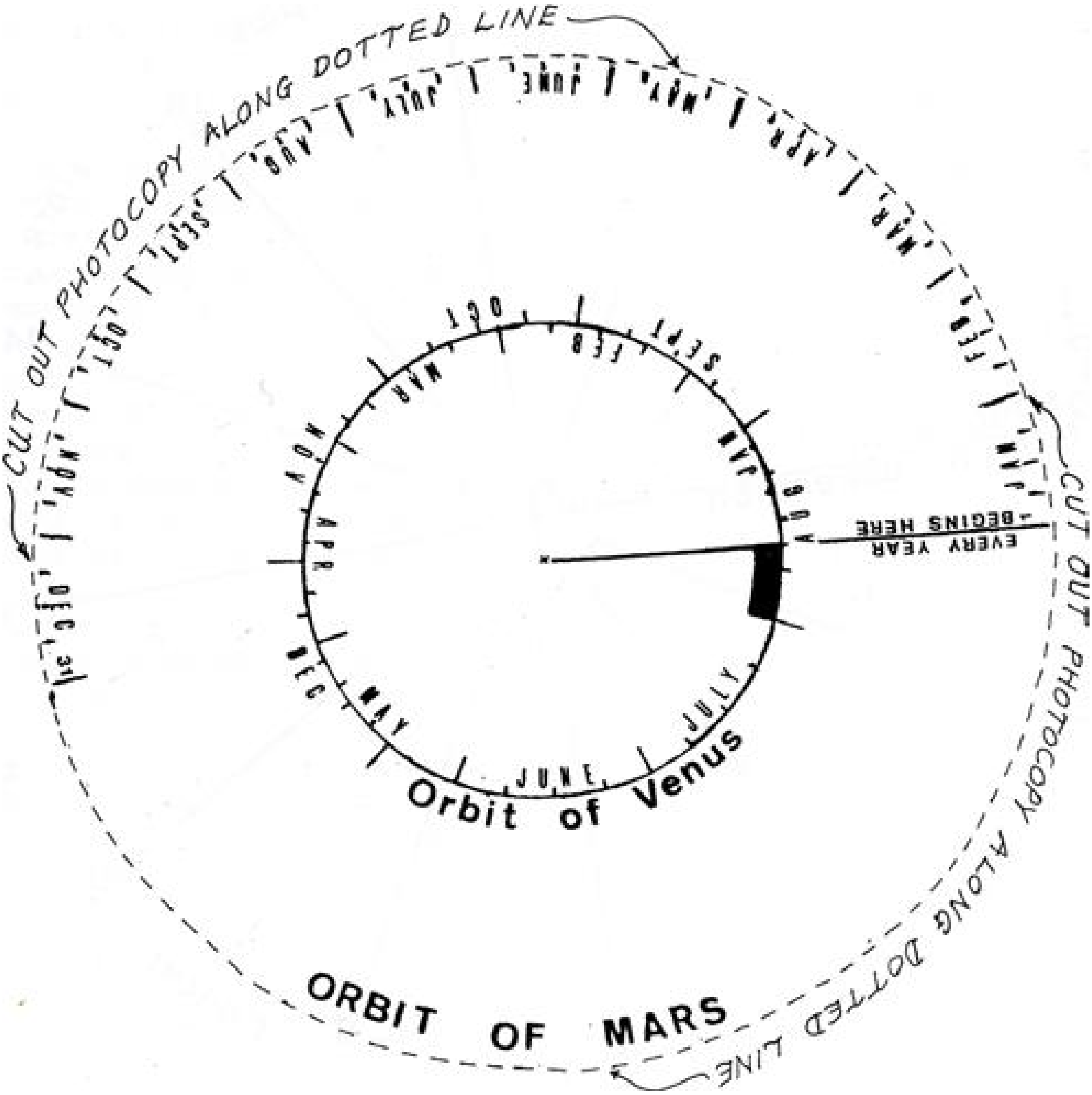
APPENDIX 3

If you ever lose the transparent overlays, you can make new copies onto clear acetate, using a photocopier. All three overlays are printed on these pages, for your private use, but not for distribution to other people.

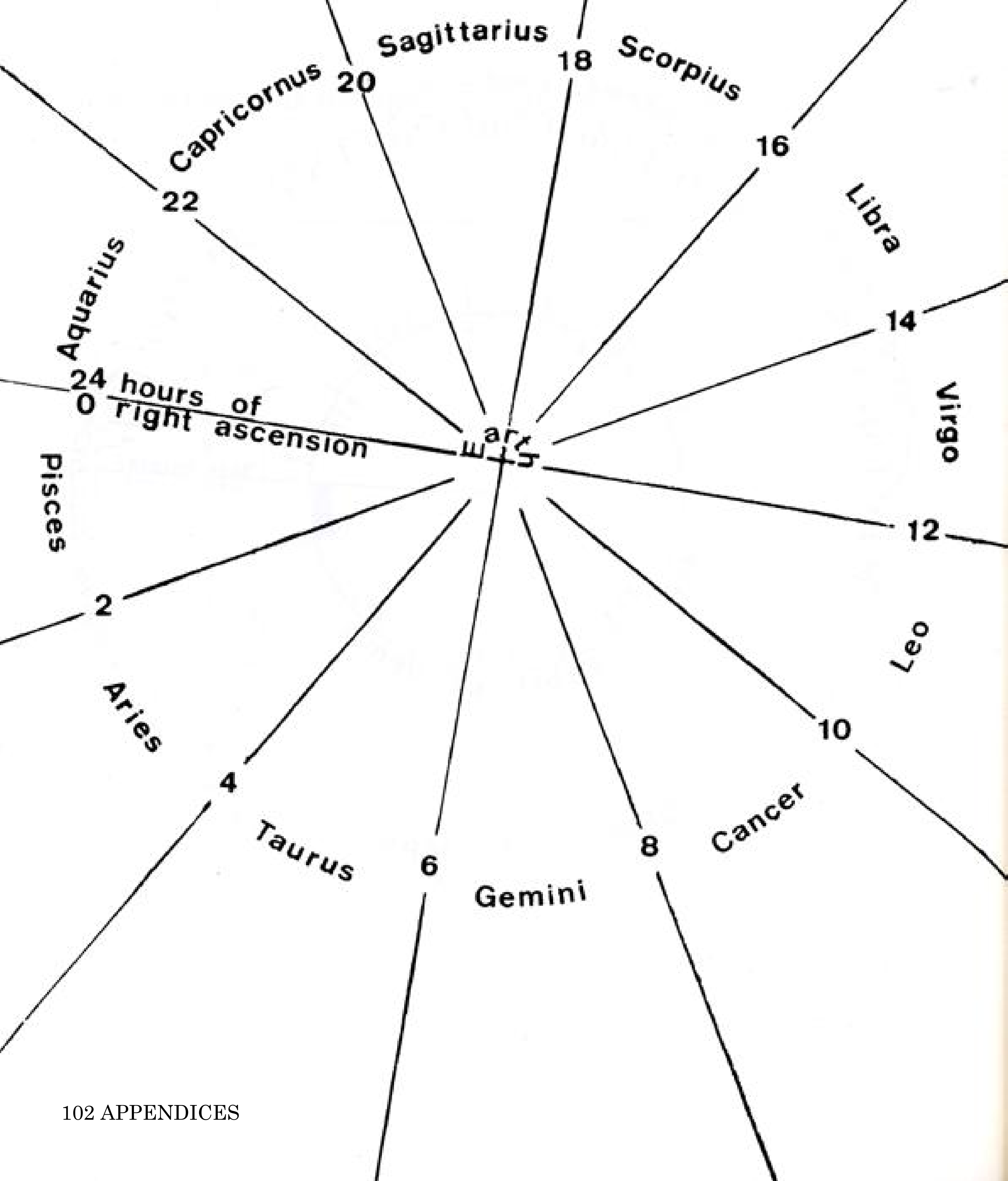
OVERLAY FOR THE MERIDIAN STRIP STAR CHARTS OF CHAPTER 3:



OVERLAY FOR THE MERIDIAN STRIP STAR CHARTS OF CHAPTER 3:



OVERLAY TO GET THE DIRECTIONS OF VENUS, MARS, JUPITER, AND SATURN BY LAYING ON TOP OF THOSE CHARTS IN CHAP 5, AND THEN LOOKING AT THE CORRECT MERIDIAN STAR CHART OF CHAP 3 TO FIND THE PLANET IN THE SKY.



CONCISE GLOSSARY

Many of the following terms are better explained in the main text of the book. Not all the items in the glossary appear in this book; they have been included because you often see the terms used in other books and magazines. Explanations have been kept very brief.

ABSOLUTE MAGNITUDE:	Visual magnitude of a star at 10 parsecs distance.
ABSOLUTE ZERO:	Lowest temperature possible, minus 273 °C.
ACHROMATIC (REFRACTOR):	Corrected to show little spurious colour.
AETHER:	Debunked theory of EMR transmitting medium filling Space.
ALBEDO:	Fraction of light reflected from an object. Scale 0-1.
ALTAZIMUTH MOUNTING:	One axis horizontal, the other vertical.
ALTITUDE:	Angle between a celestial body and the horizon.
ANGSTROM UNIT:	0.000 000 000 1 meters.
ANGULAR DIAMETER:	Width of object as an angle seen by observer.
ANTIMATTER:	Atomic particles with the opposite charges to matter.
APHELION:	Greatest distance from the Sun of an object in Solar orbit.
APOCHROMAT:	A highly corrected lens that shows no spurious colour.
APOGEE:	Greatest distance from the Earth of an object in Earth orbit.
ASTEROIDS:	200 m to 900 km-sized bodies between Mars & Jupiter.
ASTIGMATISM:	An optical defect of telescopes and eyepieces.
AU, ASTRONOMICAL UNIT:	Mean radius of Earth's orbit = 150 million Km.
AURORA:	Near N & S Poles, solar wind hits the ionosphere & gives light.
BARLOW LENS:	Put in front of the eyepiece to increase magnification.
BIG BANG:	One theory for the origin of the Universe is an explosion.
BINARY STARS:	Two stars in orbit about each other.
BLACK BODY RADIATOR:	EMR source with continuous spectrum.
BLACK DWARF:	A star that has cooled & no longer emits light.
BLACK HOLE:	An object whose escape velocity exceeds that of light.
BLUE SHIFT:	Increased frequency of EMR due to motion towards us.
BOLIDE:	Large meteor, or fireball. Usually reaches the ground.
BROWN DWARF:	Star still hot enough to appear dull red.
CASSEGRAIN:	A type of reflecting telescope, with an eyepiece at the rear.
CASSINI DIVISION:	A major gap in rings of Saturn. Easily visible.
CATADIOPTRIC:	Popular telescope designs using lenses & mirrors.
CELESTIAL POLES:	Two points around which all stars seem to rotate.
CELESTIAL SPHERE:	Space around us in which the stars seem to be.
CCD, CHARGED COUPLED DEVICE:	An electronic device for light detection
CHROMATIC ABERRATION:	False colour fringes seen through a telescope.
COSMIC RAYS:	Highly energetic charged particles from deep space.
COSMOLOGY:	Study of origins, evolution & structure of the Universe.
COUDE FOCUS:	Transfer of focus of telescope to polar axis.
CREPE RING:	Innermost of Saturn's rings. Semi-transparent.
CULMINATION:	When star is at highest point in sky, i.e. on meridian.
DAWES LIMIT:	Resolution of telescope in arcseconds = 11.6/diameter cm

DECLINATION:	Degree's north or south of the celestial equator.
DEGREE (OF ARC):	One 360th part of a circle of revolution.
DENSITY:	Mass/volume. Value for water = 1000 Kg per cubic metre
DIFFRACTION:	Bending of light as it passes a sharp edge.
DIFFRACTION GRATING:	A device used instead of a prism in spectroscopes.
DOPPLER SHIFT:	Frequency change of light due to relative motion.
EARTH-SHINE:	Sunlight reflected off Earth that lights the dark part of the Moon.
ECCENTRICITY:	Amount of elongation of the elliptical orbit.
ECLIPSE:	One body passing directly in front of another.
ECLIPTIC:	Sun's path across background stars. The plane of Earth's orbit.
EMR, ELECTROMAGNETIC RADIATION:	Radio Waves, Light, X & Gamma rays.
ELLIPSE:	Oval, squashed circle. The shape of the orbits of all planets.
ELONGATION:	Angle subtended at the Sun, between the Earth & another planet.
EMISSION SPECTRUM:	Wavelengths of EMR given out by a hot body.
ENCKE DIVISION:	Tiny gap in Saturn's rings. Difficult to see.
ENTROPY:	The Universe tends from a state of order to chaos.
EQUATORIAL MOUNT:	Polar axis points to poles. The other axis is at 90 degrees
EQUINOX:	When the Sun crosses the Celestial Equator. 21 March & 23 Sept.
ESCAPE VELOCITY:	Minimum speed needed to escape a planet, star, etc.
EVENT HORIZON:	Radius from the black hole within which EMR is trapped.
EYEPIECE:	Part of the telescope you look through. Usually removable.
FILTER:	An optical or electronic device for passing only certain EMR.
FIREBALL:	Or bolide, a very large meteor, often reaching the ground.
FLARE:	Gas eruption from the surface of the Sun. Goes thousands of Km high.
FRAUNHOFFER LINES:	Dark lines in the spectrum due to absorption.
FREQUENCY:	Number of vibrations passing a given point per second.
FUSION:	Atoms of light elements fuse and release energy.
GALAXY:	A Collection of billions of stars in isolation from others.
GAMMA RAYS:	Highest frequency & energy EMR, even beyond X-rays.
GEOCENTRIC THEORY:	Earth at the centre of the Universe. Still a popular myth.
GIBBOUS PHASE (MOON & INNER PLANETS):	Halfway between quarter & full.
GLOBULAR CLUSTER:	Hundreds of thousands of stars huddled together.
GRATICULE:	Eyepiece marked with ruler divisions to measure angles.
GRAVITY:	Mutual attraction of all matter. Decreases with distance.
GRAVITATIONAL LENS:	Large mass (e.g. galaxy) bends light like a lens.
GRAVITY WAVE:	Theory that gravity is transmitted by radiation.
HERTZSPRUNG-RUSSELL DIAGRAM:	Shows the evolution of various stars.
HUBBLE CONSTANT:	About 50 to 100 Km per second per megaparsec of distance. Observed the speed of recession of distant galaxies.
HYPERBOLA:	Open curve with arms diverging at a set angle at infinity.
IAU:	International Astronomical Union; Coordinating organisation.
IMAGE INTENSIFIER:	An electro-optical device to enhance brightness.
INCLINATION:	Angle of tilt of planet or comet orbit to ecliptic.
INFERIOR CONJUNCTION:	Mercury or Venus passing between us & Sun.

INFRARED:	EMR between microwaves & red light. Same as heat.
IONIZED GAS:	Electrically charged due to too few or too many electrons.
IONOSPHERE:	Atmosphere from 50 to 500 km. Stops some radio waves.
JANSKY:	10-20 watts per square metre per hertz radio astronomy).
KELVIN, K:	Celsius temperature scale, but starting at absolute zero.
LIBRATION:	Moon wobbles slightly, so we see 59% of its surface.
LIGHT YEAR, LY:	Distance light goes in one year. 9.46 x 10 Km.
LOCAL GROUP:	Galaxies near us with which we move through Space.
MAGNETIC STARS:	Stars with strong magnetic fields.
MAGNETOPAUSE:	Border between the magnetic field of the planet & Solar wind.
MAGNETOSPHERE:	Far above the planet, where the magnetic field is dominant.
MAGNITUDE:	Brightness scale for stars. A larger number means fainter.
MAKSUTOV:	A catadioptric telescope. Compact, rugged, superb.
MAIN SEQUENCE:	Evolutionary path for most stars.
MARE:	Latin name given to dry smooth areas on the Moon (means sea!)
MAUNDER MINIMUM:	Lack of sunspots from 1645 to 1715.
METEORITE:	A meteor that survives to hit the ground.
MICROMETER:	A device used for measuring minute angles in a telescope.
MICRO-WAVE:	EMR between radio waves and infra-red.
MINUTE OF ARC:	One-sixtieth of a degree. Sun & Moon = 32 mins across.
MOVING GROUP:	Stars that move in the same direction at the same speed.
NADIR:	Point directly beneath you. Opposite your zenith.
NEBULAE:	Dark or bright gas and/or dust clouds in deep space.
NEUTRON STAR:	Smallest & most dense stars, left over after a supernova.
NEWTONIAN SCOPE:	1 parabolic mirror, 1 flat mirror. Eyepiece on the side.
NGC:	New General Catalogue. List of clusters, nebulae, and galaxies.
NOCTILUCENT CLOUDS:	Highest clouds at about 80 km. Made of ice.
NOVAE:	Exploding stars, some mild, some not. Due to several causes.
OBJECTIVE:	The main lens or mirror of the telescope. Gathers the light.
OBLATENESS:	Ratio of polar to equatorial diameter of planet.
OCCULTATION:	Like an eclipse. One body obscures another.
OORT CLOUD:	A region about 1 LY away where comets may come from.
OPPOSITION:	When outer planets are directly opposite us from the Sun.
ORBIT:	The path of a planet about the Sun, or a moon about a planet.
ORRERY:	Mechanical moving model of the Solar System. 18th century.
PANSPERMIA:	Ancient theory that life has migrated through the Universe.
PARABOLA:	Open curve with sides parallel at infinity.
PARALLAX:	Slight apparent movement of stars due to Earth's orbit.
PARSEC:	Distance at which parallax = 1 arcsecond. Equal to 3.26 LY
PENUMBRA:	Area of semi-shadow cast by planet/moon. Seen at the eclipse.
PERIASTRON:	Closest approach of a satellite or moon to the Earth.
PERIHELION:	Closest approach of a comet, planet or asteroid to the Sun.
PERTURBATION:	Unexpected variation in orbit or speed of the body.
PHASE:	A moon or planet, lit from one side, viewed from another.

PHOTOMETER: An instrument for measuring the amount of light objectively.
PHOTON: Smallest amount of EMR possible. Speed 300 000 km per sec.
PLANETARIUM: A theatre where the appearance of the night sky is shown.
PLASMA: Ionised gas, often at high temperature. Electrons are free of atoms.
POLARIZATION: Filtering of light, allowing only monoplanar vibrations.
PRIME FOCUS: The lens or mirror brings light to focus.
PRISM: A piece of glass splits light into separate colours.
PULSAR: Rapidly spinning neutron star left after supernova.
QUADRATURE: Moon or planet perpendicular to the Sun as seen from Earth.
QUASAR, QSO: Brightest & Furthest objects known of. Young galaxies?
RADIANT: Part of the sky where the meteor shower seems to fall from
RADIATION: EMR or energetic atomic particles from any source.
RADIATION BELT: Energetic particles trapped by the magnetic field.
RADIO ASTRONOMY: Celestial observation at radio wavelengths.
RADIO GALAXIES: Galaxies that are brightest at radio wavelengths.
RADIO TELESCOPE: Radio & aerial (e.g. dish) designed for astronomy.
RADIO WAVES: EMR from microwave down to the longest wavelengths known.
RECIPROCITY FAILURE: Failure of film to react linearly to exposure.
RED GIANT: A Star much larger than the Sun, with a temperature < 5000 degrees.
REDSHIFT: Lower frequency of EMR due to motion away from us.
REFLECTOR: Any telescope using a mirror for collecting light.
REFRACTOR: Any telescope using a lens for collecting light.
REFRACTION: EMR (e.g. light) changes direction due to a medium change.
RELATIVITY: Event perception depends on the subject's relative location.
RESOLVING POWER: The amount of detail the scope can see. Depends on the diameter.
RESONANCE: Positive feedback produces a dominant frequency.
REST MASS: Mass of nuclear particles when not moving.
RICH FIELD TELESCOPE: One with a low-power, wide-angle eyepiece.
SCATTERING: When any photon is deflected from a direct path.
SCHMIDT TELESCOPE: Photographic scope with corrector plate (lens).
SCHMIDT CASSAGRAIN: Superb photo-visual scope with Schmidt plate.
SCHWARZSCHILD LIMIT: Density beyond which a body becomes Black Hole.
SCHWARZSCHILD RADIUS: See Event Horizon.
SEEING: Conditions of the air above the observer affect the telescope image.
SHADOW BANDS: Near total solar eclipse, light bands run along the ground.
SINGULARITY: Situation in a black hole. Known Physics laws are irrelevant.
SOLAR CONSTANT: 1370 watts/m^2. Average solar energy reaching Earth.
SOLAR WIND: A stream of ionised gas that blows out from the Sun.
SOUTHERN LIGHTS: Aurora Australis, light effects due to solar wind.
SPECKLE INTERFEROMETRY: Microsecond exposures combined by computer.
SPECTROSCOPE: Device (e.g. prism) that splits light into a spectrum.
SPECTRUM: Light & other EMR of radiators contain many wavelengths.
SPHERICAL ABERRATION: One of several optical faults in a telescope.
STEADY STATE THEORY: Infinite Universe has been & ever will be as it is.

STRATOSPHERE:	Earth's atmosphere from 25 to 50 Km high.
SUNSPOTS:	Dark areas seen on the Sun using special filters.
SUNSPOT CYCLE:	The number of sunspots rises and falls over 11 years.
SUPERIOR CONJUNCTION:	Mercury or Venus on the other side of the Sun to us.
SUPERIOR PLANETS:	Solar system planets with orbits outside Earth's.
SUPERNOVA:	The most violent explosion of a star. Briefly outshines the Galaxy.
TELE-COMPRESSOR:	Opposite of a Barlow Lens. Reduces magnification.
TELE-EXTENDER:	Used for eyepiece projection photography.
TIME DILATION:	Effect of relativity. Time slows when we move faster.
TRANSIT TELESCOPE:	Firmly mounted. Can scan only meridian stars.
TROPICS:	Within the furthest north/south where the Sun is ever overhead.
TWINKLING:	Flickering effect of a star due to Earth's atmosphere.
ULTRAVIOLET:	EMR between violet light and X-rays. Blocked by Ozone.
UMBRA:	Total shadow area cast by Earth. Seen during a Lunar Eclipse.
UNIVERSAL TIME:	Solar time at Earth longitude 0 (at Greenwich, UK)
VAN ALLEN BELTS:	Magnetosphere areas are very high in charged particles
VARIABLE STARS:	Those whose brightness changes markedly with time.
VELOCITY:	Speed in a specified straight line.
WAVE THEORY:	That light is vibrations in a medium (Aether).
WHITE HOLE:	Possible opposite of a black hole. Spills energy & matter.
X-RAYS:	High-frequency EMR between ultraviolet and gamma rays.
ZERO GRAVITY:	State of free fall, so no resistance is felt at all.
ZENITH:	Point of sky directly above your head.

BEST CHOICES FOR TELESCOPES AND BINOCULARS

This brief & simple guide does not pretend to give advice for all people, for all time & all places, it's current for 2024 & tries to keep beginners away from devices that are disappointing or useless; things that will be locked up & discarded. Later, the user may want a specialist, large or expensive instrument. All in good time.

The best optics to get are those that are versatile & can be used most often. Not everything will be explained in detail. There's not enough room, and many books & sources will explain the reasons; with some disagreeing with others. So be careful what advice you follow: Wishful thinking is not a good guide.

If you have binoculars, use them. If you don't, then buy an 8x30 folding pocket binoculars, or a 10x50 wide angle model. Either of these is quite cheap & versatile. Keep the dust caps on, and only clean rarely & lightly.

Once you've looked at the Milky Way, landscapes, wildlife, ships & sports, you should get a small telescope that does much the same things in more detail.

Do NOT buy the toy telescopes, especially not for children. It will put them off star-gazing for life. I will cut to the chase. A versatile telescope should be a refractor about 100mm diameter, F5 to F10, with a lightweight tripod, and robotic control with an AA battery compartment. It should ideally be able to take 2 inch (50mm) eyepieces for when you want to take in wide angle vistas. Reflectors have a minimum magnification, refractors have no lowest magnification & thus wider field of view. Never let batteries corrode in the device.

The only telescope I know of that fulfils the above for an affordable price (less than $1,000) is a **Celestron Nexstar 102SLT**. or its equivalent **Sky-Watcher BK 1025 AZGT**. The optics of refractors last 200 years if looked after well & dust caps are used at both ends, with exterior cleaning done very rarely & gently. Don't buy something that's not identical to the above. "close enough isn't good enough".

Especially do NOT buy a reflector; it collects dust, has a central obstruction, and less resolution & brightness than an equivalent diameter refractor, is cumbersome, and Newtonian reflectors cannot be used for terrestrial viewing. Reflectors also have a limited use-by date due to mirror corrosion, and need to be collimated if transported. Catadioptrics have some of the same problems.

The above two telescopes come with a few eyepieces and a Barlow lens to double or triple the magnification, depending on whether it is in front of the star-diagonal or behind it. Add more accessories later.

You'll need 2 diagonals; a 45º erecting one for terrestrial viewing & a 90º one for objects high overhead. The 90º diagonal should be a 2 inch model with a 11/4 inch adaptor sleeve at the output end. This setup allows you to use a wide angle 50mm focal length eyepiece for window-like views of extended objects, or use 11/4 inch short focal length eyepieces for high magnifications. Remember that no telescope is useful for terrestrial magnifications above 100x, due to ground/sea level turbulence.

The highest magnification of these telescopes for astronomy is about 250x. That's also the useful limit for any telescope near sea level. Higher magnifications show no more detail, but merely enlarge the blur. When buying further eyepieces, get the widest angle ones you can, and nothing less than a Plossl type.

NEVER be tempted to point your telescope at the Sun, not even to project an image. A 4" or 102mm scope gathers too much light & heat and both scope & eyepiece is damaged by pointing them at the Sun. Of course NEVER look at the Sun with a telescope or binoculars unless you have a correct filter:

A telescope shop will have "Mylar" solar filters of the right diameter to fit in front of the telescope so that you can view through it safely. (but the image will be too dim for projection).

Happy stargazing. And if in doubt always research from several knowledgeable sources, directly & online.

REFERENCES & CREDITS

Pre-montage star charts. John Bartholomew & Sons. Edinburgh. Scotland.

Astronomical Handbook. Editors: Peter Birch & Arie Verveer. 1989. Perth Observatory, Western Australia.

Burnham's Celestial Handbook. Robert Burnham Jr., 1978. Dover Publications Inc., New York, U.S.A.

Mathematical Astronomy. C. Barlow & G. Bryan. 1934. University Tutorial Press. Cambridge, U.K.

Principles of Astrometry. Peter Van De Kamp. 1967. W.H. Freeman & Co. San Francisco, U.S.A.

Flammarion Book of Astronomy. Camille Flammarion & Andre Danjon. 1964 George Allen & Unwin. London, U.K.

The Astronomy Encyclopedia Editor. Patrick Moore. 1987. RD Press. N.S.W. Australia.

Hamlyn Guide to Astronomy. David Baker. 1978. Hamlyn Publishing Group Ltd., London, U.K.

Cambridge Atlas of Astronomy. Editors: Jean Audouze & Guy Israel. 1985. Cambridge Universi-ty Press. Cambridge, U.K.

Amateur Astronomy, Editor: Colin Ronan. 1984. Newness Books, London, UK

The Universe. Iain Nicolson & Patrick Moore. 1985. William Collins & Sons Company Ltd, Lon-don, UK

New Scientist Weekly magazine. IPC Magazines Ltd. London UK

Sky and Telescope Monthly magazine. Sky Publishing Corp. Cambridge, Massachusetts, USA

Astronomy Monthly Magazine. Kalmbach Publishing Co., Wisconsin, USA.

Skywatch. Sam Nejad. Monthly feature. Geraldton Guardian. Western Australia

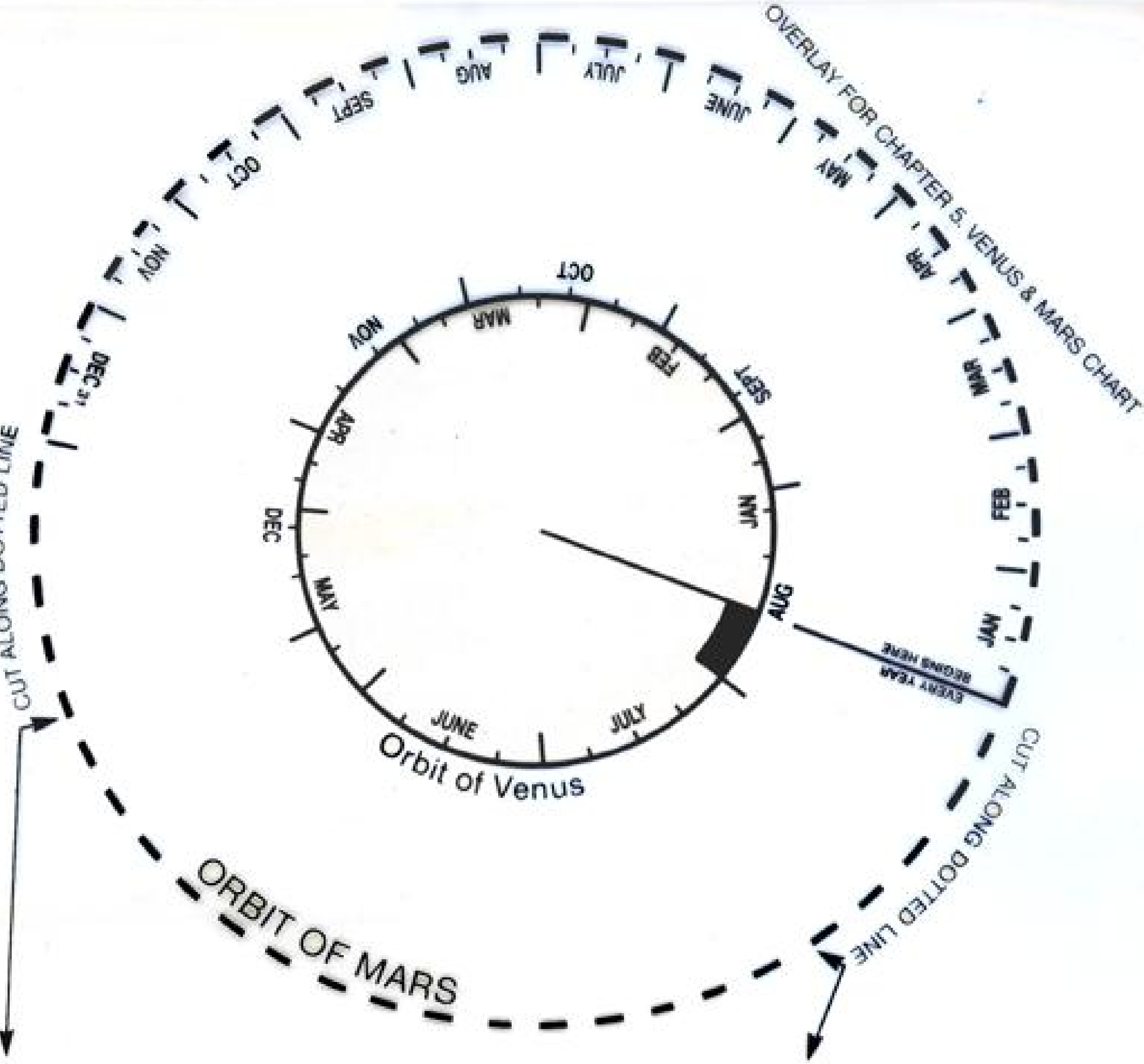
Phillips' Planisphere Rotary Star Chart. George Philip & Son, Ltd, London, UK

Meade 2080 Schmidt Cassegrain Telescope Used for all photographs. Meade Instruments Corp., Costa Mesa, California, USA.

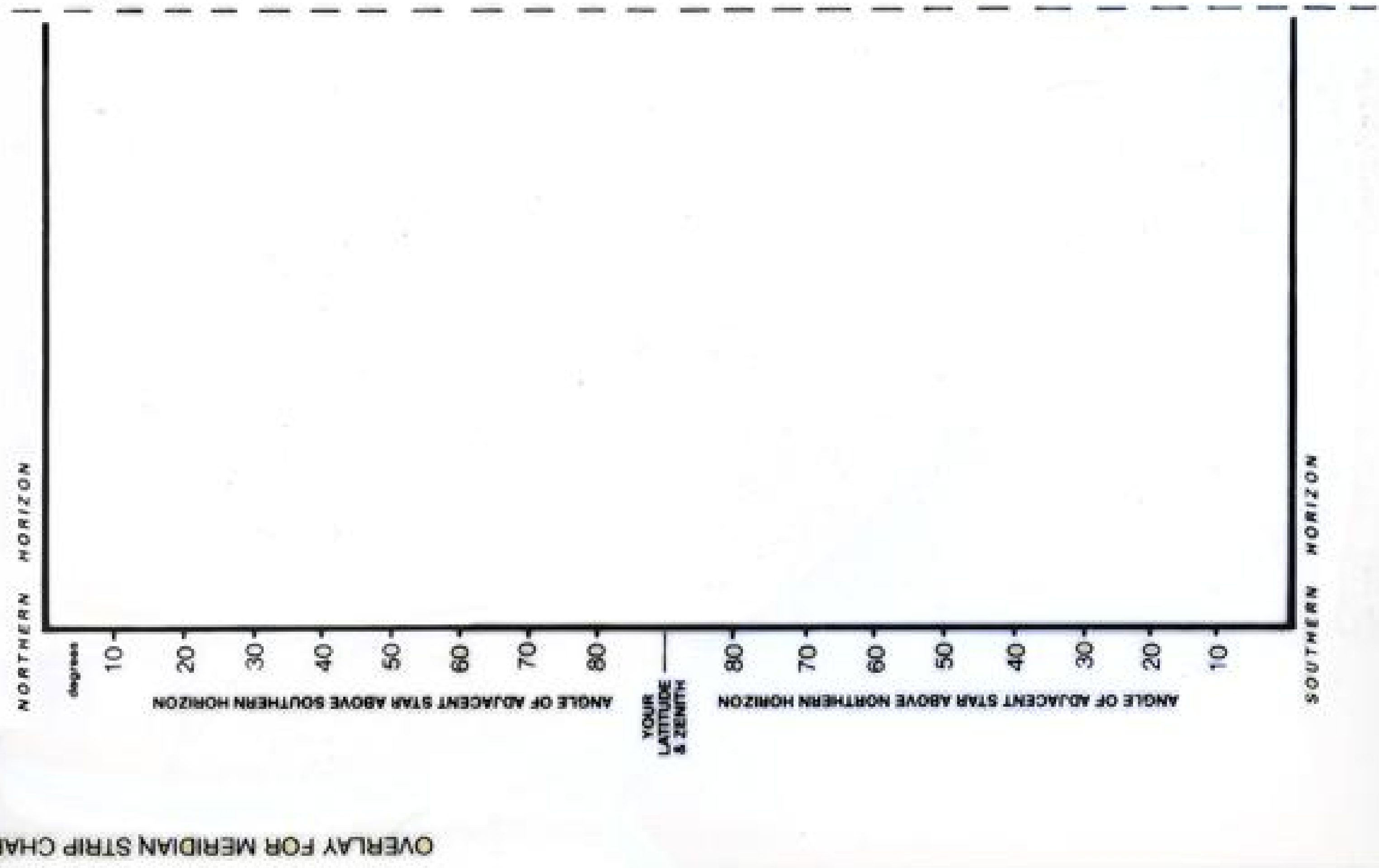
Minolta XD 5 SLR Camera. Used for all photographs. Minolta Camera Corp. has offices in most countries.

Konica SRV 3200 Film is used for most photographs. Konica Corp. has offices in most coun-tries.

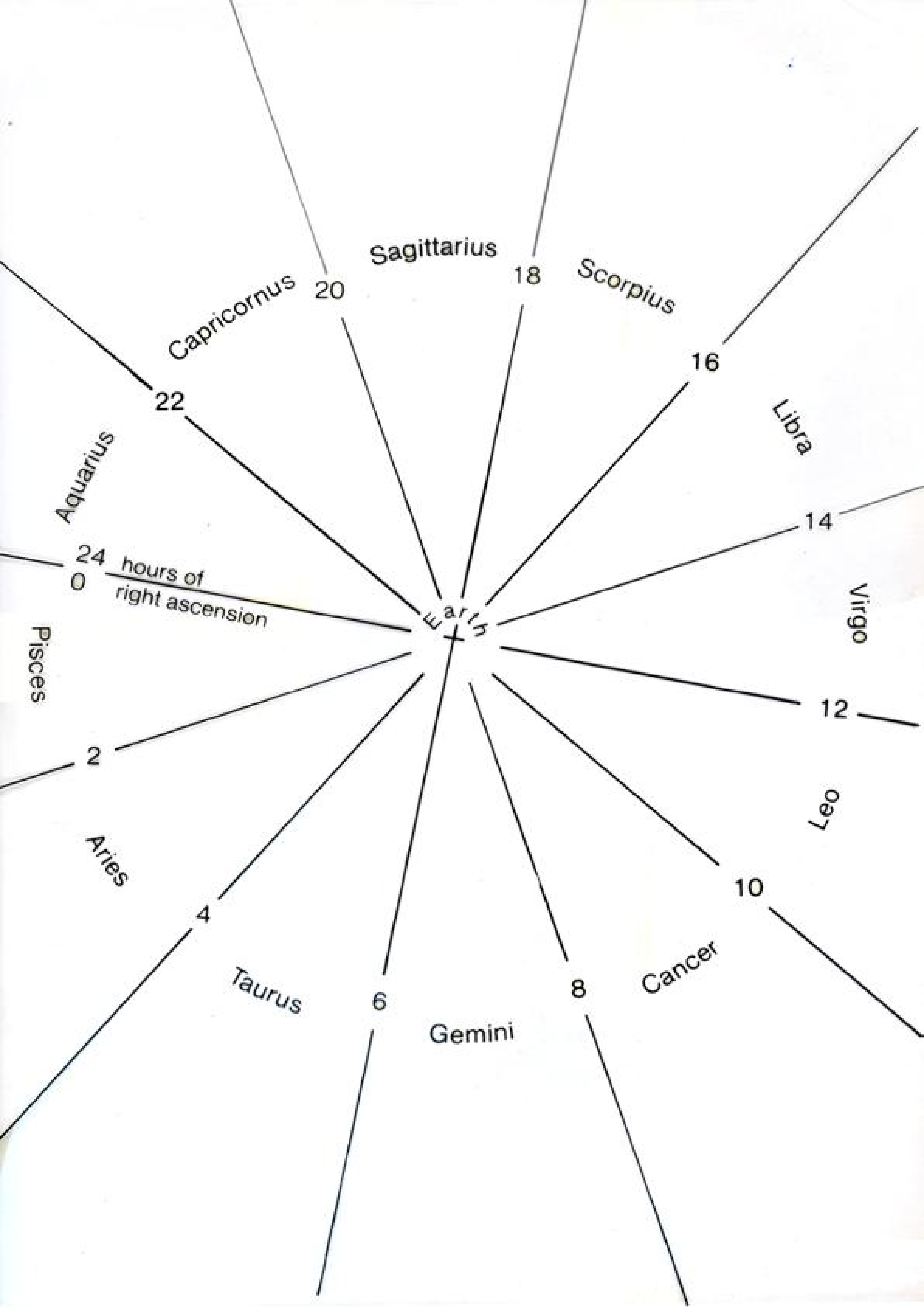
Commodore Amiga Computer Used for typing, artwork & setting out. Commodore Business Machines. Offices in most countries.



OVERLAY FOR CHAPTER 5, VENUS & MARS CHART
CUT ALONG DOTTED LINE
CUT ALONG DOTTED LINE
ORBIT OF MARS
Orbit of Venus
EVERY YEAR BEGINS HERE
JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC



NORTHERN HORIZON
SOUTHERN HORIZON
degrees
10 20 30 40 50 60 70 80
80 70 60 50 40 30 20 10
ANGLE OF ADJACENT STAR ABOVE SOUTHERN HORIZON
YOUR LATITUDE & ZENITH
ANGLE OF ADJACENT STAR ABOVE NORTHERN HORIZON
OVERLAY FOR MERIDIAN STRIP CHARTS


Sagittarius
18
Scorpius
20
Capricornus
16
22
Libra
Aquarius
14
24
0
hours of
right ascension
Earth
Virgo
Pisces
12
2
Leo
Aries
10
4
Cancer
Taurus
6
8
Gemini

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