

Celestial BASIC



Eric
Burgess

Astronomy
On Your Computer



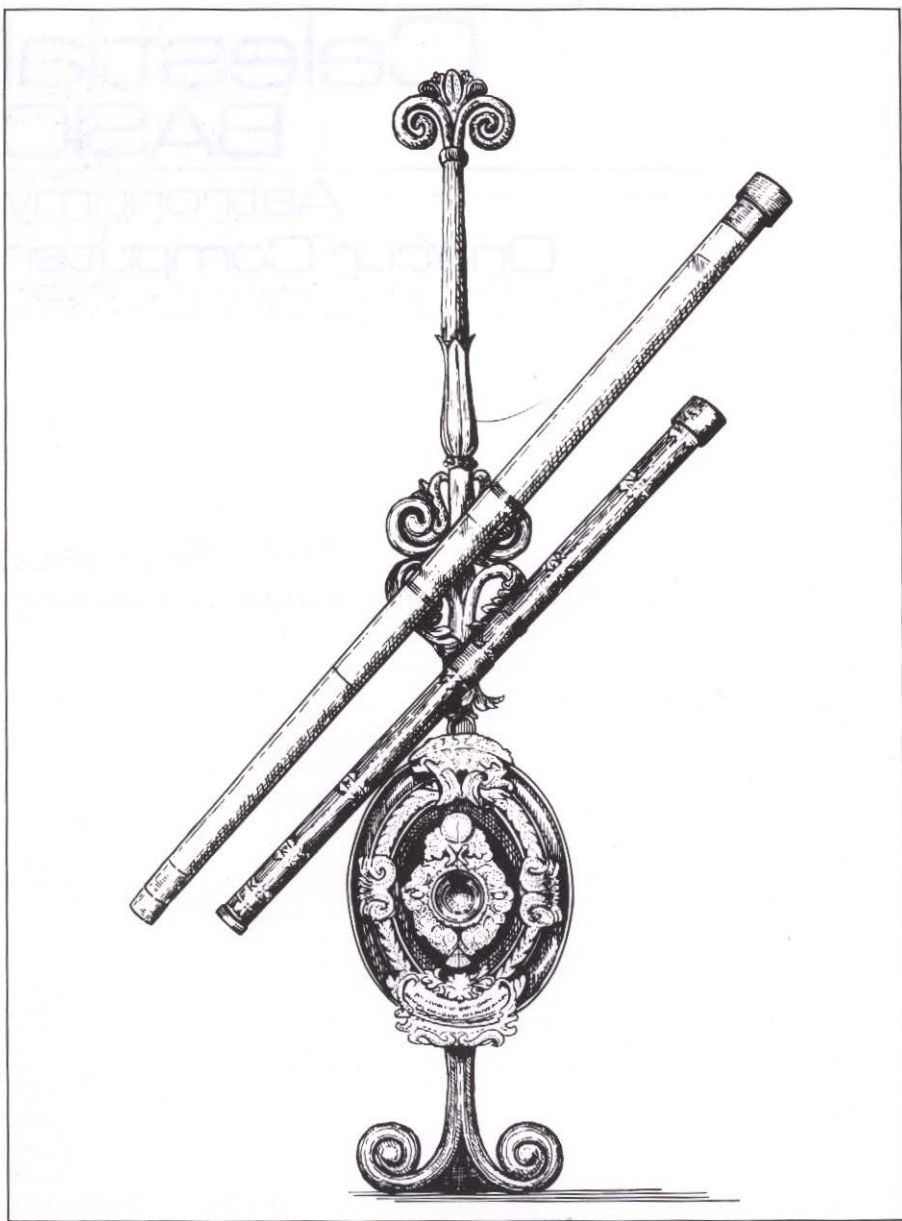
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Excerpt • Paris • Charente





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Fellow of the Royal Astronomical Society



Berkeley • Paris • Düsseldorf

Celestial
of BASIC
Astronomy
On Your Computer
Eric Burgess
The Astronomer's
Handbook

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I also express my thanks to Christopher Williams for arranging the SKYSET/SKYPLT programs to suit the Apple computer, and to Barbara Gordon for her untiring efforts in editing the manuscript.

*Eric Burgess
Sebastopol, California
July 1982*

Introduction

Microcomputers are becoming increasingly commonplace in homes and small offices. As the applications for which the computers were originally developed are mastered, new applications are springing up. One of the most recent and, indeed, most natural of the microcomputer's applications is to amateur astronomy. Now many amateur and armchair astronomers can have immediate access to useful astronomical information that before had to be obtained from almanacs, monthly astronomical magazines, or by laborious calculations with pocket calculators. Relatively simple programs, written in the BASIC language, can be used to relieve the chores of typical astronomical calculations.

Although these calculations can be made using a programmable handheld calculator, the process is inherently more laborious and error prone, and the results are displayed less conveniently than with a computer. Alternatively, the amateur astronomer can subscribe to the astronomical almanacs or wait for the monthly issue of an astronomical magazine, but then he must extrapolate or interpolate by hand from the data provided in these publications. How much more convenient it is to load a program from a cassette file or a floppy disk into your home computer and, for example, have the configurations and names of the Galilean satellites of Jupiter identified before you go to your telescope, any time you choose to observe, anywhere in the world!

The programs in *Celestial BASIC* provide amateur and armchair astronomers and students with important aids to observing and understanding the configurations, motions, and apparitions of our Sun and Moon, the planets, and the stars. Planetary positions, as well as the rising and setting times of all the planets, Sun, and Moon, can be quickly found for any locality in the world, at any time, on any date. Astronomical (star) times can be converted to local times and vice versa. Circles can be set on equatorially mounted telescopes, and true north can be determined with

the aid of Polaris. You can find out when the next lunar eclipse will occur and how much of our satellite will be covered by Earth's shadow. You can learn when Mars will be in opposition next and how large it will appear in a telescope, or when Venus or Mercury are favorably placed for observation in the morning or evening sky.

In the comfort of your own living room, these programs allow you to experience changes of hours and years in the configurations of the night sky previously impossible except in a planetarium. You can have the night (or day) sky displayed on the monitor screen with the planets, Moon, and meteor showers. You can see how the stars look from Antarctica, or see how the midnight sun appears on the oil fields of Alaska's North Slope. You can follow the diurnal and annual progression of the star sphere. And if you are not up to steam in recognizing the constellations, use a tutorial to learn how to identify the major constellations and their brightest stars.

Educators, who are increasingly using computers at all levels in teaching, will find the programs useful to illustrate the dynamics of observational astronomy. In addition to the tutorial on recognizing the constellations, other tutorials aid in converting astronomical measurements and in learning the latest details about the planets and their satellites.

This book originated as a practical tool. I began to share the programs with others, and the interest was such that I decided to incorporate them into a handbook. In addition to providing current information about the planets, these programs provide the convenience of checking observations in the past and predicting them into the future. I have compared the results of several of these programs with my observational notebooks that extend back to the 1930s, and I find them sufficiently accurate for everyday observations.

As mentioned in the introduction to the Bibliography, it is possible to add further steps within the structure of the program to increase the accuracy of the computer's readout. The references cited in the Bibliography provide the information necessary to achieve higher orders of accuracy. (Larger random access memories may be required to incorporate these refinements.)

The book is divided into four major sections and an Appendix. Part One covers times, dates, and conversions among them, updating of coordinates, and using Polaris to determine true north. Part Two concentrates on our Moon, and Part Three concentrates on the planets. Part Four provides general and tutorial programs. The Appendix consists of alternative programs not requiring use of Applesoft™ high resolution graphics for three major programs in the book. Written in the Exidy Sorcerer™ computer's BASIC format, these programs are provided as an aid to those readers who wish to modify them for use in computers other than the Apple II™.

There is also an Observer's Guide to the Programs, which can serve as a checklist of programs to run through to help you make the most of your

observing time. A Bibliography is provided to refer you to further information on astronomical computations.

Originally written for an Exidy Sorcerer computer, the programs have been rewritten for an Apple II to make them available to a wider range of users. The programs are written in the popular BASIC language, and complex programming techniques have been avoided. This has been done to minimize complications of program structure so that the programs are readily understandable to the beginner and adaptable to other computers. There are also plenty of remark (REM) statements to help the reader understand what the program is asking the computer to do. All the programs are usable on computers such as the IBM™ Personal Computer, Radio Shack TRS-80™, Atari™, Commodore PET™, Exidy Sorcerer, and similar microprocessors, without major changes.

Some of the programs will require modifications, however, to suit specialized functions of different computers. These modifications will occur especially in connection with the graphic displays, as the various computers would handle such displays quite differently. For this reason the use of high resolution graphics peculiar to the Apple computer were not used more generally. Most of the graphic displays consist of characters from the ASCII character set; for example, periods, colons, X's, and asterisks represent the positions of the stars. For the program that uses Applesoft high resolution graphics to plot objects in the sky (SKYSET/SKYPLT), an alternative method of programming is given in the Appendix. Instruction lines that may need modification are identified in REM statements or in the preamble to each program. Most programs can be adapted relatively easily for use in the Southern Hemisphere, where constellations will need to be inverted. Several programs have the capability of offering Northern or Southern Hemisphere viewing without modification—SKYSET/SKYPLT, for example. All programs have been carefully edited, run, and checked against actual astronomical observations over many years.

The programs are designed so that large memories are not required. Amateur astronomers having computers with 48K of random access memory (RAM) can readily combine several of these programs. They may be conveniently placed in one package when needed concurrently, or they can be selected by menus.

I am grateful to the many people who have derived the equations forming the basic algorithms of the computer programs, many of which have been used in their fundamental forms for a long time. My intention is to provide a useful service to amateur and armchair astronomers, educators, and students by presenting the equations in a form that allows them to be manipulated on a small microprocessing system.

PART 1



TIME



THE SCIENCE OF ASTRONOMY is an outgrowth of man's need to measure time. Early studies of the sky resulted in finding a relationship between the motions of the heavenly bodies and the recurrence of seasonal and other natural phenomena. Time was measured, calendars were derived, and religious functions were set from observations of the motions of the Sun, Moon, and stars. As astronomy progressed and greater precision of observations became possible, more precise systems of time measurement were needed.

The following programs provide easy access to and conversions between the various systems for measuring time. Because the celestial bodies are not fixed in space relative to Earth-centered coordinates, two programs also provide a means to update the positions of the stars over the years.

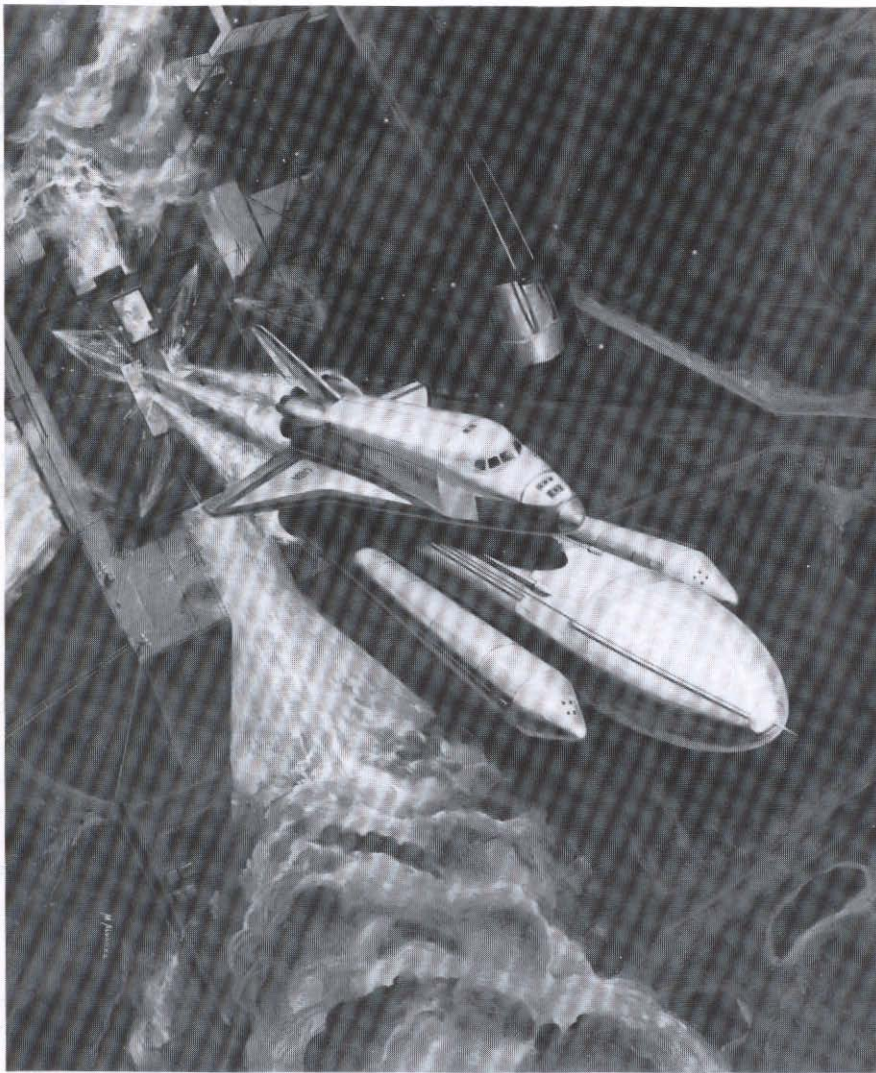


Photo Credit: Rockwell International Space Division

Mankind's need to measure time and establish calendars relied on careful observations of the heavens. The development of astronomy stimulated interest in other worlds and encouraged mankind to move out from Earth. In this painting a space shuttle lifts off the launch pad at the Kennedy Space Center in Florida, with main engines and solid rocket motors roaring. The space shuttle is the first reusable space vehicle, and it offers enormous potential for future manned operations in space.

Program 1: CALDR

Perpetual Calendar and Day of Week

All measurements of time have historically depended on astronomical observations—the day is measured from the rotation of Earth on its axis, the week approximates the changing phases of our Moon, the month is measured from the revolution of the Moon around Earth, and the year is measured from the revolution of Earth around the Sun.

Many ancient peoples, particularly the Babylonians, based their calendars on the cycles of the Moon, and the lunar measurement of years has been preserved in the modern Jewish, Chinese, and Moslem calendars. By contrast, the Egyptians based their calendars on the Sun, which also figured prominently in their religion. The Egyptian civilization depended upon the seasonal rising of the Nile, which was closely associated with the solar cycle. Ancient peoples determined the solar year by observing the helical rising of a bright star after it had been invisible because of the proximity of the Sun. Sirius was often used for this purpose. By averaging many such helical observations, the solar year was found to be very close to 365 days.

In ancient Rome, months were based on the lunar cycles. The pontifices watched for the first appearance of the thin crescent moon after the new moon so that they could declare the beginning of the new month. This first day, shouted from the steps of the Capitol, was termed *Kalendae*, which means *the calling*. Our word calendar is derived from this term.

Unfortunately for our measurement of time, the lunar cycle is not a whole number of days, nor is the time Earth takes to complete an orbit of the Sun relative to the stars. The Moon's cycle is 29.53059 days. Earth's orbit around the Sun takes 365.242196 . . . days. So 12 months are short of a year, and 13 months would give us a year that is too long. And our seven-day week (based on religion), although close to the lunar phases, is not a factor of the lunar period, the month, or the year.

When the Romans adopted the Egyptian solar year at the time of Julius Caesar, their own lunar-solar calendar was very much in error. Introduced to Rome by an astronomer, Sosigenes of Alexandria, the Egyptian calendar was ordered into official Roman use by Julius Caesar in 45 B.C. It was called the Julian calendar, and it was based on a solar year of 365.25 days. The year was divided into months, of which eleven contained 30 or 31 days and the twelfth had 28 days only. The first month was March and the last month was February. July is named after Julius Caesar and August after Augustus Caesar, both months being allocated the full 31 days, as befitted a caesar. The seventh month was named September, the eighth October, the ninth November, and the tenth December, after the Latin *septem*, *octo*, *novem*, and *decem*, for seven, eight, nine, and ten, respectively.

The Julian calendar lost approximately one-quarter day each year. This loss was corrected by adding an extra day to the twelfth month (February) every fourth year, which was the leap year. Nevertheless, this calendar gradually became out of step with the seasonal position of the Sun relative to the stars. The year of the Julian calendar was actually 11 minutes 4 seconds longer than the time it takes the apparent Sun to revolve to precisely the same position. By 1500 the error amounted to approximately 11 days. Christian religious festivities based on Easter assumed a fixed vernal equinox of March 21, and as a consequence they were becoming gradually out of step with the seasons. Accordingly, Pope Gregory XIII entrusted a reformation of the calendar to a German Jesuit, Christopher Schlüssel, whose latinized name was Clavius. (Clavius is immortalized by a large crater that bears his name near the Moon's south pole.) Clavius used a scheme devised by a Neapolitan astronomer, Aloysius Lilius, in which centuries would not be leap years unless perfectly divisible by 400. To correct the calendar, Pope Gregory ordered that October 15, 1582, should follow October 4. Despite protests from angry mobs, who thought that ten days of their lives were being stolen, the correction was made and the new calendar was called the Gregorian calendar. The new calendar also moved the beginning of the year from March 25 to January 1.

The Gregorian calendar was adopted by most of the Roman Catholic countries and by Denmark and the Netherlands in 1582. But it was nearly two centuries before it was generally accepted. During that time a traveler could leave England in February 1679, for example, and find that it was February 1680 in some parts of Europe and in Scotland. The day of the month was also different between England and some parts of Europe.

Finally, other countries began to accept the new calendar. The Protestants in Germany and Switzerland adopted it in 1700. Britain and the American colonies adopted the Gregorian calendar in 1752, omitting eleven days between September 2 and 14. Prussia began to use the new

calendar in 1778. Other countries followed—Ireland in 1782, Russia in 1902. Following the French Revolution, a new calendar was adopted in France, the first day of the year being September 22, 1792. This calendar was used until December 31, 1805, when France accepted the Gregorian calendar again.

Other calendars are still in use, however, particularly in regard to religious events. The Jewish calendar uses a lunar and a solar cycle. The months are lunar months, but they are about 11 days short of a solar year. A thirteenth month periodically has to be intercalated to maintain some synchronism with the solar cycle. The Moslem calendar ignores the solar cycle entirely and is tied to lunar cycles with alternate months of 30 and 29 days. The year begins at different seasons over a 32.5-year cycle. Prior to World War II there was an attempt among some businesses in Europe to introduce a 13-month calendar in which all months would have four weeks. This business calendar would have allowed more meaningful financial comparisons, but it did not receive wide acceptance.

The CALDR program offers several alternatives. You can choose to ask the computer to tell you the day of the week for any date, provide you with a calendar for any month of any year, or provide you with a calendar for the holidays of any year.

The program automatically adjusts for leap years. It adjusts all months of the calendar, the number of days from the beginning of the year to the beginning of each month, and the number of days remaining in the year at the end of any month, and it displays them as well.

The program starts by asking you to select one of the routines. If you select the calendar routine, it then asks you to select the month of the year that you wish to have displayed. It jumps to a subroutine that finds the day of the week for the first day of the year and then runs through the months to the month requested, which it displays on the screen. While the program could be simplified by jumping to the single month and finding the day of the week for the start of that month, the present form allows you to modify the program if you wish so that it would display a calendar for a whole year, month by month.

The routine to print the day of the week for any date is a standard routine.

The third routine displays the holidays in any year and is somewhat more complicated. It uses the day-of-the-week routine and a subroutine based on EASTR (Program 2). Since many holidays are based on actual dates, such as Christmas, the program easily adds the day of the week to the date. Other holidays, such as Thanksgiving, are related to a particular day of the week in a given month. The program ascertains the first Thursday (in the case of Thanksgiving) in the required month and then adds the appropriate number of weeks to find such holidays. Other holidays, such as

CALDR

```
10 HOME : PRINT
20 PRINT : PRINT
30 PRINT TAB( 10)"-----"
40 PRINT TAB( 10)"I    CALENDAR    I"
50 PRINT TAB( 10)"-----"
60 PRINT : PRINT : PRINT
70 PRINT TAB( 2)"A PERPETUAL CALENDAR, DAY-OF-WEEK,"
80 PRINT TAB( 7)"AND HOLIDAY PROGRAM"
90 PRINT : PRINT
100 PRINT TAB( 5)"BY ERIC BURGESS F.R.A.S."
110 FOR K = 1500 TO 0 STEP - 1: NEXT K
120 HOME
130 PRINT : PRINT : PRINT
140 DIM M(12)
150 PRINT "YOU CAN SELECT A CALENDAR FOR ANY MONTH"
160 PRINT "OR THE DAY OF THE WEEK FOR ANY DATE"
170 PRINT "OR THE HOLIDAYS FOR ANY YEAR."
180 PRINT : PRINT : PRINT
190 PRINT : PRINT : PRINT
200 PRINT "SELECT CALENDAR    (C)"
210 PRINT "    DAY OF WEEK (D)"
220 PRINT "    OR HOLIDAYS (H)"
230 PRINT : INPUT "TYPE C, D, OR H ";B$
240 IF B$ = "D" GOTO 1840
250 IF B$ = "H" GOTO 2250
260 IF B$ < > "C" THEN PRINT "INVALID ENTRY": PRINT : GOTO 230
270 HOME : PRINT : PRINT
280 GOTO 460
290 REM SUB TO SELECT MONTH FOR PRINTING
300 ON N GOTO 310,320,350,360,370,380,390,400,410,420,430,440
310 PRINT "JANUARY";: GOTO 450
320 IF LY = 1 THEN X = 1
330 IF H = 1 AND W < > N THEN GOTO 1180
340 PRINT "FEBRUARY";: GOTO 450
350 PRINT "MARCH";: GOTO 450
360 PRINT "APRIL";: GOTO 450
370 PRINT "MAY";: GOTO 450
380 PRINT "JUNE";: GOTO 450
390 PRINT "JULY";: GOTO 450
400 PRINT "AUGUST";: GOTO 450
410 PRINT "SEPTEMBER";: GOTO 450
420 PRINT "OCTOBER";: GOTO 450
430 PRINT "NOVEMBER";: GOTO 450
440 PRINT "DECEMBER";: GOTO 450
450 RETURN
460 PRINT : PRINT : PRINT
470 RESTORE
480 INPUT "YEAR REQUIRED ";Y
490 HOME : PRINT : PRINT : PRINT
500 IF Y > 1752 THEN 520
510 PRINT : PRINT "YEAR MUST BE AFTER 1752": GOTO 470
520 IF Y / 4 - INT (Y / 4) = 0 AND Y / 100 - INT (Y / 100) < > 0 THEN
LY = 1
530 PRINT : INPUT "MONTH REQUIRED ";W
```

CALDR (continued)

```

540 IF W < 1 OR W > 12 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 530
550 H = 1
560 GOTO 730
570 Q = 1: E = 1
580 GOSUB 600
590 GOTO 710
600 K = INT (0.6 + (1 / Q))
610 L = Y - K
620 O = Q + 12 * K
630 P = L / 100
640 Z1 = INT (P / 4): Z2 = INT (P): Z3 = INT ((5 * L) / 4)
650 Z4 = INT (13 * (O + 1) / 5)
660 Z = Z4 + Z3 - Z2 + Z1 + E - 1
670 Z = Z - (7 * INT (Z / 7)) + 1
680 IF B$ = "H" THEN RETURN
690 D = - (Z - 1)
700 RETURN
710 S = 0
720 DATA 0,31,28,31,30,31,30,31,31,30,31,30,31
730 HOME : PRINT : PRINT : PRINT : PRINT
740 Q = 1: E = 1: GOSUB 600
750 PRINT "CALENDAR FOR "; Y
760 FOR F = 1500 TO 0 STEP - 1: NEXT F
770 FOR N = 0 TO 12: READ M(N): NEXT N
780 FOR N = 1 TO 12
790 PRINT : PRINT : PRINT : PRINT : IF (N - 1) < > W GOTO 800
800 HOME : PRINT : PRINT "PLEASE WAIT"
810 S = S + M(N - 1)
820 IF M(N) < > 28 THEN 840
830 IF LY = 1 THEN 940
840 IF H = 1 AND W < > N THEN GOTO 320
850 IF LY = 1 AND H = 1 AND W > 2 THEN GOTO 870
860 GOTO 910
870 HOME : PRINT : PRINT
880 PRINT "- "; S + 1; TAB( 7);
890 IF H = 1 AND W < > N THEN GOTO 320
900 GOTO 980
910 HOME : PRINT : PRINT
920 PRINT "- "; S; TAB( 7);
930 GOTO 980
940 IF H = 1 AND W < > N THEN GOTO 320
950 HOME : PRINT : PRINT
960 PRINT "- "; 31; TAB( 7): S = S + 1
970 V = 0
980 FOR I = 1 TO 10: PRINT "-";: NEXT I
990 IF H = 1 GOTO 1700
1000 GOSUB 300
1010 GOTO 1160
1020 PRINT "JANUARY";: GOTO 1160
1030 IF LY = 1 THEN X = 1
1040 IF H = 1 AND W < > N GOTO 1180
1050 PRINT "FEBRUARY";: GOTO 1160
1060 PRINT "MARCH";: GOTO 1160
1070 PRINT "APRIL";: GOTO 1160
1080 PRINT "MAY";: GOTO 1160

```

CALDR (continued)

```
1090 PRINT "JUNE";: GOTO 1160
1100 PRINT "JULY";: GOTO 1160
1110 PRINT "AUGUST";: GOTO 1160
1120 PRINT "SEPTEMBER";: GOTO 1160
1130 PRINT "OCTOBER";: GOTO 1160
1140 PRINT "NOVEMBER";: GOTO 1160
1150 PRINT "DECEMBER";: GOTO 1160
1160 FOR I = 1 TO 10: PRINT "-";: NEXT I
1170 PRINT " ";
1180 IF H = 1 AND W < > N GOTO 1290
1190 IF LY = 1 THEN GOTO 1220
1200 PRINT 365 - S;" -";
1210 GOTO 1290
1220 IF LY = 1 AND H = 1 AND W > 2 THEN 1280
1230 IF M(N) < > 28 THEN GOTO 1260
1240 PRINT 335;" -";
1250 GOTO 1290
1260 PRINT 366 - S;" -";
1270 GOTO 1290
1280 PRINT 366 - S - 1;" -";
1290 REM PRINT HEADING OF DAYS OF WEEK
1300 IF H = 1 AND W < > N THEN GOTO 1350
1310 PRINT CHR$(10)
1320 PRINT : PRINT " S      M      T      W      T      F      S"
1330 PRINT
1340 FOR I = 1 TO 40: PRINT "-";: NEXT I
1350 FOR C = 1 TO 6
1360 IF N < > W THEN 1380
1370 PRINT
1380 IF H = 1 AND W < > N THEN GOTO 1400
1390 PRINT TAB(2)
1400 FOR G = 1 TO 7
1410 D = D + 1
1420 IF N > 2 AND LY = 1 AND H = 1 THEN GOTO 1440
1430 IF N > 1 AND LY = 1 THEN GOTO 1460
1440 D2 = D - S
1450 GOTO 1470
1460 D2 = D - (S - 1)
1470 IF D2 > M(N) + X THEN GOTO 1550
1480 IF H = 1 AND W < > N THEN GOTO 1520
1490 IF LY = .1 AND N > 2 THEN D2 = D2 - 1
1500 IF D2 > 0 THEN PRINT D2;
1510 PRINT TAB(2 + 6 * G);
1520 NEXT G
1530 IF D2 = M(N) + X THEN GOTO 1560
1540 NEXT C
1550 D = D - G
1560 IF H = 1 AND W < > N THEN GOTO 1600
1570 PRINT : PRINT
1580 INPUT "PRESS RETURN TO CONTINUE ";A$
1590 GOTO 1630
1600 NEXT N
1610 IF H = 1 AND W < > N THEN GOTO 1630
1620 FOR I = 1 TO 6: PRINT ;: NEXT I
1630 PRINT : PRINT
```

CALDR (continued)

```
1640 HOME : PRINT : PRINT : PRINT
1650 INPUT "WANT TO RETURN TO MENU? Y/N ";A$
1660 PRINT
1670 IF A$ = "Y" THEN CLEAR : GOTO 120
1680 IF A$ < > "N" THEN 1650
1690 GOTO 1820
1700 IF W = 1 THEN 1020
1710 IF W = 2 THEN 1030
1720 IF W = 3 THEN 1060
1730 IF W = 4 THEN 1070
1740 IF W = 5 THEN 1080
1750 IF W = 6 THEN 1090
1760 IF W = 7 THEN 1100
1770 IF W = 8 THEN 1110
1780 IF W = 9 THEN 1120
1790 IF W = 10 THEN 1130
1800 IF W = 11 THEN 1140
1810 IF W = 12 THEN 1150
1820 HOME
1830 GOTO 2230
1840 PRINT
1850 HOME
1860 PRINT : PRINT : PRINT
1870 J$(1) = "SUNDAY"
1880 J$(2) = "MONDAY"
1890 J$(3) = "TUESDAY"
1900 J$(4) = "WEDNESDAY"
1910 J$(5) = "THURSDAY"
1920 J$(6) = "FRIDAY"
1930 J$(7) = "SATURDAY"
1940 IF HY = 1 THEN GOTO 2020
1950 HOME : PRINT : PRINT : PRINT
1960 PRINT : PRINT : PRINT
1970 PRINT "ENTER DATE"
1980 PRINT : PRINT
1990 INPUT " THE YEAR ";Y
2000 INPUT " THE MONTH ";M
2010 INPUT " THE DAY ";D
2020 Q = M:E = D
2030 IF HY = 1 THEN GOTO 2080
2040 IF Y > 1752 THEN GOTO 2080
2050 HOME : PRINT : PRINT : PRINT
2060 PRINT "YEAR MUST BE AFTER 1752"
2070 GOTO 1950
2080 GOSUB 600
2090 IF HY = 1 THEN RETURN
2100 HOME : PRINT : PRINT : PRINT
2110 VTAB 10
2120 PRINT Y;"", "M;", "E
2130 PRINT
2140 PRINT ".....IS A ";J$(Z)
2150 PRINT : PRINT : PRINT
2160 INPUT "WANT ANOTHER DATE? Y/N ";D$
2170 IF D$ = "Y" THEN GOTO 1950
2180 IF D$ = "N" THEN GOTO 2200
```

CALDR (continued)

```

2190 PRINT "INVALID RESPONSE ": PRINT : GOTO 2160
2200 PRINT : INPUT "WANT TO RETURN TO MENU? Y/N ";C$
2210 IF C$ = "Y" THEN CLEAR : GOTO 120
2220 IF C$ < > "N" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 2200
2230 HOME
2240 END
2250 REM HOLIDAY ROUTINES
2260 HOME : PRINT : PRINT
2270 INPUT "YEAR REQUIRED ";Y$:Y = VAL (Y$)
2280 IF Y / 4 - INT (Y / 4) = 0 AND Y / 100 - INT (Y / 100) < > 0 THEN
LY = 1
2290 REM GET DAY OF FIRST DAY OF YEAR
2300 D = 1:M = 1:HY = 1: GOSUB 1870
2310 HOME
2320 PRINT
2330 PRINT "FOR YEAR ";Y;" THE HOLIDAYS ARE ..."
2340 PRINT
2350 PRINT "NEW YEAR'S DAY.....";J$(Z);", ";
2360 PRINT TAB( 30)"JAN. 1"
2370 REM LINCOLN'S BIRTHDAY
2380 M = 2:D = 12
2390 GOSUB 2020
2400 PRINT "LINCOLN'S BIRTHDAY ";J$(Z);", ";
2410 PRINT TAB( 30)"FEB.12"
2420 REM WASHINGTON'S BIRTHDAY
2430 M = 2:ZW = 2:D = 1
2440 GOSUB 2020
2450 IF Z < > ZW THEN D = D + 1: GOTO 2440
2460 D = D + 14
2470 PRINT "WASHINGTON'S B'DAY MONDAY,";
2480 PRINT TAB( 30)"FEB.";D
2490 REM VALENTINE'S DAY
2500 D = 14:M = 2: GOSUB 2020
2510 PRINT "VALENTINE'S DAY ";J$(Z);", ";
2520 PRINT TAB( 30)"FEB.14"
2530 REM ASH WEDNESDAY
2540 GOSUB 3220
2550 D = D - 46
2560 IF M = 4 THEN D = D + 31:M = 3: GOTO 2590
2570 IF LY = 1 AND M = 3 THEN D = D + 29:M = 2: GOTO 2590
2580 IF M = 3 THEN D = D + 28:M = 2
2590 IF LY = 1 AND D < 1 THEN D = D + 29:M = 3: GOTO 2610
2600 IF D < 1 THEN D = D + 28:M = 2
2610 GOSUB 3480
2620 PRINT "ASH WEDNESDAY WEDNESDAY,"; TAB( 30)M$;D
2630 D = 17:M = 3: GOSUB 2020
2640 PRINT "ST.PATRICK'S DAY ";J$(Z);", "; TAB( 30)"MAR.17"
2650 REM EASTER
2660 GOSUB 3220
2670 MX = M
2680 DF = D - 2
2690 IF DF < 1 THEN M = M - 1:DF = DF - 31
2700 GOSUB 3480
2710 PRINT "GOOD FRIDAY FRIDAY, "; TAB( 30)M$;DF
2720 M = MX

```

CALDR (continued)

```

2730 PRINT "EASTER SUNDAY          SUNDAY, "; TAB( 30)M$;D
2740 REM MOTHER'S DAY
2750 M = 5:ZW = 1:D = 1
2760 GOSUB 2020
2770 IF Z < > ZW THEN D = D + 1: GOTO 2760
2780 D = D + 7
2790 PRINT "MOTHER'S DAY          SUNDAY, "; TAB( 30)"MAY ";D
2800 D = 1:M = 5:ZW = 2
2810 GOSUB 2020
2820 IF Z < > ZW THEN D = D + 1: GOTO 2810
2830 D = D + 28
2840 IF D > 31 THEN D = D - 7
2850 PRINT "MEMORIAL DAY          MONDAY, " TAB( 30)"MAY ";D
2860 D = 4:M = 7: GOSUB 2020
2870 PRINT "INDEPENDENCE DAY     ";J$(Z);", "; TAB( 30)"JUL. 4"
2880 REM LABOR DAY
2890 M = 9:ZW = 2:D = 1
2900 GOSUB 2020
2910 IF Z < > ZW THEN D = D + 1: GOTO 2900
2920 PRINT "LABOR DAY            MONDAY, "; TAB( 30)"SEP.";D
2930 REM COLUMBUS DAY
2940 M = 10:ZW = 2:D = 1
2950 GOSUB 2020
2960 IF Z < > ZW THEN D = D + 1: GOTO 2950
2970 D = D + 7
2980 PRINT "COLUMBUS DAY          MONDAY, "; TAB( 30)"OCT.";D
2990 D = D - 9: IF D < 2 THEN D = D + 7
3000 PRINT "ELECTION DAY         TUESDAY, "; TAB( 30)"NOV.";D
3010 D = 11:M = 11: GOSUB 2020
3020 PRINT "VETERAN'S DAY       ";J$(Z);", "; TAB( 30)"NOV.11"
3030 REM THANKSGIVING
3040 M = 11:ZW = 5:D = 1
3050 GOSUB 2020
3060 IF Z < > ZW THEN D = D + 1: GOTO 3050
3070 D = D + 21
3080 PRINT "THANKSGIVING          THURSDAY, "; TAB( 30)"NOV.";D
3090 REM CHRISTMAS
3100 D = 25:M = 12
3110 GOSUB 2020
3120 PRINT "CHRISTMAS DAY          ";J$(Z);", "; TAB( 30)"DEC.25"
3130 D = 26:M = 12
3140 GOSUB 2020
3150 PRINT "BOXING DAY            ";J$(Z);", "; TAB( 30)"DEC.26"
3160 PRINT
3170 PRINT
3180 INPUT "WANT TO RETURN TO MENU? Y/N ";A$
3190 IF A$ = "Y" THEN CLEAR : GOTO 120
3200 IF A$ < > "N" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 3180
3210 GOTO 2230
3220 REM SUB TO CALC D AND M FOR EASTER SUNDAY
3230 N = Y - 1900
3240 A = N / 19
3250 A = 19 * (A - INT (A))
3260 B = INT ((7 * A + 1) / 19)
3270 M = 0

```


CALDR (continued)

```
3280 M = (11 * A + 4.00001 - B) / 29
3290 X = M - INT (M)
3300 IF X = 1 THEN GOTO 3330
3310 IF X < > 1 THEN M = 29 * X
3320 GOTO 3340
3330 M = 0
3340 Q = INT (N / 4)
3350 W = (N + Q + 31 - M) / 7
3360 W = 7 * (W - INT (W))
3370 W = INT (W)
3380 DE = INT (25 - M - W)
3390 IF DE > 0 THEN M = 4
3400 IF DE < 0 THEN M = 3
3410 IF DE = 0 THEN M = 3: D = 31
3420 IF DE < - 9 THEN DE = DE + 9: GOTO 3420
3430 IF DE < 0 THEN D = 31 - ABS (DE)
3440 IF DE > 0 THEN D = DE
3450 IF Y = 1974 OR Y = 1984 THEN D = D + 7
3460 IF Y = 1994 THEN D = D + 7 - 31: M = 4
3470 RETURN
3480 IF M = 1 THEN M$ = "JAN.": RETURN
3490 IF M = 2 THEN M$ = "FEB.": RETURN
3500 IF M = 3 THEN M$ = "MAR.": RETURN
3510 IF M = 4 THEN M$ = "APR.": RETURN
3520 IF M = 5 THEN M$ = "MAY ": RETURN
3530 IF M = 6 THEN M$ = "JUN.": RETURN
3540 IF M = 7 THEN M$ = "JUL.": RETURN
3550 IF M = 8 THEN M$ = "AUG.": RETURN
3560 IF M = 9 THEN M$ = "SEP.": RETURN
3570 IF M = 10 THEN M$ = "OCT.": RETURN
3580 IF M = 11 THEN M$ = "NOV.": RETURN
3590 IF M = 12 THEN M$ = "DEC.": RETURN
```

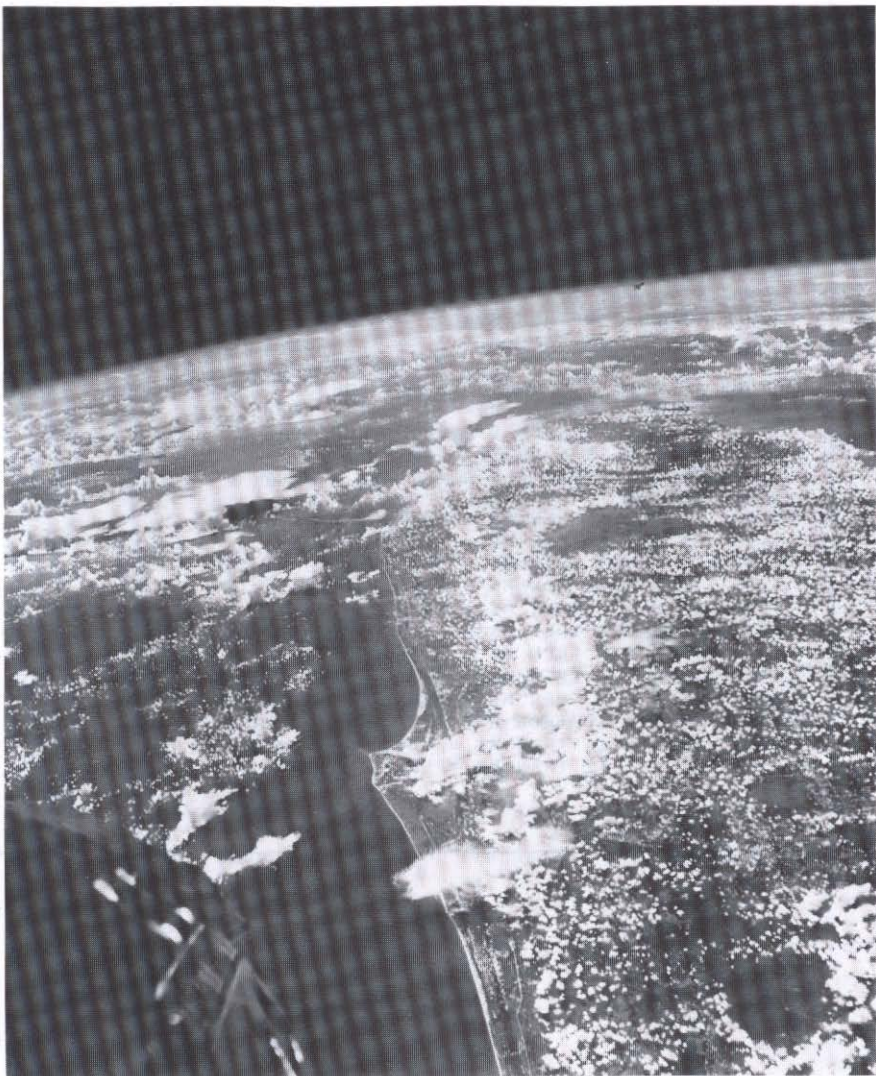


Photo Credit: NASA

Astronauts leaving Earth see the launch site on the Florida coastline and the distant curvature of Earth's horizon. Views like this put a new perspective on our planet and our attitude toward it.

Program 2: EASTR

Date of Easter Sunday for Any Year _____

The date of Easter is very important in the Christian ecclesiastical calendar. It governs events over almost a third of each year, from Septuagesima Sunday (nine weeks before Easter Sunday) to Trinity Sunday (eight weeks after).

The date of Easter Sunday is derived astronomically. At first Easter was synchronized with the Jewish Passover, but this, although accepted by the Eastern Church, was rejected by the Church in Rome. In the year 325 it was decreed at the Council of Nicaea that Easter should be celebrated on the same date by all Christians. That date was decided to be the first Sunday following the first full moon on or after the vernal (spring) equinox. The vernal equinox occurs when the Sun passes the point at which the ecliptic crosses Earth's equatorial plane from south to north. At the time of the Council of Nicaea, the vernal equinox was assumed to be fixed at March 21.

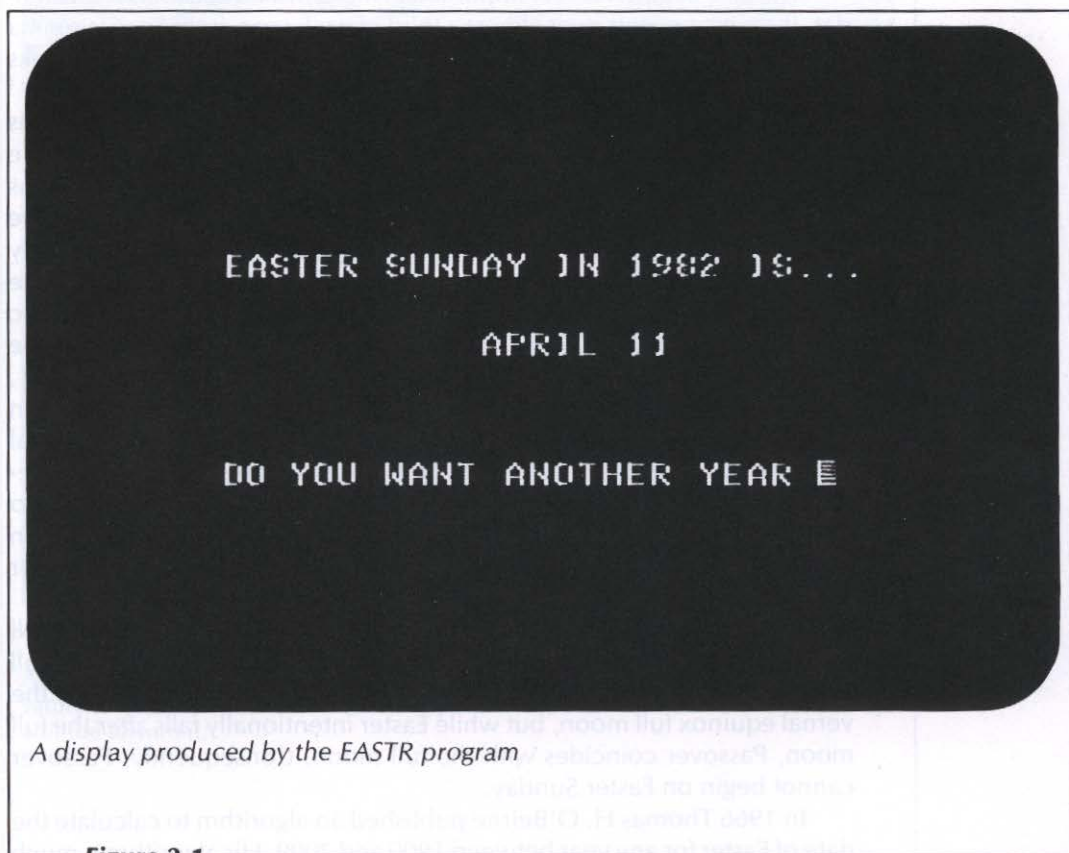
As mentioned in connection with the CALDR program, the old Julian calendar had a year that was too long. By the sixteenth century the vernal equinox was actually occurring on March 11, not March 21. Thus the celebration of Easter would inevitably move toward the summer season. To stop this, Pope Gregory XIII introduced his revised calendar to maintain the Easter celebration in the spring season and to maintain a better approximation of the solar year.

Today Easter Sunday is calculated as the Sunday following the first full moon after the vernal equinox, which occurs on March 21. It can thus fall as early as March 22 or as late as April 25. Passover is also governed by the vernal equinox full moon, but while Easter intentionally falls *after* the full moon, Passover coincides with the full moon. Consequently, Passover cannot begin on Easter Sunday.

In 1966 Thomas H. O'Beirne published an algorithm to calculate the date of Easter for any year between 1900 and 2099. His algorithm is much

simpler than the complex algorithms developed in the early 1800s by Gauss. Gauss's theories for the congruence of numbers allowed calendrical problems to be solved, but some of his theories were quite complex and required special rules to allow for exceptions. The O'Beirne algorithm, which works for two centuries only in the form used in this book, divides the year by 19 and a multiple of the remainder by 19. Then it uses a multiple of that remainder for another division and further manipulates the remainders. This short program uses the O'Beirne algorithm (instructions 170 through 320). It quickly provides the date of Easter Sunday for any year between 1900 and 2099. However, even this algorithm needs to be corrected for certain years (1974, 1984, and 1994). The date given by the program has been adjusted by adding 7 days to the date for Easter 1974 and 1984. For Easter 1994 the date has been adjusted by adding 7 days, subtracting 31 days, and changing the month to April.

The listing for the EASTR program follows.



A display produced by the EASTR program

Figure 2.1

EASTR

```

10 HOME
20 PRINT : PRINT : PRINT : PRINT
30 PRINT "THIS PROGRAM CALCULATES THE DATE"
40 PRINT "OF EASTER SUNDAY FOR ANY YEAR"
50 PRINT "    BETWEEN 1900 AND 2099"
60 PRINT : PRINT : PRINT
70 PRINT "    BY ERIC BURGESS F.R.A.S."
80 PRINT : PRINT
90 PRINT TAB( 6)"ALL RIGHTS RESERVED BY"
100 PRINT TAB( 6)"S & T SOFTWARE SERVICES"
110 FOR J = 3000 TO 1 STEP - 1: NEXT
120 HOME : PRINT : PRINT : PRINT : PRINT
130 INPUT "YEAR REQUIRED ";Y$
140 Y = VAL (Y$)
150 IF Y < 1900 OR Y > 2099 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 130
160 IF Y = 0 THEN PRINT "INVALID RESPONSE" PRINT : GOTO 130
170 N = Y - 1900
180 A = N / 19
190 A = 19 * (A - INT (A))
200 B = INT ((7 * A + 1) / 19)
210 M = 0
220 M = (11 * A + 4.00001 - B) / 29
230 X = M - INT (M)
240 IF X = 1 THEN GOTO 270
250 IF X < > 1 THEN M = 29 * X
260 GOTO 280
270 M = 0
280 Q = INT (N / 4)
290 W = (N + Q + 31 - M) / 7
300 W = 7 * (W - INT (W))
310 W = INT (W)
320 DE = INT (25 - M - W)
330 HOME
340 PRINT : PRINT : PRINT : PRINT : PRINT
350 PRINT TAB( 5)"EASTER SUNDAY IN ";Y;" IS..."
360 PRINT : PRINT : PRINT TAB( 15);
370 IF DE > 0 THEN M$ = "APRIL"
380 IF DE < 0 THEN M$ = "MARCH"
390 IF DE = 0 THEN PRINT "MARCH 31": GOTO 460
400 IF DE < - 9 THEN DE = DE + 9: GOTO 400
410 IF DE < 0 THEN D = 31 - ABS (DE)
420 IF DE > 0 THEN D = DE
430 IF Y = 1974 OR Y = 1984 THEN D = D + 7
440 IF Y = 1994 THEN D = D + 7 - 31:M$ = "APRIL"
450 PRINT " ";M$;" ";D
460 FOR J = 2000 TO 1 STEP - 1: NEXT
470 PRINT : PRINT : PRINT : PRINT
480 PRINT TAB( 5)"";
490 INPUT "DO YOU WANT ANOTHER YEAR ";A$
500 IF A$ = "y" THEN GOTO 120
510 IF A$ < > "n" THEN PRINT "INVALID REPLY": GOTO 490
520 HOME
530 END

```

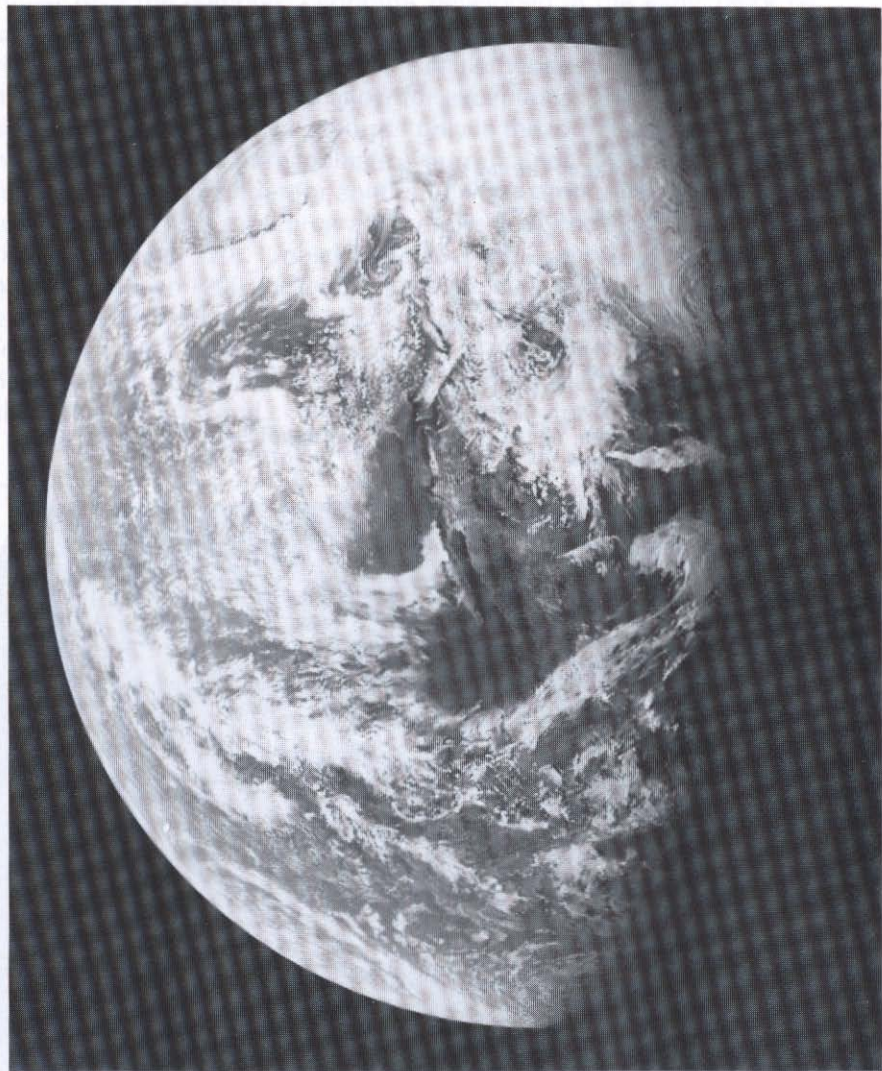


Photo Credit: NASA/Johnson

Our perspective changes when we see Earth from space. Our blue-green planet becomes an astronomical body like the other worlds of space. Watching our planet spin on its axis gave a new dimension to our measurement of time. This photograph was obtained by the astronauts in Apollo 13 on their journey home from the Moon. It shows the southwestern United States through a great clearing of the cloud deck surrounding our planet. Part of Mexico, the peninsula of Baja California, and the Gulf of California are also clearly visible.

Program 3: TIMES

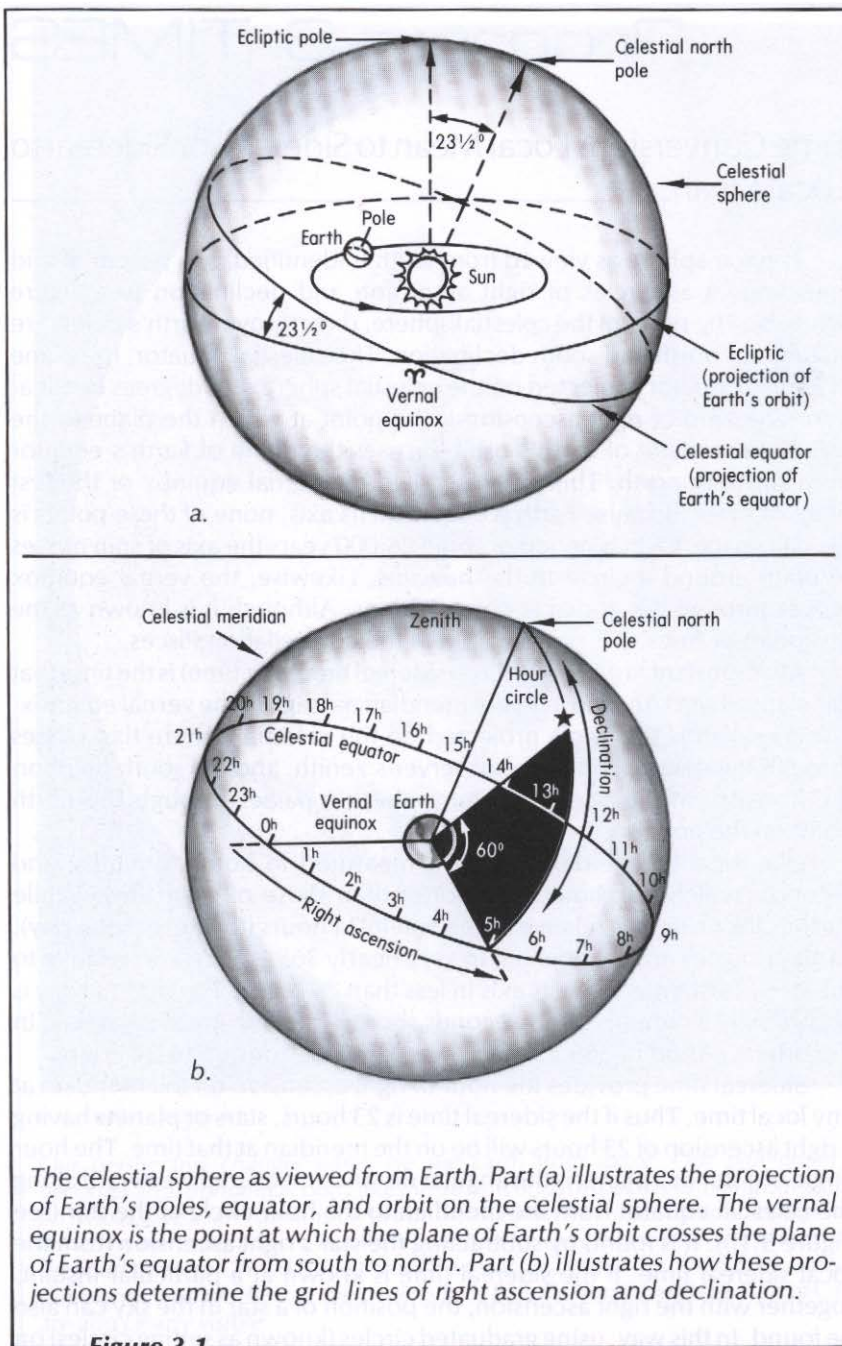
Time Conversion: Local Mean to Sidereal, or Sidereal to Local Mean

The star sphere as viewed from Earth is identified by a system of grid lines known as circles of right ascension and declination (see Figure 3.1a–b). The poles of the celestial sphere, directly over Earth's poles, are 90 degrees north and south declination. The celestial equator, the plane of Earth's equator projected on the celestial sphere, is 0 degrees declination. The zero of right ascension is the point at which the plane of the ecliptic (the plane of Earth's orbit) crosses the plane of Earth's equator from south to north. This point is called the vernal equinox or the first point of Aries. Because Earth wobbles on its axis, none of these points is fixed in space. Over a period of some 26,000 years the axis of spin moves to point around a circle in the heavens. Likewise, the vernal equinox moves through the zodiacal constellations. Although it is known as the first point of Aries, it is now located in the constellation Pisces.

At any instant, a given locality's sidereal time (star time) is the time that has elapsed since the most recent meridian passage of the vernal equinox. The meridian is the circle projected on the celestial sphere that passes through the celestial pole, the observer's zenith, and the south point on the horizon. In the Southern Hemisphere it passes through the north point on the horizon.

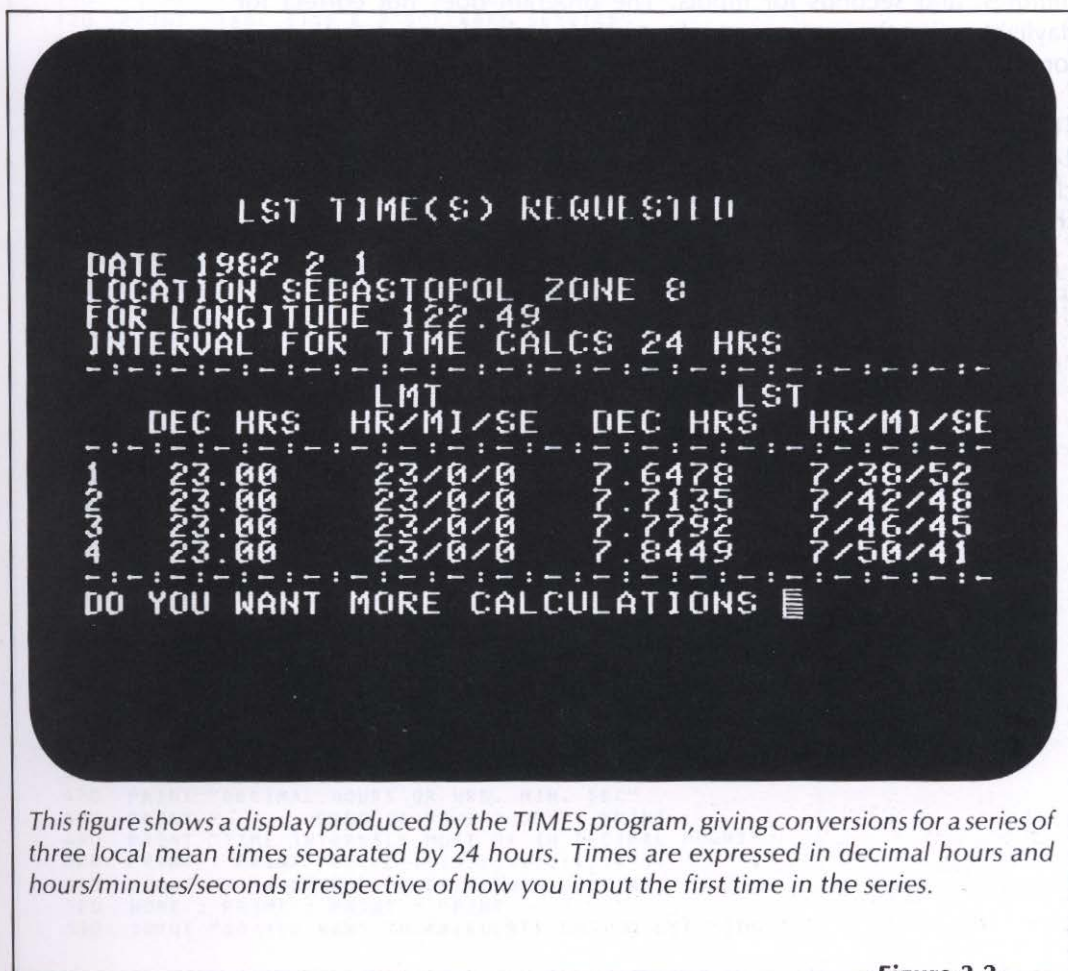
Like local time, sidereal time is measured in hours, minutes, and seconds, which are, however, shorter than those of solar time. While Earth spins on its axis relative to the Sun in 24 hours (the mean solar day), Earth also goes around the Sun in very nearly 365.25 days. So relative to the stars, Earth rotates on its axis in less than 24 hours. The sidereal day is accordingly 3 minutes 55.91 seconds shorter than the mean solar day. In the orbital period of 365.25 days this difference adds up to 24 hours.

Sidereal time provides the hour of right ascension on the meridian at any local time. Thus if the sidereal time is 23 hours, stars or planets having a right ascension of 23 hours will be on the meridian at that time. The hour angle of a star or a planet is the angular distance measured westward along the celestial equator from the meridian to the hour circle of the star (see Figure 3.1b). It is found by subtracting the star's right ascension from the local sidereal time. If the sidereal time is known at a particular instant, together with the right ascension, the position of a star in the sky can also be found. In this way, using graduated circles (known as setting circles) on



the axes of an equatorially mounted telescope, astronomers can direct a telescope to point toward faint objects whose right ascension and declination are given in star atlases.

This program computes local sidereal time given local clock time, or vice versa. It applies worldwide; you can enter location parameters (time zone, town name, longitude) each time you run the program, or you can set up your local parameters when you key in the program (instruction 190) and change them when asked during a run, still leaving your own locality permanently in the program. This would be useful if you wish to compute time for some other locality, such as a vacation observing site. A typical display produced by this program is shown in Figure 3.2.



This figure shows a display produced by the TIMES program, giving conversions for a series of three local mean times separated by 24 hours. Times are expressed in decimal hours and hours/minutes/seconds irrespective of how you input the first time in the series.

Figure 3.2

The program asks for your time zone and longitude and applies a correction to clock time to take into account your location within your time zone. You can convert between universal time (U.T.) and sidereal time at 0 longitude by entering time zone 0 and longitude 0 when asked. The program can be modified easily if you wish to accept longitude only, ignoring the time zone. Alternatively, you can have it ignore longitude and calculate times more approximately from the time zone input only. This also applies to other programs in this book where both time zone and longitude are shown as inputs.

Times are computed within a few seconds' accuracy, suitable for setting circles on equatorial mounts. You can use decimal hours or hours, minutes, and seconds for inputs. The program does not correct for daylight saving time; you must adjust inputs and outputs when this is in force at your locality or at the locality for which you are computing data.

The program is written for and tested on an Apple II. If you are using a TRS-80, substitute CLS for HOME to clear the screen (in instructions 20, 140, 270, etc.). For other computers you must use an ASCII instruction to clear the screen, such as PRINT CHR\$(12) or CHR\$(24). TRS-80 users also should substitute the ENTER key for the RETURN key in instruction 510.

The listing of the TIMES program follows.

```
DO YOU WANT MORE TIME INFORMATION? (Y/N)
TIME INFORMATION
UNIVERSAL TIME (UT)
LOCAL TIME
LONGITUDE
TIME ZONE
DO YOU WANT MORE TIME INFORMATION? (Y/N)
```

TIMES

```

10 FLG = 0
20 HOME : PRINT : PRINT : PRINT
30 PRINT : PRINT : PRINT
40 PRINT TAB( 12)"TIME CONVERSIONS"
50 PRINT
60 PRINT TAB( 10)"A COMPUTER PROGRAM"
70 PRINT TAB( 12)"FOR ASTRONOMERS"
80 PRINT
90 PRINT TAB( 8)"BY ERIC BURGESS F.R.A.S."
100 PRINT
110 PRINT TAB( 8)"ALL RIGHTS RESERVED BY"
120 PRINT TAB( 8)"S & T SOFTWARE SERVICE"
130 FOR J = 3000 TO 1 STEP - 1: NEXT
140 HOME : PRINT : PRINT : PRINT
150 REM SET INITIAL CONDITIONS ZN TIME ZONE
160 REM - IF EAST OF GREENWICH L$ NAME OF
170 REM YOUR LOCALITY LO IS LONGITUDE - IF EAST
180 REM EXAMPLE IS FOR WEST COAST
190 ZN = 8:L$ = "SEBASTOPOL":LO = 122.49
200 PRINT "INITIAL CONDITIONS SET FOR "L$
210 : PRINT : PRINT TAB( 10)"TIME ZONE ";ZN
220 PRINT TAB( 10)"LONGITUDE ";LO
230 PRINT
240 INPUT "DO YOU WANT TO CHANGE CONDITIONS (Y/N) ";A$
250 IF A$ = "N" THEN 330
260 IF A$ < > "Y" THEN PRINT "INVALID REPLY": PRINT : GOTO 240
270 HOME : PRINT : PRINT
280 INPUT "LOCATION NAME ";L$
290 INPUT "TIME ZONE ";ZN$
300 ZN = VAL (ZN$)
310 INPUT "LONGITUDE ";LO$
320 LO = VAL (LO$)
330 HOME : PRINT : PRINT : PRINT
340 Z = ZN
350 IF FLG = 1 THEN 820
360 A$ = "":A1$ = "":A2$ = "":A3$ = ""
370 PRINT "PROGRAM COMPUTES LOCAL MEAN TIME (LMT)"
380 PRINT
390 PRINT " WHEN GIVEN LOCAL SIDEREAL TIME (LST)"
400 PRINT
410 PRINT "OR LOCAL SIDEREAL TIME WHEN GIVEN"
420 PRINT " LOCAL MEAN TIME"
430 PRINT
440 PRINT "AND YOU CAN REQUEST CALCULATIONS"
450 PRINT "FOR A NUMBER OF TIME INTERVALS": PRINT
460 PRINT "TIME MAY BE ENTERED AND DISPLAYED IN"
470 PRINT "DECIMAL HOURS OR HRS. MIN. SEC"
480 PRINT " USING 24 HOUR CLOCK": PRINT
490 PRINT "TIME INTERVALS MUST BE IN DECIMAL HOURS"
500 PRINT : PRINT ":::::::::::::::::::"
510 INPUT "TO CONTINUE PRESS RETURN KEY";A$
520 HOME : PRINT : PRINT : PRINT
530 INPUT "DO YOU WANT TO CALCULATE LMT OR LST ";T$

```

TIMES (continued)

```

540 PRINT : IF T$ = "LMT" GOTO 570
550 IF T$ = "LST" GOTO 570
560 PRINT "INVALID REPLY": PRINT : GOTO 530
570 PRINT "ENTER THE DATE ": PRINT
580 INPUT "THE YEAR ";YD$:Y = VAL (YD$)
590 IF Y = 0 THEN PRINT "INVALID REPLY": PRINT : GOTO 580
600 IF Y > 1800 GOTO 650
610 PRINT "IS ";Y;" THE CORRECT YEAR"
620 INPUT Y$
630 IF Y$ = "Y" THEN 650
640 IF Y$ = "N" THEN PRINT : GOTO 570
650 PRINT : INPUT "THE MONTH ";MD$:M = VAL (MD$)
660 IF M = 0 OR M > 12 THEN PRINT "INVALID REPLY": PRINT : GOTO 650
670 PRINT : INPUT "THE DAY ";DD$:D = VAL (DD$)
680 IF D = 0 OR D > 31 THEN PRINT "INVALID REPLY": PRINT : GOTO 670
690 IF M = 2 AND D > 29 THEN PRINT "INVALID REPLY": PRINT : GOTO 670
700 PRINT : PRINT
710 INPUT "WANT TO SEE LOCATION CONDITIONS? ";A$
720 IF A$ = "Y" THEN 750
730 IF A$ = "N" THEN 790
740 PRINT "INVALID REPLY": PRINT : GOTO 710
750 PRINT "LOCATION CONDITIONS ARE..."
760 PRINT "   LOCATION NAME... ";L$
770 PRINT "   TIME ZONE..... ";ZN
780 PRINT "   LONGITUDE..... ";LO
790 PRINT
800 INPUT "DO YOU WANT TO CHANGE THEM ";A5$
810 IF A5$ = "Y" THEN FLG = 1: GOTO 270
820 FLG = 0
830 GOSUB 1650
840 IF T$ = "LST" THEN U$ = "LMT": GOTO 860
850 U$ = "LST"
860 GOSUB 1900
870 INPUT "SPECIFY NUMBER OF CALCULATIONS ";NO
880 PRINT : INPUT "AND TIME INTERVALS ";IN
890 HOME
900 REM CALCS FOR DAYS FROM EPOCH
910 EP = 722895: GOSUB 1950:DE = DG:ND = DE - EP
920 REM CALC AND PRINT TIME TABLE
930 PRINT TAB( 8)T$;" TIME(S) REQUESTED": PRINT
940 TC = .065753
950 PRINT "DATE ";Y;" ";M;" ";D
960 PRINT "LOCATION ";L$;" ZONE ";ZN - LGC / 15
970 PRINT "FOR LONGITUDE ";LO
980 PRINT "INTERVAL FOR TIME CALCS ";IN;" HRS"
990 PRINT ":-:--:-:--:-:--:-:--:-:--:-:--:-:--:-:--:-:--:-:--:-:"
1000 PRINT "        ";U$;"        ";T$
1010 PRINT "   DEC HRS HR/MI/SE   DEC HRS HR/MI/SE"
1020 PRINT ":-:--:-:--:-:--:-:--:-:--:-:--:-:--:-:--:-:--:-:"
1030 FOR K = 1 TO NO
1040 H1 = INT (T1):M1 = INT ((T1 - H1) * 100)
1050 S1 = INT (((T1 - H1) * 100) - M1) * 100
1060 GOSUB 1230
1070 IF INT (T2) > 24 THEN T2 = T2 - 24: GOTO 1080
1080 H2 = INT (T2):M2 = INT ((T2 - H2) * 100)

```

TIMES (continued)

```

1090 S2 = INT (((T2 - H2) * 100) - M2) * 100)
1100 HR2 = INT (T2):MI2 = (T2 - INT (T2)) * 60
1110 SE2 = (MI2 - INT (MI2)) * 60:SE2 = INT (SE2)
1120 MI2 = INT (MI2):GOSUB 2050
1130 H1$ = STR$ (H1):M1$ = STR$ (M1):S1$ = STR$ (S1):P$ = "."
1140 HA$ = H1$ + P$ + M1$ + S1$
1150 H2$ = STR$ (H2):M2$ = STR$ (M2):S2$ = STR$ (S2)
1160 HB$ = H2$ + P$ + M2$ + S2$
1170 PRINT K; TAB( 5);HA$; TAB( 14)RR;"/";IM;"/";ES;
1180 PRINT TAB( 23);HB$; TAB( 32)HR2;"/";MI2;"/";SE2
1190 T1 = T1 + IN
1200 IF T1 > 24 THEN T1 = T1 - 24:ND = ND + 1: GOTO 1200
1210 NEXT K
1220 GOTO 1450
1230 REM PARAMETERS FOR TIME CALCS
1240 REM GMST AT EPOCH 1979 MARCH 22
1250 GC = 11.927485
1260 REM DAILY RATE OF CHANGE OF GMST
1270 TC = .065711
1280 IF T$ = "LMT" THEN 1370
1290 REM CONVERSION TO LST
1300 T2 = TC * ND + GC + (((ZN + T1) / 24) * TC) + T1
1310 REM CONVERSION FOR NON MID TIME ZONE
1320 T2 = T2 + (.0656667 * LGC)
1330 IF T2 > 24 THEN T2 = T2 - 24: GOTO 1330
1340 IF T2 < - 24 THEN T2 = T2 + 24: GOTO 1340
1350 IF T2 < 0 THEN T2 = T2 + 24
1360 RETURN
1370 REM CONVERSION TO LMT
1380 T2 = T1 - (TC * ND + GC) - (ZN / 24 * TC)
1390 REM CONVERSION TO NON MID TIME ZONE
1400 T2 = T2 - (.0656667 * LGC)
1410 IF T2 < 0 THEN T2 = T2 + 24: GOTO 1410
1420 IF T2 > 24 THEN T2 = T2 - 24: GOTO 1420
1430 T2 = T2 - (T2 / 24 * TC)
1440 RETURN
1450 PRINT "-:--:--:--:--:--:--:--:--:--:--:--:--:--"
1460 INPUT "DO YOU WANT MORE CALCULATIONS ";A$
1470 HOME : PRINT : PRINT : PRINT
1480 IF A$ = "N" THEN GOTO 1630
1490 IF A$ < > "Y" THEN PRINT "INVALID REPLY": PRINT : GOTO 1460
1500 H1$ = "":M1$ = "":S1$ = "":HA$ = "":H2$ = "":M2$ = "":S2$ = "":HB$ = ""
1510 T1 = 0:T2 = 0
1520 HOME : PRINT : PRINT : PRINT
1530 PRINT "DO YOU STILL WANT TO CALCULATE ";T$
1540 INPUT A$
1550 IF A$ = "N" AND T$ = "LST" THEN T$ = "LMT": GOTO 1580
1560 IF A$ = "N" AND T$ = "LMT" THEN T$ = "LST": GOTO 1580
1570 IF A$ < > "Y" THEN PRINT "INVALID REPLY": PRINT : GOTO 1530
1580 HOME : PRINT : PRINT : PRINT
1590 INPUT "DO YOU WANT TO CHANGE DATE ";A$
1600 IF A$ = "N" THEN ZN = Z: GOTO 700
1610 IF A$ < > "Y" THEN PRINT "INVALID REPLY": PRINT : GOTO 1590
1620 PRINT :ZN = Z: GOTO 570
1630 HOME

```

TIMES (continued)

```

1640 END
1650 HOME : PRINT : PRINT : PRINT
1660 PRINT "DO YOU WANT INPUT IN DEC. HRS (1)"
1670 PRINT "          OR IN HRS MIN SEC (2)"
1680 PRINT : PRINT
1690 PRINT TAB( 10) " ";: INPUT PT$
1700 PT = VAL (PT$): PRINT : PRINT
1710 IF PT = 1 THEN GOTO 1750
1720 IF PT = 2 THEN GOTO 1820
1730 PRINT "INVALID REPLY": PRINT : GOTO 1650
1740 IF T$ = "LMT" THEN T$ = "LST"
1750 PRINT "          WHAT IS THE INPUT TIME"
1760 PRINT "          HR.XXXX (24-HR CLOCK)"
1770 PRINT : PRINT
1780 PRINT "          ";: INPUT T1: PRINT
1790 IF T1 > 23.9999 THEN PRINT : PRINT "INVALID ENTRY": GOTO 1780
1800 PRINT : PRINT : PRINT
1810 GOTO 1890
1820 PRINT "          WHAT IS THE INPUT TIME"
1830 PRINT "          HR,MIN,SEC (24-HR CLOCK)"
1840 PRINT : PRINT
1850 PRINT "          ";: INPUT HR,MI,SE
1860 PRINT : PRINT : PRINT
1870 IF HR > 23 OR MI > 59 OR SE > 59.99 THEN PRINT "INVALID ENTRY":
PRINT :GOTO 1850
1880 T1 = HR + MI / 60 + SE / 3600
1890 RETURN
1900 LGC = (ZN * 15) - L0
1910 IF LGC < 0 THEN GOTO 1930
1920 ZN = ZN + ABS (LGC / 15): GOTO 1940
1930 ZN = ZN + LGC / 15
1940 RETURN
1950 REM CALC GREGORIAN DAYS TO DATE REQUESTED
1960 IF M > = 3 GOTO 2020
1970 REM CALCS FOR JAN AND FEB
1980 DG = 365 * Y + D
1990 DG = DG + ((M - 1) * 31) + INT ((Y - 1) / 4)
- INT ((.75) * INT ((Y - 1) / 100 + 1))
2000 RETURN
2010 REM CALCS FOR MAR THRU DEC
2020 DG = 365 * Y + D + ((M - 1) * 31) - INT (M * .4 + 2.3)
2030 DG = DG + INT (Y / 4) - INT ((.75) * INT ((Y / 100) + 1))
2040 RETURN
2050 REM SUB FOR PRINTING HR,MI,SE
2060 RR = INT (T1)
2070 IM = (T1 - INT (T1)) * 60:ES = (IM - INT (IM)) * 60
2080 ES = INT (ES):IM = INT (IM)
2090 RETURN

```



The photograph above shows a person, possibly a woman, wearing a wide-brimmed hat and a long coat. The image is very faded and blurry, making details difficult to discern. The person appears to be standing in an outdoor setting, possibly a field or garden. The background is indistinct but suggests an outdoor environment. The overall quality of the image is poor, likely due to age or fading.

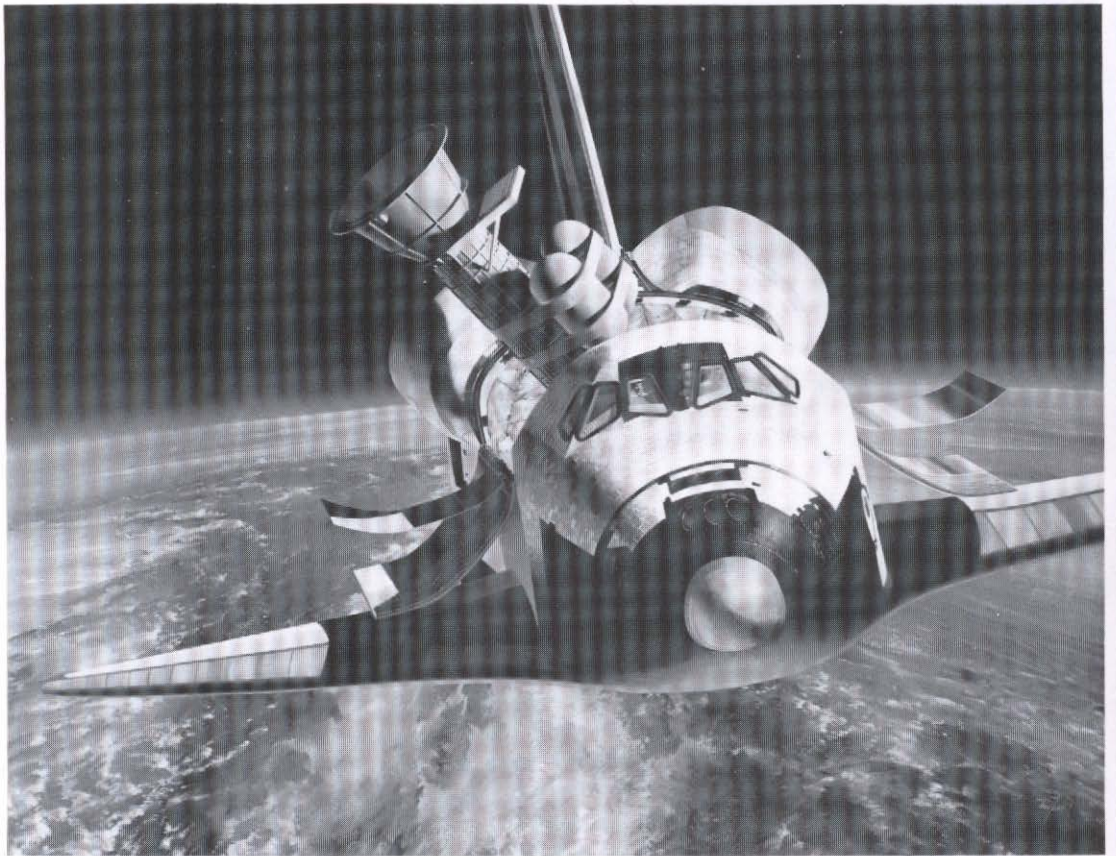


Photo Credit: NASA/Ames

Until recently, astronomers had to be content with looking at the other worlds in our universe through Earth's atmosphere. With the advent of the space shuttle, a new breed of telescopes and other sophisticated instruments of observation will be placed into space and enable us to look much farther afield and

back into time. This drawing shows the new infrared space telescope that will be put into operation by the space shuttle. It will penetrate the dust of space to enormous distances, almost to the edge of the knowable universe.

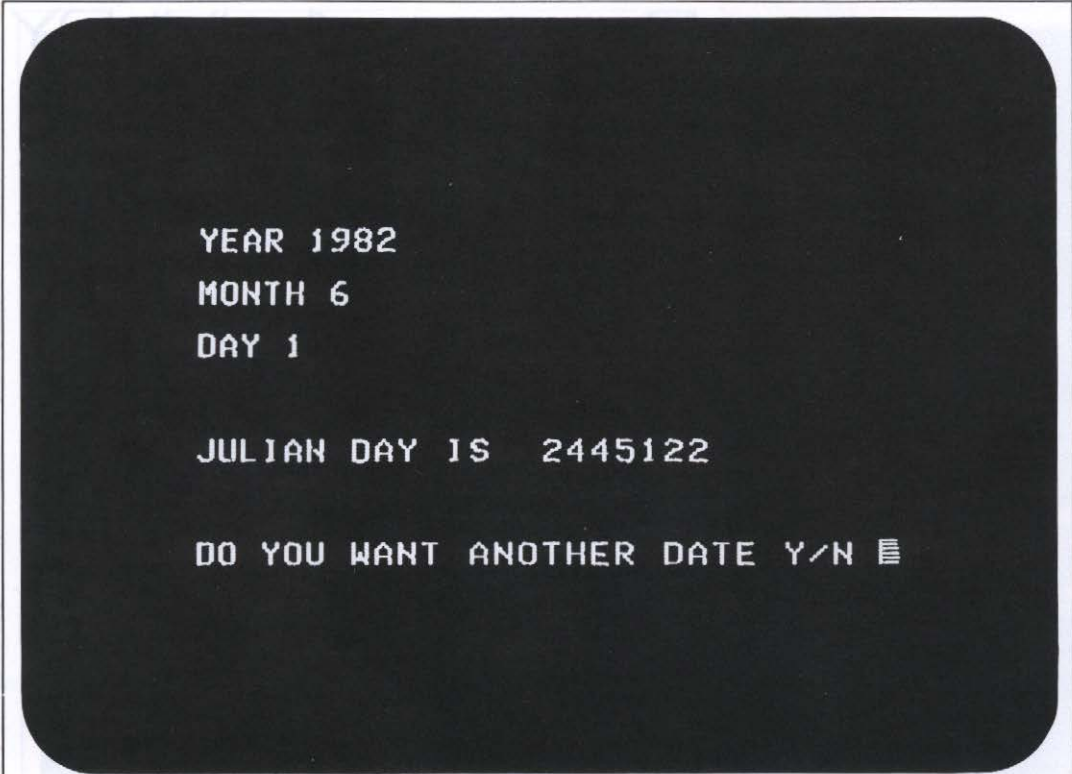
Program 4: JULDY

Calendar Date to Julian Day _____

Many astronomical events are referred to by their Julian day, which measures an arbitrary time period starting from 1 January 4713 B.C., the first day being Julian day 0. Julian day does not refer to the Julian calendar. It is a method of counting days that was introduced in 1582 by a mathematician named Scaliger. The name was derived from Scaliger's father, Julius. Use of this day number by astronomers avoids confusion that might arise from the use of different calendars at different times and places. The Julian day begins at noon, 12 hours later than our calendar day.

This program provides the Julian day for any Gregorian calendar day between 1100 and 2200. The program takes the Julian day for the beginning of the year 1900 and calculates Gregorian days from that date to the date selected. It then either adds or subtracts, as appropriate, the number of Gregorian days to or from the Julian day at the epoch 1900. The program can be modified easily to apply to other centuries also. This program can be merged with CDATE, its complement. See Program 5 for instructions.

The listing of the JULDY program follows.



A typical display generated by the JULDY program

Figure 4.1

JULDY

```
20 HOME
30 PRINT : PRINT : PRINT
40 PRINT TAB( 5)"-----"
50 PRINT TAB( 5)"I          JULIAN DAY          I"
60 PRINT TAB( 5)"-----"
70 PRINT : PRINT : PRINT
80 PRINT TAB( 10)"AN ASTRONOMY PROGRAM"
90 PRINT : PRINT TAB( 9)"BY ERIC BURGESS F.R.A.S."
100 PRINT : PRINT : PRINT
110 PRINT TAB( 9)"ALL RIGHTS RESERVED BY"
120 PRINT TAB( 9)"S & T SOFTWARE SERVICE"
130 PRINT : PRINT : PRINT
140 PRINT TAB( 3)"THIS PROGRAM PROVIDES THE JULIAN DAY"
150 PRINT TAB( 5)"FOR A CALENDAR DATE 1100 TO 2200"
160 FOR K = 1 TO 3000: NEXT K
170 HOME : PRINT : PRINT : PRINT
180 INPUT "YEAR ";Y1
190 PRINT
200 IF Y1 < 0 THEN Y1 = Y1 - 100
210 Y = Y1 - 1900
220 INPUT "MONTH ";M1
230 PRINT
240 INPUT "DAY ";D1
250 PRINT : PRINT : PRINT
260 M2 = M1 - 1
270 IF M2 = 1 THEN DY = 31
280 IF M2 = 2 THEN DY = 59
290 IF M2 = 3 THEN DY = 90
300 IF M2 = 4 THEN DY = 120
310 IF M2 = 5 THEN DY = 151
320 IF M2 = 6 THEN DY = 181
330 IF M2 = 7 THEN DY = 212
340 IF M2 = 8 THEN DY = 243
350 IF M2 = 9 THEN DY = 273
360 IF M2 = 10 THEN DY = 304
370 IF M2 = 11 THEN DY = 334
380 D3 = D1 + DY
390 D4 = 365 * Y + INT (Y / 4)
400 IF Y1 > 1999 THEN D4 = D4 - 2
410 D5 = 15020 + INT (D4) + D3
420 JD = D5
430 IF Y / 4 - INT (Y / 4) = 0 AND M1 < 3 THEN JD = JD - 1
440 JD = JD + 2400000
450 JD = JD - INT ((Y1 - 1900) / 100)
460 IF Y1 < 1583 THEN JD = JD + (10 - INT ((1583 - Y1) / 100))
470 IF Y1 > 1999 THEN JD = JD + 3
480 PRINT "JULIAN DAY IS ";JD
490 PRINT : PRINT : PRINT
500 INPUT "DO YOU WANT ANOTHER DATE Y/N ";A$
510 IF A$ = "Y" THEN 170
520 IF A$ < > "N" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 500
530 HOME
540 END
```

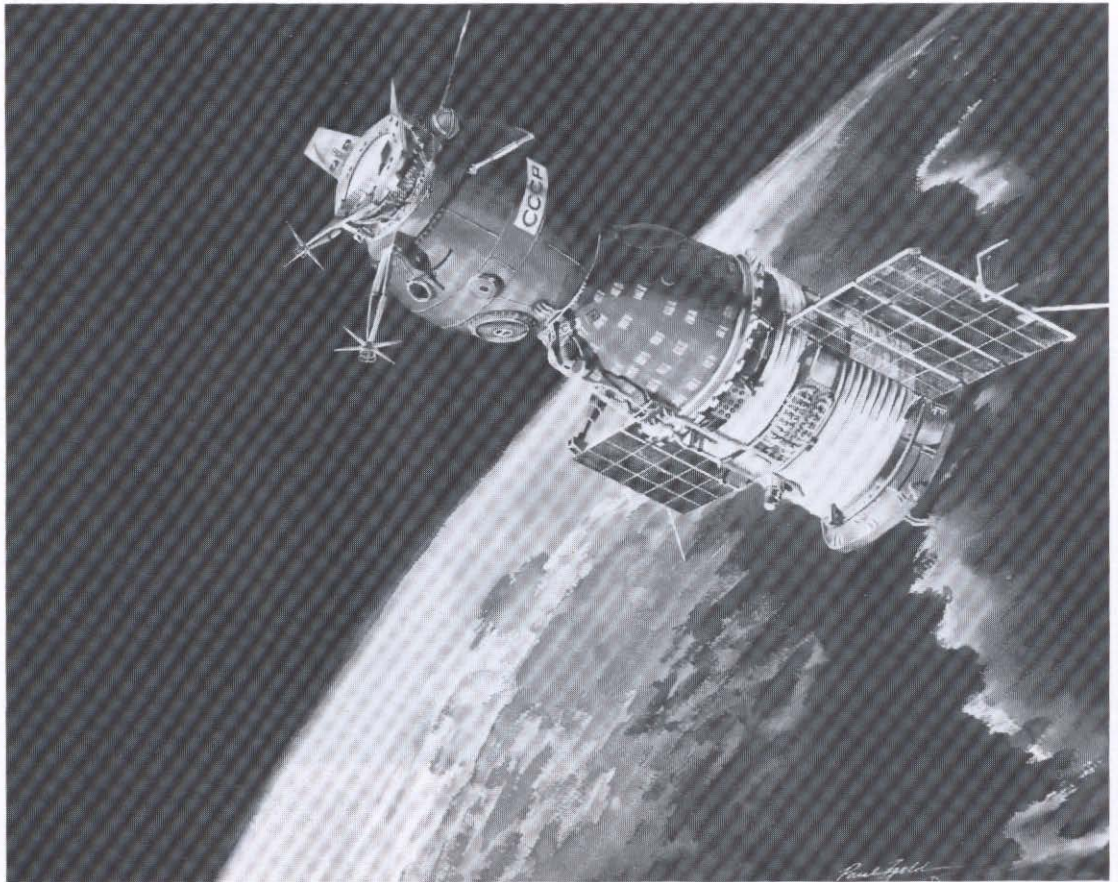


Photo Credit: NASA/Johnson

As man moves out into space it becomes imperative that he forget some of the differences that have divided people on Earth. Common measurements of time and space have to be adapted and used. This was first demonstrated in the Apollo-Soyuz program, in

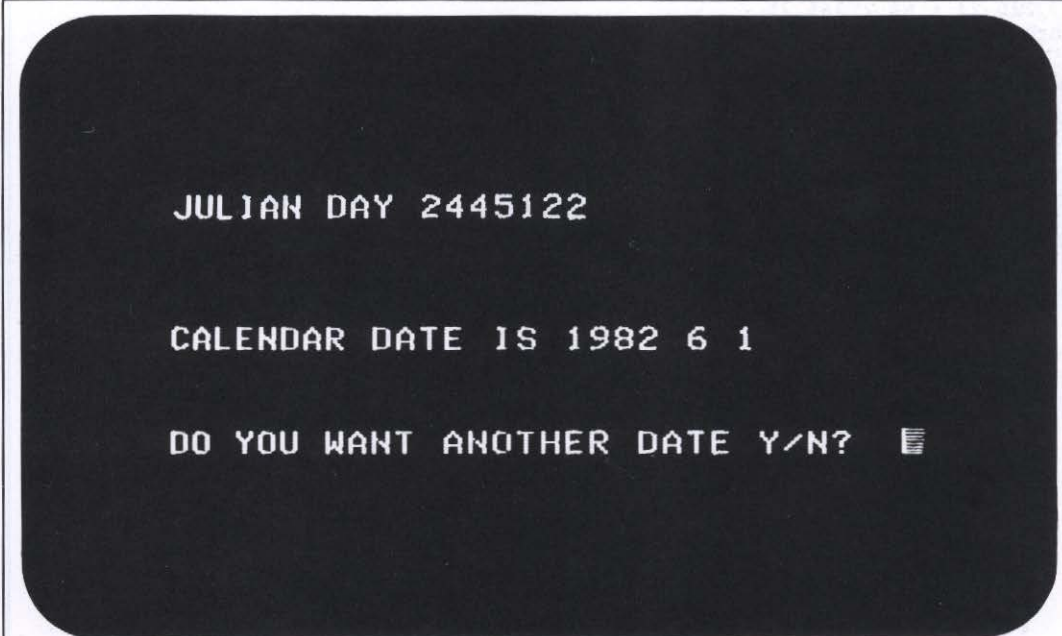
which United States' and Russian spacecraft had to be capable of docking and working with one another. This picture shows the Soyuz spacecraft of the USSR, which docked with an Apollo command module in the first international manned space venture.

Program 5: CDATE

Julian Day to Calendar Date

This program complements the JULDY program. It provides a Gregorian calendar date for any Julian day between 1100 and 2000. Again, it is easily modified for application in other centuries. These two programs, JULDY and CDATE, can be merged into one if you wish, with a selection of one or the other at the beginning of the merged program. If you intend to do this, you should increase all the line numbers in CDATE by 1000 when you key them in so that you can merge the two programs later. Then you must add an appropriate selection and branch routine at the beginning of JULDY.

The listing of the CDATE program follows.



```
JULIAN DAY 2445122
```

```
CALENDAR DATE IS 1982 6 1
```

```
DO YOU WANT ANOTHER DATE Y/N? 
```

This display generated by the CDATE program is the converse of the display in Figure 4.1.

Figure 5.1

CDATE

```

20 HOME
30 PRINT : PRINT : PRINT
40 PRINT TAB( 5) "-----"
50 PRINT TAB( 5) "I JULIAN DAY TO CALENDAR DATE I"
60 PRINT TAB( 5) "-----"
70 PRINT : PRINT : PRINT
80 PRINT TAB( 10) "AN ASTRONOMY PROGRAM"
90 PRINT : PRINT TAB( 9) "BY ERIC BURGESS F.R.A.S."
100 PRINT : PRINT : PRINT
110 PRINT TAB( 9) "ALL RIGHTS RESERVED BY"
120 PRINT TAB( 9) "S&T SOFTWARE SERVICE"
130 PRINT : PRINT : PRINT
140 PRINT "THIS PROGRAM PROVIDES THE CALENDAR DATE"
150 PRINT TAB( 2) "FOR A JULIAN DAY BETWEEN 1100-2000"
160 FOR K = 1 TO 2000: NEXT K
170 HOME : PRINT : PRINT : PRINT : PRINT
180 INPUT "JULIAN DAY ";JD
190 JD = JD - 2400000
200 PRINT
210 ND = JD - 15018
220 Y1 = ND / 365.25
230 Y = 1900 + INT (Y1)
240 IF Y / 4 - INT (Y / 4) = 0 AND Y / 100 - INT (Y / 100) < > 0 THEN
    LY = 1
250 D = 365.25 * (Y1 - INT (Y1))
260 IF D - INT (D) > .5 THEN D = D + 1
270 D = INT (D)
280 IF LY = 0 AND M < 3 THEN D = D - 1
290 D = D + INT ((Y - 2000) / 100)
300 IF Y < 1583 THEN D = D - (10 + INT ((Y - 1500) / 100))
310 IF D - 31 < 0 THEN M = 1: D = D: GOTO 430
320 IF D - 59 < 0 THEN M = 2: D = D - 31: GOTO 430
330 IF D - 90 < 0 THEN M = 3: D = D - 59: GOTO 430
340 IF D - 120 < 0 THEN M = 4: D = D - 90: GOTO 430
350 IF D - 151 < 0 THEN M = 5: D = D - 120: GOTO 430
360 IF D - 181 < 0 THEN M = 6: D = D - 151: GOTO 430
370 IF D - 212 < 0 THEN M = 7: D = D - 181: GOTO 430
380 IF D - 243 < 0 THEN M = 8: D = D - 212: GOTO 430
390 IF D - 273 < 0 THEN M = 9: D = D - 243: GOTO 430
400 IF D - 304 < 0 THEN M = 10: D = D - 273: GOTO 430
410 IF D - 334 < 0 THEN M = 11: D = D - 304: GOTO 430
420 IF D - 365 < 0 THEN M = 12: D = D - 334
430 IF LY = 1 AND M > 2 THEN D = D - 1
440 IF LY = 1 AND M > 2 THEN D = D - 1
450 IF D = > 1 THEN GOTO 510
460 IF D < 1 AND LY = 1 AND M = 3 THEN D = 29: M = 2: GOTO 510
470 IF D < 1 AND LY = 0 AND M = 3 THEN D = 28: M = 2: GOTO 510
480 IF D < 1 AND M = 1 THEN D = 31: M = 12: Y = Y - 1: GOTO 510
490 IF D < 1 AND M = 2 OR M = 4 OR M = 6 OR M = 9 OR M = 11 THEN D = 31:
    M = M - 1: GOTO 510
500 IF D < 1 THEN D = 30: M = M - 1
510 IF D = 365 THEN D = 31: M = 12
520 IF D = 366 THEN D = 1: M = 1: Y = Y + 1

```

CDATE (continued)

```
530 PRINT : PRINT : PRINT
540 PRINT "CALENDAR DATE IS ";Y;" ";M;" ";D
550 IF Y < > 1582 THEN GOTO 600
560 PRINT
570 PRINT "(NOTE: IN 1582 DATES BEFORE OCT 15"
580 PRINT "MUST BE DECREASED BY 10 DAYS"
590 PRINT "TO MATCH THE JULIAN CALENDAR)"
600 PRINT : PRINT : PRINT
610 INPUT "DO YOU WANT ANOTHER DATE Y/N? ";A$
620 IF A$ = "Y" THEN LY = 0:Y = 0:D = 0:M = 0: GOTO 170
630 IF A$ < > "N" THEN PRINT "      INVALID RESPONSE": PRINT :
    GOTO 610
640 HOME
650 END
```

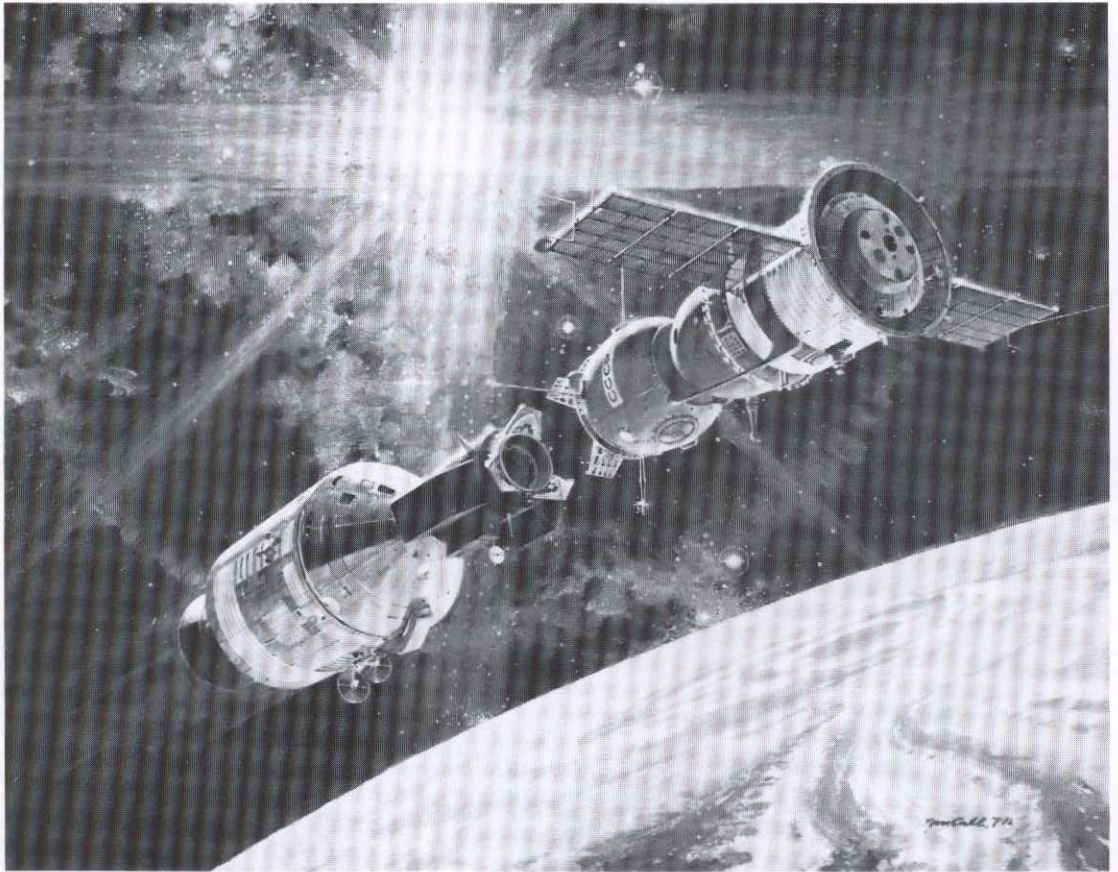


Photo Credit: NASA/Johnson

This picture portrays the American and Russian spacecraft in orbit around Earth. During their voyage the crews passed freely from one spacecraft to the other, unhindered by artificial national boundaries,

boundaries that are invisible when one looks at Earth from space. There were high hopes that this cooperation in space would be the beginning of a new epoch in the history of mankind.

Program 6: EPOCH

Updating Star Coordinates

Earth acts like a wobbling gyroscope or a spinning top, and over a period of some 26,000 years the axis of spin moves to point around a circle in the heavens. At present the north axis points nearly toward the star Polaris in Ursa Minor, which is our pole star. But 12,000 years ago it pointed toward the bright star Vega in the constellation Lyra. At the time of ancient Egypt, the pole star was a star in the constellation of Draco.

Because Earth wobbles on its axis, there are changes from year to year in the positions of all stars relative to the right ascension and declination grid (see Program 3 for a discussion of right ascension and declination). Right ascensions and declinations are listed in nebula and star tables for a given epoch, say 1950. If you want to find a faint stellar object by setting to the circles of an equatorially mounted telescope, you will need to update positions to the current epoch of observation. This program does this for you with sufficient accuracy to position the stellar object within the field of view of a typical finder telescope (see Figure 6.1).

You must input the epoch of the star table you are using, your present epoch, and then each right ascension and declination you need updated. The program provides the updated values by computing the following equations.

The change in right ascension is given by:

$$W = .0042 \times T \times [X + (Z \times \sin R_1 \times \tan D_1)]$$

and the change in declination is given by:

$$D = .00028 \times T \times Y \times \cos R_1$$

where R_1 is right ascension at epoch, D_1 is declination at epoch, and T is the time in years from the first epoch. X , Y , and Z are determined from the

time between the epochs as follows:

$$X = 3.07234 + (.00186 \times T_2)$$

$$Y = 20.0468 - (.0085 \times T_2)$$

$$Z = Y/15$$

where

$$T_2 = \frac{[(Y_1 + Y_2)/2] - 1900}{100}$$

where Y_1 is the first epoch year and Y_2 is the second epoch year.

The listing of the EPOCH program follows.

```

INPUT R.A. AT EPOCH 1950 .. 14.5
INPUT DEC. AT EPOCH 1950 .. 5.85

AT EPOCH 1982

RIGHT ASCENSION IS ... 14.52 HRS
                  OR ... 14,31,36
                  HR,MI,SE

DECLINATION IS ... 5.707 DEG
              OR ... 5,42,27
              HR,MI,SE

ANOTHER CONVERSION? Y/N █

```

The program EPOCH updates star coordinates to allow for the precession of the equinox. This is a typical display generated by the program.

Figure 6.1

EPOCH

```

10 CLEAR
20 HOME : PRINT : PRINT
30 DEF FN RAD(X) = X / 57.29878
40 PRINT : PRINT : PRINT
50 PRINT TAB( 10) "-----"
60 PRINT TAB( 10) "I      EPOCH      I"
70 PRINT TAB( 10) "-----"
80 PRINT : PRINT
90 PRINT TAB( 9) "AN ASTRONOMY PROGRAM"
100 PRINT
110 PRINT TAB( 7) "BY ERIC BURGESS F.R.A.S."
120 PRINT : PRINT
130 PRINT TAB( 8) "ALL RIGHTS RESERVED BY"
140 PRINT TAB( 8) "S & T SOFTWARE SERVICE"
150 PRINT
160 FOR J = 1 TO 2000: NEXT J
170 HOME : PRINT : PRINT : PRINT
180 PRINT : PRINT : PRINT : PRINT
190 PRINT TAB( 9) "THIS PROGRAM COMPUTES"
200 PRINT TAB( 5) "RIGHT ASCENSION AND DECLINATION"
210 PRINT TAB( 4) "FOR AN EPOCH WHEN GIVEN RA AND DEC"
220 PRINT TAB( 5) "FOR ANOTHER EPOCH, REDUCING FOR"
230 PRINT TAB( 14) "PRECESSION"
240 FOR J = 1 TO 3000: NEXT J
250 HOME
260 PRINT : PRINT : PRINT
270 INPUT "WHAT IS FIRST EPOCH (YEAR) ";Y1
280 PRINT
290 INPUT "WHAT IS SECOND EPOCH ";Y2
300 T2 = ((Y2 + Y1) / 2 - 1900) / 100
310 X = 3.07234 + (.00186 * T2)
320 Y = 20.0468 - (.0085 * T2)
330 Z = Y / 15
340 PRINT : PRINT : PRINT
350 REM CALC DAYS BETWEEN EPOCHS
360 T = Y2 - Y1
370 PRINT "PICK MODE OF INPUT:"
380 PRINT : PRINT
390 PRINT " R.A. IN DECIMAL HRS (1)"
400 INPUT " OR IN HR,MI,SE (2) ";RAS
410 RA = VAL (RAS)
420 IF RA = 0 OR RA > 2 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 390
430 PRINT : PRINT
440 PRINT " DEC. IN DECIMAL DEG. (3)"
450 INPUT " OR IN DE,MI,SE (4) ";DE$
460 DE = VAL (DE$)
470 IF DE < 3 OR DE > 4 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 440
480 HOME : PRINT : PRINT : PRINT
490 IF RA = 2 THEN 510
500 PRINT "INPUT R.A. AT EPOCH ";Y1;" ";: INPUT " .. ";R1: GOTO 530
510 PRINT "INPUT R.A. AT EPOCH ";Y1;: INPUT " .. ";R1,MI,SI
520 IF DE = 4 THEN 540
530 PRINT : PRINT "INPUT DEC. AT EPOCH ";Y1;: INPUT " .. ";D1: GOTO 550

```

EPOCH (continued)

```

540 PRINT "INPUT DEC. AT EPOCH ";Y1;: INPUT " .. ";DC,MC,SC
550 IF RA = 2 THEN R1 = RI + MI / 60 + SI / 3600
560 IF DE = 4 THEN D1 = DC + MC / 60 + SC / 3600
570 R1 = R1 * 15
580 PRINT : PRINT
590 W = .0042 * T * (X + (Z * SIN ( FN RAD(R1)) * TAN ( FN RAD(D1))))
600 R2 = R1 + W
610 D2 = D1 + .00028 * T * Y * COS ( FN RAD(R1))
620 PRINT : PRINT
630 PRINT " AT EPOCH ";Y2
640 PRINT : PRINT
650 R2 = R2 / 15
660 IF R2 > 24 THEN R2 = R2 - 24
670 IF R2 < 0 THEN R2 = R2 + 24
680 RC = VAL ( LEFT$ ( STR$ (R2),5))
690 PRINT " RIGHT ASCENSION IS ... ";RC;" HRS"
700 R3$ = STR$ ( INT (R2))
710 M2 = 60 * (R2 - INT (R2))
720 M2$ = STR$ ( INT (M2))
730 S2 = 60 * (M2 - INT (M2))
740 S2 = INT (S2)
750 S2$ = STR$ (S2)
760 R4$ = R3$ + "," + M2$ + "," + S2$
770 PRINT " OR ... ";R4$
780 PRINT TAB( 26)"HR,MI,SE"
790 PRINT : PRINT
800 IF D2 < - 90 THEN D2 = - 90 + ABS (D2) - INT ( ABS (D2))
810 IF D2 < 0 THEN DD = VAL ( LEFT$ ( STR$ (D2),6)): GOTO 840
820 IF D2 > 90 THEN DD = 90 - (D2 - INT (D2)): GOTO 840
830 DD = VAL ( LEFT$ ( STR$ (D2),5))
840 PRINT " DECLINATION IS ..... ";DD;" DEG"
850 IF D2 < 0 THEN D4 = INT (D2) + 1: GOTO 870
860 D4 = INT (D2)
870 IF D2 < 0 THEN ME = 1 + 60 * (D2 - INT (D2)): GOTO 890
880 ME = 60 * (D2 - INT (D2)): GOTO 900
890 ME = 60 - ME
900 ME$ = STR$ ( INT (ME))
910 SE = 60 * (ME - INT (ME))
920 SE = INT (SE)
930 SE$ = STR$ (SE)
940 ED$ = STR$ (D4) + "," + ME$ + "," + SE$
950 PRINT " OR ..... ";ED$
960 PRINT TAB( 26)"HR,MI,SE"
970 PRINT : PRINT
980 INPUT "ANOTHER CONVERSION? Y/N ";A$
990 IF A$ = "Y" THEN HOME : PRINT : PRINT : GOTO 480
1000 PRINT : PRINT
1010 INPUT "ANOTHER EPOCH? Y/N ";A$
1020 IF A$ = "Y" THEN GOTO 250
1030 HOME
1040 END

```



The photograph shows a large, multi-lobed plant, possibly a water hyacinth, with several long, narrow leaves extending from a central point. The plant is set against a dark background, and the overall image is very faded and blurry. The text below the image is illegible due to fading.

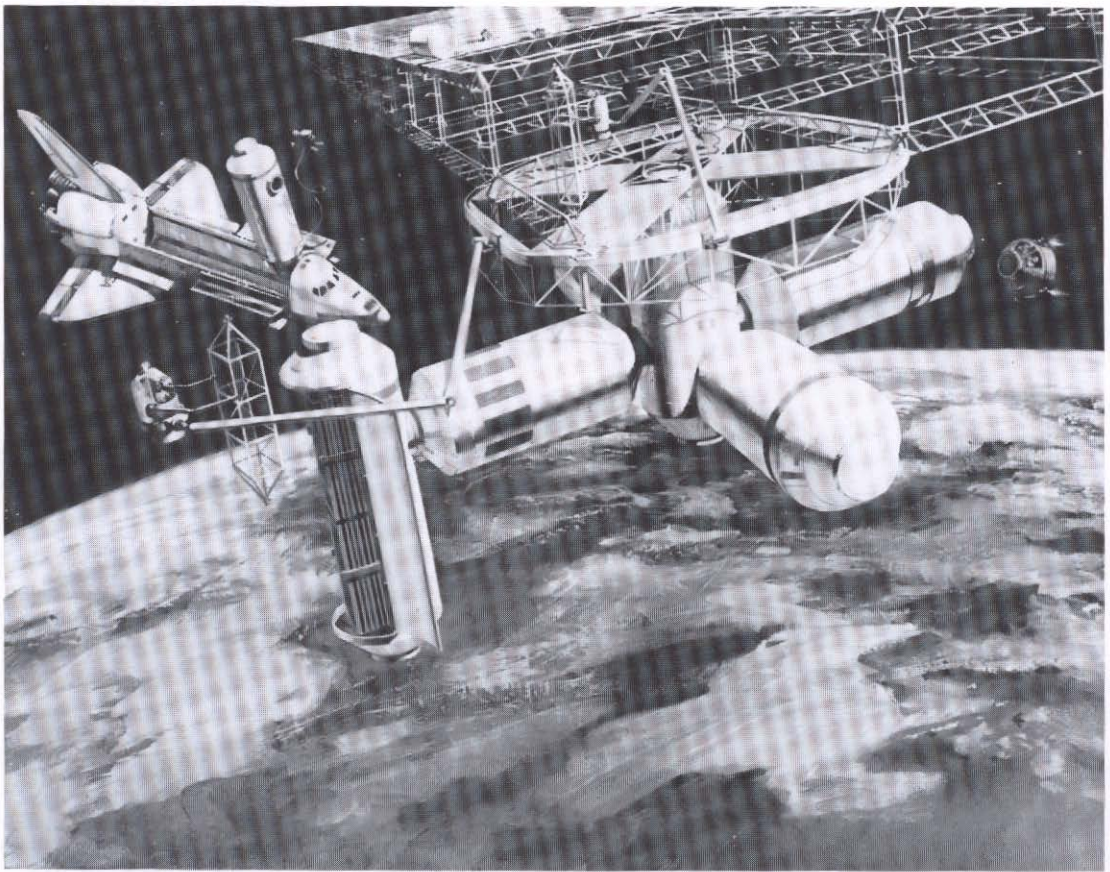


Photo Credit: Rockwell International Space Division

As more nations achieve the capability of developing space, large structures will be built in orbit around Earth. Huge telescopes, space hotels, solar power satellites, space settlements, and space manufacturing

facilities will become common sights. A new era will dawn, and people will begin to move out into the unlimited economic commons of the solar system and start to reach for the stars.

Program 7: PSTAR

Transits and Elongations of Polaris

Our pole star, Polaris, is not exactly at the north pole of the celestial sphere, i.e., at 90 degrees north declination. So it oscillates in the course of each day and year to the east and west of true north.

When an equatorial mount of a telescope is set up, the polar axis should point to the celestial pole. The exact elevation of the pole at any observing site can be determined from the elevation of Polaris when it is at east or west elongation, and the azimuth of true north can be determined by observing Polaris when the star is at upper or lower transit. The elevation of the pole is also the latitude of the observer.

This program determines these times (see Figure 7.1) within ten minutes for any date, which is sufficiently accurate to set a polar axis, except for a very large telescope.

Starting from epoch 1980, the program uses the right ascension of Polaris, the hour angle, and the sidereal time for a given date to determine the local time at which the transits and elongations take place.

The listing of the PSTAR program follows.

```
ON 1982 10 5 LONGITUDE 128
NEXT WEST ELONGATION WILL BE 7.226 HRS
OR 7 HR 13 MI

WANT ANOTHER ELONG. OR TRANSIT (Y/N)
```

By observing the transits and elongations of Polaris you can ascertain true north and your latitude. This is a typical display generated by the PSTAR program.

Figure 7.1

PSTAR

```
10 REM PSTAR POSITIONS
20 HOME : PRINT : PRINT : PRINT : PRINT
30 PRINT TAB( 8)"-----"
40 PRINT TAB( 8)"I POLARIS I"
50 PRINT TAB( 8)"-----"
60 PRINT : PRINT
70 PRINT TAB( 8)"AN ASTRONOMY PROGRAM"
80 PRINT TAB( 7)"BY ERIC BURGESS F.R.A.S."
90 PRINT : PRINT
100 PRINT TAB( 8)"ALL RIGHTS RESERVED BY"
110 PRINT TAB( 8)"S & T SOFTWARE SERVICE"
120 PRINT : PRINT
130 FOR K = 3000 TO 1 STEP - 1: NEXT
140 HOME : PRINT : PRINT : PRINT
150 PRINT TAB( 5)"THIS PROGRAM PROVIDES THE TIMES OF"
160 PRINT
170 PRINT TAB( 10)"ELONGATIONS AND TRANSITS"
180 PRINT
190 PRINT TAB( 10)"OF POLARIS FOR ANY DATE"
200 PRINT
210 PRINT TAB( 10)"WITH SUFFICIENT ACCURACY"
220 PRINT
230 PRINT TAB( 13)"(WITHIN 10 MINUTES)"
240 PRINT
250 PRINT TAB( 10)"FOR SETTING OR CHECKING": PRINT
260 PRINT TAB( 12)"THE ALIGNMENT OF THE": PRINT
270 PRINT TAB( 6)"EQUATORIAL MOUNT OF A TELESCOPE"
280 PRINT : PRINT : PRINT
290 INPUT "PRESS RETURN WHEN READY";A$
300 HOME : PRINT : PRINT : PRINT
310 INPUT "YEAR ";Y
320 IF Y / 4 - INT ( Y / 4 ) = 0 AND Y / 100 - INT ( Y / 100 ) < > 0 THEN
LY = 1
330 PRINT
340 INPUT "MONTH ";M
350 D2 = 0
360 IF M = 2 THEN D2 = 31
370 IF M = 3 THEN D2 = 59
380 IF M = 4 THEN D2 = 90
390 IF M = 5 THEN D2 = 120
400 IF M = 6 THEN D2 = 151
410 IF M = 7 THEN D2 = 181
420 IF M = 8 THEN D2 = 212
430 IF M = 9 THEN D2 = 243
440 IF M = 10 THEN D2 = 273
450 IF M = 11 THEN D2 = 304
460 IF M = 12 THEN D2 = 334
470 PRINT : INPUT "DAY ";D1
480 D = D1 + D2
490 IF LY = 1 AND M > 2 THEN D = D + 1
500 REM GST AT 0 HR OF EPOCH 1980
510 REM ADJUST FOR YEAR
520 G = Y - 1980
```

PSTAR (continued)

```

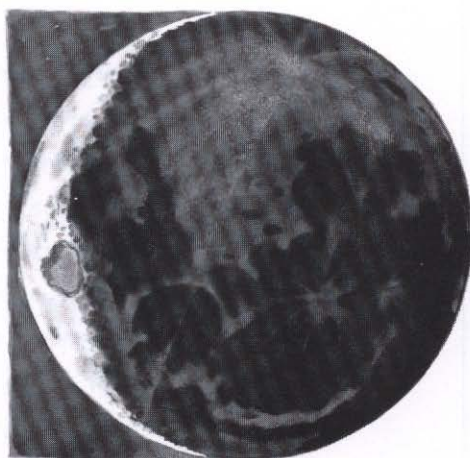
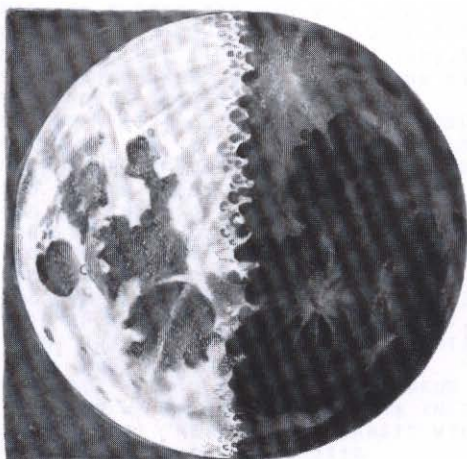
530 YC = - .01638889 * G
540 GST = 6.65422 + YC
550 REM ADJUST FOR DAILY GAIN OF SID TIME
560 DG = D * .0657096
570 GT = GST + DG
580 IF GT > 24 THEN GT = GT - 24
590 IF GT < 0 THEN GT = GT + 24
600 PRINT : INPUT "LONGITUDE ";LO
610 REM ADJUST ST FOR LONGITUDE
620 CF = .065556 * LO / 360
630 REM GET HOUR ANGLE
640 GT = GT + GT * CF
650 HA = 2.183333 - GT
660 IF HA < 0 THEN HA = HA + 24
670 REM ADJUST FOR DAILY LOSS OF MEAN TIME
680 MT = HA
690 QD = 5.98362:QE = 5.933333
700 QW = 5.933333:QL = 11.967222
710 HOME : PRINT : PRINT
720 PRINT : PRINT "WHICH ELONGATION OR TRANSIT"
730 PRINT : PRINT
740 PRINT TAB( 4)"WEST ELONGATION NEXT (1)"
750 PRINT TAB( 4)"          PREVIOUS (2)"
760 PRINT TAB( 4)"EAST ELONGATION NEXT (3)"
770 PRINT TAB( 4)"          PREVIOUS (4)"
780 PRINT TAB( 4)"LOWER TRANSIT   NEXT (5)"
790 PRINT TAB( 4)"UPPER TRANSIT  NEXT (6)"
800 PRINT : PRINT
810 INPUT "SELECT BY NUMBER ";S$
820 S = VAL (S$)
830 IF S = 0 OR S > 6 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 710
840 HOME : PRINT : PRINT : PRINT : PRINT
850 PRINT : "ON ";Y;" ";M;" ";D1;" LONGITUDE ";LO
860 PRINT
870 ON S GOTO 880,920,960,1000,1040,1080
880 WN = MT + QW:IN = WN: GOSUB 1280: GOSUB 1190:WN = IN
890 WN = VAL ( LEFT$ ( STR$ (WN),5))
900 PRINT "NEXT WEST ELONGATION WILL BE ";WN;" HRS"
910 GOSUB 1250: GOTO 1110
920 WP = MT - QL - QE:IN = WP: GOSUB 1280: GOSUB 1190:WP = IN
930 WP = VAL ( LEFT$ ( STR$ (WP),5))
940 PRINT "PREVIOUS WEST ELONGATION WAS ";WP;" HRS"
950 GOSUB 1250: GOTO 1110
960 EN = MT + QL + QW:IN = EN: GOSUB 1280: GOSUB 1190:EN = IN
970 EN = VAL ( LEFT$ ( STR$ (EN),5))
980 PRINT "NEXT EAST ELONGATION WILL BE ";EN;" HRS"
990 GOSUB 1250: GOTO 1110
1000 EP = MT - QW:IN = EP: GOSUB 1280: GOSUB 1190:EP = IN
1010 EP = VAL ( LEFT$ ( STR$ (EP),5))
1020 PRINT "PREVIOUS EAST ELONGATION WAS ";EP;" HRS"
1030 GOSUB 1250: GOTO 1110
1040 NLT = MT + QL:IN = NLT: GOSUB 1280: GOSUB 1190:NLT = IN
1050 NLT = VAL ( LEFT$ ( STR$ (NLT),5))
1060 PRINT "NEXT LOWER TRANSIT WILL BE ";NLT;" HRS"
1070 GOSUB 1250: GOTO 1110

```

PSTAR (continued)

```
1080 NUT = HA:IN = NUT: GOSUB 1280: GOSUB 1190:NUT = IN
1090 NUT = VAL ( LEFT$ ( STR$ (NUT),5))
1100 PRINT "NEXT UPPER TRANSIT WILL BE ";NUT;" HRS": GOSUB 1250
1110 PRINT : PRINT : PRINT
1120 INPUT "WANT ANOTHER ELONG. OR TRANSIT (Y/N)";A$
1130 IF A$ = "Y" THEN HOME : PRINT : PRINT : GOTO 720
1140 PRINT
1150 INPUT "WANT ANOTHER DATE (Y/N)";A$
1160 IF A$ = "Y" THEN 300
1170 HOME
1180 GOTO 1310
1190 REM CONVERT TO HR,MIN,SEC
1200 IN = IN + IN * .00273043
1210 HM = INT (IN)
1220 MI = 60 * (IN - INT (IN))
1230 M2 = INT (M1)
1240 RETURN
1250 PRINT
1260 PRINT TAB( 20)"OR ";HM;" HR ";M2;" MI"
1270 RETURN
1280 IF IN > 24 THEN IN = IN - 24
1290 IF IN < 0 THEN IN = IN + 24
1300 RETURN
1310 END
```

PART 2



THE MOON



THE MOON HAS ALWAYS beckoned and intrigued mankind; its phases and cycles are recorded on bones recovered from the sites of prehistoric settlements. The Moon has provided us with light, it has served as a timekeeper, and it has been a basis for romantic ideas and flights of fanciful fiction.

With the advent of the computer age and space exploration, the Moon has become much less of a mystery to us. The programs in this section allow you to determine the phases of the Moon, the dates of lunar eclipses, and the position of the Moon relative to the stars for any date.



Photo Credit: U.S. Naval Observatory

The closest heavenly body to Earth, through even a small telescope the Moon is revealed as a fascinating world of great craters, mountains, and plains.

Program 8: RADEM

Right Ascension and Declination of Moon for Any Date

This program computes approximate right ascension and declination of the Moon for any requested date. This data enables you to fix the Moon's position relative to the stars and also to determine its rising and setting (described in later programs).

Astronomers in ancient times paid great attention to observing the motions of the Moon. Calendars and many religious festivals were based on these motions. The Moon's orbit, however, is difficult to accurately predict; its orbit is not circular, and the Moon is actually more strongly bound to the Sun than to Earth. Earth and Moon behave somewhat as two planets gyrating together around the Sun. The Moon is about 226,000 miles from Earth at perigee and 252,000 miles away at apogee. Moreover, the positions of apogee and perigee gradually move around Earth. The orbit is also inclined to the orbit of Earth around the Sun, so the Moon moves above and below the apparent path of the Sun through the stars (called the ecliptic). The lunar orbit also wobbles, so that the points where the Moon crosses the ecliptic plane (the nodes) also move around Earth. In addition, there are perturbations due to the bulge of the Earth, smaller perturbations from the planets, and perturbations from Earth and Moon following an elliptical orbit around the Sun. Obviously, the motion of the Moon is complex. Nevertheless, it can be approximated to a level of accuracy suitable for most observations or for finding the position of the Moon among the stars.

Right ascension is expressed in sidereal hours and is measured eastward along the celestial equator from the vernal equinox (first point of Aries). One sidereal hour is equal to 15 degrees on the celestial sphere. Celestial objects that are on the meridian (in other words, they culminate) at the same time as the vernal equinox have a right ascension of 0 hours. Those that culminate 1 hour later have a right ascension of 1 hour, and so on up to 24 hours when the right ascension becomes zero again.

Declination is measured in degrees north (+) or south (−) of the celestial equator. (For a more complete explanation of right ascension and declination, see TIMES—Program 3.)

The program determines the position of Moon in its orbit by counting from its position at epoch 1960 (instructions 1010 through 1030) to the current date. It eliminates complete revolutions (instructions 1120 through 1160). It also adjusts for the motion of the nodes and the perigee position during the period since or before the epoch (instructions 1080 through 1280). Then it adjusts for the eccentricity of the Moon's orbit and for the inclination of the orbit to the plane of the ecliptic (instructions 1290 and 1300). The program prints out the right ascension and declination and repeats for the requested number of intervals (see Figure 8.1).

```
INTERVALS OF 1 DAYS FOR TIME ZONE 8
LOCL TIME 22 HR:YR 1982 MNTH 3 DY 21
UNIV TIME 6 HR:YR 1982 MNTH 3 DY 22
RA OF MOON IS 21.44 DECLINATION IS -17.1
-----
LOCL TIME 22 HR:YR 1982 MNTH 3 DY 22
UNIV TIME 6 HR:YR 1982 MNTH 3 DY 23
RA OF MOON IS 22.29 DECLINATION IS -13.6
-----
LOCL TIME 22 HR:YR 1982 MNTH 3 DY 23
UNIV TIME 6 HR:YR 1982 MNTH 3 DY 24
RA OF MOON IS 23.17 DECLINATION IS -9.37
-----
PRESS RETURN TO CONTINUE
```

The RADEM program calculates the right ascension and declination of the Moon for any date and time. It generates the type of display shown here.

Figure 8.1

The Moon's orbit is perturbed in many ways and other corrections can be added to achieve higher orders of accuracy. But for most purposes this program provides sufficient accuracy in locating the approximate position of the Moon among the stars for any date and time.

As with earlier programs, for computers other than Apple you may need to modify HOME statements to CLS or PRINT CHR\$(12) statements and use the ENTER key instead of the RETURN key.

If you wish, this program can be merged with RADEC, the program for finding right ascensions and declinations of the planets. If you intend to do this, you should key in this program using line numbers starting at 2000. Then you can use it as a subroutine for RADEC.

The listing of the RADEM program follows.

RADEM

```

20 REM RA AND DEC OF MOON FOR ANY DATE
30 DEF FN RAD(X) = .01745328 * (X)
40 HOME : PRINT : PRINT : PRINT
50 PRINT TAB( 9)"ASTRONOMY PROGRAM": PRINT
60 PRINT TAB( 9)"-----"
70 PRINT TAB( 9)"I RADEM I"
80 PRINT TAB( 9)"-----"
90 PRINT
100 PRINT TAB( 7)"BY ERIC BURGESS F.R.A.S."
110 PRINT : PRINT
120 FL = 0
130 PRINT TAB( 7)"ALL RIGHTS RESERVED BY"
140 PRINT TAB( 7)"S & T SOFTWARE SERVICE"
150 PRINT
160 PRINT TAB( 10)"VERSION 4/82"
170 PRINT : PRINT
180 INPUT "DO YOU WANT INSTRUCTIONS Y/N ";A$
190 IF A$ = "N" THEN HOME : PRINT : PRINT : GOTO 390
200 IF A$ < > "Y" THEN PRINT : PRINT "INVALID RESPONSE: GOTO 180
210 HOME : PRINT : PRINT
220 PRINT "THIS PROGRAM DISPLAYS THE APPROXIMATE"
230 PRINT "RIGHT ASCENSION AND DECLINATION"
240 PRINT "OF THE MOON FOR A REQUESTED DATE"
250 PRINT TAB( 12)"AND TIME": PRINT
260 PRINT "FOR A SERIES OF INTERVALS"
270 PRINT : PRINT
280 PRINT "ENTER YEAR, MONTH, DAY, TIME ZONE,"
290 PRINT " AND LOCAL TIME"
300 PRINT "ALSO TIME INTERVALS IN DAYS AND THE"
310 PRINT "NUMBERS OF INTERVALS REQUIRED"
320 PRINT : PRINT
330 PRINT "THE PROGRAM WILL DISPLAY UNIVERSAL TIME"
340 PRINT "AND THE APPROXIMATE RA AND DECLINATION"
350 PRINT "FOR EACH DAY AT THE SELECTED INTERVALS"
360 PRINT : PRINT
370 INPUT "WHEN READY PRESS RETURN";A$
380 HOME : PRINT : PRINT : PRINT
390 PRINT "ENTER THE DATE": PRINT
400 INPUT "THE YEAR ";YD$:Y = VAL (YD$)
410 IF Y = 0 THEN PRINT "INVALID RESPONSE"; PRINT : GOTO 400
420 IF Y > 1800 GOTO 480
430 PRINT "IS ";Y;" THE CORRECT YEAR?"
440 INPUT Y$
450 IF Y$ = "Y" THEN 480
460 IF Y$ < > "N" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 430
470 IF Y$ = "N" THEN PRINT : GOTO 400
480 LY = 0
490 IF Y / 4 - INT (Y / 4) = 0 AND Y / 100 - INT (Y / 100) < > 0 THEN
LY = 1
500 PRINT : INPUT "THE MONTH ";MD$:M = VAL (MD$)
510 IF M = 0 OR M > 12 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 500
520 PRINT : INPUT "THE DAY ";DD$:D = VAL (DD$)
530 IF D = 0 OR D > 31 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 520

```

RADEM (continued)

```
540 IF M = 2 AND D > 29 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 520
550 IF LY < > 1 AND M = 2 AND D > 28 THEN PRINT "INVALID RESPONSE": PRINT
: GOTO 520
560 PRINT : INPUT "TIME ZONE ";TZ
570 PRINT : INPUT "TIME HRS ";T1
580 REM STORE INITIAL DATE AND TIME
590 YP = Y:MP = M:DP = D
600 DU = D:TU = TZ + T1: IF TU > 24 THEN TU = TU - 24:DU = DU + 1
610 DU = DU + TU / 24
620 IF (LY = 1 AND M = 2 AND INT (DU) > 29) THEN M = 3:DU = DU - 29:
GOTO 670
630 IF (LY = 0 AND M = 2 AND INT (DU) > 28) THEN M = 3:DU = DU - 28:
GOTO 670
640 IF DU < 31 GOTO 670
650 IF (M = 4 OR M = 6 OR M = 9 OR M = 11) THEN M = M + 1:DU = DU - 30:
GOTO 670
660 IF INT (DU) > 31 THEN M = M + 1:DU = DU - 31
670 IF M = 13 THEN M = 1:Y = Y + 1
680 IF F9 = 1 THEN 710
690 T2 = TU:D2 = DU:Y2 = Y:M2 = M
700 IF FL = 5 THEN GOTO 860
710 PRINT : PRINT : PRINT
720 PRINT "SELECT INTERVALS AND HOW MANY"
730 PRINT "ENTER 1'S IF YOU NEED ONE PLOT ONLY"
740 PRINT "UP TO THREE INTERVALS ARE DISPLAYED"
750 PRINT "ON SCREEN BEFORE SCROLLING"
760 PRINT : PRINT
770 INPUT "WHAT IS THE TIME INTERVAL (DAYS) ";TI$
780 PRINT
790 TI = VAL (TI$)
800 IF TI = 0 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 770
810 INPUT "HOW MANY INTERVALS ";IN$: PRINT
820 IN = VAL (IN$)
830 IF IN = 0 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 810
840 REM SETS INTERVAL COUNT AT 1
850 NC = 1
860 REM CALC DAYS FROM EPOCH 1960,1,1
870 IF NC > 1 GOTO 900
880 HOME : PRINT
890 PRINT "INTERVALS OF ";TI;" DAYS FOR TIME ZONE ";TZ
900 DG = 365 * Y + DU + ((M - 1) * 31)
910 IF M > = 3 GOTO 950
920 REM CALC IF JAN OR FEB
930 DG = DG + INT ((Y - 1) / 4) - INT ((.75) * INT ((Y - 1) / 100 + 1))
940 GOTO 970
950 REM CALC FOR MAR THRU DEC
960 DG = DG - INT (M * .4 + 2.3) + INT (Y / 4)
- INT ((.75) * INT ((Y / 100) + 1))
970 NM = DG - 715875
980 NM = NM - .5
990 REM FIND RA AND DEC OF MOON
1000 REM LONG OF MOON
1010 LZ = 311.1687
1020 LE = 178.699
1030 LP = 255.7433
```

RADEM (continued)

```

1040 PG = .111404 * NM + LP
1050 IF PG < - 360 THEN PG = PG + 360: GOTO 1050
1060 IF PG < 0 THEN PG = PG + 360
1070 IF PG > 360 THEN PG = PG - 360: GOTO 1070
1080 LMD = LZ + 360 * NM / 27.321582
1090 PG = LMD - PG
1100 DR = 6.2886 * SIN (.01745328 * PG)
1110 LMD = LMD + DR
1120 IF LMD < - 360 THEN LMD = LMD + 360: GOTO 1120
1130 IF LMD < - 360 THEN LMD = LMD + 360: GOTO 1130
1140 IF LMD < 0 THEN LMD = LMD + 360: GOTO 1140
1150 IF LMD > 360 THEN LMD = LMD - 360: GOTO 1150
1160 IF LMD > 360 THEN LMD = LMD - 360: GOTO 1160
1170 RM = LMD / 15
1180 IF RM > 24 THEN RM = RM - 24: GOTO 1180
1190 IF RM < 0 THEN RM = RM + 24
1200 AL = LE - NM * .052954
1210 IF AL < - 360 THEN AL = AL + 360: GOTO 1210
1220 IF AL < - 360 THEN AL = AL + 360: GOTO 1220
1230 IF AL < 0 THEN AL = AL + 360: GOTO 1230
1240 IF AL > 360 THEN AL = AL - 360: GOTO 1240
1250 IF AL > 360 THEN AL = AL - 360: GOTO 1250
1260 AL = LMD - AL
1270 IF AL < 0 THEN AL = AL + 360
1280 IF AL > 360 THEN AL = AL - 360
1290 HE = 5.1454 * SIN (AL * 3.14159 / 180)
1300 DM = HE + 23.1444 * SIN (LMD * 3.14159 / 180)
1310 PRINT
1320 RA$ = STR$ (RM):DE$ = STR$ (DM)
1330 RA$ = LEFT$ (RA$,5):DE$ = LEFT$ (DE$,5)
1340 IF VAL (RA$) < 10 THEN RA$ = LEFT$ (RA$,4)
1350 IF VAL (DE$) < - 9 THEN DE$ = LEFT$ (DE$,5): GOTO 1370
1360 IF VAL (DE$) < 10 AND VAL (DE$) > - 10 THEN DE$ = LEFT$ (DE$,4)
1370 PRINT "LOCL TIME ";T1;" HR:YR ";YP;" MNTH ";MP;" DY ";DP
1380 PRINT "UNIV TIME ";TU;" HR:YR ";Y2;" MNTH ";M2;" DY "; INT (D2)
1390 PRINT
1400 PRINT "RA OF MOON IS ";RA$;" DECLINATION IS ";DE$
1410 PRINT "-----"
1420 IF NC / 3 - INT (NC / 3) = 0 THEN INPUT "PRESS RETURN TO CONTINUE";Z$
1430 IF NC < IN GOTO 1450
1440 GOTO 1550
1450 NC = NC + 1:D = DP + TI
1460 Y = YP:M = MP
1470 IF (LY = 1 AND M = 2 AND D > 29) THEN M = 3:D = D - 29: GOTO 1530
1480 IF (LY = 0 AND M = 2 AND D > 28) THEN M = 3:D = D - 28: GOTO 1530
1490 IF D < 31 GOTO 1530
1500 IF (M = 4 OR M = 6 OR M = 9 OR M = 11) THEN M = M + 1:D = D - 30:
GOTO 1530
1510 IF D > 31 THEN M = M + 1:D = D - 31
1520 IF M = 2 THEN GOTO 1470
1530 IF M = 13 THEN M = 1:Y = Y + 1
1540 FL = 5: GOTO 590
1550 PRINT

```

RADEM (continued)

```
1560 INPUT "DO YOU WANT ANOTHER DATE Y/N ";A$
1570 IF A$ = "N" THEN HOME : GOTO 1610
1580 IF A$ < > "Y" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 1560
1590 FL = 0
1600 HOME : PRINT : PRINT : GOTO 390
1610 END
```

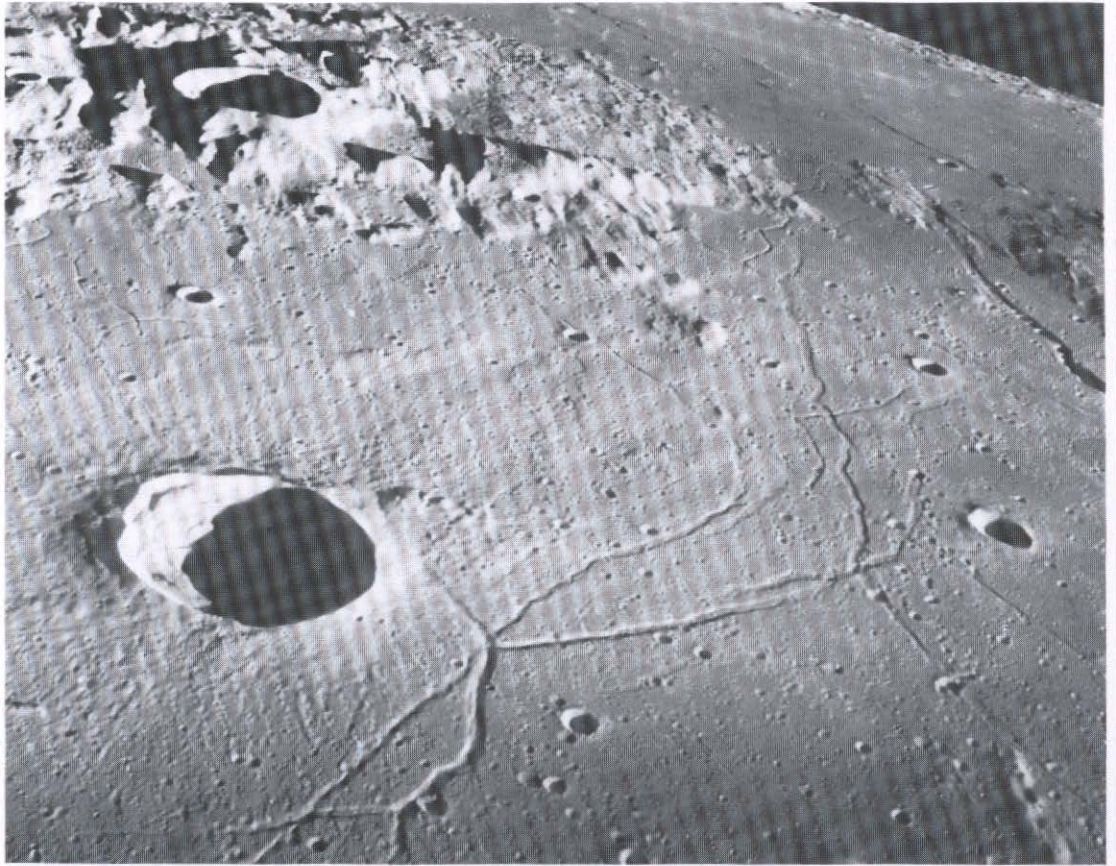


Photo Credit: NASA

Seen from orbit, the surface of the Moon is awe-inspiring—a series of vast circular mountain rings, great clefts running for hundreds of miles across the smooth plains, and innumerable crater pits. Its surface

has been bombarded from space by countless natural projectiles and repeatedly churned into rubble—the lunar regolith. This picture shows the crater Triesnecker and its associated system of rilles.

Program 9: ECLIP

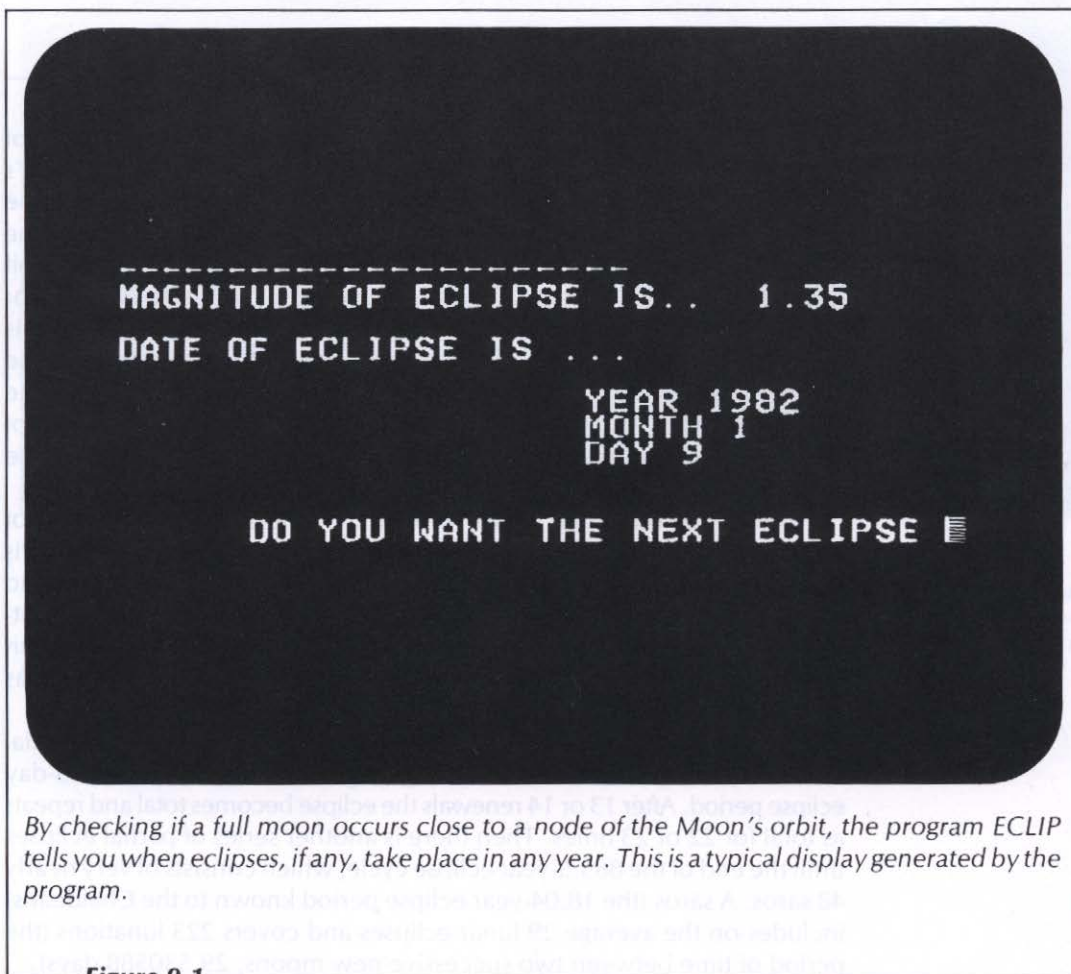
Umbral Lunar Eclipses for Any Year

Umbral eclipses occur when the Moon passes through the umbra of Earth's shadow. The umbra is the central conical portion of Earth's shadow, geometrically excluding all light from the Sun. It stretches some 857,000 miles from Earth, always extending beyond the distance of the Moon. However, the inclination of the Moon's orbit relative to Earth's orbit usually causes the Moon at full (when such eclipses occur) to be above or below Earth's shadow. Under favorable circumstances, when the Moon is at perigee, Earth is at aphelion, and the path of the Moon goes through the center of Earth's shadow, a total lunar eclipse can last for two hours. The partial phases can extend two more hours on either side of the period of totality. (Perigee is the point nearest Earth in the lunar orbit; aphelion is the point farthest from the Sun in Earth's orbit.)

Even when the Moon passes through the umbra or central portion of Earth's shadow, its surface does not become completely dark. This is because some sunlight is refracted through Earth's atmosphere and into the cone of the umbra. As this refracted light passes through the atmosphere it is reddened—a phenomenon similar to our seeing a red Sun at sunrise and sunset—and thereby causes the eclipsed Moon to appear as a dark red globe, an awe-inspiring sight in the night sky.

Lunar eclipses occur in concurrent sets. Each set begins with a partial lunar eclipse repeated with increasing magnitude each 18-year 11.3-day eclipse period. After 13 or 14 renewals the eclipse becomes total and repeats as total for 22 or 23 times. Then there is another series of partial eclipses until the end of the 865.5-year eclipse cycle, which consists of very nearly 48 saros. A saros (the 18.04-year eclipse period known to the Chaldeans) includes on the average 29 lunar eclipses and covers 223 lunations (the period of time between two successive new moons, 29.530588 days).

This program computes the date of the first umbral eclipse of the Moon in any year requested and shows the magnitude of the eclipse, that is, the fraction of the Moon's disk covered by the umbral shadow of Earth. When this fraction reaches or exceeds 1, the eclipse is total. Since the obscuring effects of Earth's penumbra are barely perceptible, penumbral eclipses are not identified. If there is no umbral eclipse in the year requested, the program continues until it finds the first eclipse in subsequent years. You can also ask the computer to display subsequent umbral eclipses. If there are no more eclipses in the year requested, the computer will search for and display the first umbral eclipse in subsequent years. A screen display generated by this program is shown in Figure 9.1.



By checking if a full moon occurs close to a node of the Moon's orbit, the program ECLIP tells you when eclipses, if any, take place in any year. This is a typical display generated by the program.

Figure 9.1

The program checks each full moon from the date requested to find if it occurs within the required distance from a node, and cycles until it finds the Julian day of the first full moon occurring close to the node. It calculates the amount of the Moon's disk covered by Earth's shadow, and determines the date on which the eclipse occurs by converting Julian day to calendar date.

The only modifications to the program required by computers other than the Apple II are to lines 10, 70, 190, 420, 850, and 870. In these lines HOME to clear the screen will need to be changed to your own computer's instruction to clear the screen.

The listing for the ECLIP program follows.

ECLIP

```

10 HOME : PRINT : PRINT : PRINT : PRINT
20 PRINT TAB( 10)"LUNAR UMBRAL ECLIPSES"
30 PRINT TAB( 10)"BY ERIC BURGESS F.R.A.S."
40 PRINT : PRINT TAB( 10)"ALL RIGHTS RESERVED BY"
50 PRINT TAB( 10)"S & T SOFTWARE SERVICES"
60 FOR KZ = 2000 TO 1 STEP - 1: NEXT KZ
70 HOME
80 PRINT : PRINT : PRINT : PRINT
90 REM ECLIPSE
100 PRINT TAB( 5)"THIS PROGRAM GIVES MAGNITUDE"
110 PRINT TAB( 5)"AND DATE OF LUNAR UMBRAL ECLIPSES"
120 PRINT TAB( 5)"STARTING AT ANY YEAR REQUESTED"
130 FOR J5 = 2000 TO 1 STEP - 1: NEXT J5
140 PRINT : PRINT
150 PRINT "PLEASE STATE THE"
160 PRINT
170 INPUT "YEAR TO START ";Y
180 FL = 0
190 HOME : PRINT : PRINT : PRINT : PRINT
200 PRINT "RUNNING....PLEASE WAIT"
210 Z = Y - 1900
220 ZD = (Z * 12.368267) - 2
230 A = INT (ZD)
240 DEF FN RAD(X) = X * 3.141592 / 180
250 A = A + 1
260 B = 29.1053561 * A
270 C = B + 13.7774
280 D = (25.81691806 * A) + 138.94
290 E = (30.670565 * A) + 216.6378
300 F = E - ( SIN ( FN RAD(D))) * .412
310 G = F + ( SIN ( FN RAD(2 * D))) / 8.8
320 H = G + ( SIN ( FN RAD(C))) * 2.2265
330 I = H + ( SIN ( FN RAD(2 * E))) * .13
340 I = SIN ( FN RAD(I))
350 J = 0.7128 - ( COS ( FN RAD(D))) / 36
360 W = I * 10 ^ J
370 IF W < 0 THEN W = 1.84769 + W * 1.8216: GOTO 390
380 IF W > 0 THEN W = 1.84769 - W * 1.8216
390 K = W + ( COS ( FN RAD(D))) / 30
400 IF K < 0 THEN GOTO 250
410 IF FL = 1 GOTO 430
420 HOME : PRINT : PRINT : PRINT : PRINT
430 PRINT : PRINT "-----"
440 PRINT "MAGNITUDE OF ECLIPSE IS.. ";
450 K = VAL ( LEFT$ ( STR$ (K),4) )
460 PRINT K
470 PRINT
480 L = 2415036.025 + (A * 29.53058868)
490 L = L - (.406 * SIN ( FN RAD(D))) + (.174 * SIN ( FN RAD(C)))
500 L = L + ( SIN ( FN RAD(2 * D))) / 62
510 L = INT (L - ( SIN ( FN RAD(2 * E))) / 97)
520 IF L < 2299161 THEN GOTO 580
530 L2 = INT ((2299161 - 1867216.25) / 36525.25)

```

ECLIP (continued)

```
540 L = L2 + L
550 M = INT (L2 / 4)
560 L = L - M
570 L = L + 1
580 N = L - 1720995
590 O = INT ((N - 122.1) / 365.25)
600 P = INT (O * 365.25)
610 Q = INT ((N - P) / 30.6001)
620 R = ((N - P) - INT (Q * 30.6001)) / 10000
630 IF Q < 13.7774 THEN GOTO 650
640 S = Q - 12 - 1: GOTO 660
650 S = Q - 1
660 T = S
670 T2 = T + R
680 IF SQR (5) < S GOTO 700
690 O = O + 1
700 U = O + T2
710 R = 3 + R * 10000
720 IF T = 2 AND R > 28 THEN T = T + 1: R = R - 28
730 IF T = 3 AND R > 31 THEN T = T + 1: R = R - 31
740 PRINT "DATE OF ECLIPSE IS ..."
750 PRINT
760 PRINT "          YEAR ";O
770 PRINT "          MONTH ";T
780 PRINT "          DAY ";R
790 PRINT : PRINT
800 INPUT "          DO YOU WANT THE NEXT ECLIPSE ";A$
810 PRINT : PRINT
820 IF A$ = "Y" THEN PRINT : FL = 1: GOTO 250
830 IF A$ < > "N" THEN PRINT "INVALID REPLY": PRINT : GOTO 800
840 INPUT "          DO YOU WANT ANOTHER YEAR ";A$
850 IF A$ = "Y" THEN HOME : PRINT : PRINT : GOTO 170
860 IF A$ < > "N" THEN PRINT "INVALID REPLY": PRINT : GOTO 840
870 HOME
880 END
```



Photo Credit: NASA

By all terrestrial standards, the Moon is an inhospitable world. Black skies are dominated on the Earth-facing hemisphere by the huge Earth. The terrain is relatively smooth, but broken by scattered

rocks. Hills are rounded by their bombardment from space. This photo shows one of the Apollo astronauts making scientific measurements near a huge boulder in the Taurus-Littrow region of the Moon.

Program 10: PHASE

Approximate Phase of Moon for Any Date_____

In many religious and calendrical systems the time of the new moon is most important, since from it the beginning of each lunar cycle can be established. Actually, the new moon cannot be observed—it occurs when the Moon is between Earth and the Sun. The time of the new moon has to be computed backward from the first observation of the extremely thin crescent (often referred to as the new moon) following the astronomical new moon.

The period from one new moon to the next is known as the synodic month. It is 29.530589 days in length and is divided into quarters—new moon, first quarter, full moon, and last quarter. The sidereal month is the passage of the Moon around its orbit to the right ascension of a certain fixed star. This is 27.321662 days. There are two other important lunar cycles. One is the draconic month, which is the period from node to node of the lunar orbit. Each 27.212221 days the Moon crosses Earth's orbital plane from south to north, and that crossing defines the draconic month. The period from perigee (closest approach to Earth) to perigee is the anomalistic month (27.554550 days), and it is used to determine the distance of the Moon from Earth. These various numbers are used in several of the

programs in this book, adjusted where necessary to agree with epochs relating to the calculations.

Phases of the Moon were very important to people before the advent of street lighting. Without the light of the Moon, activities outdoors at night were greatly curtailed. The waxing moon is that period between new moon and full moon when more and more of the hemisphere of the Moon facing Earth is illuminated by the Sun. From a thin crescent, the Moon day by day expands to a half moon, then to a gibbous moon, and finally to a full moon rising opposite to the setting sun. The half moon illuminates the evening sky, the full moon brightens most of the night, and the waning half moon lights up the predawn hours.

Many artists hopelessly confuse the Moon's phases in their illustrations, indicating a late night scene by a crescent moon. If the crescent-shaped moon is regarded as a bow, an arrow placed in that bow ready to be shot always points toward the Sun. A thin crescent moon can appear only for a short period after sunset or before sunrise.

Because of the inclination of the ecliptic to Earth's equator, different phases of the Moon are more readily observed at certain seasons. The new crescent is best observed in the spring months because it sets well after the Sun compared with in the fall. The waning crescent is best placed for observation in fall, when it appears high in the sky before sunrise. In summer the full moon is low in the southern sky, while in winter it rides high. In fall, during the period around the full moon, the Moon moves along the ecliptic higher into the sky each evening, so moonrise occurs only a few minutes later each night. For nearly a week, an almost full moon rises shortly after sunset each day. People referred to this as the period of the harvest moon, because light is provided for harvesting after the Sun has set. You can visualize these effects by running SKYSET (Program 16).

The four lunar phases are separated by about 7.4 days on the average. Because the Moon's orbit is elliptical, the Moon does not travel at a constant speed around its orbit, so the interval between the phases varies at different lunations.

This program calculates the date of each new moon and then interpolates for the other phases. The date of the new moon is accurate within one day; the others are approximate only. Starting at instruction 380, the program changes the calendar date to a day number and then proceeds to calculate the next new moon from the date requested, making use of the synodic month (period from one new moon to the next). It derives the calendar date for this new moon and loops to calculate the calendar date for the next new moon. The program then interpolates for the other phases. It repeats this sequence for the number of months requested. Subroutines take care of month ends and year ends and the effects of leap years on the derived dates.

The program will list phases for three months after a year and month requested. If the first new moon is toward the end of the month requested, you will need to ask for a month earlier to obtain all the phases within the requested month. An example of the display provided by this program is shown in Figure 10.1.

The program is useful if you wish to find out quickly whether or not any special astronomical observations on a given date are going to be troubled by excessive moonlight—for example, observation of a meteor shower in the early morning hours. For such observation you would like to have the Moon either a fine waning crescent or between the new moon and first quarter. You might also want to know whether the Moon is going to be bright before you decide to take a telescope to the top of a mountain to photograph some faint objects in the sky.

The listing for the PHASE program follows.

```

NEW MOON < 07 1982 JUL 28
FIRST QUARTER < 07 1982 JUL 28
FULL MOON < 07 1982 AUG 11
LAST QUARTER < 1982 AUG 13
DO YOU WANT MORE?

```

Figure 10.1: The output of the PHASE program. The program lists the phases of the Moon for three months after a given year and month. The user can request more information.

```

MOON'S PHASES ARE ...

NEW MOON           0 1982  MAY 22
FIRST QUARTER     > 1982  MAY 30
FULL MOON         (<0) 1982  JUN  6
LAST QUARTER      (< 1982  JUN 13
1

NEW MOON           0 1982  JUN 20
FIRST QUARTER     > 1982  JUN 28
FULL MOON         (<0) 1982  JUL  4
LAST QUARTER      (< 1982  JUL 11
2

NEW MOON           0 1982  JUL 20
FIRST QUARTER     > 1982  JUL 28
FULL MOON         (<0) 1982  AUG  4
LAST QUARTER      (< 1982  AUG 11
3

DO YOU WANT MORE █

```

The PHASE program provides a table showing the approximate dates of the phases of the Moon for any period of up to three months.

Figure 10.1

PHASE

```

10 REM LUNAR PHASES
20 DEF FN RAD(X) = .01745328 * (X)
30 HOME : PRINT : PRINT : PRINT : PRINT
40 PRINT : PRINT : PRINT
50 PRINT TAB( 10)"-----"
60 PRINT TAB( 10)"I PHASES OF MOON I"
70 PRINT TAB( 10)"-----"
80 PRINT : PRINT : PRINT
90 PRINT TAB( 9)"BY ERIC BURGESS F.R.A.S."
100 PRINT : PRINT
110 PRINT TAB( 10)"ALL RIGHTS RESERVED BY"
120 PRINT TAB( 10)"S & T SOFTWARE SERVICE"
130 FOR J = 3000 TO 1 STEP - 1: NEXT
140 HOME : PRINT : PRINT : PRINT
150 PRINT TAB( 5)"THIS PROGRAM PROVIDES DATES FOR"
160 PRINT TAB( 5)"PHASES OF THE MOON STARTING AT"
170 PRINT TAB( 5)"ANY MONTH OR ANY DATE AND FOR"
180 PRINT TAB( 5)"A PERIOD OF UP TO THREE MONTHS"
190 PRINT TAB( 8)" (WITHIN ONE DAY)"
200 PRINT : PRINT : PRINT
210 PRINT "START DATE REQUIRED"
220 PRINT : INPUT "YEAR ";Y$:Y = VAL (Y$)
230 IF Y = 0 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 220
240 PRINT : INPUT "MONTH ";M$:M = VAL (M$)
250 IF M = 0 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 240
260 PRINT : INPUT "NUMBER OF MONTHS REQUIRED (1 TO 3) ";N$
270 N = VAL (N$)
280 IF N > 3 THEN N = 3
290 IF N = 0 THEN PRINT "INVALID RESPONSE"; PRINT : GOTO 260
300 HOME :NS = 1: PRINT
310 PRINT "MOON'S PHASES ARE ... "
320 MS = M
330 IN = 0
340 IF XP = 1 THEN M = M + 1
350 YP = Y
360 TY = Y + M / 100
370 IF 1582.10 > TY THEN FL = 2
380 P2 = M
390 P1 = Y
400 P3 = D
410 P4 = M / 100 + D / 10000
420 IF SQR (5) = < P2 THEN GOTO 440
430 P1 = P1 - 1:P2 = P2 + 12
440 P5 = INT (365.25 * P1) + INT ((P2 + 1) * 30.6001) + P3 + 1720995
450 IF FL = 2 GOTO 480
460 P0 = INT (P1 / 100)
470 P5 = P5 - P0 + 2 + INT (P0 / 4)
480 P6 = .0338631922
490 Q = (P6 * P5) + .67094
500 Q1 = 1 - (Q - INT (Q))
510 P7 = Q1 / P6
520 P5 = (P5 + P7) * .985600267
530 P7 = P7 + (.1743 * ( SIN ( FN RAD(P5 + 73.63))))

```

PHASE (continued)

```

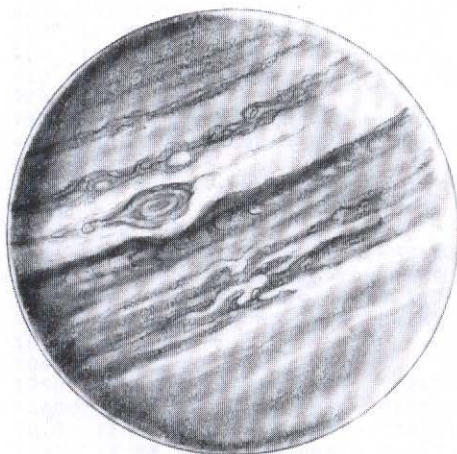
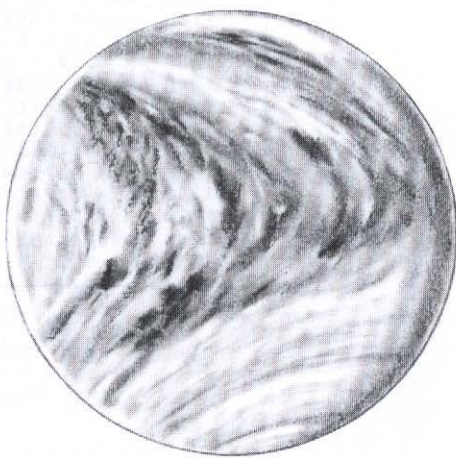
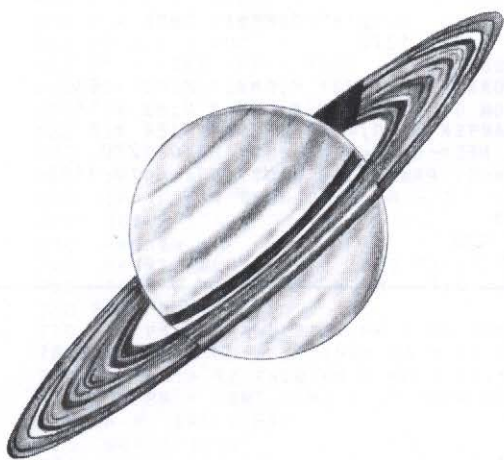
540 P8 = (13.06499245 * P5) + 271.5
550 P7 = P7 - (.4089 * ( SIN ( FN RAD(P8))))
560 P7 = (( SIN ( FN RAD(2 * P8))) * .0161) + P7
570 P8 = ((P7 - .5) / 10000) + P4
580 IF IN = 0 THEN P9 = P8
590 IF IN < > 0 THEN M = M - 1: GOTO 610
600 IN = IN + 1:M = M + 1:P1 = 0:P2 = 0:P3 = 0:P4 = 0: GOTO 360
610 Z = P9 - P8
620 Z = Z * 10000
630 Z = ABS (30.6001 * Z)
640 PH = Z / 400
650 PM = INT (P9 * 100)
660 PD = INT ((P9 * 100 - INT (P9 * 100)) * 100)
670 IF NS = 4 OR NS = 8 THEN PD = PD + 1
680 IF PD = 0 THEN PM = PM - 1:PD = 31
690 IF PD > 31 THEN PD = PD - 31: GOTO 690:PD = PD - 6:PM = PM + 1:Q = 1
700 IF PM > 12 THEN PM = PM - 12:Y = Y + 1
710 IF XP = 1 THEN PM = PM - 1
720 GOSUB 1050
730 PRINT
740 PRINT "NEW MOON      0 ";Y;" ";PM$;" ";PD
750 IF Q = 1 THEN PM = PM - 1:Q = 0
760 PD = PD + 1
770 IF PM = 2 AND PD + PH > 28 THEN PD = PD + 3
780 IF PD + PH > 31 THEN PD = PD - 31:PM = PM + 1
790 IF PM > 12 THEN PM = PM - 12:Y = Y + 1
800 IF PH - INT (PH) < .5 THEN PH = INT (PH) + 1
810 PH = INT (PH)
820 GOSUB 1050
830 PRINT "FIRST QUARTER ) ";Y;" ";PM$;" ";PD + PH
840 IF PM = 2 AND PD + 2 * PH > 28 THEN PD = PD + 3
850 IF PD + 2 * PH > 31 THEN PD = PD - 31:PM = PM + 1
860 IF PM > 12 THEN PM = PM - 12:Y = Y + 1
870 GOSUB 1050
880 PRINT "FULL MOON      (0) ";Y;" ";PM$;" ";PD + 2 * PH
890 IF PM = 2 AND PD + 3 * PH > 28 THEN PD = PD + 3
900 IF PD + 3 * PH > 31 THEN PD = PD - 31:PM = PM + 1
910 IF PM > 12 THEN PM = PM - 12:Y = Y + 1
920 GOSUB 1050
930 IF XP = 1 THEN M = M - 1
940 PRINT "LAST QUARTER ( ";Y;" ";PM$;" ";PD + 3 * PH
950 PRINT NS
960 IF PD + 3 * PH + 7 = 30 OR PD + 3 * PH + 7 = 31 THEN GOTO 1170
970 Y = YP
980 M = M + 1
990 IF NS < N THEN NS = NS + 1:IN = 0:P9 = 0: GOTO 330
1000 PRINT : INPUT "DO YOU WANT MORE ";A$
1010 IF A$ = "Y" THEN GOTO 140
1020 IF A$ < > "N" THEN PRINT "ANSWER Y OR N ": GOTO 1000
1030 HOME
1040 END
1050 IF PM = 1 THEN PM$ = "JAN": RETURN
1060 IF PM = 2 THEN PM$ = "FEB": RETURN
1070 IF PM = 3 THEN PM$ = "MAR": RETURN
1080 IF PM = 4 THEN PM$ = "APR": RETURN

```

—PHASE (continued)—

```
1090 IF PM = 5 THEN PM$ = "MAY": RETURN
1100 IF PM = 6 THEN PM$ = "JUN": RETURN
1110 IF PM = 7 THEN PM$ = "JUL": RETURN
1120 IF PM = 8 THEN PM$ = "AUG": RETURN
1130 IF PM = 9 THEN PM$ = "SEP": RETURN
1140 IF PM = 10 THEN PM$ = "OCT": RETURN
1150 IF PM = 11 THEN PM$ = "NOV": RETURN
1160 IF PM = 12 THEN PM$ = "DEC": RETURN
1170 PRINT :PZ = 30
1180 PRINT "NEW MOON      0 ";Y;" ";PM$;" ";PZ
1190 IF NS = N THEN GOTO 1270
1200 PM = PM + 1: GOSUB 1050
1210 PRINT "FIRST QUARTER ) ";Y;" ";PM$;" ";PZ - 23
1220 PRINT "FULL MOON      (0)";Y;" ";PM$;" ";PZ - 15
1230 PRINT "LAST QUARTER  ( ";Y;" ";PM$;" ";PZ - 8
1240 IF NF = 1 THEN NF = 0: NS = NS + 1: GOTO 1270
1250 NF = 1: PZ = 30 - 1: PRINT :NS = NS + 1: GOTO 1180
1260 PZ = 0: PD = 0
1270 XP = 1: M = M + 1
1280 PRINT NS: GOTO 970
```

PART 3



THE PLANETS

PLANETS WERE KNOWN as wandering stars to the ancient Greeks, because they appear to move relatively quickly with respect to the fixed background of stars. Observations of the motions of the planets led to new explanations. These new theories of planetary motion eventually caused the demise of the dogma of an Earth-centered universe and spurred the Copernican revolution of human thought. This was part of the transformation that ultimately resulted in the Industrial Revolution. Continued developments in physics and astronomy played an important part in accelerating the pace of the Industrial Revolution.

The programs contained in this section all deal with the motions of the planets. There are programs to find the planets among the stars of the zodiac, programs that determine when planets are in certain positions, such as when Mars is closest to Earth, and programs to aid in planetary observations.

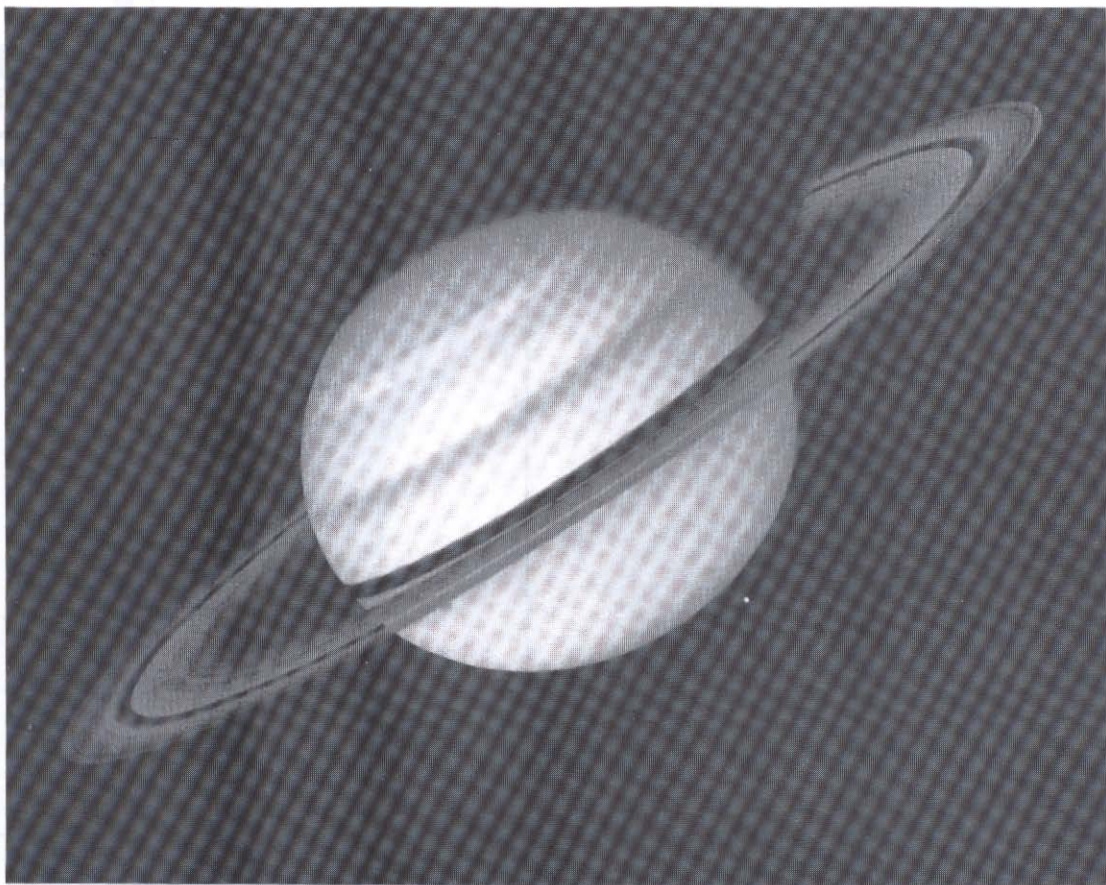


Photo Credit: NASA/Jet Propulsion Laboratory

Spacecraft have now visited all the planets of the solar system known to the ancients; the most recent flyby was that of Voyager past Saturn. This huge planet possesses a bizarre collection of satellites and an extremely complex ring system. This photograph shows the shadow of the planet on the rings and some of the

many gaps between the individual ringlets making up the system. Voyager showed that far from being empty gaps, they are actually filled with even fainter and narrower ringlets. One of Saturn's small satellites, Dione, is the bright spot close to the south pole of the planet.

Program 11: RADEC

Right Ascension and Declination for All Planets for Any Date

The location of any star or other celestial object can be placed on the celestial sphere in terms of its right ascension and declination, just as the location of any city on Earth can be described in terms of latitude and longitude. The right ascension of a planet is analogous to longitude on Earth; it is measured eastward along the celestial equator from the vernal equinox (see TIMES, Program 3). One sidereal hour is equal to 15 degrees on the celestial sphere. Celestial objects that are on the meridian (that is, they culminate) at the same time as the vernal equinox have a right ascension of 0 hours. Those that culminate 1 hour later have a right ascension of 1 hour, and so on.

The declination of a planet is analogous to latitude on Earth. It is measured in degrees north (+) or south (–) of the celestial equator.

The right ascension and declination of a planet allows you to place the planet in relation to the constellations and thus find where it can be seen in the night sky. You can plot a planet's position by using the right ascension/declination grid of a star map. By asking the computer to provide right ascensions and declinations for different days or months, you can plot the apparent motion of the planets relative to the stars and to each other. Other programs in this book do some of these plots for you (for example, Programs 16 and 17).

This program computes right ascensions and declinations of the planets Mercury, Venus, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto for any requested date. An example of the display provided by the program is shown in Figure 11.1.

```

PLANETARY DATA FOR . . . 1982 12 1
WHICH IS 8370 DAYS FROM EPOCH 1960
-----:-----:-----:-----:-----:
          HELIO          DIST          R. A.          DEC
          LONG          TO PLANET          HRS          DEG
-----:-----:-----:-----:-----:
MERCURY  266.2          1.432          16.92         -26.8
VENUS    263.6          1.697          16.98         -23
MARS     322.7          1.899          19.51         -23.4
JUPITER  231.6          6.343          15.61         -18.1
SATURN   206.4          10.54          14            -9.24
URANUS   244.3          19.96          16.3          -21
NEPTUNE  266.1          31.19          17.7          -22
PLUTO    210.2          30.36          14.09         4.718
DO YOU WANT ANOTHER DATE? █

```

The program RADEC provides a table of right ascension and declination of all the planets for any requested date.

Figure 11.1

Calculations are based on the 1960 epoch (about midcentury to allow forward and backward calculations without perturbations becoming too large). The program calculates the number of days from the epoch to the requested date. It uses planetary orbital data from the data statements, in which angles are expressed in radians. These statements provide information about each planet at the epoch, such as average motion per day, position at the epoch, eccentricity of the orbit, longitude of the perihelion, length in astronomical units of the semi-major axis, inclination of the orbit, and longitude of the ascending node. As indicated in the remark (REM) statements, the program uses standard trigonometrical formulas to derive for each planet the current heliocentric longitude, the distance from the

Sun in astronomical units, the angular distance above or below the ecliptic plane, and the distance in astronomical units from Earth. The angular distance from the Sun is then derived from the three sides of the triangle of distances of Earth, planet, and Sun. From this are derived the geocentric coordinates of each planet. These are then converted to right ascension and declination by changing degrees (measured from the first point of Aries) to hours of right ascension, and using the inclination of Earth's axis to derive declination (angular distance north or south of the celestial equator). String functions are used to prepare the data for display to an appropriate number of decimal places.

As with earlier programs, you may need to modify HOME statements and use the ENTER key instead of the RETURN key. The statements that may require modification are: 60, 180, 270, 280, 810, and 1100.

The listing of the RADEC program follows.

RADEC

```

10 REM RA AND DEC OF ALL PLANETS
20 DEF FN ASN(X) = ATN (X / SQR ( - X * X + 1))
30 DEF FN ACO(X) = - ATN (X / SQR ( - X * X + 1)) + 1.5707963
40 DEF FN RAD(X) = .01745328 * (X)
50 DEF FN DEG(X) = 57.29578 * (X)
60 HOME : PRINT : PRINT : PRINT : PRINT
70 PRINT TAB( 11)"ASTRONOMY PROGRAM"
80 PRINT : PRINT
90 PRINT TAB( 11)"-----"
100 PRINT TAB( 11)"I RADEC I"
110 PRINT TAB( 11)"-----"
120 PRINT : PRINT
130 PRINT TAB( 8)"BY ERIC BURGESS F.R.A.S."
140 PRINT : PRINT
150 PRINT TAB( 9)"ALL RIGHTS RESERVED BY"
160 PRINT TAB( 9)"S & T SOFTWARE SERVICE"
170 FOR J = 3000 TO 1 STEP - 1: NEXT
180 HOME : PRINT : PRINT : PRINT
190 PRINT : PRINT : PRINT : PRINT
200 PRINT TAB( 2)"THIS PROGRAM GIVES RIGHT ASCENSION"
210 PRINT TAB( 11)"AND DECLINATIONS"
220 PRINT TAB( 3)"HELIOCENTRIC LONGITUDES AND THE"
230 PRINT TAB( 3)"DISTANCES FROM EARTH OF ALL THE"
240 PRINT TAB( 12)"PLANETS": PRINT : PRINT
250 PRINT TAB( 4)"FOR THE DATE WHICH YOU INPUT"
260 PRINT : PRINT : PRINT : PRINT
270 INPUT "TO CONTINUE PRESS RETURN";A$
280 HOME : PRINT : PRINT : PRINT : PRINT
290 PRINT "ENTER THE DATE": PRINT
300 FL = 2
310 INPUT "THE YEAR ";YD$:Y = VAL (YD$)
320 IF Y = 0 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 310
330 IF Y > 1800 GOTO 370
340 PRINT "IS ";Y;" THE CORRECT YEAR? ": INPUT Y$
350 IF Y$ = "Y" THEN 370
360 IF Y$ < > "N" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 340
370 PRINT : INPUT "THE MONTH ";MD$:M = VAL (MD$)
380 IF M = 0 OR M > 12 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 370
390 PRINT : INPUT "THE DAY ";DD$:D = VAL (DD$)
400 IF D = 0 OR D > 31 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 390
410 IF M = 2 AND D > 29 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 390
420 REM CALC GREG. DAYS TO DATE
430 REM FROM EPOCH 1960,1,1
440 DG = 365 * Y + D + ((M - 1) * 31)
450 IF M > = 3 GOTO 490
460 REM CALC FOR JAN AND FEB
470 DG = DG + INT ((Y - 1) / 4) - INT ((.75) * INT ((Y - 1) / 100 + 1))
480 GOTO 510
490 REM CALC FOR MAR THRU DEC
500 DG = DG - INT (M * .4 + 2.3) + INT (Y / 4)
- INT ((.75) * INT ((Y / 100) + 1))
510 NI = DG - 715875
520 REM PLANETARY DATA FOR EPOCH 1960

```

RADEC (continued)

```

530 IF F = 1 GOTO 790
540 RESTORE
550 DIM PD(9,10)
560 FOR YY = 0 TO 8: FOR XX = 0 TO 8
570 READ PD(YY,XX)
580 NEXT XX,YY
590 REM MERCURY
600 DATA .071422,3.8484,.388301,1.34041,.3871,.07974,2.73514,.122173,.836013
610 REM VENUS
620 DATA .027962,3.02812,.013195,2.28638,.7233,.00506,3.85017,.059341,
1.33168
630 REM EARTH
640 DATA .017202,1.74022,.032044,1.78547,1,.017,3.33929,0,0
650 REM MARS
660 DATA .009146,4.51234,.175301,5.85209,1.5237,.141704,1.04656,.03142,
.858702
670 REM JUPITER
680 DATA .00145,4.53364,.090478,.23911,5.2028,.249374,1.76188,.01972,
1.74533
690 REM SATURN
700 DATA .000584,4.89884,.105558,1.61094,9.5385,.534156,3.1257,.043633,
1.977458
710 REM URANUS
720 DATA .000205,2.46615,.088593,2.96706,19.182,.901554,4.49084,.01396,
1.28805
730 REM NEPTUNE
740 DATA .000104,3.78556,.016965,.773181,30.06,.27054,2.33498,.031416,
2.29162
750 REM PLUTO
760 DATA .000069,3.16948,.471239,3.91303,39.44,9.86,5.23114,.300197,1.91812
770 FOR I9 = 1 TO 9: READ P$(I9): NEXT I9
780 DATA MERCURY,VENUS,EARTH,MARS,JUPITER,SATURN,URANUS,NEPTUNE,PLUTO
790 F = 1
800 REM CALC DATA FOR PLANETS
810 HOME : PRINT
820 PRINT "PLANETARY DATA FOR.. ";Y;" ";M;" ";D
830 PRINT "WHICH IS ";NI;" DAYS FROM EPOCH 1960"
840 PRINT "-----:-----:-----:-----:-----:-----:-----:"
850 PRINT "          HELIO      DIST      R.A.      DEC"
860 PRINT "          LONG      TO PLANET  HRS      DEG"
870 PRINT "-----:-----:-----:-----:-----:-----:-----:"
880 PRINT :I = 1
890 FOR J = 0 TO 8: GOSUB 1120
900 A(I) = A:D(I) = D:L(I) = L
910 I = I + 1: NEXT
920 FOR I = 1 TO 9
930 REM SKIP EARTH
940 IF I = 3 THEN NEXT
950 GOSUB 1260
960 Q(I) = Q:R(I) = R:V(I) = V
970 NEXT
980 FOR I = 1 TO 9:A(I) = FN DEG(A(I))
990 IF I = 3 THEN NEXT
1000 PRINT P$(I);
1010 PRINT TAB( 10); VAL ( LEFT$ ( STR$ ( A(I)),5));

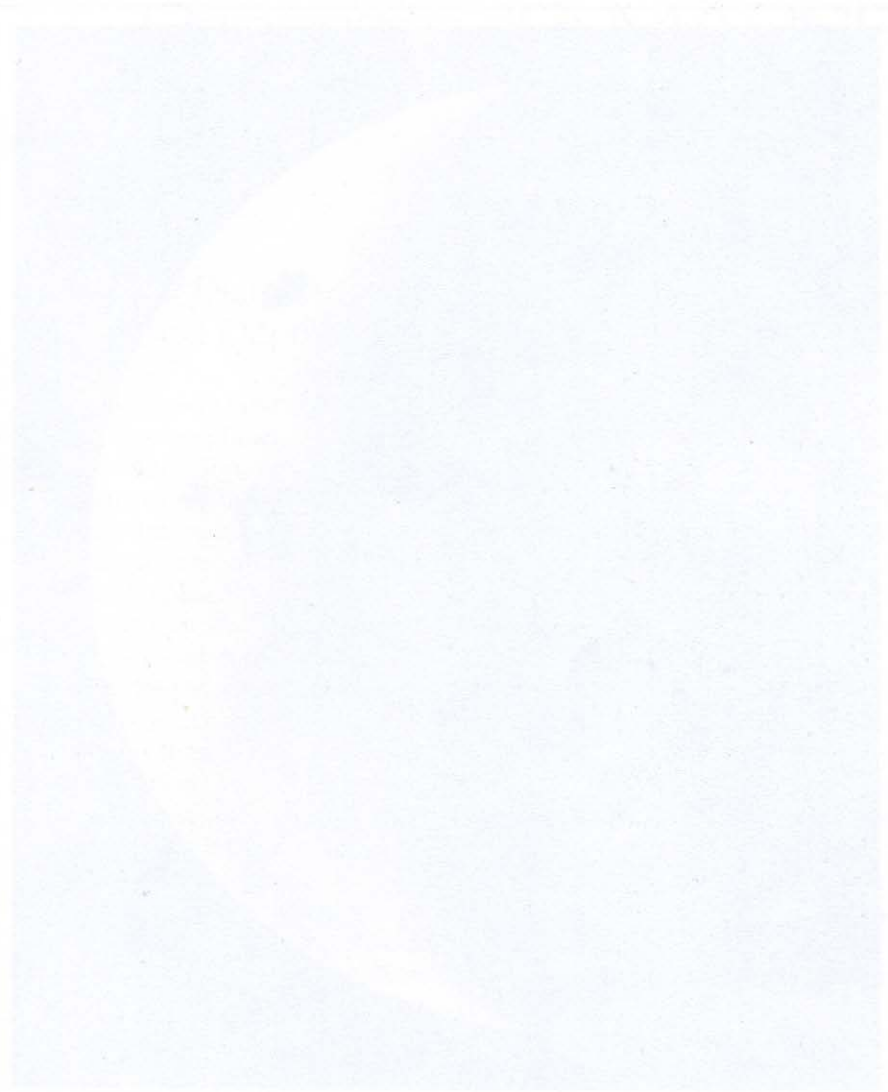
```

RADEC (continued)

```

1020 PRINT TAB( 18); VAL ( LEFT$ ( STR$ (Q(I)),5));
1030 PRINT TAB( 27); VAL ( LEFT$ ( STR$ (R(I)),5));
1040 PRINT TAB( 34); VAL ( LEFT$ ( STR$ (V(I)),5))
1050 PRINT
1060 NEXT
1070 INPUT "DO YOU WANT ANOTHER DATE? ";A$
1080 IF A$ = "Y" GOTO 280
1090 IF A$ < > "N" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 1070
1100 HOME
1110 END
1120 REM CALC A,D,AND L
1130 REM CALC HELIOCENTRIC LONG A
1140 A = NI * PD(J,0) + PD(J,1)
1150 IF A > 6.28318 THEN A = ((A / 6.28318) - INT (A / 6.28318)) * 6.28318
1160 IF A < 0 THEN A = A + 6.28318: GOTO 1160
1170 C = PD(J,2) * SIN (A - PD(J,3))
1180 A = A + C
1190 IF A > 6.28318 THEN A = A - 6.28318
1200 IF A < 0 THEN A = A + 6.28318: GOTO 1200
1210 REM CALC DIST OF PLANET FROM SUN D
1220 D = PD(J,4) + PD(J,5) * SIN (A - PD(J,6))
1230 REM CALC DIST. OF PLANET FROM ECLIPTIC L
1240 L = PD(J,7) * SIN (A - PD(J,8))
1250 RETURN
1260 REM CALC RA AND DEC R, V
1270 REM AND DISTANCE FROM EARTH Q
1280 Z = A(3) - A(I)
1290 IF ABS (Z) > 3.14159 AND Z < 0 THEN Z = Z + 6.28318
1300 IF ABS (Z) > 3.14159 AND Z > 0 THEN Z = Z - 6.28318
1310 REM DISTANCE FROM EARTH
1320 Q = SQR (D(I) ^ 2 + D(3) ^ 2 - 2 * D(I) * D(3) * COS (Z))
1330 REM CALC ANG DISTANCE FROM SUN
1340 P = (D(I) + D(3) + Q) / 2
1350 X = 2 * FN ACO ( SQR ((P * (P - D(I))) / (D(3) * Q)))
1360 REM CALC RA
1370 IF Z < 0 THEN R = FN DEG(A(3) + 3.14159 - X) / 15
1380 IF Z > 0 THEN R = FN DEG(A(3) + 3.14159 + X) / 15
1390 IF R > 24 THEN R = R - 24: GOTO 1390
1400 IF R < - 24 THEN R = R + 24: GOTO 1400
1410 IF R < 0 THEN R = R + 24: GOTO 1410
1420 REM CALC DEC.
1430 IF Z < 0 THEN V = SIN (A(3) + 3.14159 - X) * 23.44194 + FN DEG(L(I))
1440 IF Z > 0 THEN V = SIN (A(3) + 3.14159 + X) * 23.44194 + FN DEG(L(I))
1450 X = FN DEG(X)
1460 RETURN

```



The following text is extremely faint and illegible due to low contrast and blurring. It appears to be a paragraph of text located at the bottom of the page, possibly a caption or a short description related to the image above.



Photo Credit: NASA/Jet Propulsion Laboratory

Mars, known as the red planet, has intrigued mankind from time immemorial. Long associated with the god of war, the baleful planet until recently elicited images of Martians and invaders from space. Although the Viking expeditions to Mars threw considerable doubt on the possibility of there being life on Mars, it is still an intriguing planet. In this photograph Mars appears somewhat Earth-like, with clouds, volcanoes, and vast plains. Some parts of Mars are heavily cratered. The dark spots in the photograph are the huge volcanoes of the Tharsis region. In general Mars is a cold and icy planet.

Program 12: MARSP

Angular Diameter and Distance of Mars for Any Date, and Next Opposition

Because Mars orbits the Sun outside the orbit of Earth, it is referred to as a superior planet. The planet takes 687 Earth days to revolve completely around the Sun, compared with Earth's 365.25 days. Although Mars approaches relatively close to Earth compared with other outer planets, its small size makes it a difficult object to observe. The orbit of Mars is very elliptical compared with that of Earth, and consequently there are optimal times for observing the planet through any telescope. At closest approach (perihelion) Mars is 128.41 million miles from the Sun, while at its greatest distance (aphelion) the planet is 154.86 million miles from the Sun.

When Mars and Earth are aligned on the same side of the Sun, Mars is said to be in opposition (that is, opposite to the Sun in the terrestrial sky), and it is then at its closest to Earth and at its best position for telescopic observation. However, because of the elliptical Martian orbit, some oppositions are good (August and September) while others are bad (February and March). At a bad opposition Mars has an angular diameter of only about half that at a good opposition. The resolution of surface details is accordingly quite poor at a bad opposition. Consequently, favorable oppositions are welcomed by amateur astronomers.

On the average, oppositions of Mars take place once every two years and two months (780 days). When oppositions occur with Mars close to aphelion, the oppositions are only about 764 days apart, while perihelic oppositions are about 811 days apart. The best (perihelic) oppositions occur approximately every 16 years, and at those times Mars approaches within 34.9 million miles of Earth. At aphelic oppositions Mars is some 63.2 million miles from Earth. Unfortunately for observers located in the Northern Hemisphere, the August oppositions take place when Mars is on that part of the ecliptic which dips south of the celestial equator; the planet is low in the southern sky even at midnight. Good oppositions of Mars are best observed in the Southern Hemisphere. You will see why this is so if you use SYKSET/SKYPLT (Program 16) to display the midnight sky

for an August and a February opposition of Mars as seen from a location in the Northern Hemisphere and then from a location in the Southern Hemisphere.

This program offers two options: you can find the angular diameter of Mars at any date, or you can find the next opposition following any date. Both result in a similar display of the angular diameter of Mars, its distance from Earth, its angular distance from the Sun, and a comparison of its angular diameter with the greatest and smallest possible angular diameters. Figure 12.1 shows the detailed display of information given by the program.

When you choose to find the next opposition following any date, the program counts down dates toward the opposition. While doing so it

```

FOR YEAR 1982 MONTH 3 DAY 30
-----
DISTANCE OF MARS IS 634 A.U.
OR 58.9 MILLION MILES
ANG. DISTANCE FROM SUN IS 178. DEGREES
ANG DIAM OF MARS IS 14.67 SEC OF ARC
MAX AT CLOSEST OPPOSITION IS 25 SEC
COMPARISONS ARE.....
MAXIMUM DIAM (-----)
AT OPPOSITION
DIAM AT DATE ( )
MINIMUM DIAM (-)
AT CONJUNCTION

WANT ANOTHER DATE █

```

The MARSP program will display the information shown here for any date, or it will find the next opposition of Mars and display the information for that date.

Figure 12.1

displays a graphic plot showing the Sun, Earth, and Mars relative to the direction of the vernal equinox (first point of Aries). It also shows the movement of the two planets around the Sun toward the approaching opposition, to the point where they become aligned on the same side of the Sun at the opposition.

To accomplish this the program first calculates the positions of Mars and Earth at the beginning date. The calculations are made in terms of heliocentric longitude, which is the angle between the planet and the first point of Aries, measured at the Sun. Using high resolution graphics it plots the Sun, the direction of the first point of Aries, Mars, and Earth on the screen (subroutine 1980). The plot positions are derived (instructions 2130 and 2140) from the heliocentric longitudes of Earth and Mars (AE and MA), and they are converted to a suitable scale for the monitor screen (instructions 1990 through 2030). The display appears as though seen from high above the Sun.

The program next compares the heliocentric longitudes of Mars and Earth. If they differ by more than 120 degrees it jumps a month, recalculates the positions, and replots, erasing the first plot. When the difference in longitude of the two planets is less than 120 degrees, the increments of time are reduced to five days. As the angle between the planets narrows still further, the increments are reduced to two days, and finally to one day. When the two longitudes are within two degrees of each other the program declares an opposition and calculates the right ascension of Mars. The program then ascertains in which zodiacal constellation the opposition occurs (instructions 1780 through 1890) and prints the date and the name of the constellation. The program then calculates more details about the opposition and displays them (see Figure 12.1).

The listing of the MARSP program follows.

MARS

```

10 DEF FN ACO(X) = - ATN (X / SQR ( - X * X + 1)) + 1.5707963
20 LY = 0
30 FL = 0
40 P1 = 3.14159;P2 = 6.28318
50 HOME : PRINT : PRINT : PRINT
60 PRINT TAB( 10)"-----"
70 PRINT TAB( 10)"I    M A R S    I"
80 PRINT TAB( 10)"-----"
90 PRINT : PRINT
100 PRINT TAB( 8)"AN ASTRONOMY PROGRAM": PRINT : PRINT
110 PRINT TAB( 7)"BY ERIC BURGESS F.R.A.S.": PRINT : PRINT
120 PRINT TAB( 8)"ALL RIGHTS RESERVED BY"
130 PRINT TAB( 8)"S & T SOFTWARE SERVICE": PRINT : PRINT
140 PRINT
150 INPUT "DO YOU WANT INSTRUCTION (Y/N)";A$
160 IF A$ = "N" THEN HOME : PRINT : PRINT : GOTO 250
170 IF A$ < > "Y" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 150
180 HOME : PRINT : PRINT : PRINT
190 PRINT "THIS PROGRAM OFFERS TWO ALTERNATIVES": PRINT
200 PRINT " 1) CALCULATES APPROXIMATE ANGULAR"
210 PRINT "    DIAMETER OF MARS FOR ANY DATE"
220 PRINT " 2) PROVIDES APPROXIMATE DATE OF"
230 PRINT "    NEXT OPPOSITION AFTER ANY DATE": PRINT
240 PRINT : PRINT : PRINT
250 PRINT "SELECT 1) ANGULAR DIAMETER"
260 PRINT "    2) NEXT OPPOSITION"
270 PRINT
280 INPUT B$
290 IF B$ = "1" THEN 320
300 IF B$ < > "2" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 250
310 GOTO 1390
320 GOSUB 670: REM GET DISTANCE FROM EARTH
330 HOME : PRINT : PRINT
340 MD$ = LEFT$ ( STR$ (9.31 / Q),5)
350 PRINT "FOR YEAR ";Y;" MONTH ";M;" DAY ";D: PRINT
360 PRINT "-----": PRINT
370 Q$ = LEFT$ ( STR$ (Q),4)
380 PRINT "DISTANCE OF MARS IS ";Q$;" A.U."
390 PRINT "    OR "; LEFT$ ( STR$ (Q * 92.96),4);" MILLION MILES"
400 PRINT
410 MW$ = LEFT$ ( STR$ (W * 57.29578),4)
420 PRINT "ANG. DISTANCE FROM SUN IS ";MW$;
430 PRINT " DEGREES": PRINT
440 IF VAL (MD$) > 25 THEN MD$ = "25"
450 PRINT "ANG DIAM OF MARS IS ";MD$;
460 PRINT " SEC OF ARC"
470 PRINT " MAX AT CLOSEST OPPOSITION IS 25 SEC"
480 PRINT
490 PRINT "COMPARISONS ARE....."
500 PRINT
510 PRINT "MAXIMUM DIAM (-----)"
520 PRINT " AT OPPOSITION"
530 IF 9.36 / Q > = 25 THEN OP = 24: GOTO 550
540 OP = INT (9.36 / Q)

```

MARSP (continued)

```

550 PRINT "DIAM AT DATE (";
560 PRINT TAB( 14 + OP)");"
570 PRINT "MINIMUM DIAM (-)
580 PRINT " AT CONJUNCTION"
590 PRINT : PRINT
600 INPUT "WANT ANOTHER DATE ";A$
610 IF A$ = "N" THEN HOME : GOTO 660
620 IF A$ < > "Y" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 600
630 HOME :FL = 0: PRINT : PRINT : PRINT
640 IF B$ = "1" THEN GOTO 320
650 GOTO 1390
660 END
670 REM ROUTINE FOR ANGULAR DIAMETER
680 GOSUB 930: REM ENTER DATE
690 GOSUB 1180
700 REM CALC DISTANCE FROM EARTH
710 REM AND ANGULAR DISTANCE FROM SUN
720 AE = NI * .017202 + 1.74022
730 IF AE > P2 THEN AE = ((AE / P2) - INT (AE / P2)) * P2
740 IF AE < 0 THEN AE = AE + P2: GOTO 740
750 CE = .032044 * SIN (AE - 1.78547)
760 AE = AE + CE
770 IF AE > P2 THEN AE = AE - P2
780 IF AE < 0 THEN AE = AE + P2: GOTO 780
790 DE = 1 + .017 * SIN (AE - 3.33926)
800 GOSUB 1290
810 Z = AE - MA
820 IF ABS (Z) > P1 AND Z < 0 THEN Z = Z + P2
830 IF ABS (Z) > P1 AND Z > 0 THEN Z = Z - P2
840 IF Z = 0 THEN Q = MD - DE:W = P1: GOTO 920
850 IF Z = P1 THEN Q = MD + DE:W = 0: GOTO 920
860 REM CALC DISTANCE (Q) FROM EARTH (AU)
870 Q = SQR (MD ^ 2 + DE ^ 2 - 2 * MD * DE * COS (Z))
880 P = (MD + DE + Q) / 2
890 REM CALC ANGULAR DISTANCE (W) FROM SUN
900 V = SQR ((P * (P - MD)) / (DE * Q))
910 W = 2 * FN ACO(V)
920 RETURN
930 REM ENTER DATE
940 IF B$ = "2" AND FL = 1 THEN GOTO 1160
950 PRINT : PRINT
960 PRINT "ENTER THE DATE": PRINT
970 INPUT " THE YEAR ";Y$:Y = VAL (Y$)
980 IF Y = 0 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 970
990 IF Y > 1800 GOTO 1040
1000 PRINT "IS ";Y;" THE CORRECT YEAR": INPUT A$
1010 IF A$ = "Y" THEN 1040
1020 IF A$ < > "N" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 1000
1030 IF A$ = "N" THEN 970
1040 REM CHECK FOR LEAP YEAR
1050 GOSUB 1070
1060 GOTO 1100
1070 Y4 = Y / 4:Y5 = Y / 100
1080 IF Y4 - INT (Y4) = 0 AND Y5 - INT (Y5) < > 0 THEN LY = 1
1090 RETURN

```

MARS (continued)

```

1100 PRINT : INPUT " THE MONTH ";M$:M = VAL (M$)
1110 IF M = 0 OR M > 12 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 1070
1120 PRINT : INPUT " THE DAY ";D$:D = VAL (D$)
1130 IF D = 0 OR D > 31 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 1120
1140 IF M = 2 AND D > 29 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 1120
1150 REM STORE INITIAL DATE
1160 YI = Y:MJ = M:DI = D
1170 RETURN
1180 REM CALC DAYS FROM EPOCH
1190 DG = 365 * Y + D + ((M - 1) * 31)
1200 IF M > = 3 GOTO 1240
1210 REM CALC IF JAN OR FEB
1220 DG = DG + INT ((Y - 1) / 4) - INT ((.75) * INT ((Y - 1) / 100 + 1))
1230 GOTO 1260
1240 REM CALC FOR MAR THRU DEC
1250 DG = DG - INT (M * .4 + 2.3) + INT (Y / 4)
      - INT ((.75) * INT ((Y / 100) + 1))
1260 NI = DG - 715875
1270 RETURN
1280 GOTO 320
1290 REM CALC MARS'S POSITION
1300 MA = NI * .009146 + 4.51234
1310 IF MA > P2 THEN MA = ((MA / P2) - INT (MA / P2)) * P2
1320 IF MA < 0 THEN MA = MA + P2: GOTO 1320
1330 MC = .175301 * SIN (MA - 5.85209)
1340 MA = MA + MC
1350 IF MA > P2 THEN MA = MA - P2
1360 IF MA < 0 THEN MA = MA + P2: GOTO 1360
1370 MD = 1.5237 + .141704 * SIN (MA - 1.04656)
1380 RETURN
1390 GOSUB 930: GOSUB 1180
1400 GOSUB 710
1410 PRINT : PRINT
1420 HOME : PRINT : PRINT : PRINT
1430 VTAB 23
1440 PRINT YI;" ";MJ;" ";DI
1450 GOSUB 1980: REM TO PLOT PLANETS
1460 FL = 1
1470 DS = W * 57.29578
1480 IF DS > 120 THEN GOTO 1540
1490 FL = 1
1500 M = M + 1
1510 IF M > 12 THEN M = 1:Y = Y + 1
1520 GOSUB 1070
1530 GOTO 1390
1540 REM COMPUTE FOR DAYS
1550 IF DS < 160 THEN D = D + 5: GOTO 1580
1560 IF DS < 170 THEN D = D + 2: GOTO 1580
1570 D = D + 1
1580 GOSUB 1630
1590 D2 = DS
1600 IF DS > 178 THEN GOTO 1710
1610 IF D2 < DS THEN D = D + 1: GOSUB 1630
1620 GOTO 1700
1630 REM CORRECT FOR MONTH AND YEAR ENDS
1640 IF (LY = 1 AND M = 2 AND D > 29) THEN M = 3:D = D - 29: GOTO 1640

```

MARSF (continued)

```
1650 IF (LY = 0 AND M = 2 AND D > 28) THEN M = 3:D = D - 28: GOTO 1650
1660 IF D < 31 THEN GOTO 1690
1670 IF (M = 4 OR M = 6 OR M = 9 OR M = 11) THEN M = M + 1:D = D - 30:
GOTO 1690
1680 IF D > 31 THEN M = M + 1:D = D - 31
1690 RETURN
1700 GOTO 1390
1710 REM COMPUTE RA FOR YI,MI,DI
1720 IF Z < 0 THEN R = AE + P1 - W
1730 IF Z > 0 THEN R = AE + P1 + W
1740 R = 57.29578 * R / 15
1750 IF R > 24 THEN R = R - 24: GOTO 1750
1760 IF R < - 24 THEN R = R + 24: GOTO 1760
1770 IF R < 0 THEN R = R + 24: GOTO 1770
1780 IF R > 0 AND R < 2 THEN C$ = "PISCES": GOTO 1900
1790 IF R > 2 AND R < 4 THEN C$ = "ARIES": GOTO 1900
1800 IF R > 4 AND R < 6 THEN C$ = "TAURUS": GOTO 1900
1810 IF R > 6 AND R < 8 THEN C$ = "GEMINI": GOTO 1900
1820 IF R > 8 AND R < 10 THEN C$ = "CANCER": GOTO 1900
1830 IF R > 10 AND R < 12 THEN C$ = "LEO": GOTO 1900
1840 IF R > 12 AND R < 14 THEN C$ = "VIRGO": GOTO 1900
1850 IF R > 14 AND R < 16 THEN C$ = "LIBRA": GOTO 1900
1860 IF R > 16 AND R < 18 THEN C$ = "SCORPIO": GOTO 1900
1870 IF R > 18 AND R < 20 THEN C$ = "SAGITTARIUS": GOTO 1900
1880 IF R > 20 AND R < 22 THEN C$ = "CAPRICORNUS": GOTO 1900
1890 IF R > 22 AND R < 24 THEN C$ = "AQUARIUS"
1900 PRINT
1910 TEXT
1920 PRINT "NEXT OPPOSITION OF MARS IS"
1930 PRINT "      "YI;" ";MI;" ";DI
1940 PRINT "IN THE CONSTELLATION OF ";C$
1950 PRINT
1960 INPUT "FOR FURTHER DETAILS PRESS RETURN KEY";Q$
1970 Y = YI:M = MI:D = DI: GOTO 320
1980 REM SUB TO PLOT PLANETS
1990 AD = 50:DM = 75
2000 EY = AD * SIN (AE)
2010 EX = 1.5 * AD * COS (AE)
2020 MY = DM * SIN (MA)
2030 MX = 1.5 * DM * COS (MA)
2040 HGR
2050 HPLOT 138,78: HPLOT 139,79: HPLOT 137,77
2060 HPLOT 136,76: HPLOT 140,80: HPLOT 139,81
2070 HPLOT 138,81: HPLOT 137,81: HPLOT 136,80
2080 HPLOT 138,75: HPLOT 137,75: HPLOT 139,75
2090 HPLOT 140,76: HPLOT 139,75: HPLOT 140,76
2100 FOR J = 150 TO 250 STEP 10
2110 HPLOT J,78 TO J + 5,78
2120 NEXT J
2130 HPLOT (138 + EX),(78 - EY)
2140 HPLOT (138 + MX),(78 - MY)
2150 HPLOT 269,76: HPLOT 270,79: HPLOT 270,78
2160 HPLOT 270,77: HPLOT 269,76: HPLOT 268,76
2170 HPLOT 267,77: HPLOT 271,76: HPLOT 272,76
2180 HPLOT 273,77
2190 RETURN
```

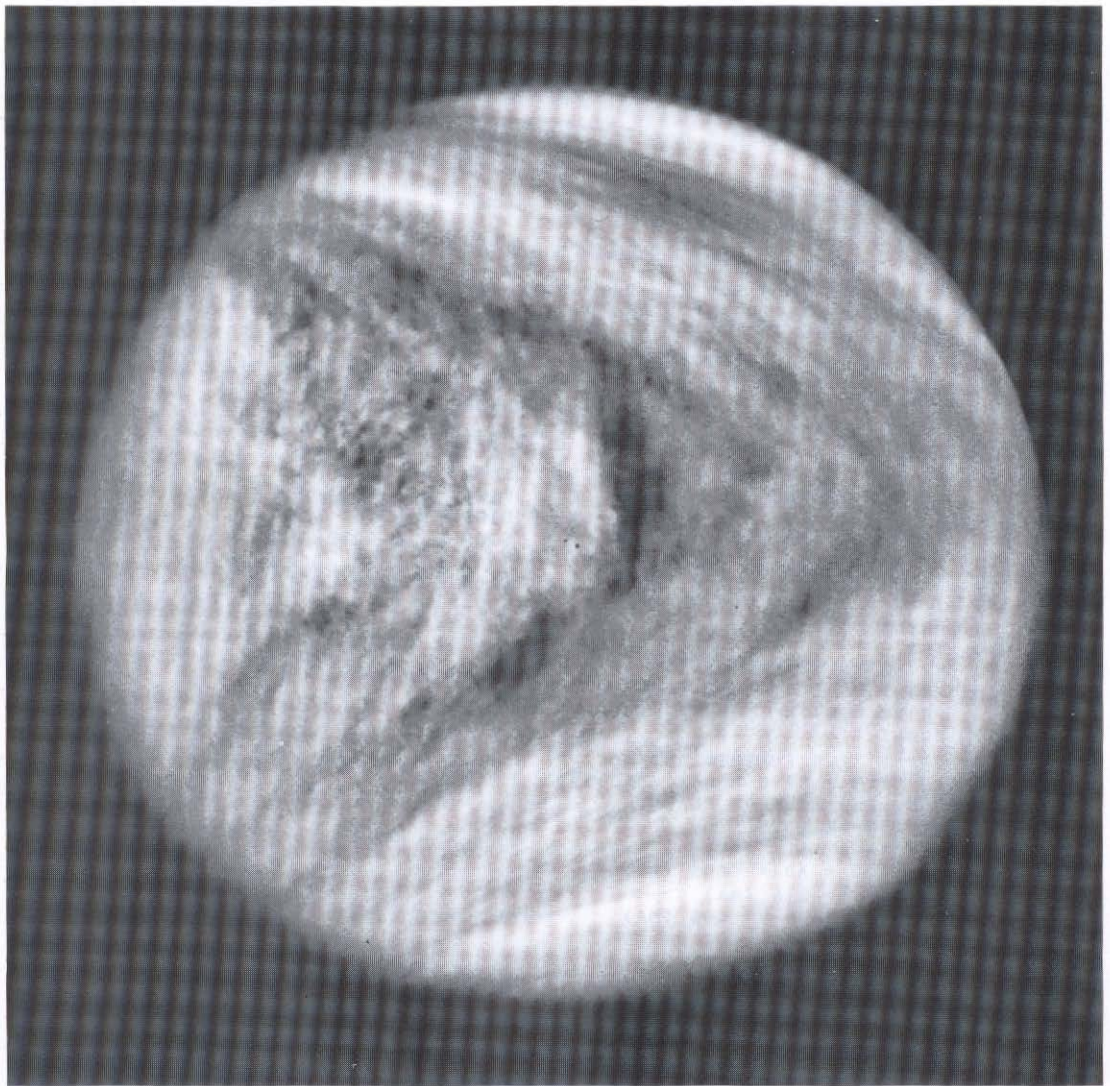


Photo Credit: NASA/Ames

By contrast with Mars, Venus is a hot planet whose surface is obscured completely by its cloud system. Venus is larger than Mars and almost the same size as Earth. A question we still have not been able to answer is why Venus should have evolved so differently from Earth. Radar carried by spacecraft has

penetrated the clouds to reveal highlands, plains, and what may be two large volcanic regions through which heat escapes from the interior. This picture is a view of the cloud-shrouded planet obtained by the Pioneer Venus orbiting spacecraft.

Program 13: MVENC and MERVE

Elongations, Phases, Angular Diameters, and Distances of Mercury and Venus, and Next Elongations_____

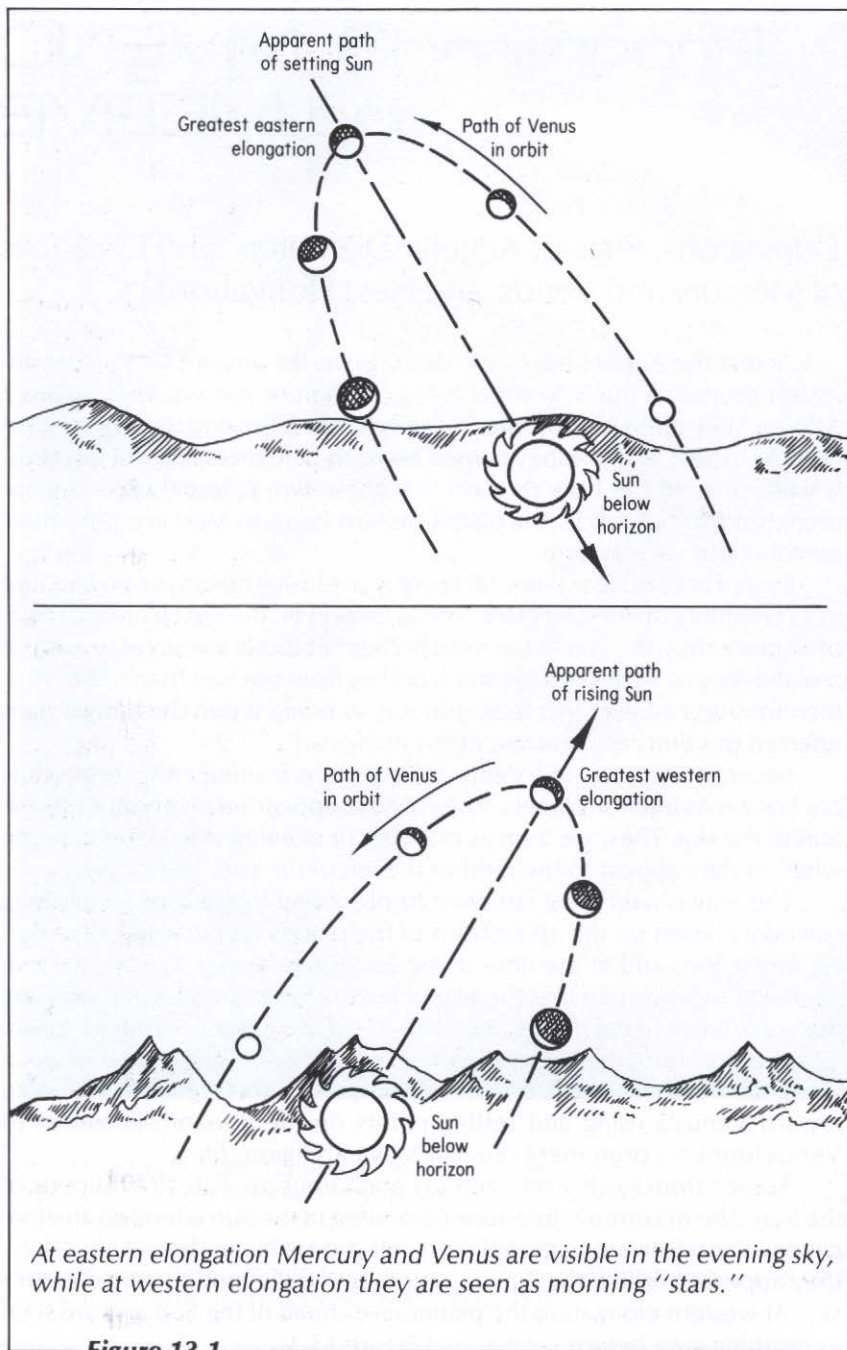
Across the Aegean Sea in the dawn glow, the ancient Greeks periodically observed a dull white star rising just before sunrise. They called it Apollo. They often saw another dull white star following the Sun to set in the Ionian Sea, and this they named Mercury, the messenger of the gods. It was not until the time of Plato that these two celestial objects were recognized as being one: the planet we now know as Mercury, innermost planet of our solar system.

Except in very clear skies, Mercury is an elusive object to find because of its proximity to the solar glare. Venus, however, the next planet in terms of distance from the Sun, is the most brilliant object in the sky after the Sun and the Moon. Venus moves much farther from the Sun than Mercury in the morning and evening skies, and it is so brilliant that the Babylonians referred to Venus as "mistress of the heavens."

Because Mercury and Venus follow orbits inside Earth's orbit, they are known as inferior planets. They always appear relatively close to the Sun in the sky. They are seen as morning or evening stars depending on whether they appear to the right or the left of the Sun, respectively.

The Mayas paid great attention to observing Venus and establishing calendars based on the apparitions of the planet. Venus was called *noh ek*, Great Star, and at the time of the Spanish conquest the accuracy of observations was such that the Mayas never made mistakes in predicting the apparitions of the planet. Pages 46–50 of the Dresden Codex contain information about the cycles of Venus in a dot-bar notation to base 20, a vigesimal numbering system. Much Mayan architecture is also oriented toward Venus's rising and setting points on the horizon. Sacrifices to Venus formed a prominent ritual of Mayan religious life.

As seen from Earth, both Mercury and Venus oscillate to either side of the Sun. The maximum distance east or west of the Sun is termed an elongation. At eastern elongation the planets are visible in the evening sky—they appear to follow the Sun in its apparent daily motion across Earth's sky. At western elongation the planets are ahead of the Sun and are seen as morning stars before sunrise (see Figure 13.1).



At eastern elongation Mercury and Venus are visible in the evening sky, while at western elongation they are seen as morning "stars."

Figure 13.1

Venus repeats its apparitions approximately every 584 days, while Mercury repeats every 116 days. Mercury's orbit is quite elliptical, so its apparitions vary greatly; its elongation from the Sun can be as little as 18 degrees and as much as 27 degrees. Mercury can be seen for a maximum of only 2.5 hours before sunrise or after sunset at a favorable elongation. By contrast, Venus moves about 47 degrees from the Sun at its maximum elongation and can be observed for a much greater period. On the average, Venus passes from greatest eastern elongation as an evening star to greatest western elongation as a morning star in about 140 days, and from a morning star back to an evening star in about 430 days. Venus is unobservable with the unaided eye for about eight days as it passes between Earth and the Sun, except on those very rare occasions when the planet passes in transit across the face of the Sun. When Venus swings behind the Sun it is hidden in the solar glare for about seven weeks. Thus Venus has four distinct periods to its cycle: two unequal periods of invisibility, and two periods, each of about nine months' visibility, as an evening or morning "star."

This program offers two alternatives. It will provide information on the two planets' distances from Earth, angular sizes, and phases for any date and graphically display the positions of both planets relative to the Sun (see Figure 13.2). It will also calculate the date of the next elongation of Mercury or Venus following any date.

When you select the alternative to seek the next elongation, the display counts down in dates toward the elongation and shows the positions of Mercury and Venus relative to the Sun. On arrival at the elongation, you can then ask for more details, such as distance from Earth, phase, angular distance from the Sun, and angular diameter of the planet at the date of elongation (see Figure 13.3).

Using similar routines to those of earlier planetary programs, the program determines the angular distance of the planets from the Sun (starting with instruction 930). It finds the angular distance of the planet for which you seek the next elongation, repeats the calculation for a later date, and searches for a maximum angular distance from the Sun by repeated comparisons following increments of the date. The next elongation is identified as the first maximum of angular distance to be encountered after the start date. Next the program determines if this is east or west of the Sun. For the date of the elongation it then calculates the other parameters for the display. Through a simple sort routine (instructions 1790 through 1960) the program develops a graphic display of the Sun with the planets configured alongside as they appear from Earth.

Another version of this program (MERVE) plots the positions of Mercury and Venus relative to the Sun for a number of intervals. This version gives a graphic display of the planets moving from side to side of the Sun. It allows

the display to overlay earlier displays or to scroll, to show several configurations on the screen at once. When all the intervals have been plotted, the program allows you to select details about either or both planets—such as distance, phase, and angular diameter. It uses the same basic algorithms and sort routine for the graphic display as the MVENC program uses, but it does not seek an elongation. Instead it counts displays to the number of intervals requested. An example of the display provided by the MERVE program is shown in Figure 13.4.

The listings for the MVENC and MERVE programs follow.

```

FOR YEAR 1982 MONTH 1 DAY 16
-----
DISTANCE OF MERCURY .967 A.U.
                OR 89.87 MILLION MI
MERCURY'S ANG. DIST. FROM SUN -18. DEG.
MERCURY'S ANG. DIAMETER 6.905 ARCSEC
  MAX AT INFER. CONJ. IS 12 SEC
MERCURY'S PHASE NEAR HALF 96 DEG ILLUM

VISUAL CONFIGURATION ON 1982 1 16
V = VENUS; M = MERCURY; 0 = SUN
      M   V   0

DO YOU WANT ANOTHER DATE Y/N? █

```

Details of either or both planets can be displayed by the MVENC and MERVE programs.

Figure 13.2

```

NEXT ELONGATION OF MERCURY 1982 1 16
AND THE PLANET IS....
    EAST OF SUN (AN EVENING STAR)
VISUAL CONFIGURATION ON 1982 1 16
V = VENUS; M = MERCURY; 0 = SUN
    M    V    0
DO YOU WANT MORE DETAILS Y/N? █

```

Information on the next elongation of Mercury or Venus is displayed by the MVENC program.

Figure 13.3

```

DISPLAY 1 IS DATE 1982 1 1
    V    M    0
DISPLAY 2 IS DATE 1982 1 31
                M 0    V
DISPLAY 3 IS DATE 1982 3 2
                0    M    V
SELECT DETAILS FOR DISPLAY
MERCURY (1); VENUS (2); OR BOTH (3) █

```

Positions of Mercury (M) and Venus (V) are shown relative to the Sun (0) for a series of intervals in this typical display generated by the MERVE program.

Figure 13.4

MVENC

```

10 REM INNER PLANETS' ELONGATIONS
20 DEF FN ACO(X) = - ATN (X / SQR ( - X * X + 1)) + 1.5707963
30 P1 = 3.14159:P2 = 6.28318
40 HOME : PRINT : PRINT : PRINT
50 PRINT TAB( 10)"AN ASTRONOMY PROGRAM"
60 PRINT : PRINT
70 PRINT TAB( 10)"-----"
80 PRINT TAB( 10)"I INNER PLANETS I"
90 PRINT TAB( 10)"-----"
100 PRINT : PRINT
110 PRINT TAB( 9)"BY ERIC BURGESS F.R.A.S."
120 PRINT : PRINT
130 PRINT TAB( 9)"ALL RIGHTS RESERVED BY"
140 PRINT TAB( 9)"S & T SOFTWARE SERVICE"
150 PRINT : PRINT : PRINT
160 INPUT "DO YOU WANT INSTRUCTIONS Y/N? ";A$
170 IF A$ = "N" THEN HOME : PRINT : PRINT : GOTO 350
180 IF A$ < > "Y" THEN PRINT "INVALID RESPONSE:PRINT:GOTO140
190 HOME : PRINT : PRINT : PRINT
200 PRINT "THIS PROGRAM OFFERS TWO ALTERNATIVES"
210 PRINT : PRINT
220 PRINT " 1) CALCULATES APPROXIMATE ANGULAR"
230 PRINT "     DISTANCES OF MERCURY AND VENUS"
240 PRINT "     FROM THE SUN, AND APPROXIMATE"
250 PRINT "     DISTANCES FROM EARTH, AND"
260 PRINT "     PROVIDES APPROXIMATE ANGULAR"
270 PRINT "     DIAMETER AND PHASE FOR ANY DATE"
280 PRINT
290 PRINT " 2) PROVIDES DATE OF THE NEXT"
300 PRINT "     ELONGATION OF MERCURY OR VENUS"
310 PRINT "     AFTER ANY DATE"
320 PRINT : PRINT
330 INPUT "TO CONTINUE PRESS RETURN ";A$
340 HOME : PRINT : PRINT : PRINT
350 PRINT "SELECT 1) ANGULAR DISTANCES"
360 PRINT "     2) NEXT ELONGATION"
370 PRINT : INPUT B$
380 IF B$ = "1" THEN 410
390 IF B$ < > "2" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 340
400 GOTO 2110
410 GOSUB 890: REM GET DISTANCE FROM EARTH
420 HOME : PRINT : PRINT
430 GOSUB 440: GOTO 820
440 MD$ = LEFT$ ( STR$ (6.68 / MQ),5)
450 VD$ = LEFT$ ( STR$ (16.82 / VQ),5)
460 PRINT "FOR YEAR ";Y;" MONTH ";M;" DAY ";D: PRINT
470 PRINT "-----": PRINT
480 MQ$ = LEFT$ ( STR$ (MQ),4)
490 VQ$ = LEFT$ ( STR$ (VQ),4)
500 IF E$ = "2" THEN GOTO 540
510 PRINT "DISTANCE OF MERCURY ";MQ$;" A.U."
520 PRINT TAB( 10)"OR "; VAL ( LEFT$ ( STR$ (MQ * 92.9),5));" MILLION MI"
530 IF E$ = "1" THEN GOTO 560
540 PRINT "DISTANCE OF VENUS ";VQ$;" A.U."

```

MVENC (continued)

```

550 PRINT TAB( 10)"OR "; VAL ( LEFT$ ( STR$ (VQ * 92.9),5));" MILLION MI"
560 PRINT
570 MW$ = LEFT$ ( STR$ (MW * 57.29578),4)
580 VW$ = LEFT$ ( STR$ (VW * 57.29578),4)
590 IF E$ = "2" THEN GOTO 620
600 PRINT "MERCURY'S ANG. DIST. FROM SUN ";MW$;" DEG."
610 IF E$ = "1" THEN PRINT : GOTO 640
620 PRINT "VENUS'S ANGULAR DIST. FROM SUN ";VW$;" DEG."
630 PRINT
640 IF E$ = "2" THEN GOTO 690
650 PRINT "MERCURY'S ANG. DIAMETER ";MD$;" ARCSEC"
660 PRINT " MAX AT INFER. CONJ. IS 12 SEC"
670 IF E$ = "1" THEN GOTO 710
680 PRINT
690 PRINT "VENUS'S ANG. DIAMETER ";VD$;" ARCSEC"
700 PRINT " MAX AT INFER. CONJ. IS 61 SEC"
710 PRINT
720 PH = ABS (MW) + ABS (MZ): GOSUB 2880
730 IF E$ = "2" THEN GOTO 760
740 PRINT "MERCURY'S PHASE ";PH$;" ";PH;" DEG ILLUM"
750 IF E$ = "1" THEN GOTO 820
760 PH = ABS (VW) + ABS (ZV): GOSUB 2880
770 PRINT "PHASE OF VENUS ";PH$;" ";PH;" DEG ILLUM"
780 :
790 IF E$ = "2" THEN 820
800 GOSUB 1790
810 GOSUB 1970
820 :
830 IF B$ = "2" THEN RETURN
840 INPUT "WANT ANOTHER DATE Y/N ? ";A$
850 IF A$ = "N" THEN HOME : GOTO 880
860 IF A$ < > "Y" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 840
870 HOME : PRINT : PRINT : PRINT : GOTO 410
880 END
890 REM ROUTINE FOR ANG. DIAMETER
900 HOME : PRINT : PRINT : PRINT
910 GOSUB 1180: REM ENTER DATE
920 GOSUB 1360
930 REM CALC DIST. FROM EARTH
940 REM AND ANG. DISTANCE FROM SUN
950 AE = NI * .017202 + 1.74022
960 IF AE > P2 THEN AE = ((AE / P2) - INT (AE / P2)) * P2
970 IF AE < 0 THEN AE = AE + P2: GOTO 970
980 CE = .032044 * SIN (AE - 1.78547)
990 AE = AE + CE
1000 IF AE > P2 THEN AE = AE - P2
1010 IF AE < 0 THEN AE = AE + P2: GOTO 1010
1020 DE = 1 + .017 * SIN (AE - 3.33926)
1030 GOSUB 1470
1040 MZ = AE - MA
1050 ZM = MZ
1060 IF ABS (MZ) > P1 AND MZ < 0 THEN MZ = MZ + P2
1070 IF ABS (MZ) > P1 AND MZ > 0 THEN MZ = MZ - P2
1080 REM CALC DISTANCE FROM EARTH IN AU
1090 MQ = SQR (MD ^ 2 + DE ^ 2 - 2 * MD * DE * COS (MZ))

```

MVENC (continued)

```

1100 MP = (MD + DE + MQ) / 2
1110 REM CALC ANG. DISTANCE FROM SUN
1120 MV = SQR ((MP * (MP - MD)) / (DE * MQ))
1130 MW = 2 * FN ACO(MV)
1140 IF ABS (ZM) > P1 THEN ZM = ZM + P2
1150 IF ZM > 0 THEN MW = - MW
1160 GOSUB 1570
1170 RETURN
1180 REM ENTER DATE
1190 PRINT : PRINT
1200 PRINT : PRINT "ENTER THE DATE ": PRINT
1210 INPUT "THE YEAR ";Y$:Y = VAL (Y$)
1220 IF Y = 0 THEN PRINT "INVALID RESPONSE"; PRINT : GOTO 1210
1230 IF Y > 1800 GOTO 1280
1240 PRINT "IS ";Y;" THE CORRECT YEAR": INPUT A$
1250 IF A$ = "Y" THEN 1280
1260 IF A$ < > "N" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 1240
1270 IF A$ = "N" THEN 1210
1280 PRINT : INPUT "THE MONTH ";M$:M = VAL (M$)
1290 IF M = 0 OR M > 12 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 1280
1300 PRINT : INPUT "THE DAY ";D$:D = VAL (D$)
1310 IF D = 0 OR D > 31 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 1300
1320 IF M = 2 AND D > 29 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 1300
1330 REM STORE INITIAL DATE AND TIME
1340 YI = Y:MI = M:DI = D
1350 RETURN
1360 REM CALC DAYS FROM EPOCH 1960
1370 DG = 365 * Y + D + ((M - 1) * 31)
1380 IF M > = 3 GOTO 1420
1390 REM CALC IF JAN OR FEB
1400 DG = DG + INT ((Y - 1) / 4) - INT ((.75) * INT ((Y - 1) / 100 + 1))
1410 GOTO 1440
1420 REM CALC FOR MAR THRU DEC
1430 DG = DG - INT (M * .4 + 2.3) + INT (Y / 4)
  - INT ((.75) * INT ((Y / 100) + 1))
1440 NI = DG - 715875
1450 RETURN
1460 GOTO 410
1470 REM CALC MERCURY'S POSITION
1480 MA = NI * .071425 + 3.8494
1490 IF MA > P2 THEN MA = ((MA / P2) - INT (MA / P2)) * P2
1500 IF MA < 0 THEN MA = MA + P2: GOTO 1500
1510 MC = .388301 * SIN (MA - 1.34041)
1520 MA = MA + MC
1530 IF MA > P2 THEN MA = MA - P2
1540 IF MA < 0 THEN MA = MA + P2: GOTO 1540
1550 MD = .3871 + .079744 * SIN (MA - 2.73514)
1560 RETURN
1570 REM CALC VENUS'S POSITION
1580 VA = NI * .027962 + 3.02812
1590 IF VA > P2 THEN VA = ((VA / P2) - INT (VA / P2)) * P2
1600 IF VA < 0 THEN VA = VA + P2: GOTO 1600
1610 VC = .013195 * SIN (VA - 2.28638)
1620 VA = VA + VC
1630 IF VA > P2 THEN VA = VA - P2

```

MVENC (continued)

```

1640 IF VA < 0 THEN VA = VA + P2: GOTO 1640
1650 VD = .7233 + .00506 * SIN (VA - 3.85017)
1660 ZV = AE - VA
1670 VZ = ZV
1680 IF ABS (ZV) > P1 AND ZV < 0 THEN ZV = ZV + P2
1690 IF ABS (ZV) > P1 AND ZV > 0 THEN ZV = ZV - P2
1700 REM CALC DISTANCE FROM EARTH IN AU
1710 VQ = SQR (VD ^ 2 + DE ^ 2 - 2 * VD * DE * COS (ZV))
1720 VP = (VD + DE + VQ) / 2
1730 REM CALC ANG. DISTANCE FROM SUN
1740 VV = SQR ((VP * (VP - VD)) / (DE * VQ))
1750 VW = 2 * FN ACO(VV)
1760 IF ABS (VZ) > P1 THEN VZ = VZ + P2
1770 IF VZ > 0 THEN VW = - VW
1780 RETURN
1790 REM SHOW SUN AND PLANETS
1800 Z$(0) = MW$ + "M":Z$(1) = VW$ + "V"
1810 Z$(2) = STR$(0) + ""
1820 FOR I = 0 TO 2
1830 E$(I) = "XXX"
1840 NEXT I
1850 K = 0
1860 FOR I = 0 TO 2
1870 IF Z$(I) = "XXX" GOTO 1950
1880 FOR J = I TO 2
1890 IF Z$(J) = "XXX" GOTO 1910
1900 IF VAL (Z$(J)) < VAL (Z$(I)) THEN I = J: GOTO 1910
1910 NEXT J
1920 E$(K) = Z$(I):Z$(I) = "XXX"
1930 K = K + 1
1940 I = - 1
1950 NEXT I
1960 RETURN
1970 INPUT "FOR VISUAL CONFIGURATION PRESS RETURN";A$
1980 PRINT
1990 PRINT "VISUAL CONFIGURATION ON ";YI;" ";MI;" ";DI
2000 PRINT
2010 PRINT "V = VENUS; M = MERCURY; 0 = SUN"
2020 PRINT
2030 M1 = 20 + .8 * VAL ( LEFT$ (E$(0),5)) / 2
2040 PRINT TAB( M1); RIGHT$ (E$(0),1);
2050 M2 = 20 + .8 * VAL ( LEFT$ (E$(1),5)) / 2
2060 PRINT TAB( M2); RIGHT$ (E$(1),1);
2070 M3 = 20 + .8 * VAL ( LEFT$ (E$(2),5)) / 2
2080 PRINT TAB( M3); RIGHT$ (E$(2),1)
2090 PRINT : PRINT
2100 RETURN
2110 HOME : REM ROUTINE FOR ELONGATIONS
2120 PRINT : PRINT : PRINT
2130 PRINT "SELECT MERCURY (1)"
2140 INPUT " OR VENUS (2) ";E$
2150 IF E$ = "1" THEN GOSUB 2170: GOTO 2430
2160 GOSUB 2620
2170 HOME : GOSUB 1200: REM GET DATE
2180 FL = 0

```

MVENC (continued)

```

2190 GOSUB 1360: REM  CALC DAYS FROM EPOCH
2200 GOSUB 930: REM  CALC FOR EARTH AND PLANETS
2210 VW$ = STR$(VW * 57.29578)
2220 HOME
2230 PRINT
2240 PRINT YI;" ";MI;" ";DI
2250 PRINT : PRINT : PRINT : PRINT : PRINT
2260 MW$ = STR$(MW * 57.29578): GOSUB 1790: GOSUB 2030
2270 PRINT : PRINT : PRINT : PRINT
2280 PRINT "M = MERCURY, V = VENUS, 0 = SUN"
2290 DS = MW * 57.29578
2300 IF FL = 0 AND ABS(DS) < 20 THEN D = D + 5: GOTO 2350
2310 CK = ABS(DS) - ABS(D2)
2320 IF CK < .05 AND CK > - .05 THEN 2400
2330 IF ABS(DS) < 15 THEN D = D + 5: GOTO 2350
2340 IF CK < .1 OR CK > - .1 THEN D = D + 1: GOTO 2350
2350 IF D > 30 THEN M = M + 1:D = D - 30
2360 IF M > 12 THEN M = 1:Y = Y + 1
2370 D2 = DS:FL = 1
2380 GOSUB 1340
2390 GOTO 2190
2400 HOME : PRINT : PRINT : PRINT
2410 PRINT "NEXT ELONGATION OF MERCURY ";Y;" ";M;" ";D
2420 PRINT : PRINT
2430 IF MW < 0 THEN P$ = "EAST OF SUN (AN EVENING STAR)": GOTO 2450
2440 P$ = "WEST OF SUN (A MORNING STAR)"
2450 PRINT "AND THE PLANET IS...."
2460 PRINT
2470 PRINT TAB( 5);P$
2480 GOSUB 1980
2490 INPUT "DO YOU WANT MORE DETAILS Y/N? ";A$
2500 IF A$ = "N" THEN HOME : PRINT : GOTO 2530
2510 IF A$ = "Y" THEN HOME : PRINT : GOSUB 440
2520 PRINT : GOSUB 1980: PRINT
2530 INPUT "DO YOU WANT ANOTHER DATE Y/N? ";A$
2540 IF E$ = "2" AND A$ = "Y" THEN GOTO 2620
2550 IF E$ = "1" AND A$ = "Y" THEN GOTO 2170
2560 IF A$ < > "N" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 2530
2570 PRINT : PRINT
2580 INPUT "DO YOU WANT ANOTHER PLANET Y/N? ";A$
2590 IF A$ = "Y" THEN GOTO 2110
2600 IF A$ < > "N" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 2580
2610 GOTO 880
2620 HOME : GOSUB 1200: REM  GET DATE
2630 FL = 0
2640 GOSUB 1360: REM  CALC DAYS FROM EPOCH
2650 GOSUB 930: REM  CALC FOR EARTH AND PLANETS
2660 HOME
2670 MW$ = STR$(MW * 57.29578)
2680 PRINT
2690 PRINT YI;" ";MI;" ";DI
2700 PRINT : PRINT : PRINT : PRINT : PRINT
2710 VW$ = STR$(VW * 57.29578): GOSUB 1790: GOSUB 2030
2720 PRINT : PRINT : PRINT : PRINT
2730 PRINT "V= VENUS, M = MERCURY, S = SUN"

```


MVENC (continued)

```
2740 VS = VW * 57.29578
2750 IF FL = 0 AND ABS (VS) < 45 THEN D = D + 20: GOTO 2800
2760 CK = ABS (VS) - ABS (V2)
2770 IF CK < .05 AND CK > - .05 THEN 2850
2780 IF ABS (VS) < 40 THEN D = D + 10: GOTO 2800
2790 IF CK < .1 OR CK > - .1 THEN D = D + 1: GOTO 2800
2800 IF D > 30 THEN M = M + 1: D = D - 30
2810 IF M > 12 THEN M = 1: Y = Y + 1
2820 V2 = VS: FL = 1
2830 GOSUB 1340
2840 GOTO 2640
2850 HOME : PRINT : PRINT : PRINT
2860 PRINT "NEXT ELONGATION OF VENUS IS "; Y; " "; M; " "; D
2870 MW = VW: PRINT : GOTO 2430
2880 REM SUB FOR PHASES
2890 PH = 180 - PH * 57.2958
2900 IF PH > 150 THEN PH$ = "THIN CRESCENT"
2910 IF PH > 120 AND PH < 151 THEN PH$ = "FAT CRESCENT"
2920 IF PH > 70 AND PH < 121 THEN PH$ = "NEAR HALF"
2930 IF PH > 29 AND PH < 71 THEN PH$ = "GIBBOUS"
2940 IF PH < 21 THEN PH$ = "NEAR FULL"
2950 PH = INT (180 - PH)
2960 RETURN
```

MERVE

```

10 HOME
20 DEF FN ACO(X) = - ATN ( X / SQR ( - X * X + 1)) + 1.570793
30 P1 = 3.14159:P2 = 6.28318
40 PRINT : PRINT
50 PRINT TAB( 5)"-----"
60 PRINT TAB( 5)"I          MERCURY AND VENUS          I"
70 PRINT TAB( 5)"-----"
80 PRINT : PRINT
90 PRINT TAB( 11)"AN ASTRONOMY PROGRAM": PRINT : PRINT
100 PRINT TAB( 10)"BY ERIC BURGESS F.R.A.S.": PRINT : PRINT
110 PRINT TAB( 11)"ALL RIGHTS RESERVED BY"
120 PRINT TAB( 11)"S $ T SOFTWARE SERVICE"
130 PRINT : PRINT
140 PRINT TAB( 13)"JAN. 82 VERSION": PRINT : PRINT
150 PRINT TAB( 5)"";
160 INPUT "DO YOU WANT INSTRUCTIONS? Y/N ";A$
170 IF A$ = "N" THEN HOME : PRINT : PRINT : PRINT : GOTO 320
180 IF A$ < > "Y" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 160
190 HOME : PRINT : PRINT : PRINT
200 PRINT : PRINT : PRINT
210 PRINT TAB( 5)"THIS PROGRAM PLOTS THE POSITIONS"
220 PRINT TAB( 5)"OF MERCURY AND VENUS RELATIVE"
230 PRINT TAB( 5)"TO THE SUN AT INTERVALS CHOSEN BY"
240 PRINT TAB( 5)"YOU IN UNITS OF DAYS FOR AS MANY"
250 PRINT TAB( 5)"INTERVALS AS YOU REQUEST."
260 PRINT : PRINT
270 PRINT TAB( 5)"YOU CAN THEN ASK TO SEE DATA ABOUT"
280 PRINT TAB( 5)"EITHER OR BOTH PLANETS, SUCH AS"
290 PRINT TAB( 5)"DISTANCE, APPARENT SIZE,& PHASE."
300 PRINT : PRINT : PRINT
310 INPUT "TO CONTINUE PRESS RETURN ";A$
320 FL = 0
330 HOME : PRINT : PRINT : PRINT
340 F9 = 0:NT = 1
350 INPUT "SELECT INTERVAL (DAYS) ";ND
360 PRINT : PRINT : PRINT
370 INPUT "SCROLLED DISPLAY? Y/N ";FL$
380 IF FL$ = "N" THEN F9 = 1
390 PRINT : PRINT
400 INPUT "HOW MANY INTERVALS? ";NS
410 GOTO 2200
420 GOSUB 990: REM GET DISTANCE FROM EARTH
430 HOME : PRINT : PRINT
440 GOSUB 450: GOTO 930
450 HOME : PRINT : PRINT
460 MQ$ = LEFT$ ( STR$ ( 6.68 / MQ),5)
470 VQ$ = LEFT$ ( STR$ ( 16.82 / VQ),5)
480 PRINT "FOR YEAR ";Y;" MONTH ";M;" DAY ";D: PRINT
490 PRINT "-----": PRINT
500 MQ$ = LEFT$ ( STR$ (MQ),4)
510 VQ$ = LEFT$ ( STR$ (VQ),4)
520 IF E$ = "2" THEN GOTO 560
530 PRINT "DISTANCE OF MERCURY IS ";MQ$;" A.U."
540 PRINT TAB( 15)"OR "; VAL ( LEFT$ ( STR$ (MQ * 92.9),5));" MILLION
MILES"

```

MERVE (continued)

```

550 IF E$ = "1" THEN GOTO 580
560 PRINT "DISTANCE OF VENUS IS ";VQ$;" A.U."
570 PRINT TAB( 15)"OR "; VAL ( LEFT$ ( STR$ ( VQ * 92.9),5));" MILLION
    MILES"
580 PRINT
590 MW$ = LEFT$ ( STR$ ( MW * 57.29578),4)
600 VW$ = LEFT$ ( STR$ ( VW * 57.29578),4)
610 IF E$ = "2" THEN GOTO 670
620 PRINT "MERCURY ANG.DIST. FROM SUN IS ";MW$;
630 PRINT " DEG"
640 GOSUB 2710
650 PRINT TAB( 2)"(LOCATED ";AP$;" FOR VIEWING)"
660 IF E$ = "1" THEN PRINT : GOTO 700
670 PRINT "ANG. DIST. OF VENUS FROM SUN IS ";VW$;
680 PRINT " DEG"
690 IF E$ = "3" OR VAL (SD$) = 3 THEN INPUT "PRESS RETURN TO
    CONTINUE ";A$: HOME : PRINT
700 IF E$ = "2" THEN GOTO 760
710 PRINT "ANG. DIAM. OF MERCURY IS ";MD$;
720 PRINT " ARCSEC"
730 PRINT " (AT INFER.CONJ. DIAM. IS 12 ARCSEC)"
740 IF E$ = "1" THEN GOTO 790
750 PRINT
760 PRINT "ANG. DIAM. OF VENUS IS ";VD$;
770 PRINT " ARCSEC"
780 PRINT " (AT INFER. CONJ. DIAM. IS 61 ARCSEC)"
790 PRINT
800 PH = ABS (MW) + ABS (MZ): GOSUB 2520
810 IF E$ = "2" THEN GOTO 860
820 PRINT "MERCURY'S PHASE IS ";PH$
830 PRINT TAB( 5)PH$;" DEG. ILLUMINATED"
840 PRINT
850 IF E$ = "1" THEN GOTO 890
860 PH = ABS (VW) + ABS (ZV): GOSUB 2520
870 PRINT "PHASE OF VENUS IS ";PH$
880 PRINT TAB( 5);PH$;" DEG. ILLUMINATED"
890 PRINT
900 GOSUB 1920
910 GOSUB 2100
920 RETURN
930 PRINT : INPUT "WANT ANOTHER DATE? ";A$
940 IF A$ = "N" THEN HOME : GOTO 980
950 IF A$ < > "Y" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 930
960 HOME : PRINT : PRINT : PRINT
970 GOTO 320
980 END
990 REM FIND ANGULAR DIAM
1000 HOME : PRINT : PRINT : PRINT
1010 GOSUB 1290: REM ENTER DATE
1020 GOSUB 1480: REM CALC DAYS FROM EPOCH
1030 REM CALC DIST. FROM EARTH
1040 REM AND ANG. DIST. FROM SUN
1050 AE = NI * .017202 + 1.74022
1060 IF AE > P2 THEN AE = ((AE / P2) - INT (AE / P2)) * P2
1070 IF AE < 0 THEN AE = AE + P2: GOTO 1070

```

MERVE (continued)

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1080 CE = .032044 * SIN (AE - 1.78547)
1090 AE = AE + CE
1100 IF AE > P2 THEN AE = AE - P2
1110 IF AE < 0 THEN AE = AE + P2: GOTO 1110
1120 DE = 1 + .017 * SIN (AE - 3.33926)
1130 GOSUB 1590: REM CALC MERCURY'S POSITION
1140 MZ = AE - MA
1150 ZM = MZ
1160 IF ABS (MZ) > P1 AND MZ < 0 THEN MZ = MZ + P2
1170 IF ABS (MZ) > P1 AND MZ > 0 THEN MZ = MZ - P2
1180 REM CALC DIST FROM EARTH
1190 MQ = SQR (MD ^ 2 + DE ^ 2 - 2 * MD * DE * COS (MZ))
1200 MP = (MD + DE + MQ) / 2
1210 REM CALC ANG DIST. FROM SUN
1220 MV = SQR ((MP * (MP - MD)) / (DE * MQ))
1230 MW = 2 * FN ACO(MV)
1240 IF ABS (ZM) > P1 AND ZM < 0 THEN ZM = ZM + P2
1250 IF ABS (ZM) > P1 AND ZM > 0 THEN ZM = ZM - P2
1260 IF ZM > 0 THEN MW = - MW
1270 GOSUB 1690: REM CALC VENUS'S POSITION
1280 RETURN
1290 REM ENTER DATE
1300 PRINT : PRINT
1310 PRINT "ENTER THE DATE": PRINT
1320 INPUT " THE YEAR ";Y$:Y = VAL (Y$)
1330 IF Y = 0 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 1320
1340 IF Y > 1800 THEN GOTO 1390
1350 PRINT " ";Y;" THE CORRECT YEAR? ": INPUT A$
1360 IF A$ = "Y" THEN GOTO 1390
1370 IF A$ < > "N" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 1350
1380 IF A$ = "N" THEN GOTO 1320
1390 PRINT : INPUT " THE MONTH ";M$:M = VAL (M$)
1400 IF M = 0 OR M > 12 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 1390
1410 PRINT : INPUT " THE DAY ";D$:D = VAL (D$)
1420 IF D = 0 OR D > 31 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 1410
1430 IF M = 2 AND D > 29 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 1410
1440 HOME
1450 REM STORE INITIAL DATE
1460 YI = Y:MI = M:DI = D
1470 RETURN
1480 REM CALC DAYS FROM EPOCH
1490 DG = 365 * Y + D + ((M - 1) * 31)
1500 IF M > = 3 THEN GOTO 1540
1510 REM CALC FOR JAN OR FEB
1520 DG = DG + INT ((Y - 1) / 4) - INT ((.75) * INT ((Y - 1) / 100 + 1))
1530 GOTO 1560
1540 REM CALC FOR MAR THRU DEC
1550 DG = DG - INT (M * .4 + 2.3) + INT (Y / 4)
- INT ((.75) * INT ((Y / 100) + 1))
1560 NI = DG - 715875
1570 RETURN
1580 GOTO 420
1590 REM CALC MERCURY'S POSITION
1600 MA = NI * .071425 + 3.8494
1610 IF MA > P2 THEN MA = ((MA / P2) - INT (MA / P2)) * P2

```

MERVE (continued)

```

1620 IF MA < 0 THEN MA = MA + P2: GOTO 1620
1630 MC = .388301 * SIN (MA - 1.34041)
1640 MA = MA + MC
1650 IF MA > P2 THEN MA = MA - P2
1660 IF MA < 0 THEN MA = MA + P2: GOTO 1660
1670 MD = .3871 + .079744 * SIN (MA - 2.73514)
1680 RETURN
1690 REM CALC VENUS'S POSITION
1700 VA = NI * .027962 + 3.02812
1710 IF VA > P2 THEN VA = ((VA / P2) - INT (VA / P2)) * P2
1720 IF VA < 0 THEN VA = VA + P2: GOTO 1720
1730 VC = .013195 * SIN (VA - 2.28638)
1740 VA = VA + VC
1750 IF VA > P2 THEN VA = VA - P2
1760 IF VA < 0 THEN VA = VA + P2: GOTO 1760
1770 VD = .7233 + .00506 * SIN (VA - 3.85017)
1780 ZV = AE - VA
1790 VZ = ZV
1800 IF ABS (ZV) > P1 AND ZV < 0 THEN ZV = ZV + P2
1810 IF ABS (ZV) > P1 AND ZV > 0 THEN ZV = ZV - P2
1820 REM CALC DIST FROM EARTH
1830 VQ = SQR (VD ^ 2 + DE ^ 2 - 2 * VD * DE * COS (ZV))
1840 VP = (VD + DE + VQ) / 2
1850 REM CALC ANG DIST FROM SUN
1860 VV = SQR ((VP * (VP - VD)) / (DE * VQ))
1870 VW = 2 * FN ACO(VV)
1880 IF ABS (VZ) > P1 AND VZ < 0 THEN VZ = VZ + P2
1890 IF ABS (VZ) > P1 AND VZ > 0 THEN VZ = VZ - P2
1900 IF VZ > 0 THEN VW = - VW
1910 RETURN
1920 REM SHOW SUN AND PLANETS
1930 Z$(0) = MW$ + "M":Z$(1) = VW$ + "V"
1940 Z$(2) = STR$(0) + "0"
1950 FOR I = 0 TO 2
1960 U$(I) = "999"
1970 NEXT I
1980 K = 0
1990 FOR I = 0 TO 2
2000 IF Z$(I) = "999" THEN GOTO 2080
2010 FOR J = I TO 2
2020 IF Z$(J) = "999" THEN GOTO 2040
2030 IF VAL (Z$(J)) < VAL (Z$(I)) THEN I = J: GOTO 2040
2040 NEXT J
2050 U$(K) = Z$(I):Z$(I) = "999"
2060 K = K + 1
2070 I = - 1
2080 NEXT I
2090 RETURN
2100 PRINT "VISUAL CONFIG. RELATIVE TO SUN"
2110 PRINT
2120 M1 = 20 + .8 * VAL (LEFT$ (U$(0),5)) / 2
2130 PRINT TAB (M1); RIGHT$ (U$(0),1);
2140 M2 = 20 + .8 * VAL (LEFT$ (U$(1),5)) / 2
2150 PRINT TAB (M2); RIGHT$ (U$(1),1);
2160 M3 = 20 + .8 * VAL (LEFT$ (U$(2),5)) / 2

```

MERVE (continued)

```

2170 PRINT TAB( M3); RIGHT$( U$(2),1)
2180 PRINT
2190 RETURN
2200 HOME : REM ROUTINE FOR ELONGATIONS
2210 GOSUB 2220
2220 HOME : GOSUB 1290: REM GET DATE
2230 FL = 0
2240 GOSUB 1480: REM CALC DAYS FROM EPOCH
2250 :
2260 GOSUB 1030:VW$ = STR$( VW * 57.29578)
2270 MW$ = STR$( MW * 57.29578): GOSUB 1920
2280 IF F9 = 1 THEN HOME : PRINT : PRINT : PRINT
2290 PRINT "DISPLAY ";NT;" IS DATE ";YI;" ";MI;" ";DI: PRINT : GOSUB 2110
2300 IF NT = NS THEN PRINT : PRINT
2310 IF NT = NS THEN GOSUB 2800
2320 IF NT = NS THEN HOME : GOTO 2390
2330 PRINT
2340 D = D + ND
2350 GOSUB 2610
2360 YI = Y:DI = D:MI = M
2370 FL = 1:NT = NT + 1
2380 GOTO 2240
2390 GOSUB 450
2400 IF SD$ = "3" THEN E$ = "":SD$ = "": PRINT : GOTO 2480
2410 IF OP = 1 THEN OP = 0: GOTO 2480
2420 INPUT "WANT THE OTHER PLANET? Y/N ";A$
2430 IF A$ = "Y" AND E$ = "1" THEN E$ = "2":A$ = "": GOSUB 450: GOTO 2460
2440 IF A$ = "Y" AND E$ = "2" THEN E$ = "1":A$ = "": GOSUB 450: GOTO 2460
2450 IF A$ < > "N" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 2420
2460 PRINT : INPUT "WANT BOTH PLANETS? Y/N ";A$
2470 IF A$ = "Y" THEN E$ = "3":OP = 1: GOSUB 450:E$ = "":OP = 0
2480 INPUT "DO YOU WANT ANOTHER DATE? Y/N ";A$
2490 IF A$ = "Y" THEN GOTO 320
2500 IF A$ < > "N" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 2480
2510 HOME : GOTO 980
2520 REM SUB FOR PHASES
2530 PH = 180 - PH * 57.2958
2540 IF PH > 150 THEN PH$ = "THIN CRESCENT"
2550 IF PH > 120 AND PH < 151 THEN PH$ = "FAT CRESCENT"
2560 IF PH > 70 AND PH < 121 THEN PH$ = "NEAR HALF"
2570 IF PH > 29 AND PH < 71 THEN PH$ = "GIBBOUS"
2580 IF PH < 30 THEN PH$ = "NEAR FULL"
2590 PH = INT (180 - PH)
2600 RETURN
2610 REM SUB FOR MONTH END ADJUSTS
2620 IF Y / 4 - INT (Y / 4) = 0 AND Y / 100 - INT (Y / 100) < > 0 THEN
LY = 1
2630 IF M > 12 THEN M = M - 12:Y = Y + 1
2640 IF LY = 1 AND M = 2 AND D > 29 THEN M = 3:D = D - 29: GOTO 2660
2650 IF LY = 0 AND M = 2 AND D > 28 THEN M = 3:D = D - 28: GOTO 2660
2660 IF D < 31 GOTO 2700
2670 IF (M = 4 OR M = 6 OR M = 9 OR M = 11) THEN M = M + 1:D = D - 30:
GOTO 2630
2680 IF D > 31 THEN M = M + 1:D = D - 31: GOTO 2630

```

MERVE (continued)

```
2690 IF M > 12 THEN M = M - 12:Y = Y + 1
2700 RETURN
2710 REM SUB FOR VIEWING MERCURY
2720 MX = VAL (MW$)
2730 AP$ = ""
2740 IF MX > 13 AND M > 7 AND M < 12 THEN AP$ = "FAVORABLY": GOTO 2790
2750 IF MX > 18 AND M > 7 AND M < 12 THEN AP$ = "VERY FAVORABLY": GOTO 2790
2760 IF MX < - 13 AND M > 1 AND M < 7 THEN AP$ = "FAVORABLY": GOTO 2790
2770 IF MX < - 18 AND M > 1 AND M < 7 THEN AP$ = "VERY FAVORABLY":
    GOTO 2790
2780 AP$ = "UNFAVORABLY"
2790 RETURN
2800 PRINT "SELECT DETAILS FOR DISPLAY"
2810 INPUT "MERCURY (1); VENUS (2); OR BOTH (3) ";SD$
2820 IF VAL (SD$) = 3 THEN RETURN
2830 E$ = SD$: RETURN
2840 PRINT "INVALID RESPONSE": PRINT : GOTO 2800
```

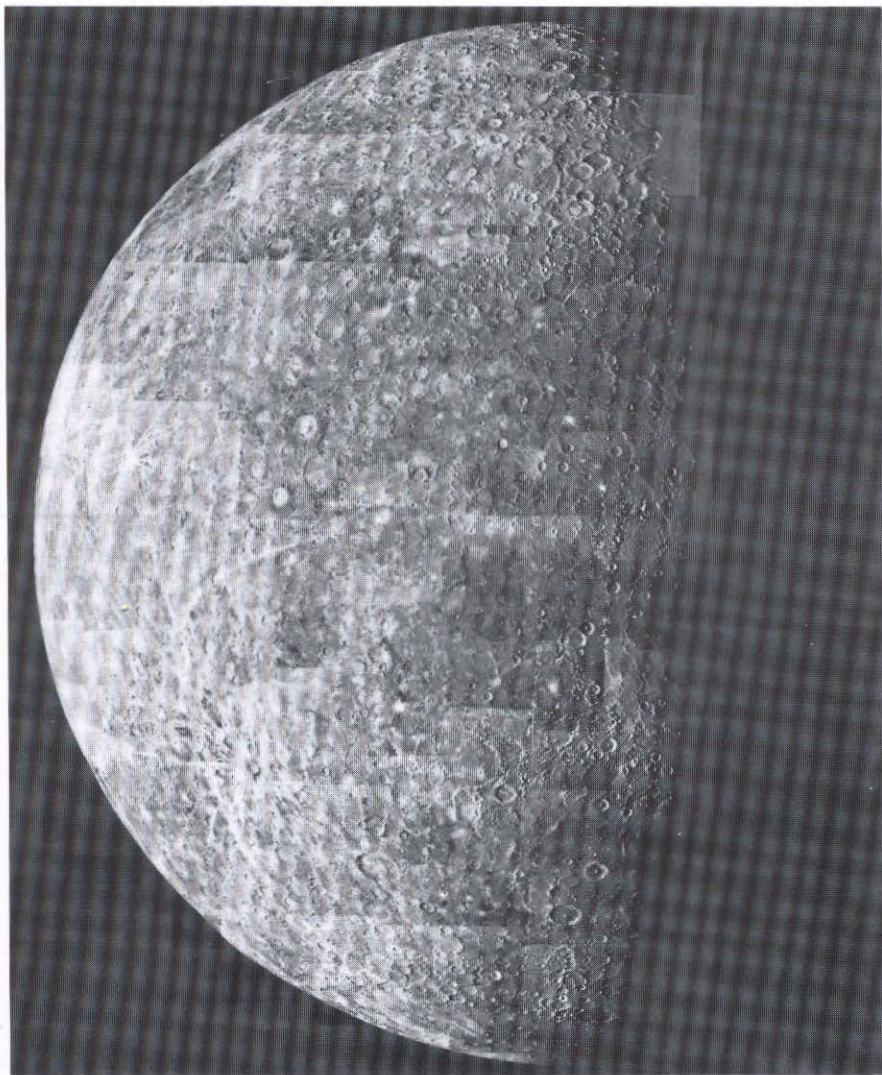


Photo Credit: NASA/Jet Propulsion Laboratory

The closest planet to the Sun, Mercury has a Moon-like, heavily-cratered surface, first revealed by the spacecraft Mariner 10. Mercury is so difficult to observe from Earth that prior to the space mission no definite details had been identified on its surface. This photograph shows one hemisphere of the planet with the large impact basin Caloris half illuminated by the Sun. The feature is just below the middle of the curved terminator on the right of the image. The terminator is the boundary between day and night on the planet.

Program 14: PRISE

Times of Rising and Setting of Mercury and Venus before or after the Sun for Any Date _____

Because of the inclination of the ecliptic to the celestial equator, there are times of the terrestrial year when Venus and Mercury are configured more easily for observation; that is, when they rise before the Sun or set after the Sun with sufficient time for observation in a dark sky. In the Northern Hemisphere, spring is the best time to observe either of these planets as an evening star. Fall is the best time to observe them as morning stars. During spring the ecliptic makes a large angle with the western horizon after sunset. In fall it is inclined at a large angle to the eastern horizon before sunrise. Opposite conditions apply for the Southern Hemisphere.

This program calculates for Venus and Mercury the approximate number of minutes between sunset and planet set and between sunrise and planet rise for any given date, longitude, and latitude. It also indicates whether the planet is a morning or an evening star. Used with RISES and MVENC, this program helps you select the best times to observe Venus and the elusive planet Mercury. A typical display generated by this program appears in Figure 14.1.

The listing is set for a given longitude and latitude. You can change this when you key in the program by altering line 80 to your local coordinates. You can also change these coordinates during the running of the program if you wish—to a vacation observing site, for example.

The program calculates the right ascension and declination of the planets and of the Sun. From the right ascension difference (instruction 1820), the difference in declination (instruction 1810), and the latitude of the observing site (LA), it calculates the time differences at the horizon (instructions 1700 through 1830).

The listing for the PRISE program follows.

```
DATA REQUESTED FOR 1982 1 1
```

```
MERCURY IS AN EVENING STAR  
SETTING 48.5 MINUTES AFTER THE SUN
```

```
VENUS IS AN EVENING STAR  
SETTING 112. MINUTES AFTER THE SUN
```

```
WANT ANOTHER DATE Y/N? █
```

For good observation it is important to know how long after the Sun Venus or Mercury sets, or how soon they rise before the Sun. The program PRISE gives this information in the display format shown.

Figure 14.1

PRISE

```

20 HOME : PRINT : PRINT
30 DEF FN ASN(X) = ATN (X / SQR ( - X * X + 1))
40 DEF FN ACO(X) = - ATN (X / SQR ( - X * X + 1)) + 1.5707963
50 DEF FN RAD(X) = .01745328 * (X)
60 DEF FN DEG(X) = 57.29578 * (X)
70 REM INSERT LOCAL LONGITUDE AND LATITUDE IN FOLLOWING STATEMENT
80 LO = 122.49:LA = 38.24
90 PRINT : PRINT : PRINT : PRINT
100 PRINT TAB( 10)"ASTRONOMY PROGRAM": PRINT
110 PRINT TAB( 9)"-----"
120 PRINT TAB( 9)"I INNER PLANETS I"
130 PRINT TAB( 9)"I TIMES FROM SUN I"
140 PRINT TAB( 9)"-----"
150 PRINT
160 PRINT TAB( 7)"BY ERIC BURGESS F.R.A.S."
170 PRINT
180 PRINT TAB( 7)"ALL RIGHTS RESERVED BY"
190 PRINT TAB( 7)"S & T SOFTWARE SERVICE"
200 FOR J = 2000 TO 1 STEP - 1: NEXT J
210 HOME : PRINT : PRINT : PRINT
220 PRINT : PRINT : PRINT : PRINT
230 PRINT "THIS PROGRAM GIVES APPROXIMATE"
240 PRINT "TIME IN MINUTES THAT MERCURY AND"
250 PRINT "VENUS RISE BEFORE THE SUN AS"
260 PRINT "MORNING STARS, OR SET AFTER THE"
270 PRINT "SUN AS EVENING STARS, FOR ANY DATE"
280 PRINT "          WHICH YOU INPUT"
290 PRINT : PRINT
300 PRINT "INITIAL CONDITIONS ARE SET FOR....."
310 PRINT TAB( 5)"SEBASTOPOL, CA LONG. 122.49"
320 PRINT TAB( 21)"LAT. 38.24": PRINT
330 PRINT : INPUT "WANT TO CHANGE THEM Y/N? ";A$
340 IF A$ < > "Y" GOTO 380
350 HOME : PRINT : PRINT : PRINT : PRINT
360 INPUT "      GIVE LATITUDE ";LA
370 INPUT "      AND LONGITUDE ";LO
380 HOME : PRINT : PRINT : PRINT
390 PRINT "ENTER THE DATE": PRINT
400 FL = 2
410 INPUT "  THE YEAR ? ";YD$:Y = VAL (YD$)
420 IF Y = 0 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 410
430 IF Y > 1800 THEN GOTO 490
440 PRINT "IS ";Y;" THE CORRECT YEAR? "
450 INPUT ;Y$
460 IF Y$ = "Y" THEN GOTO 490
470 IF Y$ < > "N" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 440
480 IF Y$ = "N" THEN PRINT : GOTO 410
490 LY = 0
500 IF Y / 4 - INT (Y / 4) = 0 AND Y / 100 - INT (Y / 100) < > 0 THEN
    LY = 1
510 PRINT : INPUT "  THE MONTH? ";MD$:M = VAL (MD$)
520 IF M = 0 OR M > 12 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 490

```

PRISE (continued)

```

530 PRINT : INPUT " THE DAY? ";DD$:D = VAL (DD$)
540 IF D = 0 OR D > 31 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 530
550 IF M < > 2 THEN GOTO 580
560 IF LY = 0 AND D > 28 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 530
570 IF LY = 1 AND D > 29 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 530
580 DX = D:MX = M:YX = Y
590 D = D + (LO / 15) / 24
600 IF (LY = 1 AND M = 2 AND INT (D) > 29) THEN M = 3:D = D - 29: GOTO 660
610 IF (LY = 0 AND M = 2 AND INT (D) > 28) THEN M = 3:D = D - 28: GOTO 660
620 IF D < 31 GOTO 660
630 IF (M = 4 OR M = 6 OR M = 9 OR M = 11) THEN M = M + 1:D = D - 30:
GOTO 660
640 IF INT (D) > 31 THEN M = M + 1:D = D - 31
650 IF M = 13 THEN M = 1:Y = Y + 1
660 REM CALC DAYS TO DATE REQUESTED
670 REM FROM 1960,1,1 EPOCH
680 DG = 365 * Y + D + (M - 1) * 31
690 IF M > = 3 THEN GOTO 730
700 REM CALC FOR JAN OR FEB
710 DG = DG + INT ((Y - 1) / 4) - INT ((.75) * INT ((Y - 1) / 100 + 1))
720 GOTO 750
730 REM CALC FOR MAR THRU DEC
740 DG = DG - INT (M * .4 + 2.3) + INT (Y / 4)
- INT ((.75) * INT ((Y / 100) + 1))
750 NI = DG - 715875
760 GOSUB 1620: REM GET SIDEREAL TIME
770 REM INPUT OF ORBIT DATA FOR PLANETS
780 IF F = 1 THEN GOTO 950
790 RESTORE
800 DIM PD(3,9)
810 FOR YY = 0 TO 2: FOR XX = 0 TO 8
820 READ PD(YY,XX)
830 NEXT XX,YY
840 REM MERCURY
850 DATA .071422,3.8484,.388301,1.34041,.3871,.07974,2.73514
860 DATA .12223,.836013
870 REM VENUS
880 DATA .027962,3.02812,.013195,2.28638,.7233,.00506,3.85017
890 DATA .059341,1.33168
900 REM EARTH
910 DATA .017202,1.74022,.032044,1.78547,1,.017,3.33926
920 DATA 0,0
930 FOR I9 = 1 TO 3: READ P$(I9): NEXT I9
940 DATA MERCURY,VENUS,SUN
950 F = 1
960 REM CALC DATA FOR PLANETS
970 HOME
980 PRINT : PRINT : PRINT
990 PRINT "DATA REQUESTED FOR ";YX;" ";MX;" ";DX
1000 PRINT : PRINT : PRINT
1010 PRINT :I = 1
1020 FOR J = 0 TO 2: GOSUB 1230
1030 A(I) = A:D(I) = DS:L(I) = L
1040 I = I + 1: NEXT
1050 FOR I = 1 TO 2

```

PRISE (continued)

```

1060 REM SKIP EARTH
1070 IF I = 3 THEN NEXT
1080 GOSUB 1370
1090 Q(I) = Q:X(I) = X:R(I) = R:V(I) = V
1100 NEXT
1110 FOR K = 1 TO 2
1120 I = K:A(I) = FN DEG(A(I))
1130 GOSUB 1710
1140 NEXT
1150 PRINT : PRINT : PRINT
1160 INPUT "WANT ANOTHER DATE Y/N? ";A$
1170 IF A$ = "Y" THEN GOTO 380
1180 IF A$ < > "N" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 1160
1190 HOME
1200 END
1210 REM CALC POSITION DATA
1220 REM CALC HELIOCENTRIC LONGITUDE
1230 A = NI * PD(J,0) + PD(J,1)
1240 IF A > 6.28318 THEN A = ((A / 6.28318) - INT (A / 6.28318)) * 6.28318
1250 IF A < 0 THEN A = A + 6.28318: GOTO 1250
1260 C = PD(J,2) * SIN (A - PD(J,3))
1270 A = A + C
1280 IF A > 6.28318 THEN A = A - 6.28318
1290 IF A < 0 THEN A = A + 6.28318: GOTO 1290
1300 REM CALC PLANET DIST FROM SUN
1310 DS = PD(J,4) + PD(J,5) * SIN (A - PD(J,6))
1320 REM CALC DIST FROM ECLIPTIC
1330 L = PD(J,7) * SIN (A - PD(J,8))
1340 RETURN
1350 REM CALC PLANETARY DATA
1360 REM CALC ANG DISTANCE FROM EARTH
1370 Z = A(3) - A(I)
1380 IF ABS (Z) > 3.14159 AND Z < 0 THEN Z = Z + 6.28318
1390 IF ABS (Z) > 3.14159 AND Z > 0 THEN Z = Z - 6.28318
1400 REM CALC DISTANCE FROM EARTH
1410 Q = SQR (D(I) ^ 2 + D(3) ^ 2 - 2 * D(I) * D(3) * COS (Z))
1420 REM CALC ANG DISTANCE FROM SUN
1430 P = (D(I) + D(3) + Q) / 2
1440 X = 2 * FN AC0( SQR (((P * (P - D(I))) / (D(3) * Q))))
1450 REM CALC RA OF PLANET
1460 IF Z < 0 THEN R = FN DEG(A(3) + 3.14159 - X) / 15
1470 IF Z > 0 THEN R = FN DEG(A(3) + 3.14159 + X) / 15
1480 IF R > 24 THEN R = R - 24: GOTO 1480
1490 IF R < - 24 THEN R = R + 24: GOTO 1490
1500 IF R < 0 THEN R = R + 24: GOTO 1500
1510 REM CALC DECLINATION
1520 IF Z < 0 THEN V = SIN (A(3) + 3.14159 - X) * 23.44194 + FN DEG(L(I))
1530 IF Z > 0 THEN V = SIN (A(3) + 3.14159 + X) * 23.44194 + FN DEG(L(I))
1540 X = FN DEG(X)
1550 R(3) = FN DEG(A(3) + 3.14159) / 15
1560 IF R(3) > 24 THEN R(3) = R(3) - 24: GOTO 1560
1570 IF R(3) < - 24 THEN R(3) = R(3) + 24: GOTO 1570
1580 IF R(3) < 0 THEN R(3) = R(3) + 24
1590 V(3) = SIN (A(3) + 3.14159) * 23.44194
1600 RETURN

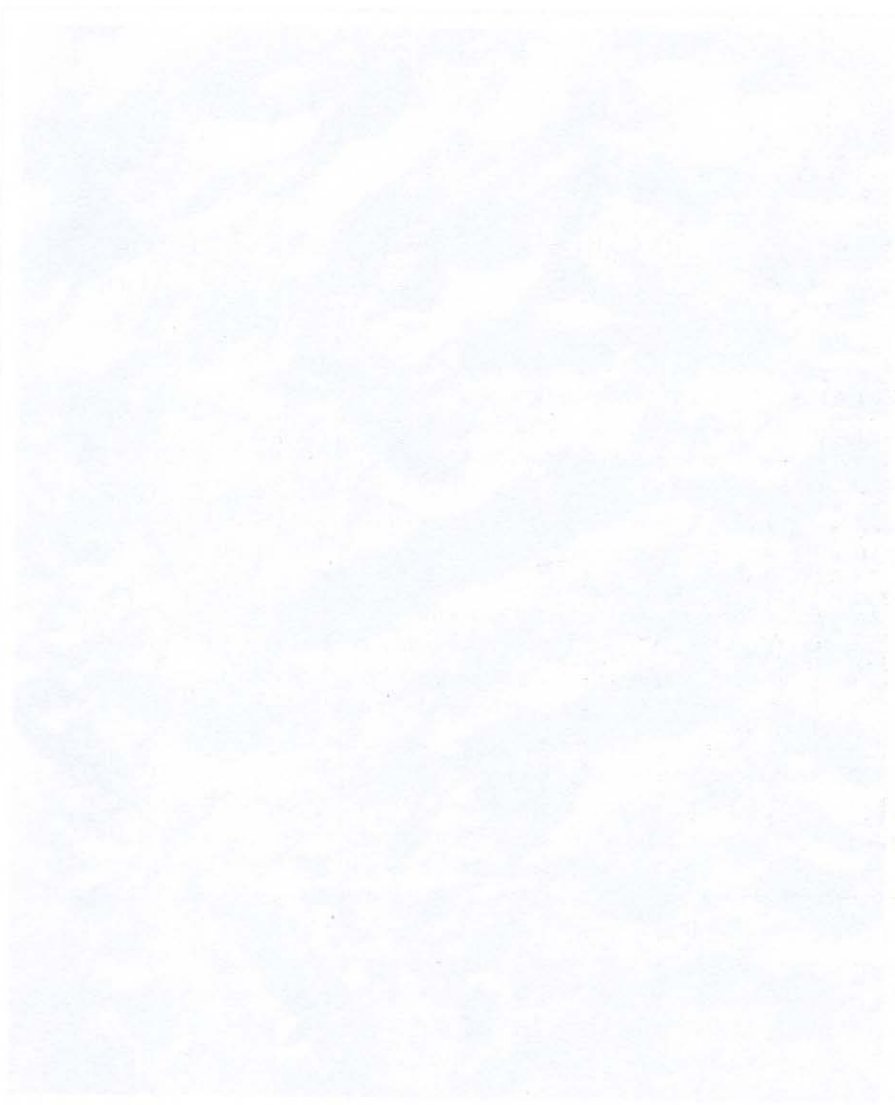
```

PRISE (continued)

```

1610 RETURN
1620 REM CALC SIDEREAL TIME
1630 GC = 11.927485
1640 TC = .065711
1650 T2 = TC * (NI - 7020) + GC
1660 IF T2 > 24 THEN T2 = T2 - 24: GOTO 1660
1670 IF T2 < - 24 THEN T2 = T2 + 24: GOTO 1670
1680 IF T2 < 0 THEN T2 = T2 + 24
1690 RETURN
1700 REM GET TIME DIFFERENCES
1710 A1 = SIN ( FN RAD(V(3))) * SIN ( FN RAD(LA))
1720 IF A1 < 0 THEN A1 = ABS (A1): GOTO 1740
1730 IF A1 > 0 THEN A1 = - A1
1740 A1 = (A1 - .01454) / COS ( FN RAD(LA))
1750 A1 = A1 / COS ( FN RAD(V(3)))
1760 B1 = SIN ( FN RAD(D(I))) * SIN ( FN RAD(LA))
1770 IF B1 < 0 THEN B1 = ABS (B1): GOTO 1790
1780 IF B1 > 0 THEN B1 = - B1
1790 B1 = (B1 - .00989) / COS ( FN RAD(LA))
1800 B1 = B1 / COS ( FN RAD(V(I)))
1810 C1 = 4 * (A1 - B1)
1820 D1 = 60 * (R(3) - R(I))
1830 M1 = C1 + D1
1840 REM ADJUST FOR RA PASSING ZERO
1850 IF M1 > 720 THEN M1 = M1 - 1440: GOTO 1870
1860 IF M1 < - 720 THEN M1 = M1 + 1440
1870 IF M1 < 0 THEN AS$ = "AN EVENING STAR ":MS$ = "SETTING":BA$ = " AFTER"
1880 IF M1 > 0 THEN AS$ = " A MORNING STAR ":MS$ = "RISING ":BA$ = " BEFORE"
1890 M1 = ABS (M1)
1900 M1$ = LEFT$ ( STR$ (M1),4)
1910 PRINT P$(I); " IS "; AS$
1920 PRINT " "; MS$; " "; M1$; " MINUTES "; BA$; " THE SUN"
1930 PRINT : PRINT : PRINT
1940 RETURN

```



The following text is extremely faint and illegible, appearing as a block of light blue characters at the bottom of the page. It likely contains a caption or a short paragraph of text, but the specific words and sentences cannot be discerned.



Photo Credit: NASA/Jet Propulsion Laboratory

When inspected at close hand from spacecraft, all the planets of the solar system have proved to be quite different from what was anticipated. Mars has intriguing features, many of which cannot be easily explained. This picture from the Viking Orbiter shows an interesting area of hills and valleys with streamlike channels at the bottom of many of the valleys. The region has very few craters and is believed to be geologically young. It is located in the Nilosyrtris region of the planet.

Program 15: RISES

Times of Rising, Transit, and Setting of Planets, Sun, and Moon for Any Date

Observing the risings, transits, and settings of the Sun, Moon, and planets occupied generations of ancient astronomers. They painstakingly sighted on these objects through window slits, by stone monuments and obelisks, and in more primitive societies, by arrangements of sticks. Because of the inclination of Earth's orbit and the complex motions of the planets, such observations were not easy. It took many years to accumulate sufficient data for the priest-astronomers to make realistic predictions. Examples of the ancient horizon-scanning observatories are found worldwide, indicating the importance many civilizations attached to knowing the motions of the heavenly bodies. Their observations had religious, astrological, and agricultural significance.

Today a personal computer and this program can give you such data with reasonable accuracy almost instantaneously. The only things you have to do are provide it with a date and choose the Sun, the Moon, or a planet. This program calculates the approximate time of rising, transit, and setting of any of these bodies for any date, at any latitude and longitude. Times of actual visibility after rising and before setting depend on local horizon and atmospheric conditions as well as on the rate of rising and setting—that is, the body's position on the ecliptic relative to the latitude of the observer. The Sun and Moon, because of their brightness, are often visible sooner after rising and closer to setting than are the planets. A typical display generated by this program is shown in Figure 15.1.

The program loads data on the planetary orbits, as did Program 11, and calculates for each planet its right ascension and declination at the requested date. It displays these data for the selected planet together with its distance from Earth and its angular distance from the Sun. The program uses the calculated sidereal time for the chosen date together with the latitude to calculate the rise, transit, and set times of the first point of Aries (subroutine 2480). From this the program calculates the local times when that point in the celestial sphere with the right ascension and declination of the planet rises above the horizon, culminates, and sets below the horizon at the observer's location.

```

MOON DATA REQUESTED FOR
  YEAR 1982 MONTH 6 DAY 15

AT NOON
R.A. OF MOON IS .615 HRS
DECLINATION IS ..-1.4 DEG
-----

MOON  RISES AT . . . . . 1 HR 10 MIN
      TRANSITS AT . . . . . 7 HR 4 MIN
      SETS AT . . . . . 13 HR 4 MIN

WANT ANOTHER PLANET, SAME DATE Y/N? [E]

```

The program RISES displays the times of rising and setting for a planet, the Sun, or the Moon on a selected date.

Figure 15.1

The basic equations are:

$$\text{Sidereal Rise Time} = \text{RA} - (1/15) \times \arccos[\tan(\text{lat}) \times \tan(\text{dec})]$$

$$\text{Sidereal Transit Time} = \text{RA}$$

$$\text{Sidereal Set Time} = \text{RA} + (1/15) \times \arccos[\tan(\text{lat}) \times \tan(\text{dec})]$$

Starting at instruction 2690, the program calculates the right ascension and declination of the Moon. It calculates the Moon's rise, culmination, and set times by using the 2480 subroutine.

The listing of the RISES program follows.

RISES

```
10 HOME : PRINT : PRINT
20 PRINT : PRINT : PRINT
30 DIM PD(9,9): DIM IP(10): DIM A(9): DIM DS(9): DIM L(9)
40 DIM Q(9): DIM X(9): DIM R(9): DIM V(9)
50 DEF FN ASN(X) = ATN (X / SQR ( - X * X + 1))
60 DEF FN ACO(X) = - ATN (X / SQR ( - X * X + 1)) + 1.5707963
70 DEF FN RAD(X) = .01745328 * (X)
80 DEF FN DEG(X) = 57.299578 * (X)
90 REM INSERT YOUR LOCAL LONGITUDE AND LATITUDE IN NEXT LINE
100 LO = 122.49:LA = 38.24
110 PRINT TAB( 8)"ASTRONOMY PROGRAM"
120 PRINT TAB( 5)"-----"
130 PRINT TAB( 5)"I RISE AND SET TIMES I"
140 PRINT TAB( 5)"-----"
150 PRINT
160 PRINT TAB( 5)"BY ERIC BURGESS F.R.A.S."
170 PRINT : PRINT
180 PRINT TAB( 5)"ALL RIGHTS RESERVED BY"
190 PRINT TAB( 5)"S & T SOFTWARE SERVICE"
200 PRINT : PRINT
210 PRINT TAB( 7)"VERSION APR.1982"
220 FOR J = 3000 TO 1 STEP - 1: NEXT J
230 HOME : PRINT : PRINT : PRINT
240 PRINT : PRINT : PRINT
250 PRINT "THIS PROGRAM GIVES APPROXIMATE TIMES"
260 PRINT "OF THE RISING, TRANSIT, AND SETTING"
270 PRINT "OF A SELECTED PLANET, OR THE SUN"
280 PRINT TAB( 13)"OR THE MOON"
290 PRINT : PRINT : PRINT
300 PRINT "INITIAL CONDITIONS ARE SET FOR"
310 PRINT
320 REM CHANGE NEXT TWO LINES TO YOUR LOCAL LAT AND LONG.
330 PRINT TAB( 5)"SEBASTOPOL, CALIFORNIA"
340 PRINT TAB( 5)"LONGITUDE 122.49; LATITUDE 38.24"
350 PRINT
360 INPUT "DO YOU WANT TO CHANGE THEM Y/N? ";A$
370 IF A$ < > "Y" GOTO 430
380 HOME : PRINT : PRINT : PRINT
390 PRINT : PRINT
400 INPUT "GIVE LATITUDE ";LA
410 PRINT
420 INPUT "AND LONGITUDE ";LO
430 HOME : PRINT : PRINT : PRINT : PRINT
440 PRINT "ENTER THE DATE": PRINT
450 FL = 2
460 INPUT "THE YEAR ";YD$:Y = VAL (YD$)
470 IF Y = 0 THEN PRINT "INVALID RESPONSE:PRINT:GOTO410
480 IF Y > 1800 THEN GOTO 540
490 PRINT "IS ";Y;" THE CORRECT YEAR? "
500 INPUT "Y/N ";Y$
510 IF Y$ = "Y" THEN GOTO 540
520 IF Y$ = "N" THEN PRINT : GOTO 460
530 PRINT "INVALID RESPONSE": PRINT : GOTO 490
```

RISES (continued)

```

540 LY = 0
550 IF Y / 4 - INT (Y / 4) = 0 AND Y / 100 - INT (Y / 100) < > 0 THEN
    LY = 1
560 PRINT
570 INPUT "THE MONTH ";MD$:M = VAL (MD$)
580 IF M = 0 OR M > 12 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 570
590 PRINT
600 INPUT "THE DAY ";DD$:D = VAL (DD$)
610 IF D = 0 OR D > 31 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 600
620 IF M < > 2 THEN GOTO 650
630 IF LY = 0 AND D > 28 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 600
640 IF LY = 1 AND D > 29 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 600
650 GOSUB 2190: REM TO SELECT PLANET
660 DX = D:MX = M:YX = Y
670 D = D + (LO / 15) / 24
680 IF (LY = 1 AND M = 2 AND INT (D) > 29) THEN M = 3:D = D - 29: GOTO 740
690 IF (LY = 0 AND M = 2 AND D > 28) THEN M = 3:D = D - 28: GOTO 740
700 IF D < 31 THEN GOTO 740
710 IF (M = 4 OR M = 6 OR M = 9 OR M = 11) THEN M = M + 1:D = D - 30:
    GOTO 740
720 IF INT (D) > 31 THEN M = M + 1:D = D - 31
730 IF M = 13 THEN M = 1:Y = Y + 1
740 REM CALC DAYS TO DATE REQUESTED FROM EPOCH 1960,1,1
750 DG = 365 * Y + D + ((M - 1) * 31)
760 IF M > 2 THEN GOTO 800
770 REM FOR JAN AND FEB
780 DG = DG + INT ((Y - 1) / 4) - INT ((.75) * INT ((Y - 1) / 100 + 1))
790 GOTO 820
800 REM FOR MAR THRU DEC
810 DG = DG - INT (M * .4 + 2.3) + INT (Y / 4)
    - INT ((.75) * INT ((Y / 100) + 1))
820 NI = DG - 715875
830 GOSUB 2400: REM TO GET SIDEREAL TIME (T2)
840 IF CI = 10 THEN GOTO 2690
850 REM INPUT OF PLANETARY ORBIT DATA
860 IF F = 1 THEN GOTO 1210
870 RESTORE
880 FOR PY = 0 TO 8: FOR PX = 0 TO 8
890 READ PD(PY,PX)
900 NEXT PX,PY
910 REM MERCURY
920 DATA .071422,3.8484,.388301,1.34041
930 DATA .3871,.07974,2.73514,.12223,.836013
940 REM VENUS
950 DATA .027962,3.02812,.013195,2.28638
960 DATA .7233,.00506,3.85017,.059341,1.33168
970 REM EARTH
980 DATA .017202,1.74022,.032044,1.78547,1
990 DATA .017,3.33926,0,0
1000 REM MARS
1010 DATA .009146,4.51234,.175301,5.85209,1.5237
1020 DATA .141704,1.04656,.03142,.858702
1030 REM JUPITER
1040 DATA .00145,4.53364,.090478,.23911,5.2028
1050 DATA .249374,1.76188,.01972,1.74533

```


RISES (continued)

```

1610 PRINT P$(I)" RISES AT..... ";TR;" HR "; INT (TM);" MIN"
1620 PRINT TAB( LEN (P$(I))); " TRANSITS AT.... ";TT;" HR ";
1630 PRINT INT (TN);" MIN"
1640 PRINT TAB( LEN (P$(I)))" SETS AT..... ";TS;" HR ";
1650 PRINT INT (TP);" MIN"
1660 PRINT : PRINT
1670 INPUT "WANT ANOTHER PLANET, SAME DATE Y/N? ";A$
1680 IF A$ = "N" THEN GOTO 1740
1690 IF A$ < > "Y" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 1670
1700 IF CI = 10 THEN D = DX:M = MX:Y = YX: GOTO 650
1710 GOSUB 2200: IF CI = 3 THEN FL = AP
1720 IF CI = 10 THEN GOSUB 2690: GOTO 1740
1730 GOTO 1230
1740 PRINT : INPUT "WANT ANOTHER DATE Y/N? ";A$
1750 IF A$ = "Y" THEN FL = 0:F = 0: RESTORE : GOTO 430
1760 IF A$ < > "N" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 1740
1770 HOME : GOTO 3200
1780 REM CALC A,DS, AND L
1790 REM HELIOCENTRIC LONGITUDE (A)
1800 A = NI * PD(J,0) + PD(J,1)
1810 IF A > 6.28318 THEN A = ((A / 6.28318) - INT (A / 6.28318)) * 6.28318
1820 IF A < 0 THEN A = A + 6.28318: GOTO 1820
1830 C = PD(J,2) * SIN (A - PD(J,3))
1840 A = A + C
1850 IF A > 6.28318 THEN A = A - 6.28318
1860 IF A < 0 THEN A = A + 6.28318: GOTO 1860
1870 REM DISTANCE OF PLANET FROM SUN (DS)
1880 DS = PD(J,4) + PD(J,5) * SIN (A - PD(J,6))
1890 REM DISTANCE FROM ECLIPTIC (L)
1900 L = PD(J,7) * SIN (A - PD(J,8))
1910 RETURN
1920 REM CALC RA AND DEC
1930 REM ANG. DIST FROM SUN (Z)
1940 Z = A(3) - A(I)
1950 IF ABS (Z) > 3.14159 AND Z < 0 THEN Z = Z + 6.28318
1960 IF ABS (Z) > 3.14159 AND Z > 0 THEN Z = Z - 6.28318
1970 IF CI = 3 THEN X = 0: GOTO 2040
1980 Q = SQR (DS(I) ^ 2 + DS(3) ^ 2 - 2 * DS(I) * DS(3) * COS (Z))
1990 P = (DS(I) + DS(3) + Q) / 2
2000 AC = SQR (((P * (P - DS(I))) / (DS(3) * Q)))
2010 IF AC = 1 THEN AC = .999999
2020 X = 2 * FN ACO(AC)
2030 REM R.A.
2040 IF Z < 0 THEN R = FN DEG(A(3) + 3.14159 - X) / 15
2050 IF Z > 0 THEN R = FN DEG(A(3) + 3.14159 + X) / 15
2060 IF R > 24 THEN R = R - 24: GOTO 2060
2070 IF R < - 24 THEN R = R + 24: GOTO 2070
2080 IF R < 0 THEN R = R + 24: GOTO 2080
2090 REM DECLINATION
2100 IF Z < 0 THEN V = SIN (A(3) + 3.14159 - X) * 23.44194 + FN DEG(L(I))
2110 IF Z > 0 THEN V = SIN (A(3) + 3.14159 + X) * 23.44194 + FN DEG(L(I))
2120 X = FN DEG(X)
2130 R(3) = FN DEG(A(3) + 3.14159) / 15
2140 IF R(3) > 24 THEN R(3) = R(3) - 24: GOTO 2140
2150 IF R(3) < - 24 THEN R(3) = R(3) + 24: GOTO 2150

```

RISES (continued)

```
2160 IF R(3) < 0 THEN R(3) = R(3) + 24
2170 V(3) = SIN (A(3) + 3.141159) * 23.44194
2180 RETURN
2190 REM PICK PLANET, SUN, OR MOON
2200 HOME : PRINT : PRINT
2210 PRINT : PRINT : PRINT
2220 PRINT "SELECT PLANET, SUN, OR MOON BY NUMBER"
2230 PRINT
2240 PRINT TAB( 8)"MERCURY.....1"
2250 PRINT TAB( 8)"VENUS.....2"
2260 PRINT TAB( 8)"          3....SUN"
2270 PRINT TAB( 8)"MARS.....4"
2280 PRINT TAB( 8)"JUPITER.....5"
2290 PRINT TAB( 8)"SATURN.....6"
2300 PRINT TAB( 8)"URANUS.....7"
2310 PRINT TAB( 8)"NEPTUNE.....8"
2320 PRINT TAB( 8)"PLUTO.....9"
2330 PRINT TAB( 8)"          10....MOON"
2340 PRINT
2350 INPUT "PLEASE SELECT NUMBER .. ";SS$
2360 SS = VAL (SS$)
2370 IF SS < 1 OR SS > 10 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 2190
2380 CI = SS
2390 RETURN
2400 REM CALC SIDEREAL TIME T2
2410 GC = 11.927485
2420 TC = .065711
2430 T2 = TC * (NI - 7020) + GC
2440 IF T2 > 24 THEN T2 = T2 - 24: GOTO 2440
2450 IF T2 < - 24 THEN T2 = T2 + 24: GOTO 2450
2460 IF T2 < 0 THEN T2 = T2 + 24
2470 RETURN
2480 REM CALC RISE, TRANSIT, AND SET TIMES
2490 TA = TAN ( FN RAD(LA)) * TAN ( FN RAD(V(I)))
2500 IF TA < 0 THEN TA = ABS (TA): GOTO 2520
2510 IF TA > 0 THEN TA = - TA
2520 TA = FN ACO(TA)
2530 TA = FN DEG(TA)
2540 B = - TA / 15
2550 TZ = 0
2560 TR = (B + R(I) + TZ - T2) * .99727
2570 TR = TR - 1 / 60
2580 IF TR < 0 THEN TR = TR + 24
2590 IF TR > 24 THEN TR = TR - 24
2600 C = TA / 15
2610 TS = (C + R(I) + TZ - T2) * .99727
2620 TS = TS + 3 / 60
2630 IF TS < 0 THEN TS = TS + 24
2640 IF TS > 24 THEN TS = TS - 24
2650 TT = R(I) - T2 + 1 / 60
2660 IF TT < 0 THEN TT = TT + 24
2670 IF TT > 24 THEN TT = TT - 24
2680 RETURN
2690 REM CALC RISE, TRANSIT, SET FOR MOON
2700 HOME : PRINT
```

RISES (continued)

```

2710 REM RA AND DEC OF MOON
2720 LZ = 311.1687
2730 LE = 178.699
2740 LP = 255.7433
2750 PG = .111404 * NI + LP
2760 IF PG < - 360 THEN PG = PG + 360: GOTO 2760
2770 IF PG < 0 THEN PG = PG + 360
2780 IF PG > 360 THEN PG = PG - 360: GOTO 2780
2790 LMD = LZ + 360 * NI / 27.32158
2800 PG = LMD - PG
2810 DR = 6.2886 * SIN ( FN RAD(PG))
2820 LMD = LMD + DR
2830 IF LMD < - 360 THEN LMD = LMD + 3600: GOTO 2830
2840 IF LMD < - 360 THEN LMD = LMD + 360: GOTO 2840
2850 IF LMD < 0 THEN LMD = LMD + 360: GOTO 2850
2860 IF LMD > 3600 THEN LMD = LMD - 3600: GOTO 2860
2870 IF LMD > 360 THEN LMD = LMD - 360: GOTO 2870
2880 RM = LMD / 15
2890 IF RM > 24 THEN RM = RM - 24: GOTO 2890
2900 IF RM < 0 THEN RM = RM + 24
2910 AL = LE - NI * .052954
2920 IF AL < - 3600 THEN AL = AL + 3600: GOTO 2920
2930 IF AL < - 360 THEN AL = AL + 360: GOTO 2920
2940 IF AL < 0 THEN AL = AL + 360: GOTO 2940
2950 IF AL > 3600 THEN AL = AL - 3600: GOTO 2950
2960 IF AL > 360 THEN AL = AL - 360: GOTO 2960
2970 AL = LMD - AL
2980 IF AL < 0 THEN AL = AL + 360
2990 IF AL > 360 THEN AL = AL - 360
3000 HE = 5.1454 * SIN (AL * 3.14159 / 180)
3010 DM = HE + 23.1444 * SIN (LMD * 3.14159 / 180)
3020 PRINT : PRINT
3030 RA$ = STR$ (RM):DE$ = STR$ (DM)
3040 RA$ = LEFT$ (RA$,5):DE$ = LEFT$ (DE$,5)
3050 IF VAL (RA$) < 10 THEN RA$ = LEFT$ (RA$,4)
3060 IF VAL (DE$) < - 9 THEN DE$ = LEFT$ (DE$,5): GOTO 3080
3070 IF VAL (DE$) < 10 AND VAL (DE$) > - 10 THEN DE$ = LEFT$ (DE$,4)
3080 PRINT "MOON DATA REQUESTED FOR ..."
3090 PRINT TAB( 5)"YEAR ";YX;" MONTH ";MX;" DAY ";DX
3100 PRINT
3110 PRINT "AT NOON"
3120 PRINT "R.A. OF MOON IS ";RA$;" HRS"
3130 PRINT "DECLINATION IS...";DE$;" DEG"
3140 PRINT "-----"
3150 REM CALC RISE, TRANSIT, SET TIMES
3160 R(I) = RM:V(I) = DM
3170 P$(I) = "MOON"
3180 GOSUB 2480
3190 GOTO 1560
3200 END

```




The following text is extremely faint and illegible. It appears to be a multi-paragraph document or a list of items, but the specific content cannot be discerned from the image.

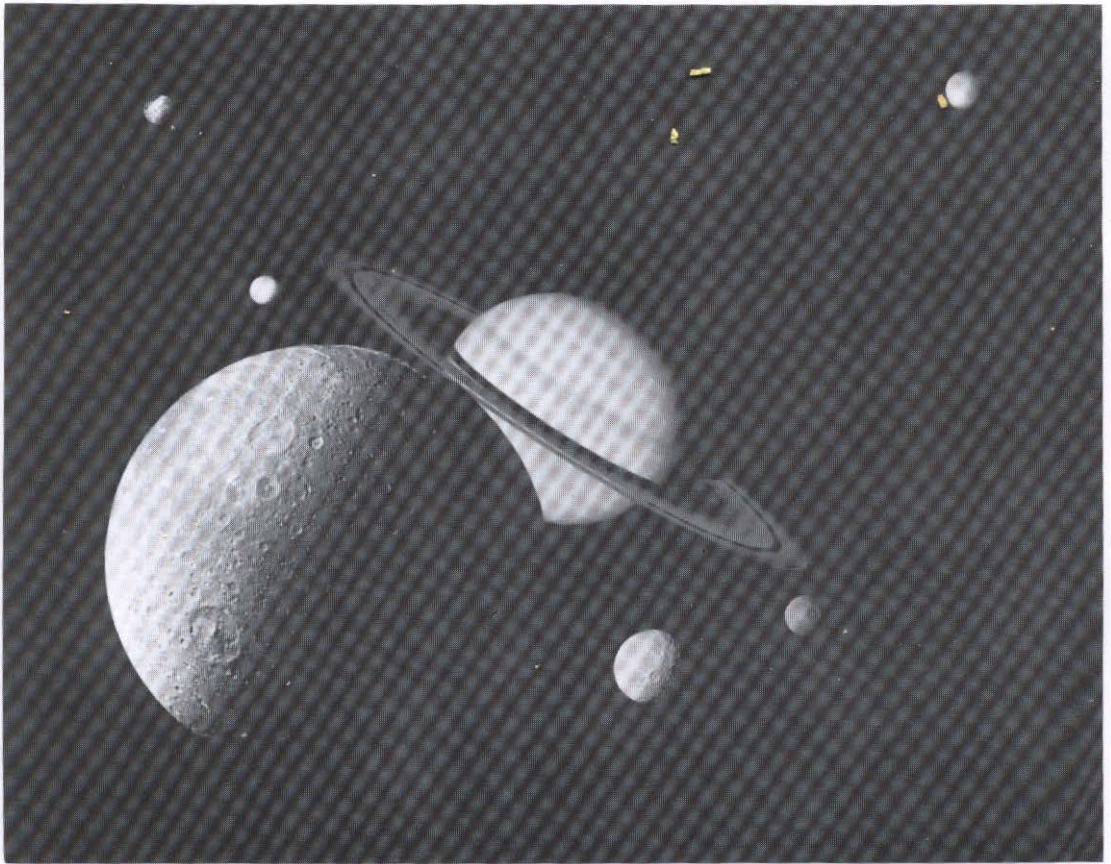


Photo Credit: NASA/Jet Propulsion Laboratory

The bizarre system of Saturn is shown in this photomosaic. In the foreground is the satellite Dione, and Mimas are to the right of the planet, Enceladus and Rhea to the left, and Titan is at the top right in the far distance. Tethys

Program 16: SKYSET/ SKYPLT

Horizon Plots of Visible Planets, Sun, Moon, and Stars for Any Date, Time, and Location

Before home computers became available to generate displays, the configuration of the stars had to be shown on planispheres or on monthly star charts. But the planets, Sun, and Moon had to be inserted on such charts by hand. In 1700 mechanical devices called orreries were devised to duplicate the orbital motions of the celestial bodies and show their locations. These devices required great skills in craftsmanship and engraving and were very expensive. In the current century the planetarium was developed by Zeis in Germany, and many planetaria associated with colleges and museums were established after World War II. In a planetarium an optical system projects stars and planets onto a domed ceiling in a theaterlike room. Today the personal computer can bring the planetarium into your living room. The monitor screen becomes the domed ceiling, and on it you can see the sky for any date and time, at any location on our planet.

For the Apple computer this program has two parts, SKYSET and SKYPLT. It requires use of the CHAIN program from the system master diskette. SKYSET is loaded first and calls SKYPLT when it is run. The program has all the instructions needed to run it. It is also adequately supplied with remark (REM) statements in case you wish to modify it in any way for your use or special needs. When you run the program there is some delay as

the various arrays are loaded, but you will see the PLEASE WAIT, LOADING DATA message before the program begins.

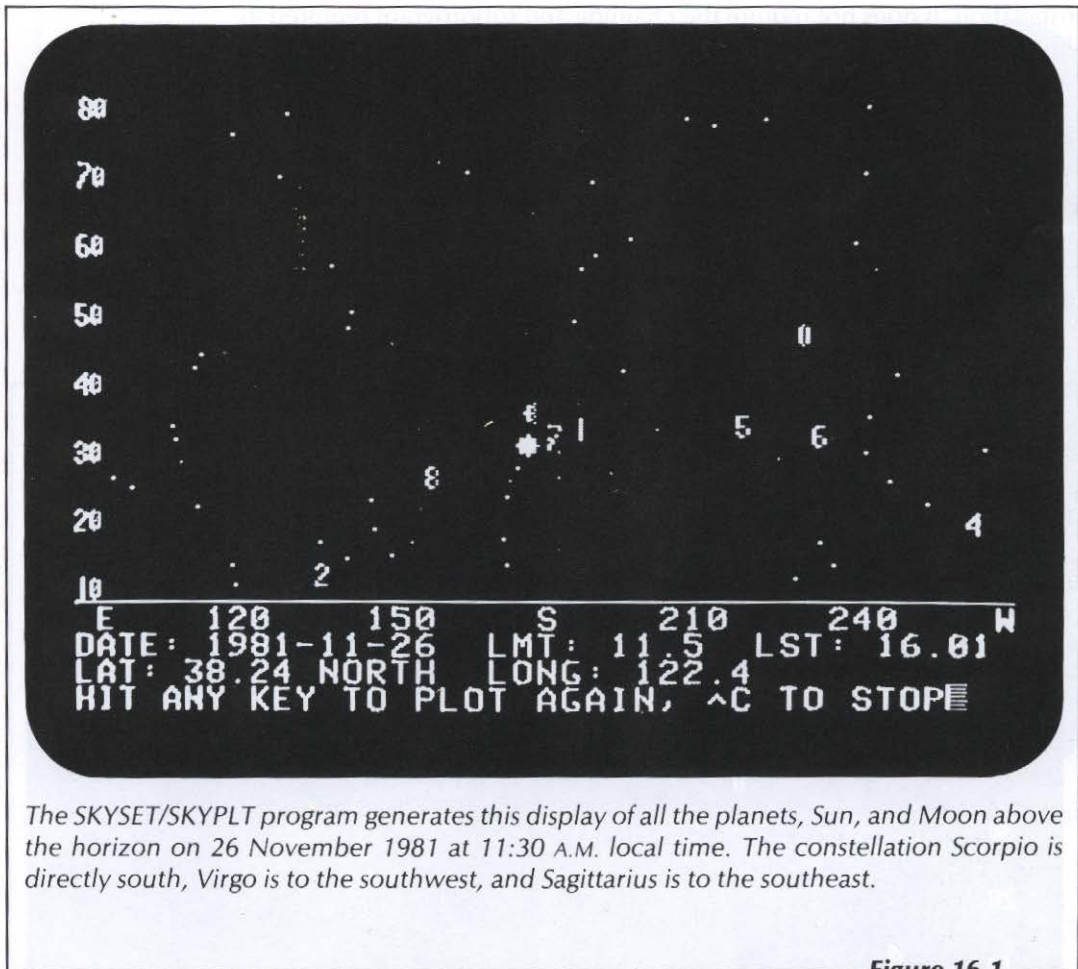
Then you will be asked for date and other input information, as well as whether you want to change the location parameters of time zone, latitude, and longitude. Next you are asked to select a horizon of 180 degrees centered on east, south, west, or north. You can then select whether you want the planets, Sun, and Moon displayed without showing any stars (which gives a quick display), or with stars included (which takes somewhat longer to complete all the coordinate conversions). As the program begins its calculations the screen displays the message COMPUTING .. PLEASE WAIT. During this period it calls CHAIN and the subprogram SKYPLT.

Next the horizon chart is generated. For the particular horizon you have requested, the azimuth is shown below the display and the elevation is shown at the left. Date and time information are displayed below the chart. If you select planets only, the Sun, Moon, and planets are plotted and the stars are omitted. If you select stars as well, the stars are plotted first (this takes about five minutes). Next the program plots the Sun and any planets above that horizon at the time and date selected. Finally it plots the Moon and shows it as) before full, @ when close to full, and (after full. Since the projection is Mercator, constellations toward the zenith are somewhat distorted by being stretched out horizontally, but they are still recognizable.

Variables have been set initially for your latitude, longitude, and time zone. While running the program you can change the variables to other latitudes, longitudes, and time zones. The program should not be expected to run accurately at latitudes exceeding 85 degrees north and south.

Planets are identified by numbers; 1, Mercury; 2, Venus; 4, Mars; 5, Jupiter; 6, Saturn; 7, Uranus; 8, Neptune; and 0, Pluto. The shape table can be changed if you wish to have symbols, letters, or a different set of numbers identify the planets, Sun, and Moon. Letters are used in the alternative Program 16A (see Appendix). Note that if planets are within one pixel of each other, the outermost planet will overprint the innermost and only the symbol for the outer planet will be displayed.

To see how the program works, you might choose to display the sky on 26 November 1981 at 11:30 A.M. for the south horizon (Figure 16.1). This shows all the planets, the Sun, and the Moon above the horizon at the same time. If you then ask for the same date and time in the Southern Hemisphere (for example, for -40 degrees latitude) and request the north horizon, you will see these same planets and constellations inverted (Figure 16.2). Another interesting plot (Figure 16.3) is the south horizon at 7:30 A.M. on 5 February 1982, when all the planets are again displayed (but not the Sun and Moon). This display also demonstrates how the program can more quickly display the planets without the stars.



The SKYSET/SKYPLT program generates this display of all the planets, Sun, and Moon above the horizon on 26 November 1981 at 11:30 A.M. local time. The constellation Scorpio is directly south, Virgo is to the southwest, and Sagittarius is to the southeast.

Figure 16.1

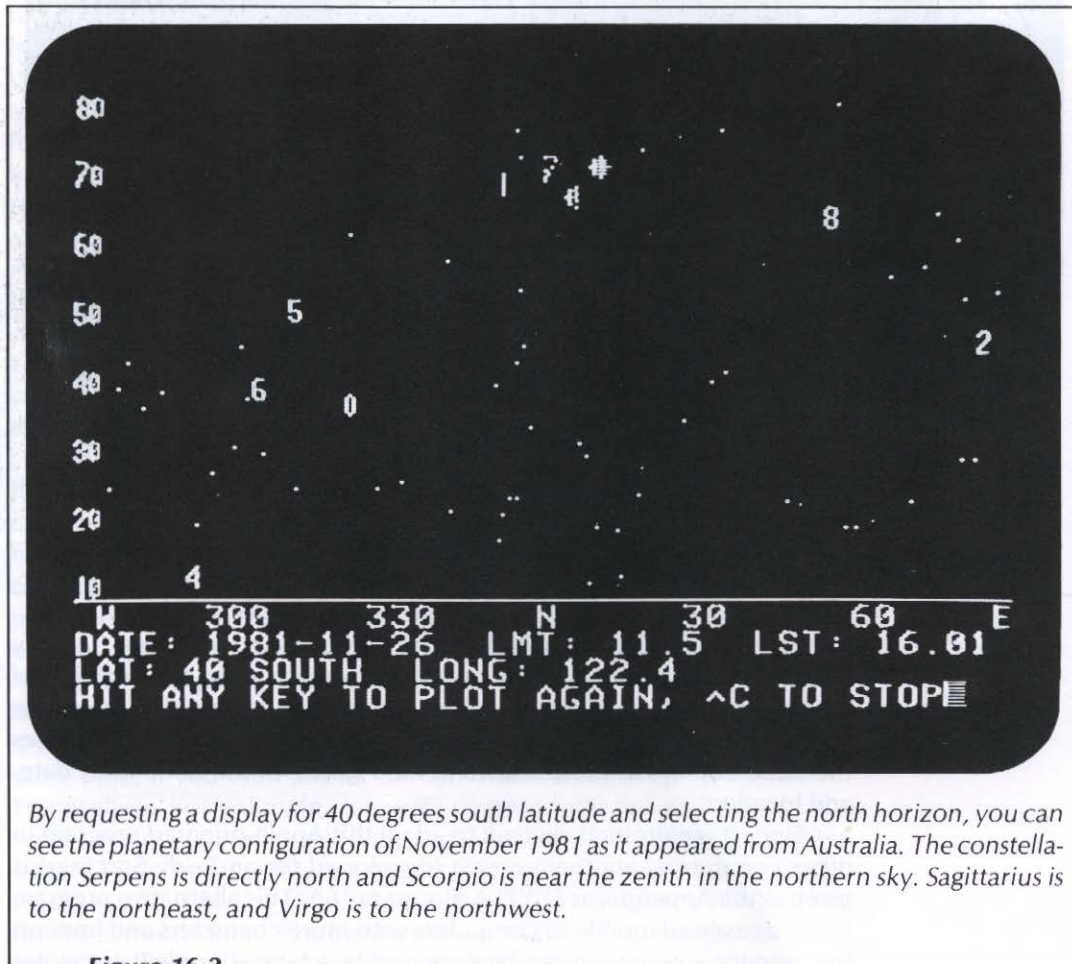
Be extremely careful when keying in the star coordinates. If at any place you use a comma instead of a period, or vice versa, the positions of all the stars following the error will be incorrect and constellations will be unrecognizable. You can check yourself by seeing if your program produces the same displays as those shown in the Figures for the same time, date, and location.

Since it is extremely difficult to adapt this Apple-oriented program to other computers, another version (developed for an Exidy Sorcerer) is given in the Appendix as SKYPLA, Program 16A. This alternative program is more easily adaptable to computers with more characters and lines on the monitor screen than can be displayed by a typical Apple II computer

installation. It does not require the chaining and subprogram required in the Apple program, and it can provide improved horizon graphics, depending on your computer.

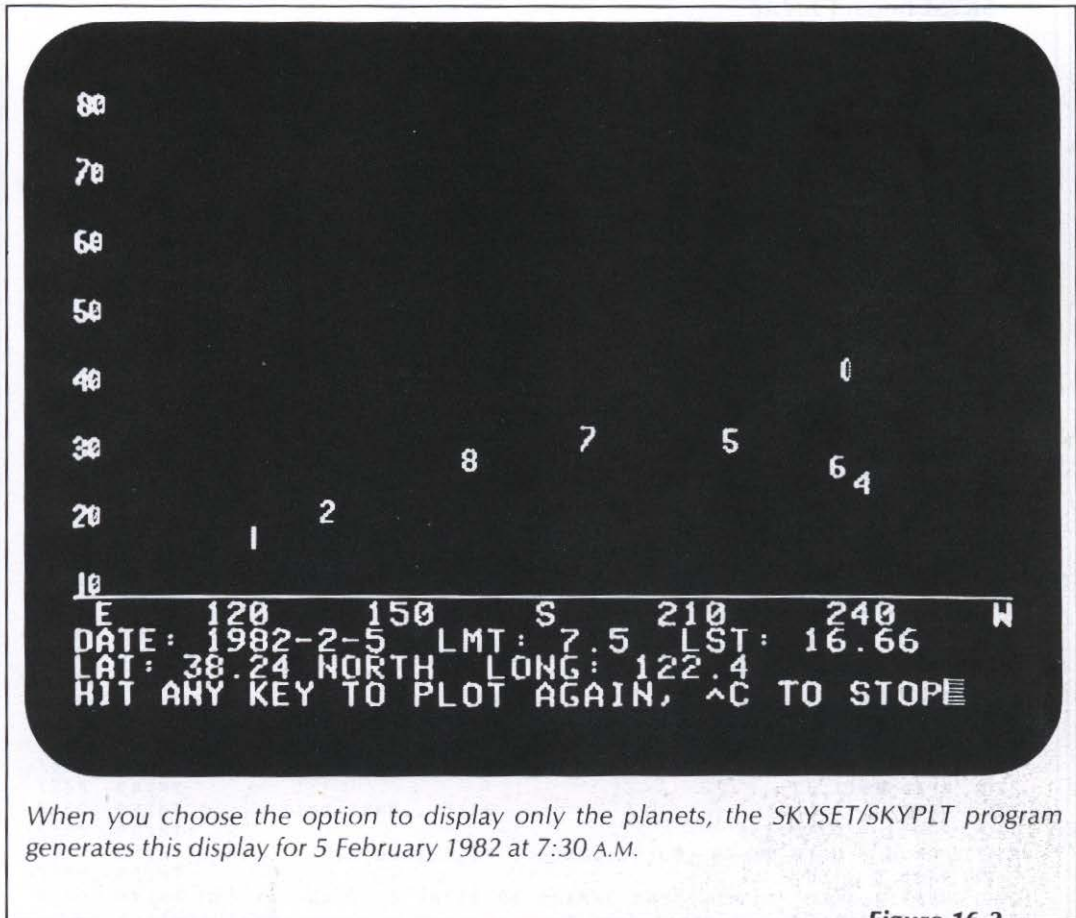
To run the program you load SKYSET. You must make sure that your disk contains the CHAIN program from the Apple DOS software. When you run SKYSET it calls SKYPLT. To end the program you give the command Control C when asked. You also have the option at this point of rerunning the program for a different date, time, or location. You press any key and after a short delay SKYSET is reloaded and you are asked if you want to change any variables.

The listings of the SKYSET and SKYPLT programs follow.



By requesting a display for 40 degrees south latitude and selecting the north horizon, you can see the planetary configuration of November 1981 as it appeared from Australia. The constellation Serpens is directly north and Scorpio is near the zenith in the northern sky. Sagittarius is to the northeast, and Virgo is to the northwest.

Figure 16.2



When you choose the option to display only the planets, the SKYSET/SKYPLT program generates this display for 5 February 1982 at 7:30 A.M.

Figure 16.3

SKYSET

```

10 HOME
12 IF DF = 1 THEN GOTO 100
15 PRINT : PRINT
20 PRINT : PRINT : PRINT
25 PRINT TAB( 8)"ASTRONOMY PROGRAM"
30 PRINT
35 PRINT TAB( 10)"-----"
40 PRINT TAB( 10)"I SKYSET I"
45 PRINT TAB( 10)"-----"
50 PRINT : PRINT
55 PRINT TAB( 5)"BY ERIC BURGESS F.R.A.S."
57 PRINT : PRINT : PRINT
60 PRINT TAB( 5)"ALL RIGHTS RESERVED BY"
65 PRINT TAB( 5)"S & T SOFTWARE SERVICE"
70 PRINT
75 PRINT TAB( 10)"(VERSION 4/82)"
80 FOR K = 1 TO 2000: NEXT K
100 REM --- SET FUNCTIONS ---
110 DEF FN ASN(X) = ATN (X / SQR ( - X * X + 1))
120 DEF FN ACO(X) = - ATN (X / SQR ( - X * X + 1)) + 3.141593 / 2
130 DEF FN RAD(X) = (X) * 3.14159 / 180
140 DEF FN DEG(X) = (X) * 180 / 3.14159
150 IF DF = 1 GOTO 1320
160 REM --- INITIALIZE DATA VARIABLES ---
170 DIM PD(8,8),ST(236,1)
180 RESTORE
190 HOME : PRINT "PLEASE WAIT, LOADING DATA"
200 FOR I = 0 TO 8
210 FOR J = 0 TO 8
220 READ PD(I,J)
230 NEXT J,I
240 FOR I = 0 TO 236
250 FOR J = 0 TO 1
260 READ ST(I,J)
270 NEXT J,I
280 PI = 3.141593
290 REM --- SET HGR SHAPE TABLE ---
300 HIMEM: 38143
310 POKE 232,0: POKE 233,149
320 BA = 38144
330 READ N: POKE BA,N:BA = BA + 2:BD = BA + 2 * N
340 FOR X = 1 TO N
350 BR = BD - 38144
360 POKE BA,(BR - INT (BR / 256) * 256)
370 POKE BA + 1, INT (BR / 256)
380 BA = BA + 2
390 READ Y: POKE BD,Y
400 BD = BD + 1
410 IF Y < > 0 GOTO 390
420 NEXT X
1000 REM --- INTRO PRINT ROUTINE ---
1010 HOME
1020 PRINT : PRINT : PRINT

```


SKYSET (continued)

```
1040 PRINT TAB( 6);"ASTRONOMY PROGRAM FOR APPLE II"
1050 ZN = 8:LA = FN RAD(38.24):L$ = "SEBASTOPOL,CAL.":LO = 122.49
1060 PRINT : PRINT
1070 PRINT "INITIAL CONDITIONS ARE SET"
1075 PRINT "FOR ... "L$: PRINT
1080 PRINT
1090 PRINT TAB( 10);"LATITUDE "; FN DEG(LA)
1100 PRINT TAB( 10);"LONGITUDE ";LO
1110 PRINT TAB( 10);"TIME ZONE ";ZN: PRINT : PRINT
1120 PRINT "YOU CAN CHANGE THESE LATER IF YOU WISH"
1130 DF = 0
1140 FOR I = 1 TO 4400: NEXT I
1150 HOME : PRINT : PRINT : PRINT : PRINT
1160 PRINT : PRINT
1180 PRINT : PRINT
1190 PRINT : PRINT TAB( 7)"PLOTS THE STARS FOR A REQUESTED"
1200 PRINT TAB( 8)"TIME AND DATE, AND SHOWS THE"
1210 PRINT TAB( 7)"PLANETS, SUN AND MOON ABOVE THE"
1220 PRINT TAB( 16)"HORIZON"
1230 PRINT : PRINT TAB( 4)"CLOSE TO FULL THE MOON IS SHOWN AS @"
1240 PRINT TAB( 7)"BEFORE FULL IT IS SHOWN AS ) AND"
1250 PRINT TAB( 8)"AFTER FULL IT IS SHOWN AS (: PRINT : PRINT
1260 PRINT : PRINT
1280 PRINT : PRINT
1290 FOR I = 1 TO 6500: NEXT I: HOME : PRINT
1300 REM *** BEGIN MAIN PROGRAM ***
1310 IF DF = 0 THEN PRINT : PRINT : PRINT : GOTO 1460
1320 NC = 0
1330 PRINT : INPUT "DO YOU WANT TO SEE THE VARIABLES? (Y/N) ";YNS
1340 IF YNS = "N" THEN GOTO 1380
1350 PRINT : PRINT "DATE.. ";YR;"-";MO;"-";DA;" LMT.. ";T1;" HRS"
1355 PRINT
1360 PRINT " TIME ZONE.. ";ZN
1365 PRINT
1370 PRINT "LAT.. "; FN DEG(LA);" LONG.. ";LO: PRINT
1380 PRINT
1390 PRINT "DO YOU WANT TO ENTER OR CHANGE ANY": INPUT "VARIABLES?
(Y)(N) ";YNS
1400 IF YNS = "N" THEN NC = 1: GOTO 1770
1405 HOME : PRINT : PRINT : PRINT
1410 PRINT : PRINT
1420 PRINT "DO YOU WANT TO CHANGE:": PRINT " THE DATE OF: "YR;"-";MO;
"-";DA
1430 PRINT
1440 INPUT "(Y)(N)? ";YNS
1450 IF YNS = "N" GOTO 1550
1460 PRINT : PRINT "WHAT IS THE DATE TO BE DISPLAYED?"
1465 PRINT
1470 INPUT "...THE YEAR: ";Y
1475 PRINT
1480 INPUT "...THE MONTH: ";M
1485 PRINT
1490 INPUT "...THE DAY: ";D
1500 MO = M:DA = D:YR = Y
1510 IF Y > 1800 GOTO 1550
```

SKYSET (continued)

```

1520 PRINT : PRINT "IS ";Y;: INPUT " THE YEAR YOU WANT(Y)(N)? ";YNS
1530 IF YNS = "N" THEN PRINT : GOTO 1470
1540 IF YNS < > "Y" GOTO 1520
1550 PRINT : PRINT
1560 IF DF = 0 THEN PRINT "WHAT IS THE LMT TO BE DISPLAYED?": GOTO 1590
1570 PRINT " THE LMT OF: ";T1;: INPUT " (Y)(N)? ";YNS
1580 IF YNS = "N" GOTO 1640
1590 GOSUB 3000
1600 IF DF < > 0 THEN 1640
1605 HOME : PRINT : PRINT : PRINT
1610 PRINT : PRINT "IF YOU WANT TO CHANGE VARIABLES"
1620 PRINT "ANSWER 'Y' WHEN ASKED, OTHERWISE 'N'"
1625 PRINT
1630 PRINT "DO YOU WANT TO CHANGE:"
1640 PRINT
1650 PRINT " THE TIME ZONE OF: ";ZN;: INPUT " (Y)(N)? ";YNS
1660 IF YNS = "N" GOTO 1680
1670 PRINT : INPUT "WHAT IS THE TIME ZONE(0-23)? ";ZN
1680 PRINT
1690 PRINT " THE LONGITUDE OF: ";LO;: INPUT " (Y)(N)? ";YNS
1700 IF YNS = "N" GOTO 1720
1710 PRINT : INPUT "WHAT IS THE LONGITUDE? ";LO: GOSUB 3300
1720 PRINT
1730 PRINT " THE LATITUDE OF: "; FN DEG(LA);: INPUT " (Y)(N)? ";YNS
1740 IF YNS = "N" GOTO 1770
1750 PRINT : INPUT "WHAT IS THE LATITUDE? ";LA
1760 LA = FN RAD(LA)
1770 HOME : PRINT : PRINT : PRINT : PRINT
1780 PRINT "WHICH HORIZON DO YOU WANT TO SEE?"
1790 PRINT
1800 PRINT " 1 EAST HORIZON ... 0 TO 180 DEG"
1810 PRINT " 2 WEST HORIZON ... 180 TO 360 DEG"
1820 PRINT " 3 SOUTH HORIZON .. 90 TO 270 DEG"
1830 PRINT " 4 NORTH HORIZON .. 270 TO 90 DEG"
1840 PRINT : INPUT "SELECT (1-4): ";HZ
1850 IF (HZ = 1 OR HZ = 2 OR HZ = 3 OR HZ = 4) THEN 2000
1860 PRINT "INVALID ENTRY": GOTO 1780
2000 REM *** BEGIN CALCS ***
2001 PRINT : PRINT
2002 SP = 0
2003 PRINT "DO YOU WANT PLANETS ONLY SHOWN"
2004 PRINT "WITHOUT SHOWING STARS AS WELL?"
2006 PRINT : PRINT "PLANETS IDENTIFIED AS.. "
2007 PRINT "MERCURY 1 VENUS 2"
2008 PRINT "MARS 4 JUPITER 5"
2009 PRINT "SATURN 6 URANUS 7"
2010 PRINT "NEPTUNE 8 PLUTO 0"
2011 PRINT : INPUT "(Y/N)";A$
2012 IF A$ = "Y" THEN SP = 1
2015 IF NC = 1 GOTO 2090
2020 HOME : PRINT "COMPUTING...PLEASE WAIT": PRINT
2030 REM *** SET PLANETS ***
2040 GOSUB 4000
2050 REM --- POSITION SUN ---
2060 GOSUB 5000

```

SKYSET (continued)

```

2070 REM --- POSITION MOON ---
2080 GOSUB 7000
2090 PRINT CHR$(4);"BLOAD CHAIN, A520"
2100 CALL 520"SKYPLT"
2110 REM *****
3000 REM *** TIME INPUT ***
3010 PRINT "DO YOU WANT INPUT IN DEC.HRS (D)"
3020 INPUT "          OR IN HR, MI, SE (H)? ";YNS
3030 IF YNS = "D" THEN 3060
3040 IF YNS = "H" THEN 3080
3050 PRINT "INVALID REPLY": PRINT : GOTO 3010
3060 PRINT : INPUT "WHAT IS THE LMT(HH.XXX)? ";T1
3070 PRINT : GOTO 3100
3080 PRINT : INPUT "WHAT IS THE LMT(HR,MI,SE)? ";HR,MI,SE
3090 T1 = HR + MI / 60 + SE / 3600: PRINT
3100 RETURN
3300 REM *** CORRECT ZN FOR LONGITUDE ***
3320 LGC = (ZN * 15) - LO
3330 IF LGC < 0 THEN 3350
3340 ZN = ZN + ABS (LGC / 15): GOTO 3360
3350 ZN = ZN + LGC / 15
3360 RETURN
4000 REM *** ENTER VAR.FOR CALC LST ***
4010 GOSUB 4400
4020 GOSUB 4300:ND = G - 715875 + T1 / 24
4030 REM --- POSITION PLANETS ---
4040 FOR J = 0 TO 8
4050 GOSUB 4500
4060 A(J + 1) = A:D(J + 1) = D:L(J + 1) = L
4070 NEXT J
4080 FOR I = 1 TO 9
4090 IF I = 3 GOTO 4120
4100 GOSUB 4700
4110 AL(I) = AL:AZ(I) = AZ
4120 NEXT I
4130 RETURN
4300 REM *** DAYS FROM EPOCH ***
4310 G = 365 * YR + DA + ((MO - 1) * 31)
4320 IF MO > = 3 GOTO 4340
4330 G = G + INT ((YR - 1) / 4) - INT (.75 * INT ((YR - 1) / 100 + 1)):
      GOTO 4350
4340 G = G - INT (2.3 + MO * .4) + INT (YR / 4)
      - INT (.75 * INT ((YR / 100) + 1))
4350 RETURN
4400 REM *** CALCUL OF LST ***
4410 GOSUB 4300:NS = G - 722895
4420 SG = .065711
4430 T2 = SG * NS + 12.064707 + (((ZN + T1) / 24) * SG) + T1
4440 IF T2 > 24 THEN T2 = T2 - 24: GOTO 4440
4450 IF T2 < 0 THEN T2 = T2 + 24: GOTO 4450
4460 RETURN
4500 REM *** SUB FOR A,D,L ***
4510 A = ND * PD(J,0) + PD(J,1)
4520 IF A > PI * 2 THEN A = (A / (PI * 2)) - INT (A / (PI * 2)) * PI * 2
4530 IF A < 0 THEN A = A + PI * 2: GOTO 4530

```

SKYSET (continued)

```

4540 C = PD(J,2) * SIN (A - PD(J,3))
4550 A = A + C
4560 IF A > PI * 2 THEN A = A - PI * 2: GOTO 4560
4570 IF A < 0 THEN A = A + PI * 2: GOTO 4570
4580 D = PD(J,4) + PD(J,5) * SIN (A - PD(J,6))
4590 L = PD(J,7) * SIN (A - PD(J,8))
4600 RETURN
4700 REM --- ELEV & AZ OF PLANETS ---
4710 Z = A(3) - A(I)
4720 IF ABS (Z) > PI AND Z < 0 THEN Z = Z + (PI * 2)
4730 IF ABS (Z) > PI AND Z > 0 THEN Z = Z - (PI * 2)
4740 Q = SQR (D(I) ^ 2 + D(3) ^ 2 - 2 * D(I) * D(3) * COS (Z))
4750 P = (D(I) + D(3) + Q) / 2
4760 X = 2 * FN ACO( SQR ((P * (P - D(I))) / (D(3) * Q)))
4770 T = X * (12 / PI)
4780 IF Z < 0 THEN R = FN DEC(A(3) + PI - X) / 15
4790 IF Z > 0 THEN R = FN DEC(A(3) + PI + X) / 15
4800 IF R > 24 THEN R = R - 24: GOTO 4800
4810 IF R < 0 THEN R = R + 24: GOTO 4810
4820 IF Z < 0 THEN V = SIN (A(3) + PI - X) * 23.44194 + FN DEG(L(I))
4830 IF Z > 0 THEN V = SIN (A(3) + PI + X) * 23.44194 + FN DEG(L(1))
4840 HA = T2 - R
4850 IF HA < - 12 THEN HA = HA + 24
4860 IF HA > 12 THEN HA = HA - 24
4870 HA = FN RAD(HA * 15):V = FN RAD(V)
4880 AL = FN ASN( SIN (V) * SIN (LA) + COS (V) * COS (LA) * COS (HA))
4890 AZ = FN ACO(( SIN (V) - SIN (LA) * SIN (AL)) / ( COS (LA)
  * COS (AL)))
4900 IF HA > 0 THEN AZ = PI * 2 - AZ
4910 AL = FN DEG(AL):AZ = FN DEG(AZ)
4920 RETURN
5000 REM --- POSITION SUN ---
5010 RS = FN DEG(A(3) + PI) / 15
5020 IF RS > 24 THEN RS = RS - 24: GOTO 5020
5030 IF RS < 0 THEN RS = RS + 24: GOTO 5030
5040 VS = SIN (A(3) + P1) * 23.44194
5050 HS = T2 - RS
5060 IF HS < - 12 THEN HS = HS + 24
5070 IF HS > 12 THEN HS = HS - 24
5080 HS = FN RAD(HS * 15):VS = FN RAD(VS)
5090 AS = FN ASN( SIN (VS) * SIN (LA) + COS (VS) * COS (LA) * COS (HS))
5100 ZS = FN ACO(( SIN (VS) - SIN (LA) * SIN (AS)) / ( COS (LA)
  * COS (AS)))
5110 IF HS > 0 THEN ZS = PI * 2 - ZS
5120 AS = FN DEG(AS):ZS = FN DEG(ZS)
5130 RETURN
7000 REM --- POSITION MOON ---
7010 ND = ND - .5
7020 LP = 255.7433
7030 LZ = 311.1687:LE = 178.699
7035 LM = LZ + 360 * ND / 27.32158
7040 MD = LM:GOSUB 7700:LM = MD
7070 PG = .111404 * ND + LP
7080 MD = PG:GOSUB 7700:PG = MD
7090 PG = LM - PG

```

SKYSET (continued)

```

7095 REM CORRECT FOR ELLIPTICAL ORBIT
7100 DR = 6.2886 * SIN ( FN RAD(PG))
7110 LM = LM + DR
7115 IF LM > 360 THEN LM = LM - 360: GOTO 7120
7117 IF LM < 0 THEN LM = LM + 360
7120 RQ = LM:RM = LM / 15
7130 IF RM > 24 THEN RM = RM - 24: GOTO 7130
7140 IF RM < 0 THEN RM = RM + 24
7150 AL = LE - ND * .052954
7160 ND = ND + .5
7170 MD = AL: GOSUB 7700:AL = MD
7180 AL = RQ - AL
7190 IF AL < 0 THEN AL = AL + 360
7200 IF AL > 360 THEN AL = AL - 360
7210 HE = 5.1454 * SIN ( FN RAD(AL))
7220 DM = HE + 23.1444 * SIN ( FN RAD(RQ))
7230 HD = T2 - RM
7240 IF HD < - 12 THEN HD = HD + 24
7250 IF HD > 12 THEN HD = HD - 24
7260 IF (HD > 12 OR HD < - 12) THEN RETURN
7270 HA = FN RAD(HD * 15):DM = FN RAD(DM)
7280 ML = FN ASN( SIN (DM) * SIN (LA) + COS (DM) * COS (LA) * COS (HA))
7290 MZ = FN AC0(( SIN (DM) - SIN (LA) * SIN (ML)) / ( COS (LA)
* COS (ML)))
7300 IF HA > 0 THEN MZ = PI * 2 - MZ
7310 MZ = FN DEG(MZ)
7320 ML = FN DEG(ML)
7330 GOSUB 7600
7340 RETURN
7600 PM = RS + 12 - RQ / 15
7620 IF PM > 12 THEN PM = PM - 24
7630 IF (PM > = - 2 AND PM < = 2) THEN MS = 11: RETURN
7640 IF LA < 0 AND PM < - 2 THEN MS = 12
7650 IF PM < - 2 THEN MS = 13
7660 IF LA < 0 AND PM > 2 THEN MS = 13: RETURN
7670 IF PM > 2 THEN MS = 12
7680 RETURN
7700 IF MD < - 3600 THEN MD = MD + 3600: GOTO 7700
7710 IF MD < 0 THEN MD = MD + 360: GOTO 7710
7730 IF MD > 3600 THEN MD = MD - 3600: GOTO 7730
7740 IF MD > 360 THEN MD = MD - 360: GOTO 7740
7750 RETURN
9000 REM *** ORBITAL ELEMENTS OF PLANETS, MERCURY-PLUTO ***
9010 DATA .071425,3.8494,.388301,1.34041,.3871,.07974,2.73514,.122173,
.836015
9020 DATA .027962,3.02812,.013195,2.28638,.7233,.00506,3.85017,.059341,
1.33168
9030 DATA .017202,1.74022,.032044,1.78547,1,.017,3.33926,0,0
9040 DATA .009146,4.51234,.175301,5.85209,1.5237,.141704,1.04656,.03142,
.858702
9050 DATA .001451,4.53364,.090478,.23911,5.2028,.249374,1.76188,.01972,
1.74533
9060 DATA .000584,4.89884,.105558,1.61094,9.5385,.534156,3.1257,.043633,
1.977458
9070 DATA .000205,2.46615,.088593,2.96706,19.182,.901554,4.49084,.01396,
1.28805

```

SKYSET (continued)

9080 DATA .000104,3.78556,.016965,.773181,30.06,.27054,2.33498,.031416,
 2.29162
 9090 DATA .000069,3.16948,.471239,3.91303,39.44,9.86,5.23114,.300197,1.91812
 9500 REM *** DATA ON RA AND DEC OF STARS ***
 9510 REM URSA MINOR
 9520 DATA 2,89,18,86,17,82,16,78,15,75,15.4,72,16.3,76
 9530 REM CEPHEUS
 9540 DATA 20.8,61,21.5,70
 9550 REM CASSIOPEIA
 9560 DATA 1.9,63,1.4,60,0.9,60,0.6,56,0.1,59
 9570 REM PERSEUS
 9580 DATA 3.3,50,3.0,53,3.7,48,3.1,41,3.9,40,3.9,32
 9590 REM URSA MAJOR
 9600 DATA 11,57,11,63,11.9,54,12.2,58,12.9,57,13.4,55,13.7,50
 9610 REM DRACO
 9620 DATA 16,59,16.4,62,17.1,66,17.5,52,17.9,51,18.3,73,19.2,68
 9630 REM CEPHEUS
 9640 DATA 23.8,78,21.3,62,22.1,58,22.8,67
 9650 REM ANDROMEDA
 9660 DATA 2,42,1.1,35,.6,31
 9670 REM TRIANGULUM
 9680 DATA 2.1,35,1.8,29,2.2,34
 9690 REM PEGASUS
 9700 DATA 22.7,30,0.1,29,0.2,14,21.7,10,22.2,6,22.7,10,23,4,23,28
 9710 REM AURIGA
 9720 DATA 5.2,46,5.9,45,5.9,37,4.9,33,5,41
 9730 REM BOOTES
 9740 DATA 14.5,39,15,40,15.3,33,14.2,20,13.9,19,14.7,27,15.5,27,15.4,29
 9750 REM CORONA
 9760 DATA 15.6,27
 9770 REM HERCULES
 9780 DATA 16.7,39,16.7,31,17,31,17.2,37,17.2,25,16.5,21,16.4,19
 9790 REM LYRA
 9800 DATA 18.7,39,18.8,33,19,32
 9810 REM CYGNUS
 9820 DATA 20.7,45,20.3,40,19.8,45,20.8,34,19.5,28
 9830 REM TAURUS
 9840 DATA 3.6,24,3,4,2.7,3,4.5,17,5.4,29,5.6,21,3.7,24,4.3,15,4.45,19
 9850 REM ARIES
 9860 DATA 2.1,23,1.8,21,1.8,19
 9870 REM ERIDANUS
 9880 DATA 3.9,-13,3.3,-20
 9890 REM PISCES
 9900 DATA 1.5,-9,1.2,-10
 9910 REM CETUS
 9920 DATA .7,-18,1.1,-10,1.3,-9,2,2
 9930 REM ORION
 9940 DATA 5.8,8,5.4,8,5.75,-2,5.6,-1,5.45,0,5.8,-10,5.6,-6,5.6,10,5.5,-21,
 5.2,-9
 9943 REM CANIS MAJOR
 9946 DATA 6.7,-17,6.3,-18,6.9,-29,7.2,-27,7.4,-29
 9950 REM CANIS MINOR
 9960 DATA 7.6,7,7.4,9
 9970 REM GEMINI

SKYSET (continued)

```

9980 DATA 7.6,32,7.7,28,7.3,22,6.7,25,6.6,16,6.4,22,6.3,22
9990 REM LEO
10000 DATA 10.1,12,10.1,17,10.3,20,10.3,24,11.2,20,11.2,16,11.8,15,9.8,
      28,9.7,26
10010 REM CANCER
10020 DATA 8.7,29,8.6,21
10030 REM HYDRA
10040 DATA 9.5,-9,8.7,7,8.9,7,9.2,2,10.4,-17
10050 REM VIRGO
10060 DATA 11.8,2,13.4,-11,13,11,12.9,3,12.7,-1,12.3,-1,13.1,-5
10070 REM CRATER
10080 DATA 10.8,-16,10.9,-18,11.3,-15,11.4,-18
10090 REM CORVUS
10100 DATA 12.5,-16,12.2,-17,12.5,-23,12.2,-22
10110 REM SERPENS
10120 DATA 15.8,17,15.5,10,15.7,7,15.8,5,15.8,-3
10130 REM LIBRA
10140 DATA 15.3,-9,14.8,-16
10150 REM OPHIUCHUS
10160 DATA 17.5,12,17.2,25,17.6,5,17.7,3
10170 REM SAGITTARIUS
10180 DATA 18.3,-30,18,-30,18.4,-25,18.9,-26,19,-30,19.1,-21,18.3,-21
10190 REM SCORPIO
10200 DATA 16.5,-26,16.6,-28,16.4,-24,16,-20,15.9,-22,15.9,-26,18.6,-43,
      16.7,-34,18.5,-37,18.7,-40,16.7,-38,22.9,-30
10210 REM CAPRICORNUS
10220 DATA 21.7,-18,21.6,-18,21.4,-22,20.8,-28,20.7,-26,20.3,-14,20.2,-12,
      22.9,-30
10230 REM DELPHINUS
10240 DATA 20.5,11,20.6,15,20.7,15,20.6,16,20.8,16
10250 REM AQUARIUS
10260 DATA 22.6,0,22.5,0,22.4,1,22.3,-2,22,0,21.5,-6
10270 REM AQUILA
10280 DATA 19.8,9,19.7,10.5,19.9,6,19.1,13,18.95,14,20.1,-1
10290 REM SOUTHPOLAR REGION
10300 DATA 12.2,-59,12.1,-50,12.4,-57,12.7,-59,12.3,-63
10310 DATA 14,-60,14.7,-60,14.7,-65,15.9,-63,15.1,-69,16.9,-69
10320 DATA 20.3,-57,1.7,-57,2,-62,0.4,-63,6.3,-52,6.8,-51
10330 DATA 8.8,-55,9.3,-55,9.2,-59,8.3,-60,9.1,-70,9.8,-65
10340 DATA 3.9,-75,12.5,-69,12.6,-68
11000 REM *** SHAPE TABLE DATA ***
11005 DATA 13
11010 DATA 36,12,21,54,54,30,7,32,4,0
11020 DATA 32,12,173,182,246,63,32,12,45,0
11030 DATA 146,100,100,12,32,63,63,0
11040 DATA 54,14,45,32,28,63,32,12,45,5,0
11050 DATA 22,21,45,32,28,63,32,44,45,05,00
11060 DATA 12,12,12,54,54,54,196,63,4,0
11070 DATA 41,12,228,191,150,114,45,32,4,0
11080 DATA 64,99,173,246,30,30,46,45,5,0
11090 DATA 146,9,36,36,36,4,0
11100 DATA 36,188,119,247,45,62,46,53,36,53,37,44,63,44,60,7,0
11110 DATA 36,188,55,21,63,14,46,14,12,37,12,39,60,22,214,7,0
11120 DATA 182,12,37,12,63,12,60,28,54,6,0
11130 DATA 182,28,39,28,45,28,44,12,54,6,0

```

SKYPLT

```

100  REM --- SKYPLT PROGRAM ---
1000 REM --- RESET FUNCTIONS ---
1010 DEF FN ASN(X) = ATN (X / SQR ( - X * X + 1))
1020 DEF FN ACO(X) = - ATN (X / SQR ( - X * X + 1)) + 3.14159 / 2
1030 DEF FN RAD(X) = X * 3.14159 / 180
1040 DEF FN DEG(X) = X * 180 / 3.14159
1050 REM --- SET COORDINATES AND DATA ---
1060 HOME
1070 HGR
1080 HCOLOR= 7: SCALE= 1: ROT= 0
1090 X = FRE (0)
1100 FOR X = 1 TO 8
1110 DRAW X + 1 AT 0,X * 21 - 13
1120 DRAW 1 AT 5,X * 21 - 13
1130 NEXT X
1140 HPLLOT 0,159 TO 279,159
1150 VTAB (21)
1160 ON HZ GOTO 1170,1180,1190,1200
1170 PRINT " N      30      60      E      120      150      S";: GOTO 1210
1180 PRINT " S      210     240     W      300     330     N";: GOTO 1210
1190 PRINT " E      120     150     S      210     240     W";: GOTO 1210
1200 PRINT " W      300     330     N      30      60      E";
1210 PRINT "DATE: "YR"-"MO"-"DA" LMT: " LEFT$ ( STR$ ( T1),5)" LST:"
LEFT$ ( STR$ ( T2),5)
1220 PRINT "LAT: "; LEFT$ ( STR$ ( ABS ( FN DEG(LA))),5);
1230 IF LA > 0 THEN PRINT " NORTH";
1240 IF LA < 0 THEN PRINT " SOUTH";
1250 PRINT " LONG: " LEFT$ ( STR$ ( L0),5)
1260 REM --- GET AZ AND EL FOR EACH STAR AND POKE IT ON CHART ---
1265 IF SP = 1 THEN GOTO 1490
1270 FOR K = 0 TO 236
1280 SR = ST(K,0):SD = ST(K,1)
1290 HD = T2 - SR
1300 IF HD < - 12 THEN HD = HD + 24
1310 IF HD > 12 THEN HD = HD - 24
1320 HA = HD * 15
1330 HA = FN RAD(HA):SD = FN RAD(SD)
1340 SL = FN ASN( SIN (SD) * SIN (LA) + COS (SD) * COS (LA) * COS (HA))
1350 SZ = ( SIN (SD) - SIN (LA) * SIN (SL)) / ( COS (LA) * COS (SL))
1360 IF SZ > = 1 THEN SZ = 0: GOTO 1400
1370 IF SZ < = - 1 THEN SZ = PI: GOTO 1400
1380 SZ = FN ACO(SZ)
1390 IF HA > 0 THEN SZ = PI * 2 - SZ
1400 SZ = FN DEG(SZ)
1410 IF SZ > 360 THEN SZ = SZ - 360
1420 IF SZ < 0 THEN SZ = SZ + 360
1430 SL = FN DEG(SL)
1440 X1 = SZ:Y1 = SL
1450 GOSUB 2000
1460 IF X2 < 0 GOTO 1480
1470 HPLLOT X2,Y2
1480 NEXT K
1490 REM --- PLOT SUN ---

```


SKYPLT (continued)

```
1500 X1 = ZS:Y1 = AS
1510 GOSUB 2000
1520 IF X2 < 0 GOTO 1540
1530 DRAW 10 AT X2,Y2
1540 REM --- PLOT PLANETS ---
1550 FOR X = 1 TO 9
1560 IF X = 3 THEN 1610
1570 X1 = AZ(X):Y1 = AL(X)
1580 GOSUB 2000
1590 IF X2 < 0 GOTO 1610
1600 DRAW 10 - X AT X2,Y2
1610 NEXT X
1620 REM --- PLOT MOON ---
1630 X1 = MZ:Y1 = ML
1640 GOSUB 2000
1650 IF X2 < 0 GOTO 1670
1660 DRAW MS AT X2,Y2
1670 REM --- END ---
1680 PRINT "HIT ANY KEY TO PLOT AGAIN, ^C TO STOP";
1690 GET YN$
1700 TEXT : HOME
1710 IF YN$ = CHR$(3) THEN END
1720 DF = 1
1730 PRINT : PRINT CHR$(4);"BLOAD CHAIN, A520"
1740 CALL 520"SKYSET"
1750 REM *****
2000 REM --- BRACKET VALUES ---
2010 IF Y1 < 10 OR Y1 > 81.4 GOTO 2150
2020 ON HZ GOTO 2030,2050,2070,2090
2030 IF X1 > 0 AND X1 < 180 THEN GOTO 2120
2040 GOTO 2150
2050 IF X1 > 180 AND X1 < 360 THEN X1 = X1 - 180: GOTO 2120
2060 GOTO 2150
2070 IF X1 > 90 AND X1 < 270 THEN X1 = X1 - 90: GOTO 2120
2080 GOTO 2150
2090 IF X1 > = 0 AND X1 < 90 THEN X1 = X1 + 90: GOTO 2120
2100 IF X1 > 270 AND X1 < = 360 THEN X1 = X1 - 270: GOTO 2120
2110 GOTO 2150
2120 X2 = (265 / 180) * X1 + 11
2130 Y2 = (150 / 71.4) * (81.4 - Y1) + 5
2140 RETURN
2150 X2 = - 1
2160 RETURN
```

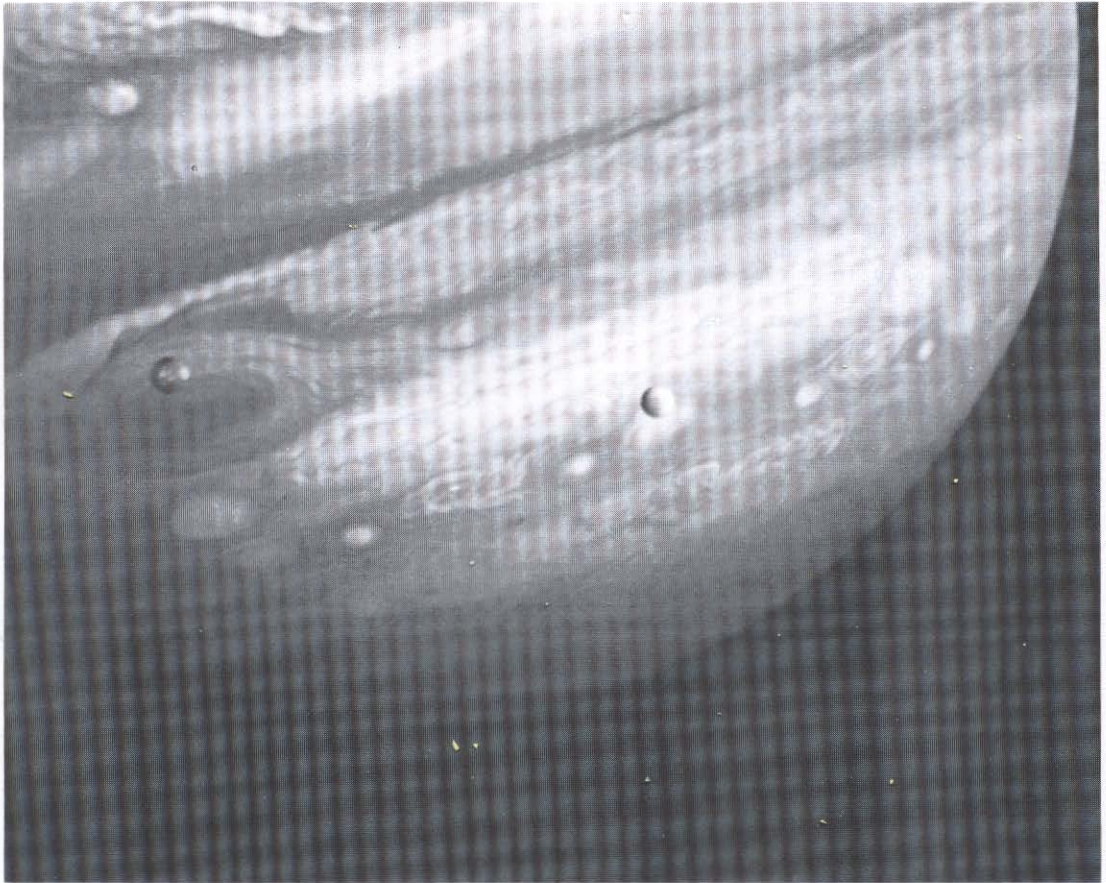


Photo Credit: NASA/Jet Propulsion Laboratory

Jupiter, the giant planet of our solar system, was explored for the first time by a Pioneer spacecraft in 1973. It was later revealed as a planet of incredibly complex detail by the Voyager flybys. Even in a small telescope Jupiter presents an interesting pattern of

light and dark bands with a large red spot. In close-up pictures like the one shown here, the light and dark bands are resolved into intricate details of swirling storms. This Voyager picture shows the satellites Io and Europa in transit across the face of Jupiter.

Program 17: PLNTF

Finds and Plots Planets, Sun, and Moon in Constellations for Any Date and Time

How do you find out where a planet, the Sun, or the Moon is on any date? Some astronomical books give this type of information, but it is usually out of date when you most want to use it. The astronomical magazines provide the information on a monthly basis. But if you want the information for a few months ahead you must refer to a yearly almanac. If you want the information a year or years ahead you have to make laborious calculations, perhaps helped by a handheld calculator. However, with a personal computer and this program you can quickly and easily locate a planet, the Moon, or the Sun at any date.

When you select a date and a planet, the Sun, or the Moon, this program calculates where the object is located among the "fixed" stars of the celestial sphere. It selects a suitable zodiacal star chart (2 hours of right ascension and 30 degrees of declination), displays its name, and shows the object among the stars. The dotted line across the middle of each chart is the ecliptic. Because of the limitations of resolution of any monitor screen, the selected object's accurate right ascension and declination is displayed before the object is shown on the star chart.

The program then offers the option of having other planets, the Sun and the Moon displayed on the chart if they are located on the same chart region on the date requested (see Figure 17.1).

When you have obtained the information, the computer asks you if you want another planet on the same date. If you answer 'Y', it will then select an appropriate chart to display the new selection and offer again the ability to chart other planets in that new star chart.

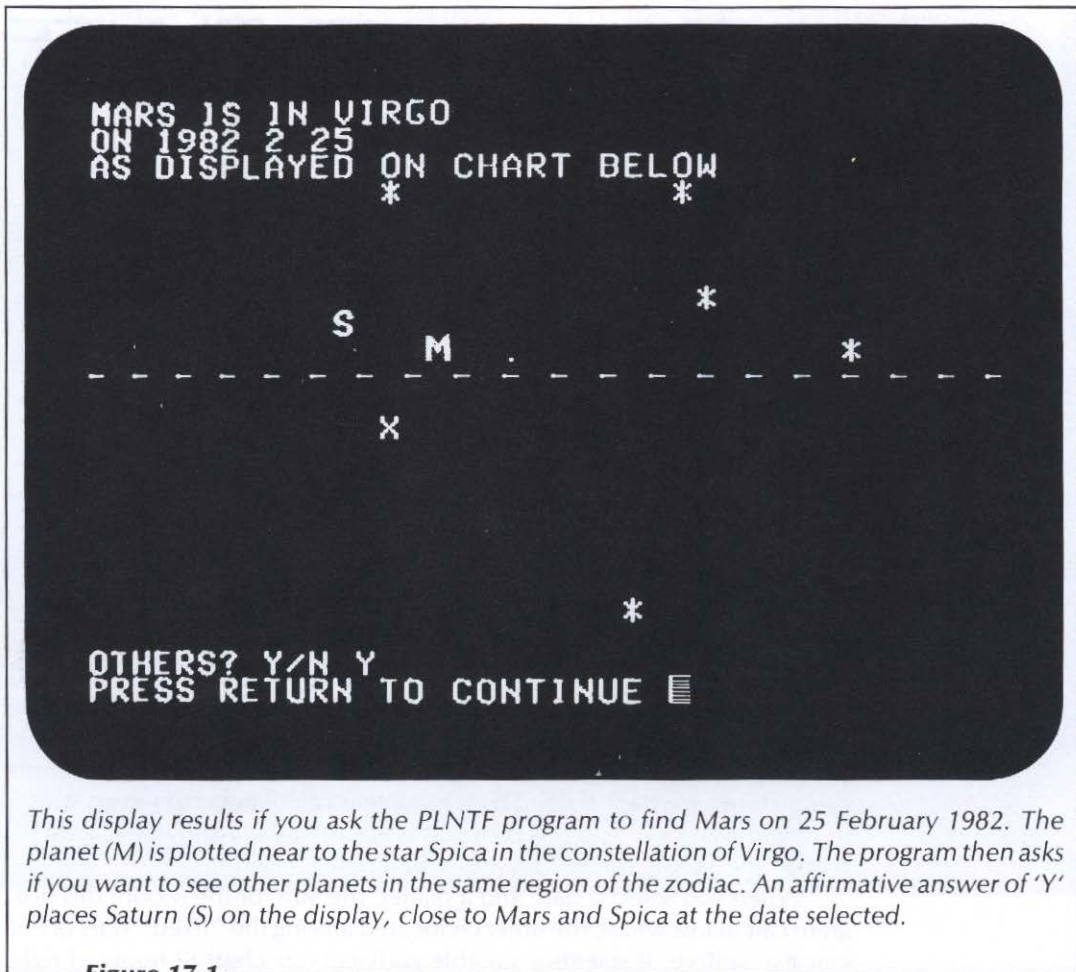
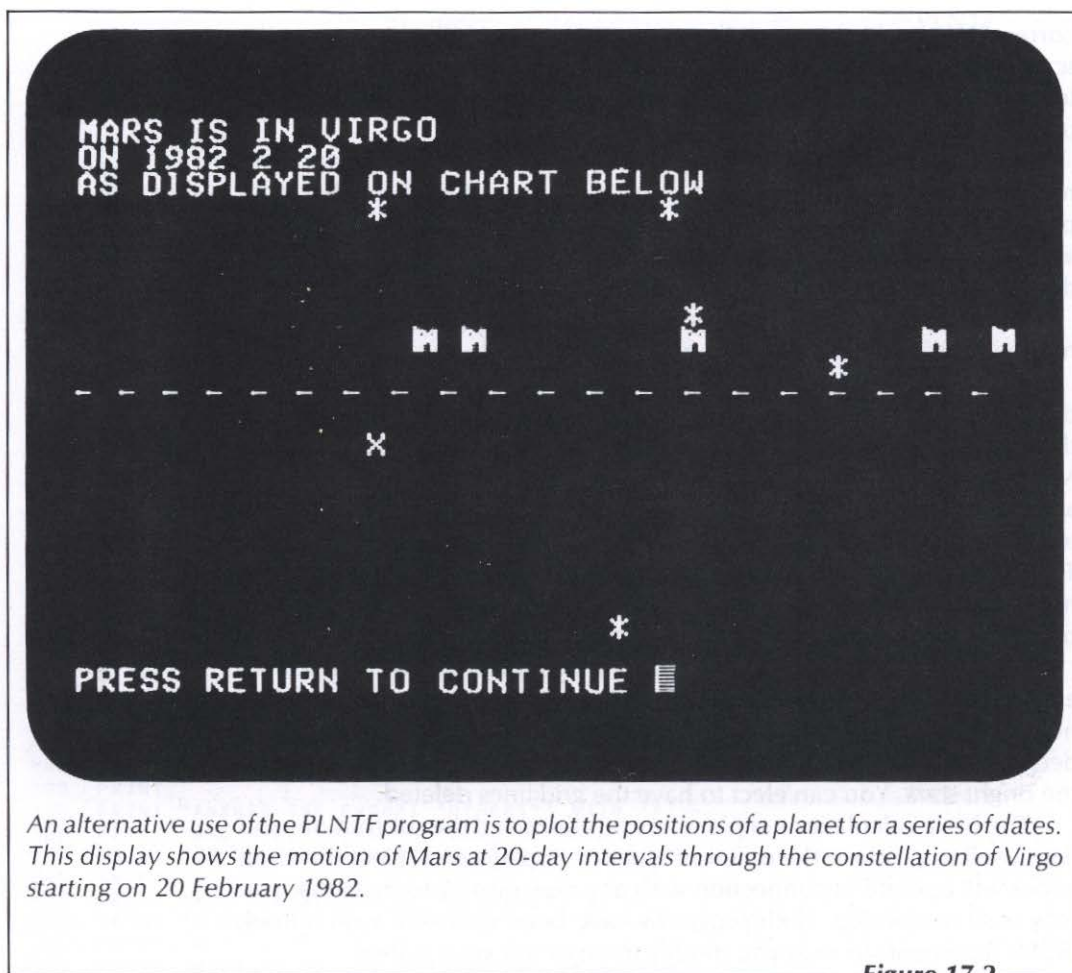


Figure 17.1

Other alternatives available are to ask for another date for the same planet, or another date and another planet.

You can also select, when determining the date, whether you require a series of plots. If you do not, insert 1's in answer to the interval in days and the number of plots required. If you require a series, you must input the number of plots and the time interval (in days) between each plot. If your series of plots runs off the screen, the monitor will display the name of the planet and the message OFF CHART for every plot that is off the chart. Figure 17.2 illustrates the option of displaying a series of plots.



The program operates by first loading planetary data, as in other programs, and then computing the right ascension and declination of the planet you wish to find for the date you have requested. It displays this information on the monitor screen. Next the program determines (in instructions 2490 through 2590) which zodiacal region must be displayed. It then jumps to the part of the program (beginning at instruction 3660) containing the screen coordinates for the stars in that region of the sky, and displays the appropriate stars on the monitor screen. Converting the right ascension and declination to screen coordinates, the program places the planet at its

correct location in the constellation by poking its ASCII character at the screen coordinate. Use of POKE statements enables the celestial objects to be displayed on the monitor screen without scrolling or erasing the other characters on the display.

When you request the display of other planets in the same star chart region, the program checks the right ascension of each of the other planets, the Sun, and the Moon. If any of these fall within the range of right ascensions covered by the chart displayed on the monitor, the program displays them at the correct location in the zodiacal constellation.

If you have requested a series of displays, the program loops until the number of displays matches the number requested.

The program will need modification to suit each individual computer's display format. The parts of the program requiring such modification are those that display the constellations and POKE the planets, Sun, and Moon in the star chart. Refer to the alternative program for guidance in adapting this program to your computer. You can also modify this program to use the high resolution graphics of the Apple by changing the VTAB and TAB instructions to high resolution graphic coordinates. If you do this, you must incorporate a short routine to allow the main program to continue beyond the region of memory reserved for the high resolution graphics.

For computers with screens having 64 characters and 30 lines, the alternative PLNTA, Program 17A in the Appendix, identifies and displays nearby constellations over 4 hours of right ascension and 60 degrees of declination, provides a grid of right ascension and declination, and names the bright stars. You can elect to have the grid lines deleted.

The basic calculations of planetary positions and the subroutines and flags used to produce the different types of displays and select the chart zones will operate in connection with any new display formats that you may wish to develop. Both programs have been sprinkled with remark (REM) statements to help you modify them to suit your system.

The listing of the PLNTF program follows.

PLNTF

```
10 CLEAR
20 HOME
30 DIM PD(9,9)
40 PRINT : PRINT
50 DEF FN ACO(X) = - ATN (X / SQR ( - X * X + 1)) + 1.5707963
60 DEF FN RAD(X) = .01745328 * (X)
70 DEF FN DEG(X) = 57.29578 * (X)
80 PRINT : PRINT : PRINT
90 PRINT TAB( 8)"ASTRONOMY PROGRAM"
100 PRINT
110 PRINT TAB( 5)"-----"
120 PRINT TAB( 5)"I   PLANET FINDER   I"
130 PRINT TAB( 5)"-----"
140 PRINT
150 PRINT TAB( 5)"BY ERIC BURGESS F.R.A.S."
160 PRINT : PRINT
170 PRINT TAB( 5)"ALL RIGHTS RESERVED BY"
180 PRINT TAB( 5)"S & T SOFTWARE SERVICE"
190 PRINT
200 PRINT TAB( 8)"(VERSION 4.82)"
210 FOR K = 1 TO 3000: NEXT K
220 HOME : PRINT : PRINT
230 INPUT "DO YOU WANT INSTRUCTIONS? Y/N ";A$
240 IF A$ = "N" THEN 480
250 IF A$ < > "Y" THEN PRINT : PRINT "INVALID RESPONSE": PRINT : GOTO 220
260 HOME : PRINT : PRINT
270 PRINT "THIS PROGRAM PLACES A PLANET, OR THE"
280 PRINT "SUN, OR THE MOON AMONG THE ZODIACAL"
290 PRINT "CONSTELLATIONS FOR ANY DATE."
300 PRINT
310 PRINT "ANSWER THE PROMPT 'OTHERS?' WITH 'Y'"
320 PRINT "AND OTHER PLANETS, SUN, OR MOON"
330 PRINT "IN THE SAME CHART WILL BE DISPLAYED"
340 PRINT
350 PRINT "YOU CAN ALSO PLOT THE POSITIONS OF"
360 PRINT "A PLANET FOR A SERIES OF INTERVALS"
370 PRINT
380 PRINT "BECAUSE OF THE LIMITATIONS OF SCREEN"
390 PRINT "RESOLUTION, THE RIGHT ASCENSION AND"
400 PRINT "DECLINATION OF THE CHOSEN PLANET, SUN,"
410 PRINT "OR MOON IS GIVEN BEFORE THE MONITOR"
420 PRINT "DISPLAYS THE ZODIACAL STAR CHART"
430 PRINT
440 PRINT "THE DOTTED LINE ACROSS THE MIDDLE"
450 PRINT "OF EACH CHART IS THE ECLIPTIC"
460 PRINT : PRINT : PRINT
470 INPUT "PRESS RETURN TO CONTINUE ";A$
480 HOME : PRINT : PRINT
490 PRINT "ENTER THE DATE": PRINT
500 INPUT " THE YEAR ";YD$:Y = VAL (YD$)
510 IF Y = 0 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 500
520 IF Y > 1800 THEN GOTO 590
530 PRINT "IS ";Y;" THE CORRECT YEAR? ";
```

PLNTF (continued)

```

540 INPUT Y$
550 IF PS = 10 OR F8 = 1: THEN GOSUB 7210
560 IF Y$ = "Y" THEN GOTO 590
570 IF Y$ < > "N" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 530
580 IF Y$ = "N" THEN PRINT : GOTO 500
590 PRINT : INPUT " THE MONTH "; MD$: M = VAL (MD$)
600 IF M = 0 OR M > 12 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 590
610 PRINT : PRINT " THE DAY "
620 INPUT "(USE DECIMAL FOR HRS) "; DD$
630 D = VAL (DD$)
640 REM STORES INITIAL DATE IN D2,M2,Y2
650 IF F9 = 1 THEN GOTO 670
660 D2 = VAL (DD$): Y2 = Y: M2 = M
670 IF D = 0 OR D > 31 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 610
680 IF M = 2 AND D > 29 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 610
690 PRINT : PRINT
700 PRINT "SELECT INTERVALS AND HOW MANY"
710 PRINT TAB( 5)"ENTER 1'S IF YOU NEED ONE PLOT ONLY"
720 PRINT : PRINT
730 INPUT "WHAT IS THE INTERVAL (DAYS) "; TI$: PRINT
740 TI = VAL (TI$): IF TI = 0 THEN PRINT "INVALID RESPONSE": PRINT :
GOTO 730
750 INPUT "HOW MANY INTERVALS "; IN$: PRINT
760 IN = VAL (IN$): IF IN = 0 THEN PRINT "INVALID RESPONSE": PRINT :
GOTO 879
770 REM SETS INTERVAL COUNT AT 1
780 NC = 1
790 GOSUB 800: GOTO 920
800 REM CALC DAYS FROM 1960,1,1 EPOCH TO DATE
810 HOME : PRINT : PRINT "PLEASE WAIT"
820 DC = 365 * Y + D + ((M - 1) * 31)
830 IF M > = 3 GOTO 870
840 REM CALC FOR JAN OR FEB
850 DC = DC + INT ((Y - 1) / 4) - INT ((.75) * INT ((Y - 1) / 100 + 1))
860 GOTO 890
870 REM CALC FOR MAR THRU DEC
880 DC = DC - INT (M * .4 + 2.3) + INT (Y / 4)
- INT ((.75) * INT ((Y / 100) + 1))
890 NI = DC - 715875
900 IF F9 = 1 THEN 930
910 RETURN
920 REM JUMPS PLANETARY INPUTS IF NEW INTERVAL
930 IF F9 = 1 THEN GOTO 1490
940 REM INPUT PLANETARY DATA, ORBITAL PARAMETERS
950 REM JUMPS PLANETARY INPUT IF NEW DATE
960 IF FL = 1 THEN GOTO 1230
970 IF F8 = 1 THEN GOTO 1250
980 IF F6 = 1 THEN GOTO 1250
990 RESTORE
1000 FOR YP = 0 TO 8: FOR XP = 0 TO 8
1010 READ PD(YP,XP)
1020 NEXT XP,YP
1030 REM MERCURY
1040 DATA .071422,3.8484,.388301,1.34041,.3871,.07974,2.73514,.122173,
.836013

```


PLNTF (continued)

```

1050 REM VENUS
1060 DATA .027962,3.02812,.013195,2.28638,.7233,.00506,3.85017,.059341,
1.33168
1070 REM EARTH (FOR SUN)
1080 DATA .017202,1.74022,.032044,1.78547,1,.017,3.33926,0,0
1090 REM MARS
1100 DATA .009146,4.51234,.175301,5.85209,1.5237,.141704,1.04656,.03142,
.858702
1110 REM JUPITER
1120 DATA .001450,4.53364,.090478,.23911,5.2028,.249374,1.76188,.01972,
1.74533
1130 REM SATURN
1140 DATA .000584,4.89884,.105558,1.61094,9.5385,.534156,3.1257,.043633,
1.977458
1150 REM URANUS
1160 DATA .000205,2.46615,.088593,2.96706,19.182,.901554,4.49084,.01396,
1.28805
1170 REM NEPTUNE
1180 DATA .000104,3.78556,.016965,.773181,30.06,.27054,2.33498,.031416,
2.29162
1190 REM PLUTO
1200 DATA .000069,3.16948,.471239,3.91303,39.44,9.86,5.23114,.300197,
1.91812
1210 FOR I9 = 1 TO 9: READ PS(I9): NEXT I9
1220 DATA MERCURY,VENUS,SUN,MARS,JUPITER,SATURN,URANUS,NEPTUNE,PLUTO
1230 F = 0
1240 IF F9 = 2 THEN GOTO 1260
1250 FL = 0
1260 REM CALC DATA FOR PLANETS
1270 IF F9 = 2 THEN GOTO 1490
1280 IF F8 = 1 THEN F8 = 0: GOTO 1490
1290 HOME
1300 PRINT : PRINT : PRINT
1310 PRINT "WHICH PLANET, SUN, OR MOON"
1320 PRINT " DO YOU WANT TO FIND?"
1330 PRINT
1340 PRINT TAB( 5)"MERCURY (+)...1"
1350 PRINT TAB( 5)"VENUS (V)....2"
1360 PRINT TAB( 5)" 3...SUN (0)"
1370 PRINT TAB( 5)"MARS (M).....4"
1380 PRINT TAB( 5)"JUPITER (J)...5"
1390 PRINT TAB( 5)"SATURN (S)....6"
1400 PRINT TAB( 5)"URANUS (U)...7"
1410 PRINT TAB( 5)"NEPTUNE (N)...8"
1420 PRINT TAB( 5)"PLUTO (P)....9"
1430 PRINT TAB( 5)" 10...MOON ( )"
1440 PRINT
1450 PRINT TAB( 10): INPUT "SELECT 1 THRU 10 ";PS$
1460 PS = VAL (PS$)
1470 IF PS = 0 OR PS > 10 THEN PRINT "INVALID CHOICE": PRINT : GOTO 1450
1480 REM STORES SELECTION IN P2
1490 P2 = PS
1500 IF PS = 10 THEN GOSUB 7210
1510 I = 1
1520 REM CALC. PLANETARY DATA AT DATE

```

PLNTF (continued)

```

1530 REM AND STORE IN ARRAYS
1540 FOR J = 0 TO 8: GOSUB 1710
1550 A(I) = A:D(I) = DS:L(I) = L
1560 I = I + 1: NEXT J
1570 FOR I = 1 TO 9
1580 REM SKIP EARTH
1590 IF I = 3 THEN NEXT I
1600 GOSUB 1860
1610 Q(I) = Q:X(I) = X:R(I) = R:V(I) = V
1620 NEXT I
1630 FOR I = 1 TO 9:A(I) = FN DEG(A(I))
1640 IF I = 3 THEN NEXT I
1650 NEXT
1660 I = PS
1670 R(3) = (A(3) - 180) / 15
1680 IF R(3) < 0 THEN R(3) = R(3) + 24
1690 V(3) = ( SIN ( FN RAD(A(3) - 180))) * 23.44194
1700 GOTO 2070
1710 REM CALC A, DS, AND L
1720 REM AT DATE
1730 REM HELIOCENTRIC LONGITUDE, A
1740 A = NI * PD(J,0) + PD(J,1)
1750 IF A > 6.28318 THEN A = ((A / 6.28318) - INT (A / 6.28318)) * 6.28318
1760 IF A < 0 THEN A = A + 6.28318: GOTO 1760
1770 C = PD(J,2) * SIN (A - PD(J,3))
1780 A = A + C
1790 IF A > 6.28318 THEN A = A - 6.28318
1800 IF A < 0 THEN A = A + 6.28318: GOTO 1800
1810 REM CALC DIST OF PLANET FROM SUN DS
1820 DS = PD(J,4) + PD(J,5) * SIN (A - PD(J,6))
1830 REM CALC DISTANCE FROM ECLIPTIC, L
1840 L = PD(J,7) * SIN (A - PD(J,8))
1850 RETURN
1860 REM CALC Z,Q,X,R,V
1870 REM CALC ANG. DIST. FROM SUN Z
1880 Z = A(3) - A(I)
1890 IF ABS (Z) > 3.14159 AND Z < 0 THEN Z = Z + 6.28318
1900 IF ABS (Z) > 3.14159 AND Z > 0 THEN Z = Z - 6.28318
1910 REM CALC DISTANCE OF PLANET FROM EARTH Q
1920 Q = SQR (D(I) ^ 2 + D(3) ^ 2 - 2 * D(I) * D(3) * COS (Z))
1930 REM CALC ANG. DIST. FROM SUN, X
1940 PP = (D(I) + D(3) + Q) / 2
1950 X = 2 * FN ACO( SQR ((PP * (PP - D(I))) / (D(3) * Q)))
1960 REM CALC RIGHT ASCENSION, R
1970 IF Z < 0 THEN R = FN DEG(A(3) + 3.14159 - X) / 15
1980 IF Z > 0 THEN R = FN DEG(A(3) + 3.14159 + X) / 15
1990 IF R > 24 THEN R = R - 24: GOTO 1990
2000 IF R < -24 THEN R = R + 24: GOTO 2000
2010 IF R < 0 THEN R = R + 24: GOTO 2010
2020 REM CALC DECLINATION, V
2030 IF Z < 0 THEN V = SIN (A(3) + 3.14159 - X) * 23.44194 + FN DEG(L(I))
2040 IF Z > 0 THEN V = SIN (A(3) + 3.14159 + X) * 23.44194 + FN DEG(L(I))
2050 X = FN DEG(X)
2060 RETURN
2070 RA = R(PS)

```

PLNTF (continued)

```
2080 DE = V(PS)
2090 REM JUMPS PRINTING RA AND DEC IF NEW INTERVAL
2100 IF F9 = 1 THEN 2210
2110 IF F9 = 2 THEN 2210
2120 PRINT : PRINT
2130 RA$ = STR$(RA):DE$ = STR$(DE)
2140 RA$ = LEFT$(RA$,5):DE$ = LEFT$(DE$,5)
2150 PRINT "R.A. OF ";P$(PS);" IS ";RA$
2160 PRINT "DECLINATION IS ";DE$
2170 PRINT
2180 PRINT "PRESS RETURN TO DISPLAY PLANET,"
2190 INPUT "SUN, OR MOON ON STAR CHART ";A$
2200 REM STORES RA FOR SELECTED PLANET
2210 R3 = RA:DC = DE
2220 GOSUB 2250: GOTO 2360
2230 REM ASCII CODES FOR POKING PLANETS
2240 REM AS FLASHING SYMBOLS
2250 IF PS = 1 THEN P$ = "MERCURY":P = 107: GOTO 2350
2260 IF PS = 2 THEN P$ = "VENUS" :P = 86: GOTO 2350
2270 IF PS = 3 THEN P$ = "SUN":P = 79: GOTO 2350
2280 IF PS = 4 THEN P$ = "MARS":P = 77: GOTO 2350
2290 IF PS = 5 THEN P$ = "JUPITER":P = 74: GOTO 2350
2300 IF PS = 6 THEN P$ = "SATURN":P = 83: GOTO 2350
2310 IF PS = 7 THEN P$ = "URANUS":P = 85: GOTO 2350
2320 IF PS = 8 THEN P$ = "NEPTUNE":P = 78: GOTO 2350
2330 IF PS = 9 THEN P$ = "PLUTO":P = 80: GOTO 2350
2340 IF PS = 10 THEN P$ = "MOON":P = 105: GOTO 2350
2350 RETURN
2360 REM
2370 IF F9 = 1 OR F5 = 1 GOTO 2390
2380 PN = P
2390 REM SELECT STAR CHART FOR DISPLAY
2400 GOSUB 2440
2410 IF F9 = 1 THEN 6580
2420 IF (F7 = 1 AND F5 = 1) THEN RETURN
2430 GOTO 2720
2440 REM SELECT CHART AND ADJUST
2450 REM HORIZONTAL PLOT
2460 PDE = DE
2470 REM JUMPS CHART SELECTION IF SHOWING OTHER PLANETS
2480 IF F9 = 1 OR F5 = 1 THEN GOTO 2610
2490 IF RA > 22 AND RA < 23.99999 THEN RA = RA - 22:CH = 12: GOTO 2640
2500 IF RA > 20 AND RA < 21.99999 THEN RA = RA - 20:CH = 11: GOTO 2640
2510 IF RA > 18 AND RA < 19.99999 THEN RA = RA - 18:CH = 10: GOTO 2640
2520 IF RA > 16 AND RA < 17.99999 THEN RA = RA - 16:CH = 9: GOTO 2640
2530 IF RA > 14 AND RA < 15.99999 THEN RA = RA - 14:CH = 8: GOTO 2640
2540 IF RA > 12 AND RA < 13.99999 THEN RA = RA - 12:CH = 7: GOTO 2640
2550 IF RA > 10 AND RA < 11.99999 THEN RA = RA - 10:CH = 6: GOTO 2640
2560 IF RA > 8 AND RA < 9.99999 THEN RA = RA - 8:CH = 5: GOTO 2640
2570 IF RA > 6 AND RA < 7.99999 THEN RA = RA - 6:CH = 4: GOTO 2640
2580 IF RA > 4 AND RA < 5.99999 THEN RA = RA - 4:CH = 3: GOTO 2640
2590 IF RA > 2 AND RA < 3.99999 THEN RA = RA - 2:CH = 2: GOTO 2640
2600 CH = 1
2610 IF F9 = 1 THEN GOSUB 6790
2620 IF F5 = 1 THEN GOSUB 6790
```

PLNTF (continued)

```

2630 IF F7 = 1 THEN RETURN
2640 IF F9 = 1 THEN GOSUB 6670
2650 IF F5 = 1 THEN GOSUB 6670
2660 RA = RA * 15
2670 IF (RA - INT (RA)) > .49 THEN RA = 1 + INT (RA)
2680 PL = INT (1.3 * RA)
2690 IF F5 = 1 THEN GOTO 2710
2700 PX = PL
2710 RETURN
2720 REM IN EACH CHART POKE PL,P
2730 REM WHERE P IS NAME OF PLANET
2740 REM SUCH AS +,V,M,J,S,U,N,P,O,)
2750 HOME
2760 S = 1487
2770 GOSUB 2790
2780 GOTO 2930
2790 REM SUB FOR ABOVE AND BELOW ECLIPTIC PLANE
2800 IF PS = 10 THEN CF = HE: GOTO 2820
2810 CF = FN DEG(L(PS))
2820 IF CF - INT (CF) > .49 THEN CF = CF + 1
2830 CF = INT (CF)
2840 IF CF < - 9 OR CF > 8 THEN S = 0:OC$ = "OFF CHART": GOTO 2910
2850 IF CF > 0 AND CF < 4 THEN CF = 128 * CF: GOTO 2890
2860 IF CF < 9 AND CF > 3 THEN CF = (CF * 128) - 984: GOTO 2890
2870 IF CF < 0 AND CF > - 5 THEN CF = 128 * CF: GOTO 2890
2880 IF CF < - 4 AND CF > - 10 THEN CF = 984 + 128 * CF: GOTO 2890
2890 S = S - CF
2900 RETURN
2910 REM PRINT ECLIPTIC
2920 RETURN
2930 FOR J = 1 TO 39 STEP 2
2940 VTAB 12: PRINT TAB( J) "-";
2950 NEXT J
2960 PRINT
2970 GOTO 3290
2980 HOME : PRINT : PRINT : PRINT
2990 PRINT "WANT ANOTHER PLANET, SAME DATE? Y/N "
3000 PRINT : PRINT : INPUT "..... ";A$
3010 IF A$ = "N" THEN GOTO 3100
3020 IF A$ < > "Y" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 2990
3030 REM RESET Y,M,D TO ORIGINAL SELECTION
3040 RA = 0:DE = 0:RA$ = "":DE$ = ""
3050 Y = Y2:M = M2:D = D2
3060 F9 = 0:F8 = 0:F6 = 0
3070 FL = 0:F1 = 0:F2 = 0:F3 = 0:F4 = 0:F5 = 0:F7 = 0:FX = 0
3080 HOME : PRINT : PRINT : PRINT
3090 GOTO 770
3100 HOME
3110 PRINT : PRINT : PRINT : PRINT
3120 PRINT "WANT ANOTHER DATE, SAME PLANET? Y/N "
3130 PRINT : PRINT : INPUT "..... ";A$
3140 IF A$ = "N" THEN HOME : PRINT : PRINT : GOTO 3200
3150 IF A$ < > "Y" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 3120
3160 PL = P2:F9 = 0:FL = 0:F1 = 0:F2 = 0:F3 = 0:F4 = 0:F5 = 0:F6 = 0:F7
= 0:F8 = 0:FX = 0

```

PLNTF (continued)

```

3170 F9 = 2
3180 GOTO 480
3190 PRINT
3200 PRINT "WANT ANOTHER DATE, ANOTHER PLANET? Y/N "
3210 PRINT : PRINT
3220 INPUT "..... ";A$
3230 IF A$ = "N" THEN HOME : GOTO 3280
3240 IF A$ < > "Y" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 3200
3250 HOME
3260 FL = 0:F1 = 0:F2 = 0:F3 = 0:F4 = 0:F5 = 0:F6 = 0:F7 = 0:F9 = 0:F8 = 0
3270 FX = 0: GOTO 480
3280 END
3290 REM SELECT ZODIACAL CHART REGION
3300 IF CH = 1 GOTO 3660
3310 IF CH = 2 GOTO 3910
3320 IF CH = 3 GOTO 4160
3330 IF CH = 4 GOTO 4330
3340 IF CH = 5 GOTO 4580
3350 IF CH = 6 GOTO 4810
3360 IF CH = 7 GOTO 5020
3370 IF CH = 8 GOTO 5170
3380 IF CH = 9 GOTO 5280
3390 IF CH = 10 GOTO 5510
3400 IF CH = 11 GOTO 5720
3410 IF CH = 12 GOTO 5930
3420 REM PLOT OTHER PLANETS
3430 IF IN > 1 THEN F6 = 1: GOTO 3520
3440 INPUT "OTHERS? Y/N ";A$
3450 IF A$ = "N" THEN F6 = 1: GOTO 3520
3460 IF A$ < > "Y" THEN GOTO 3440
3470 IF A$ = "Y" THEN F5 = 1
3480 F6 = 0
3490 REM SUB TO PLOT OTHER PLANETS
3500 CF = 0
3510 GOSUB 6120
3520 REM CHECKS IF MORE CYCLES
3530 IF NC < IN GOTO 3560
3540 IF NC > = IN GOTO 3590
3550 REM SUB TO INCREASE DATE BY INTERVAL AND REPEAT PROGRAM
3560 GOSUB 6480
3570 IF F9 = 1 THEN GOTO 3530
3580 REM RESETS F9 WHEN ALL CYCLES COMPLETED
3590 REM RESETS NC,D,M AND Y TO INITIAL VALUES
3600 NC = 1:D = D2:M = M2:Y = Y2
3610 PS = P2:RA = R3:DE = DC
3620 P = PN:PL = PX
3630 INPUT "PRESS RETURN TO CONTINUE ";A$
3640 :
3650 GOTO 2980
3660 REM CHART 1 PISCES
3670 C$ = "PISCES"
3680 GOSUB 3700
3690 GOTO 3810
3700 IF FN DEG(L(PS)) < - 10 THEN W$ = "OFF CHART BOTTOM"

```

PLNTF (continued)

```

3710 IF FN DEG(L(PS)) > 10 THEN W$ = "OFF CHART TOP"
3720 VTAB 2
3730 PRINT P$;" IS IN ";C$;" ";W$
3740 VTAB 3
3750 PRINT "ON ";Y2;" ";M2;" ";D2
3760 VTAB 4
3770 IF LEFT$(W$,3) = "OFF" THEN GOTO 3790
3780 PRINT "AS DISPLAYED ON CHART BELOW"
3790 W$ = ""
3800 RETURN
3810 VTAB 7: PRINT TAB( 9) ". "
3820 VTAB 7: PRINT TAB( 37) "*"
3830 VTAB 10: PRINT TAB( 23) ". "
3840 VTAB 11: PRINT TAB( 19) ". "
3850 VTAB 13: PRINT TAB( 5) ". "
3860 VTAB 15: PRINT TAB( 9) ". "
3870 VTAB 19: PRINT TAB( 5) "*"
3880 VTAB 20: PRINT TAB( 38) ". "
3890 POKE S - PL,P
3900 GOTO 7190
3910 REM CHART 2 ARIES
3920 C$ = "ARIES"
3930 GOSUB 3700
3940 VTAB 5
3950 PRINT TAB( 33) "X"
3960 VTAB 6
3970 PRINT TAB( 37) "*"
3980 VTAB 7
3990 PRINT TAB( 37) ". "
4000 VTAB 10
4010 PRINT TAB( 4) ". . ."
4020 VTAB 10
4030 PRINT TAB( 15) ". "
4040 VTAB 15
4050 PRINT TAB( 36) ". "
4060 VTAB 16
4070 PRINT TAB( 27) ". "
4080 VTAB 19
4090 PRINT TAB( 33) ". "
4100 VTAB 18
4110 PRINT TAB( 5) "*" ; TAB( 16) ". . "
4120 VTAB 21
4130 PRINT TAB( 24) "*" ; TAB( 30) "*"
4140 POKE S - PL,P
4150 GOTO 7190
4160 REM CHART 3 TAURUS
4170 C$ = "TAURUS"
4180 GOSUB 3700
4190 VTAB 6
4200 PRINT TAB( 11) "*"
4210 VTAB 13
4220 PRINT TAB( 9) "*" ; TAB( 19) ". " ; TAB( 29) ". "
4230 VTAB 14
4240 PRINT TAB( 30) ". "
4250 VTAB 16

```

PLNTF (continued)

```
4260 PRINT TAB( 27)"X"; TAB( 29)": "; TAB( 32)". "
4270 VTAB 21
4280 PRINT TAB( 21)". "
4290 VTAB 22
4300 PRINT TAB( 10)". "; TAB( 22)". "
4310 POKE S - PL,P
4320 GOTO 7190
4330 REM CHART 4 GEMINI
4340 C$ = "GEMINI"
4350 GOSUB 3700
4360 VTAB 6
4370 PRINT TAB( 6)"*"
4380 VTAB 7
4390 PRINT TAB( 9)". "
4400 VTAB 8
4410 PRINT TAB( 6)". "
4420 VTAB 9
4430 PRINT TAB( 23)"*"
4440 VTAB 11
4450 PRINT TAB( 15)"*"
4460 VTAB 13
4470 PRINT TAB( 19)". "; TAB( 31)"*"; TAB( 33)"*"
4480 VTAB 14
4490 PRINT TAB( 29)". "
4500 VTAB 16
4510 PRINT TAB( 26)"*"
4520 VTAB 19
4530 PRINT TAB( 23)". "
4540 VTAB 22
4550 PRINT TAB( 11)"*"
4560 POKE S - PL,P
4570 GOTO 7190
4580 REM CHART 5 CANCER
4590 C$ = "CANCER"
4600 GOSUB 3700
4610 VTAB 9
4620 PRINT TAB( 26)". "
4630 VTAB 10
4640 PRINT TAB( 25)". "
4650 VTAB 14
4660 PRINT TAB( 6)"*"
4670 VTAB 15
4680 PRINT TAB( 19)". "
4690 VTAB 18
4700 PRINT TAB( 18)"*"; TAB( 21)"*"
4710 VTAB 19
4720 PRINT TAB( 26)". "; TAB( 29)"*"
4730 VTAB 20
4740 PRINT TAB( 12)". "; TAB( 23)". "
4750 VTAB 21
4760 PRINT TAB( 20)". "
4770 VTAB 22
4780 PRINT TAB( 22)". "
4790 POKE S - PL,P
4800 GOTO 7190
```

PLNTF (continued)

```
4810 REM CHART 6 LEO
4820 C$ = "LEO"
4830 GOSUB 3700
4840 VTAB 5
4850 PRINT TAB( 20)"*"; TAB( 36)"*"
4860 VTAB 6
4870 PRINT TAB( 15)". "
4880 VTAB 7
4890 PRINT TAB( 3)". "; TAB( 37)". "
4900 VTAB 8
4910 PRINT TAB( 7)". "
4920 VTAB (10)
4930 PRINT TAB( 14)". "; TAB( 19)". "
4940 VTAB 11
4950 PRINT TAB( 3)"*"; TAB( 28)". "; TAB( 36)"X"
4960 VTAB 14
4970 PRINT TAB( 7)". "
4980 VTAB 18
4990 PRINT TAB( 12)". "
5000 POKE S - PL,P
5010 GOTO 7190
5020 REM CHART 7 VIRGO
5030 C$ = "VIRGO"
5040 GOSUB 3700
5050 VTAB 5
5060 PRINT TAB( 14)"*"; TAB( 26)"*"
5070 VTAB 9
5080 PRINT TAB( 27)"*"
5090 VTAB 11
5100 PRINT TAB( 19)". "; TAB( 33)"*"
5110 VTAB 14
5120 PRINT TAB( 14)"X"
5130 VTAB 21
5140 PRINT TAB( 24)"*"
5150 POKE S - PL,P
5160 GOTO 7190
5170 REM CHART 8 LIBRA
5180 C$ = "LIBRA"
5190 GOSUB 3700
5200 VTAB 6
5210 PRINT TAB( 18)"*"
5220 VTAB 11
5230 PRINT TAB( 22)"*"
5240 VTAB 19
5250 PRINT TAB( 16)". "
5260 POKE S - PL,P
5270 GOTO 7190
5280 REM CHART 9 SCORPIO
5290 C$ = "SCORPIO"
5300 GOSUB 3700
5310 VTAB 5
5320 PRINT TAB( 8)". "; TAB( 13)". "
5330 VTAB 7
5340 PRINT TAB( 10)"*"; TAB( 18)"*"
5350 VTAB 10
```


PLNTF (continued)

```
5360 PRINT TAB( 36)"*"
5370 VTAB 13
5380 PRINT TAB( 37)"*"
5390 VTAB 14
5400 PRINT TAB( 29)"*"
5410 VTAB 15
5420 PRINT TAB( 27)"X"
5430 VTAB 16
5440 PRINT TAB( 37)
5450 VTAB 17
5460 PRINT TAB( 25)"*"
5470 VTAB 21
5480 PRINT TAB( 21)"*"
5490 POKE S - PL,P
5500 GOTO 7190
5510 REM CHART 10 SAGITTARIUS
5520 C$ = "SAGITTARIUS"
5530 GOSUB 3700
5540 VTAB 10
5550 PRINT TAB( 29)". "
5560 VTAB 11
5570 PRINT TAB( 18)". "; TAB( 21)". "
5580 VTAB 14
5590 PRINT TAB( 30)"*"
5600 VTAB 15
5610 PRINT TAB( 22)"*"
5620 VTAB 16
5630 PRINT TAB( 24)". "
5640 VTAB 17
5650 PRINT TAB( 24)"*"; TAB( 36)"*"
5660 VTAB 18
5670 PRINT TAB( 20)"*"
5680 VTAB 22
5690 PRINT TAB( 31)"*"
5700 POKE S - PL,P
5710 GOTO 7190
5720 REM CHART 11 CAPRICORNUS
5730 C$ = "CAPRICORNUS"
5740 GOSUB 3700
5750 VTAB 5
5760 PRINT TAB( 6)"*"
5770 VTAB 6
5780 PRINT TAB( 20)". "; TAB( 30)"*"
5790 VTAB 8
5800 PRINT TAB( 30)"*"
5810 VTAB 13
5820 PRINT TAB( 13)". "; TAB( 18)"*"
5830 VTAB 14
5840 PRINT TAB( 6)"*"; TAB( 8)"*"
5850 VTAB 17
5860 PRINT TAB( 13)". ."
5870 VTAB 18
5880 PRINT TAB( 26)". "
5890 VTAB 19
5900 PRINT TAB( 20)". "; TAB( 25)". "
```

PLNTF (continued)

```

5910 POKE S - PL,P
5920 GOTO 7190
5930 REM CHART 12 AQUARIUS
5940 C$ = "AQUARIUS"
5950 GOSUB 3700
5960 VTAB 5
5970 PRINT TAB( 7)"; TAB( 14)"; TAB( 33)"*"
5980 VTAB 6
5990 PRINT TAB( 5)"; TAB( 11)"; TAB( 25)"*" ; TAB( 29)"*"
6000 VTAB 13
6010 PRINT TAB( 23)";
6020 VTAB 16
6030 PRINT TAB( 18)";
6040 VTAB 17
6050 PRINT TAB( 26)";
6060 VTAB 19
6070 PRINT TAB( 26)"*"
6080 VTAB 20
6090 PRINT TAB( 2)"*"
6100 POKE S - PL,P
6110 GOTO 7190
6120 REM SUB TO PLOT NEARBY PLANETS
6130 PN = P
6140 FOR I = 1 TO 10
6150 PS = I:F5 = 1
6160 REM JUMPS R RANGE IF BEEN THROUGH TABLE ONCE
6170 IF F4 = 1 THEN 6300
6180 IF CH = 1 THEN R2 = 0: GOTO 6300
6190 IF CH = 2 THEN R2 = 2: GOTO 6300
6200 IF CH = 3 THEN R2 = 4: GOTO 6300
6210 IF CH = 4 THEN R2 = 6: GOTO 6300
6220 IF CH = 5 THEN R2 = 8: GOTO 6300
6230 IF CH = 6 THEN R2 = 10: GOTO 6300
6240 IF CH = 7 THEN R2 = 12: GOTO 6300
6250 IF CH = 8 THEN R2 = 14: GOTO 6300
6260 IF CH = 9 THEN R2 = 16: GOTO 6300
6270 IF CH = 10 THEN R2 = 18: GOTO 6300
6280 IF CH = 11 THEN R2 = 20: GOTO 6300
6290 IF CH = 12 THEN R2 = 22
6300 IF R(I) < R2 OR R(I) > (R2 + 1.99999) THEN GOTO 6410
6310 REM GET PLANET SYMBOL
6320 GOSUB 2250
6330 RA = R(I):DE = V(I)
6340 REM GET POKE FOR PLANET
6350 GOSUB 2440
6360 IF F7 = 1 THEN F7 = 0: GOTO 6400
6370 CF = 0:S = 1487
6380 GOSUB 2790
6390 POKE S - PL,P
6400 F4 = 1
6410 NEXT I
6420 PS = P2
6430 P = PN
6440 GOSUB 7210
6450 RA = R3:DE = DC

```

PLNTF (continued)

```
6460 F4 = 0:F5 = 0:F = 1: RETURN
6470 REM INCREASE COUNTER BY ONE
6480 NC = NC + 1
6490 PS = P2
6500 F9 = 1
6510 D = D + TI
6520 REM INCREMENTS DATE
6530 IF D > 30 THEN D = D - 30:M = M + 1: GOTO 6530
6540 IF M > 12 THEN M = M - 12:Y = Y + 1
6550 REM GOES THROUGH PROG. AGAIN FOR NEW DATE
6560 GOSUB 820
6570 REM PLOT PLANET'S NEW POSITION
6580 IF F7 = 1 THEN F7 = 0: GOTO 6600
6590 POKE S - PL,P
6600 REM POKE OTHER PLANETS ON NEW DATE
6610 IF F6 = 1 THEN 6630
6620 F9 = 0: GOSUB 6120
6630 REM REPEATS IF MORE INTERVALS
6640 F9 = 1
6650 RETURN
6660 REM ADJUST RA PLOT TO CHART
6670 IF RA > 22 AND RA < 23.99999 THEN RA = RA - 22: RETURN
6680 IF RA > 20 AND RA < 21.99999 THEN RA = RA - 20: RETURN
6690 IF RA > 18 AND RA < 19.99999 THEN RA = RA - 18: RETURN
6700 IF RA > 16 AND RA < 17.99999 THEN RA = RA - 16: RETURN
6710 IF RA > 14 AND RA < 15.99999 THEN RA = RA - 14: RETURN
6720 IF RA > 12 AND RA < 13.99999 THEN RA = RA - 12: RETURN
6730 IF RA > 10 AND RA < 11.99999 THEN RA = RA - 10: RETURN
6740 IF RA > 8 AND RA < 9.99999 THEN RA = RA - 8: RETURN
6750 IF RA > 6 AND RA < 7.99999 THEN RA = RA - 6: RETURN
6760 IF RA > 4 AND RA < 5.99999 THEN RA = RA - 4: RETURN
6770 IF RA > 2 AND RA < 3.99999 THEN RA = RA - 2: RETURN
6780 RETURN
6790 IF CH = 1 THEN GOTO 6920
6800 IF CH = 2 THEN GOTO 6940
6810 IF CH = 3 THEN GOTO 6960
6820 IF CH = 4 THEN GOTO 6980
6830 IF CH = 5 THEN GOTO 7000
6840 IF CH = 6 THEN GOTO 7020
6850 IF CH = 7 THEN GOTO 7040
6860 IF CH = 8 THEN GOTO 7060
6870 IF CH = 9 THEN GOTO 7080
6880 IF CH = 10 THEN GOTO 7100
6890 IF CH = 11 THEN GOTO 7120
6900 GOTO 7140
6910 REM REJECT OBJECTS NOT ON CHART
6920 IF RA > 1.99999 THEN GOTO 7160
6930 RETURN
6940 IF RA < 2 OR RA > 3.99999 THEN GOTO 7160
6950 RETURN
6960 IF RA < 4 OR RA > 5.99999 THEN GOTO 7160
6970 RETURN
6980 IF RA < 6 OR RA > 7.99999 THEN GOTO 7160
6990 RETURN
7000 IF RA < 8 OR RA > 9.99999 THEN GOTO 7160
```

PLNTF (continued)

```

7010 RETURN
7020 IF RA < 10 OR RA > 11.99999 THEN GOTO 7160
7030 RETURN
7040 IF RA < 12 OR RA > 13.99999 THEN GOTO 7160
7050 RETURN
7060 IF RA < 14 OR RA > 15.99999 THEN GOTO 7160
7070 RETURN
7080 IF RA < 16 OR RA > 17.99999 THEN GOTO 7160
7090 RETURN
7100 IF RA < 18 OR RA > 19.99999 THEN GOTO 7160
7110 RETURN
7120 IF RA < 20 OR RA > 21.99999 THEN GOTO 7160
7130 RETURN
7140 IF RA < 22 OR RA > 23.99999 THEN GOTO 7160
7150 RETURN
7160 F7 = 1
7170 PRINT P$(PS);" OFF CHART";
7180 RETURN
7190 VTAB 23
7200 GOTO 3420
7210 REM POKE MOON
7220 REM LONG OF MOON
7230 LZ = 311.1687:LP = 255.7433:LE = 178.699
7240 NM = NI - .5
7250 PG = .111404 * NM + LP
7260 IF PG < - 3600 THEN PG = PG + 3600: GOTO 7260
7270 IF PG < - 360 THEN PG = PG + 360: GOTO 7270
7280 IF PG < 0 THEN PG = PG + 360
7290 IF PG > 3600 THEN PG = PG - 3600: GOTO 7290
7300 IF PG > 360 THEN PG = PG - 360: GOTO 7300
7310 LMD = LZ + 360 * NM / 27.32158
7320 PG = LMD - PG
7330 DR = 6.2886 * SIN ( FN RAD(PG))
7340 LMD = LMD + DR
7350 IF LMD < - 3600 THEN LMD = LMD + 3600: GOTO 7350
7360 IF LMD < - 360 THEN LMD = LMD + 360: GOTO 7360
7370 IF LMD < 0 THEN LMD = LMD + 360: GOTO 7370
7380 IF LMD > 3600 THEN LMD = LMD - 3600: GOTO 7380
7390 IF LMD > 360 THEN LMD = LMD - 360: GOTO 7390
7400 RM = LMD / 15
7410 RQ = RM
7420 IF RM > 24 THEN RM = RM - 24: GOTO 7420
7430 IF RM < 0 THEN RM = RM + 24
7440 AL = LE - NM * .052954
7450 IF AL < - 3600 THEN AL = AL + 3600: GOTO 7450
7460 IF AL < - 360 THEN AL = AL + 360: GOTO 7460
7470 IF AL < 0 THEN AL = AL + 360: GOTO 7470
7480 IF AL > 3600 THEN AL = AL - 3600: GOTO 7480
7490 IF AL > 360 THEN AL = AL - 360: GOTO 7490
7500 AL = LMD - AL
7510 IF AL < 0 THEN AL = AL + 360
7520 IF AL > 360 THEN AL = AL - 360
7530 HE = 5.1333 * SIN (AL * 3.14159 / 180)
7540 DM = HE + 23.1444 * SIN (LMD * 3.14159 / 180)
7550 R(10) = RM:V(10) = DM

```

PLNTF (continued)

```
7560 P$(10) = "MOON"  
7570 RETURN  
7580 GOSUB 2090: GOSUB 2470  
7590 IF RA < 0 OR RA > 1.99999 THEN 7610  
7600 GOTO 2090  
7610 PRINT "MOON OFF CHART"  
7620 RETURN
```

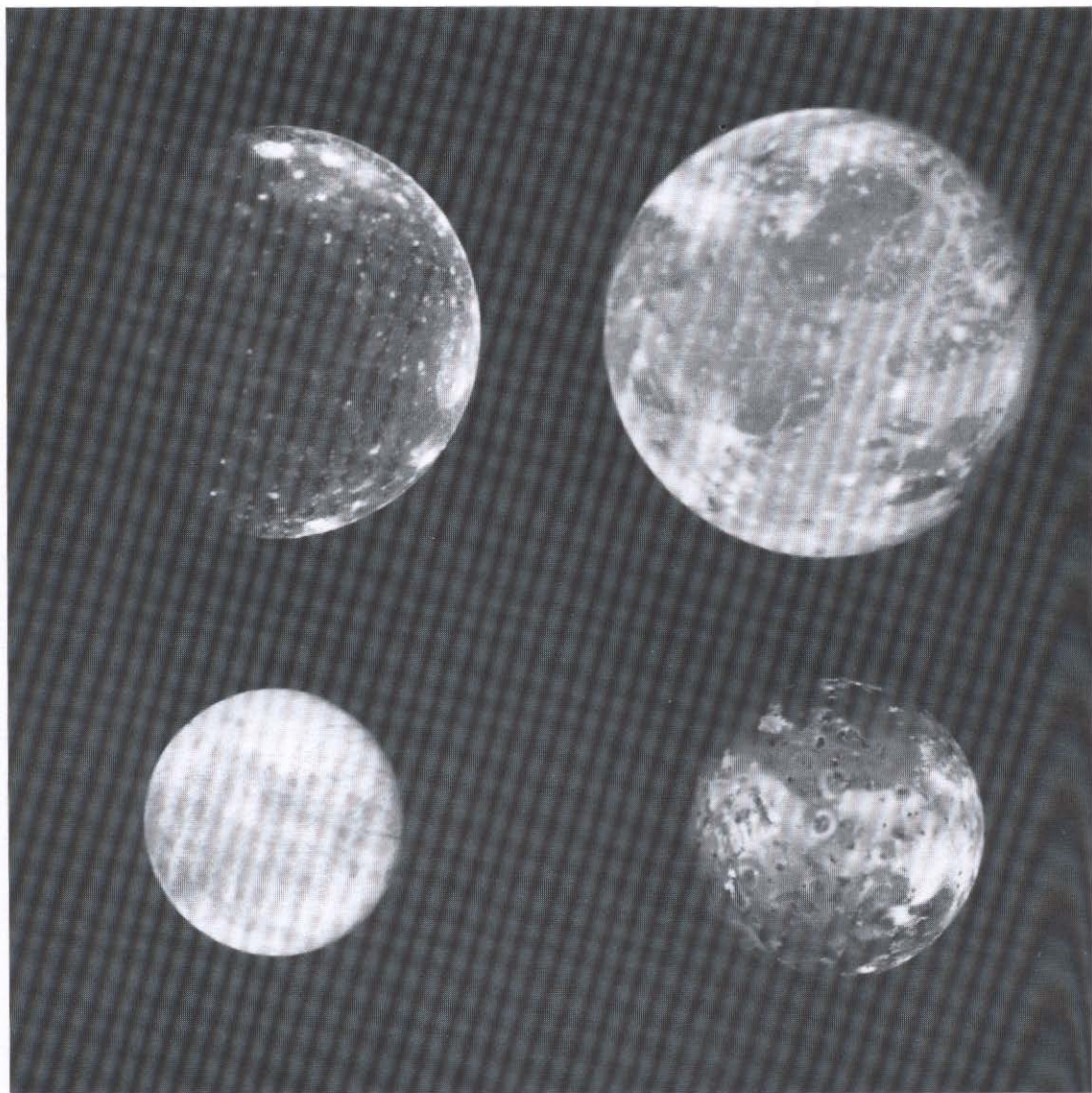


Photo Credit: NASA/Jet Propulsion Laboratory

Io is one of the four Galilean satellites of Jupiter. All four are strange, planet-sized worlds, ranging from Io with its active volcanoes to the frigid outer worlds of Ganymede and Callisto. These large satellites are shown in this montage of pictures returned by the

Voyager spacecraft. Io is bottom right; Europa, bottom left; Ganymede, top right; and Callisto, top left. Their sizes are shown proportionately; Ganymede is slightly larger than the planet Mercury.

Program 18: JSATS

Positions of Galilean Satellites of Jupiter for Any Date and Time

In 1610 Galileo in Padua startled his contemporaries with his discovery that Jupiter has four large satellites. He thereby provided evidence that ultimately helped to shatter the dogma of an Earth-centered universe and led to the Copernican revolution of human thought. In Paris 65 years later, Roemer used the timing of the motion of these satellites to measure the velocity of light across Earth's orbit. His observations showed that light travels at 186,000 miles per second.

Even the smallest telescope reveals the four Galilean satellites of Jupiter moving over the course of days from side to side of the planet. The close-up photographs returned by the Voyager spacecraft revealed much greater detail. Io, the innermost of the large moons, is a volcanic world of brimstone and sulfur with volcanic fountains shooting material hundreds of miles into space. It is a world torn by the gravities of mighty Jupiter and the other satellites, and bombarded by energetic particles trapped in the magnetic field of the giant planet. Europa is a very different but equally strange world. At first it appeared to be as smooth as a bowling ball, but it was later revealed as a world whose icy surface is marked by an intricate pattern of eggshell-like cracks. Mighty Ganymede, larger than the planet Mercury, displays several different types of terrain, very different from the surfaces of Io and Europa. There are great plains patterned by strange areas of grooves and ghostlike rings of ruined craters. Unlike the inner satellites, Ganymede has regions of heavily cratered terrain. The outermost of the big satellites, Callisto, is more like our Moon. Its surface is pockmarked with innumerable craters.

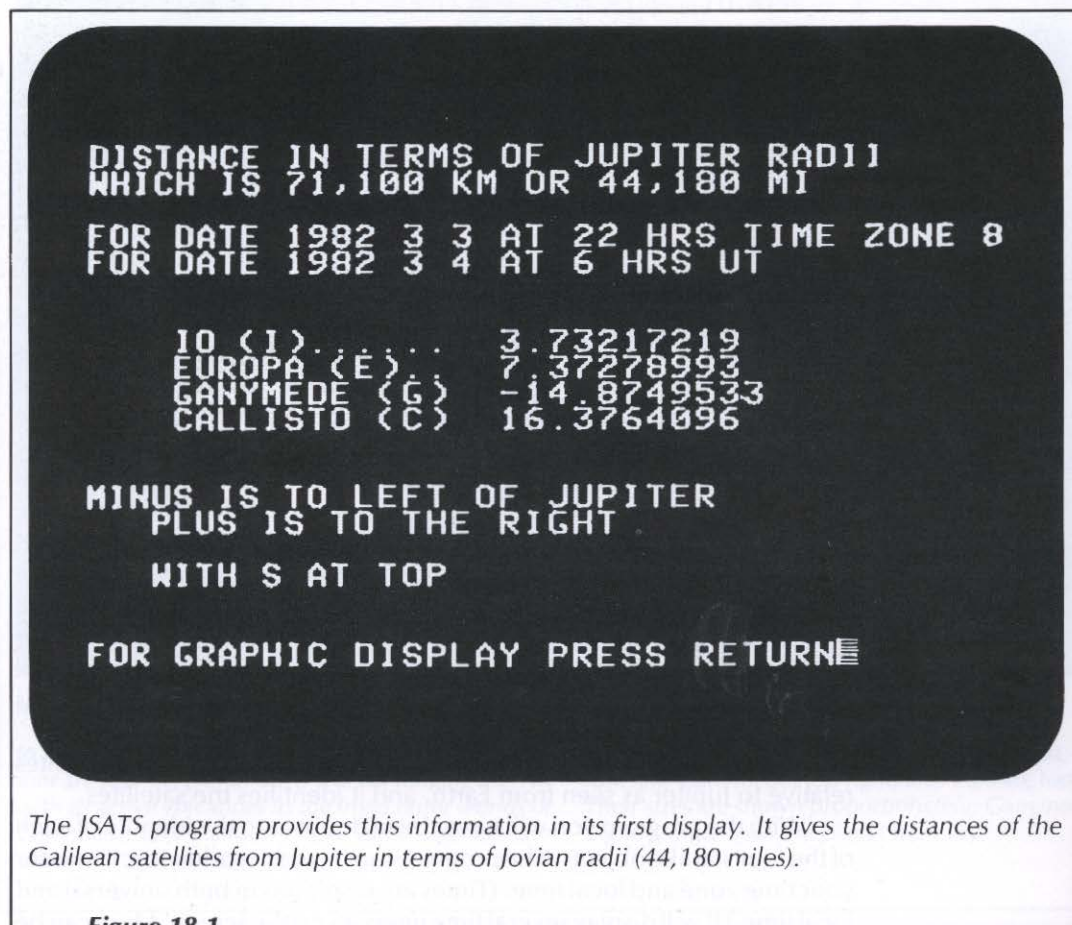
This program allows you to compute the positions of the four satellites relative to Jupiter as seen from Earth, and it identifies the satellites.

With the program you will never be in doubt as to the identity of each of the four starlike objects. The program can be used worldwide; it asks for your time zone and local time. (Times are displayed in both universal and local time.) It will display several time intervals on the screen. More can be

requested, but the display will scroll on the screen after these have been displayed. If you habitually need more time intervals displayed together on the monitor screen, you can tighten the display by eliminating instructions 1410 and 1500.

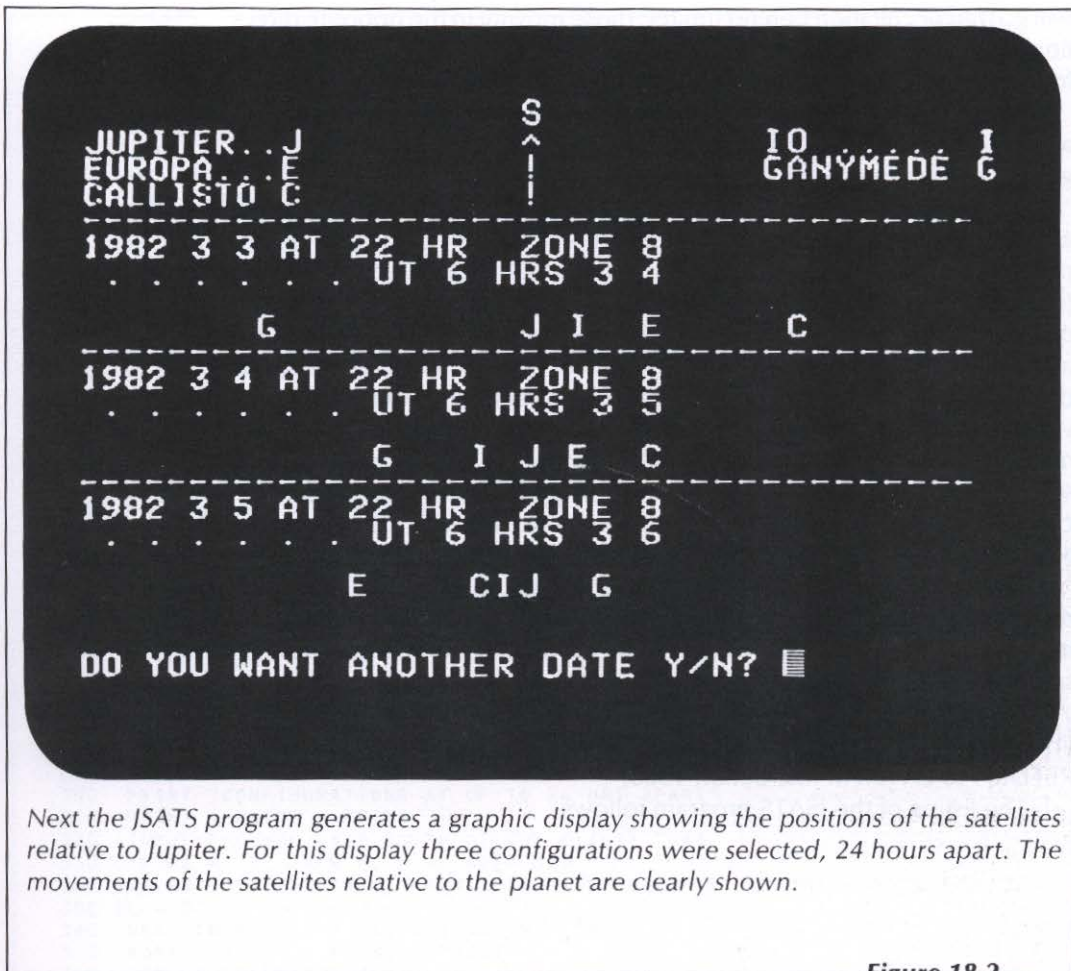
The display can be oriented with either north or south at the top to suit observers with different types of telescopes and for Northern or Southern Hemisphere viewing.

When you run this program, the computer first displays the distances of the satellites in terms of Jupiter radii for exact observations (see Figure 18.1). When you are ready to continue it displays the satellites and the planet, identified as follows: J, Jupiter; I, Io; E, Europa; G, Ganymede; and C, Callisto (see Figure 18.2).



The JSATS program provides this information in its first display. It gives the distances of the Galilean satellites from Jupiter in terms of Jovian radii (44,180 miles).

Figure 18.1



Next the JSATS program generates a graphic display showing the positions of the satellites relative to Jupiter. For this display three configurations were selected, 24 hours apart. The movements of the satellites relative to the planet are clearly shown.

Figure 18.2

Jupiter is always centrally located on the display line. It also shows which format, north or south at top, is being used. The program does not show positions out of the horizontal plane, so sometimes if two of the satellites are visible, one slightly above the other at the same angular distance from Jupiter, the display shows them side by side. You can quickly ascertain which is which by asking for displays a few hours on either side. The display also shows the satellites alongside Jupiter when in occultation or transit—they are not erased from the screen. Again, by asking for other displays at earlier times you can identify transits and occultations. With north at top, satellites moving toward Jupiter from the right of the planet

will go into occultation behind Jupiter; those moving in the opposite direction will go into transit across Jupiter. With south at top, satellite movement from the right results in transit and from the left it results in occultation.

You can add to the program and simplify the sorting out of occultations and transits by showing an orbit projection, using the high resolution graphics technique given in the MARSP program.

The program first calculates the number of days from the epoch of 1900, adjusting for time and time zone. It uses this calculation to determine the position of each satellite in its orbit around Jupiter at the requested date (instructions 920 through 1040). Next it determines the relative positions of Earth and Jupiter at the requested date (instructions 1050 through 1120) and corrects for the viewing angle from Earth. Then it calculates the radial distance of each satellite from Jupiter (in terms of the radius of Jupiter) as viewed from Earth's position, and it displays this information on the monitor screen. When you are ready to continue, the program uses a simple sort subroutine (starting at instruction 2100) to arrange the satellites in the correct order. They can then be displayed together with Jupiter on one line across the screen, at proportional distances from Jupiter.

Next the program increments the time and date as requested and develops a second and third display. Housekeeping routines adjust for month and year ends in the display of dates for each configuration of the satellites.

As with other programs, you may have to change HOME statements (instructions 30, 200, 370, 660, 1380, 1570, 2060, and 2080) and change RETURN to ENTER in instruction 1560.

The listing of the JSATS program follows.

JSATS

```

10 CLEAR
20 REM SATELLITES OF JUPITER
30 HOME : PRINT : PRINT : PRINT : PRINT
40 DIM Z$(4),B$(4),Y$(4),M$(2),DA$(2),LT$(5)
50 DIM TZ$(2),ND$(1),IN$(2)
60 PRINT TAB( 8)"AN ASTRONOMY PROGRAM"
70 PRINT
80 PRINT TAB( 6)"-----"
90 PRINT TAB( 6)"I GALILEAN SATELLITES I"
100 PRINT TAB( 6)"-----"
110 PRINT : PRINT
120 PRINT TAB( 7)"BY ERIC BURGESS F.R.A.S."
130 PRINT
140 PRINT TAB( 12)"VERSION APR.82"
150 PRINT
160 PRINT TAB( 8)"ALL RIGHTS RESERVED BY"
170 PRINT TAB( 8)"S & T SOFTWARE SERVICE"
180 PRINT : PRINT
190 FOR K = 3000 TO 1 STEP - 1: NEXT
200 HOME : PRINT : PRINT : PRINT : PRINT
210 PRINT TAB( 5)"THIS PROGRAM SHOWS THE GALILEAN"
220 PRINT "SATELLITES POSITIONED RELATIVE"
230 PRINT TAB( 5)"TO JUPITER AT THEIR APPROXIMATE"
240 PRINT TAB( 11)"RELATIVE POSITIONS"
250 PRINT : PRINT
260 PRINT "YOU CAN CHOOSE TO HAVE THEM SHOWN WITH"
270 PRINT "NORTH AT THE TOP, OR WITH SOUTH AT THE"
280 PRINT "TOP AS SEEN IN A TELESCOPE, AND YOU"
290 PRINT "CAN SELECT UP TO FIVE DISPLAYS OF THEIR"
300 PRINT "CONFIGURATIONS AT UP TO 24 HRS APART"
310 PRINT : PRINT : PRINT
320 INPUT "DO YOU WANT SOUTH AT TOP (Y/N)? ";A$
330 IF A$ = "Y" THEN FL = 1: GOTO 360
340 IF A$ < > "N" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 320
350 FL = 0
360 DEF FN RAD(X) = (X) * 3.14159 / 180
370 HOME : PRINT : PRINT : PRINT
380 REM ENTER DATE
390 LY = 0: PRINT "ENTER THE DATE"
400 PRINT : PRINT
410 INPUT "YEAR ";Y$:Y = VAL (Y$)
420 IF Y = 0 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 410
430 IF Y / 4 - INT (Y / 4) = 0 AND Y / 100 - INT (Y / 100) < > 0 THEN
LY = 1
440 PRINT
450 INPUT "MONTH ";M$
460 M = VAL (M$)
470 IF M = 0 OR M > 12 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 450
480 PRINT
490 INPUT "DAY ";D$:DA = VAL (D$)
500 IF DA = 0 OR DA > 31 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 490
510 IF LY = 1 AND M = 2 AND DA < 30 THEN GOTO 550
520 IF LY = 0 AND M = 2 AND DA < 29 THEN GOTO 550

```

JSATS (continued)

```

530 IF M < > 2 THEN GOTO 550
540 PRINT "INVALID RESPONSE": PRINT : GOTO 490
550 PRINT : INPUT "TIME ZONE ";TZ$:TZ = VAL (TZ$)
560 IF TZ < - 12 OR TZ > 12 THEN PRINT "INVALID RESPONSE": PRINT :
    GOTO 550
570 PRINT : INPUT "LOCAL TIME (DEC.HRS.) ";LT$:
580 LT = VAL (LT$)
590 IF LT < 0 OR LT > 24 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 570
600 PRINT
610 INPUT "HOW MANY DISPLAYS (1 TO 5)? ";ND$:ND = VAL (ND$)
620 IF ND < 1 OR ND > 5 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 610
630 PRINT
640 INPUT "WHAT IS INTERVAL (UP TO 24 HR)? ";IN
650 IF IN < 0 OR IN > 24 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 640
660 HOME : PRINT : PRINT : PRINT
670 PRINT "PROGRAM RUNNING...PLEASE WAIT"
680 L = 1
690 YP = Y:MP = M:DP = DA
700 IF L > 1 GOTO 720
710 UT = LT + TZ
720 REM CORRECT FOR DAY MONTH AND YR ENDS
730 IF UT > 24 THEN UT = UT - 24:DA = DA + 1
740 IF (LY = 1 AND M = 2 AND DA = 30) THEN M = 3:DA = 1: GOTO 790
750 IF (LY = 0 AND M = 2 AND DA = 29) THEN M = 3:DA = 1: GOTO 790
760 IF DA < 31 GOTO 790
770 IF (M = 4 OR M = 6 OR M = 9 OR M = 11) THEN M = M + 1:DA = 1: GOTO 790
780 IF DA > 31 THEN M = M + 1:DA = 1
790 IF M = 13 THEN M = 1:Y = Y + 1
800 IF FL = 1 THEN 820
810 YP = Y:MP = M:DP = DA
820 T = UT / 24
830 YC = Y:MC = M:DC = DA + T
840 IF MC > 2 THEN 880
850 YC = Y - 1
860 MC = M + 12
870 TD = INT (365.25 * YC) + INT ((MC + 1) * 30.6001) + DC
880 :
890 YZ = INT (YC / 100)
900 REM CALC DAYS SINCE 1900 EPOCH
910 I = TD - YZ + 2 + INT (YZ / 4) - 694025.5
920 REM DEG/DAY*NUMBR DAYS + POSTN AT EPOCH
930 A = I * 203.40586 + 84.55061
940 ZZ = A: GOSUB 2290
950 A = ZZ
960 B = I * 101.2916323 + 41.50155
970 ZZ = B: GOSUB 2290
980 B = ZZ
990 C = I * 50.23451687 + 109.97702
1000 ZZ = C: GOSUB 2290
1010 C = ZZ
1020 D = I * 21.48798021 + 176.35864
1030 ZZ = D: GOSUB 2290
1040 D = ZZ
1050 REM ORBITAL MOTION IN PERIOD
1060 REM EARTH AND JUPITER

```

JSATS (continued)

```

1070 P1 = I * .9856003 + 358.476
1080 ZZ = P1: GOSUB 2290
1090 P1 = ZZ
1100 I2 = I * .0830853 + 225.328
1110 ZZ = I2: GOSUB 2290: I2 = ZZ
1120 P2 = I * .9025179 + 221.647
1130 ZZ = P2: GOSUB 2290
1140 P2 = ZZ
1150 P2 = P2 + ( SIN ( FN RAD(2 * P1)) / 50) + ( SIN ( FN RAD(P1)) / .521)
1160 P3 = ( SIN ( FN RAD(2 * I2)) * .1673) + ( SIN ( FN RAD(I2)) * 5.5372)
1170 P2 = P2 - P3
1180 P1 = SQR (28.07 - ( COS ( FN RAD(P2)) * 10.406))
1190 J = ( SIN ( FN RAD(P2)) / P1)
1200 I3 = 57.2958 * ( ATN (( SIN ( FN RAD(J))) /
      SQR (1 - ( SIN ( FN RAD(J))) ^ 2)))
1210 I3 = I3 * 57.2958
1220 P1 = P1 / 173
1230 REM CALC RADIAL DISTANCE FROM JUPITER
1240 S1 = 5.906 * SIN ( FN RAD(A + I3 - P3 - (P1 * 203.405863)))
1250 S2 = 9.397 * SIN ( FN RAD(B + I3 - P3 - (P1 * 101.2916323)))
1260 S3 = 14.989 * SIN ( FN RAD(C + I3 - P3 - (P1 * 50.23451687)))
1270 S4 = 26.364 * SIN ( FN RAD(D + I3 - P3 - (P1 * 21.48798021)))
1280 IF FL < > 1 THEN GOTO 1370
1290 IF S1 < 0 THEN S1 = 0 + ABS (S1): GOTO 1310
1300 IF S1 > 0 THEN S1 = 0 - ABS (S1)
1310 IF S2 < 0 THEN S2 = 0 + ABS (S2): GOTO 1330
1320 IF S2 > 0 THEN S2 = 0 - ABS (S2)
1330 IF S3 < 0 THEN S3 = 0 + ABS (S3): GOTO 1350
1340 IF S3 > 0 THEN S3 = 0 - ABS (S3)
1350 IF S4 < 0 THEN S4 = 0 + ABS (S4): GOTO 1370
1360 IF S4 > 0 THEN S4 = 0 - ABS (S4)
1370 IF L > 1 THEN GOTO 1580
1380 HOME : PRINT : PRINT : PRINT
1390 PRINT "DISTANCE IN TERMS OF JUPITER RADII"
1400 PRINT "WHICH IS 71,100 KM OR 44,180 MI"
1410 PRINT
1420 PRINT "FOR DATE ";YP;" ";MP;" ";DP;" AT ";LT;" HRS TIME ZONE ";TZ
1430 PRINT "FOR DATE ";Y;" ";M;" ";DA;" AT ";UT;" HRS UT"
1440 EM = M
1450 PRINT : PRINT
1460 PRINT TAB(5)"IO (I)..... ";S1
1470 PRINT TAB(5)"EUROPA (E).. ";S2
1480 PRINT TAB(5)"GANYMEDE (G) ";S3
1490 PRINT TAB(5)"CALLISTO (C) ";S4
1500 PRINT : PRINT
1510 PRINT "MINUS IS TO LEFT OF JUPITER"
1520 PRINT " PLUS IS TO THE RIGHT": PRINT
1530 IF FL = 1 THEN PRINT TAB(4)"WITH S AT TOP ": GOTO 1550
1540 PRINT TAB(4)"WITH N AT TOP"
1550 PRINT : PRINT
1560 INPUT "FOR GRAPHIC DISPLAY PRESS RETURN";A$
1570 HOME
1580 GOSUB 2100
1590 REM REGENERATE LMT
1600 LT = UT - TZ

```

JSATS (continued)

```

1610 IF LT > 0 THEN GOTO 1690
1620 DP = DA - 1:LT = LT + 24: IF DP > 0 THEN 1690
1630 IF DP < 1 THEN MP = EM - 1
1640 IF (LY = 1 AND MP = 2) THEN DP = 29: GOTO 1690
1650 IF (LY = 0 AND MP = 2) THEN DP = 28: GOTO 1690
1660 IF (MP = 4 OR MP = 6 OR MP = 9 OR MP = 11) THEN DP = 30: GOTO 1690
1670 DP = 31
1680 PRINT
1690 IF MP = 0 THEN MP = 12: YP = Y - 1
1700 IF L > 1 THEN GOTO 1760
1710 IF FL = 1 THEN PRINT TAB( 20); "S": GOTO 1730
1720 PRINT TAB( 20); "N"
1730 PRINT "JUPITER..J"; TAB( 20); "-"; TAB( 30); "10 ..... I"
1740 PRINT "EUROPA...E"; TAB( 20); "!"; TAB( 30); "GANYMEDE G"
1750 PRINT "CALLISTO C"; TAB( 20); "!"
1760 PRINT "-----"
1770 PRINT YP; " "; MP; " "; DP; " AT "; LT; " HR ZONE "; TZ
1780 PRINT " . . . . . UT "; UT; " HRS "; EM; " "; DA
1790 PRINT
1800 M1 = 20 + INT (.7 * VAL (B$(0)))
1810 PRINT TAB( M1); RIGHT$( B$(0),1);
1820 M2 = 20 + INT (.7 * VAL (B$(1)))
1830 PRINT TAB( M2); RIGHT$( B$(1),1);
1840 M3 = 20 + INT (.7 * VAL (B$(2)))
1850 PRINT TAB( M3); RIGHT$( B$(2),1);
1860 M4 = 20 + INT (.7 * VAL (B$(3)))
1870 PRINT TAB( M4); RIGHT$( B$(3),1);
1880 M5 = 20 + INT (.7 * VAL (B$(4)))
1890 PRINT TAB( M5); RIGHT$( B$(4),1)
1900 IF L = ND THEN GOTO 2020
1910 REM INCREMENT FOR INTERVAL
1920 REM AND ADJUST MONTH ENDS
1930 UT = UT + IN
1940 IF UT > 24 THEN UT = UT - 24: DA = DA + 1
1950 IF (LY = 1 AND M = 2 AND DA = 30) THEN M = 3: DA = 1: GOTO 2000
1960 IF (LY = 0 AND M = 2 AND DA = 29) THEN M = 3: DA = 1: GOTO 2000
1970 IF DA < 31 GOTO 2000
1980 IF (M = 4 OR M = 6 OR M = 9 OR M = 11) THEN M = M + 1: DA = 1:
GOTO 2000
1990 IF DA > 31 THEN M = M + 1: DA = 1
2000 IF M = 13 THEN M = 1: Y = Y + 1
2010 L = L + 1: GOTO 690
2020 PRINT : PRINT
2030 INPUT "DO YOU WANT ANOTHER DATE Y/N? "; A$
2040 IF A$ = "N" THEN GOTO 2080
2050 IF A$ < > "Y" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 2030
2060 HOME
2070 FL = 0: GOTO 320
2080 HOME
2090 END
2100 REM SUB TO DISPLAY SATELLITES
2110 Z$(0) = STR$( S1) + "I": Z$(1) = STR$( S2) + "E"
2120 Z$(2) = STR$( S3) + "G": Z$(3) = STR$( S4) + "C"
2130 Z$(4) = STR$( 0) + "J"
2140 FOR I = 0 TO 4

```

JSATS (continued)

```
2150 B$(I) = "****"
2160 NEXT I
2170 K = 0
2180 FOR I = 0 TO 4
2190 IF Z$(I) = "****" GOTO 2270
2200 FOR J = I TO 4
2210 IF Z$(J) = "****" GOTO 2230
2220 IF VAL (Z$(J)) < VAL (Z$(I)) THEN I = J: GOTO 2230
2230 NEXT J
2240 B$(K) = Z$(I):Z$(I) = "****"
2250 K = K + 1
2260 I = - 1
2270 NEXT I
2280 RETURN
2290 REM SUB FOR REDUCING ANGLES
2300 ZZ = (ZZ / 360 - INT (ZZ / 360)) * 360
2310 IF ZZ < 0 THEN ZZ = ZZ + 360
2320 RETURN
```

PART 4



GENERAL AND TUTORIAL

THERE IS A BASIC HUMAN fascination in the night sky, which is especially captivating when our view is unhindered by the glaring lights of the cities. The stars beckon—bright diamonds sparkling in the blackness, some glaring to our dark-adjusted night vision, others elusively winking in and out at the limit of visibility. At first the stars and planets seem distant and aloof, but once you learn to recognize them, they represent both a comforting presence and a new horizon.

This group of programs helps you find and recognize constellations and bright stars, know when there are meteor showers, and have data about the solar system at your fingertips. One of the programs gives helpful information for photographing planets, and another provides useful astronomical conversions.

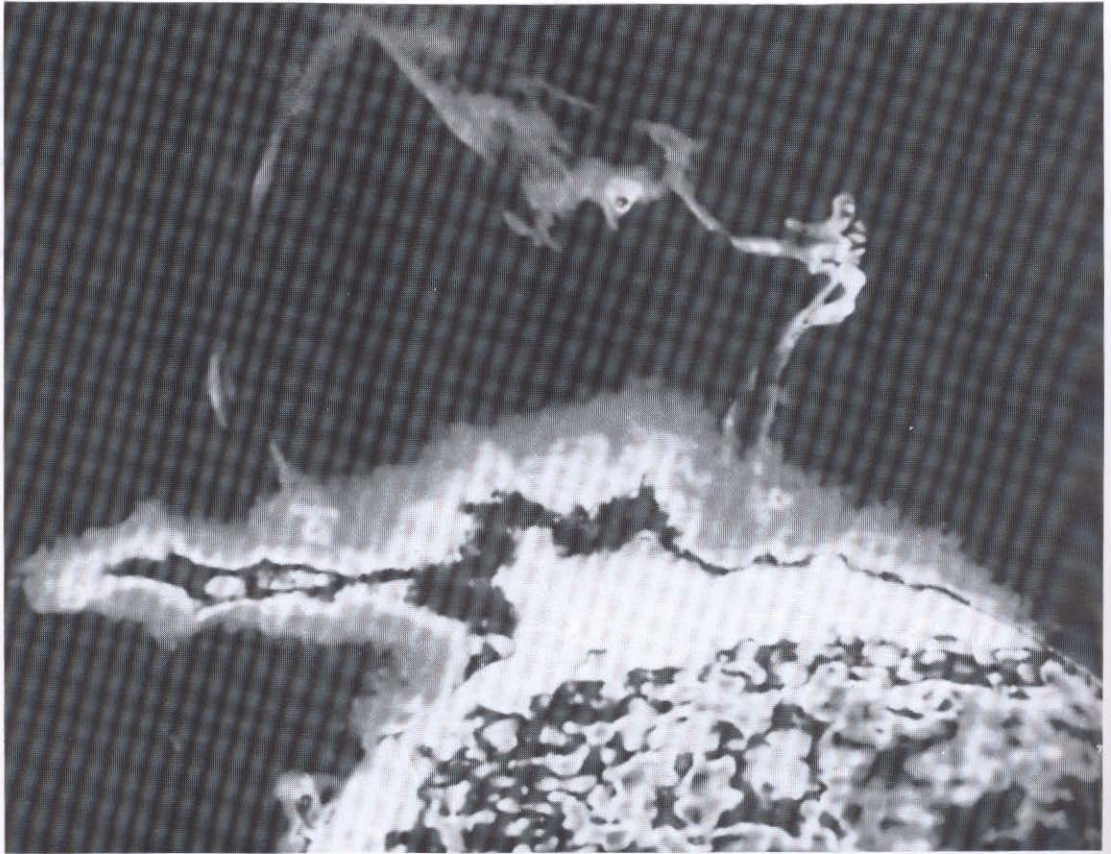


Photo Credit: NASA/Johnson

The Sun is our nearest star. The central body of the solar system, it is an enormous nuclear power station converting the nuclear energy of fusion into life-giving heat and light for our planet. This photograph,

taken from the telescope carried by the Skylab spacecraft while it was still in orbit, shows a solar eruption rising over half a million miles from the solar surface.

Program 19: ACONV

Useful Astronomical Conversions

This program is a straightforward conversion routine useful when astronomical measurements need to be expressed in other units. It includes light years, astronomical units, parsecs, telescope resolving power, and metric conversions. It allows conversions either way. If you desire other conversions, these can be added easily, following the pattern shown.

The listing of the ACONV program follows.

```

ASTRONOMY CONVERSION PROGRAM

YOU CAN HAVE . . . .

KM TO MI . . . . (1) OR MI TO KM . . . . (2)
LY TO MI . . . . (3) OR MI TO LY . . . . (4)
PARS. TO LY . . (5) OR LY TO PARS. . . (6)
'C TO 'F . . . . (7) OR 'F TO 'C . . . . (8)
A.U. TO MI . . . (9) OR MI TO A.U. . . (10)
A.U. TO KM . . . (9) OR KM TO A.U. . . (10)
DEG. MIN. SEC. TO DECIMAL DEG. . . (11)
DECIMAL DEG. TO DEG. MIN. SEC. . . (12)
HRS. MIN. SEC. TO DECIMAL HRS. . . (13)
DECIMAL HRS. TO HRS. MIN. SEC. . . (14)
RES. PWR. TO INS. OF APERTURE . . (15)
INS. OF APERTURE TO RES. PWR. . . (16)

TYPE 999 TO END OR TO CHANGE
TO ANOTHER CONVERSION

SELECT CONVERSION REQUIRED 1-16 █

```

The menu of astronomical conversions available on the ACONV program

Figure 19.1

ACONV

```

10 HOME : PRINT : PRINT : PRINT : PRINT : PRINT
20 PRINT TAB( 7)"-----"
30 PRINT TAB( 7)"I  C  O  N  V  E  R  S  I  O  N  S  I"
40 PRINT TAB( 7)"-----"
50 PRINT : PRINT
60 PRINT TAB( 11)"AN ASTRONOMY PROGRAM": PRINT : PRINT
70 PRINT TAB( 10)"BY ERIC BURGESS F.R.A.S.": PRINT : PRINT
80 PRINT TAB( 11)"ALL RIGHTS RESERVED BY"
90 PRINT TAB( 11)"S & T SOFTWARE SERVICE": PRINT : PRINT
100 FOR K = 2000 TO 1 STEP - 1: NEXT K
110 HOME : PRINT
120 PRINT : PRINT TAB( 10)"ASTRONOMY CONVERSION PROGRAM"
130 PRINT : PRINT "YOU CAN HAVE....": PRINT
140 PRINT TAB( 5);"KM TO MI....(1) OR MI TO KM....(2)"
150 PRINT TAB( 5);"LY TO MI....(3) OR MI TO LY....(4)"
160 PRINT TAB( 5);"PARS. TO LY.(5) OR LY TO PARSE.(6)"
170 PRINT TAB( 5);"C TO 'F....(7) OR 'F TO 'C....(8)"
180 PRINT TAB( 5);"A.U. TO MI..(9) OR MI TO A.U. (10)"
190 PRINT TAB( 5);"A.U. TO KM..(9) OR KM TO A.U. (10)"
200 PRINT TAB( 5);"DEG.MIN.SEC. TO DECIMAL DEG.. (11)"
210 PRINT TAB( 5)"DECIMAL DEG. TO DEG.MIN.SEC.. (12)"
220 PRINT TAB( 5);"HRS.MIN.SEC. TO DECIMAL HRS.. (13)"
230 PRINT TAB( 5);"DECIMAL HRS. TO HRS.MIN.SEC..(14)"
240 PRINT TAB( 5);"RES. PWR. TO INS. OF APERTURE (15)"
250 PRINT TAB( 5);"INS. OF APERTURE TO RES. PWR. (16)"
260 PRINT : PRINT "TYPE 999 TO END OR TO CHANGE"
270 PRINT "TO ANOTHER CONVERSION"
280 PRINT : INPUT "SELECT CONVERSION REQUIRED 1-16 ";D
290 IF D = 999 THEN GOTO 1680
300 ON D GOTO 310,420,510,580,660,740,820,890,970,1060,1220,1290,1380,1450,
    1540,1610
310 HOME
320 PRINT
330 PRINT "KM TO MI CONVERSION"
340 PRINT "TO STOP ENTER 999"
350 PRINT : INPUT "KM ";X
360 IF X = 999 THEN GOTO 110
370 Y = X * ( 1 / 1.60934)
380 PRINT "MI = ";Y
390 PRINT : GOTO 350
400 GOTO 130
410 IF X = 999 THEN GOTO 110
420 HOME : PRINT
430 PRINT "MI TO KM CONVERSION"
440 PRINT "TO STOP ENTER 999"
450 PRINT : INPUT "MI ";X
460 IF X = 999 THEN GOTO 110
470 Y = X * 1.609344
480 PRINT "KM = ";Y
490 GOTO 450
500 GOTO 10
510 HOME : PRINT
520 PRINT "LY TO TRILLION MI CONVERSION"

```

ACONV (continued)

```
530 PRINT : INPUT "LY ";X
540 IF X = 999 THEN GOTO 110
550 Y = X * 5.88
560 PRINT "TRILLION MI = "; LEFT$ ( STR$ (Y),5)
570 GOTO 530
580 HOME : PRINT
590 PRINT "TRILLION MI TO LY CONVERSION"
600 PRINT "TO STOP ENTER 999"
610 PRINT : INPUT "TRILLION MI ";X
620 IF X = 999 THEN GOTO 110
630 Y = X * 1 / 5.88
640 PRINT "LY = "; LEFT$ ( STR$ (Y),5)
650 PRINT : GOTO 610
660 HOME : PRINT
670 PRINT "PARSECS TO LY CONVERSION"
680 PRINT "TO STOP ENTER 999"
690 PRINT : INPUT "PARSECS ";X
700 IF X = 999 THEN GOTO 110
710 Y = X * 3.26
720 PRINT "LY = "; LEFT$ ( STR$ (Y),5)
730 PRINT : GOTO 690
740 HOME : PRINT
750 PRINT "LY TO PARSECS CONVERSION"
760 PRINT "TO STOP ENTER 999"
770 PRINT : INPUT "LY ";X
780 IF X = 999 THEN GOTO 110
790 Y = X * 1 / 3.26
800 PRINT "PARSECS = "; LEFT$ ( STR$ (Y),5)
810 GOTO 770
820 HOME : PRINT : PRINT "'C TO 'F CONVERSION"
830 PRINT "TO STOP ENTER 999"
840 PRINT : INPUT "'C ";X
850 IF X = 999 GOTO 110
860 Y = X * 1.8 + 32
870 PRINT "'F = "; LEFT$ ( STR$ (Y),5)
880 GOTO 840
890 HOME : PRINT : PRINT "'F TO 'C CONVERSION"
900 PRINT "TO STOP ENTER 999"
910 PRINT : INPUT "'F ";X
920 IF X = 999 GOTO 110
930 Y = (X - 32) * .555555556
940 PRINT "'C = "; LEFT$ ( STR$ (Y),5);
950 PRINT " = "; LEFT$ ( STR$ (Y + 273),5);"K"
960 GOTO 910
970 HOME : PRINT : PRINT "A.U. TO MILES/KILOMETERS CONVERSION"
980 PRINT "TO STOP ENTER 999"
990 PRINT : INPUT "A.U.";X
1000 IF X = 999 GOTO 110
1010 Y = X * 92.95721: REM MILES
1020 Z = X * 149.598: REM KILOMETERS
1030 PRINT "MILES (MILLIONS) = "; LEFT$ ( STR$ (Y),5)
1040 PRINT "KILOMETERS (MILLIONS) = "; LEFT$ ( STR$ (Z),5)
1050 GOTO 990
1060 HOME : PRINT : PRINT "MILES/KMS TO A.U. CONVERSION"
1070 PRINT "TO STOP TYPE 999"
```

ACONV (continued)

```
1080 PRINT : INPUT "TYPE KMS OR MI ";Q$
1090 IF Q$ = "KMS" GOTO 1120
1100 IF Q$ = "MI" GOTO 1170
1110 PRINT "PLEASE TYPE KMS OR MI ": GOTO 1080
1120 PRINT : INPUT "KILOMETERS (MILLIONS) ";X
1130 IF X = 999 GOTO 110
1140 Y = X * (1 / 149.598)
1150 PRINT "A.U. = "; LEFT$ ( STR$ (Y),5)
1160 GOTO 1120
1170 PRINT : INPUT "MILES (MILLIONS) ";X
1180 IF X = 999 GOTO 110
1190 Y = X * (1 / 92.15721)
1200 PRINT "A.U. = "; LEFT$ ( STR$ (Y),5)
1210 GOTO 1170
1220 HOME : PRINT : PRINT "DEG.MIN.SEC. TO DECIMAL DEG."
1230 PRINT "TO STOP ENTER 999,0,0"
1240 PRINT : INPUT "DEG,MIN,SEC ";X,X1,X2
1250 IF X = 999 GOTO 110
1260 Y = X + X1 / 60 + X2 / 3600
1270 PRINT "DECIMAL DEG.= "; LEFT$ ( STR$ (Y),5)
1280 GOTO 1240
1290 HOME : PRINT : PRINT "DECIMAL DEGREES TO DEG.MIN.SEC."
1300 PRINT "TO STOP GO TO 999"
1310 PRINT : INPUT "DECIMAL DEGREES";X
1320 IF X = 999 GOTO 110
1330 Y = INT (X)
1340 Y1 = 60 * (X - INT (X))
1350 Y2 = 60 * (Y1 - INT (Y1))
1360 PRINT "DEG.MIN.SEC.="Y; INT (Y1);Y2
1370 GOTO 1310
1380 HOME : PRINT "HRS.MIN.SEC. TO DECIMAL HRS "
1390 PRINT "TO STOP ENTER 999,0,0"
1400 PRINT : INPUT "HRS,MIN,SEC ";X,X1,X2
1410 IF X = 999 GOTO 110
1420 Y = X + X1 / 60 + X2 / 3600
1430 PRINT "DECIMAL HRS - ";Y
1440 GOTO 1400
1450 HOME : PRINT "DECIMAL HRS TO HRS.MIN.SEC. "
1460 PRINT "TO STOP ENTER 999"
1470 PRINT : INPUT "DEC.HRS. ";X
1480 IF X = 999 GOTO 110
1490 Y = INT (X)
1500 Y1 = 60 * (X - INT (X))
1510 Y2 = 60 * (Y1 - INT (Y1))
1520 PRINT "HRS.MIN.SEC.="Y;" "; INT (Y1);" "; INT (Y2)
1530 GOTO 1470
1540 HOME : PRINT "RESOLVING POWER TO APERTURE"
1550 PRINT "TO STOP ENTER 999"
1560 PRINT : INPUT "RESOLVING POWER SEC. OF ARC ";X
1570 IF X = 999 GOTO 110
1580 Y = 4.56 / X
1590 PRINT "APERTURE IN INCHES MUST BE ";Y
1600 GOTO 1560
1610 HOME : PRINT "APERTURE TO RESOLVING POWER"
1620 PRINT "TO STOP ENTER 999"
```

ACONV (continued)

```
1630 PRINT : INPUT "APERTURE IN INCHES ";X
1640 IF X = 999 GOTO 110
1650 Y = 4.56 / X
1660 PRINT "RESOLVING POWER IN ARC SECS. IS ";Y
1670 GOTO 1630
1680 HOME
1690 END
```

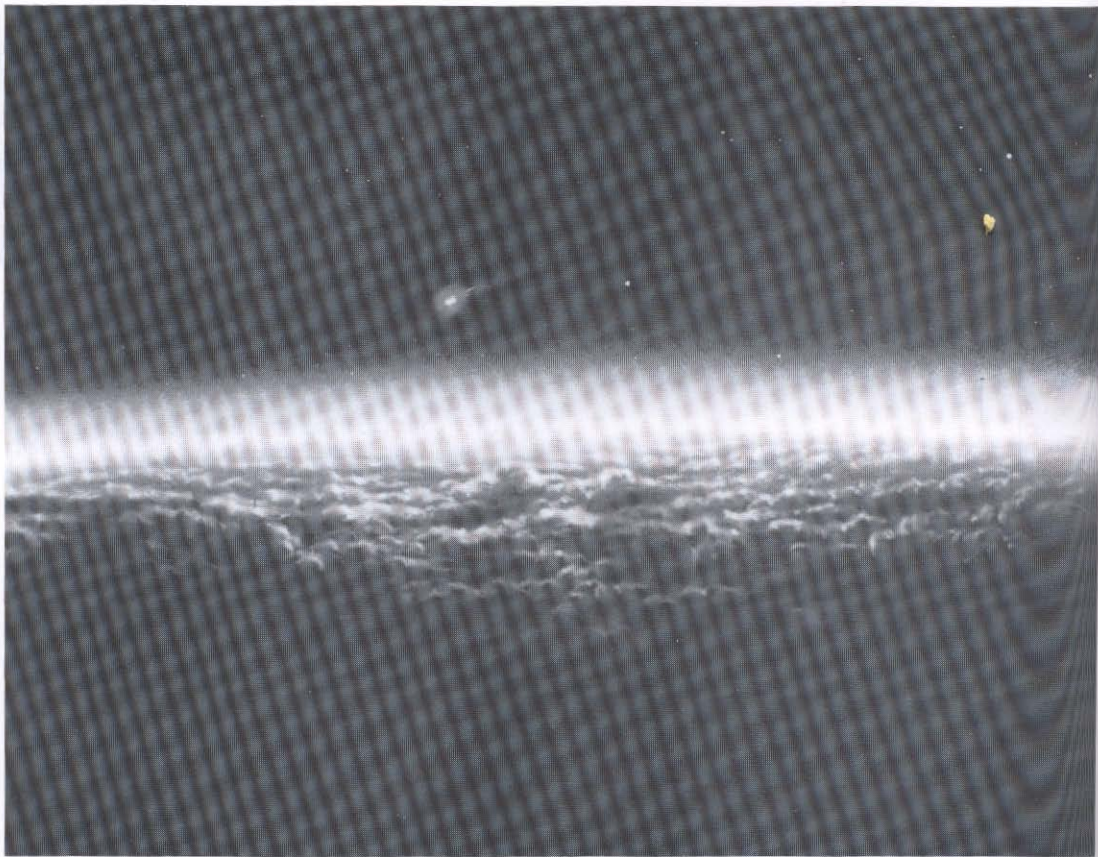


Photo Credit: NASA/Ames

Earth and the other worlds of our solar system have been bombarded for billions of years by projectiles from space, believed to be the debris from the formation of the system. Today some of these projectiles still enter Earth's atmosphere and produce glowing

trails of "shooting stars" as they burn up in the upper atmosphere. Spacecraft such as Pioneer Venus have been sent into the atmospheres of other worlds, and they also glow brightly like meteors as they plunge into those atmospheres.

Program 20: SSTAR

Dates and Radiants of Annual Meteor Showers_____

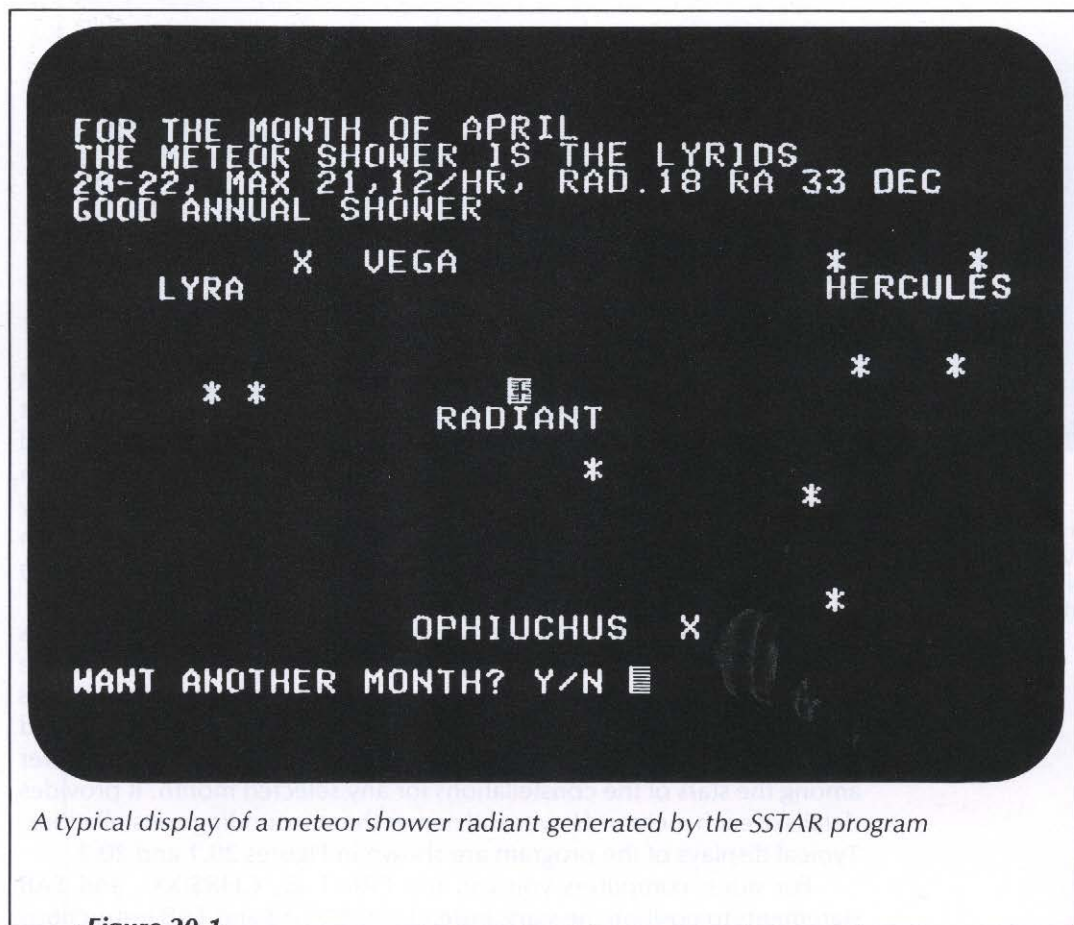
Meteors, often referred to as "shooting stars" or "falling stars," result from small particles of matter, called meteorites, that encounter Earth at high speed and burn up in its atmosphere. Many meteors are associated with the orbits of comets; an annual meteor shower results when Earth crosses the cometary orbit. Meteors are usually more numerous in the early morning hours because at that time the observer is on the face of Earth moving into the meteors, that is, the leading hemisphere of the planet in its orbital motion around the Sun.

The program asks you to select any month and then provides the details of any annual meteor shower expected during that month. If you use PHASE with this program you will be able to find out whether observations of the meteor shower will be affected by a bright Moon (between full and last quarter). The program graphically displays the radiant for the shower among the stars of the constellations for any selected month. It provides details of each meteor shower and names the surrounding constellations. Typical displays of the program are shown in Figures 20.1 and 20.2.

For other computers you can use PRINT @, CHR\$(XX), and TAB statements to position the stars, instead of the VTAB and TAB instructions

used for the Apple. For a more dynamic display, POKE statements can be used to randomly display meteors from the radiant. POKE statements allow ASCII characters to be displayed on the screen at a specified screen coordinate without scrolling the screen display. A routine to do this for the Exidy Sorcerer's 64 by 29 character display is shown in the Appendix and can be adapted to other computers. For the Apple, POKE instructions for screen visuals are more complex (see PLNTF, Program 17). To use high resolution graphics to plot stars and names in a long routine like this, the program must contain a routine to jump over the area of memory reserved for pages 1 and 2 of the high resolution graphics (see your Apple manual).

The listing of the SSTAR program follows.



A typical display of a meteor shower radiant generated by the SSTAR program

Figure 20.1

```
IN JUNE THERE ARE TWO SHOWERS

      THE LYRIDS
JUNE 10-21, MAX 15, BLUISH METEORS
      AVERAGING 8 PER HOUR

      AND

      THE OPHIUCIDS
JUNE 17-26, MAX 19
      AVERAGING 6 PER HOUR

PLEASE SELECT LYRIDS (1)
      OR OPHIUCIDS (2)

?E
```

If there are two meteor showers in a requested month, the program develops the display shown here for you to select the shower you wish to be displayed.

Figure 20.2

SSTAR

```

10 HOME
20 PRINT : PRINT : PRINT
30 PRINT TAB( 6 )"-----"
40 PRINT TAB( 6 )"I      M E T E O R S      I"
50 PRINT TAB( 6 )"-----"
60 PRINT : PRINT : PRINT
70 PRINT TAB( 10 )"AN ASTRONOMY PROGRAM"
80 PRINT : PRINT TAB( 9 )"BY ERIC BURGESS F.R.A.S."
90 PRINT : PRINT : PRINT
100 PRINT TAB( 9 )"ALL RIGHTS RESERVED BY"
110 PRINT TAB( 9 )"S & T SOFTWARE SERVICE"
120 PRINT : PRINT
130 PRINT TAB( 3 )"THIS PROGRAM PROVIDES PARTICULARS OF"
140 PRINT TAB( 3 )"ANNUAL METEOR SHOWERS FOR ANY MONTH"
150 FOR K = 1 TO 3000: NEXT K
160 HOME : PRINT : PRINT
170 INPUT "SELECT MONTH (1 THRU 12) ";M
180 PRINT
190 IF M < 1 OR M > 12 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 170
200 HOME : PRINT : PRINT
210 M2 = M
220 IF M2 = 1 THEN M$ = "JANUARY": GOTO 340
230 IF M2 = 2 THEN M$ = "FEBRUARY": GOTO 470
240 IF M2 = 3 THEN M$ = "MARCH": GOTO 520
250 IF M2 = 4 THEN M$ = "APRIL": GOTO 570
260 IF M2 = 5 THEN M$ = "MAY": GOTO 750
270 IF M2 = 6 THEN M$ = "JUNE": GOTO 900
280 IF M2 = 7 THEN M$ = "JULY": GOTO 1140
290 IF M2 = 8 THEN M$ = "AUGUST": GOTO 1340
300 IF M2 = 9 THEN M$ = "SEPTEMBER": GOTO 1300
310 IF M2 = 10 THEN M$ = "OCTOBER": GOTO 1490
320 IF M2 = 11 THEN M$ = "NOVEMBER": GOTO 1680
330 IF M2 = 12 THEN M$ = "DECEMBER": GOTO 2280
340 PRINT "FOR THE MONTH OF ";M$
350 PRINT "THE METEOR SHOWER IS QUADRANTIDS"
360 PRINT "4 JAN MAX 24 HRS, RAD 15.5 RA 50 DEC"
370 PRINT "GOOD ANNUAL SHOWER 40 PER HOUR"
380 PRINT : GOSUB 3330: PRINT : PRINT
390 PRINT TAB( 19 )"*"
400 PRINT TAB( 26 )"X": PRINT
410 PRINT TAB( 15 )"*" ; TAB( 28 )"BOOTES"
420 PRINT TAB( 30 )"."
430 PRINT TAB( 13 )"." ; TAB( 29 )"." : PRINT TAB( 2 )"CORONA"
440 PRINT TAB( 12 )"*" ; TAB( 24 )"X": PRINT
450 PRINT TAB( 30 )"X ARCTURUS"
460 GOTO 3270
470 PRINT "DURING THE MONTH OF ";M$
480 PRINT
490 PRINT "THERE IS NO MAJOR ANNUAL METEOR SHOWER"
500 PRINT : PRINT : PRINT
510 GOTO 3280
520 PRINT "DURING THE MONTH OF ";M$
530 PRINT
540 PRINT "THERE IS NO MAJOR ANNUAL METEOR SHOWER"

```

SSTAR (continued)

```
550 PRINT : PRINT : PRINT
560 GOTO 3280
570 PRINT "FOR THE MONTH OF ";M$
580 PRINT "THE METEOR SHOWER IS THE LYRIDS"
590 PRINT "20-22, MAX 21,12/HR, RAD.18 RA 33 DEC"
600 PRINT "GOOD ANNUAL SHOWER": PRINT
610 PRINT TAB( 11)"X VEGA"; TAB( 33)"*"; TAB( 39)"*"
620 PRINT TAB( 5)"LYRA"; TAB( 33)"HERCULES"
630 PRINT
640 PRINT TAB( 34)"*"; TAB( 38)"*"
650 PRINT TAB( 7)"* *";: GOSUB 3330
660 PRINT : PRINT
670 PRINT TAB( 23)"*"
680 PRINT TAB( 32)"*"
690 PRINT
700 PRINT : PRINT
710 PRINT TAB( 33)"*"
720 PRINT TAB( 16)"OPHIUCHUS"; TAB( 27)"X"
730 PRINT
740 GOTO 3270
750 PRINT "FOR THE MONTH OF ";M$
760 PRINT "THE METEOR SHOWER IS ETA AQUARIDS"
770 PRINT "4-13,MAX 6, RAD 22.5 RA, 0 DEC"
780 PRINT "WEAK DISPLAY"
790 PRINT TAB( 15)"."; TAB( 30)"*"; TAB( 36)".."
800 PRINT TAB( 24)"."; TAB( 35)".": PRINT : PRINT
810 PRINT TAB( 17)"*"; TAB( 24)"*"
820 PRINT TAB( 15)"*";: GOSUB 3330
830 PRINT TAB( 30)"AQUARIUS": PRINT
840 PRINT TAB( 33)"X": PRINT : PRINT
850 PRINT : PRINT
860 PRINT TAB( 12)"."
870 PRINT TAB( 11)"."; TAB( 29)"*"; TAB( 31)"."; TAB( 35)"."; TAB( 39)"."
880 PRINT TAB( 19)"CAPRICORNUS"
890 GOTO 3270
900 PRINT : PRINT
910 PRINT "IN JUNE THERE ARE TWO SHOWERS"
920 PRINT : PRINT
930 PRINT TAB( 5)"THE LYRIDS"
940 PRINT "JUNE 10-21, MAX 15, BLUISH METEORS"
950 PRINT TAB( 5)"AVERAGING 8 PER HOUR"
960 PRINT : PRINT : PRINT TAB( 8)"AND"
970 PRINT : PRINT TAB( 5)"THE OPHIUCIDS"
980 PRINT : PRINT "JUNE 17-26, MAX 19"
990 PRINT TAB( 5)"AVERAGING 6 PER HOUR"
1000 PRINT : PRINT "PLEASE SELECT LYRIDS (1)"
1010 PRINT "          OR OPHIUCIDS (2)"
1020 PRINT : INPUT A$:JS = VAL (A$)
1030 IF JS < 1 OR JS > 2 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 1000
1040 IF JS = 1 THEN GOSUB 2820: GOTO 1070
1050 IF JS = 2 THEN GOSUB 3050
1060 IF A$ = "N" THEN GOTO 3280
1070 FOR J = 1 TO 3000: NEXT J
1080 INPUT "DO YOU WANT TO SEE OTHER SHOWER Y/N ";A$
1090 HOME
1100 IF A$ = "Y" AND JS = 1 THEN GOSUB 3050: GOTO 1130
1110 IF A$ = "Y" AND JS = 2 THEN GOSUB 2820
```

SSTAR (continued)

```

1120 IF A$ = "N" THEN GOTO 3280
1130 GOTO 3270
1140 PRINT "FOR THE MONTH OF ";M$
1150 PRINT "THE METEOR SHOWER IS DELTA AQUARIDS"
1160 PRINT "7/25-8/4,MAX 28,RAD 22.8 RA -16 DEC"
1170 PRINT "DIFFUSE SHOWER"
1180 PRINT TAB( 17)". "
1190 PRINT : PRINT
1200 PRINT TAB( 32)"AQUARIUS"
1210 PRINT TAB( 28)". "
1220 PRINT TAB( 11)"DELTA *";: GOSUB 3330
1230 PRINT TAB( 33)"*"; TAB( 37)". "
1240 PRINT
1250 PRINT TAB( 39)". ": PRINT
1260 PRINT : PRINT TAB( 19)"X": PRINT
1270 PRINT TAB( 11)"FOMALHAUT"
1280 PRINT TAB( 31)"*": PRINT : PRINT : PRINT
1290 GOTO 3270
1300 PRINT "DURING THE MONTH OF ";M$
1310 PRINT
1320 PRINT "THERE IS NO MAJOR METEOR SHOWER"
1330 PRINT : PRINT : PRINT : GOTO 3280
1340 PRINT "FOR THE MONTH OF ";M$
1350 PRINT "THE METEOR SHOWER IS THE PERSEIDS"
1360 PRINT "4-16,MAX 12, RAD 3 RA 58 DEC"
1370 PRINT "A SPECTACULAR SHOWER, 50 PER HR"
1380 PRINT TAB( 6)". "; TAB( 39)"X"
1390 PRINT : PRINT TAB( 29)"CASSIOPEIA"
1400 PRINT : GOSUB 3330
1410 PRINT TAB( 23)". "
1420 PRINT TAB( 10)"PERSEUS";
1430 PRINT TAB( 20)"*": PRINT TAB( 21)". "
1440 PRINT TAB( 12)"*": PRINT : PRINT
1450 PRINT TAB( 39)"X": PRINT TAB( 8)"X"; TAB( 20)"X"
1460 PRINT TAB( 20)". "; TAB( 30)"ANDROMEDA"
1470 PRINT TAB( 37)"*"
1480 GOTO 3270
1490 PRINT "FOR THE MONTH OF ";M$
1500 PRINT "THE METEOR SHOWER IS THE ORIONIDS"
1510 PRINT "16-26,MAX 21, RAD. 6.4 RA, 15 DEC"
1520 PRINT "SLOW PERSISTENT TRAIL METEORS, 30/HR"
1530 PRINT TAB( 6)". "; TAB( 23)"*"; TAB( 26)". "
1540 PRINT TAB( 11)". "; TAB( 22)". "; TAB( 34)"*"
1550 PRINT TAB( 10)"GEMINI"
1560 PRINT TAB( 8)". "; TAB( 18)"*"
1570 GOSUB 3330
1580 PRINT : PRINT TAB( 16)". "
1590 PRINT : PRINT TAB( 8)"*"; TAB( 32)". "
1600 PRINT TAB( 28)"X"; TAB( 36)"X"
1610 PRINT TAB( 4)"X"
1620 PRINT "PROCYON"; TAB( 35)"ORION"
1630 PRINT : PRINT TAB( 35)"X"
1640 PRINT TAB( 33)"X": PRINT TAB( 31)"X"; TAB( 38)". "
1650 PRINT TAB( 34)":": PRINT TAB( 2)". "; TAB( 38)"X"
1660 PRINT TAB( 30)"*"
1670 GOTO 3270

```

SSTAR (continued)

```
1680 PRINT : PRINT
1690 PRINT "IN ";M$;" THERE ARE TWO SHOWERS"
1700 PRINT : PRINT
1710 PRINT TAB( 5)"THE TAURIDS"
1720 PRINT : PRINT "10/20-11/30,MAX 8/11,RAD 3.7 RA,14 DEC"
1730 PRINT "SLOW 12/HR, SCATTERED FIREBALLS"
1740 PRINT : PRINT TAB( 8)"AND"
1750 PRINT : PRINT TAB( 5)"THE LEONIDS"
1760 PRINT
1770 PRINT "15-19,MAX 17, RAD 10 RA, 22 DEC"
1780 PRINT "SWIFT METEORS, 10 PER HOUR"
1790 PRINT : PRINT
1800 PRINT "PLEASE SELECT TAURIDS (1)"
1810 PRINT "          OR LEONIDS (2)"
1820 PRINT : INPUT A$:JS = VAL (A$)
1830 IF JS < 1 OR JS > 2 THEN PRINT "INVALID RESPONSE": PRINT : GOTO 1790
1840 IF JS = 1 THEN GOSUB 1930: GOTO 1860
1850 IF JS = 2 THEN GOSUB 2120
1860 FOR J = 1 TO 3000: NEXT J
1870 INPUT "WANT TO SEE OTHER SHOWER Y/N ";A$
1880 HOME
1890 IF A$ = "Y" AND JS = 1 THEN GOSUB 2120: GOTO 1920
1900 IF A$ = "Y" AND JS = 2 THEN GOSUB 1930
1910 IF A$ = "N" THEN GOTO 3280
1920 GOTO 3270
1930 REM NOV TAURIDS
1940 HOME
1950 PRINT "FIRST ";M$;" SHOWER IS TAURIDS"
1960 PRINT "10/20-11/30,MAX 8, 12 PER HOUR"
1970 PRINT "WITH 2 RAD.,3.73 RA, 14 & 22 DEC"
1980 PRINT "SLOW METEORS, SCATTERED FIREBALLS"
1990 PRINT : PRINT TAB( 16)"PLEIADES": PRINT
2000 PRINT TAB( 19)".:."
2010 PRINT "TAURUS": GOSUB 3330
2020 PRINT TAB( 39)"*"
2030 PRINT "ALDEBARAN"; TAB( 11)"."
2040 PRINT TAB( 10)"X"; TAB( 11) "; TAB( 13)".: "; TAB( 34)"ARIES"
2050 GOSUB 3330: PRINT ""
2060 PRINT
2070 PRINT
2080 PRINT
2090 PRINT TAB( 30)"*"; TAB( 45)".:": PRINT : PRINT
2100 PRINT
2110 RETURN
2120 REM NOV LEONIDS
2130 HOME
2140 PRINT "SECOND ";M$;" SHOWER IS LEONIDS"
2150 PRINT "15-19,MAX 17, RAD 10.13 RA, 22 DEC"
2160 PRINT "SWIFT METEORS, 10 PER HOUR"
2170 PRINT TAB( 3)".: "; TAB( 10)".:": PRINT TAB( 7)"."
2180 PRINT : PRINT TAB( 24)".:": PRINT TAB( 18)".: "; TAB( 26)"*"
2190 GOSUB 3330
2200 PRINT : PRINT TAB( 17)"*": PRINT TAB( 3)"*"
2210 PRINT TAB( 20)".:": PRINT TAB( 3)"X"; TAB( 8)"LEO"
2220 PRINT TAB( 20)"X REGULUS"
2230 PRINT ".: "; TAB( 28)".:"
```

SSTAR (continued)

```

2240 PRINT TAB( 37)"* ."
2250 PRINT : PRINT : PRINT
2260 PRINT
2270 RETURN
2280 PRINT : PRINT : PRINT
2290 PRINT "IN ";M$;" THERE ARE TWO METEOR SHOWERS"
2300 PRINT
2310 PRINT : PRINT TAB( 5)"THE GEMINIDS"
2320 PRINT "9-13, MAX 13, 60 PER HOUR"
2330 PRINT "SWIFT BRIGHT METEORS, SOME FIREBALLS"
2340 PRINT : PRINT : PRINT TAB( 8)"AND"
2350 PRINT : PRINT : PRINT TAB( 5)"THE URSIDS"
2360 PRINT "17-24, MAX 22, 5 PER HOUR"
2370 PRINT "WEAK DISPLAY"
2380 PRINT
2390 PRINT : PRINT "PLEASE SELECT GEMINIDS (1)"
2400 PRINT " OR URSIDS (2)"
2410 PRINT : INPUT A$:JS = VAL (A$)
2420 IF JS = 1 THEN GOSUB 2510: GOTO 2440
2430 IF JS = 2 THEN GOSUB 2660
2440 FOR J = 1 TO 3000: NEXT J
2450 INPUT "WANT TO SEE THE OTHER SHOWER Y/N ";A$
2460 HOME
2470 IF A$ = "Y" AND JS = 1 THEN GOSUB 2660: GOTO 2500
2480 IF A$ = "Y" AND JS = 2 THEN GOSUB 2510
2490 IF A$ = "N" THEN GOTO 3280
2500 GOTO 3270
2510 REM DEC. GEMINIDS
2520 HOME
2530 PRINT "FIRST ";M$;" SHOWER IS GEMINIDS"
2540 PRINT "9-13,MAX 13, RAD. 7.46 RA 32 DEC"
2550 PRINT "BRIGHT SWIFT METEORS 60 PER HOUR"
2560 PRINT TAB( 40)". "
2570 PRINT : PRINT TAB( 22)"* "
2580 GOSUB 3330
2590 PRINT ".": PRINT TAB( 18)"*"; TAB( 33)". "
2600 PRINT TAB( 18)".": PRINT " ."; TAB( 24)"*"; TAB( 38)"* * "
2610 PRINT TAB( 28)".": PRINT TAB( 25)"GEMINI"
2620 PRINT TAB( 36)"*": PRINT
2630 PRINT TAB( 35)".": PRINT
2640 PRINT TAB( 23)"*"; TAB( 46)"X": PRINT TAB( 19)"X PROCYON"
2650 RETURN
2660 REM DEC URSIDS
2670 HOME
2680 PRINT "SECOND ";M$;" SHOWER IS THE URSIDS"
2690 PRINT "17-24,MAX 22, RAD 14.6 RA, 78 DEC"
2700 PRINT "FAINT, MEDIUM SPEED, 5 PER HOUR"
2710 PRINT
2720 PRINT TAB( 10)"POLARIS"; TAB( 20)"* "
2730 PRINT : PRINT TAB( 16)".": PRINT : PRINT : PRINT
2740 PRINT TAB( 12)".": PRINT
2750 PRINT : GOSUB 3330: PRINT "": PRINT TAB( 13)". "
2760 PRINT " Ursa"; TAB( 39)". "
2770 PRINT " MINOR"
2780 PRINT TAB( 10)".": TAB( 16)"*": PRINT
2790 PRINT TAB( 14)"*"; TAB( 30)"DRACO"
2800 PRINT

```


SSTAR (continued)

```
2810 RETURN
2820 REM JUNE LYRIDS
2830 HOME
2840 PRINT "FIRST ";M$;" SHOWER IS THE LYRIDS"
2850 PRINT "10-20,MAX 15, RAD 18.3 RA, 35 DEC"
2860 PRINT "BLUISH METEORS, 8 PER HOUR"
2870 PRINT
2880 PRINT TAB( 40)"*"
2890 PRINT TAB( 6)"VEGA"; TAB( 13)"X"; TAB( 30)"*";
2900 PRINT TAB( 37)"*": GOSUB 3330
2910 PRINT ""
2920 PRINT TAB( 9)"* *"; TAB( 30)" * *"
2930 PRINT " LYRA";
2940 PRINT TAB( 32)"HERCULES"
2950 PRINT " X"
2960 PRINT TAB( 28)"*"
2970 PRINT TAB( 39)"*": PRINT
2980 PRINT : PRINT : PRINT
2990 PRINT TAB( 12)". "
3000 PRINT TAB( 10)"*"; TAB( 38)"*"
3010 PRINT TAB( 33)"*"
3020 PRINT "*" ; TAB( 31)"OPHIUCHUS"
3030 PRINT
3040 RETURN
3050 REM JUNE OPHIUCIDS
3060 HOME
3070 PRINT "SECOND ";M$;" SHOWER IS THE OPHIUCIDS"
3080 PRINT "17-26,MAX 19, RAD 17.3 RA, -20 DEC"
3090 PRINT "6 PER HOUR"
3100 PRINT TAB( 18)"OPHIUCHUS";
3110 PRINT TAB( 33)". "
3120 PRINT "-."; TAB( 10)".."; TAB( 30)"*"
3130 PRINT : PRINT
3140 PRINT TAB( 15)".."; TAB( 21)"*": PRINT
3150 GOSUB 3330
3160 PRINT TAB( 38)"*": PRINT
3170 PRINT " *"; TAB( 39)"*"
3180 PRINT TAB( 34)"*"
3190 PRINT TAB( 22)"ANTARES";
3200 PRINT TAB( 31)"X"; TAB( 39)"*"
3210 PRINT " *"; TAB( 8)"*"; TAB( 30)"*"
3220 PRINT : PRINT "SAGITTARIUS"
3230 PRINT " *"; TAB( 26)"*"
3240 PRINT TAB( 5)"*"; TAB( 12)".."; TAB( 15)"*"
3250 PRINT TAB( 12)"*"; TAB( 26)"*"; TAB( 31)"SCORPIO"
3260 RETURN
3270 FOR K = 1 TO 5000: NEXT K
3280 INPUT "WANT ANOTHER MONTH? Y/N ";A$
3290 IF A$ = "Y" THEN 160
3300 IF A$ < > "N" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 3280
3310 HOME
3320 END
3330 REM SUB FOR METEOR RADIANT
3340 PRINT TAB( 20);: FLASH : PRINT "+": NORMAL
3350 PRINT TAB( 17)"RADIANT";
3360 RETURN
```

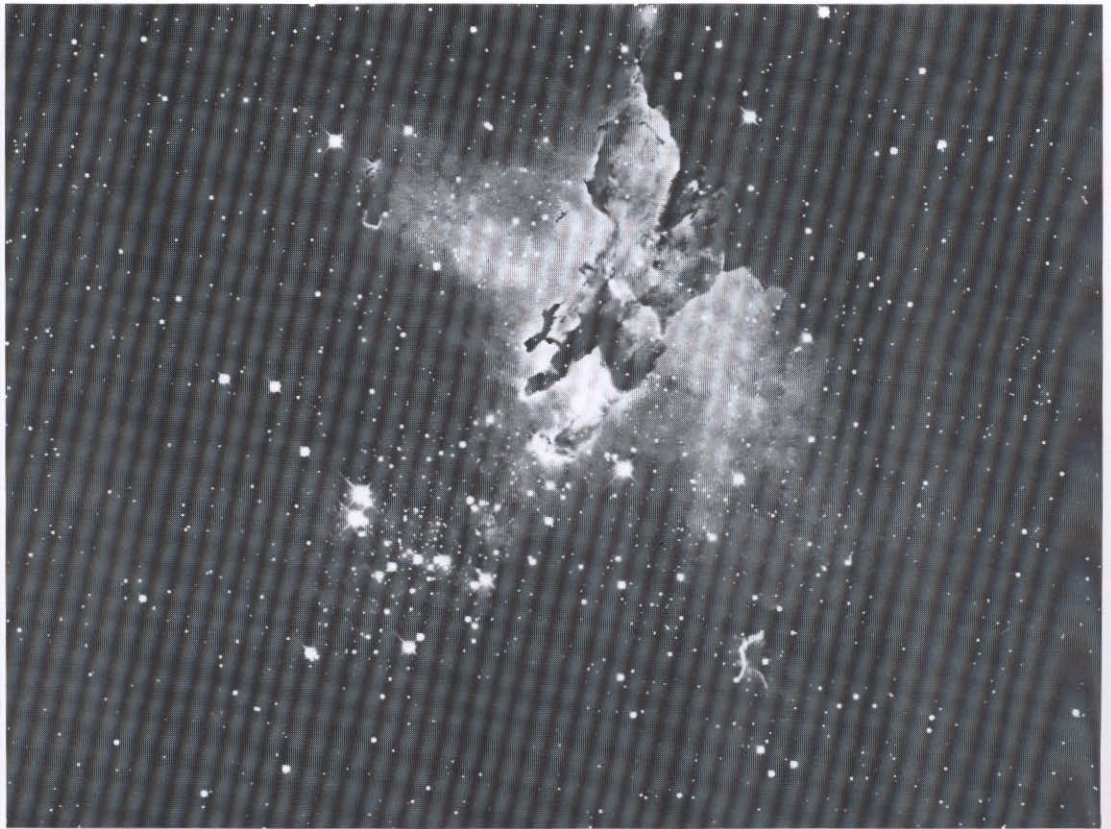


Photo: NASA/University of California

Beyond the solar system the stars beckon. Countless stars clump into our island universe, the Milky Way. Out in the farther depths of space we have discovered other island universes as numerous as the stars in our own Milky Way system. Between the stars are clouds

of dust, some illuminated by nearby stars to form glowing areas of nebulosity. In this picture gas mingles with dust in the constellation of Serpens and shows us what may be the birth of new star systems.

Program 21: CONST and CONSH

Recognizing the Constellations

When the Sun has set and twilight deepens, the night sky begins to develop the pinprick points of starlight. If we watch these stars from night to night we soon see that they rise, move together in a procession across the sky, and set, making a complete circuit once each day and once each year. In the northern sky, however, some groups of stars do not rise and set, but daily and annually circle around the celestial north pole, approximately marked by the pole star, Polaris. Similarly, in the Southern Hemisphere other groups of stars are always visible around the celestial south pole. You can use Program 16 to show how these motions and the constellations appear in different parts of the world, at different times of the night and in different seasons. You will notice that the individual stars do not appear to move relative to one another.

The patterns of the stars can be imagined to be joined by lines to represent objects, animals, and people. Since ancient times people have grouped the stars into constellations in this way, forming imaginary figures of mythological heroes and heroines in the night sky. Orion and the Pleiades are mentioned in the Book of Job, and the division of the stars into constellations is ascribed by Josephus to Seth, a son of Adam. Often these constellations are in groups telling a story, such as that concerning Andromeda, Perseus, Cassiopeia, Pegasus, and their surrounding constellations. Legend has it that Queen Cassiopeia (Figure 21.1) of Ethiopia and her husband, Cepheus, consented to the sacrifice of their daughter Andromeda to placate the gods. Andromeda was chained to a rock to await the coming of a sea monster. But Perseus saw the maiden, fell in love with her, and came to her rescue on the winged horse Pegasus. He slew the monster as he had the Gorgon.

Because of the revolution of Earth around the Sun, the Sun appears to pass through a series of constellations, called the zodiacal constellations.

These zodiacal constellations figure prominently in astrology, and can be memorized by the old English rhyme:

The Ram, the Bull, the Heavenly Twins,
And next the Crab, the Lion, shines,
The Virgin and the Scales;
The Scorpion, Archer, and Sea-Goat,
The Man that pours the water out,
And Fish with glittering scales.

Many bright stars have also been given names, usually derived from the Arabic names given them during the Middle Ages. In modern astronomy the stars of the constellations are assigned Greek letters; alpha for the brightest, then beta, and so on through the Greek alphabet. When these letters have been used up, the stars are designated by numbers.

The constellations and the stars within them were aids to navigation by seafaring peoples, and some modern research suggests that birds migrate by reference to the stars. The latitude of any place on Earth in the Northern Hemisphere can be quickly determined to within a few degrees by measuring the elevation of Polaris (see Program 7). The longitude is somewhat more difficult to establish. However, traveling toward the east an observer finds that the stars cross the meridian earlier, one hour for each fifteen degrees of longitude. Toward the west, the meridian crossing occurs later. But to determine how much earlier or later, an observer must have a clock that tells him the time at his original location. This need to know time exactly was one reason for the establishment of Greenwich Observatory and the zero meridian of longitude. Without an accurate measurement of when stars crossed the meridian at a particular place, determined by a transit instrument, and accurate clocks to maintain this time on long voyages, exploration of our globe would have been much more difficult.

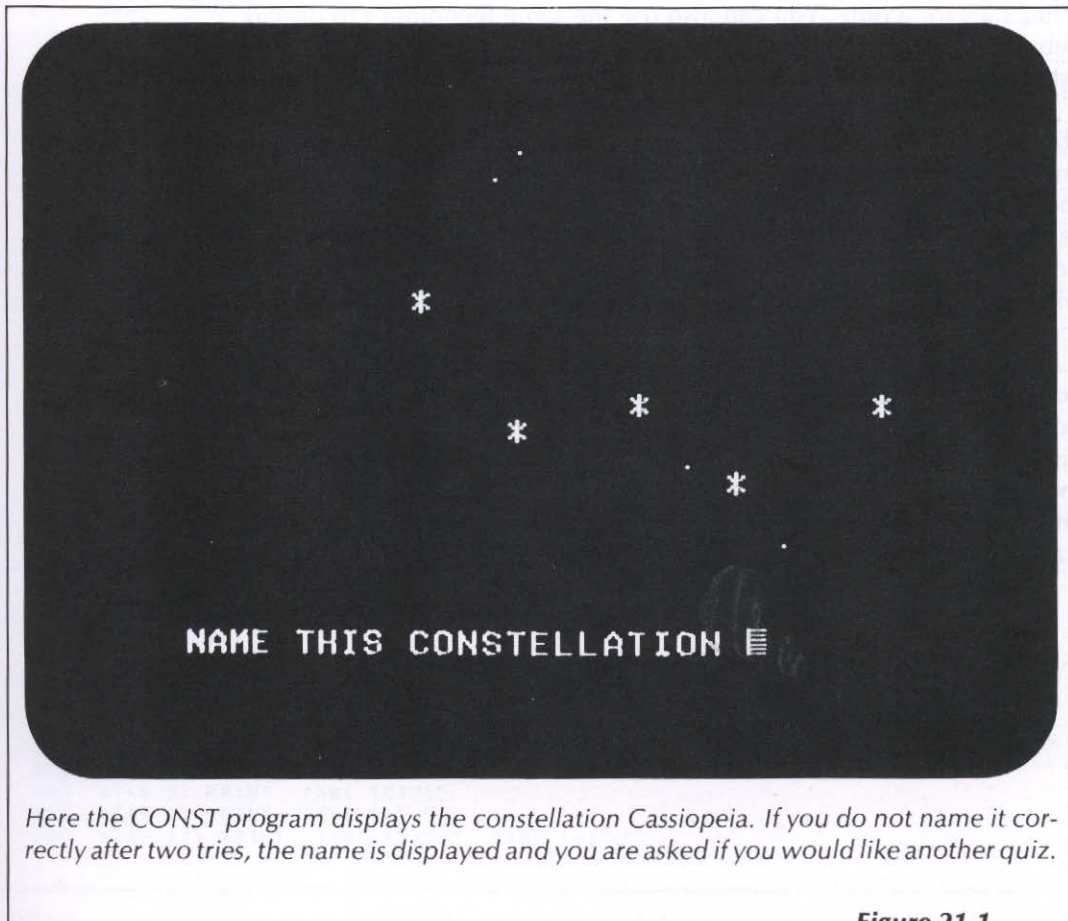
Once you recognize the constellations they become friends of the night sky, recognizable not only anywhere on our planet but also throughout our solar system. The groupings of stars that we see in the skies of Earth are the same as those in the skies of the Moon and of Mars, for example.

A well-known astronomer once wrote that the best way to learn the constellations is to get someone to teach them to you. An alternative is to refer to them in an astronomical textbook. But the lines shown on the star maps in such books are not available when you look at the night sky. This program is designed to help you learn the constellations by pattern recognition. It does not show the imaginary lines of the star charts. But when you remember the patterns of bright and faint stars you should have no problem in identifying the constellations in the night sky. It does not take long to become familiar with the constellations. Unfortunately, not

all are visible at any one time or season. With this program you can learn to recognize 42 major constellations before going out to search for them in the night sky. A supplementary program (CONSH) is appended to identify the southern circumpolar constellations for readers in the Southern Hemisphere.

The program offers two alternatives. You can be shown a constellation and asked to name it, and then be asked to name the bright star within it. Or you can have questions mingling stars and constellations unrelated to each other.

The program randomly selects the constellations for display and gives you two tries at naming the chosen constellation correctly. Then it tells you the name, so you should remember to associate it with the star pattern the next time you see it. You can continue being tested as long as you



Here the CONST program displays the constellation Cassiopeia. If you do not name it correctly after two tries, the name is displayed and you are asked if you would like another quiz.

Figure 21.1

wish, or you can quit at any time. Figure 21.1, which shows Cassiopeia, is typical of the displays generated by this program.

There are no complex algorithms in the program. It selects the constellations by use of the random function and jumps to the appropriate section of the program at instruction 450. Each section is a straightforward routine that prints stars on the monitor screen and then uses the subroutine (instruction 7450) to ask you to name the constellation. It checks if your answer is correct. If your answer is incorrect it allows you one more try before printing the name of the constellation. A similar subroutine (instruction 7540) is used to quiz you on the name of a bright star within the constellation.

For several of the constellations the name of a second star is given in the constellation routines, but it is not displayed with this version of the program. If you wish you can add a second subroutine to display these other stars for a quiz. You can also use the same techniques to display nebulae when you want a more advanced tutorial. These would be interesting projects for an astronomy class.

If you are in the Southern Hemisphere you will probably find it preferable to invert all the constellations when you key in the routines for each constellation by changing the VTAB and TAB instructions. To do this you should subtract each TAB instruction number from 40 and use the difference as the new TAB number; then subtract each VTAB instruction number from 24 and use the difference as the new VTAB number. This procedure will invert all the constellations when they are displayed on the monitor screen.

This program is easily adapted to other computers. The VTAB instructions have been purposely left in for all lines even though they often are not required. This has been done to provide line information so that VTAB instructions can be substituted to select a line position on the screen. For the TRS-80, for example, the VTAB/PRINTTAB(X) instructions can be changed to PRINT @ instructions. Other computers can use simple PRINT statements to count the number of lines in place of the VTAB statement.

The listings of the CONST and CONSH programs follow.

CONST

```
10 HOME
20 PRINT : PRINT : PRINT : PRINT
30 PRINT TAB( 5)"AN ASTRONOMY PROGRAM"
40 PRINT TAB( 5)"      TUTORIAL"
50 PRINT : PRINT
60 PRINT TAB( 5)"-----"
70 PRINT TAB( 5)"I CONSTELLATIONS I"
80 PRINT TAB( 5)"-----"
90 PRINT : PRINT : PRINT
100 PRINT TAB( 4)"BY ERIC BURGESS F.R.A.S."
110 PRINT
120 PRINT TAB( 4)"ALL RIGHTS RESERVED BY"
130 PRINT TAB( 4)"S & T SOFTWARE SERVICE"
140 FOR K = 1 TO 3000: NEXT K
150 PRINT : PRINT : PRINT
160 HOME
170 PRINT : PRINT : PRINT
180 INPUT "WANT INSTRUCTIONS Y/N ";A$
190 IF A$ = "N" THEN GOTO 370
200 IF A$ < > "Y" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 180
210 HOME : PRINT : PRINT
220 PRINT "THIS PROGRAM DISPLAYS A CONSTELLATION"
230 PRINT "SELECTED AT RANDOM AND ASKS FOR ITS NAME"
240 PRINT "YOU HAVE TWO TRIES BEFORE THE NAME"
250 PRINT TAB( 8)"IS REVEALED"
260 PRINT
270 PRINT "NEXT THE PROGRAM ASKS FOR THE NAME OF"
280 PRINT "A BRIGHT STAR IN THE CONSTELLATION"
290 PRINT "AGAIN YOU HAVE TWO CHANCES TO NAME IT"
300 PRINT "BEFORE BEING TOLD THE NAME"
310 PRINT : PRINT
320 PRINT : PRINT "THE PROGRAM OFFERS TWO ALTERNATIVES"
330 PRINT "CONSTELLATIONS FOLLOWED BY STARS"
340 PRINT "OR STARS AND CONSTELLATIONS MIXED"
350 PRINT : PRINT
360 INPUT "PRESS RETURN WHEN READY";A$
370 HOME : PRINT : PRINT : PRINT : PRINT
380 PRINT : PRINT "CHOOSE CONSTELLATIONS (1)"
390 PRINT "OR": INPUT "STARS AND CONSTELLATIONS (2)";AL$
400 IF AL$ = "2" THEN AL = 1
410 IF AL$ = "1" THEN AL = 0
420 Z = 1
430 C = RND (Z) * 42
440 C = INT (C) + 1
450 ON C GOSUB 460,590,790,990,1200,1320,1520,1710,1840,2050,2220,2360,2510,
2740,2900,3090,3230,3420,3530,3640,3820,3960,4080,4280,4460,4710,4880,
5040,5210,5430,5610,5690,5810,5950,6160,6330,6470,6660,6830,7010,7170,
7310
460 C$ = "PISCES"
470 HOME
480 VTAB 5: PRINT TAB( 10)". "
490 VTAB 9: PRINT TAB( 8)". "
500 VTAB 12: PRINT TAB( 12)". "; TAB( 16)". "
```

CONST (continued)

```

510 VTAB 13: PRINT TAB( 24)"; TAB( 31)"; TAB( 35)";
520 VTAB 14: PRINT TAB( 4)"; TAB( 28)";
530 VTAB 15: PRINT TAB( 33)";
540 VTAB 16: PRINT TAB( 28)"; TAB( 31)";
550 VTAB 22
560 GOSUB 7450
570 INPUT "PRESS RETURN TO CONTINUE ";A$
580 GOTO 7610
590 C$ = "ARIES"
600 S$ = "HAMAL"
610 HOME
620 VTAB 6: PRINT TAB( 23)";
630 VTAB 7: PRINT TAB( 22)";
640 VTAB 9: PRINT TAB( 26)";
650 VTAB 10: PRINT TAB( 12)";
660 VTAB 11: PRINT TAB( 13)";
670 VTAB 12: PRINT TAB( 11)";
680 IF FL = 1 THEN VTAB 15: PRINT TAB( 25)"";
690 IF FL = 1 THEN FLASH : PRINT TAB( 25)"";
700 IF FL = 1 THEN FLASH : PRINT "X": NORMAL : GOTO 720
710 VTAB 15: PRINT TAB( 25)"X"
720 VTAB 16: PRINT TAB( 9)"; TAB( 28)*"
730 VTAB 17: PRINT TAB( 5)"; TAB( 28)";
740 VTAB 20
750 IF FL = 1 THEN FL = 0: GOTO 7540
760 GOSUB 7450
770 INPUT "PRESS RETURN TO CONTINUE ";A$
780 GOTO 610
790 C$ = "TAURUS"
800 S$ = "ALDEBARAN"
810 S2$ = "PLEIADES":S3$ = "HYADES"
820 HOME
830 VTAB 10: PRINT TAB( 7)*"
840 VTAB 13: PRINT TAB( 31)";:":
850 VTAB 15: PRINT TAB( 13)";
860 VTAB 16: PRINT TAB( 3)*"
870 VTAB 17: PRINT TAB( 20)";
880 VTAB 18: PRINT TAB( 21)";
890 IF FL = 1 THEN VTAB 19: PRINT TAB( 18)"";: FLASH
900 IF FL = 1 THEN PRINT "X": NORMAL : GOTO 920
910 VTAB 19: PRINT TAB( 18)"X"
920 VTAB 21: PRINT TAB( 32)"; TAB( 37)";
930 VTAB 23: PRINT TAB( 36)";
940 VTAB 24: PRINT TAB( 30)"; TAB( 37)";
950 IF FL = 1 THEN FL = 0: GOTO 7540
960 GOSUB 7450
970 INPUT "PRESS RETURN TO CONTINUE ";A$
980 GOTO 820
990 C$ = "GEMINI"
1000 S$ = "CASTOR":S2$ = "POLLUX"
1010 HOME
1020 VTAB 7: PRINT TAB( 22)";
1030 IF FL = 1 THEN VTAB 7: PRINT TAB( 9)"";
1040 IF FL = 1 THEN FLASH : PRINT "X": NORMAL : GOTO 1060
1050 VTAB 8: PRINT TAB( 9)"X"

```


CONST (continued)

```
1060 VTAB 10: PRINT TAB( 17) ". "
1070 VTAB 12: PRINT TAB( 6) "X"
1080 VTAB 13: PRINT TAB( 10) ". "
1090 VTAB 14: PRINT TAB( 25) "*"
1100 VTAB 15: PRINT TAB( 7) ". "
1110 VTAB 16: PRINT TAB( 15) "*" ; TAB( 32) "*" *
1120 VTAB 17: PRINT TAB( 20) ". " ; TAB( 31) ". "
1130 VTAB 19: PRINT TAB( 15) "*"
1140 VTAB 20: PRINT TAB( 29) "X"
1150 VTAB 22: PRINT TAB( 27) "*"
1160 IF FL = 1 THEN FL = 0: GOTO 7540
1170 GOSUB 7450
1180 INPUT "PRESS RETURN TO CONTINUE ";A$
1190 GOTO 1010
1200 C$ = "CANCER"
1210 HOME
1220 VTAB 5: PRINT TAB( 15) ". "
1230 VTAB 11: PRINT TAB( 15) ". "
1240 VTAB 12: PRINT TAB( 19) ". "
1250 VTAB 15: PRINT TAB( 15) ". " ; TAB( 26) ". "
1260 VTAB 19: PRINT TAB( 11) ". "
1270 VTAB 21: PRINT TAB( 25) ". "
1280 PRINT
1290 GOSUB 7450
1300 INPUT "PRESS RETURN TO CONTINUE ";A$
1310 GOTO 7610
1320 C$ = "LEO"
1330 S$ = "REGULUS"
1340 HOME
1350 VTAB 7: PRINT TAB( 34) ". "
1360 VTAB 8: PRINT TAB( 38) "*"
1370 VTAB 9: PRINT TAB( 29) ". "
1380 VTAB 11: PRINT TAB( 14) "*" ; TAB( 17) ". " ; TAB( 29) "*"
1390 VTAB 12: PRINT TAB( 4) ". "
1400 VTAB 14: PRINT TAB( 31) ". " ; VTAB 15: PRINT TAB( 14) "*"
1410 VTAB 16: PRINT TAB( 4) "*"
1420 IF FL = 1 THEN VTAB 17: PRINT TAB( 30) " " ;
1430 IF FL = 1 THEN FLASH : PRINT "X": NORMAL : GOTO 1450
1440 VTAB 17: PRINT TAB( 30) "X"
1450 VTAB 19: PRINT TAB( 12) ". " ; TAB( 25) ". " ; TAB( 36) ". "
1460 VTAB 20: PRINT TAB( 18) ". "
1470 VTAB 22: PRINT TAB( 14) ". " : PRINT
1480 IF FL = 1 THEN FL = 0: GOTO 7540
1490 GOSUB 7450
1500 INPUT "PRESS RETURN TO CONTINUE ";A$
1510 GOTO 1340
1520 C$ = "VIRGO"
1530 S$ = "SPICA"
1540 HOME
1550 VTAB 5: PRINT TAB( 18) "*"
1560 VTAB 7: PRINT TAB( 31) ". "
1570 VTAB 8: PRINT TAB( 33) ". " ; TAB( 37) ". "
1580 VTAB 10: PRINT TAB( 20) "*"
1590 VTAB 11: PRINT TAB( 36) "*"
1600 VTAB 12: PRINT TAB( 12) ". "
```

CONST (continued)

```
1610 VTAB 13: PRINT TAB( 22)"*"; TAB( 28)"*"
1620 VTAB 15: PRINT TAB( 13)". "
1630 IF FL = 1 THEN VTAB 19: PRINT TAB( 10)"";
1640 IF FL = 1 THEN FLASH : PRINT "X": NORMAL : GOTO 1660
1650 VTAB 19: PRINT TAB( 10)"X"
1660 PRINT
1670 IF FL = 1 THEN FL = 0: GOTO 7540
1680 GOSUB 7450
1690 INPUT "PRESS RETURN TO CONTINUE ";A$
1700 GOTO 1540
1710 C$ = "LIBRA"
1720 HOME
1730 VTAB 5: PRINT TAB( 22)". "
1740 VTAB 10: PRINT TAB( 18)"*"
1750 VTAB 12: PRINT TAB( 7)". "
1760 VTAB 13: PRINT TAB( 13)". "
1770 VTAB 14: PRINT TAB( 8)". "
1780 VTAB 15: PRINT TAB( 23)"*"
1790 VTAB 20: PRINT TAB( 18)". "
1800 PRINT : PRINT
1810 GOSUB 7450
1820 INPUT "PRESS RETURN TO CONTINUE ";A$
1830 GOTO 7610
1840 C$ = "SCORPIO"
1850 S$ = "ANTARES"
1860 HOME
1870 VTAB 5: PRINT TAB( 30)". *"
1880 VTAB 6: PRINT TAB( 33)". "
1890 VTAB 7: PRINT TAB( 34)"*"
1900 VTAB 10: PRINT TAB( 27)"*"; TAB( 34)"*"
1910 IF FL = 1 THEN VTAB 11: PRINT TAB( 25)"";
1920 IF FL = 1 THEN FLASH : PRINT "X": NORMAL : GOTO 1940
1930 VTAB 11: PRINT TAB( 25)"X"
1940 VTAB 12: PRINT TAB( 24)"*"; TAB( 34)". "
1950 VTAB 16: PRINT TAB( 8)"*"; TAB( 11)"*"; TAB( 21)"*"; TAB( 25)". "
1960 VTAB 17: PRINT TAB( 24)". "
1970 VTAB 18: PRINT TAB( 10)"*"
1980 VTAB 19: PRINT TAB( 9)"*"; TAB( 21)"*"
1990 VTAB 22: PRINT TAB( 12)"*"; TAB( 18)"*"
2000 PRINT
2010 IF FL = 1 THEN FL = 0: GOTO 7540
2020 GOSUB 7450
2030 INPUT "PRESS RETURN TO CONTINUE ";A$
2040 GOTO 1860
2050 C$ = "SAGITTARIUS"
2060 HOME
2070 VTAB 6: PRINT TAB( 9)". "
2080 VTAB 7: PRINT TAB( 9)". "
2090 VTAB 9: PRINT TAB( 12)"*"; TAB( 15)". "
2100 VTAB 10: PRINT TAB( 14)". "
2110 VTAB 12: PRINT TAB( 15)"*"; TAB( 25)"*"
2120 VTAB 13: PRINT TAB( 17)"*"; TAB( 27)". "
2130 VTAB 14: PRINT TAB( 12)"*"; TAB( 29)". "
2140 VTAB 15: PRINT TAB( 13)"*"; TAB( 26)"*"
2150 VTAB 16: PRINT TAB( 29)"*"

```

CONST (continued)

```
2160 VTAB 19: PRINT TAB( 24)"*"
2170 VTAB 21: PRINT TAB( 25)"*"
2180 PRINT : PRINT
2190 GOSUB 7450
2200 INPUT "PRESS RETURN TO CONTINUE ";A$
2210 GOTO 7610
2220 C$ = "CAPRICORNUS"
2230 HOME
2240 VTAB 6: PRINT TAB( 32)"*"
2250 VTAB 8: PRINT TAB( 31)"*"
2260 VTAB 10: PRINT TAB( 6)"* ."; TAB( 13)"."; TAB( 18)"."
2270 VTAB 14: PRINT TAB( 9)"."
2280 VTAB 15: PRINT TAB( 13)":!"
2290 VTAB 16: PRINT TAB( 19)"."; TAB( 26)"."
2300 VTAB 17: PRINT TAB( 17)"*"
2310 VTAB 21: PRINT TAB( 18)"*"
2320 PRINT : PRINT
2330 GOSUB 7450
2340 INPUT "PRESS RETURN TO CONTINUE ";A$
2350 GOTO 7610
2360 C$ = "AQUARIUS"
2370 HOME
2380 VTAB 8: PRINT TAB( 13)"."
2390 VTAB 9: PRINT TAB( 11)"* *"; TAB( 19)"*"
2400 VTAB 10: PRINT TAB( 15)"*"
2410 VTAB 12: PRINT TAB( 28)"*"; TAB( 36)"."
2420 VTAB 14: PRINT TAB( 9)"."
2430 VTAB 15: PRINT TAB( 37)"."
2440 VTAB 16: PRINT TAB( 32)"."
2450 VTAB 18: PRINT TAB( 10)"."
2460 VTAB 20: PRINT TAB( 8)"*"
2470 PRINT : PRINT : PRINT
2480 GOSUB 7450
2490 INPUT "PRESS RETURN TO CONTINUE ";A$
2500 GOTO 7610
2510 C$ = "ORION"
2520 S$ = "RIGEL":S2$ = "BETELGEUX":S3$ = "ORION NEBULA"
2530 HOME
2540 VTAB 4: PRINT TAB( 8)"."; TAB( 16)".":; TAB( 30)"."
2550 VTAB 5: PRINT TAB( 31)"."
2560 VTAB 6: PRINT TAB( 10)"X"; TAB( 31)"."
2570 VTAB 7: PRINT TAB( 19)"."; TAB( 21)"*"; TAB( 31)"."
2580 VTAB 9: PRINT TAB( 16)"."
2590 VTAB 10: PRINT TAB( 30)"."
2600 VTAB 13: PRINT TAB( 19)"*"
2610 VTAB 14: PRINT TAB( 17)"*"
2620 VTAB 15: PRINT TAB( 15)"*"; TAB( 21)"."
2630 VTAB 17: PRINT TAB( 16)"."
2640 VTAB 18: PRINT TAB( 16)"::"
2650 IF FL = 1 THEN VTAB 19: PRINT TAB( 24)"";
2660 IF FL = 1 THEN FLASH : PRINT "X": NORMAL : GOTO 2680
2670 VTAB 19: PRINT TAB( 24)"X"
2680 VTAB 20: PRINT TAB( 12)"*"
2690 PRINT : PRINT
2700 IF FL = 1 THEN FL = 0: GOTO 7540
```

CONST (continued)

```

2710 GOSUB 7450
2720 INPUT "PRESS RETURN TO CONTINUE ";A$
2730 GOTO 2530
2740 C$ = "LEPUS"
2750 HOME
2760 VTAB 5: PRINT TAB( 25)". "
2770 VTAB 6: PRINT TAB( 22)". "
2780 VTAB 7: PRINT TAB( 7)". "; TAB( 10)". "
2790 VTAB 8: PRINT TAB( 4)". "
2800 VTAB 9: PRINT TAB( 24)"*"
2810 VTAB 11: PRINT TAB( 16)"*"
2820 VTAB 13: PRINT TAB( 9)". "
2830 VTAB 14: PRINT TAB( 18)"*"
2840 VTAB 15: PRINT TAB( 12)". "
2850 VTAB 16: PRINT TAB( 27)"*"
2860 PRINT : PRINT : PRINT
2870 GOSUB 7450
2880 INPUT "PRESS RETURN TO CONTINUE ";A$
2890 GOTO 7610
2900 C$ = "CANIS MAJOR"
2910 S$ = "SIRIUS"
2920 HOME
2930 VTAB 7: PRINT TAB( 17)". "
2940 IF FL = 1 THEN VTAB 8: PRINT TAB( 21)"";
2950 IF FL = 1 THEN FLASH : PRINT "X": NORMAL : GOTO 2970
2960 VTAB 8: PRINT TAB( 21)"X"
2970 VTAB 10: PRINT TAB( 23)". "; TAB( 27)"*"
2980 VTAB 12: PRINT TAB( 16)"*"
2990 VTAB 13: PRINT TAB( 12)". "; TAB( 18)". "
3000 VTAB 14: PRINT TAB( 14)"*"
3010 VTAB 15: PRINT TAB( 9)"*"
3020 VTAB 16: PRINT TAB( 15)"*"
3030 VTAB 18: PRINT TAB( 15)". "; TAB( 24)"*"
3040 VTAB 20: PRINT TAB( 20)". ": PRINT : PRINT
3050 IF FL = 1 THEN FL = 0: GOTO 7540
3060 GOSUB 7450
3070 INPUT "PRESS RETURN TO CONTINUE ";A$
3080 GOTO 2920
3090 C$ = "CANIS MINOR"
3100 S$ = "PROCYON"
3110 HOME
3120 VTAB 8: PRINT TAB( 21)". "
3130 VTAB 9: PRINT TAB( 22)"*"
3140 IF FL = 1 THEN VTAB 12: PRINT TAB( 16)"";
3150 IF FL = 1 THEN FLASH : PRINT "X": NORMAL : GOTO 3170
3160 VTAB 12: PRINT TAB( 16)"X"
3170 VTAB 15: PRINT TAB( 6)". "
3180 VTAB 22
3190 IF FL = 1 THEN FL = 0: GOTO 7540
3200 GOSUB 7450
3210 INPUT "PRESS RETURN TO CONTINUE ";A$
3220 GOTO 3110
3230 C$ = "CETUS"
3240 S$ = "MIRA"
3250 HOME

```

CONST (continued)

```
3260 VTAB 2: PRINT TAB( 5) ". "; TAB( 8) ". "
3270 VTAB 5: PRINT TAB( 4) "*"
3280 VTAB 6: PRINT TAB( 8) "*"
3290 VTAB 8: PRINT TAB( 10) ". "
3300 IF FL = 1 THEN VTAB 9: PRINT TAB( 14) "" ;
3310 IF FL = 1 THEN FLASH : PRINT ". : NORMAL : GOTO 3330
3320 VTAB 9: PRINT TAB( 14) ". "
3330 VTAB 13: PRINT TAB( 32) "*"
3340 VTAB 14: PRINT TAB( 25) "*" ; TAB( 35) "*"
3350 VTAB 15: PRINT TAB( 8) ". "; TAB( 26) "*"
3360 VTAB 18: PRINT TAB( 26) "*" ; TAB( 39) "*"
3370 VTAB 21: PRINT TAB( 22) ". " : PRINT : PRINT
3380 IF FL = 1 THEN FL = 0: GOTO 7540
3390 GOSUB 7450
3400 INPUT "PRESS RETURN TO CONTINUE " ; A$
3410 GOTO 3250
3420 C$ = "CORVUS"
3430 HOME
3440 VTAB 7: PRINT TAB( 14) ". "
3450 VTAB 8: PRINT TAB( 15) "*"
3460 VTAB 10: PRINT TAB( 21) "*"
3470 VTAB 15: PRINT TAB( 13) "*" ; TAB( 22) "*"
3480 VTAB 17: PRINT TAB( 22) "*"
3490 VTAB 22
3500 GOSUB 7450
3510 INPUT "PRESS RETURN TO CONTINUE " ; A$
3520 GOTO 7610
3530 C$ = "CRATER"
3540 HOME
3550 VTAB 13: PRINT TAB( 13) "*"
3560 VTAB 16: PRINT TAB( 10) "*"
3570 VTAB 17: PRINT TAB( 20) "*"
3580 VTAB 20: PRINT TAB( 15) "*"
3590 PRINT : PRINT : PRINT : PRINT
3600 PRINT : PRINT
3610 GOSUB 7450
3620 INPUT "PRESS RETURN TO CONTINUE " ; A$
3630 GOTO 7610
3640 C$ = "HYDRA"
3650 HOME
3660 VTAB 5: PRINT TAB( 33) ". ."
3670 VTAB 6: PRINT TAB( 34) ". ."
3680 VTAB 7: PRINT TAB( 31) "*"
3690 VTAB 9: PRINT TAB( 27) ". "
3700 VTAB 10: PRINT TAB( 22) ". " ; TAB( 28) ". "
3710 VTAB 11: PRINT TAB( 25) ". "
3720 VTAB 14: PRINT TAB( 11) ". "
3730 VTAB 16: PRINT TAB( 5) ". "
3740 VTAB 17: PRINT TAB( 18) ". ."
3750 PRINT : PRINT
3760 VTAB 21: PRINT TAB( 14) ". " ; TAB( 17) ". "
3770 VTAB 23: PRINT TAB( 14) "*" ; TAB( 17) "*"
3780 PRINT : PRINT
3790 GOSUB 7450
3800 INPUT "PRESS RETURN TO CONTINUE " ; A$
```

CONST (continued)

```
3810 GOTO 7610
3820 C$ = "SERPENS"
3830 HOME
3840 VTAB 5: PRINT TAB( 20)". "
3850 VTAB 6: PRINT TAB( 18)". "
3860 VTAB 7: PRINT TAB( 16)". "; TAB( 19)". "
3870 VTAB 12: PRINT TAB( 21)"*"
3880 VTAB 14: PRINT TAB( 18)". "
3890 VTAB 15: PRINT TAB( 19)"*"
3900 VTAB 17: PRINT TAB( 17)"*"
3910 VTAB 21: PRINT TAB( 18)"*"
3920 PRINT : PRINT
3930 GOSUB 7450
3940 INPUT "PRESS RETURN TO CONTINUE ";A$
3950 GOTO 7610
3960 C$ = "DELPHINUS"
3970 HOME
3980 VTAB 8: PRINT TAB( 17)". "
3990 VTAB 9: PRINT TAB( 21)". "
4000 VTAB 10: PRINT TAB( 18)". "
4010 VTAB 11: PRINT TAB( 22)". "
4020 VTAB 13: PRINT TAB( 23)". "
4030 VTAB 15: PRINT TAB( 24)". "
4040 PRINT : PRINT
4050 GOSUB 7450
4060 INPUT "PRESS RETURN TO CONTINUE ";A$
4070 GOTO 7610
4080 C$ = "AQUILA"
4090 S$ = "ALTAIR"
4100 HOME
4110 VTAB 4: PRINT TAB( 27)". "
4120 VTAB 5: PRINT TAB( 25)"*"
4130 VTAB 7: PRINT TAB( 16)"*"
4140 IF FL = 1 THEN VTAB 8: PRINT TAB( 15)"";
4150 IF FL = 1 THEN FLASH : PRINT "X": NORMAL : GOTO 4170
4160 VTAB 8: PRINT TAB( 15)"X"
4170 VTAB 9: PRINT TAB( 20)". "
4180 VTAB 10: PRINT TAB( 14)"*"
4190 VTAB 14: PRINT TAB( 14)". "; TAB( 22)"*"
4200 VTAB 15: PRINT TAB( 9)"*"
4210 VTAB 19: PRINT TAB( 27)"*"
4220 VTAB 20: PRINT TAB( 29)"*"
4230 PRINT : PRINT
4240 IF FL = 1 THEN FL = 0: GOTO 7540
4250 GOSUB 7450
4260 INPUT "PRESS RETURN TO CONTINUE ";A$
4270 GOTO 4100
4280 C$ = "LYRA"
4290 S$ = "VEGA"
4300 HOME
4310 VTAB 5: PRINT TAB( 15)". "
4320 VTAB 9: PRINT TAB( 19)". "
4330 VTAB 10: PRINT TAB( 8)". ";
4340 IF FL = 1 THEN PRINT TAB( 21)"";
4350 IF FL = 1 THEN FLASH : PRINT "X": NORMAL : GOTO 4370
```

CONST (continued)

```
4360 PRINT TAB( 21)"X"
4370 VTAB 11: PRINT TAB( 7)"."; TAB( 18)"."
4380 VTAB 12: PRINT TAB( 15)"."; TAB( 27)"."
4390 VTAB 16: PRINT TAB( 17)"*"
4400 VTAB 17: PRINT TAB( 14)"*"
4410 PRINT : PRINT : PRINT
4420 IF FL = 1 THEN FL = 0: GOTO 7540
4430 GOSUB 7450
4440 INPUT "PRESS RETURN TO CONTINUE ";A$
4450 GOTO 4300
4460 C$ = "CYGNUS"
4470 S$ = "DENEb"
4480 HOME
4490 VTAB 5: PRINT TAB( 30)"."
4500 VTAB 6: PRINT TAB( 28)"."
4510 VTAB 9: PRINT TAB( 20)"."
4520 VTAB 10: PRINT TAB( 20)"."
4530 VTAB 11: PRINT TAB( 6)".";
4540 IF FL = 1 THEN PRINT TAB( 15)"";
4550 IF FL = 1 THEN FLASH : PRINT "X";: NORMAL : GOTO 4570
4560 PRINT TAB( 15)"X";
4570 PRINT TAB( 26)"*"
4580 VTAB 12: PRINT TAB( 10)"."
4590 VTAB 13: PRINT TAB( 11)"."
4600 VTAB 14: PRINT TAB( 19)"*"
4610 VTAB 15: PRINT TAB( 7)"."
4620 VTAB 17: PRINT TAB( 24)"."
4630 VTAB 18: PRINT TAB( 14)"*"; TAB( 20)"."
4640 VTAB 20: PRINT TAB( 8)"."; TAB( 18)"."
4650 VTAB 22: PRINT TAB( 30)"*"
4660 PRINT : PRINT
4670 IF FL = 1 THEN FL = 0: GOTO 7540
4680 GOSUB 7450
4690 INPUT "PRESS RETURN TO CONTINUE ";A$
4700 GOTO 4480
4710 C$ = "HERCULES"
4720 HOME
4730 VTAB 5: PRINT TAB( 18)"*"; TAB( 30)". ."
4740 VTAB 6: PRINT TAB( 31)"."
4750 VTAB 7: PRINT TAB( 28)"."; TAB( 36)"."
4760 VTAB 9: PRINT TAB( 26)"*"
4770 VTAB 10: PRINT TAB( 13)"*"; TAB( 20)"*"
4780 VTAB 13: PRINT TAB( 26)"*"
4790 VTAB 14: PRINT TAB( 11)"."; TAB( 22)"*"
4800 VTAB 15: PRINT TAB( 9)". ."
4810 VTAB 16: PRINT TAB( 13)"*"
4820 VTAB 17: PRINT TAB( 19)"*"
4830 VTAB 19: PRINT TAB( 4)"."; TAB( 30)"*"
4840 VTAB 20: PRINT TAB( 32)"*": PRINT : PRINT
4850 GOSUB 7450
4860 INPUT "PRESS RETURN TO CONTINUE ";A$
4870 GOTO 7610
4880 C$ = "OPHIUCHUS"
4890 HOME
4900 VTAB 5: PRINT TAB( 17)"*"; TAB( 26)"."
```

CONST (continued)

```

4910 VTAB 6: PRINT TAB( 25)". "
4920 VTAB 9: PRINT TAB( 31)". "
4930 VTAB 10: PRINT TAB( 15)"*"
4940 VTAB 11: PRINT TAB( 10)". " ; TAB( 14)"*"
4950 VTAB 12: PRINT TAB( 36)"*"
4960 VTAB 13: PRINT TAB( 34)"*"
4970 VTAB 17: PRINT TAB( 30)"*"
4980 VTAB 18: PRINT TAB( 14)". "
4990 VTAB 20: PRINT TAB( 22)"*"
5000 PRINT : PRINT
5010 GOSUB 7450
5020 INPUT "PRESS RETURN TO CONTINUE ";A$
5030 GOTO 7610
5040 C$ = "URSA MINOR"
5050 S$ = "POLARIS"
5060 HOME
5070 IF FL = 1 THEN VTAB 7: PRINT TAB( 22)"";
5080 IF FL = 1 THEN FLASH : PRINT "X": NORMAL : GOTO 5100
5090 VTAB 7: PRINT TAB( 22)"X"
5100 VTAB 9: PRINT TAB( 19)". "
5110 VTAB 11: PRINT TAB( 17)". "
5120 VTAB 14: PRINT TAB( 14)". " ; TAB( 17)"*"
5130 VTAB 15: PRINT TAB( 20)". "
5140 VTAB 16: PRINT TAB( 18)"*"
5150 VTAB 17: PRINT TAB( 15)"*"
5160 PRINT : PRINT : PRINT
5170 IF FL = 1 THEN FL = 0: GOTO 7540
5180 GOSUB 7450
5190 INPUT "PRESS RETURN TO CONTINUE ";A$
5200 GOTO 5060
5210 C$ = "URSA MAJOR"
5220 S$ = "DUBHE":S2$ = "ALCOR"
5230 HOME
5240 VTAB 8: PRINT TAB( 35)". "
5250 IF FL = 1 THEN VTAB 10: PRINT TAB( 25)"";
5260 IF FL = 1 THEN FLASH : PRINT "*";: NORMAL : PRINT TAB( 34)". "
: GOTO 5280
5270 VTAB 10: PRINT TAB( 25)"*"; TAB( 34)". "
5280 VTAB 11: PRINT TAB( 8)"*"
5290 VTAB 12: PRINT TAB( 12)"*"; TAB( 17)"*"
5300 VTAB 13: PRINT TAB( 3)"*"
5310 VTAB 14: PRINT TAB( 25)"*"
5320 VTAB 15: PRINT TAB( 18)"*"
5330 VTAB 16: PRINT TAB( 35)". "
5340 VTAB 17: PRINT TAB( 18)". "
5350 VTAB 19: PRINT TAB( 25)". " ; TAB( 33)". "
5360 VTAB 20: PRINT TAB( 32)". "
5370 VTAB 24: PRINT TAB( 24)": "
5380 PRINT : PRINT
5390 IF FL = 1 THEN FL = 0: GOTO 7540
5400 GOSUB 7450
5410 INPUT "PRESS RETURN TO CONTINUE ";A$
5420 GOTO 5230
5430 C$ = "DRACO"
5440 HOME

```


CONST (continued)

```
5450 VTAB 5: PRINT TAB( 36)"*"
5460 VTAB 7: PRINT TAB( 34)"*"
5470 VTAB 10: PRINT TAB( 14)"* ."
5480 VTAB 11: PRINT TAB( 14)"."; TAB( 35)"*"
5490 VTAB 12: PRINT TAB( 7)" ."
5500 VTAB 13: PRINT TAB( 6)"."; TAB( 9)"*"
5510 VTAB 14: PRINT TAB( 8)"."; TAB( 20)"*"
5520 VTAB 15: PRINT TAB( 24)"*"
5530 VTAB 16: PRINT TAB( 31)"*"
5540 VTAB 17: PRINT TAB( 25)"*"
5550 VTAB 21: PRINT TAB( 14)"."; TAB( 17)" ."
5560 VTAB 23: PRINT TAB( 14)"*"; TAB( 17)"*"
5570 PRINT
5580 GOSUB 7450
5590 INPUT "PRESS RETURN TO CONTINUE ";A$
5600 GOTO 7610
5610 C$ = "CANES VENATICI"
5620 HOME
5630 VTAB 11: PRINT TAB( 16)"."; TAB( 27)" ."
5640 VTAB 14: PRINT TAB( 20)"*"
5650 VTAB 20
5660 GOSUB 7450
5670 INPUT "PRESS RETURN TO CONTINUE ";A$
5680 GOTO 7610
5690 C$ = "CEPHEUS"
5700 HOME
5710 VTAB 5: PRINT TAB( 18)"*"
5720 VTAB 11: PRINT TAB( 24)"*"
5730 VTAB 13: PRINT TAB( 16)"*"
5740 VTAB 17: PRINT TAB( 25)"*"
5750 VTAB 18: PRINT TAB( 30)"*"
5760 VTAB 19: PRINT TAB( 17)"*"
5770 PRINT : PRINT : PRINT
5780 GOSUB 7450
5790 INPUT "PRESS RETURN TO CONTINUE ";A$
5800 GOTO 7610
5810 C$ = "CASSIOPEIA"
5820 HOME
5830 VTAB 6: PRINT TAB( 15)" ."
5840 VTAB 7: PRINT TAB( 14)" ."
5850 VTAB 12: PRINT TAB( 11)"*"
5860 VTAB 16: PRINT TAB( 20)"*"; TAB( 30)"*"
5870 VTAB 17: PRINT TAB( 15)"*"
5880 VTAB 18: PRINT TAB( 22)" ."
5890 VTAB 19: PRINT TAB( 24)"*"
5900 VTAB 21: PRINT TAB( 26)" ."
5910 PRINT : PRINT : PRINT
5920 GOSUB 7450
5930 INPUT "PRESS RETURN TO CONTINUE ";A$
5940 GOTO 7610
5950 C$ = "PERSEUS"
5960 S$ = "ALGOL"
5970 HOME
5980 VTAB 5: PRINT TAB( 23)" ."
5990 VTAB 7: PRINT TAB( 21)"* ."
```

CONST (continued)

```

6000 VTAB 10: PRINT TAB( 6) ". "; TAB( 18) "X"; TAB( 21) ". "; TAB( 25) ". "
6010 VTAB 11: PRINT TAB( 6) ". "
6020 VTAB 12: PRINT TAB( 8) ". "; TAB( 13) "*"
6030 VTAB 13: PRINT TAB( 22) ". "
6040 VTAB 16: PRINT TAB( 14) ". "
6050 IF FL = 1 THEN VTAB 17: PRINT TAB( 23) "" ;
6060 IF FL = 1 THEN FLASH : PRINT "*" : NORMAL : GOTO 6080
6070 VTAB 17: PRINT TAB( 23) "*"
6080 VTAB 18: PRINT TAB( 11) "*"
6090 VTAB 19: PRINT TAB( 24) ". "
6100 VTAB 21: PRINT TAB( 12) ". "
6110 VTAB 23: PRINT TAB( 13) "*" : PRINT
6120 IF FL = 1 THEN FL = 0: GOTO 7540
6130 GOSUB 7450
6140 INPUT "PRESS RETURN TO CONTINUE ";$
6150 GOTO 5970
6160 C$ = "ANDROMEDA"
6170 HOME
6180 VTAB 5: PRINT TAB( 14) ". "
6190 VTAB 6: PRINT TAB( 15) ". "
6200 VTAB 7: PRINT TAB( 33) ". "
6210 VTAB 8: PRINT TAB( 33) ". "
6220 VTAB 9: PRINT TAB( 34) ". "
6230 VTAB 10: PRINT TAB( 9) "*"
6240 VTAB 11: PRINT TAB( 14) ". "; TAB( 24) ". "
6250 VTAB 12: PRINT TAB( 23) ". "
6260 VTAB 14: PRINT TAB( 20) "*" ; TAB( 27) ". "
6270 VTAB 15: PRINT TAB( 26) ". "
6280 VTAB 16: PRINT TAB( 33) "*"
6290 VTAB 17: PRINT TAB( 26) ". " : PRINT : PRINT
6300 GOSUB 7450
6310 INPUT "PRESS RETURN TO CONTINUE ";$
6320 GOTO 7610
6330 C$ = "PEGASUS"
6340 HOME
6350 VTAB 6: PRINT TAB( 22) ". "
6360 VTAB 7: PRINT TAB( 19) "*"
6370 VTAB 9: PRINT TAB( 21) ". "
6380 VTAB 10: PRINT TAB( 22) ". "
6390 VTAB 13: PRINT TAB( 8) "*" ; TAB( 19) "*"
6400 VTAB 16: PRINT TAB( 23) "*"
6410 VTAB 17: PRINT TAB( 34) "*"
6420 VTAB 18: PRINT TAB( 28) "*"
6430 VTAB 22
6440 GOSUB 7450
6450 INPUT "PRESS RETURN TO CONTINUE ";$
6460 GOTO 7610
6470 C$ = "BOOTES"
6480 S$ = "ARCTURUS"
6490 HOME
6500 VTAB 6: PRINT TAB( 21) ". "
6510 VTAB 8: PRINT TAB( 22) ". "
6520 VTAB 10: PRINT TAB( 17) "*"
6530 VTAB 11: PRINT TAB( 20) "*"
6540 VTAB 13: PRINT TAB( 14) "*"
6550 VTAB 15: PRINT TAB( 21) ". "
6560 VTAB 17: PRINT TAB( 19) "*"

```

CONST (continued)

```

6570 IF FL = 1 THEN VTAB 20: PRINT TAB( 25)"";
6580 IF FL = 1 THEN FLASH : PRINT "X": NORMAL : GOTO 6600
6590 VTAB 20: PRINT TAB( 25)"X"
6600 VTAB 21: PRINT TAB( 30)"*"
6610 PRINT : PRINT
6620 IF FL = 1 THEN FL = 0: GOTO 7540
6630 GOSUB 7450
6640 INPUT "PRESS RETURN TO CONTINUE ";A$
6650 GOTO 6490
6660 C$ = "CORONA"
6670 S$ = "ALPHEKKA"
6680 HOME
6690 VTAB 7: PRINT TAB( 20)""
6700 VTAB 8: PRINT TAB( 9)""
6710 VTAB 10: PRINT TAB( 9)""; TAB( 22)""
6720 VTAB 12: PRINT TAB( 24)"*"
6730 VTAB 13: PRINT TAB( 14)"*"
6740 VTAB 14: PRINT TAB( 16)"* *";
6750 IF FL = 1 THEN PRINT TAB( 21)"";
6760 IF FL = 1 THEN FLASH : PRINT "X": NORMAL : GOTO 6780
6770 PRINT TAB( 21)"X"
6780 VTAB 21
6790 IF FL = 1 THEN FL = 0: GOTO 7540
6800 GOSUB 7450
6810 INPUT "PRESS RETURN TO CONTINUE ";A$
6820 GOTO 6680
6830 C$ = "AURIGA"
6840 S$ = "CAPELLA"
6850 HOME
6860 VTAB 5: PRINT TAB( 16)""
6870 IF FL = 1 THEN VTAB 10: PRINT TAB( 22)"";
6880 IF FL = 1 THEN FLASH : PRINT "X": NORMAL : GOTO 6900
6890 VTAB 10: PRINT TAB( 22)"X"
6900 VTAB 11: PRINT TAB( 14)"*"
6910 VTAB 12: PRINT TAB( 25)""
6920 VTAB 13: PRINT TAB( 24)""
6930 VTAB 15: PRINT TAB( 16)""
6940 VTAB 16: PRINT TAB( 14)"*"
6950 VTAB 18: PRINT TAB( 26)"*"
6960 VTAB 22
6970 IF FL = 1 THEN FL = 0: GOTO 7540
6980 GOSUB 7450
6990 INPUT "PRESS RETURN TO CONTINUE ";A$
7000 GOTO 6850
7010 C$ = "ERIDANUS"
7020 HOME
7030 VTAB 5: PRINT TAB( 25)""
7040 VTAB 6: PRINT TAB( 26)""
7050 VTAB 7: PRINT TAB( 19)""
7060 VTAB 10: PRINT TAB( 11)""; TAB( 14)""
7070 VTAB 11: PRINT TAB( 6)""
7080 VTAB 12: PRINT TAB( 17)""
7090 VTAB 13: PRINT TAB( 24)""; TAB( 28)""; TAB( 34)""
7100 VTAB 15: PRINT TAB( 24)""
7110 VTAB 16: PRINT TAB( 20)""
7120 VTAB 24: PRINT TAB( 15)""
7130 PRINT

```

CONST (continued)

```
7140 GOSUB 7450
7150 INPUT "PRESS RETURN TO CONTINUE ";A$
7160 GOTO 7610
7170 C$ = "MONOCEROS"
7180 HOME
7190 VTAB 6: PRINT TAB( 24)";."
7200 VTAB 8: PRINT TAB( 25)";."
7210 VTAB 10: PRINT TAB( 22)";."
7220 VTAB 11: PRINT TAB( 18)";."
7230 VTAB 12: PRINT TAB( 6)";."
7240 VTAB 14: PRINT TAB( 28)";."
7250 VTAB 15: PRINT TAB( 25)";."
7260 VTAB 16: PRINT TAB( 12)";."
7270 PRINT : PRINT
7280 GOSUB 7450
7290 INPUT "PRESS RETURN TO CONTINUE ";A$
7300 GOTO 7610
7310 C$ = "PISCIS AUSTRALIS"
7320 S$ = "FOMALHAUT"
7330 HOME
7340 VTAB 12: PRINT TAB( 16)";."
7350 IF FL = 1 THEN VTAB 14: PRINT TAB( 13)"";:
7360 IF FL = 1 THEN FLASH : PRINT "X": NORMAL : GOTO 7380
7370 VTAB 14: PRINT TAB( 13)"X"
7380 VTAB 15: PRINT TAB( 18)";." ; TAB( 24)";." ; TAB( 28)";."
7390 VTAB 16: PRINT TAB( 14)";."
7400 VTAB 20
7410 IF FL = 1 THEN FL = 0: GOTO 7540
7420 GOSUB 7450
7430 INPUT " PRESS RETURN TO CONTINUE";A$
7440 GOTO 7330
7450 REM SUB QUERY
7460 INPUT "NAME THIS CONSTELLATION ";A$
7470 IF A$ = C$ THEN FLASH : PRINT "CORRECT": NORMAL :FL = 1: RETURN
7480 A$ = ""
7490 PRINT CL$;: INPUT "TRY AGAIN ";A$
7500 IF A$ = C$ THEN GOTO 7470
7510 PRINT "YOU ARE STILL WRONG"
7520 PRINT " THE CONSTELLATION IS ";C$
7530 FL = 1: RETURN
7540 REM SUB STAR QUERY
7550 INPUT "NAME THIS STAR ";A$
7560 IF A$ = S$ THEN FLASH : PRINT "CORRECT": NORMAL : GOTO 7600
7570 INPUT "WRONG; TRY AGAIN ";A$
7580 IF A$ = S$ THEN GOTO 7560
7590 PRINT "STILL WRONG, THE STAR IS ";S$
7600 INPUT "PRESS RETURN TO CONTINUE ";A$
7610 HOME : PRINT : PRINT : PRINT : PRINT
7620 INPUT "ANOTHER TEST? Y/N ";A$
7630 IF A$ = "N" THEN HOME : GOTO 7700
7640 IF A$ < > "Y" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 7620
7650 HOME
7660 IF FL = 1 THEN GOTO 7680
7670 FL = 0
7680 Z = Z + 1
7690 X = FRE (0):Y = FRE (A$): GOTO 420
7700 END
```

CONSH

```
8000 REM SUPPLEMENTARY PROGRAM
8010 REM FOR CONSTELLATIONS OF
8020 REM THE SOUTHERN HEMISPHERE
8030 HOME
8040 VTAB 10: PRINT "SOUTHERN HEMISPHERE CONSTELLATIONS"
8050 PRINT : PRINT : PRINT : PRINT
8060 PRINT TAB( 6)"BY ERIC BURGESS F.R.A.S."
8070 PRINT TAB( 6)"ALL RIGHTS RESERVED BY"
8080 PRINT TAB( 6)"S & T SOFTWARE SERVICE"
8090 PRINT : PRINT : PRINT
8100 INPUT "PRESS RETURN WHEN READY ";A$
8110 W = 1
8120 A = RND (W) * 14
8130 A = INT (A) + 1
8140 FL = 0
8150 ON A GOSUB 8160,8260,8370,8530,8670,8780,8880,9010,9200,9370,9500,
9620,9720,9830
8160 C$ = "CHAMAELEON"
8170 HOME
8180 VTAB 11: PRINT TAB( 21)"*"
8190 VTAB 12: PRINT TAB( 28)"*"
8200 VTAB 14: PRINT TAB( 9)"*"; TAB( 20)"*"; TAB( 27)"*"
8210 VTAB 15: PRINT TAB( 8)"*"
8220 VTAB 22
8230 GOSUB 9940
8240 INPUT "PRESS RETURN TO CONTINUE ";A$
8250 GOTO 10030
8260 C$ = "MUSCA"
8270 HOME
8280 VTAB 9: PRINT TAB( 18)"*"; TAB( 22)"*"
8290 VTAB 12: PRINT TAB( 19)"*"
8300 VTAB 13: PRINT TAB( 20)"*"
8310 VTAB 14: PRINT TAB( 17)". "
8320 VTAB 15: PRINT TAB( 13)". "
8330 VTAB 22
8340 GOSUB 9940
8350 INPUT "PRESS RETURN TO CONTINUE ";A$
8360 GOTO 10030
8370 C$ = "HYDRUS"
8380 HOME
8390 S$ = "ACHERNAR"
8400 VTAB 5: PRINT TAB( 11)"*"
8410 VTAB 7: PRINT TAB( 26)". "; TAB( 31)"*"
8420 VTAB 13: PRINT TAB( 22)". "
8430 VTAB 14: PRINT TAB( 19)". "; TAB( 24)". "
8440 VTAB 19: PRINT TAB( 19)"*"
8450 IF FL = 1 THEN VTAB 21: PRINT TAB( 14)"";
8460 IF FL = 1 THEN FLASH : PRINT TAB( 14)"";
8470 IF FL = 1 THEN FLASH : PRINT "X": NORMAL : GOTO 8490
8480 VTAB 21: PRINT TAB( 14)"X"
8490 IF FL = 1 THEN FL = 0: GOTO 10080
8500 GOSUB 9940
8510 INPUT "PRESS RETURN TO CONTINUE ";A$
```

CONSH (continued)

```
8520 HOME : GOTO 8400
8530 C$ = "PAVO"
8540 HOME
8550 VTAB 6: PRINT TAB( 25)"*"
8560 VTAB 8: PRINT TAB( 18)"*"
8570 VTAB 12: PRINT TAB( 19)"*"
8580 VTAB 13: PRINT TAB( 25)"*"; TAB( 31)"*"; TAB( 36)"*"
8590 VTAB 14: PRINT TAB( 5)"*"
8600 VTAB 15: PRINT TAB( 9)"."
8610 VTAB 16: PRINT TAB( 13)"."; TAB( 17)"*"
8620 VTAB 17: PRINT TAB( 12)"."
8630 VTAB 20: PRINT TAB( 28)"*"
8640 GOSUB 9940
8650 INPUT "PRESS RETURN TO CONTINUE ";A$
8660 GOTO 10030
8670 C$ = "TUCANA"
8680 HOME
8690 VTAB 9: PRINT TAB( 11)"."; TAB( 26)"."
8700 VTAB 10: PRINT TAB( 28)"*"
8710 VTAB 12: PRINT TAB( 31)"*"
8720 VTAB 14: PRINT TAB( 9)"*"
8730 VTAB 16: PRINT TAB( 21)"*"
8740 VTAB 22
8750 GOSUB 9940
8760 INPUT "PRESS RETURN TO CONTINUE ";A$
8770 GOTO 10030
8780 C$ = "APUS"
8790 HOME
8800 VTAB 11: PRINT TAB( 11)"."
8810 VTAB 12: PRINT TAB( 11)"."
8820 VTAB 13: PRINT TAB( 13)"*"; TAB( 22)"* *"
8830 VTAB 15: PRINT TAB( 25)"*"
8840 VTAB 22
8850 GOSUB 9940
8860 INPUT "PRESS RETURN TO CONTINUE ";A$
8870 GOTO 10030
8880 C$ = "CENTAURUS"
8890 HOME
8900 VTAB 5: PRINT TAB( 31)"*"
8910 VTAB 9: PRINT TAB( 20)"."; TAB( 26)"*"; TAB( 31)"X"
8920 VTAB 12: PRINT TAB( 28)"."
8930 VTAB 15: PRINT TAB( 10)"."; TAB( 22)"*"
8940 VTAB 16: PRINT TAB( 23)"."
8950 VTAB 17: PRINT TAB( 8)"*"
8960 VTAB 19: PRINT TAB( 23)"*"
8970 VTAB 21: PRINT TAB( 20)"." ."; TAB( 29)"*"
8980 GOSUB 9940
8990 INPUT "PRESS RETURN TO CONTINUE ";A$
9000 GOTO 10030
9010 C$ = "CARINA"
9020 S$ = "CANOPUS"
9030 HOME
9040 VTAB 5: PRINT TAB( 20)"*"; TAB( 27)"*"
9050 VTAB 8: PRINT TAB( 15)"."; TAB( 19)"*"
9060 VTAB 9: PRINT TAB( 23)"*"; TAB( 30)"*"
```

CONSH (continued)

```

9070 VTAB 12: PRINT TAB( 26)"* *"
9080 VTAB 14: PRINT TAB( 15)"*"; TAB( 20)"**"; TAB( 24)". "
9090 VTAB 17: PRINT TAB( 18)"*"; TAB( 24)"*"
9100 VTAB 19: PRINT TAB( 12)"*"
9110 IF FL = 1 THEN VTAB 20: PRINT TAB( 3)"";
9120 IF FL = 1 THEN FLASH : PRINT TAB( 3)"";
9130 IF FL = 1 THEN FLASH : PRINT "X": NORMAL : GOTO 9150
9140 VTAB 20: PRINT TAB( 3)"X"
9150 VTAB 21
9160 IF FL = 1 THEN FL = 0: GOTO 10080
9170 GOSUB 9940
9180 INPUT "PRESS RETURN TO CONTINUE ";A$
9190 GOTO 9030
9200 C$ = "LUPUS"
9210 HOME
9220 VTAB 6: PRINT TAB( 22)"*"
9230 VTAB 7: PRINT TAB( 12)". "
9240 VTAB 8: PRINT TAB( 14)". "
9250 VTAB 9: PRINT TAB( 22)". "
9260 VTAB 10: PRINT TAB( 15)"*"; TAB( 20)". "; TAB( 23)". "
9270 VTAB 11: PRINT TAB( 21)". "
9280 VTAB 12: PRINT TAB( 23)"*"
9290 VTAB 13: PRINT TAB( 18)"*"
9300 VTAB 14: PRINT TAB( 23)"*"; TAB( 26)"*"
9310 VTAB 17: PRINT TAB( 22)". "; TAB( 32)"*"
9320 VTAB 19: PRINT TAB( 29)". "
9330 VTAB 22
9340 GOSUB 9940
9350 INPUT "PRESS RETURN TO CONTINUE ";A$
9360 GOTO 10030
9370 C$ = "ARA"
9380 HOME
9390 VTAB 6: PRINT TAB( 26)". "
9400 VTAB 9: PRINT TAB( 24)"*"
9410 VTAB 11: PRINT TAB( 17)"*"
9420 VTAB 13: PRINT TAB( 23)"*"
9430 VTAB 14: PRINT TAB( 18)"*"; TAB( 23)"*"
9440 VTAB 16: PRINT TAB( 18)". "
9450 VTAB 19: PRINT TAB( 24)"*"; TAB( 30)". "
9460 VTAB 22
9470 GOSUB 9940
9480 INPUT "PRESS RETURN TO CONTINUE ";A$
9490 GOTO 10030
9500 C$ = "PHOENIX"
9510 HOME
9520 VTAB 7: PRINT TAB( 22)"*"
9530 VTAB 13: PRINT TAB( 28)"*"
9540 VTAB 14: PRINT TAB( 8)"*"; TAB( 16)". "; TAB( 22)"*"
9550 VTAB 15: PRINT TAB( 31)". "
9560 VTAB 16: PRINT TAB( 12)"*"; TAB( 33)". "
9570 VTAB 18: PRINT TAB( 12)"*"; TAB( 26)"*"
9580 VTAB 22
9590 GOSUB 9940
9600 INPUT "PRESS RETURN TO CONTINUE ";A$
9610 GOTO 10030

```

CONSH (continued)

```

9620 C$ = "TRIANGULUM AUSTRALIS"
9630 HOME
9640 VTAB 9: PRINT TAB( 22) ". "
9650 VTAB 10: PRINT TAB( 14) "*" ; TAB( 25) "*"
9660 VTAB 12: PRINT TAB( 16) ". "
9670 VTAB 14: PRINT TAB( 18) "*" ; TAB( 22) ". "
9680 VTAB 22
9690 GOSUB 9940
9700 INPUT "PRESS RETURN TO CONTINUE ";A$
9710 GOTO 10030
9720 C$ = "GRUS"
9730 HOME
9740 VTAB 7: PRINT TAB( 22) ". "
9750 VTAB 8: PRINT TAB( 20) "*"
9760 VTAB 12: PRINT TAB( 12) "*" ; TAB( 21) "*"
9770 VTAB 14: PRINT TAB( 28) ". "
9780 VTAB 16: PRINT TAB( 27) ". "
9790 VTAB 22
9800 GOSUB 9940
9810 INPUT "PRESS RETURN TO CONTINUE ";A$
9820 GOTO 10030
9830 C$ = "CRUX"
9840 HOME
9850 VTAB 8: PRINT TAB( 20) "X"
9860 VTAB 11: PRINT TAB( 17) ". "
9870 VTAB 12: PRINT TAB( 25) "*"
9880 VTAB 13: PRINT TAB( 15) "*"
9890 VTAB 15: PRINT TAB( 20) "*" ; TAB( 25) ". "
9900 VTAB 22
9910 GOSUB 9940
9920 INPUT "PRESS RETURN TO CONTINUE ";A$
9930 GOTO 10030
9940 REM SUBROUTINE FOR QUERY
9950 INPUT "NAME THIS CONSTELLATION ";A$
9960 IF A$ = C$ THEN FLASH : PRINT "CORRECT": NORMAL : FL = 1: RETURN
9970 A$ = ""
9980 PRINT CL$;: INPUT "TRY AGAIN ";A$
9990 IF A$ = C$ THEN GOTO 9960
10000 PRINT "YOU ARE STILL WRONG"
10010 PRINT "THE CONSTELLATION IS ";C$
10020 FL = 1: RETURN
10030 HOME : PRINT : PRINT : PRINT
10040 INPUT "ANOTHER TEST? Y/N ";A$
10050 IF A$ = "N" THEN HOME : GOTO 10160
10060 IF A$ < > "Y" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 10030
10070 W = W + A: GOTO 8120
10080 REM SUB STAR QUERY
10090 INPUT "NAME THIS STAR ";A$
10100 IF A$ = S$ THEN FLASH : PRINT "CORRECT": NORMAL : GOTO 10140
10110 INPUT "WRONG; TRY AGAIN ";A$
10120 IF A$ = S$ THEN GOTO 10100
10130 PRINT "STILL WRONG, THE STAR IS ";S$
10140 INPUT "PRESS RETURN TO CONTINUE ";A$
10150 HOME : PRINT : PRINT : PRINT : GOTO 10030
10160 HOME
10170 END

```




11

Faint, illegible text or a caption located below the illustration, possibly describing the scene or providing a title.



Photo Credit: NASA

Anyone interested in astronomy often wants to refer to data about the planets and their satellites: How large is the Moon? How far away is it from Earth? How massive are other satellites compared with our Moon? The questions are unlimited. The following

program gives a menu from which to select information about the planets and their satellites and about the larger asteroids, the Sun, and the Moon. This Apollo 15 picture shows the brightest crater on the Moon, Aristarchus.

Program 22: PLNDT

Solar System Data

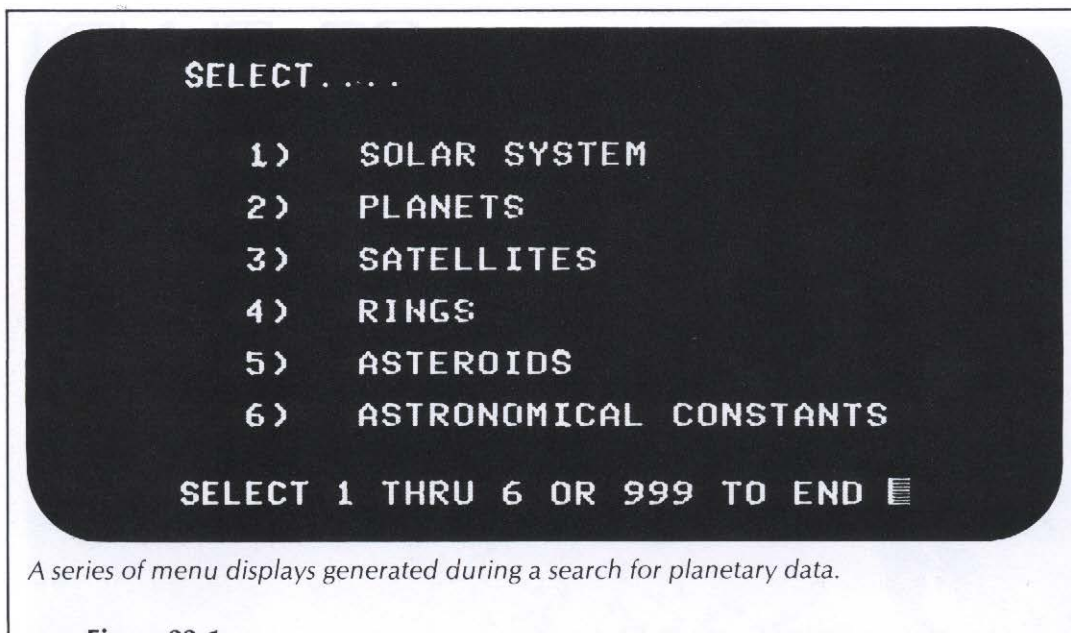
Amateur astronomers often find themselves trying to locate data about a planet or a satellite for observation, for calculations, or merely for information. Sometimes the item of data you want does not appear in the books you have access to, or cannot be located easily. With this program you can always have these important items of astronomical data available for quick access—in the time it takes to load a disk into your system. The program offers several menus—the solar system, planets, satellites, rings, and astronomical constants. There are also submenus allowing quick access to information of greater detail. Typical displays of the program are shown in Figure 22.1a–d.

The data are the most current available, but the remark (REM) statements will allow you to update data as it becomes available or is refined in the future.

Not all of the small satellites of Jupiter and Saturn are included, but when you are keying in the program these could be added, if you wish, at the appropriate places. Note that in the data statements 0.0 is used where values are either extremely small or not clearly defined. These data also can be amended if you wish.

Take great care when entering the data. A single misplaced comma or period can produce wild data throughout the program.

The listing for the PLNDT program follows.



A series of menu displays generated during a search for planetary data.

Figure 22.1a

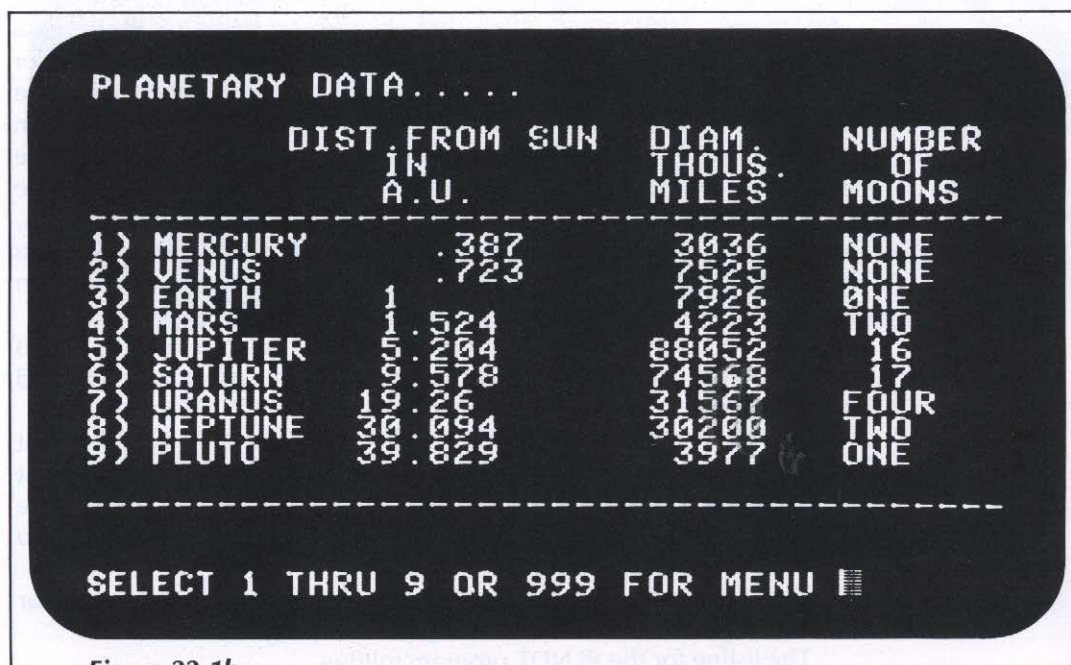


Figure 22.1b

SELECT . . .

- 1) ORBITAL DETAILS
- 2) PHYSICAL DETAILS
OF PLANET
- 3) SATELLITES
- 4) RINGS
- 999) RETURN TO MENU

SELECT 1 THRU 4 OR 999 █

Figure 22.1c

PHYSICAL DETAILS OF MARS

EQUATORIAL DIAM. (MILES)	4223
POLAR DIAM. (MILES)	4201
MASS (EARTH=1)	.108
DENSITY	3.9
ROTATION PERIOD (HOURS)	24.62
AXIS INCLINATION (DEG.)	25.2
SURFACE GRAVITY (G'S)	.38
ALBEDO	.15

PRESS RETURN TO CONTINUE █

Figure 22.1d

PLNDT

```

10 HOME : PRINT : PRINT
20 DIM PD(10,16),JD(12,6),SD(18,8)
30 DIM UD(5,6),ND(2,6),DM(2,6),DA(10,9)
40 PRINT "PLEASE WAIT; LOADING DATA"
50 GOSUB 1680: GOSUB 1910: GOSUB 2080: GOSUB 2310
60 GOSUB 2420: GOSUB 2490: GOSUB 2560
70 HOME : PRINT : PRINT
80 PRINT : PRINT
90 PRINT TAB( 8)"-----"
100 PRINT TAB( 8)"I    SOLAR SYSTEM    I"
110 PRINT TAB( 8)"-----"
120 PRINT : PRINT
130 PRINT TAB( 9)"AN ASTRONOMY PROGRAM"
140 PRINT TAB( 6)"BY ERIC BURGESS F.R.A.S."
150 PRINT : PRINT
160 PRINT TAB( 7)"ALL RIGHTS RESERVED BY"
170 PRINT TAB( 7)"S & T SOFTWARE SERVICE"
180 PRINT : PRINT
190 PRINT "PROVIDES DATA ON SOLAR SYSTEM OBJECTS"
200 FOR K = 1500 TO 0 STEP - 1: NEXT K
210 HOME : PRINT : PRINT
220 PRINT "SELECT...."
230 PRINT : PRINT
240 PRINT TAB( 4)"1)    SOLAR SYSTEM"
250 PRINT : PRINT TAB( 4)"2)    PLANETS"
260 PRINT : PRINT TAB( 4)"3)    SATELLITES"
270 PRINT : PRINT TAB( 4)"4)    RINGS"
280 PRINT : PRINT TAB( 4)"5)    ASTEROIDS"
290 PRINT : PRINT TAB( 4)"6)    ASTRONOMICAL CONSTANTS"
300 PRINT : PRINT
310 INPUT "SELECT 1 THRU 6 OR 999 TO END ";M
320 IF M = 999 THEN M = 7
330 ON M GOTO 340,2710,5590,580,3510,7730,8100
340 HOME : PRINT
350 PRINT "SOLAR SYSTEM... ": PRINT
360 PRINT TAB( 20)"DIST. FROM SUN"
370 PRINT TAB( 24)"IN A.U."
380 PRINT "-----"
390 PRINT "1)  SUN"; TAB( 27)"N/A"
400 PRINT "2)  MERCURY"; TAB( 28)PD(1,1)
410 PRINT "3)  VENUS"; TAB( 28)PD(2,1)
420 PRINT "4)  EARTH"; TAB( 26)PD(3,1)
430 PRINT "5)  MARS"; TAB( 26)PD(4,1)
440 PRINT "6)  ASTEROIDS"; TAB( 26)PD(10,1)
450 PRINT "7)  JUPITER"; TAB( 26)PD(5,1)
460 PRINT "8)  SATURN"; TAB( 26)PD(6,1)
470 PRINT "9)  URANUS"; TAB( 25)PD(7,1)
480 PRINT "10) NEPTUNE"; TAB( 25)PD(8,1)
490 PRINT "11) PLUTO"; TAB( 25)PD(9,1)
500 PRINT
510 PRINT "-----"
520 PRINT
530 INPUT "SELECT 1 THRU 11 OR 999 FOR MENU ";N

```

PLNDT (continued)

```

540 IF N > 1 AND N < 6 THEN P = N - 1: GOTO 560
550 IF N > 6 THEN P = N - 2
560 IF N = 999 THEN N = 12
570 ON N GOTO 1450,2940,3050,3160,3280,3510,3840,4180,4710,5030,5260,210
580 HOME : PRINT : PRINT
590 PRINT "PLANETARY RINGS"
600 PRINT : PRINT
610 PRINT "-----"
620 PRINT TAB( 4)"1) JUPITER"
630 PRINT : PRINT TAB( 4)"2) SATURN"
640 PRINT : PRINT TAB( 4)"3) URANUS"
650 PRINT : PRINT TAB( 4)"4) OTHERS"
660 PRINT "-----"
670 PRINT : PRINT
680 INPUT "SELECT 1 THRU 4 OR 999 FOR MENU ";Z
690 IF Z = 999 THEN Z = 5
700 ON Z GOTO 710,900,1130,1320,210
710 HOME : PRINT : PRINT : PRINT
720 PRINT "JUPITER'S RING SYSTEM"
730 PRINT
740 PRINT "-----"
750 PRINT TAB( 8)"INNER DIAM."; TAB( 20)"WIDTH"
760 PRINT TAB( 12)"MILES"; TAB( 20)"MILES"
770 PRINT
780 PRINT "RING 1"; TAB( 10)"29,200"; TAB( 20)"3,100"
790 PRINT
800 PRINT "RING 2"; TAB( 10)"32,435"; TAB( 20)" 500"
810 PRINT
820 PRINT "A VERY TENUOUS RING SYSTEM EXTENDS"
830 PRINT "FROM THE INNERMOST RING TO THE PLANET"
840 PRINT
850 PRINT "-----"
860 PRINT
870 INPUT "PRESS RETURN TO CONTINUE ";A$
880 IF F = 1 THEN F = 0: GOTO 3840
890 GOTO 580
900 REM SATURN'S RINGS
910 HOME : PRINT : PRINT : PRINT
920 PRINT "RING SYSTEM OF SATURN"
930 PRINT "-----"
940 PRINT : PRINT TAB( 8)"INNER DIAM."; TAB( 20)"WIDTH"
950 PRINT TAB( 12)"MILES"; TAB( 20)"MILES"
960 PRINT
970 PRINT "D RING"; TAB( 10)" 41,600"; TAB( 20)" 4,350"
980 PRINT "C RING"; TAB( 10)" 49,580"; TAB( 20)" 11,120"
990 PRINT "B RING"; TAB( 10)" 56,850"; TAB( 20)" 15,840"
1000 PRINT "A RING"; TAB( 10)" 75,740"; TAB( 20)" 9,130"
1010 PRINT "F RING"; TAB( 10)" 87,180"; TAB( 20)" 6,60"
1020 PRINT "G RING"; TAB( 10)"105,630"; TAB( 20)" 6,210"
1030 PRINT "E RING"; TAB( 10)"111,845"; TAB( 20)"186,400"
1040 PRINT
1050 PRINT "DIVISIONS"
1060 PRINT "CASINI"; TAB( 10)" 72950"; TAB( 20)" 2,800"
1070 PRINT "ENCKE"; TAB( 10)" 82,790"; TAB( 20)" 200"
1080 PRINT

```

PLNDT (continued)

```

1090 PRINT "-----"
1100 INPUT "PRESS RETURN TO CONTINUE ";A$
1110 IF F = 1 THEN F = 0: GOTO 4180
1120 GOTO 580
1130 REM URANUS' RINGS
1140 HOME : PRINT : PRINT : PRINT
1150 PRINT "URANUS' RING SYSTEM"
1160 PRINT "-----"
1170 PRINT TAB( 8)"INNER DIAM."; TAB( 20)"WIDTH"
1180 PRINT TAB( 12)"MILES"; TAB( 20)"MILES"
1190 PRINT
1200 PRINT "RING 6"; TAB( 10)"26,300"; TAB( 22)"5"
1210 PRINT "RING 7"; TAB( 10)"26,500"; TAB( 22)"5"
1220 PRINT "RING 1"; TAB( 10)"27,800"; TAB( 22)"6"
1230 PRINT "RING 2"; TAB( 10)"28,700"; TAB( 22)"6"
1240 PRINT "RING 3"; TAB( 10)"29,600"; TAB( 22)"6"
1250 PRINT "RING 4"; TAB( 10)"30,600"; TAB( 22)"6"
1260 PRINT "RING 5"; TAB( 10)"31,500"; TAB( 20)"100"
1270 PRINT
1280 PRINT "-----"
1290 INPUT "PRESS RETURN TO CONTINUE ";A$
1300 IF F = 1 THEN F = 0: GOTO 4710
1310 GOTO 580
1320 REM OTHERS
1330 HOME : PRINT : PRINT : PRINT
1340 PRINT "OTHER RINGS?"
1350 PRINT "-----"
1360 PRINT : PRINT
1370 PRINT "NO PLANETS OTHER THAN JUPITER, SATURN,"
1380 PRINT "AND URANUS APPEAR TO HAVE RINGS"
1390 PRINT "BUT THERE HAVE BEEN SPECULATIONS"
1400 PRINT "THAT NEPTUNE MAY HAVE A RING SYSTEM"
1410 PRINT "-----"
1420 INPUT "PRESS RETURN TO CONTINUE ";A$
1430 IF F = 1 THEN F = 0: GOTO 5030
1440 GOTO 580
1450 REM DATA FOR SUN
1460 HOME : PRINT : PRINT : PRINT
1470 PRINT "THE SUN - OUR NEAREST STAR"
1480 PRINT "-----"
1490 PRINT "DISTANCE (MILLION MI)"; TAB( 30)" 92.953"
1500 PRINT
1510 PRINT "DIAMETER (MILES)"; TAB( 30)"864,000"
1520 PRINT
1530 PRINT "MASS (EARTH=1)"; TAB( 30)"332,958"
1540 PRINT
1550 PRINT "ROTATION PERIOD (DAYS)"; TAB( 30)" 25.38"
1560 PRINT
1570 PRINT "AXIS INCLINATION (DEG..)"; TAB( 30)" 7.25"
1580 PRINT " (TO ECLIPTIC)"
1590 PRINT
1600 PRINT "SUNSPOT CYCLE (YEARS)"; TAB( 30)" 11"
1610 PRINT
1620 PRINT "SPECTRAL TYPE"; TAB( 30)" G"
1630 PRINT

```


PLNDT (continued)

```

1640 PRINT "-----"
1650 PRINT
1660 INPUT "PRESS RETURN TO CONTINUE ";A$
1670 GOTO 210
1680 REM DATA FOR PLANETS
1690 FOR XP = 1 TO 9: FOR YP = 1 TO 16
1700 READ PD(XP,YP)
1710 NEXT YP,XP
1720 REM MERCURY
1730 DATA .387,3036,3036,.055,5.4,.06,.27,58.7,0,.2056,7.0044,.241,48.0994,
77.1511,4.0923,158.2455
1740 REM VENUS
1750 DATA .723,7525,7525,.817,5.2,.65,.85,243,178,.0068,3.9444,.6115,
76.5038,131.2958,1.6021,226.0461
1760 REM EARTH
1770 DATA 1.7926,7899,1,5.5,.55,1,23.92,23.4,.0167,0,1,0,102.604,.9856,
357.2227
1780 REM MARS
1790 DATA 1.524,4223,4201,.108,3.9,.15,.38,24.62,25.2,.0934,1.85,1.881,
49.4066,335.699,.5240,151.1544
1800 REM JUPITER
1810 DATA 5.204,88052,82417,318.4,1.31,.42,2.33,9.84,3.07,.0478,1.3057,
11.86,100.2448,14.5847,.0831,132.7203
1820 REM SATURN
1830 DATA 9.578,74568,67111,95.2,.7,.45,.92,10.22,26.74,.0555,2.4864,29.46,
113.5115,95.4709,.0334,69.5615
1840 REM URANUS
1850 DATA 19.260,31567,30052,15,1.31,.46,.85,10.82,97.93,.00503,.7716,84.01,
74.0054,172.9222,.01166,54.9953
1860 REM NEPTUNE
1870 DATA 30.094,30200,29596,17.2,1.66,.53,1.12,15.67,28.8,.0066,1.7730,
164.8,131.5228,58.512,.00597,199.748
1880 REM PLUTO
1890 RETURN
1900 DATA 39.829,3977,3977,.1,4.9,.14,.44,153.84,0,.2548,17.1372,248.6,
109.9658,223.0141,.00392,346.4629
1910 REM DATA FOR JOVIAN SATELLITES
1920 FOR JS = 1 TO 12: FOR SJ = 1 TO 6
1930 READ JD(JS,SJ)
1940 NEXT SJ,JS
1950 DATA 112.8,.0028,.455,.498,.00008,125
1960 DATA 262.2,0,.027,1.77,.98,2262
1970 DATA 417.2,.0003,.47,3.55,.65,1864
1980 DATA 665.5,.0015,.18,7.15,2.1,3274.6
1990 DATA 1170.6,.0075,.25,16.69,1.3,3107
2000 DATA 7137,.158,27.6,250.57,.00003,106
2010 DATA 7299,.207,24.8,259.65,0.0,50
2020 DATA 7370,.13,29,263.55,0.0,15
2030 DATA 13204,.169,147,631,0.0,12
2040 DATA 14005,.207,164,692,0.0,20
2050 DATA 14608,.378,145,739,0.0,22
2060 DATA 14707,.275,153,758,0.0,17
2070 RETURN
2080 REM DATA FOR SATURN SATELLITES
2090 FOR SS = 1 TO 18: FOR SA = 1 TO 8

```

PLNDT (continued)

```

2100 READ SD(SS,SA)
2110 NEXT SA: NEXT SS
2120 DATA 85.5,0.0,0.0,.602,0.0,48,0.0,.4
2130 DATA 86.6,0.0,0.0,-.613,0.0,37,0.0,.6
2140 DATA 88.0,0.0,0.0,-.629,0.0,56,0.0,.6
2150 DATA 94.1,0.0,0.0,.694,0.0,75,0.0,.4
2160 DATA 94.1,0.0,0.0,.694,0.0,125,0.0,.4
2170 DATA 115.3,.02,1.5,.943,.00005,244,1.44,.6
2180 DATA 115.6,0.0,0.0,0.0,0.0,0.0,0.0,0.0
2190 DATA 147.9,.004,.0002,1.37,.001,310,1.16,.9
2200 DATA 183.1,0,.0008,1.888,.0088,659,1.21,.8
2210 DATA 183.1,0.0,0.0,1.888,0.0,18,0.0,.6
2220 DATA 183.1,0.0,0.0,1.888,0.0,17,0.0,.8
2230 DATA 234.5,.002,.0002,2.737,.0143,696,1.43,.62
2240 DATA 234.9,0.0,0.0,2.739,0.0,21,0.0,.5
2250 DATA 327.5,.001,.35,4.518,.02,951,1.33,.65
2260 DATA 759.2,.029,.333,15.945,1.87,3200,1.88,.2
2270 DATA 920.2,-.104,0.0,21.27,0.0,186,0.0,.3
2280 DATA 2212.5,.028,14.72,79.58,.02,907,1.16,.5
2290 DATA 8048.9,.163,150.05,550.45,0.0,137,0.0,.06
2300 RETURN
2310 REM DATA FOR OTHER SATELLITES
2320 REM URANUS
2330 FOR US = 1 TO 5: FOR SU = 1 TO 6
2340 READ UD(US,SU)
2350 NEXT SU: NEXT US
2360 DATA 80.65,.01,0.0,1.414,.0004,186
2370 DATA 118.6,.0033,0.0,2.52,.018,497
2380 DATA 165.3,.011,0.0,4.144,.0073,342
2390 DATA 270.9,.0018,0.0,8.706,.0593,621
2400 DATA 362.5,.0007,0.0,13.463,.034,559
2410 RETURN
2420 REM NEPTUNE SATELLITES
2430 FOR NS = 1 TO 2: FOR SN = 1 TO 6
2440 READ ND(NS,SN)
2450 NEXT SN,NS
2460 DATA 220.9,0,159.95,5.88,1.9,2361
2470 DATA 3459.1,.75,27.71,359.9,.006,186
2480 RETURN
2490 REM MARS SATELLITES
2500 FOR MS = 1 TO 2: FOR SM = 1 TO 6
2510 READ MD(MS,SM)
2520 NEXT SM: NEXT MS
2530 DATA .5828,.015,1.0,.3189,0.0,13.5
2540 DATA 1457.7,.0005,2.0,1.2624,0.0,7.1
2550 RETURN
2560 REM SUB FOR ASTEROID DATA
2570 FOR AA = 1 TO 10: FOR MA = 1 TO 9
2580 READ DA(AA,MA)
2590 NEXT MA: NEXT AA
2600 DATA 2.7675,623,.0783,10.605,4.604,.21408,80.051,73.545,88.020
2610 DATA 2.7737,378,.2326,34.794,4.6195,.21336,172.712,310.045,78.086
2620 DATA 2.3612,334,.0892,7.143,3.6284,.27164,103.442,150.133,57.113
2630 DATA 3.1355,280,-.1196,3.836,5.5522,-.17752,283.125,317.987,289.675
2640 DATA 2.9223,155,-.1370,3.092,4.9956,-.19730,150.123,226.152,167.565

```

PLNDT (continued)

```

2650 DATA 3.1462,230,.2276,26.343,5.5808,.17661,30.676,63.506,241.231
2660 DATA 3.4363,192,.1075,3.549,6.3704,.115472,155.472,110.074,337.052
2670 DATA 3.061,172,.0674,15.213,5.3739,.18341,89.06,341.210,153.493
2680 DATA 3.1806,200,.1744,15.908,5.6723,.17376,107.387,338.661,151.999
2690 DATA 3.0596,217,.1522,17.288,5.3517,.18417,280.481,91.777,159.192
2700 RETURN
2710 HOME : PRINT
2720 PRINT "PLANETARY DATA..... "
2730 PRINT
2740 PRINT TAB( 10)"DIST.FROM SUN"; TAB( 25)"DIAM."; TAB( 33)"NUMBER"
2750 PRINT TAB( 14)"IN"; TAB( 25)"THOUS."; TAB( 35)"OF"
2760 PRINT TAB( 14)"A.U."; TAB( 25)"MILES"; TAB( 33)"MOONS"
2770 PRINT "-----"
2780 PRINT "1) MERCURY"; TAB( 16)PD(1,1); TAB( 26)PD(1,2); TAB( 33)"NONE"
2790 PRINT "2) VENUS"; TAB( 16)PD(2,1); TAB( 26)PD(2,2); TAB( 33)"NONE"
2800 PRINT "3) EARTH"; TAB( 14)PD(3,1); TAB( 26)PD(3,2); TAB( 33)"ONE"
2810 PRINT "4) MARS"; TAB( 14)PD(4,1); TAB( 26)PD(4,2); TAB( 33)"TWO"
2820 PRINT "5) JUPITER"; TAB( 14)PD(5,1); TAB( 25)PD(5,2); TAB( 33)" 16"
2830 PRINT "6) SATURN"; TAB( 14)PD(6,1); TAB( 25)PD(6,2); TAB( 33)" 17"
2840 PRINT "7) URANUS"; TAB( 13)PD(7,1); TAB( 25)PD(7,2); TAB( 33)"FOUR"
2850 PRINT "8) NEPTUNE"; TAB( 13)PD(8,1); TAB( 25)PD(8,2); TAB( 33)"TWO"
2860 PRINT "9) PLUTO"; TAB( 13)PD(9,1); TAB( 26)PD(9,2); TAB( 33)"ONE"
2870 PRINT
2880 PRINT "-----"
2890 PRINT : PRINT
2900 INPUT "SELECT 1 THRU 9 OR 999 FOR MENU ";N
2910 IF N = 999 THEN N = 10
2920 P = N
2930 ON N GOTO 2940,3050,3160,3280,3840,4180,4710,5030,5260,210
2940 REM SUB FOR MERCURY
2950 P$ = "MERCURY"
2960 GOSUB 7930
2970 IF DS = 3 THEN HOME : PRINT "MERCURY HAS NO SATELLITE": GOTO 3020
2980 IF DS = 4 THEN HOME : PRINT "MERCURY HAS NO RINGS": GOTO 3020
2990 ON DS GOSUB 7220,7460,7730,210
3000 IF DS < > 5 GOTO 2960
3010 GOTO 210
3020 PRINT : PRINT
3030 INPUT "PRESS RETURN TO CONTINUE ";A$
3040 GOTO 2960
3050 REM SUB FOR VENUS
3060 P$ = "VENUS"
3070 GOSUB 7930
3080 IF DS = 3 THEN HOME : PRINT "VENUS HAS NO SATELLITE": GOTO 3130
3090 IF DS = 4 THEN HOME : PRINT "VENUS HAS NO RINGS": GOTO 3130
3100 ON DS GOSUB 7220,7460,7730,210
3110 IF DS < > 5 GOTO 3070
3120 GOTO 210
3130 PRINT : PRINT
3140 INPUT "PRESS RETURN TO CONTINUE ";A$
3150 GOTO 3070
3160 REM SUB FOR EARTH
3170 P$ = "EARTH"
3180 GOSUB 7930
3190 IF DS = 3 THEN S$ = "MOON": GOTO 3240

```

PLNDT (continued)

```

3200 IF DS = 4 THEN HOME : PRINT "EARTH HAS NO RINGS": GOTO 3260
3210 ON DS GOSUB 7220,7460,7730,210
3220 IF DS < > 5 GOTO 3180
3230 GOTO 210
3240 F = 1
3250 GOTO 6030
3260 PRINT : INPUT "PRESS RETURN TO CONTINUE ";A$
3270 GOTO 3180
3280 REM MARS DETAILS
3290 HOME : PRINT : PRINT : PRINT
3300 P$ = "MARS"
3310 GOSUB 7930
3320 IF DS = 3 THEN GOTO 3370
3330 IF DS = 4 THEN HOME : PRINT "MARS HAS NO RINGS": GOTO 3490
3340 ON DS GOSUB 7220,7460,7730,210
3350 IF DS < > 5 GOTO 3310
3360 GOTO 210
3370 HOME : PRINT : PRINT
3380 PRINT "SATELLITES OF MARS ARE"
3390 PRINT
3400 PRINT "1) DEIMOS"
3410 PRINT
3420 PRINT "2) PHOBOS"
3430 PRINT
3440 INPUT "SELECT 1 OR 2 ";Q
3450 IF Q = 1 THEN S$ = "DEIMOS"
3460 IF Q = 2 THEN S$ = "PHOBOS"
3470 F = 1
3480 GOTO 7020
3490 PRINT : INPUT "PRESS RETURN TO CONTINUE ";A$
3500 GOTO 3310
3510 REM SUB FOR ASTEROIDS
3520 HOME : PRINT : PRINT
3530 PRINT "ASTEROIDS LARGER THAN"
3540 PRINT TAB( 11)"155 MI (250 KM) DIAM."
3550 PRINT "-----"
3560 PRINT TAB( 5)"NAME"; TAB( 20)"DIAM. MILES KMS."
3570 PRINT
3580 PRINT "1) CERES"; TAB( 21)DA(1,2); TAB( 32)"1003"
3590 PRINT "2) DAVIDA"; TAB( 21)DA(9,2); TAB( 33)"323"
3600 PRINT "3) CYBELE"; TAB( 21)DA(7,2); TAB( 33)"309"
3610 PRINT "4) EUPHROSYNE"; TAB( 21)DA(6,2); TAB( 33)"370"
3620 PRINT "5) HYGIEA"; TAB( 21)DA(4,2); TAB( 33)"450"
3630 PRINT "6) INTERAMNIA"; TAB( 21)DA(10,2); TAB( 33)"350"
3640 PRINT "7) PALLAS"; TAB( 21)DA(2,2); TAB( 33)"608"
3650 PRINT "8) PATENTIA"; TAB( 21)DA(8,2); TAB( 33)"276"
3660 PRINT "9) PSYCHE"; TAB( 21)DA(5,2); TAB( 33)"250"
3670 PRINT "10) VESTA"; TAB( 21)DA(3,2); TAB( 33)"538"
3680 PRINT
3690 PRINT "-----"
3700 INPUT "SELECT 1 THRU 10 OR 999 FOR MENU ";N
3710 IF N = 1 THEN AS$ = "CERES":AA = 1
3720 IF N = 2 THEN AS$ = "DAVIDA":AA = 9
3730 IF N = 3 THEN AS$ = "CYBELE":AA = 7
3740 IF N = 4 THEN AS$ = "EUPHROSYNE":AA = 6

```

PLNDT (continued)

```
3750 IF N = 5 THEN AS$ = "HYGIEA":AA = 4
3760 IF N = 6 THEN AS$ = "INTERAMNIA":AA = 10
3770 IF N = 7 THEN AS$ = "PALLAS":AA = 2
3780 IF N = 8 THEN AS$ = "PATENTIA":AA = 8
3790 IF N = 9 THEN AS$ = "PSYCHE":AA = 5
3800 IF N = 10 THEN AS$ = "VESTA":AA = 3
3810 IF N = 999 THEN GOTO 210
3820 GOSUB 5390
3830 GOTO 3510
3840 REM SUB FOR JUPITER
3850 P$ = "JUPITER"
3860 GOSUB 7930
3870 IF DS = 3 THEN GOTO 3920
3880 IF DS = 4 THEN F = 1: GOTO 710
3890 ON DS GOSUB 7220,7460,7730,210
3900 IF DS < > 5 GOTO 3860
3910 GOTO 210
3920 HOME : PRINT : PRINT
3930 PRINT "SATELLITES OF JUPITER ARE"
3940 PRINT
3950 PRINT "1) JV": PRINT "2) IO"
3960 PRINT "3) EUROPA": PRINT "4) GANYMEDE"
3970 PRINT "5) CALLISTO": PRINT "6) JVI"
3980 PRINT "7) JVII": PRINT "8) JX"
3990 PRINT "9) JXII": PRINT "10) JXI"
4000 PRINT "11) JVIII": PRINT "12) JIX"
4010 PRINT
4020 PRINT "JUPITER ALSO HAS SEVERAL VERY SMALL": PRINT "SATELLITES"
: PRINT
4030 INPUT "SELECT 1 THRU 12 ";Q
4040 IF Q = 1 THEN S$ = "JV"
4050 IF Q = 2 THEN S$ = "IO"
4060 IF Q = 3 THEN S$ = "EUROPA"
4070 IF Q = 4 THEN S$ = "GANYMEDE"
4080 IF Q = 5 THEN S$ = "CALLISTO"
4090 IF Q = 6 THEN S$ = "JVI"
4100 IF Q = 7 THEN S$ = "JVII"
4110 IF Q = 8 THEN S$ = "JX"
4120 IF Q = 9 THEN S$ = "JXII"
4130 IF Q = 10 THEN S$ = "JXI"
4140 IF Q = 11 THEN S$ = "JVIII"
4150 IF Q = 12 THEN S$ = "JIX"
4160 F = 1
4170 GOTO 6360
4180 REM SUB FOR SATURN
4190 P$ = "SATURN"
4200 GOSUB 7930
4210 IF DS = 4 THEN F = 1: GOTO 900
4220 IF DS = 3 THEN GOTO 4260
4230 ON DS GOSUB 7220,7460,7730,210
4240 IF DS < > 5 GOTO 4200
4250 GOTO 210
4260 HOME : PRINT
4270 PRINT "SATELLITES OF SATURN"
4280 PRINT
```

PLNDT (continued)

```

4290 PRINT "1) 1980S28   A RING SHEPHERD"
4300 PRINT "2) 1980S27   F RING SHEPHERD"
4310 PRINT "3) 1980S26   F RING SHEPHERD"
4320 PRINT "4) 1980S3    TRAILING COORBITAL"
4330 PRINT "5) 1980S1    LEADING COORBITAL"
4340 PRINT "6) MIMAS"
4350 PRINT "7) MIMAS FOLLOWER"
4360 PRINT "8) ENCELADUS"
4370 PRINT "9) TETHYS"
4380 PRINT "10) 1980S13"
4390 PRINT "11) 1980S25"
4400 PRINT "12) DIONE"
4410 PRINT "13) 1980S6"
4420 PRINT "14) RHEA"
4430 PRINT "15) TITAN"
4440 PRINT "16) HYPERION"
4450 PRINT "17) IAPETUS"
4460 PRINT "18) PHOEBE"
4470 PRINT "SEVERAL OTHER SMALL SATELLITES HAVE"
4480 PRINT "BEEN DISCOVERED"
4490 PRINT "-----"
4500 INPUT "SELECT 1 THRU 18 ";Q
4510 IF Q = 1 THEN S$ = "1980S28"
4520 IF Q = 2 THEN S$ = "1980S27"
4530 IF Q = 3 THEN S$ = "1980S26"
4540 IF Q = 4 THEN S$ = "1980S3"
4550 IF Q = 5 THEN S$ = "1980S1"
4560 IF Q = 6 THEN S$ = "MIMAS"
4570 IF Q = 7 THEN S$ = "MIMAS FOLLOWER"
4580 IF Q = 8 THEN S$ = "ENCELADUS"
4590 IF Q = 9 THEN S$ = "TETHYS"
4600 IF Q = 10 THEN S$ = "1980S13"
4610 IF Q = 11 THEN S$ = "1980S25"
4630 IF Q = 13 THEN S$ = "1980S6"
4640 IF Q = 14 THEN S$ = "RHEA"
4650 IF Q = 15 THEN S$ = "TITAN"
4660 IF Q = 16 THEN S$ = "HYPERION"
4670 IF Q = 17 THEN S$ = "IAPETUS"
4680 IF Q = 18 THEN S$ = "PHOEBE"
4690 F = 1
4700 GOTO 6510
4710 REM SUB FOR URANUS
4720 P$ = "URANUS"
4730 GOSUB 7930
4740 IF DS = 3 THEN GOTO 4790
4750 IF DS = 4 THEN F = 1: GOTO 1130
4760 ON DS GOSUB 7220,7460,7730,210
4770 IF DS < > 5 THEN GOTO 4730
4780 GOTO 210
4790 HOME : PRINT : PRINT
4800 PRINT "SATELLITES OF URANUS"
4810 PRINT "-----"
4820 PRINT
4830 PRINT "1) MIRANDA"
4840 PRINT

```

PLNDT (continued)

```
4850 PRINT "2) ARIEL"
4860 PRINT
4870 PRINT "3) UMBRIEL"
4880 PRINT
4890 PRINT "4) TITANIA"
4900 PRINT
4910 PRINT "5) OBERON"
4920 PRINT
4930 PRINT "-----"
4940 PRINT
4950 INPUT "SELECT 1 THRU 5 ";Q
4960 IF Q = 1 THEN S$ = "MIRANDA"
4970 IF Q = 2 THEN S$ = "ARIEL"
4980 IF Q = 3 THEN S$ = "UMBRIEL"
4990 IF Q = 4 THEN S$ = "TITANIA"
5000 IF Q = 5 THEN S$ = "OBERON"
5010 F = 1
5020 GOTO 6690
5030 REM SUB FOR NEPTUNE
5040 P$ = "NEPTUNE"
5050 GOSUB 7930
5060 IF DS = 3 THEN GOTO 5110
5070 IF DS = 4 THEN F = 1: GOTO 1320
5080 ON DS GOSUB 7220,7460,7730,210
5090 IF DS < > 5 THEN GOTO 5050
5100 GOTO 210
5110 HOME : PRINT : PRINT
5120 PRINT "SATELLITES OF NEPTUNE"
5130 PRINT "-----"
5140 PRINT
5150 PRINT "1) TRITON"
5160 PRINT
5170 PRINT "2) NEREID"
5180 PRINT
5190 PRINT "-----"
5200 PRINT
5210 INPUT "SELECT 1 OR 2 ";Q
5220 IF Q = 1 THEN S$ = "TRITON"
5230 IF Q = 2 THEN S$ = "NEREID"
5240 F = 4
5250 GOTO 6850
5260 REM SUB FOR PLUTO
5270 P$ = "PLUTO"
5280 GOSUB 7930
5290 IF DS = 3 THEN 5340
5300 IF DS = 4 THEN GOTO 5350
5310 ON DS GOSUB 7220,7460,7730,210
5320 IF DS < > 5 THEN GOTO 5280
5330 GOTO 210
5340 F = 1:S$ = "CHARON": GOTO 6190
5350 HOME : PRINT : PRINT
5360 PRINT "PLUTO DOES NOT HAVE RINGS"
5370 PRINT : INPUT "PRESS RETURN TO CONTINUE ";A$
5380 GOTO 5280
5390 REM SUB FOR ASTEROID DETAILS
```

PLNDT (continued)

```

5400 HOME : PRINT : PRINT
5410 PRINT "DETAILS OF ASTEROID ";AS$
5420 PRINT "-----"
5430 PRINT
5440 PRINT "MEAN DISTANCE FROM SUN"; TAB( 25)DA(AA,1)
5450 PRINT TAB( 10)"(A.U.)"
5460 PRINT "DIAMETER (MILES)"; TAB( 25)DA(AA,2)
5470 PRINT "ECCENTRICITY"; TAB( 25)DA(AA,3)
5480 PRINT "ORBIT INCLINATION (DEG.)"; TAB( 25)DA(AA,4)
5490 PRINT "PERIOD (YEARS)"; TAB( 25)DA(AA,5)
5500 PRINT "DAILY MOTION (DEG.)"; TAB( 25)DA(AA,6)
5510 PRINT "LONG. ASCENDING NODE (DEG.)"; TAB( 25)DA(AA,7)
5520 PRINT "LONG. OF PERIHELION (DEG.)"; TAB( 25)DA(AA,8)
5530 PRINT "MEAN ANOMALY (DEG.)"; TAB( 25)DA(AA,9)
5540 PRINT " (EPOCH 1982, AUG 19)"
5550 PRINT "-----"
5560 PRINT
5570 INPUT "PRESS RETURN TO CONTINUE ";A$
5580 RETURN
5590 REM SATELLITES
5600 N = 0
5610 HOME : PRINT : PRINT
5620 PRINT "SATELLITES OF SOLAR SYSTEM"
5630 PRINT "-----"
5640 PRINT "1) ARIEL"; TAB( 20)"12) MIMAS"
5650 PRINT "2) CALLISTO"; TAB( 20)"13) MIRANDA"
5660 PRINT "3) CHARON"; TAB( 20)"14) MOON"
5670 PRINT "4) DEIMOS"; TAB( 20)"15) NEREID"
5680 PRINT "5) DIONE"; TAB( 20)"16) OBERON"
5690 PRINT "6) ENCELADUS"; TAB( 20)"17) PHOBOS"
5700 PRINT "7) EUROPA"; TAB( 20)"18) PHOEBE"
5710 PRINT "8) GANYMEDE"; TAB( 20)"19) RHEA"
5720 PRINT "9) HYPERION"; TAB( 20)"20) TETHYS"
5730 PRINT "10) IAPETUS"; TAB( 20)"21) TITAN"
5740 PRINT "11) IO"; TAB( 20)"22) TITANIA"
5750 PRINT "23) TRITON"; TAB( 20)"24) UMBRIEL"
5760 PRINT "-----"
5770 PRINT
5780 INPUT "SELECT 1 THRU 24 OR 999 FOR MENU ";N
5790 IF N = 999 THEN GOTO 210
5800 IF N = 1 THEN S$ = "ARIEL":Q = 2: GOTO 6690
5810 IF N = 2 THEN S$ = "CALLISTO":Q = 5: GOTO 6360
5820 IF N = 3 THEN S$ = "CHARON": GOTO 6190
5830 IF N = 4 THEN S$ = "DEIMOS":Q = 2: GOTO 7020
5840 IF N = 5 THEN S$ = "DIONE":Q = 12: GOTO 6510
5850 IF N = 6 THEN S$ = "ENCELADUS":Q = 8: GOTO 6510
5860 IF N = 7 THEN S$ = "EUROPA":Q = 3: GOTO 6360
5870 IF N = 8 THEN S$ = "GANYMEDE":Q = 4: GOTO 6360
5880 IF N = 9 THEN S$ = "HYPERION":Q = 16: GOTO 6510
5890 IF N = 10 THEN S$ = "IAPETUS":Q = 17: GOTO 6510
5900 IF N = 11 THEN S$ = "IO":Q = 2: GOTO 6360
5910 IF N = 12 THEN S$ = "MIMAS":Q = 6: GOTO 6510
5920 IF N = 13 THEN S$ = "MIRANDA":Q = 1: GOTO 6690
5930 IF N = 14 THEN S$ = "MOON ": GOTO 6030
5940 IF N = 15 THEN S$ = "NEREID":Q = 2: GOTO 6850

```


PLNDT (continued)

```

5950 IF N = 16 THEN S$ = "OBERON":Q = 5: GOTO 6690
5960 IF N = 17 THEN S$ = "PHOBOS":Q = 1: GOTO 7020
5970 IF N = 18 THEN S$ = "PHOEBE":Q = 18: GOTO 6510
5980 IF N = 19 THEN S$ = "RHEA":Q = 14: GOTO 6510
5990 IF N = 20 THEN S$ = "TETHYS":Q = 9: GOTO 6510
6000 IF N = 21 THEN S$ = "TITAN":Q = 15: GOTO 6510
6010 IF N = 22 THEN S$ = "TITANIA":Q = 4: GOTO 6690
6020 IF N = 23 THEN S$ = "TRITON":Q = 1: GOTO 6850
6030 HOME : PRINT : PRINT
6040 PRINT S$;" IS SATELLITE OF EARTH"
6050 PRINT "-----"
6060 PRINT
6070 PRINT "MEAN DISTANCE (1000 MI)"; TAB( 30)"238.853"
6080 PRINT "DIAMETER (MILES)"; TAB( 30)"2160"
6090 PRINT "MASS (MOON=1)"; TAB( 30)"1"
6100 PRINT "SIDEREAL PERIOD (DAYS)"; TAB( 30)"27.321661"
6110 PRINT "ECCENTRICITY"; TAB( 30)".0549"
6120 PRINT "INCLINATION (DEG.)"; TAB( 30)"18.28 TO"
6130 PRINT TAB( 30)"28.58"
6140 PRINT
6150 PRINT "-----"
6160 INPUT "PRESS RETURN TO CONTINUE ";A$
6170 IF F = 1 THEN GOTO 3160
6180 GOTO 5590
6190 HOME : PRINT : PRINT
6200 PRINT S$;" IS A SATELLITE OF PLUTO"
6210 PRINT
6220 PRINT "-----"
6230 PRINT
6240 PRINT "MEAN DISTANCE (1000 MI)"; TAB( 30)"10.563"
6250 PRINT "DIAMETER (MILES)"; TAB( 30)"745"
6260 PRINT "SIDEREAL PERIOD (DAYS)"; TAB( 30)"6.39"
6270 PRINT
6280 PRINT "FURTHER DETAILS OF CHARON ARE NOT"
6290 PRINT "      YET AVAILABLE"
6300 PRINT
6310 PRINT "-----"
6320 PRINT
6330 INPUT "PRESS RETURN TO CONTINUE ";A$
6340 IF F = 1 THEN F = 0: GOTO 5260
6350 GOTO 5590
6360 HOME : PRINT : PRINT
6370 PRINT S$;" IS A SATELLITE OF JUPITER"
6380 PRINT
6390 PRINT "-----"
6400 PRINT "MEAN DISTANCE (1000 MI)"; TAB( 30)JD(Q,1)
6410 PRINT "DIAMETER (MILES)"; TAB( 30)JD(Q,6)
6420 PRINT "MASS (MOON=1)"; TAB( 30)JD(Q,5)
6430 PRINT "SID. PERIOD (DAYS)"; TAB( 30)JD(Q,4)
6440 PRINT "ECCENTRICITY"; TAB( 30)JD(Q,2)
6450 PRINT "INCLINATION (DEG.)" TAB( 30)JD(Q,3)
6460 PRINT "-----"
6470 PRINT
6480 INPUT "PRESS RETURN TO CONTINUE ";A$
6490 IF F = 1 THEN GOTO 3860

```

PLNDT (continued)

```

6500 GOTO 5590
6510 HOME : PRINT : PRINT
6520 PRINT S$;" IS A SATELLITE OF SATURN"
6530 PRINT "-----"
6540 PRINT
6550 PRINT "MEAN DISTANCE (1000 MI)"; TAB( 30)SD(Q,1)
6560 PRINT "DIAMETER (MILES)"; TAB( 30)SD(Q,6)
6570 PRINT "MASS (MOON=1)"; TAB( 30)SD(Q,5)
6580 PRINT "DENSITY"; TAB( 30)SD(Q,7)
6590 PRINT "SIDEREAL PERIOD (DAYS)"; TAB( 30)SD(Q,4)
6600 PRINT "ALBEDO"; TAB( 30)SD(Q,8)
6610 PRINT "ECCENTRICITY"; TAB( 30)SD(Q,2)
6620 PRINT "INCLINATION (DEG.)"; TAB( 30)SD(Q,3)
6630 PRINT
6640 PRINT "-----"
6650 PRINT
6660 INPUT "PRESS RETURN TO CONTINUE ";A$
6670 IF F = 1 THEN GOTO 4180
6680 GOTO 5590
6690 HOME : PRINT : PRINT
6700 PRINT S$;" IS A SATELLITE OF URANUS"
6710 PRINT "-----"
6720 PRINT
6730 PRINT "MEAN DISTANCE (1000 MI)"; TAB( 30)UD(Q,1)
6740 PRINT "DIAMETER (MILES)"; TAB( 30)UD(Q,6)
6750 PRINT "MASS (MOON=1)"; TAB( 30)UD(Q,5)
6760 PRINT "SIDEREAL PERIOD (DAYS)"; TAB( 30)UD(Q,4)
6770 PRINT "ECCENTRICITY"; TAB( 30)UD(Q,2)
6780 PRINT "INCLINATION (DEG.)"; TAB( 30)UD(Q,3)
6790 PRINT
6800 PRINT "-----"
6810 PRINT
6820 INPUT "PRESS RETURN TO CONTINUE ";A$
6830 IF F = 1 THEN F = 0: GOTO 4200
6840 GOTO 5590
6850 HOME : PRINT : PRINT
6860 PRINT S$;" IS A SATELLITE OF NEPTUNE"
6870 PRINT
6880 PRINT "-----"
6890 PRINT
6900 PRINT "MEAN DISTANCE (1000 MI)"; TAB( 30)ND(Q,1)
6910 PRINT "DIAMETER (MILES)"; TAB( 30)ND(Q,6)
6920 PRINT "MASS (MOON=1)"; TAB( 30)ND(Q,5)
6930 PRINT "SIDEREAL PERIOD (DAYS)"; TAB( 30)ND(Q,4)
6940 PRINT "ECCENTRICITY"; TAB( 30)ND(Q,2)
6950 PRINT "INCLINATION (DEG.)"; TAB( 30)ND(Q,3)
6960 PRINT
6970 PRINT "-----"
6980 PRINT
6990 INPUT "PRESS RETURN TO CONTINUE ";A$
7000 IF F = 4 THEN GOTO 5030
7010 GOTO 5590
7020 HOME : PRINT : PRINT
7030 PRINT S$;" IS A SATELLITE OF MARS"
7040 PRINT

```

PLNDT (continued)

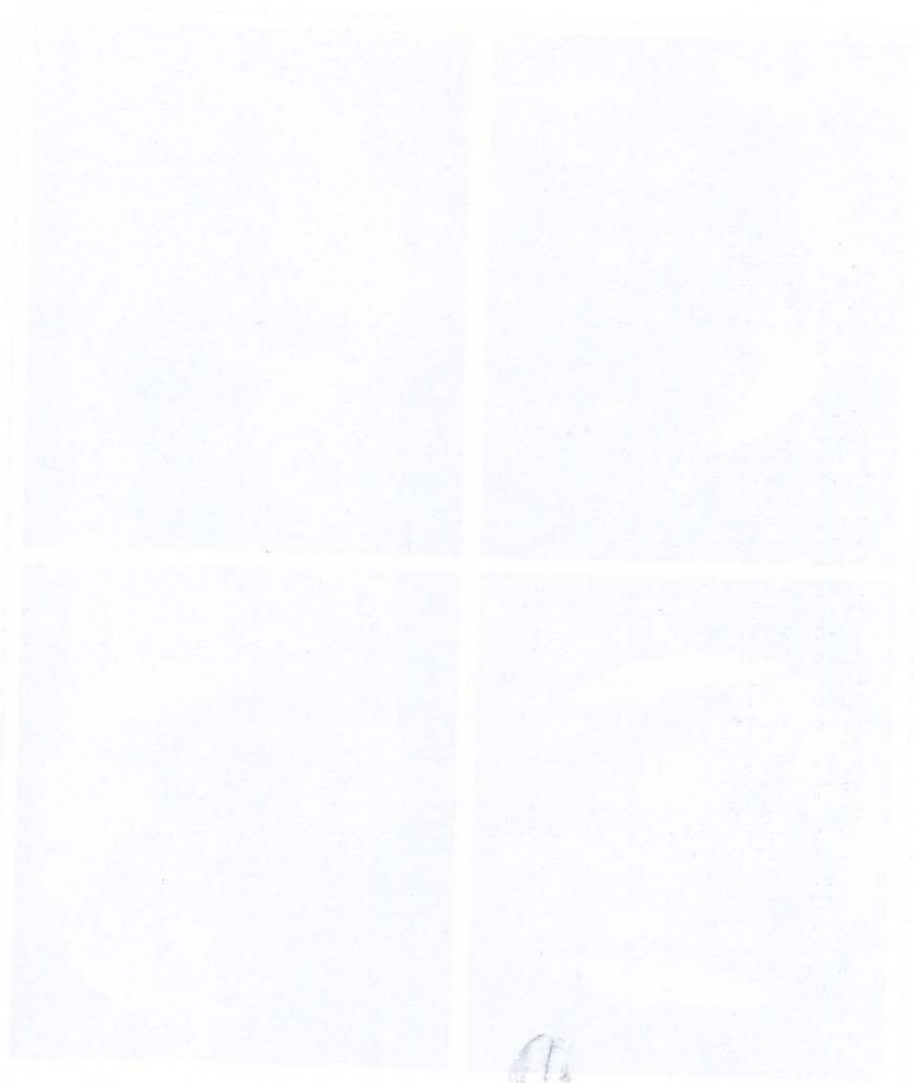
```

7050 PRINT "-----"
7060 PRINT
7070 PRINT "MEAN DISTANCE (1000 MI)"; TAB( 30)MD(Q,1)
7080 PRINT "DIAMETER (MILES)"; TAB( 30)MD(Q,6)
7090 PRINT "MASS (MOON=1)"; TAB( 30)MD(Q,5)
7100 PRINT "SIDEREAL PERIOD (DAYS)"; TAB( 30)MD(Q,4)
7110 PRINT "ECCENTRICITY"; TAB( 30)MD(Q,2)
7120 PRINT "INCLINATION (DEG.)"; TAB( 30)MD(Q,3)
7130 PRINT
7140 PRINT "-----"
7150 PRINT
7160 INPUT "PRESS RETURN TO CONTINUE ";A$
7170 IF F = 1 THEN F = 0: GOTO 3310
7180 IF F = 2 THEN F = 0: GOTO 3860
7190 IF F = 3 THEN F = 0: GOTO 4730
7200 IF F = 4 THEN F = 0: GOTO 5050
7210 RETURN
7220 REM SUB TO DISPLAY ORBIT DETAILS
7230 HOME : PRINT : PRINT : PRINT
7240 PRINT "ORBITAL DETAILS FOR ";P$
7250 PRINT
7260 PRINT "-----"
7270 PRINT
7280 PRINT "MEAN DISTANCE FROM SUN (A.U.)";
7290 PRINT TAB( 33)PD(P,1)
7300 PRINT
7310 PRINT "ECCENTRICITY"; TAB( 33)PD(P,10)
7320 PRINT
7330 PRINT "INCLINATION (DEGREES)"; TAB( 33)PD(P,11)
7340 PRINT
7350 PRINT "SIDEREAL PERIOD (YEARS)"; TAB( 33)PD(P,12)
7360 PRINT
7370 PRINT "LONG. ASCENDING NODE (DEG.)"; TAB( 32)PD(P,13)
7380 PRINT
7390 PRINT "LONG. OF PERIHELION (DEG.)"; TAB( 32)PD(P,14): PRINT
7400 PRINT "MEAN MOTION (DEG./DAY)"; TAB( 33)PD(P,15): PRINT
7410 PRINT "MEAN ANOMALY (DEG.)"; TAB( 32)PD(P,16): PRINT TAB( 5)
"(EPOCH 1980,1,1)"
7420 PRINT
7430 PRINT "-----"
7440 INPUT "PRESS RETURN TO CONTINUE ";A$
7450 RETURN
7460 REM SUB FOR PLANET DETAILS
7470 HOME : PRINT : PRINT
7480 PRINT "PHYSICAL DETAILS OF ";P$
7490 PRINT
7500 PRINT "-----"
7510 PRINT
7520 PRINT "EQUATORIAL DIAM.(MILES)"; TAB( 33)PD(P,2)
7530 PRINT
7540 PRINT "POLAR DIAM.(MILES)"; TAB( 33)PD(P,3)
7550 PRINT
7560 PRINT "MASS (EARTH=1)"; TAB( 33)PD(P,4)
7570 PRINT
7580 PRINT "DENSITY"; TAB( 33)PD(P,5)

```

PLNDT (continued)

```
7590 PRINT
7600 IF P$ = "MERCURY" OR P$ = "VENUS" THEN GOTO 7620
7610 PRINT "ROTATION PERIOD (HOURS)"; TAB( 33)PD(P,8): GOTO 7630
7620 PRINT "ROTATION PERIOD (DAYS)"; TAB( 33)PD(P,8)
7630 PRINT
7640 PRINT "AXIS INCLINATION (DEG.)"; TAB( 33)PD(P,9)
7650 PRINT
7660 PRINT "SURFACE GRAVITY (G'S)"; TAB( 33)PD(P,7)
7670 PRINT
7680 PRINT "ALBEDO"; TAB( 33)PD(P,6)
7690 PRINT
7700 PRINT "-----"
7710 INPUT "PRESS RETURN TO CONTINUE ";A$
7720 RETURN
7730 HOME : PRINT : PRINT : PRINT
7740 PRINT "ASTRONOMICAL CONSTANTS"
7750 PRINT "-----"
7760 PRINT
7770 PRINT "ASTRONOMICAL UNIT"; TAB( 25)"149.6 MILL. KM"
7780 PRINT TAB( 8)"(A.U.)"; TAB( 26)"92.953 MILL. MI"
7790 PRINT
7800 PRINT "VELOCITY OF LIGHT"; TAB( 25)"299792.5 KM/SEC"
7810 PRINT TAB( 25)"186635.4 MI/SEC"
7820 PRINT
7830 PRINT "EARTH EQUATORIAL RADIUS"; TAB( 25)"6378.16 KM"
7840 PRINT TAB( 25)"3963.3 MILES"
7850 PRINT
7860 PRINT "MASS EARTH/MASS MOON"; TAB( 25)"81.3"
7870 PRINT
7880 PRINT "MASS SUN/MASS EARTH"; TAB( 25)"332958"
7890 PRINT
7900 PRINT "-----"
7910 INPUT "PRESS RETURN TO CONTINUE ";A$
7920 GOTO 210
7930 REM SUB FOR DETAIL SELECTION
7940 HOME : PRINT : PRINT : PRINT
7950 DS = 0
7960 PRINT "SELECT...."
7970 PRINT : PRINT
7980 PRINT TAB( 6)"1) ORBITAL DETAILS"
7990 PRINT
8000 PRINT TAB( 6)"2) PHYSICAL DETAILS"
8010 PRINT TAB( 12)"OF PLANET"
8020 PRINT
8030 PRINT TAB( 6)"3) SATELLITES"
8040 PRINT : PRINT TAB( 6)"4) RINGS"
8050 PRINT : PRINT TAB( 6)"999) RETURN TO MENU"
8060 PRINT : PRINT
8070 INPUT "SELECT 1 THRU 4 OR 999 ";DS
8080 IF DS = 999 THEN DS = 5
8090 RETURN
8100 HOME
8110 END
```



11/12

[Faint, illegible text, likely bleed-through from the reverse side of the page.]

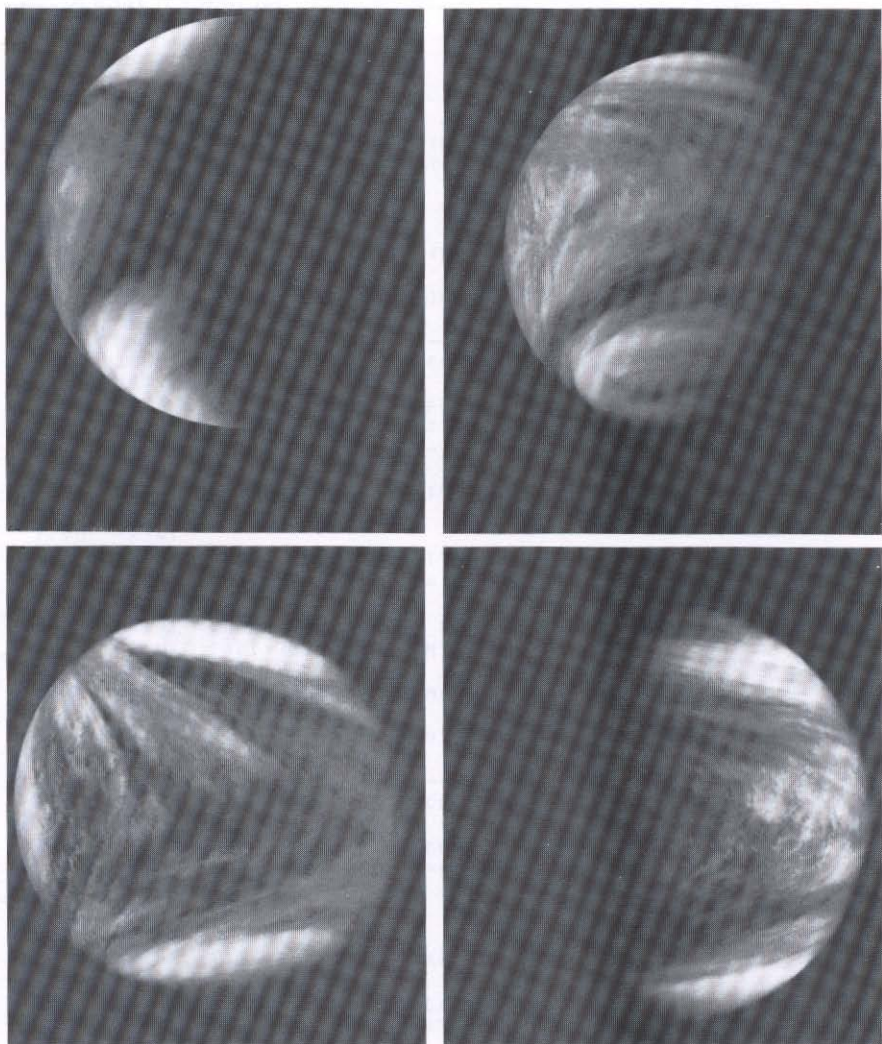


Photo Credit: NASA/Ames

While amateurs are not able to obtain pictures of the planets equal to this series of Venus taken by the Pioneer Orbiter, with suitable telescope/camera combinations and a judicious choice of film and exposure, good planetary pictures can be obtained. This program helps by providing rapid calculations for different lens combinations, exposures, and film types. These four images of Venus show variation of the illumination of the disk, as seen in ultraviolet light, from 25 December 1978 to 24 March 1979. The features shown are typical of the ultraviolet markings of the planet's clouds revealed by spacecraft photography; in normal light the clouds seem bland and uninteresting.

Program 23: PHOTO

Photographing the Planets

Obtaining good telescopic photographs of the planets has always presented a challenge to amateur astronomers. Photography is difficult because the angular size of the planets is so small. Long effective focal lengths of the telescope/camera combination are required to produce images on the photographic film that are large enough to show any detail. But long effective focal lengths mean long exposures, and then tremors of the telescope or atmospheric turbulence spoil the image detail.

Three common methods of planetary photography are:

1. Placing the photographic film at the prime focus of the telescope's objective
2. Attaching a camera (with lens) to the eyepiece of the telescope
3. Attaching a camera (without lens) to the eyepiece of the telescope (projection photography)

This program allows you to calculate exposures for the various planets for each of these three methods of photography. You have to input the diameter (in inches) of the telescope's objective (clear aperture), the focal length (in inches) of the objective, the focal length (in mm) of the eyepiece used, the focal length (in mm) of the camera lens used, and the distance (in inches) from the eyepiece to the film plane if using projection photography. Also, you must give the name of the planet and its diameter in arc seconds at the date you are making the photograph. You can determine planetary diameters in arc seconds from distance data. You must divide

the diameter at unit distance of one astronomical unit by the distance of the planet in astronomical units (given by Program 11). Diameters of the planets at unit distance are: Mercury, 6.68; Venus, 16.82; Mars, 9.36; Jupiter, 190; Saturn, 158; Uranus, 68; and Neptune, 73. Pluto is too small to be of significance. In addition, you must select an appropriate film and provide the ASA rating.

The basic equations used in the calculations are as follows:

$$\begin{array}{ll} \text{Method 1} & EFL = FLO \\ \text{Method 2} & EFL = FLO \times FC/FE \\ \text{Method 3} & EFL = FLO \times DE/FE \end{array}$$

EFL is the effective focal length of the system, *FLO* is the focal length of the telescope objective, *FE* is the focal length of the eyepiece, *FC* is the focal length of the camera lens, and *DE* is the distance from the eyepiece to the film plane. The effective *f*/number (*EFN*) is the effective focal length divided by the clear aperture of the telescope's objective. The exposure is computed from the equation:

$$EX = (EFN)^2 / (ASA \times N)$$

where *ASA* is the film speed and *N* is a number to compensate for the albedo (reflecting power) of each planet (see instruction lines 1010 through 1070).

The program provides a guide to the exposure you will need, the resolution to be expected, and the size of the image on the film plane. With this information you can effectively plan a photographic session in advance and thus avoid many disappointments. A typical display is shown in Figure 23.1.

The listing for the PHOTO program follows.

TO PHOTOGRAPH JUPITER ON FILM RATED AT
400 ASA

WITH CAMERA/EYEPIECE COMBINATION

THE EXPOSURE IS ABOUT .09 SEC

(NOTE: EXPOSURE GREATER THAN 1 SEC
IS NOT RECOMMENDED)

AND THE IMAGE ON THE FILM PLANE WILL BE
1.1 MM IN DIAMETER

(NOTE: IMAGE ON THE FILM PLANE
SHOULD EXCEED 3 MM TO BE USEFUL)

WANT ANOTHER CALCULATION? Y/N

To help you obtain better planetary photographs, PHOTO develops displays such as this for three types of camera/telescope arrangements.

Figure 23.1

PHOTO

```
10 REM PHOTO GUIDE FOR PLANETS
20 HOME : PRINT : PRINT : PRINT : PRINT
30 PRINT : PRINT
40 PRINT TAB( 9)"-----"
50 PRINT TAB( 9)"I PHOTO I"
60 PRINT TAB( 9)"-----"
70 PRINT : PRINT
80 PRINT TAB( 7)"AN ASTRONOMY PROGRAM"
90 PRINT : PRINT TAB( 6)"BY ERIC BURGESS F.R.A.S."
100 PRINT : PRINT
110 PRINT TAB( 6)"ALL RIGHTS RESERVED BY"
120 PRINT TAB( 6)"S & T SOFTWARE SERVICE"
130 PRINT : PRINT
140 PRINT : PRINT
150 INPUT "WANT INSTRUCTIONS? Y/N ";A$
160 IF A$ = "N" THEN GOTO 310
170 IF A$ < > "Y" THEN PRINT "INVALID RESPONSE"; PRINT : GOTO 150
180 HOME : PRINT
190 PRINT : PRINT : PRINT
200 PRINT "THIS PROGRAM ASKS FOR PARTICULARS OF"
210 PRINT "YOUR ASTROPHOTO INSTALLATION AND THEN"
220 PRINT "COMPUTES THE SIZE OF THE IMAGE OF ANY"
230 PRINT "SELECTED PLANET ON THE FILM PLANE"
240 PRINT : PRINT : PRINT
250 PRINT "FOR AN ASA RATING WHICH YOU INPUT"
260 PRINT "IT CALCULATES AN AVERAGE EXPOSURE"
270 PRINT "FOR THE PLANET AND THE INSTRUMENT"
280 PRINT "CONFIGURATION YOU ARE USING."
290 PRINT : PRINT : PRINT
300 INPUT "PRESS RETURN TO CONTINUE ";A$
310 HOME : PRINT : PRINT
320 PRINT "WHICH METHOD ARE YOU USING?"
330 PRINT : PRINT
340 PRINT " 1) FILM AT PRIME FOCUS OF"
350 PRINT " TELESCOPE'S OBJECTIVE"
360 PRINT
370 PRINT " 2) FILM IN CAMERA AND CAMERA"
380 PRINT " AT EYEPIECE OF TELESCOPE"
390 PRINT " WITH CAMERA LENS IN USE"
400 PRINT
410 PRINT " 3) IMAGE PROJECTED FROM EYEPIECE"
420 PRINT " OF TELESCOPE INTO CAMERA"
430 PRINT " WITHOUT A CAMERA LENS"
440 PRINT : PRINT
450 INPUT "SELECT 1, 2, OR 3 ";A
460 HOME : PRINT : PRINT
470 PRINT "GIVE FOLLOWING DATA "
480 PRINT
490 INPUT "CLEAR APERTURE OF OBJECTIVE (IN) ";AO
500 AO = AO * 30.4
510 PRINT
520 INPUT "FOCAL LENGTH OF OBJECTIVE (IN) ";FO
530 FO = FO * 30.4
```

PHOTO (continued)

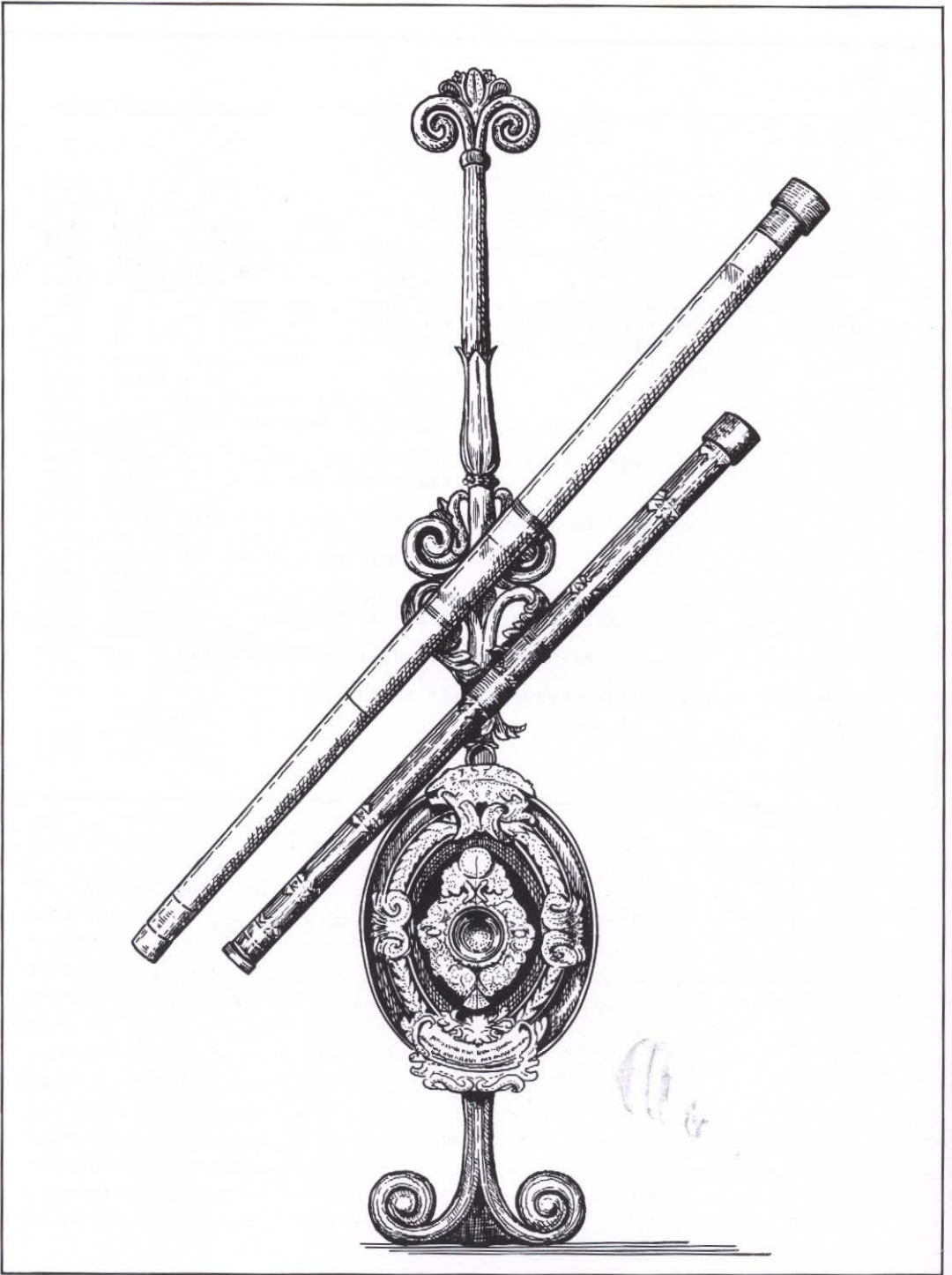
```

540 NF = FO / AO
550 IF A < > 2 THEN GOTO 580
560 PRINT
570 INPUT "FOCAL LENGTH OF CAMERA LENS (MM) ";FC
580 IF A = 1 THEN GOTO 670
590 PRINT
600 INPUT "FOCAL LENGTH OF EYEPIECE (MM) ";FE
610 IF A = 1 THEN GOTO 670
620 IF A = 2 THEN GOTO 670
630 PRINT
640 INPUT "DISTANCE EYEPIECE TO FILM PLANE (IN) ";DE
650 DE = DE * 25.4
660 REM CALC. EFFECTIVE F NUMBER
670 IF A = 1 THEN EFL = NF
680 IF A = 2 THEN EFL = NF * FC / FE: GOTO 700
690 IF A = 3 THEN EFL = NF * DE/FE
700 HOME : PRINT : PRINT
710 PRINT "YOU MUST NOW ENTER THE NAME OF"
720 PRINT "THE PLANET YOU ARE PHOTOGRAPHING"
730 PRINT "AND ITS DIAMETER IN ARCSECS"
740 PRINT
750 PRINT "(YOU CAN FIND THIS FROM ONE OF THE"
760 PRINT " PROGRAMS IN THIS SERIES)"
770 PRINT : PRINT
780 INPUT "WHAT IS PLANET'S NAME ";PL$
790 IF PL$ = "PLUTO" THEN PRINT "NO DATA ON PLUTO; PICK ANOTHER PLANET "
: GOTO 780
800 PRINT
810 INPUT "WHAT IS DIAMETER IN ARCSECS ";DP
820 F = EFL * AO
830 HOME : PRINT : PRINT : PRINT
840 DP = DP / 3600
850 DP = TAN (DP / 57.29578)
860 I = F * DP
870 R = 1450 / EFL
880 R = VAL ( LEFT$ ( STR$ (R),4))
890 PRINT : PRINT
900 PRINT "RESOLUTION FOR ";PL$;" AT"
910 PRINT "FILM PLANE WILL BE "; INT (R);" LINES/MM"
920 PRINT : PRINT
930 PRINT "YOU ARE ADVISED TO PICK A FILM WITH"
940 PRINT "AT LEAST THREE TIMES THIS RESOLUTION"
950 R = VAL ( LEFT$ ( STR$ (R * 3),4))
960 PRINT : PRINT "NAMELY "; INT (R);" LINES/MM TO AVOID"
970 PRINT "GRAIN SPOILING THE IMAGE"
980 PRINT : PRINT
990 INPUT "WHAT IS ASA RATING OF CHOSEN FILM? ";ASA
1000 HOME : PRINT : PRINT
1010 IF PL$ = "MERCURY" THEN N = 260
1020 IF PL$ = "VENUS" THEN N = 960
1030 IF PL$ = "MARS" THEN N = 40
1040 IF PL$ = "JUPITER" THEN N = 12
1050 IF PL$ = "SATURN" THEN N = 3.5
1060 IF PL$ = "URANUS" THEN N = .81
1070 IF PL$ = "NEPTUNE" THEN N = .38

```

—PHOTO (continued)—

```
1080 N = N * ASA
1090 EX = EFL ^ 2 / M
1100 HOME : PRINT : PRINT
1110 PRINT "TO PHOTOGRAPH ";PL$;" ON FILM RATED AT "
1120 PRINT ASA;" ASA"
1130 PRINT
1140 IF A = 1 THEN EQ$ = "FILM AT PRIME FOCUS OF OBJECTIVE"
1150 IF A = 2 THEN EQ$ = "CAMERA/EYEPIECE COMBINATION"
1160 IF A = 3 THEN EQ$ = "PROJECTION FROM EYEPIECE"
1170 PRINT "WITH ";EQ$
1180 PRINT : PRJNT
1190 EX = VAL ( LEFT$ ( STR$ (EX),3))
1200 PRINT "THE EXPOSURE IS ABOUT ";EX;" SEC"
1210 PRINT
1220 PRINT "      (NOTE: EXPOSURE GREATER THAN 1 SEC"
1230 PRINT "      IS NOT RECOMMENDED)"
1240 PRINT
1250 PRINT "AND THE IMAGE ON THE FILM PLANE WILL BE"
1260 I = VAL ( LEFT$ ( STR$ (I),3))
1270 PRINT I;" MM IN DIAMETER"
1280 PRINT
1290 PRINT "      (NOTE: IMAGE ON THE FILM PLANE"
1300 PRINT "      SHOULD EXCEED 3 MM TO BE USEFUL)"
1310 PRINT : PRINT
1320 INPUT "WANT ANOTHER CALCULATION? Y/N ";A$
1330 IF A$ = "N" THEN GOTO 1370
1340 IF A$ < "Y" THEN PRINT "INVALID RESPONSE": PRINT : GOTO 1320
1350 GOTO 310
1360 HOME
1370 END
```

APPENDIX

MANY READERS WILL HAVE computers other than the Apple for which the programs in this book are listed. Because the programs have been written in the popular BASIC language, they are readily adaptable to other computers. Some computers have the ability to display more information on the monitor screen, others less. The more difficult programs to adapt are those that use screen graphics. In addition to knowing BASIC, you also need to be familiar with the way your computer handles graphic displays.

Three important programs are repeated in this part of the book to aid in adapting these programs to other computers. They provide the same information as the programs designed for the Apple computer, but they use different programming techniques. By studying these programs (and the displays they produce) in conjunction with those for the Apple computer, you should have no major difficulty in converting one or the other to suit your computer.

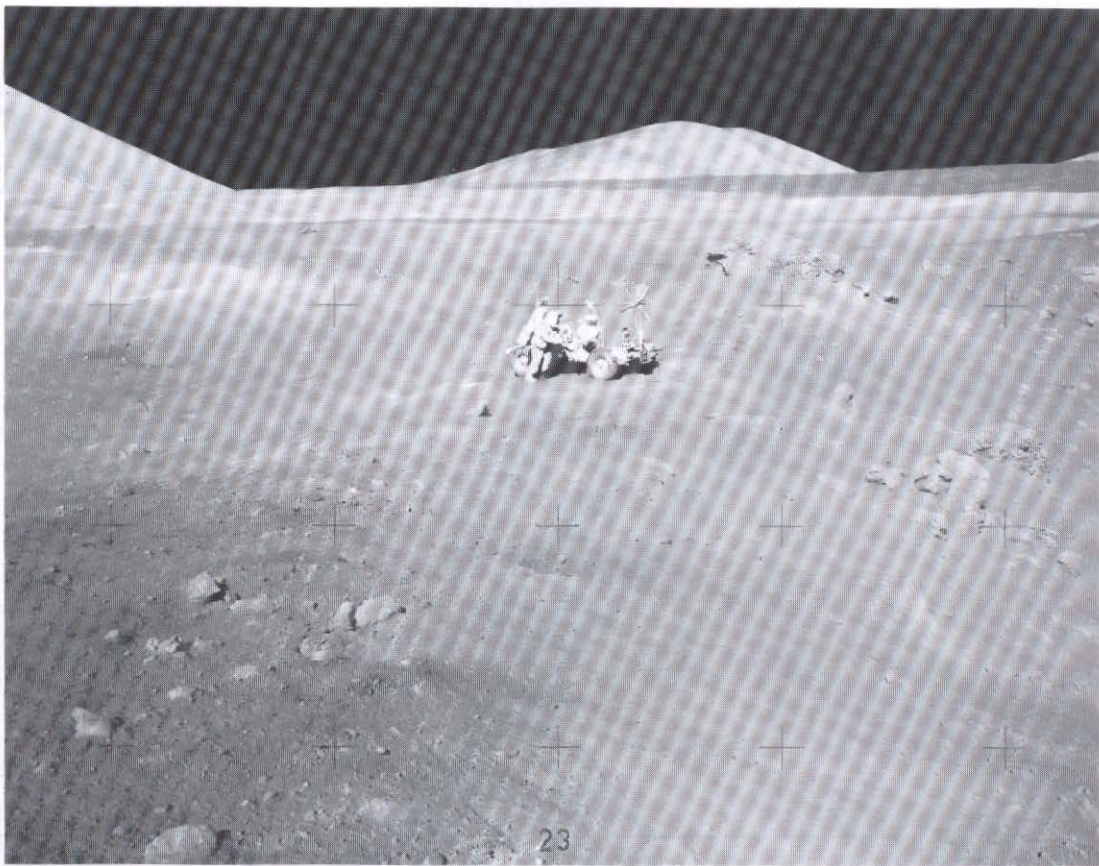


Photo Credit: NASA/Johnson

On the lonely plains of the Moon, Apollo 17 astronaut Schmitt is working at the Lunar Roving Vehicle in the Taurus-Littrow area. The peak in the center background was named Family Mountain. On the

left horizon is a part of the South Massif. Amateur astronomers can still derive much pleasure from watching the sunrise and sunset shadows across these great lunar plains and their surrounding mountains.

Program 16A: SKYPLA

Alternative Skyplot Program

This version of the sky plotting program was written for an Exidy Sorcerer and makes full use of the graphics capabilities of that computer. It is a program complete within itself; it does not require any machine language routines as in Program 16. Hence it is more readily adaptable to other computers. The program has all the instructions needed to run it. It is also adequately supplied with remark (REM) statements in case you should wish to modify it in any way for your use or special needs. When you run the program you can request detailed instructions if you wish.

You will be asked for date and other input information, as well as whether you want to change the location parameters of time zone, latitude, and longitude. Next you are asked to select a horizon of 180 degrees centered on east, west, south, or north. As the program begins its calculations the screen displays the message COMPUTING .. PLEASE WAIT. During this period it loads arrays.

The horizon chart is generated next. For the particular horizon you have requested, the azimuth is shown below the display and the elevation at the left. Date and time information is displayed above the chart. Then the stars are plotted; this takes about five minutes. Next the program plots the Sun and any planets above that horizon at the time and date selected. Finally it plots the Moon and shows it as) before full, o when close to full, and (after full, selected in instructions 5850 through 5870. Since the projection is Mercator, constellations toward the zenith are somewhat distorted (stretched out horizontally).

Variables have been initially set for your latitude, longitude, and time zone. While running the program you can change the variables to other latitudes, longitudes, and time zones. The program should not be expected to run accurately at latitudes exceeding 85 degrees north and south.

Planets are identified by letters: m, Mercury; V, Venus; M, Mars; J, Jupiter; S, Saturn; U, Uranus; N, Neptune; and P, Pluto. Note that if planets are within one pixel of each other, the outermost planet will overprint the innermost; only the symbol for the outer planet will be displayed.

Note that the numbers in lines 2420 and 2440 through 2510 refer to the Sorcerer computer's graphic symbols, which create the horizon silhouette. By referring to Figure 16A.1 you can select suitable graphic symbols from those available on your computer. You can, of course,

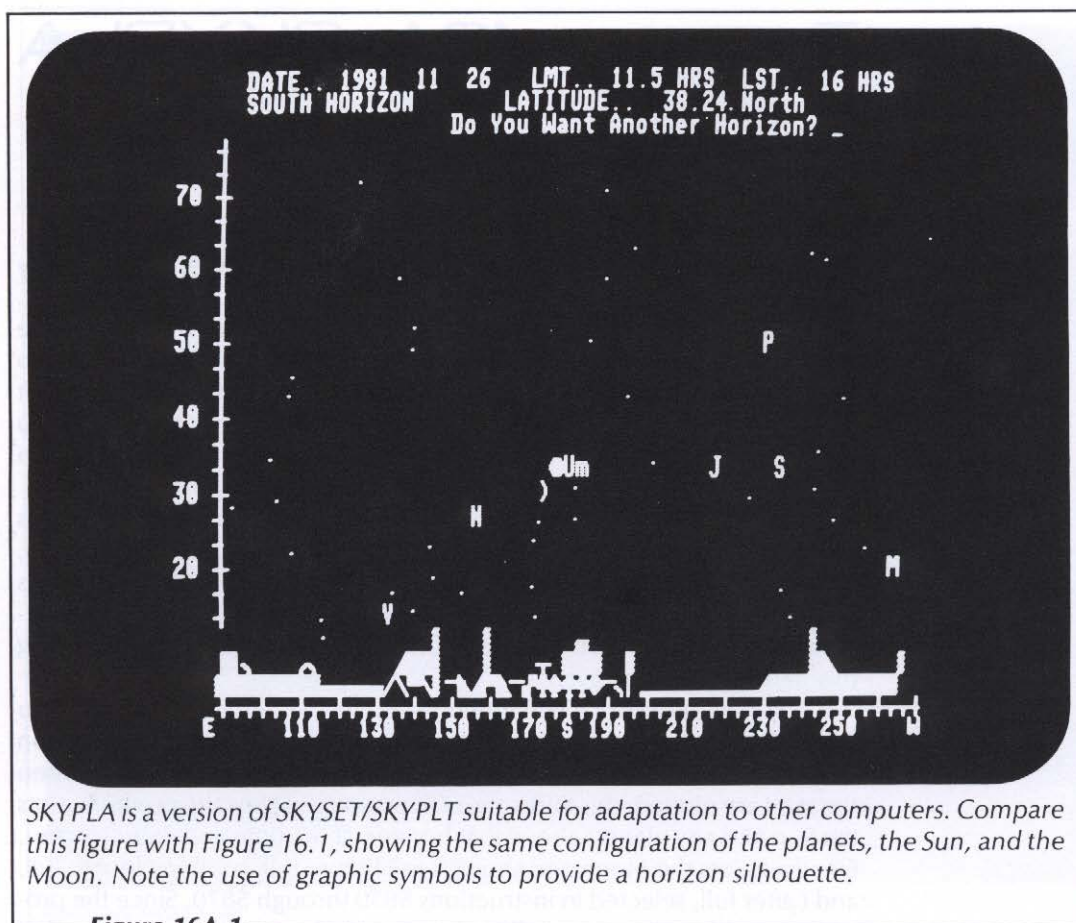


Figure 16A.1

design appropriate silhouettes for your own locality and for the different horizon views.

As with other programs containing many numerical data statements, take particular care in keying in the numbers and differentiating between commas and periods.

To demonstrate the program and compare the display with that generated by the Apple (Program 16), select the display of 26 November 1981 at 11.5 hours for the south horizon (Figure 16A.1). This shows all the planets, the Sun, and the Moon above the horizon at the same time. If you then ask for the same date and time in the Southern Hemisphere (for example, for -40 degrees latitude) and request the north horizon, you will see these same planets and constellations inverted.

The listing of the SKYPLA program follows.

SKYPLA

```

10 CLEAR
20 DEFFNASN(X)=ATN(X/SQR(-X*X+1))
30 DEFFNACO(X)=-ATN(X/SQR(-X*X+1))+3.14159/2
40 DEFFNRAD(X)=(X)*3.14159/180
50 DEFFNDEG(X)=(X)*180/3.14159
60 PI=3.14159
70 PRINTCHR$(12)
80 PRINT:PRINT:PRINT:PRINT:PRINT:PRINT:PRINT
90 PRINTTAB(20)"S K Y   P L O T":PRINT:PRINT
100 PRINTTAB(14)"ASTRONOMY PROGRAM FOR SORCERER":PRINT:PRINT
110 PRINT:PRINT
120 ZN=8:LA=FNRAD(38.24):L$="SEBASTOPOL,CAL.":LO=122.49
130 PRINT:PRINT
140 PRINT"Initial conditions are set for..."L$:PRINT
150 PRINT
160 PRINT"                               LATITUDE"FNDEG(LA)
170 PRINT"                               LONGITUDE"LO
180 PRINT"                               TIME ZONE"ZN:PRINT:PRINT
190 PRINT"You can change these later if you wish"
200 DF=0
210 FORJ7=2000TO1STEP-1:NEXTJ7
220 PRINTCHR$(12):PRINT:PRINT:PRINT:PRINT:PRINT:PRINT:PRINT
230 :PRINTTAB(21);" SKY PLOT"
240 PRINT:PRINTTAB(25);"by"
250 PRINT:PRINTTAB(18);"ERIC BURGESS F.R.A.S.":PRINT
260 PRINT:PRINTTAB(11)"Plots the stars for a requested"
270 PRINTTAB(12)"time and date, and shows the"
280 PRINTTAB(10)"planets, Sun, and Moon above the"
290 PRINTTAB(13)"          horizon."
300 PRINT:PRINTTAB(10)"Close to full the Moon is shown as o"
310 PRINTTAB(10)"Before full it is shown as ) and"
320 PRINTTAB(12)"after full it is shown as (:":PRINT:PRINT
330 PRINTTAB(13)"  All rights reserved"
340 PRINTTAB(13)"    S & T Software"
350 PRINT:PRINT
360 FORJ=2500TO1STEP-1:NEXTJ:PRINTCHR$(12):PRINT
370 GOTO1490
380 REM DAYS FROM EPOCH
390 G=365*Y+D+((M-1)*31)
400 IFM>=3THENGOTO420
410 G=G+INT((Y-1)/4)-INT(.75*INT((Y-1)/100+1)):RETURN
420 G=G-INT(2.3+M*.4)+INT(Y/4)-INT(.75*INT((Y/100)+1))
430 RETURN
440 REM CALCUL OF LST
450 SG=.065711
460 T2=SG*NS+12.064707+(((ZN+T1)/24)*SG)+T1
470 IFT2>24THENT2=T2-24:GOTO470
480 IFT2<-24THENT2=T2+24:GOTO480
490 IFT2<0THENT2=T2+24
500 T2$=STR$(T2)
510 T2=VAL(LEFT$(T2$,5))
520 RETURN
530 REM ENTER VAR.FOR CALC LST
540 GOSUB380:NS=G-722895:GOSUB440

```

SKYPLA (continued)

```
550 REM ENTER VAR.FOR CALC NO. OF DAYS
560 MO=M:DA=D:YR=Y
570 GOSUB380:ND=G-715875+T1/24
580 REM STORE DATA FOR CALCS
590 IFF4=1GOTO870
600 RESTORE
610 DIMPD(9,9)
620 FORYY=0T08
630 FORXX=0T08
640 READPD(YY,XX)
650 NEXTXX,YY
660 REM ORBITAL ELEMENTS OF PLANETS, MERCURY-PLUTO
670 DATA.071425,3.8494,.388301,1.34041,.3871
680 DATA.07974,2.73514,.122173,.836013
690 DATA.027962,3.02812,.013195,2.28638,.7233
700 DATA.00506,3.85017,.059341,1.33168
710 DATA.017202,1.74022,.032044,1.78547,1,.017,3.33926,0
720 DATA0,.009146,4.51234,.175301,5.85209,1.5237
730 DATA.141704,1.04656,.03142,.858702
740 DATA.001451,4.53364,.090478,.23911,5.2028
750 DATA.24934,1.76188,.01972,1.74533
760 DATA.000584,4.89884,.105558,1.61094,9.5385
770 DATA.534156,3.1257,.043633,1.977458
780 DATA.000205,2.46615,.088593,2.96706,19.182
790 DATA.901554,4.49084,.01396,1.28805
800 DATA.000104,3.78556,.016965,.773181,30.06
810 DATA.27054,2.33498,.031416,2.29162
820 DATA.000069,3.16948,.471239,3.91303,39.44
830 DATA9.86,5.23114,.300197,1.91812
840 FORI9=1T09
850 READP(I9):NEXTI9
860 DATA109,86,83,77,74,83,85,78,80
870 F4=1
880 I=1
890 FORJ=0T08
900 GOSUB1000
910 A(I)=A:D(I)=D:L(I)=L
920 I=I+1:NEXT
930 FORI=1T09
940 IFI=3THENNEXT
950 PRINTCHR$(12):PRINT"COMPUTING...PLEASE WAIT"
960 GOSUB1110
970 Z(I)=Z:Q(I)=Q:X(I)=X:R(I)=R:V(I)=V:AL(I)=AL:AZ(I)=AZ
980 NEXT
990 RETURN
1000 REM SUB FOR A,D,L
1010 A=ND*PD(J,0)+PD(J,1)
1020 IFA>PI*2THENA=(A/(PI*2)-INT(A/(PI*2)))*PI*2
1030 IFA<0THENA=A+PI*2:GOTO1030
1040 C=PD(J,2)*SIN(A-PD(J,3))
1050 A=A+C
1060 IFA>PI*2THENA=A-PI*2
1070 IFA<0THENA=A+PI*2:GOTO1070
1080 D=PD(J,4)+PD(J,5)*SIN(A-PD(J,6))
1090 L=PD(J,7)*SIN(A-PD(J,8))
```

SKYPLA (continued)

```

1100 RETURN
1110 REM ELEV AND AZ OF SUN AND PLANETS
1120 F=0:Z=A(3)-A(I)
1130 IFABS(Z)>PIANDZ<0THENZ=Z+(PI*2)
1140 IFABS(Z)>PIANDZ>0THENZ=Z-(PI*2)
1150 Q=SQR(D(I)^2+D(3)^2-2*D(I)*D(3)*COS(Z))
1160 P=(D(I)+D(3)+Q)/2
1170 X=2*FNACO(SQR(((P*(P-D(I)))/(D(3)*Q))))
1180 T=X*(12/PI)
1190 IFZ<0THENR=FNDEC(A(3)+PI-X)/15
1200 IFZ>0THENR=FNDEC(A(3)+PI+X)/15
1210 IFR>24THENR=R-24:GOTO1220
1220 IFR<-24THENR=R+24:GOTO1220
1230 IFR<0THENR=R+24:GOTO1230
1240 IFZ<0THENV=SIN(A(3)+PI-X)*23.44194+FNDEG(L(I))
1250 IFZ>0THENV=SIN(A(3)+PI+X)*23.44194+FNDEG(L(I))
1260 HA=T2-R
1270 IFHA<-12THENHA=HA+24
1280 IFHA>12THENHA=HA-24
1290 HA=FNRAD(HA*15):V=FNRAD(V)
1300 AL=FNASN(SIN(V)*SIN(LA)+COS(V)*COS(LA)*COS(HA))
1310 AZ=FNACO((SIN(V)-SIN(LA)*SIN(AL))/(COS(LA)*COS(AL)))
1320 IFHA>0THENAZ=PI*2-AZ
1330 AL=FNDEG(AL):AZ=FNDEG(AZ)
1340 RS=FNDEC(A(3)+PI)/15
1350 IFRS>24THENRS=RS-24:GOTO1350
1360 IFRS<-24THENRS=RS+24:GOTO1360
1370 IFRS<0THENRS=RS+24:GOTO1370
1380 VS=SIN(A(3)+PI)*23.44194
1390 HS=T2-RS
1400 IFHS<-12THENHS=HS+24
1410 IFHS>12THENHS=HS-24
1420 HS=FNRAD(HS*15):VS=FNRAD(VS)
1430 AS=FNASN(SIN(VS)*SIN(LA)+COS(VS)*COS(LA)*COS(HS))
1440 ZS=FNACO((SIN(VS)-SIN(LA)*SIN(AS))/(COS(LA)*COS(AS)))
1450 IFHS>0THENZS=PI*2-ZS
1460 AS=FNDEG(AS):ZS=FNDEG(ZS)
1470 RETURN
1480 REM BEGIN MAIN PROGRAM
1490 PRINT:PRINT"PLEASE WAIT":PRINTCHR$(12)
1500 IFDF=0THENPRINT:PRINT:PRINT:GOTO1640
1510 PRINT:INPUT"DO YOU WANT TO SEE VARIABLES";ABS
1520 IFABS="N"THENGOTO1560
1530 PRINT:PRINT"DATE..";YR;MO;DA;" LMT..";T1;"HRS";
1540 PRINT" TIME ZONE...";ZN
1550 PRINT"LAT...";FNDEG(LA);:PRINT" LONG...";LO:PRINT
1560 PRINT
1570 INPUT"DO YOU WANT TO ENTER OR CHANGE ANY VARIABLES ";AS
1580 IFAS="N"GOTO1970
1590 PRINT:PRINT
1600 PRINT"DO YOU WANT TO CHANGE THE DATE OF: ";YR;MO;DA
1610 PRINT
1620 INPUT"ANSWER 'Y'OR 'N'";A1$
1630 IFA1$="N"THENGOTO1740
1640 PRINT:PRINT"WHAT IS THE DATE REQUIRED"

```

SKYPLA (continued)

```

1650 PRINT:INPUT".....THE YEAR";Y
1660 PRINT:INPUT".....THE MONTH";M
1670 PRINT:INPUT".....THE DAY";D
1680 MO=M:DA=D:YR=Y
1690 IFY>1800GOTO1740
1700 PRINT:PRINT:PRINT"IS ";Y;" THE YEAR YOU WANT?"
1710 INPUTY$
1720 IFY$="Y"GOTO1740
1730 IFY$="N"THENPRINT:GOTO1650
1740 PRINT:PRINT:GOSUB3440
1750 IFDF=0THEN1780
1760 PRINT"                THE LMT OF: ";T1;" ";
1770 PRINT:INPUTA1$:IFA1$="N"THENGOTO1830
1780 PRINT"NOW YOU MUST INPUT THE LMT FOR THE DISPLAY":GOSUB3320
1790 PRINT:PRINT"IF YOU WANT TO CHANGE VARIABLES"
1800 PRINT"ANSWER 'Y' WHEN ASKED, OTHERWISE ANSWER 'N'"
1810 IFDF=0THEN1830
1820 PRINT:Y$="LMT":GOSUB3320
1830 PRINT:PRINT
1840 PRINT"                THE TIME ZONE OF: ";ZN:INPUTA1$
1850 IFA1$="N"THENGOTO1870
1860 PRINT:INPUT"WHAT IS THE TIME ZONE (WEST COAST IS 8)";ZN
1870 PRINT:PRINT
1880 PRINTTAB(15)"THE LONGITUDE OF: ";LO:INPUTA1$
1890 IFA1$="N"THENGOTO1910
1900 PRINT:GOSUB3510
1910 PRINT:PRINT
1920 PRINT"                THE LATITUDE OF: ";FNDEG(LA)
1930 INPUTA1$
1940 IFA1$="N"THENGOTO1980
1950 PRINT:INPUT"WHAT IS THE LATITUDE (SEBASTOPOL;38.24)";LA
1960 LA=FNRAD(LA)
1970 :
1980 IFHR=1ANDAS$="N"THENHR=0:AS$="":GOTO2680
1990 IFHR=1ANDAS$="Y"THENHR=0:AS$="":GOTO2120
2000 PRINTCHR$(12):PRINT:PRINT:PRINT:PRINT
2010 PRINT:PRINT"WHICH HORIZON DO YOU WANT TO SEE?"
2020 PRINT
2030 PRINT:PRINTTAB(5)"1 EAST HORIZON ... 0 TO 180 DEG."
2040 PRINT:PRINTTAB(5)"2 WEST HORIZON ...180 TO 360 DEG."
2050 PRINT:PRINTTAB(5)"3 SOUTH HORIZON .. 90 TO 270 DEG."
2060 PRINT:PRINTTAB(5)"4 NORTH HORIZON .. 270 TO 90 DEG."
2070 PRINT:INPUT"SELECT ";HZ$
2080 IF(HZ$="1"ORHZ$="2"ORHZ$="3"ORHZ$="4")THEN2100
2090 PRINT"INVALID ENTRY":GOTO2010
2100 HZ=VAL(HZ$)
2109 DS=0:PRINT:PRINT
2110 PRINT"Do You Want Stars Displayed As Well As Planets."
2111 PRINT"Sun, and Moon (Y/N)";
2112 INPUT DS$:IF DS$="N"THENDS=1:GOTO2120
2113 IF DS$<>"Y"THENPRINT"Invalid Response":PRINT:GOTO2110
2120 REM BEGIN CALCS
2130 FL=3
2140 PRINTCHR$(12):PRINT"COMPUTING...PLEASE WAIT":PRINT
2150 IFFP=1GOTO2330
2160 DIMPO(30,64)

```


SKYPLA (continued)

```

2640 PRINT" W 290 310 330 350 N 10 30 50 ";
2650 PRINT" 70 E"
2660 F6=1:PRINTCHR$(17):RETURN
2670 GOSUB530
2680 PRINTCHR$(12)
2690 IFHZ=1THENHZ$="EAST HORIZON"
2700 IFHZ=2THENHZ$="WEST HORIZON"
2710 IFHZ=3THENHZ$="SOUTH HORIZON"
2720 IFHZ=4THENHZ$="NORTH HORIZON"
2730 GOSUB3440
2740 GOSUB2380
2750 US="North"
2760 IFLA<0THENUS="South"
2770 PRINT" DATE.."YR;MO;DA;" LMT.."T1;"HRS";
2780 PRINT" LST.."T2"HRS":PRINT" "HZ$;
2790 PRINT" LATITUDE.." ";ABS(FNDEG(LA));US
2800 PRINT" Please Wait...Computing Positions"
2810 PRINTCHR$(17)
2820 REM PRINT SKY DOME
2825 IF DS=1THEN2850
2830 REM POKE STARS
2840 GOSUB3580
2850 REM POKE SUN
2860 IFAS<0GOTO2950
2870 BS=ZS
2880 IFHZ=3AND(BS>90ANDBS<270)THENX1=BS-90:Y1=AS:GOTO2930
2890 IFHZ=4AND(BS>270ANDBS<360)THENX1=BS-270:Y1=AS:GOTO2930
2900 IFHZ=4AND(BS>0ANDBS<85)THENX1=BS+90:Y1=AS:GOTO2930
2910 IFHZ=1ANDBS<=180THENX1=BS:Y1=AS:GOTO2930
2920 IFHZ=2ANDBS>180THENX1=BS-180:Y1=AS:GOTO2930
2925 GOTO2950
2930 Y2=28/90*Y1+2.5:X2=55/180*X1+4
2940 POKEP(INT(Y2),INT(X2)),132
2950 REM SELECT AND POKE PLANETS
2960 FORI8=1TO9
2970 BZ(I8)=AZ(I8)
2980 IFAL(I8)<5ORAL(I8)>80THENGOTO3110
2990 IFI8=3THENGOTO3110
3000 IFHZ=1ANDBZ(I8)<=180THENGOTO3060
3010 IFHZ=2ANDBZ(I8)>180THENBZ(I8)=BZ(I8)-180:GOTO3060
3020 IFHZ=3ANDBZ(I8)>90ANDBZ(I8)<270THENBZ(I8)=BZ(I8)-90:GOTO3060
3030 IFHZ=4AND(BZ(I8)>270ANDBZ(I8)<360)THENGOTO3050
3040 IFHZ=4AND(BZ(I8)>0ANDBZ(I8)<85)THENBZ(I8)=BZ(I8)+90:GOTO3060
3045 GOTO3110
3050 BZ(I8)=BZ(I8)-270
3060 REM POKE ROUTINE
3070 X1=BZ(I8):Y1=AL(I8)
3080 IF(X1<5ORX1>175)THENGOTO3110
3090 Y2=28/90*Y1+2.5:X2=55/180*X1+4
3100 POKEP(INT(Y2),INT(X2)),P(I8)
3110 NEXTI8
3120 GOSUB5230
3130 GOTO3150
3140 REM END SEQUENCE
3150 PRINT:PRINT
3160 PRINTTAB(22)"Do You Want Another Horizon";:INPUTA$

```


SKYPLA (continued)

```
3170 M=MO:D=DA:Y=YR
3180 FP=1
3190 IFAS="N" THEN GOTO 3250
3200 HR=1:PRINT CHR$(12):PRINT:PRINT:PRINT "WHICH HORIZON"
3210 PRINT:PRINT TAB(7)"EAST... 1":PRINT TAB(7)"WEST... 2"
3220 PRINT TAB(7)"SOUTH... 3":PRINT TAB(7)"NORTH... 4"
3230 PRINT:INPUT "SELECT ";HZ$:HZ=VAL(HZ$)
3240 PRINT CHR$(12):HR=1:PRINT:PRINT:PRINT:GOTO 1570
3250 PRINT CHR$(12):PRINT:PRINT:PRINT
3260 INPUT "WANT ANOTHER DATE Y/N";A$
3270 IFAS="Y" THEN GOTO 1510
3280 IFAS<>"N" THEN PRINT:PRINT "INVALID REPLY":GOTO 3260
3290 PRINT CHR$(12):PRINT:PRINT "SKYPLOT SIGNING OFF"
3300 END
3310 REM TIME INPUT
3320 PRINT:PRINT "DO YOU WANT INPUT IN DEC.HRS (1)"
3330 PRINT "OR IN HR,MI,SE (2)":PRINT
3340 INPUT PT$:PT=VAL(PT$)
3350 IF PT=1 THEN GOTO 3380
3360 IF PT=2 THEN GOTO 3400
3370 PRINT "INVALID REPLY":PRINT:GOTO 3320
3380 PRINT:PRINT "WHAT IS THE LMT -HH.XXXX"
3390 PRINT:INPUT T1:PRINT:GOTO 3430
3400 PRINT:PRINT "WHAT IS THE LMT -HR,MI,SE"
3410 PRINT:INPUT HR,MI,SE
3420 T1=HR+MI/60+SE/3600:PRINT
3430 RETURN
3440 REM PRINTING HR,MI,SE
3450 RR=INT(T1)
3460 IM=(T1-INT(T1))*60
3470 ES=(IM-INT(IM))*60
3480 ES=INT(ES)
3490 IM=INT(IM)
3500 RETURN
3510 REM CORRECT ZN FOR LONGITUDE
3520 PRINT:INPUT "WHAT IS LONGITUDE, SEBASTOPOL IS 122.49";LO
3530 LGC=(ZN*15)-LO
3540 IF LGC<0 THEN GOTO 3560
3550 ZN=ZN+ABS(LGC/15):GOTO 3570
3560 ZN=ZN-LGC/15
3570 PRINT:RETURN
3580 REM DEVELOP HA, AZ AND AL FOR STARS
3590 IFSF=1 THEN 4620
3600 DIM ST(237,2)
3610 FOR SX=0 TO 236:FOR SY=0 TO 1
3620 READ ST(SY,SX)
3630 NEXT SX,SY
3640 REM DATA ON RA AND DEC OF STARS
3650 REM URSA MINOR
3660 DATA 2.89,18.86,17.82,16.78,15.75,15.4,72,16.3,76
3670 REM CEPHEUS
3680 DATA 20.8,61,21.5,70
3690 REM CASSIOPEIA
3700 DATA 1.9,63,1.4,60,0.9,60,0.6,56,0.1,59
3710 REM PERSEUS
```

SKYPLA (continued)

3720 DATA3.3,50,3.0,53,3.7,48,3.1,41,3.9,40,3.9,32
3730 REM URSA MAJOR
3740 DATA11,57,11,63,11.9,54,12.2,58,12.9,57,13.4,55,13.7,50
3750 REM DRACO
3760 DATA16,59,16.4,62,17.1,66,17.5,52,17.9,51,18.3,73,19.2,68
3770 REM CEPHEUS
3780 DATA23.8,78,21.3,62,22.1,58,22.8,67
3790 REM ANDROMEDA
3800 DATA2,42,1.1,35,.6,31
3810 REM TRIANGULUM
3820 DATA2.1,35,1.8,29,2.2,34
3830 REM PEGASUS
3840 DATA22.7,30,0.1,29,0.2,14,21.7,10,22.2,6,22.7,10,23.0,4
3850 DATA23,28
3860 REM AURIGA
3870 DATA5.2,46,5.9,45,5.9,37,4.9,33,5,41
3880 REM BOOTES
3890 DATA14.5,39,15,40,15.3,33,14.2,20,13.9,19,14.7,27,15.5,27
3900 DATA15.4,29
3910 REM CORONA
3920 DATA15.6,27
3930 REM HERCULES
3940 DATA16.7,39,16.7,31,17,31,17.2,37,17.2,25,16.5,21,16.4,19
3950 REM LYRA
3960 DATA18.7,39,18.8,33,19,32
3970 REM CYGNUS
3980 DATA20.7,45,20.3,40,19.8,45,20.8,34,19.5,28
3990 REM TAURUS
4000 DATA3.6,24,3,4,2.7,3,4.5,17,5.4,29,5.6,21
4010 DATA3.7,24
4020 DATA4.3,15,4.45,19
4030 REM ARIES
4040 DATA2.1,23,1.8,21,1.8,19
4050 REM ERIDANUS
4060 DATA3.9,-13,3.3,-20
4070 REM PISCES
4080 DATA1.5,-9,1.2,-10
4090 REM CETUS
4100 DATA.7,-18,1.1,-10,1.3,-9,2,2
4110 REM ORION
4120 DATA5.9,8,5.4,8,5.75,-2,5.6,-1,5.45,0,5.8,-10,5.6,-6
4130 DATA5.6,10,5.5,-21,5.2,-9
4140 REM CANIS MAJOR
4150 DATA6.7,-17,6.3,-18,6.9,-29,7.2,-27,7.4,-29
4160 REM CANIS MINOR
4170 DATA7.6,7,7.4,9
4180 REM GEMINI
4190 DATA7.6,32,7.7,28,7.3,22,6.7,25,6.6,16,6.4,22,6.3,22
4200 REM LEO
4210 DATA10.1,12,10.1,17,10.3,20,10.3,24,11.2,20,11.2,16
4220 DATA11.8,15,9.8,28,9.7,26
4230 REM CANCER
4240 DATA8.7,29,8.6,21
4250 REM HYDRA
4260 DATA9.5,-9,8.7,7,8.9,7,9.2,2,10.4,-17

SKYPLA (continued)

```

4270 REM VIRGO
4280 DATA11.8,2,13.4,-11,13,11,12.9,3,12.7,-1,12.3,-1,13.1,-5
4290 REM CRATER
4300 DATA10.8,-16,10.9,-18,11.3,-15,11.4,-18
4310 REM CORVUS
4320 DATA12.5,-16,12.2,-17,12.5,-23,12.2,-22
4330 REM SERPENS
4340 DATA15.8,17,15.5,10,15.7,7,15.8,5,15.8,-3
4350 REM LIBRA
4360 DATA15.3,-9,14.8,-16
4370 REM OPHIUCHUS
4380 DATA17.5,12,17.2,25,17.6,5,17.7,3
4390 REM SAGITTARIUS
4400 DATA18.3,-30,18,-30,18.4,-25,18.9,-26,19,-30,19.1,-21
4410 DATA18.3,-21
4420 REM SCORPIO
4430 DATA16.5,-26,16.6,-28,16.4,-24,16,-20,15.9,-22,15.9,-26
4440 DATA18.6,-43,16.7,-34,18.5,-37,18.7,-40,16.7,-38
4450 DATA22.9,-30
4460 REM CAPRICORNUS
4470 DATA21.7,-18,21.6,-18,21.4,-22,20.8,-28,20.7,-26,20.3,-14
4480 DATA20.2,-12,22.9,-30
4490 REM DELPHINUS
4500 DATA20.5,11,20.6,15,20.7,15,20.6,16,20.8,16
4510 REM AQUARIUS
4520 DATA22.6,0,22.5,0,22.4,1,22.3,-2,22,0,21.5,-6
4530 REM AQUILA
4540 DATA19.8,9,19.7,10.5,19.9,6,19.1,13,18.95,14,20.1,-1
4550 REM SOUTH POLAR REGION
4560 DATA12.2,-59,12.1,-50,12.4,-57,12.7,-59,12.3,-63
4570 DATA14,-60,14.7,-60,14.7,-65,15.9,-63,15.1,-69,16.9,-69
4580 DATA20.3,-57,1.7,-57,2,-62,0.4,-63,6.3,-52,6.8,-51
4590 DATA8.8,-55,9.3,-55,9.2,-59,8.3,-60,9.1,-70,9.8,-65
4600 DATA3.9,-75,12.5,-69,12.6,-68
4610 SF=1
4620 REM GET AZ AND EL FOR EACH STAR AND POKE IT ON CHART
4630 FORK=0T0236
4640 SR=ST(K,0):SD=ST(K,1)
4650 HD=T2-SR
4660 IFHD<-12THENHD=HD+24
4670 IFHD>12THENHD=HD-24
4680 HA=HD*15
4690 HA=FN RAD(HA):SD=FN RAD(SD)
4700 SL=FNASN(SIN(SD)*SIN(LA)+COS(SD)*COS(LA)*COS(HA))
4710 SZ=(SIN(SD)-SIN(LA)*SIN(SL))/(COS(LA)*COS(SL))
4720 IFSZ=>1THENSZ=0:GOTO4760
4730 IFSZ<=-1THENSZ=3.14159:GOTO4760
4740 SZ=FNACO(SZ)
4750 IFHA>0THENSZ=PI*2-SZ
4760 SZ=FNDEG(SZ)
4770 IFSZ>360THENSZ=SZ-360
4780 IFSZ<0THENSZ=SZ+360
4790 SL=FNDEG(SL)
4800 IFSL>70ORSL<10THEN4990
4810 IFHZ=1THEN4850

```

—SKYPLA (continued)—

```
4820 IFHZ=2THEN4870
4830 IFHZ=3THEN4890
4840 IFHZ=4THEN4910
4850 IF(SZ>5ANDSZ<175)THENGOT04940
4860 GOT04990
4870 IF(SZ>185ANDSZ<355)THENSZ=SZ-180:GOT04940
4880 GOT04990
4890 IF(SZ>95ANDSZ<265)THENSZ=SZ-90:GOT04940
4900 GOT04990
4910 IF(SZ>275ANDSZ=<360)THENSZ=SZ-270:GOT04940
4920 IF(SZ>0ANDSZ<85)THENSZ=SZ+90:GOT04940
4930 GOT04990
4940 REM POKE STAR
4950 X1=SZ:Y1=SL
4960 Y2=28/90*Y1+2.5:X2=55/180*X1+4
4970 Y3=8*(Y2-INT(Y2)):X3=8*(X2-INT(X2))
4980 POKEP0(INT(Y2),INT(X2)),PP(INT(Y3),INT(X3))
4990 NEXTK
5000 X1=0:Y1=0:Y2=0:X2=0:X=0
5010 RETURN
5020 REM SET 8X8 GRID
5030 IFFS=1THENRETURN
5040 LP=-512:XP=0:AP=7:GP=128
5050 FORIP=1TO8:FORJP=1TO9
5060 IFJP=9THENAP=AP+1
5070 FORKP=1TOAP
5080 POKELP,XP
5090 LP=LP+1
5100 NEXTKP
5110 IFJP=9GOT05200
5120 POKELP,GP
5130 LP=LP+1
5140 IFFP<>1GOT05170
5150 PRINTCHR$(12):PRINT"COMPUTING...PLEASE WAIT"
5160 NEXTJP
5170 IFJP=9GOT05190
5180 AP=AP-1:FP=1
5190 NEXTJP
5200 FP=0:AP=7:XP=0:GP=GP*.5
5210 NEXTIP
5220 FS=1:RETURN
5230 REM POKE MOON ON CHART
5240 ND=ND-.5
5250 LP=255.7433
5260 LZ=311.1687:LE=178.699:LM=LZ+360*ND/27.32158
5270 MD=LM:GOSUB5890:LM=MD
5280 REM CORRECT FOR ELLIPTICAL ORBIT
5300 PG=.111404*ND+LP
5310 MD=PG:GOSUB5890
5320 PG=MD
5330 PG=LM-PG
5340 DR=6.2886*(SIN(FNRAD(PG)))
5350 LM=LM+DR
5360 RQ=LM:RM=LM/15
5370 IFRM>24THENRM=RM-24:GOT05370
5380 IFRM<0THENRM=RM+24
```

SKYPLA (continued)

```
5390 AL=LE-ND*.052954
5400 ND=ND+.5
5410 MD=AL:GOSUB5890
5420 AL=MD
5430 AL=RQ-AL
5440 IFAL<360THENAL=AL+360
5450 IFAL>360THENAL=AL-360
5460 HE=5.1333*SIN(AL*PI/180)
5470 DM=HE+23.1444*SIN(RQ*PI/180)
5480 HD=T2-RM
5490 IFHD<-12THENHD=HD+24
5500 IFHD>12THENHD=HD-24
5510 IF(HD>12ORHD<-12)THENGOTO5940
5520 HA=FNRAD(HD*15):DM=FNRAD(DM)
5530 ML=FNASN(SIN(DM)*SIN(LA)+COS(DM)*COS(LA)*COS(HA))
5540 MZ=FNACO((SIN(DM)-SIN(LA)*SIN(ML))/(COS(LA)*COS(ML)))
5560 IFHA>0THENMZ=PI*2-MZ
5570 MZ=FNDEG(MZ)
5580 ML=FNDEG(ML)
5600 IFML>80ORML<5THEN5800
5610 MX=MZ
5620 IFHZ=1THEN5660
5630 IFHZ=2THEN5680
5640 IFHZ=3THEN5700
5650 IFHZ=4THEN5720
5660 IF(MX>10ANDMX<170)THENGOTO5750
5670 GOTO5800
5680 IF(MX>190ANDMX<350)THENMX=MX-180:GOTO5750
5690 GOTO5800
5700 IF(MX>100ANDMX<260)THENMX=MX-90:GOTO5750
5710 GOTO5800
5720 IF(MX>275ANDMX=<360)THENMX=MX-270:GOTO5750
5730 IF(MX>0ANDMX<85)THENMX=MX+90:GOTO5750
5740 GOTO5800
5750 REM POKE MOON
5760 X1=MX:Y1=ML
5770 Y2=28/90*Y1+2.5:X2=55/180*X1+4
5780 GOSUB5820
5790 POKEPO(INT(Y2),INT(X2)),MS
5800 X1=0:X2=0:Y1=0:Y2=0
5810 RETURN
5820 PM=RS+12-RQ/15
5830 IFPM>24THENPM=PM-24
5840 IFPM>12THENPM=PM-24
5850 IF(PM>=-2ANDPM<=2)THENMS=111:RETURN
5855 IF LA<0ANDPM<-2THENMS=41:RETURN
5860 IFPM<-2THENMS=40:RETURN
5865 IF LA<0ANDPM>2THENMS=40:RETURN
5870 IFPM>2THENMS=41
5880 RETURN
5890 IFMD<-3600THENMD=MD+3600:GOTO5890
5900 IFMD<-360THENMD=MD+360:GOTO5900
5910 IFMD<0THENMD=MD+360
5920 IFMD>3600THENMD=MD-3600:GOTO5920
5930 IFMD>360THENMD=MD-360:GOTO5930
5940 RETURN
```

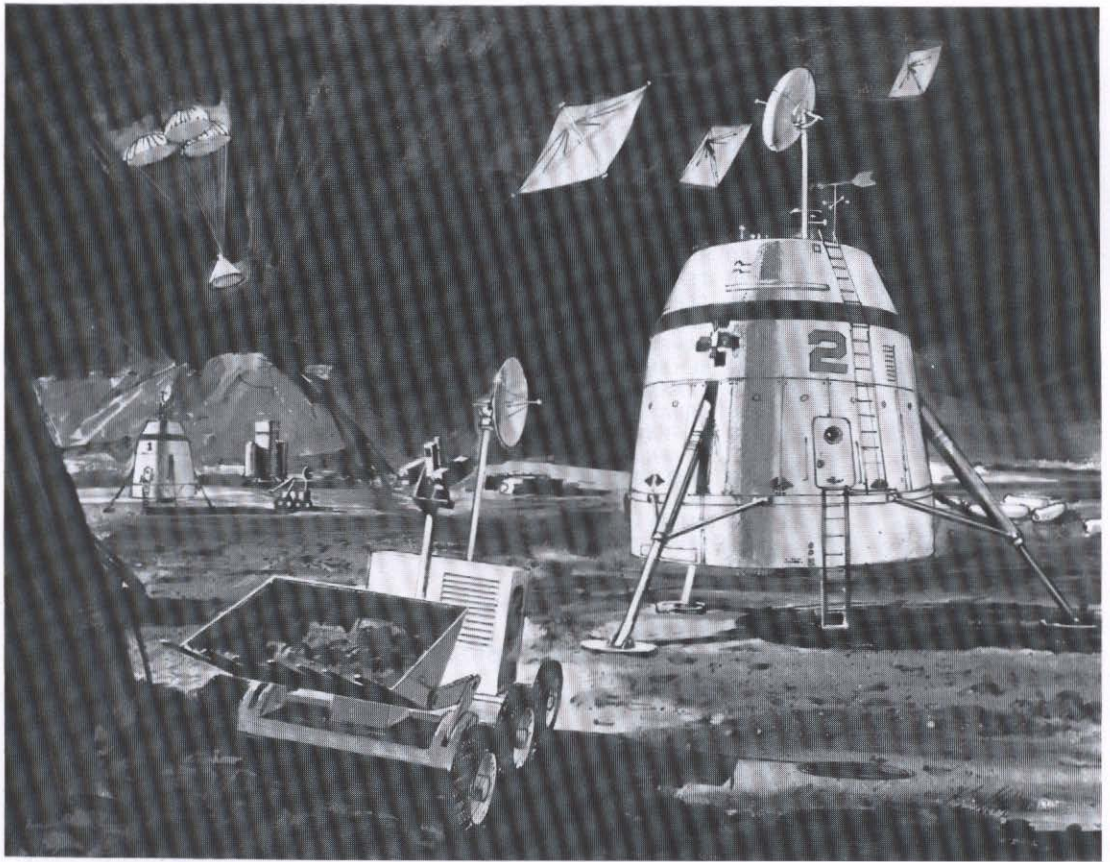


Photo Credit: NASA/Jet Propulsion Laboratory

By the end of this century man may begin to set up working bases on the planets, possibly beginning with a base on the Moon and continuing with a base on Mars, as shown in this artist's concept. In this picture solar sail spacecraft are bringing people and materials into orbit around Mars, from which descent

takes place by parachute. The landed modules are then established as parts of the base. They would gradually be interconnected like the modules of bases in Antarctica or those of the oil cities on Alaska's North Slope.

Program 17A: PLNTA

Alternative Planet Finder Program

This program is a more advanced version of Program 17, PLNTF. It is designed for use with computers having 64 by 30 screen formats. Because of the larger screen format, the program can display more detail on the screen and a wider range of stars on the star charts.

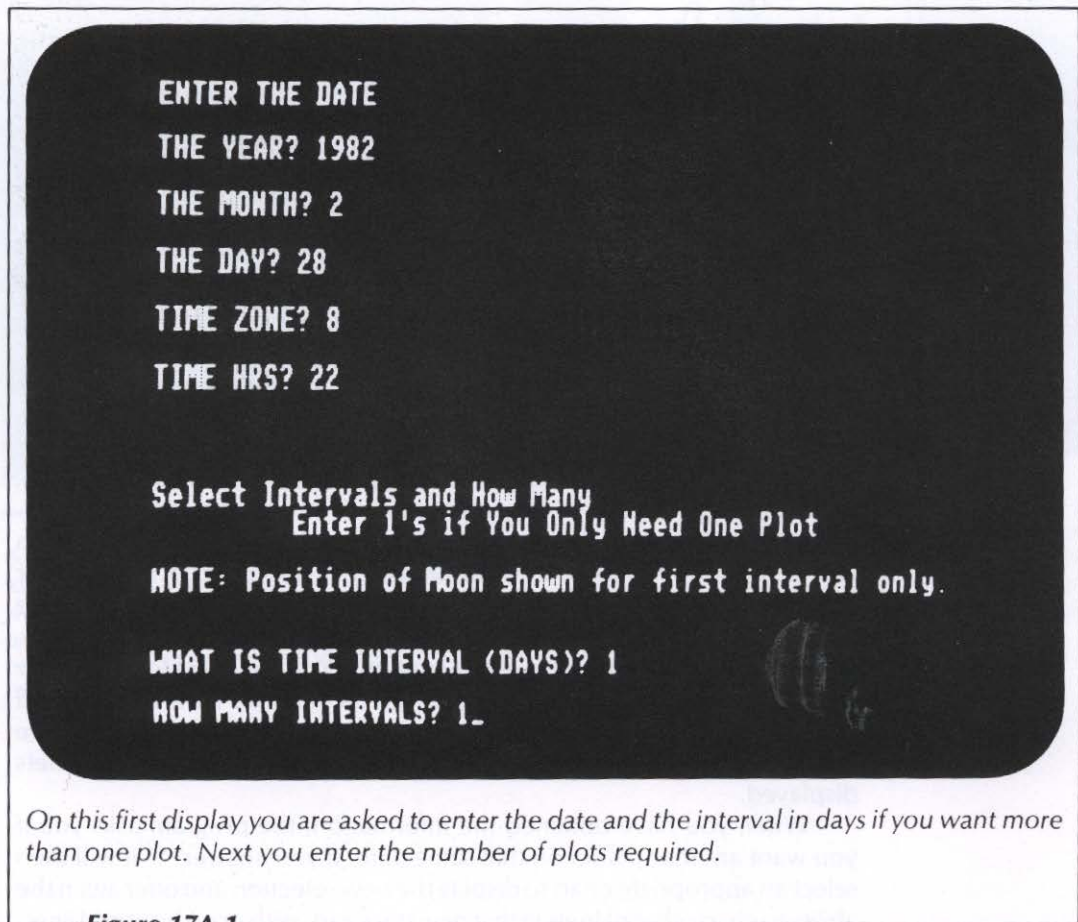
When you select a date and a planet, the Sun, or the Moon, this program calculates where the object is located among the "fixed" stars of the celestial sphere. It selects a suitable star chart, displays its name, identifies constellations, shows the object among the stars, and names bright stars. It identifies and displays nearby constellations over 4 hours of right ascension and 60 degrees of declination, and it provides a grid of right ascension and declination. Because of the limitations of resolution of the monitor screen, the selected object's accurate right ascension and declination are displayed before the object is shown on the star chart.

The program then offers several options. You can elect to have other planets, the Sun, and the Moon displayed on the chart if they are located in the same chart region on the date requested, and you can elect to have the grid lines deleted and again either have a single planet or all planets displayed.

When you have obtained the information, the program asks you if you want another planet on that same date. If you answer 'Y' it will then select an appropriate chart to display the new selection and offer again the ability to chart other planets in that new star chart, with or without grid lines.

Other alternatives available are to ask for another date for the same planet, or another date and another planet.

You can also determine, when selecting the date, whether you require a series of plots. If you do not, insert 1's for the interval in days and the number of plots required. If you require a series, you must input the number of plots and the time interval (in days) between each plot. If your series of plots runs off the screen, the monitor will display the name of the planet and the message OFF CHART for every plot that is off the chart. In this series mode you also have the choices of adding all other planets and the Sun in the same star chart region to show their movements during the period. Figures 17A.1 through 17A.5 illustrate the capabilities of this version of the planet finding program.



WHICH PLANET (OR THE SUN) DO YOU WANT TO DISPLAY

```

MERCURY (m)...1
VENUS (V)....2
              3.....SUN (☉)
MARS (M).....4
JUPITER (J)...5
SATURN (S)....6
URANUS (U)....7
NEPTUNE (N)...8
PLUTO (P)....9
  
```

SELECT 1 THRU 9? 4

RA OF MARS IS 13.2 DECLINATION IS -6.01

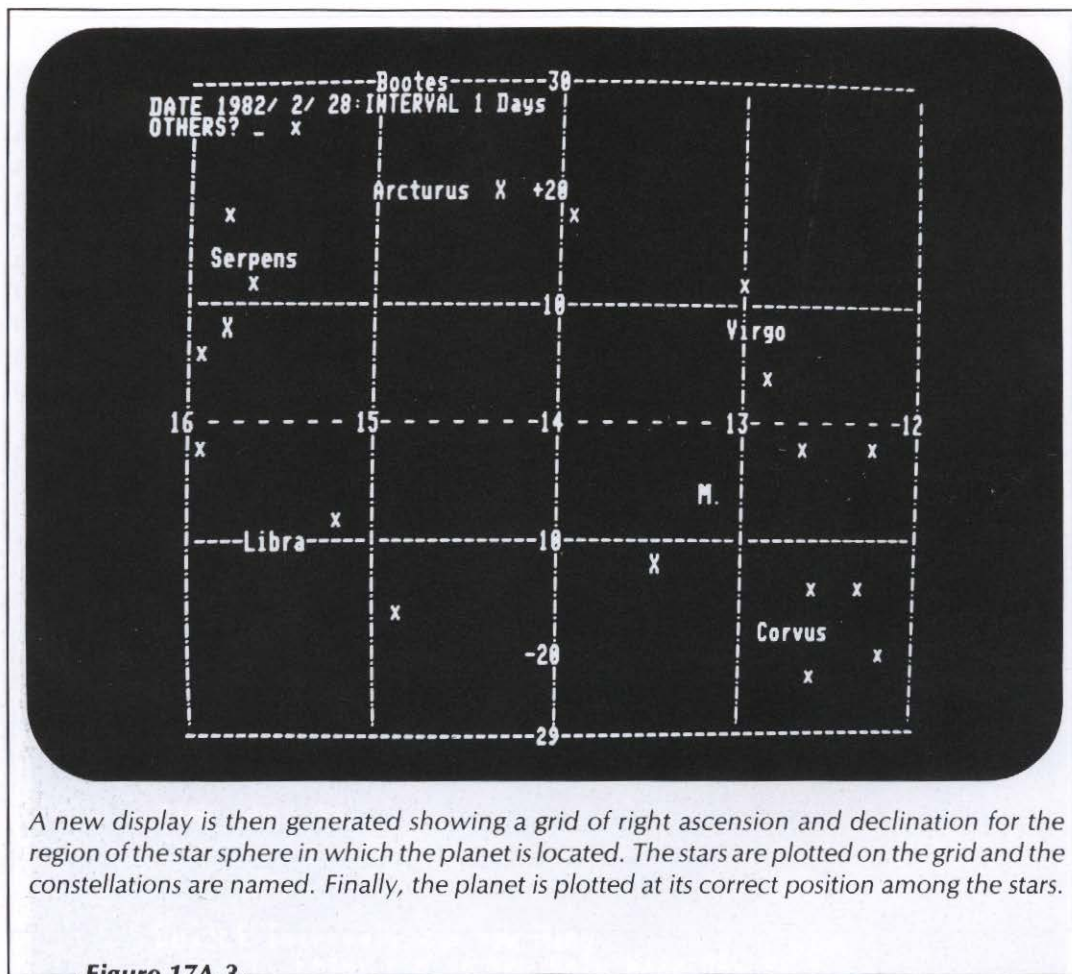
PRESS RETURN TO DISPLAY PLANET ON STAR CHART? _

The program then displays the names of the planets and asks you to select one. After a short delay it provides the right ascension and declination of the selected planet.

—Figure 17A.2—

The program will need modification to suit each computer's display format. The parts of the program requiring modification are those that display the constellations and insert (POKE) the planets, the Sun, and the Moon in the displayed star chart.

For example, a display that has a format of only 40 full characters across the screen (PET, Atari) will have to use 10 characters for 1 hour of right ascension instead of the 15 used in this program. A computer that has only 16 character lines (some TRS-80 models) will have to reduce the vertical size of the star charts and eliminate some of the constellations; that is, it must accept star charts that are plus or minus 7 degrees of declination about the mean ecliptic position in the chart area.



A new display is then generated showing a grid of right ascension and declination for the region of the star sphere in which the planet is located. The stars are plotted on the grid and the constellations are named. Finally, the planet is plotted at its correct position among the stars.

Figure 17A.3

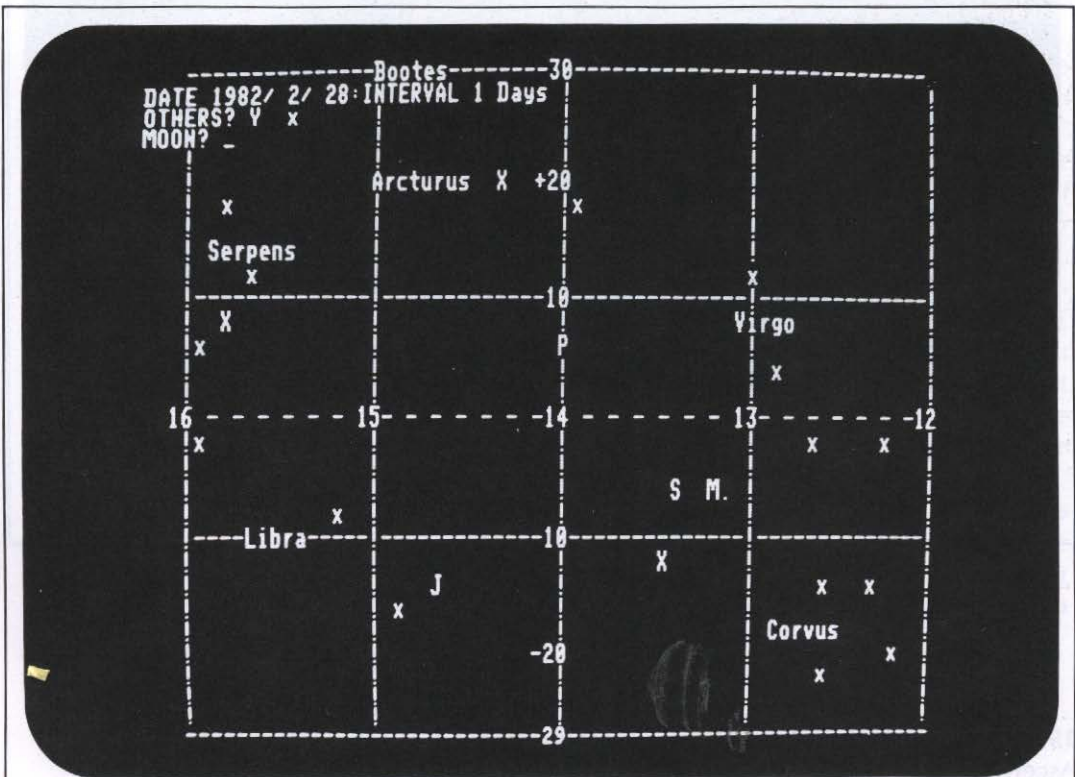
The POKEs for the planets are developed in the routine 2480 through 2590, which provides *PDE*, the planet POKE number. Instruction 2870 sets up *S*, which is the POKE constant that can be varied to suit different machines. *S* is the number to POKE that will place a character on the extreme bottom right corner of your computer's display. The POKE numbers for planets assume a 64-character-wide screen. For a 40-character-wide screen, instruction 2590 (which develops the screen coordinate for declination) must be changed to

$$PDE = DE \times 40$$

The right ascension coordinate (instruction 2730) also must be changed to

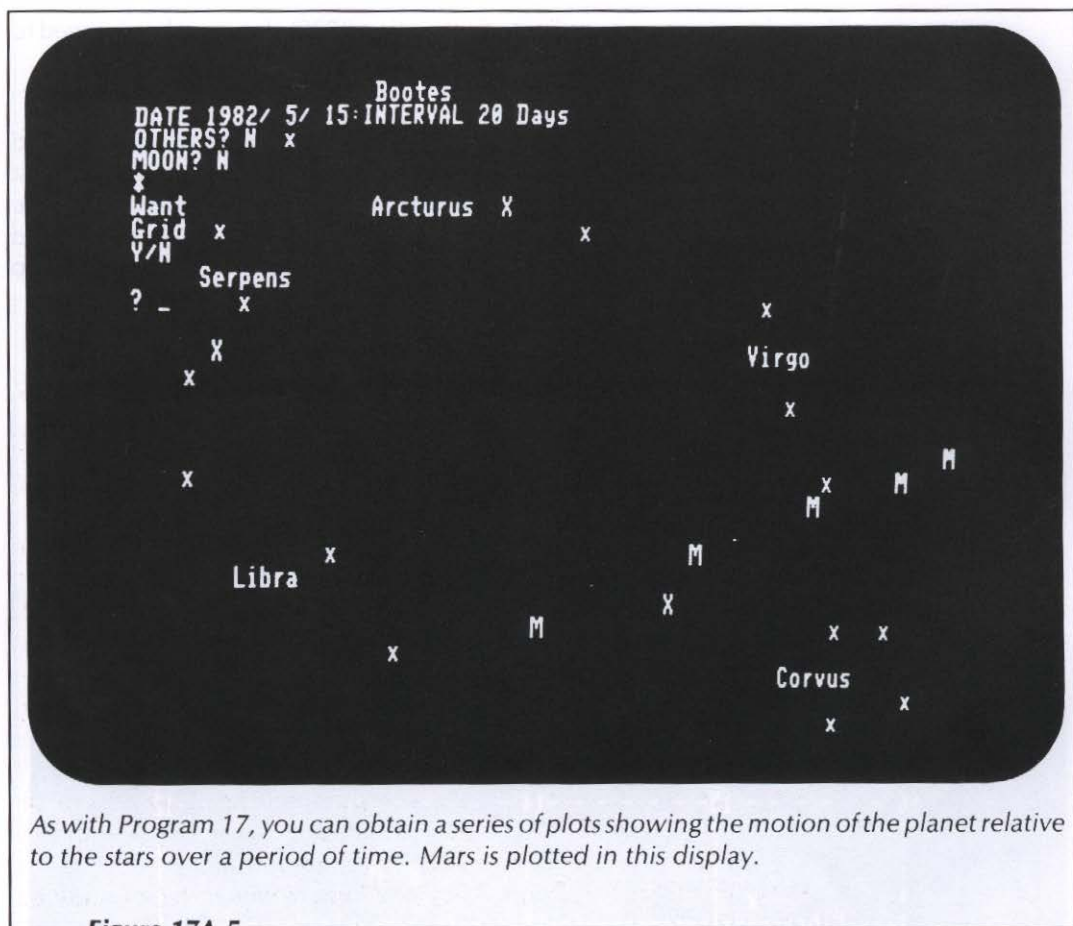
$$RA = RA \times 10$$

The POKE numbers for right ascension will also have to be changed for a 40-character-wide display. Instructions 3810, 4880, and 5640 must all be changed to FOR J=1 TO 41 STEP10; instruction 4540 must be changed to FOR J=1 TO 21 STEP10; instruction 4590 must be changed to FOR J=31 TO 41 STEP10; and instruction 5250 must be changed to FOR J=11 TO 41 STEP10.



If you answer the question 'OTHERS?' with 'Y' all other planets in the same star chart region are also plotted, as shown. You can ask for the Moon to be displayed as well. If you wish you can also have the star chart displayed without the grid lines.

Figure 17A.4



Modifications are somewhat more complicated for a monitor with only 15 text lines, since the full star charts cannot be displayed. A Table of Right Ascensions and Declinations for suitable stars to build your star charts from is provided for such a computer (see pages 266–267). This will affect all the routines to plot charts, namely, instructions 3770 through 6000, the routines to plot the grid lines (2840 through 3010), and the figures of declination on the grid (3030 through 3100). Sufficient remark statements have been included in these routines for you to select those routines that need to be modified to suit your computer's display capabilities.

For a computer with a display monitor showing only 16 lines, it is suggested that the charts be made to show the following declination ranges:

- Chart 1: Declination -1 to 14
- Chart 2: Declination 12 to 28
- Chart 3: Declination -1 to 14
- Chart 4: Declination 1 to -14
- Chart 5: Declination -12 to -28
- Chart 6: Declination 1 to -14

This will eliminate all stars in the Table that have declinations outside these ranges. The effect will be to display only the zodiacal constellations, as in the Apple version given in Program 17. Additional resolution can be obtained by providing one chart for each zodiacal constellation instead of the six used in this version.

The easiest way to make the changes is to draw a screen map of your computer monitor and put the POKE numbers on it for the four corners of your screen. Then make six tracings of the screen, dividing it into four equal parts vertically and (for a 16-line-deep display) two parts horizontally. By placing a tracing of a star chart generated from the table of right ascensions and declinations over the screen sketch you can work out the POKE numbers to be deducted from the value you have selected for S. Then you can rewrite the instructions for the six charts of the zodiac. Also, you must check the ASCII equivalents on your computer for the characters to be POKED. For the Sun, for example, you can use a zero in place of the graphic shown in the program. Refer also to Program 17.

The basic calculations of planetary positions, as well as the subroutines and flags used to produce the different types of displays and select the chart zones, will operate in connection with any new display formats you wish to develop. The program has been sprinkled with REM statements to help you modify it to suit your system.

The listing of the PLNTA program follows.

**Table of Right Ascensions and Declinations for Constellations
Displayed by PLNTA Program**

Chart 1: RA 0 to RA 4

Pegasus	0.1,	29	0.2,	14		
Pleiades	3.6,	24	(five close stars)			
Aries	2.1,	23	1.8,	21	1.8,	19
Taurus	3.0,	4	2.7,	3		
Eridanus	3.9,	-13	3.3,	-20		
Pisces	1.5,	-9	1.2,	-10		
Cetus	0.7,	-18				

Chart 2: RA 4 to RA 8

Orion	5.9,	8	5.4,	8	5.7,	-2	5.6,	-1
	5.5,	0	5.8,	-10	5.6,	-6	5.2,	-9
Sirius	6.7,	-17	6.3,	-18				
Taurus	4.5,	17	5.4,	29	5.6,	21		
Procyon	7.6,	7	7.4,	9				
Gemini (dropped slightly to be on chart)								
	7.5,	30	7.7,	28	7.3,	22	6.7,	25
	6.6,	16	6.4,	22	6.3,	22		

Chart 3: RA 8 to RA 12

Leo	10.1,	12	10.1,	17	10.3,	20	10.3,	24
	11.2,	20	11.2,	16	11.8,	15	9.8,	28
	9.7,	26						
Cancer	8.7,	29	8.6,	21				
Hydra	9.5,	-9	8.7,	7	8.9,	7	9.2,	2
	10.4,	-17						
Virgo	11.8,	2						
Crater	10.8,	-16	10.9,	-18	11.3,	-15	11.4,	-18

**Table of Right Ascensions and Declinations for Constellations
Displayed by PLNTA Program**

Chart 4: RA 12 to RA 16

Virgo	13.4,	-11	13.0,	11	12.9,	3	12.7,	-1
	12.3,	-1	13.1,	-5				
Corvus	12.5,	-16	12.2,	-17	12.5,	-23	12.2,	-22
Bootes	14.2,	20	13.9,	19	14.7,	27	15.5,	27
	15.4,	29						
Serpens	15.8,	17	15.5,	10	15.7,	7	15.8,	5
	15.8,	-3						
Libra	15.3,	-9	14.8,	-16				

Chart 5: RA 16 to RA 20

Aquila	19.7,	10	19.8,	9	19.9,	8	19.0,	13
	18.9,	14						
Ophiuchus	17.5,	12	17.2,	25	17.6,	5	17.7,	3
Sagittarius	18.3,	-30	18.0,	-30	18.4,	-25	18.9,	-26
	19.0,	-30	19.1,	-21	18.3,	-21		
Scorpio	16.5,	-26	16.6,	-28	16.4,	-24	16.0,	-20
	15.9,	-22	15.9,	-26				

Chart 6: RA 20 to RA 24

Fomalhaut	22.9,	-30						
Capricornus	21.7,	-18	21.6,	-18	21.4,	-22	20.8,	-28
	20.7,	-26	20.3,	-14	20.2,	-12		
Delphinus	20.5,	11	20.6,	15	20.7,	15	20.6,	16
	20.8,	16						
Pegasus	21.7,	10	22.2,	6	22.7,	10	23.0,	4
	23.0,	28						
Aquarius	22.6,	0	22.5,	0	22.4,	1	22.3,	-2
	22.0,	0	21.5,	-6				

PLNTA

```

10 CLEAR
20 CLEAR(150)
30 DIMPD(9,9)
40 DEFFNACO(X)=-ATN(X/SQR(-X*X+1))+1.5707963
50 DEFFNRAD(X)=.01745328*(X)
60 DEFFNDEG(X)=57.29578*(X)
70 PRINTCHR$(12):PRINT:PRINT:PRINT:PRINT:PRINT
80 PRINTTAB(14)"ASTRONOMY PROGRAM FOR SORCERER":PRINT:PRINT
90 PRINTTAB(14)"-----"
100 PRINTTAB(14)"*-*-* | PLANET FINDER | *-*-*"
110 PRINTTAB(14)"-----":PRINT
120 PRINTTAB(17)"By ERIC BURGESS F.R.A.S."
130 PRINT:PRINT
140 PRINTTAB(18)"All rights reserved by"
150 PRINT
160 PRINTTAB(18)"S & T Software Service"
165 PRINTTAB(10)"13361 Frati Lane Sebastopol CA 95472"
170 PRINT:PRINT:PRINT
180 PRINTTAB(22)"(Version 4.82)"
190 PRINT:PRINT:PRINT:PRINT:PRINT
200 INPUT"DO YOU WANT INSTRUCTIONS (Y/N)";AS
210 IFAS="N"THEN630
220 IFAS<>"Y"THENPRINT:PRINT"INVALID REPLY":GOTO190
230 PRINTCHR$(12)
240 PRINTTAB(12)"THIS PROGRAM PLACES A PLANET (OR THE SUN)"
245 PRINTTAB(25)"AND THE MOON"
250 PRINTTAB(16)" AMONG THE CONSTELLATIONS
260 PRINT
270 PRINTTAB(18)"FOR THE DATE WHICH YOU INPUT":PRINT
280 PRINTTAB(17)"AND A SERIES OF TIME INTERVALS":PRINT
290 PRINTTAB(11)"The program selects a zone of the celestial"
300 PRINTTAB(11)"sphere 4 hours of right ascension wide and"
310 PRINTTAB(11)"from 30 deg. north of the celestial equator"
320 PRINTTAB(11)"to 29 deg. south declination. It plots the"
330 PRINTTAB(11)"selected planet's position relative to the"
340 PRINTTAB(11)"stars of the constellations, naming these and"
350 PRINTTAB(11)"the brightest stars. If you answer the"
360 PRINTTAB(11)"question 'OTHERS' with 'Y', other planets"
370 PRINTTAB(11)"in the same chart region are plotted also."
380 PRINTTAB(11)"The Sun is plotted if it's in the same region."
385 PRINT
390 PRINTTAB(11)"A grid of right ascension and declination"
400 PRINTTAB(11)"is printed, but you can delete this grid"
410 PRINTTAB(11)"and later bring it back again if you wish."
420 PRINTTAB(11)"If you have the grid plotted and you answer"
430 PRINTTAB(11)"the 'Do You Want Grid' question with 'Y'"
440 PRINTTAB(11)"you will end the display and can then"
450 PRINTTAB(11)"pick another planet or another date."
460 PRINT:PRINT
470 INPUT"WHEN READY TO CONTINUE PRESS RETURN KEY";AS
480 PRINTCHR$(12):PRINT:PRINT:PRINT:PRINT:PRINT:PRINT
490 PRINTTAB(11)"Right ascension is within 1 degree on chart,"
500 PRINTTAB(11)"declination is within 2 degrees. But"
510 PRINTTAB(11);"accurate right ascension and declination"

```


PLNTA (continued)

```

520 PRINTTAB(11)"are given for the selected planet before"
530 PRINTTAB(11)"the chart is displayed."
540 PRINT:PRINTTAB(11);"If in a series of plots the selected"
550 PRINTTAB(11)"planet moves off the chart, this is indicated."
555 PRINT
560 PRINTTAB(11)"The date printed on the chart is the first"
570 PRINTTAB(11);"date in a series of plotted positions."
575 PRINT
576 PRINTTAB(11)"If you answer the question MOON? with 'Y'"
577 PRINTTAB(11)"the position of the Moon for the date"
578 PRINTTAB(11)"requested is shown; ) before full moon,"
579 PRINTTAB(11)"o when close to full, and ( afterward.":PRINT
580 PRINTTAB(11)"NOTE: If two planets are close together and"
590 PRINTTAB(11)"'OTHERS' are requested, the outer planet"
600 PRINTTAB(11)"will overprint the inner planet."
610 PRINT:PRINT:PRINT
620 INPUT"PRESS RETURN TO CONTINUE";A$
630 PRINTCHR$(12):PRINT:PRINT:PRINT
640 PRINT"ENTER THE DATE":PRINT
650 INPUT"THE YEAR";YD$:Y=VAL(YD$)
660 IFY=0THENPRINT"INVALID ENTRY":PRINT:GOTO650
670 IFY>1800GOTO730
680 PRINT"IS ";Y;" THE CORRECT YEAR?"
690 INPUTY$
700 IFY$="Y"THEN730
710 IFY$<>"N"THENPRINT"INVALID ENTRY":PRINT:GOTO680
720 IFY$="N"THENPRINT:GOTO650
730 PRINT:INPUT"THE MONTH";MD$:M=VAL(MD$)
740 IFM=0ORM>12THENPRINT"INVALID ENTRY":PRINT:GOTO730
750 PRINT:INPUT"THE DAY";DD$:D=VAL(DD$):DD=D
751 PRINT:INPUT"TIME ZONE";TZ
752 PRINT:INPUT"TIME HRS";TI
753 TI=TZ+TI:IFTI>24THEN TI=TI-24:D=D+1
760 REM STORES INITIAL DATE IN D2,M2,Y2
770 IFF9=1THEN790
780 T2=TI:D2=D:Y2=Y:M2=M
790 IFD=0ORD>31THENPRINT"INVALID ENTRY":PRINT:GOTO750
800 IFM=2ANDD>29THENPRINT"INVALID ENTRY":PRINT:GOTO750
810 PRINT:PRINT:PRINT
820 PRINT "Select Intervals and How Many"
830 PRINT "          Enter 1's if You Only Need One Plot"
835 PRINT:PRINT"NOTE: Moon's Position shown for first interval";
836 PRINT" only."
840 PRINT:PRINT
850 INPUT"WHAT IS TIME INTERVAL (DAYS)";TIS:PRINT
860 TI=VAL(TIS):IFTI=0THENPRINT"INVALID REPLY":GOTO850
870 INPUT"HOW MANY INTERVALS";INS:PRINT
880 IN=VAL(INS):IFIN=0THENPRINT"INVALID REPLY":GOTO870
890 REM SETS INTERVAL COUNT AT 1
900 NC=1
910 REM CALCULATING DAYS FROM 1960,1,1 EPOCH TO DATE
920 PRINTCHR$(12):PRINT"PLEASE WAIT"
930 REM FROM EPOCH 1960,1,1
940 IFM>=3GOTO990
950 REM CALCS IF MONTH IS JAN OR FEB

```

PLNTA (continued)

```
960 DG=365*Y+D
970 DG=DG+((M-1)*31)+INT((Y-1)/4)-INT((.75)*INT((Y-1)/100+1))
980 GOT01020
990 REM CALS FOR MAR THRU DEC
1000 DG=365*Y+D+((M-1)*31)-INT(M*.4+2.3)
1010 DG=DG+INT(Y/4)-INT((.75)*INT((Y/100)+1))
1020 NI=DG-715875
1025 NM=NI-.5
1030 REM JUMPS PLANETARY INPUTS IF NEW INTERVAL
1040 IFF9=1THEN1690
1050 REM INPUT OF PLANETARY DATA, ORBITAL PARAMETERS, ETC.
1060 REM JUMPS PLANETARY INPUTS IF NEW DATE ETC
1070 IFFL=1GOTO1440
1080 IFF8=1GOTO1460
1090 IFF6=1GOTO1460
1100 RESTORE
1110 FORYP=0T08:FORXP=0T08
1120 READPD(YP,XP)
1130 NEXTXP,YP
1140 REM MERCURY
1150 DATA.071422,3.8484,.388301,1.34041,.3871,.07974,2.73514
1160 DATA.122173,.836013
1170 REM VENUS
1180 DATA.027962,3.02812,.013195,2.28638,.7233,.00506,3.85017
1190 DATA.059341,1.33168
1200 REM EARTH FOR SUN
1210 DATA.017202,1.74022,.032044,1.78547,1,.017,3.33926
1220 DATA0,0
1230 REM MARS
1240 DATA.009146,4.51234,.175301,5.85209,1.5237,.141704
1250 DATA1.04656,.03142,.858702
1260 REM JUPITER
1270 DATA.001450,4.53364,.090478,.23911,5.2028,.249374
1280 DATA1.76188,.01972,1.74533
1290 REM SATURN
1300 DATA.000584,4.89884,.105558,1.61094,9.5385,.534156
1310 DATA3.1257,.043633,1.977458
1320 REM URANUS
1330 DATA.000205,2.46615,.088593,2.96706,19.182,.901554
1340 DATA4.49084,.01396,1.28805
1350 REM NEPTUNE
1360 DATA.000104,3.78556,.016965,.773181,30.06,.270540
1370 DATA2.33498,.031416,2.29162
1380 REM PLUTO
1390 DATA.000069,3.16948,.471239,3.91303,39.44,9.86
1400 DATA5.23114,.300197,1.91812
1410 FORI9=1T09:READP$(I9):NEXTI9
1420 DATAMERCURY,VENUS,SUN,MARS
1430 DATAJUPITER,SATURN,URANUS,NEPTUNE,PLUTO
1440 F=0
1450 IF F9=2THEN1470
1460 FL=0
1470 REM CALCULATE DATA FOR PLANETS
1480 IFF9=2THEN1690
1490 :
```

PLNTA (continued)

```

1500 IFF8=1THENF8=0:GOTO1690
1510 PRINTCHR$(12)
1520 PRINT:PRINT:PRINT
1530 PRINT"WHICH PLANET (OR THE SUN) DO YOU WANT TO DISPLAY"
1540 PRINT:PRINT
1550 PRINTTAB(10)"MERCURY (m)...1"
1560 PRINTTAB(10)"VENUS (V)....2"
1570 PRINTTAB(10)"          3.....SUN ()"
1580 PRINTTAB(10)"MARS (M).....4"
1590 PRINTTAB(10)"JUPITER (J)...5"
1600 PRINTTAB(10)"SATURN (S)....6"
1610 PRINTTAB(10)"URANUS (U)....7"
1620 PRINTTAB(10)"NEPTUNE (N)...8"
1630 PRINTTAB(10)"PLUTO (P)....9"
1640 PRINT
1650 PRINT:PRINTTAB(20):INPUT"SELECT 1 THRU 9";P$$
1660 PS=VAL(P$$)
1670 IFPS=0ORPS>9THENPRINT"INVALID SELECTION":GOTO1650
1680 REM STORES PLANET SELECTED IN P2
1690 P2=PS
1700 I=1
1710 FORJ=0TO8:GOSUB1880
1720 A(I)=A:D(I)=DS:L(I)=L
1730 I=I+1:NEXT
1740 FORI=1TO9
1750 REM SKIP EARTH
1760 IFI=3THENNEXT
1770 GOSUB2030
1780 Q(I)=Q:X(I)=X:R(I)=R:V(I)=V
1790 NEXT
1800 FORI=1TO9:A(I)=FNDEG(A(I))
1810 IFI=3THENNEXT
1820 NEXT
1830 I=PS
1840 R(3)=(A(3)-180)/15
1850 IFR(3)<0THENR(3)=R(3)+24
1860 V(3)=(SIN(FNRAD(A(3)-180)))*23.44194
1870 GOTO2240
1880 REM CALCULATE A, DS AND L
1890 REM EXPLAIN
1900 REM CALC HELIOCENTRIC LONGITUDE A
1910 A=NI*PD(J,0)+PD(J,1)
1920 IFA>6.28318THENA=((A/6.28318)-INT(A/6.28318))*6.28318
1930 IFA<0THENA=A+6.28318:GOTO1930
1940 C=PD(J,2)*SIN(A-PD(J,3))
1950 A=A+C
1960 IFA>6.28318THENA=A-6.28318
1970 IFA<0THENA=A+6.28318:GOTO1970
1980 REM CALC DIST OF PLANET FROM SUN DS
1990 DS=PD(J,4)+PD(J,5)*SIN(A-PD(J,6))
2000 REM CALC DISTANCE OF PLANET FROM ECLIPTIC L
2010 L=PD(J,7)*SIN(A-PD(J,8))
2020 RETURN
2030 REM CALCULATE Z,Q,X,T,R,V
2040 REM CALC ANGULAR DIST OF PLANET FROM SUN Z

```

PLNTA (continued)

```
2050 Z=A(3)-A(1)
2060 IFABS(Z)>3.14159ANDZ<0THENZ=Z+6.28318
2070 IFABS(Z)>3.14159ANDZ>0THENZ=Z-6.28318
2080 REM CALC DIST OF PLANET FROM EARTH Q
2090 Q=SQR(D(I)^2+D(3)^2-2*D(I)*D(3)*COS(Z))
2100 REM CALC ANGULAR DIST OF PLANET FROM SUN X
2110 PP=(D(I)+D(3)+Q)/2
2120 X=2*FNACO(SQR(((PP*(PP-D(I)))/(D(3)*Q))))
2130 REM CALC RIGHT ASCENSION R
2140 IFZ<0THENR=FNDEG(A(3)+3.14159-X)/15
2150 IFZ>0THENR=FNDEG(A(3)+3.14159+X)/15
2160 IFR>24THENR=R-24:GOTO2160
2170 IFR<-24THENR=R+24:GOTO2170
2180 IFR<0THENR=R+24:GOTO2180
2190 REM CALCULATE DECLINATION V
2200 IFZ<0THENV=SIN(A(3)+3.14159-X)*23.44194+FNDEG(L(I))
2210 IFZ>0THENV=SIN(A(3)+3.14159+X)*23.44194+FNDEG(L(I))
2220 X=FNDEG(X)
2230 RETURN
2240 RA=R(PS)
2250 DE=V(PS)
2260 REM JUMPS PRINTING RA AND DEC IF NEW INTERVAL
2270 IFF9=1THEN2360
2280 IFF9=2THEN2360
2290 PRINT:PRINT:PRINT:PRINT
2300 RA$=STR$(RA):DE$=STR$(DE)
2310 RA$=LEFT$(RA$,5):DE$=LEFT$(DE$,5)
2320 PRINT"RA OF ";P$(PS);" IS";RA$;" DECLINATION IS ";DE$
2330 PRINT
2340 INPUT"PRESS RETURN TO DISPLAY PLANET ON STAR CHART";AS
2350 REM STORES RA FOR SELECTED PLANET IN R2
2360 R3=RA:DC=DE
2370 GOSUB2380:GOTO2480
2380 IFPS=1THENP=109:GOTO2470
2390 IFPS=2THENP=86:GOTO2470
2400 IFPS=3THENP=132:GOTO2470
2410 IFPS=4THENP=77:GOTO2470
2420 IFPS=5THENP=74:GOTO2470
2430 IFPS=6THENP=83:GOTO2470
2440 IFPS=7THENP=85:GOTO2470
2450 IFPS=8THENP=78:GOTO2470
2460 IFPS=9THENP=80:GOTO2470
2470 RETURN
2480 REM DEVELOP POKE FOR RA AND DEC
2490 IFF9=1ORF5=1GOTO2510
2500 PN=P
2510 REM AND SELECT CHART FOR DISPLAY BY SETTING CH
2520 GOSUB2560
2530 IFF9=1THEN6380
2540 IF(F7=1ANDF5=1)THENRETURN
2550 GOTO2800
2560 REM POKE FOR DEC
2570 DE=(DE+29)/2
2580 DE=INT(DE)
2590 PDE=DE*64
```

PLNTA (continued)

```

2600 REM JUMPS CHANNEL SELECTION IF POKING OTHER PLANETS
2610 IFF9=1ORF5=1THEN2680
2620 IFRA>20ANDRA<23.99999THENRA=RA-20:CH=6:GOTO2710
2630 IFRA>16ANDRA<19.99999THENRA=RA-16:CH=5:GOTO2710
2640 IFRA>12ANDRA<15.99999THENRA=RA-12:CH=4:GOTO2710
2650 IFRA>8ANDRA<11.99999THENRA=RA-8:CH=3:GOTO2710
2660 IFRA>4.00001ANDRA<7.99999THENRA=RA-4:CH=2:GOTO2710
2670 CH=1
2680 IFF9=1THENOSUB6530
2690 IFF5=1THENOSUB6530
2700 IFF7=1THENRETURN
2710 IFF9=1THENOSUB6470
2720 IFF5=1THENOSUB6470
2730 RA=RA*15
2740 IF(RA-INT(RA))>.49THENRA=INT(RA)+1:GOTO2760
2750 RA=INT(RA)
2760 PL=RA+PDE
2770 IFF5=1THEN2790
2780 PX=PL
2790 RETURN
2800 REM IN EACH CHART POKE PL,P
2810 REM WHERE P IS NAME OF PLANET
2820 REM SUCH AS m,V,M,J,S
2830 PRINTCHR$(12)
2840 REM POKE HORIZONTALS
2850 IFFK=1THENFK=0:GOTO2870
2860 IFF9=2THEN3360
2870 S=2049
2880 HZ=S+1917
2890 FORJ=1TO60:POKE(-HZ+J),45:NEXTJ
2900 HZ=HZ-640
2910 IFHZ>2108GOTO2890
2920 FORJ=1TO61:POKE(-S-61+J),45:NEXTJ
2930 REM POKE VERTICALS
2940 FORK=1TO28
2950 FORJ=1TO61STEP15
2960 POKE(-S-1917+K*64+J),33
2970 NEXTJ
2980 NEXTK
2990 REM POKE EQUATOR
3000 FORJ=1TO61STEP2:POKE(-S-957+J),45
3010 NEXTJ
3020 REM POKE COORDINATES
3030 REM SET DE TO HIGHEST DECLINATION ON TOP OF CHART
3040 POKE-S-1887,51:POKE-S-1886,48
3050 POKE-S-1568,43:POKE-S-1567,50:POKE-S-1566,48
3060 POKE-S-1247,49:POKE-S-1246,48
3070 POKE-S-608,45:POKE-S-607,49:POKE-S-606,48
3080 POKE-S-288,45:POKE-S-287,50:POKE-S-286,48
3090 POKE-S-31,50:POKE-S-30,57
3100 GOTO3360
3110 PRINTCHR$(12):PRINT:PRINT:PRINT:PRINT:PRINT
3120 PRINT"DO YOU WANT ANOTHER PLANET, SAME DATE 'Y' OR 'N'"
3130 PRINT:PRINT:INPUT".....";A$
3140 IFA$="N"THEN3190

```

PLNTA (continued)

```

3150 IFAS<>"Y" THEN PRINT "INVALID REPLY": PRINT: GOTO 3120
3160 REM RESET Y, M, D TO ORIGINAL SELECTION
3170 Y=Y2: M=M2: D=D2
3180 PRINT CHR$(12): PRINT: PRINT: PRINT: GOTO 920
3190 PRINT CHR$(12)
3200 PRINT: PRINT: PRINT: PRINT: PRINT
3210 PRINT "DO YOU WANT ANOTHER DATE FOR SAME PLANET 'Y' OR 'N'"
3220 PRINT: PRINT: INPUT ".....": AS$
3230 IFAS="N" THEN PRINT CHR$(12): PRINT: PRINT: PRINT: GOTO 3270
3240 IFAS<>"Y" THEN PRINT "INVALID REPLY": PRINT: GOTO 3210
3250 F8=1: GOTO 630
3260 PRINT
3270 PRINT: PRINT "DO YOU WANT ANOTHER DATE AND ANOTHER PLANET"
3280 PRINT
3290 INPUT ".....": AS$
3300 IFAS="N" THEN PRINT CHR$(12): GOTO 3350
3310 IFAS<>"Y" THEN PRINT "INVALID REPLY": PRINT: GOTO 3270
3320 PRINT CHR$(12)
3330 FL=0: F1=0: F2=0: F3=0: F4=0: F5=0: F6=0: F7=0: F9=0: F8=0
3340 FX=0: GOTO 630
3350 END
3360 REM SELECT CHART REGION CH
3370 ON CHGOSUB 3770, 4200, 4510, 4850, 5210, 5610
3380 REM POKE OTHER PLANETS
3390 YTS=STR$(Y): MTS=STR$(M): DTS=STR$(D)
3400 PTS="/"
3410 DAS=YTS+PTS+MTS+PTS+DTS
3420 PRINT "DATE": DAS;: PRINT "INTERVAL": TI; "Days"
3430 INPUT "OTHERS": AS$
3440 IFAS="N" THEN F6=1: GOTO 3491
3450 IFAS<>"Y" GOTO 3430
3460 IFAS="Y" THEN F5=1
3470 F6=0
3480 REM SUB TO POKE OTHER PLANETS
3490 GOSUB 6010
3491 INPUT "MOON": AS$
3492 IFAS="Y" THEN GOSUB 7000
3500 REM CHECKS IF MORE CYCLES NEEDED
3510 IFNC<INGOTO 3540
3520 IFNC=>INGOTO 3570
3530 REM SUB TO INCREASE DATE BY INTERVAL AND REPEAT PROGRAM
3540 GOSUB 6280
3550 IFF9=1 THEN 3510
3560 REM RESETS F9 WHEN ALL CYCLES COMPLETED
3570 :
3580 REM RESETS NC, D, M, AND Y TO INITIAL VALUES
3590 NC=1: D=D2: M=M2: Y=Y2
3600 PS=P2: RA=R3: DE=DC
3610 P=PN: PL=PX
3620 FORK=1 TO 500: NEXT K
3630 FORJ=1 TO 5: PRINT "*": FORK=1 TO 100: NEXT
3640 PRINT "Want"
3650 PRINT "Grid"
3660 PRINT "Y/N"
3670 PRINT: INPUT DGS$

```

PLNTA (continued)

```
3680 IF(DG$="N"ANDF9=1)THENFL=1:F9=2:PS=P2:P=PN:GOTO910
3690 IFF3=1ANDDG$="N"THENF3=0:GOTO3110
3700 IFFL=1ANDDG$="N"THENF3=1
3710 IFDG$="N"THENPRINTCHR$(12)
3720 IFDG$="N"THENFL=1:PS=P2:P=PN:GOTO3370
3725 IF(DG$="Y"ANDF9=1ANDFL=0)THENF9=0:GOTO3760
3730 IF(DG$="Y"ANDF9=1)THENFL=0:FK=1:PS=P2:P=PN:F9=2:GOTO910
3740 IFFL=1ANDDG$="Y"THENFL=0:F2=1:GOTO2830
3750 IF DG$<>"Y"THEN3660
3760 GOTO3110
3770 REM CHART 1 RA AND STARS
3780 IFFL=1THENGOTO3870
3790 RA=52:GOSUB3810
3800 GOTO3870
3810 FORJ=1TO61STEP15
3820 POKE(-S-957+J),RA
3830 RA=RA-1
3840 NEXTJ
3850 RETURN
3860 REM PEGASUS
3870 POKE-S-1793,88:POKE-S-1153,88
3880 POKE-S-1544,80:POKE-S-1543,101:POKE-S-1542,103
3890 POKE-S-1541,97:POKE-S-1540,115:POKE-S-1539,117
3900 POKE-S-1538,115
3910 REM PLEIADES
3920 POKE-S-1723,46:POKE-S-1722,46:POKE-S-1719,46
3930 POKE-S-1785,46:POKE-S-1656,46
3940 POKE-S-1655,80:POKE-S-1654,108:POKE-S-1653,101
3950 POKE-S-1652,105:POKE-S-1651,97:POKE-S-1650,100
3960 POKE-S-1649,101:POKE-S-1648,115
3970 REM ARIES
3980 POKE-S-1634,88:POKE-S-1564,88:POKE-S-1499,120
3990 POKE-S-1697,65:POKE-S-1696,114:POKE-S-1695,105
4000 POKE-S-1694,101:POKE-S-1693,115
4010 POKE-S-1133,120:POKE-S-1067,120
4020 POKE-S-306,120
4030 REM TAURUS
4040 POKE-S-1207,84:POKE-S-1206,97:POKE-S-1205,117
4050 POKE-S-1204,114:POKE-S-1203,117:POKE-S-1202,115
4060 POKE-S-571,120
4070 REM ERIDANUS
4080 POKE-S-438,69:POKE-S-437,114:POKE-S-436,105
4090 POKE-S-435,100:POKE-S-434,97:POKE-S-433,110
4100 POKE-S-432,117:POKE-S-431,115
4110 REM PISCES
4120 POKE-S-786,80:POKE-S-785,105:POKE-S-784,115
4130 POKE-S-783,99:POKE-S-782,101:POKE-S-781,115
4140 POKE-S-331,88:POKE-S-594,120:POKE-S-662,120
4150 REM CETUS
4160 POKE-S-407,67:POKE-S-406,101:POKE-S-405,116
4170 POKE-S-404,117:POKE-S-403,115
4180 POKE-S-PL,P
4190 RETURN
4200 REM CHART2 RA AND STARS
4210 IFFL=1GOTO4250
```

PLNTA (continued)

```
4220 RA=56
4230 GOSUB3810
4240 REM ORION
4250 POKE-S-537,79:POKE-S-536,114:POKE-S-535,105
4260 POKE-S-534,111:POKE-S-533,110
4270 POKE-S-919,88:POKE-S-856,88:POKE-S-793,88
4280 POKE-S-1117,88:POKE-S-1174,88
4290 POKE-S-602,88:POKE-S-659,88
4300 POKE-S-727,42
4310 POKE-S-1241,120
4320 REM SIRIUS
4330 POKE-S-236,115:POKE-S-237,117:POKE-S-238,105
4340 POKE-S-239,114:POKE-S-240,105:POKE-S-241,83
4350 POKE-S-170,88:POKE-S-163,120
4360 REM TAURUS
4370 POKE-S-1416,88:POKE-S-1813,88:POKE-S-1560,88
4380 POKE-S-1802,84:POKE-S-1801,97:POKE-S-1800,117
4390 POKE-S-1799,114:POKE-S-1798,117:POKE-S-1797,115
4400 REM PROCYON
4410 POKE-S-1267,120:POKE-S-1142,88
4420 POKE-S-1080,80:POKE-S-1079,114:POKE-S-1078,111
4430 POKE-S-1077,99:POKE-S-1076,121:POKE-S-1075,111
4440 POKE-S-1074,110:POKE-S-1912,88
4450 POKE-S-1785,88:POKE-S-1699,88:POKE-S-1512,88
4460 POKE-S-1650,120
4470 POKE-S-1842,71:POKE-S-1841,101:POKE-S-1840,109
4480 POKE-S-1839,105:POKE-S-1838,110:POKE-S-1837,105
4490 POKE-S-PL,P
4500 RETURN
4510 REM CHART 3 RA AND STARS
4520 IFFL=1GOTO4630
4530 RA=50:RT=49
4540 FORJ=1TO31STEP15
4550 POKE(-S-958+J),RT:POKE(-S-957+J),RA
4560 RA=RA-1
4570 NEXTJ
4580 RA=57
4590 FORJ=46TO61STEP15
4600 POKE(-S-957+J),RA
4610 RA=RA-1
4620 NEXTJ
4630 REM LEO
4640 POKEPL,P
4650 POKE-S-1522,76:POKE-S-1521,101:POKE-S-1520,111
4660 POKE-S-1465,120:POKE-S-1585,120:POKE-S-1457,120
4670 POKE-S-1628,120:POKE-S-1694,120:POKE-S-1635,46
4680 POKE-S-1571,120:POKE-S-1504,46:POKE-S-1313,88
4690 REM CANCER
4700 POKE-S-1680,67:POKE-S-1679,97:POKE-S-1678,110
4710 POKE-S-1677,99:POKE-S-1676,101:POKE-S-1675,114
4720 POKE-S-1548,120:POKE-S-1421,120
4730 REM HYDRA
4740 POKE-S-795,72:POKE-S-794,121:POKE-S-793,100
4750 POKE-S-792,114:POKE-S-791,97:POKE-S-365,120
4760 POKE-S-1164,120:POKE-S-1166,120:POKE-S-979,120
```


PLNTA (continued)

```
4770 POKE-S-599,120:POKE-S-545,120
4780 REM CRATER
4790 POKE-S-496,67:POKE-S-495,114:POKE-S-494,97
4800 POKE-S-493,116:POKE-S-492,101:POKE-S-491,114
4810 POKE-S-499,120:POKE-S-427,120:POKE-S-373,120
4820 POKE-S-365,120
4830 POKE-S-PL,P
4840 RETURN
4850 REM CHART 4 FOR RA AND STARS
4860 IFFL=1GOTO4910
4870 RA=54:RT=49
4880 FORJ=1TO61STEP15
4890 POKE(-S-958+J),RT:NEXTJ
4900 GOSUB3810
4910 REM BOOTES
4920 POKE-S-1901,66:POKE-S-1900,111:POKE-S-1899,111
4930 POKE-S-1898,116:POKE-S-1897,101:POKE-S-1896,115
4940 POKE-S-1780,120:POKE-S-1842,120:POKE-S-1835,120
4950 POKE-S-1571,88:POKE-S-1501,120
4960 POKE-S-1581,65:POKE-S-1580,114:POKE-S-1579,99
4970 POKE-S-1578,116:POKE-S-1577,117:POKE-S-1576,114
4980 POKE-S-1575,117:POKE-S-1574,115
4990 REM SERPENS
5000 POKE-S-1402,83:POKE-S-1401,101:POKE-S-1400,114
5010 POKE-S-1399,112:POKE-S-1398,101:POKE-S-1397,110
5020 POKE-S-1396,115
5030 POKE-S-1529,120:POKE-S-1335,120:POKE-S-1209,88
5040 POKE-S-1147,120:POKE-S-891,120
5050 REM LIBRA
5060 POKE-S-631,76:POKE-S-630,105:POKE-S-629,98
5070 POKE-S-628,114:POKE-S-627,97
5080 POKE-S-688,120:POKE-S-427,120
5090 REM VIRGO
5100 POKE-S-1168,86:POKE-S-1167,105:POKE-S-1166,114
5110 POKE-S-1165,103:POKE-S-1164,111
5120 POKE-S-1295,120:POKE-S-1037,120:POKE-S-842,120
5130 POKE-S-836,120:POKE-S-721,46:POKE-S-534,88
5140 REM CORVUS
5150 POKE-S-333,67:POKE-S-332,111:POKE-S-331,114
5160 POKE-S-330,118:POKE-S-329,117:POKE-S-328,115
5170 POKE-S-457,120:POKE-S-453,120:POKE-S-201,120
5180 POKE-S-259,120
5190 POKE-S-PL,P
5200 RETURN
5210 REM CHART 5 FOR RA AND STARS
5220 IFFL=1GOTO5290
5230 RA=57
5240 POKE-S-957,50:POKE-S-956,48
5250 FORJ=16TO61STEP15
5260 POKE(-S-958+J),49:POKE(-S-957+J),RA
5270 RA=RA-1
5280 NEXTJ
5290 REM AQUILA
5300 POKE-S-1402,65:POKE-S-1401,113:POKE-S-1400,117
5310 POKE-S-1399,105:POKE-S-1398,108:POKE-S-1397,97
```

PLNTA (continued)

5320 POKE-S-1454,120:POKE-S-1391,120
5330 POKE-S-1334,120:POKE-S-1273,88:POKE-S-1210,120
5340 POKE-S-1271,65:POKE-S-1270,108:POKE-S-1269,116
5350 POKE-S-1268,97:POKE-S-1267,105:POKE-S-1266,114
5360 REM OPHIUCUS
5370 POKE-S-1501,79:POKE-S-1500,112:POKE-S-1499,104
5380 POKE-S-1498,105:POKE-S-1497,117:POKE-S-1496,99
5390 POKE-S-1495,117:POKE-S-1494,115
5400 POKE-S-1749,120:POKE-S-1305,120:POKE-S-986,120
5410 POKE-S-924,120
5420 REM SAGITTARIUS
5430 POKE-S-120,83:POKE-S-119,97:POKE-S-118,103
5440 POKE-S-117,105:POKE-S-116,116:POKE-S-115,116
5450 POKE-S-114,97:POKE-S-113,114:POKE-S-112,105
5460 POKE-S-111,117:POKE-S-110,115
5470 POKE-S-303,120:POKE-S-172,120:POKE-S-169,120
5480 POKE-S-46,120:POKE-S-228,120:POKE-S-100,120
5490 POKE-S-31,120
5500 REM SCORPIO
5510 POKE-S-330,83:POKE-S-329,99:POKE-S-328,111
5520 POKE-S-327,114:POKE-S-326,112:POKE-S-325,105
5530 POKE-S-324,111
5540 POKE-S-322,120:POKE-S-193,88:POKE-S-129,88
5550 POKE-S-134,120:POKE-S-72,88:POKE-S-10,120
5560 POKE-S-81,65:POKE-S-80,110:POKE-S-79,116
5570 POKE-S-78,97:POKE-S-77,114:POKE-S-76,101
5580 POKE-S-75,115
5590 POKE-S-PL,P
5600 RETURN
5610 REM CHART 6 FOR RA AND STARS
5620 IFFL=1G0T05680
5630 RA=52:RT=50
5640 FORJ=1T061STEP15
5650 POKE(-S-958+J),RT
5660 NEXTJ
5670 GOSUB3810
5680 REM PEGASUS
5690 POKE-S-1721,80:POKE-S-1720,101:POKE-S-1719,103
5700 POKE-S-1718,97:POKE-S-1717,115:POKE-S-1716,117
5710 POKE-S-1715,115
5720 POKE-S-1839,120:POKE-S-1455,120:POKE-S-1897,120
5730 POKE-S-1322,120:POKE-S-1185,120:POKE-S-1245,120
5740 REM DELPHINUS
5750 POKE-S-1552,68:POKE-S-1551,101:POKE-S-1550,108
5760 POKE-S-1549,112:POKE-S-1548,104:POKE-S-1547,105
5770 POKE-S-1546,110:POKE-S-1545,117:POKE-S-1544,115
5780 POKE-S-1488,46:POKE-S-1486,46:POKE-S-1423,46
5790 POKE-S-1421,46:POKE-S-1293,46
5800 REM FOMALHAUT
5810 POKE-S-180,70:POKE-S-179,111:POKE-S-178,109
5820 POKE-S-177,97:POKE-S-176,108:POKE-S-175,104
5830 POKE-S-174,97:POKE-S-173,117:POKE-S-172,116
5840 POKE-S-111,88
5850 REM AQUARIUS
5860 POKE-S-997,65:POKE-S-996,113:POKE-S-995,117

PLNTA (continued)

```
5870 POKE-S-994,97:POKE-S-993,114:POKE-S-992,105
5880 POKE-S-991,117:POKE-S-990,115
5890 POKE-S-938,120:POKE-S-936,120:POKE-S-999,120
5900 POKE-S-870,120:POKE-S-929,120:POKE-S-729,120
5910 REM CAPRICORNUS
5920 POKE-S-157,67:POKE-S-156,97:POKE-S-155,112
5930 POKE-S-154,114:POKE-S-153,105:POKE-S-152,99
5940 POKE-S-151,111:POKE-S-150,114:POKE-S-149,110
5950 POKE-S-148,117:POKE-S-147,115
5960 POKE-S-412,120:POKE-S-410,120:POKE-S-214,120
5970 POKE-S-77,120:POKE-S-139,120:POKE-S-454,120
5980 POKE-S-517,120
5990 POKE-S-PL,P
6000 RETURN
6010 REM SUBROUTINE TO POKE NEARBY PLANETS
6020 PN=P
6025 OP=1
6030 FORI=1TO9
6035 IF I=P2THEN NEXTI
6040 PS=I:F5=1
6050 REM JUMPS R RANGE IF BEEN THROUGH THIS TABLE ONCE
6060 IFF4=1THEN6130
6070 IFCH=1THENR2=0:GOTO6130
6080 IFCH=2THENR2=4:GOTO6130
6090 IFCH=3THENR2=8:GOTO6130
6100 IFCH=4THENR2=12:GOTO6130
6110 IFCH=5THENR2=16:GOTO6130
6120 IFCH=6THENR2=20
6130 IFR(I)<R2ORR(I)>(R2+3.9999)THEN6220
6135 OP=0
6140 REM GET PLANET SYMBOL
6150 GOSUB2380
6160 RA=R(I):DE=V(I)
6170 REM GET POKE FOR PLANET
6180 GOSUB2560
6190 IFF7=1THENF7=0:GOTO6210
6200 POKE-S-PL,P
6205 OP=0
6210 F4=1
6220 NEXTI
6225 IFOP=1THENPRINT"NONE":OP=0
6226 OP=0
6230 PS=P2
6240 P=PN
6250 RA=R3:DE=DC
6260 F4=0:F5=0:F=1:RETURN
6270 REM INCREASES COUNTER BY ONE
6280 NC=NC+1
6290 PS=P2
6300 F9=1
6310 D=D+TI
6320 REM INCREMENTS DATE
6330 IFD>30THEND=D-30:M=M+1:GOTO6330
6340 IFM>12THENM=M-12:Y=Y+1
6350 REM GOES THROUGH PROGRAM AGAIN FOR NEW DATE
```

PLNTA (continued)

```
6360 GOT0930
6370 REM POKE THE PLANET'S NEW POSITION
6380 IFF7=1THENF7=0:GOT06400
6390 POKE-S-PL,P
6400 REM POKES THE OTHER PLANETS ON NEW DATE
6410 IFF6=1THEN6430
6420 F9=0:GOSUB6010
6430 REM GOES BACK AND REPEATS IF STILL MORE INTERVALS
6440 F9=1
6450 RETURN
6470 IFRA>20ANDRA<23.9999THENRA=RA-20:RETURN
6480 IFRA>16ANDRA<19.9999THENRA=RA-16:RETURN
6490 IFRA>12ANDRA<15.9999THENRA=RA-12:RETURN
6500 IFRA>8ANDRA<11.9999THENRA=RA-8:RETURN
6510 IFRA>4ANDRA<7.9999THENRA=RA-4:RETURN
6520 RETURN
6530 ONCHGOT06540,6560,6580,6600,6620,6640
6540 IFRA>3.9999GOT06680
6550 RETURN
6560 IFRA<4ORRA>7.9999GOT06680
6570 RETURN
6580 IFRA<8ORRA>11.9999GOT06680
6590 RETURN
6600 IFRA<12ORRA>15.9999GOT06680
6610 RETURN
6620 IFRA<16ORRA>19.9999GOT06680
6630 RETURN
6640 IFRA<20ORRA>23.9999GOT06680
6650 RETURN
6660 IFF7=1THEN6700
6670 RETURN
6680 F7=1:GOT06690
6690 PRINTP$(PS)
6700 PRINT"OFF"
6710 PRINT"CHART"
6720 RETURN
7000 REM TO POKE MOON ON CHART
7005 REM LONG OF MOON
7010 LZ=311.1687
7015 LE=178.699
7016 LP=255.7433:PG=-.111404*NMLP
7017 IFPG<-360THENPG=PG+360:GOT07017
7018 IFPG<0THENPG=PG+360
7019 IFPG>360THENPG=PG-360:GOT07019
7020 LMD=LZ+360*NML/27.32158
7021 PG=LMD-PG
7022 DR=6.2886*SIN(FNRAD(PG))
7023 LMD=LMD+DR
7025 IFLMD<-360THENLMD=LMD+360:GOT07025
7026 IFLMD<-360THEN LMD=LMD+360:GOT07026
7030 IFLMD<0THENLMD=LMD+360:GOT07030
7035 IFLMD>360THENLMD=LMD-360:GOT07035
7040 IFLMD>360THENLMD=LMD-360:GOT07040
7050 RM=LMD/15
7055 RQ=RM
```

PLNTA (continued)

```
7060 IF RM>24 THEN RM=RM-24:GOTO7060
7070 IFRM<0 THEN RM=RM+24
7080 AL=LE-NM*.052954
7085 IFAL<-360 THEN AL=AL+360:GOTO7085
7086 IFAL<-360 THEN AL=AL+360:GOTO7086
7090 IF AL<0 THEN AL=AL+360:GOTO7090
7095 IFAL>360 THEN AL=AL-360:GOTO7095
7100 IF AL>360 THEN AL=AL-360:GOTO7100
7106 AL=LMD-AL
7107 IFAL<0 THEN AL=AL+360
7108 IFAL>360 THEN AL=AL-360
7110 HE=5.1333*SIN(AL*3.14159/180)
7120 DM=HE+23.1444*SIN(LMD*3.14159/180)
7130 DM=(DM+29)/2:DM=INT(DM):PDE=DM*64
7220 IFCH=2 THEN R2=4:GOTO7270
7230 IFCH=3 THEN R2=8:GOTO7270
7240 IFCH=4 THEN R2=12:GOTO7270
7250 IFCH=5 THEN R2=16:GOTO7270
7260 IFCH=6 THEN R2=20
7270 IFRM<R2 OR RM>(R2+3.9999) THEN 7290
7271 GOSUB7310:RM=RM*15
7272 IF (RM-INT(RM))>.49 THEN RM=INT(RM)+1:GOTO7274
7273 RM=INT(RM)
7274 PM=RM+PDE
7275 GOSUB7500
7280 POKE-S-PM,MS
7285 RETURN
7290 PRINT"OFF":PRINT"CHART":RETURN
7310 IFRM>20 AND RM<23.9999 THEN RM=RM-20:RETURN
7320 IFRM>16 AND RM<19.9999 THEN RM=RM-16:RETURN
7330 IFRM>12 AND RM<15.9999 THEN RM=RM-12:RETURN
7340 IFRM>8 AND RM<11.9999 THEN RM=RM-8:RETURN
7350 IFRM>4 AND RM<7.9999 THEN RM=RM-4:RETURN
7360 RETURN
7500 RZ=R(3)
7510 DZ=RZ-RQ
7515 IFDZ<0 THEN DZ=DZ+24
7520 IFDZ>11 AND DZ<13 THEN MS=111:RETURN
7540 IFDZ>13 THEN MS=41:RETURN
7550 MS=40
7560 RETURN
```

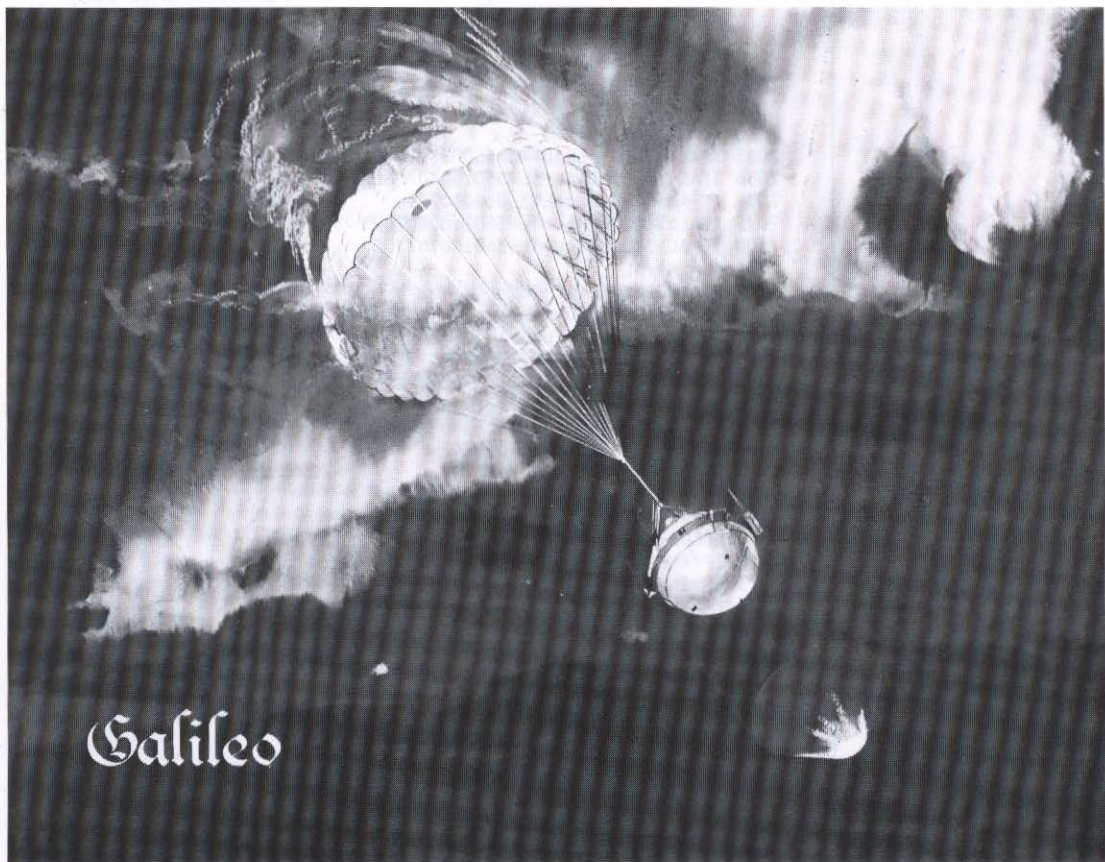


Photo Credit: NASA/Jet Propulsion Laboratory

A man-made meteor, the probe of Project Galileo is planned to penetrate into the deep atmosphere of Jupiter in the mid-1980s. This ambitious mission will

explore thoroughly the environment of the giant planet of our solar system and obtain closer looks at its larger satellites over a period of several years.

Program 20A: SSTARA

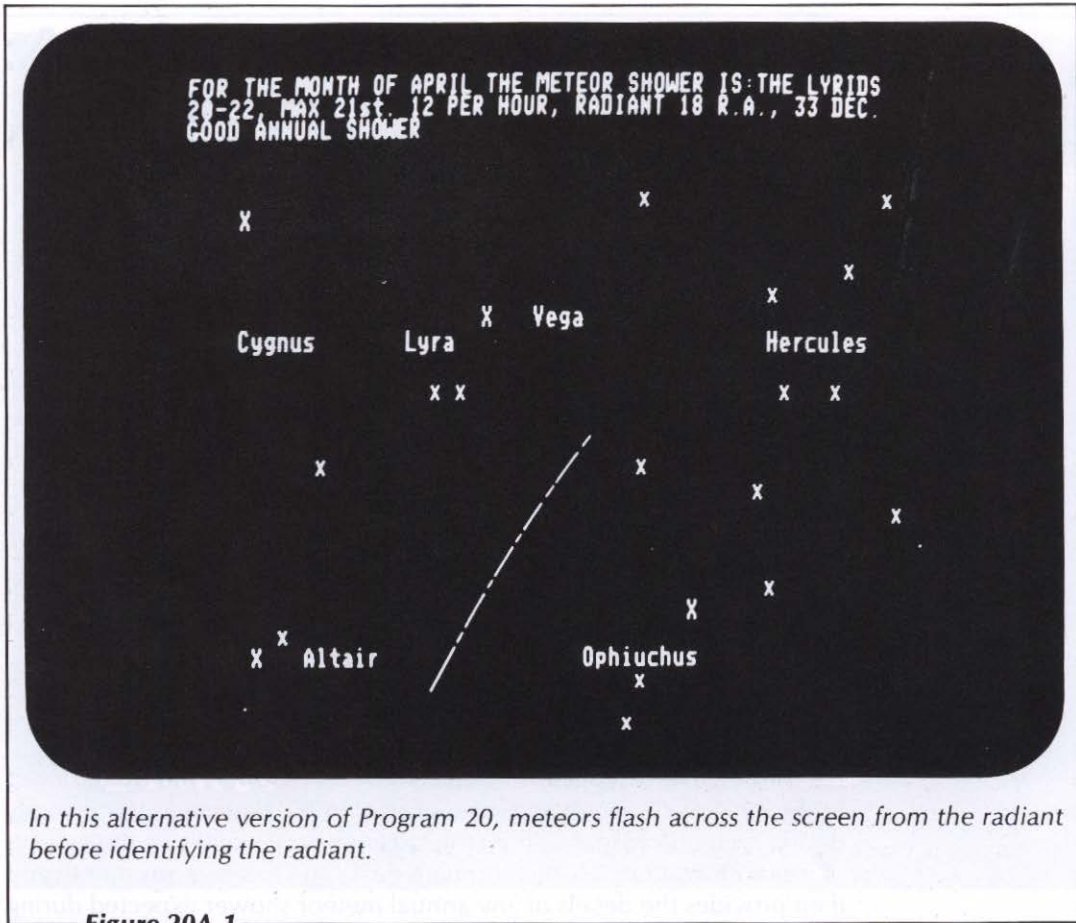
Alternative Meteor Shower Program

This alternative program for depicting meteor showers was written for an Exidy Sorcerer computer and makes use of POKE statements to randomly display meteors originating from the radiant before identifying the radiant.

As with Program 20, this alternative asks you to select any month and then provides the details of any annual meteor shower expected during that month. If you use PHASE with this program you will be able to find out whether or not observations of the meteor shower will be affected by a bright Moon (between full and last quarter). The program graphically displays first the meteors and then the radiant for the shower among the stars of the constellations for any selected month. It provides details of each meteor shower and names constellations. A typical display of this program is shown in Figure 20A.1.

For other computers, PRINT @ statements can be used to position the stars instead of the PRINT and TAB instructions used for the Sorcerer. The POKE statements also will have to be changed to suit your screen memory area in displaying the meteors coming from the radiant, as well as the radiant itself. In this program version, MS is the POKE location of the middle of the screen.

The listing of the SSTARA program follows.



In this alternative version of Program 20, meteors flash across the screen from the radiant before identifying the radiant.

Figure 20A.1

SSTARA

```
10 PRINTCHR$(12)
20 PRINT:PRINT:PRINT
30 PRINTTAB(11)"-----"
40 PRINTTAB(11)"|      M E T E O R S      |"
50 PRINTTAB(11)"-----"
60 PRINT:PRINT:PRINT
70 PRINTTAB(15)"An Astronomy Program"
80 PRINT:PRINTTAB(14)"By ERIC BURGESS F.R.A.S."
90 PRINT:PRINT:PRINT:
100 PRINTTAB(14)"All Rights Reserved by"
110 PRINTTAB(14)"S & T Software Service"
120 PRINT:PRINT:PRINT
130 PRINTTAB(8)"This program provides particulars of"
140 PRINTTAB(8)"Annual Meteor Showers for Any Month"
150 FOR K=1TO2000:NEXTK
160 PRINTCHR$(12):PRINT:PRINT:PRINT:PRINT
170 INPUT"SELECT MONTH (1 THROUGH 12)";M
180 PRINT
190 IFM<10RM>12THENPRINT:PRINT"Invalid Request":PRINT:GOTO180
200 PRINTCHR$(12):PRINT
210 M2=M
220 IFM2=1THENM$="JANUARY":GOTO340
230 IFM2=2THENM$="FEBRUARY":GOTO510
240 IFM2=3THENM$="MARCH":GOTO550
250 IFM2=4THENM$="APRIL":GOTO570
260 IFM2=5THENM$="MAY":GOTO810
270 IFM2=6THENM$="JUNE":GOTO1030
280 IFM2=7THENM$="JULY":GOTO1250
290 IFM2=8THENM$="AUGUST":GOTO1470
300 IFM2=9THENM$="SEPTEMBER":GOTO1450
310 IFM2=10THENM$="OCTOBER":GOTO1650
320 IFM2=11THENM$="NOVEMBER":GOTO1870
330 IFM2=12THENM$="DECEMBER":GOTO2500
340 PRINT"FOR THE MONTH OF ";M$;" THE METEOR SHOWER IS:";
350 PRINT"THE QUADRANTIDS"
355 PRINT"MAX ON 6th JAN. 40 PER HOUR,  RADIANT 15.5 R.A., 50 DEC
357 PRINT"GOOD ANNUAL SHOWER":PRINT
360 PRINTTAB(2)". "
370 PRINTTAB(47)". "
380 PRINTTAB(10)". ";TAB(18)"Draco"
390 PRINT:PRINTTAB(24)". "
400 PRINTTAB(16)"x":PRINTTAB(54)"Ursa":PRINTTAB(53)"Major"
410 PRINTTAB(63)"x":PRINT:PRINT:PRINT:PRINT
420 PRINTTAB(31)"x"
430 PRINTTAB(38)"x":PRINT
440 PRINTTAB(27)"x";TAB(40)"Bootes"
450 PRINTTAB(42)". "
460 PRINTTAB(25)". ";TAB(41)". ":PRINTTAB(14)"Corona"
470 PRINTTAB(24)"x";TAB(36)"x":PRINT
480 PRINTTAB(42)"X  Arcturus"
490 GOSUB3650
500 GOTO3600
510 PRINT"DURING THE MONTH OF ";M$;" THERE IS NO MAJOR"
520 PRINT:PRINT"      ANNUAL METEOR SHOWER"
```

SSTARA (continued)

```
530 PRINT:PRINT:PRINT:PRINT:PRINT:PRINT:PRINT
540 GOTO3600
550 PRINT"DURING THE MONTH OF ";M$;" THERE IS NO MAJOR"
560 GOTO520
570 PRINT"FOR THE MONTH OF ";M$;" THE METEOR SHOWER IS:";
580 PRINT"THE LYRIDS"
590 PRINT"20-22, MAX 21st. 12 PER HOUR, RADIANT 18 R.A., 33 DEC.
600 PRINT"GOOD ANNUAL SHOWER"
610 PRINT:PRINT
620 PRINTTAB(35)"x";TAB(54)"x"
630 PRINTTAB(4)"x":PRINT
640 PRINTTAB(51)"x"
650 PRINTTAB(45)"x"
660 PRINTTAB(23)"X Vega"
670 PRINTTAB(4)"Cygnus";TAB(17)"Lyra";TAB(45)"Hercules"
680 PRINT:PRINTTAB(19)"x x";TAB(46)"x";TAB(50)"x"
690 PRINT:PRINT
700 PRINTTAB(10)"x";TAB(35)"x"
710 PRINTTAB(44)"x"
720 PRINTTAB(55)"x"
730 PRINTTAB(57)".":PRINT
740 PRINTTAB(45)"x"
750 PRINTTAB(39)"X"
760 PRINTTAB(7)"x"
770 PRINTTAB(5)"X Altair";TAB(31)"Ophiuchus"
780 PRINTTAB(35)"x":PRINTTAB(4)".":PRINTTAB(34)"x"
790 GOSUB3650
800 GOTO3600
810 PRINT"FOR THE MONTH OF ";M$;" THE METEOR SHOWER IS:";
820 PRINT"THE ETA AQUARIDS"
830 PRINT"4-13, MAX ON 6th. RADIANT AT 22.54 R.A., 0 DEC."
840 PRINT"WEAK DISPLAY"
850 PRINT:PRINT:PRINTTAB(9)"Pegasus"
860 PRINTTAB(45)"Delphinus"
870 PRINTTAB(54)".":TAB(56)"."
880 PRINTTAB(3)"x";TAB(21)"x";TAB(55)".":TAB(57)".":PRINT
890 PRINTTAB(27)".":TAB(42)"x";TAB(48)".":TAB(60)"."
900 PRINTTAB(36)".":TAB(47)".":PRINT:PRINT
910 PRINT:PRINTTAB(29)"x";TAB(36)"x"
920 PRINTTAB(27)"x";TAB(32)"."
930 PRINTTAB(42)"Aquarius":PRINT
940 PRINTTAB(45)"x":PRINT:PRINT
950 PRINTTAB(56)".":PRINT
960 PRINTTAB(24)".":TAB(62)"x"
970 PRINTTAB(23)".":TAB(41)"x";TAB(43)".":TAB(47)".":
980 PRINTTAB(51)"."
990 PRINT:PRINTTAB(43)"Capricornus"
1000 PRINT
1010 GOSUB3650
1020 GOTO3600
1030 PRINT:PRINT:PRINT
1040 PRINT"FOR THE MONTH OF JUNE THERE ARE TWO SHOWERS;"
1050 PRINT:PRINT:PRINT
1060 PRINT:PRINTTAB(5)"THE LYRIDS"
```

SSTARA (continued)

```
1070 PRINT:PRINT"JUNE 10-21, MAX ON 15th, BLUISH METEORS";
1080 PRINT" AVERAGING 8 PER HOUR"
1090 PRINT:PRINT:PRINTTAB(8)"AND"
1100 PRINT:PRINT:PRINTTAB(5)"THE OPHIUCIDS"
1110 PRINT:PRINT"JUNE 17-26, MAX ON 19th";
1120 PRINT" AVERAGING 6 PER HOUR"
1130 PRINT:PRINT:PRINT
1140 PRINT:PRINT:PRINT"PLEASE SELECT LYRIDS (1)"
1150 PRINT"          OR OPHIUCIDS (2)"
1160 PRINT:INPUT$
1170 JS=VAL(A$):IFJS<1ORJS>2THENPRINT"INVALID SELECTION":GOTO1140
1180 IFJS=1THENGOSUB3070:GOTO1200
1190 IFJS=2THENGOSUB3340
1200 INPUT"DO YOU WANT TO SEE THE OTHER SHOWER Y/N";A$
1210 PRINTCHR$(12)
1220 IF$="Y"ANDJS=1THENGOSUB3340:GOTO1240
1230 IF$="Y"ANDJS=2THENGOSUB3070
1240 GOTO3600
1250 PRINT"FOR THE MONTH OF ";M$;" THE METEOR SHOWER IS";
1260 PRINT" THE DELTA AQUARIDS"
1270 PRINT"JUL.25-AUG 4, MAX JUL.28th. R.A. 22.8 DEC. -16"
1280 PRINT"DIFFUSE SHOWER"
1290 PRINT
1300 PRINTTAB(25)". ";TAB(29)". ";TAB(42)"x"
1310 PRINT:PRINTTAB(34)". ";TAB(42)"x"
1320 PRINTTAB(39)". ":PRINT
1330 PRINTTAB(52)"x":PRINTTAB(29)". "
1340 PRINTTAB(9)". ";TAB(63)". "
1350 PRINTTAB(44)"Aquarius"
1360 PRINTTAB(30)". "
1370 PRINTTAB(28)"x";TAB(45)"x";TAB(49)". ";TAB(57)". "
1380 PRINT" x"
1390 PRINTTAB(51)". ":PRINTTAB(53)". ":PRINT
1400 PRINTTAB(62)". ":PRINT:PRINTTAB(31)"x":PRINT
1410 PRINTTAB(23)"Fomalhaut"
1420 PRINTTAB(43)"x":PRINT:PRINT:PRINTTAB(5)"x"
1430 GOSUB3650
1440 GOTO3600
1450 PRINT"DURING THE MONTH OF ";M$;" THERE IS NO MAJOR"
1460 GOTO520
1470 PRINT"FOR THE MONTH OF ";M$;" THE METEOR SHOWER IS";
1480 PRINT" THE PERSEIDS"
1490 PRINT"4-16, MAX 12th, 50 PER HOUR, 3.0 R.A., 58 DEC."
1500 PRINT"A MAJOR SPECTACULAR SHOWER"
1510 PRINT:PRINT:PRINT:PRINT:PRINTTAB(18)". ";TAB(48)". "
1520 PRINTTAB(48)". ":PRINTTAB(47)"Cassiopeia"
1530 PRINT:PRINTTAB(18)". ";TAB(52)"x"
1540 PRINT:PRINTTAB(2)"x";TAB(60)"x"
1550 PRINT:PRINTTAB(32)". ";TAB(38)"Perseus"
1560 PRINTTAB(29)"x":PRINTTAB(31)". "
1570 PRINTTAB(25)"x";TAB(28)". "
1580 PRINTTAB(21)"x":PRINT:PRINT
1590 PRINTTAB(48)"x":PRINTTAB(17)"x";TAB(29)"x"
1600 PRINTTAB(29)". ";TAB(45)"Andromeda"
```

SSTARA (continued)

```
1610 PRINT:PRINTTAB(47)"x";TAB(63)"x"
1620 PRINT
1630 GOSUB3650
1640 GOTO3600
1650 PRINT"FOR THE MONTH OF ";M$;" THE METEOR SHOWER IS";
1660 PRINT" THE ORIONIDS"
1670 PRINT"16-26, MAX 21st. 30 PER HOUR, 6.4 R.A., 15 DEC."
1680 PRINT"SLOW METEORS WITH PERSISTENT TRAILS"
1690 PRINTTAB(41)"X   Auriga"
1700 PRINTTAB(15)"X   Gemini";TAB(57)"x"
1710 PRINT:PRINTTAB(12)"x";TAB(51)"x"
1720 PRINTTAB(28)".":PRINT
1730 PRINTTAB(18)".";TAB(35)"x";TAB(38)"."
1740 PRINTTAB(23)".";TAB(34)".";TAB(46)"x"
1750 PRINT:PRINTTAB(20)".";TAB(30)"x"
1760 PRINTTAB(61)"x":PRINTTAB(28)"."
1770 PRINT:PRINTTAB(5)".";TAB(20)"x";TAB(47)"."
1780 PRINTTAB(40)"x";TAB(50)"x"
1790 PRINTTAB(14)"x"
1800 PRINTTAB(10)"Procyon";TAB(47)"Orion"
1810 PRINT:PRINTTAB(47)"x"
1820 PRINTTAB(45)"x":PRINTTAB(43)"x";TAB(50)"."
1830 PRINTTAB(46)":":PRINTTAB(14)".";TAB(50)"x"
1840 PRINTTAB(42)"x"
1850 GOSUB3650
1860 GOTO3600
1870 PRINT:PRINT:PRINT
1880 PRINT"FOR THE MONTH OF ";M$;" THERE ARE TWO SHOWERS;"
1890 PRINT:PRINT:PRINT
1900 PRINT:PRINTTAB(5)"THE TAURIDS"
1910 PRINT:PRINT"OCT 20 - NOV 30, MAX ON 8 NOV. SLOW METEORS"
1920 PRINT"WITH SCATTERED FIREBALLS, AVERAGE 12 PER HOUR"
1930 PRINT:PRINT:PRINTTAB(8)"AND"
1940 PRINT:PRINT:PRINTTAB(5)"THE LEONIDS"
1950 PRINT:PRINT"NOV. 15-19, MAX ON 17th,"
1960 PRINT"AVERAGING 10 PER HOUR"
1970 PRINT:PRINT
1980 PRINT:PRINT:PRINT"PLEASE SELECT TAURIDS (1)"
1990 PRINT"          OR LEONIDS (2)"
2000 PRINT:INPUTA$
2010 JS=VAL(A$)
2020 IFJS<10RJJS>2THENPRINT"INVALID SELECTION":GOTO1980
2030 IFJS=1THENGOSUB2100:GOTO2050
2040 IFJS=2THENGOSUB2330
2050 INPUT"DO YOU WANT TO SEE THE OTHER SHOWER Y/N";A$
2060 PRINTCHR$(12)
2070 IFA$="Y"ANDJS=1THENGOSUB2330:GOTO2090
2080 IFA$="Y"ANDJS=2THENGOSUB2100
2090 GOTO3600
2100 REM NOV TAURIDS
2110 PRINTCHR$(12)
2120 PRINT"FIRST SHOWER FOR MONTH OF ";M$;" IS";
2130 PRINT" THE TAURIDS"
2140 PRINT"FROM OCT 20 - NOV 30, MAX 8th, 12 PER HOUR WITH"
2150 PRINT"TWO RADIANTS 3.73 R.A., 14 AND 22 DEC."
```

SSTARA (continued)

```
2160 PRINT"SCATTERED FIREBALLS, SLOW"
2170 PRINT:PRINTTAB(58)"X"
2180 PRINTTAB(10)". .":PRINTTAB(30)". .";TAB(42)"X"
2190 PRINTTAB(42)". ."
2200 PRINTTAB(29)". .":PRINTTAB(56)"X"
2210 PRINTTAB(14)". .";TAB(29)"X . .";TAB(60)". ."
2220 PRINTTAB(7)"X":PRINT:PRINT
2230 PRINTTAB(31)". .":TAB(58)"X"
2240 PRINTTAB(2)"X";TAB(12)"Taurus";TAB(21)". .";
2250 PRINTTAB(52)"Aries":PRINTTAB(60)". ."
2260 PRINTTAB(18)"X";TAB(22)". ."
2270 PRINTTAB(20)". ."
2280 PRINTTAB(27)". .":PRINTTAB(2)". .";TAB(35)". ."
2290 PRINTTAB(5)"X";TAB(36)". ."
2300 PRINTTAB(42)"X";TAB(57)". .":PRINT:PRINTTAB(2)"X"
2310 PRINT:PRINT:PRINT
2320 GOSUB3650:TF=1:GOSUB3650:RETURN
2330 REM NOV LEONIDS
2340 PRINTCHR$(12)
2350 PRINT"SECOND SHOWER FOR MONTH OF ";M$;" IS";
2360 PRINT" THE LEONIDS"
2370 PRINT"DEC. 15-19, MAX ON 17th., 10 PER HOUR"
2380 PRINT"R.A. 10.13, DEC 22, SWIFT METEORS"
2390 PRINTTAB(32)". .":PRINTTAB(30)". .":PRINT:PRINT:PRINT
2400 PRINTTAB(15)". .";TAB(22)". .":PRINTTAB(19)". ."
2410 PRINT:PRINTTAB(36)". .":PRINTTAB(30)". .";TAB(38)"X"
2420 PRINT:PRINTTAB(29)"X":PRINTTAB(15)"X"
2430 PRINTTAB(32)". .":PRINTTAB(6)"X";TAB(15)"X";TAB(20)"Leo"
2440 PRINTTAB(32)"X Regulus"
2450 PRINTTAB(12)". .";TAB(40)". ."
2460 PRINTTAB(7)". .";TAB(52)"X . ."
2470 PRINTTAB(57)". .":PRINTTAB(6)". .":PRINT
2480 PRINT:PRINT:PRINT
2490 GOSUB3650:RETURN
2500 PRINT:PRINT:PRINT
2510 PRINT"FOR THE MONTH OF ";M$;" THERE ARE TWO SHOWERS;"
2520 PRINT:PRINT:PRINT
2530 PRINT:PRINTTAB(5)"THE GEMINIDS"
2540 PRINT:PRINT"9-13, MAX ON 13th. SWIFT BRIGHT METEORS"
2550 PRINT"WITH SOME FIREBALLS, AVERAGE 60 PER HOUR"
2560 PRINT:PRINT:PRINTTAB(8)"AND"
2570 PRINT:PRINT:PRINTTAB(5)"THE URSIDS"
2580 PRINT:PRINT"17-24, MAX ON 22nd. WEAK DISPLAY"
2590 PRINT"AVERAGE 5 PER HOUR"
2600 PRINT:PRINT
2610 PRINT:PRINT:PRINT"PLEASE SELECT GEMINIDS (1)"
2620 PRINT" OR URSIDS (2)"
2630 PRINT:INPUTA$: JS=VAL(A$)
2640 IFJS=1THENGOSUB2710:GOTO2660
2650 IFJS=2THENGOSUB2880
2660 INPUT"DO YOU WANT TO SEE THE OTHER SHOWER Y/N";A$
2670 PRINTCHR$(12)
2680 IFAS="Y"ANDJS=1THENGOSUB2880:GOTO2700
2690 IFAS="Y"ANDJS=2THENGOSUB2710
2700 GOTO3600
```

SSTARA (continued)

```
2710 REM DEC GEMINIDS
2720 PRINTCHR$(12)
2730 PRINT"FIRST SHOWER FOR MONTH OF ";M$;" IS";
2740 PRINT" THE GEMINIDS"
2750 PRINT"FROM DEC 9-24, MAX ON 13th, 60 PER HOUR, SWIFT"
2760 PRINT"BRIGHT METEORS, 7.46 R.A., 32 DEC."
2770 PRINT:PRINT:PRINTTAB(9)".";TAB(45)"Auriga"
2780 PRINTTAB(7)".":PRINTTAB(55)"x":PRINT
2790 PRINT:PRINTTAB(58)".":PRINTTAB(55)"."
2800 PRINT:PRINTTAB(34)"x";PRINTTAB(41)"."
2810 PRINTTAB(12)".":PRINTTAB(30)"x";TAB(45)"."
2820 PRINTTAB(30)".":PRINTTAB(13)".";TAB(36)"x";TAB(52)"x x"
2830 PRINTTAB(40)".":PRINTTAB(11)".";TAB(37)"Gemini"
2840 PRINTTAB(48)"x":PRINT
2850 PRINTTAB(47)".":PRINTTAB(61)":
2860 PRINTTAB(35)"x";TAB(58)"x":PRINTTAB(31)"X Procyon"
2870 GOSUB3650:RETURN
2880 REM DEC URSIDS
2890 PRINTCHR$(12)
2900 PRINT"SECOND SHOWER FOR MONTH OF ";M$;" IS";
2910 PRINT" THE URSIDS"
2920 PRINT"FROM DEC 17-24, MAX ON 22nd., 5 PER HOUR"
2930 PRINT"FAINT MEDIUM SPEED METEORS, 14.46 R.A., 78 DEC."
2940 PRINT:PRINT:PRINTTAB(22)"Polaris";TAB(32)"x"
2950 PRINT:PRINTTAB(28)".":PRINT:PRINT:PRINT
2960 PRINTTAB(24)".":PRINT
2970 PRINTTAB(58)".":PRINT:PRINT
2980 PRINTTAB(12)"Ursa";TAB(26)".";TAB(51)"."
2990 PRINTTAB(11)"Minor"
3000 PRINTTAB(22)".";TAB(28)"x":PRINT
3010 PRINTTAB(26)"x";TAB(42)"Draco"
3020 PRINT:PRINTTAB(2)"x":PRINT:PRINT
3030 PRINTTAB(37)".":PRINTTAB(10)"x":PRINT
3040 PRINTTAB(14)"x";TAB(22)"x"
3050 GOSUB3650
3060 RETURN
3070 REM JUNE LYRIDS
3080 PRINTCHR$(12)
3090 PRINT"FIRST SHOWER FOR MONTH OF ";M$;" IS";
3100 PRINT" THE LYRIDS"
3110 PRINT"FROM 10-20, MAX 15th. 8 PER HOUR";
3120 PRINT" RADIANT 18.3 R.A., 35 DEC."
3130 PRINT"BLUISH METEORS"
3140 PRINT:PRINTTAB(43)"Draco"
3150 PRINTTAB(44)"X"
3160 PRINTTAB(37)"x":PRINT:PRINT
3170 PRINTTAB(62)"x"
3180 PRINTTAB(8)"x";TAB(43)"x":PRINT
3190 PRINTTAB(2)"x";TAB(57)"x"
3200 PRINTTAB(18)"Vega";TAB(25)"x";
3210 PRINTTAB(50)"x":PRINT:PRINT
3220 PRINTTAB(21)"x x";TAB(52)"x x"
3230 PRINTTAB(4)"Cygnus";TAB(49)"Hercules"
3240 PRINTTAB(13)"x"
3250 PRINTTAB(51)"x":PRINT
```

SSTARA (continued)

```
3260 PRINTTAB(62)"x":PRINT:PRINT
3270 PRINTTAB(24)". "
3280 PRINTTAB(22)"x";TAB(50)"x"
3290 PRINTTAB(45)"x"
3300 PRINTTAB(11)"x";TAB(43)"Ophiuchus"
3310 PRINTTAB(9)"x";TAB(12)"Altair"
3320 GOSUB3650
3330 RETURN
3340 REM JUNE OPHIUCIDS
3350 PRINTCHR$(12)
3360 PRINT"SECOND SHOWER FOR MONTH OF ";M$;" IS";
3370 PRINT" THE OPHIUCIDS"
3380 PRINT"FROM 17-26, MAX 19th, 6 PER HOUR";
3390 PRINT" RADIANT 17.3 R.A. -20 DEC."
3400 PRINTTAB(25)"x";TAB(45)". "
3410 PRINTTAB(20)"Ophiuchus"
3420 PRINTTAB(4)". ";TAB(50)"x";
3430 PRINTTAB(56)". ":PRINTTAB(5)". "
3440 PRINTTAB(7)". ";TAB(45)". "
3450 PRINTTAB(11)". ";TAB(22)". ";TAB(42)"x";TAB(60)"x"
3460 PRINT:PRINT
3470 PRINTTAB(27)". ";TAB(33)"x":PRINT
3480 PRINT:PRINTTAB(2)"x";TAB(50)"x":PRINT
3490 PRINTTAB(14)"x";TAB(51)"x"
3500 PRINTTAB(5)"x";TAB(46)"x"
3510 PRINTTAB(43)"x";TAB(51)"x"
3520 PRINTTAB(3)"x";TAB(15)"x";TAB(20)"x";TAB(42)"x"
3530 PRINT:PRINTTAB(5)"Sagittarius"
3540 PRINTTAB(14)"x";TAB(38)"x"
3550 PRINTTAB(17)"x";TAB(24)". ";TAB(27)"xx"
3560 PRINTTAB(24)"x";TAB(38);TAB(43)"Scorpio"
3570 PRINT:PRINTTAB(37)". "
3580 GOSUB3650
3590 RETURN
3600 INPUT"Do you want another Month Y/N";A$
3610 IF A$="Y"THEN160
3620 IF A$<>"N"THEN PRINT"Invalid Response":PRINT:GOTO3600
3630 PRINT CHR$(12)
3640 END
3650 FORH=1TO1000:NEXT
3660 REM PRINT METEORS
3670 N=0
3680 R=-1
3690 IF M$="NOVEMBER"ANDTF=1THENMS=-2722:TF=0:GOTO3710
3700 MS=-2978
3710 IFN=20THEN4290
3720 R=R-1
3730 GOSUB3770
3740 FOR G=1TOC*100:NEXT
3750 N=N+1
3760 GOTO3710
3770 REM PICK A METEOR
3780 A=RND(R)
3790 C=INT(7*RND(A)+1)
3800 B=INT(9*RND(A)+1)
```

SSTARA (continued)

```
3810 ONBGOTO3980,3820,3930,4090,4040,4140,4240,3870
3820 FORJ=5T014
3830 POKE MS+65*J,172:POKE MS+65*(J+1),172
3840 POKE MS+65*J,32:POKE MS+65*(J+1),32
3850 NEXT:GOTO4040
3860 RETURN
3870 FORJ=3T010
3880 :
3890 POKE MS-65*J,172:POKE MS-65*(J+1),172
3900 POKE MS-65*J,32:POKE MS-65*(J+1),32
3910 NEXT:IFC=10RC=5THEN4090
3920 RETURN
3930 FORJ=3T09
3940 POKE MS-J,140:POKE MS-J+1,140
3950 POKE MS-J,32:POKE MS-J+1,32
3960 NEXT:IFC=10RC=6THEN4190
3970 RETURN
3980 FORJ=4T030 STEP 4
3990 POKE MS+J,45:POKEMS+J+1,45:POKEMS+J+2,45
4000 POKE MS+J,32:POKE MS+J+1,32:POKE MS+J+2,32
4010 NEXT:IFC=6THEN3870
4020 GOTO4190
4030 RETURN
4040 FORJ=6T030 STEP3
4050 POKE MS-J,45:POKE MS-J+1,45:POKE MS-J+2,45
4060 POKE MS-J,32:POKE MS-J+1,32:POKE MS-J+2,32
4070 NEXT:IFC>3THEN4140
4080 RETURN
4090 FORJ=5T010
4100 POKE MS-64*J,124:POKE MS-64*(J+1),124
4110 POKE MS-64*J,32:POKE MS-64*(J+1),32
4120 NEXT:IFC>2THEN4190
4130 RETURN
4140 FORJ=4T012
4150 POKE MS+64*J,124:POKE MS+64*(J+1),124
4160 POKE MS+64*J,32:POKE MS+64*(J+1),32
4170 NEXT:IFC=2THEN3870
4180 RETURN
4190 FORJ=3T0(4+C)
4200 POKE MS-63*J,171:POKE MS-63*(J+1),171
4210 POKE MS-63*J,32:POKE MS-63*(J+1),32
4220 NEXT:IFC=4THEN3980
4230 RETURN
4240 FORJ=3T0(15-C)
4250 POKE MS+63*J,171:POKE MS+63*(J+1),171
4260 POKE MS+63*J,32:POKE MS+63*(J+1),32
4270 NEXT:IFC=2THEN4140
4280 RETURN
4290 POKE MS,111
4300 IF M$="NOVEMBER"ANDTF=1THENGOTO3650
4310 RETURN
```


Observer's Guide to the Programs

The following information is provided for observers who will be participating in the following programs:

1. **Observer's Guide to the Programs** - This guide provides information on the programs and the role of the observer.

2. **Observer's Guide to the Programs** - This guide provides information on the programs and the role of the observer.

3. **Observer's Guide to the Programs** - This guide provides information on the programs and the role of the observer.

4. **Observer's Guide to the Programs** - This guide provides information on the programs and the role of the observer.

5. **Observer's Guide to the Programs** - This guide provides information on the programs and the role of the observer.

6. **Observer's Guide to the Programs** - This guide provides information on the programs and the role of the observer.

7. **Observer's Guide to the Programs** - This guide provides information on the programs and the role of the observer.

8. **Observer's Guide to the Programs** - This guide provides information on the programs and the role of the observer.

9. **Observer's Guide to the Programs** - This guide provides information on the programs and the role of the observer.

10. **Observer's Guide to the Programs** - This guide provides information on the programs and the role of the observer.

Observer's Guide to the Programs

In preparing for an evening of observations you might select the following programs:

1. Run TIMES to find the sidereal time at the beginning and end of your planned observations.
2. Use RISES to tell you the times of sunset, sunrise, moonrise, and moonset.
3. PHASE will tell you the phase of the Moon so you can find out if a bright Moon will interfere with your observations.
4. If the Moon is full you can find out if there will be an eclipse by using ECLIP.
5. Use SKYSET/SKYPLT to show you the sky at the time you plan to begin observing. You can see which planets will be in the sky when you plan to observe, as well as the constellations that can be seen.
6. If a planet you are interested in is not above the horizon, you can use RISES to tell you when it will rise. PLNTF will tell you where in the zodiac it is located.
7. Use PRISE to find out if Mercury or Venus is visible as an evening star, and how much time after sunset will be available for observation.
8. If either Mercury or Venus is visible the evening you plan to observe, use MERVE to provide details of distance, phase, and angular diameter.

9. If neither planet is visible you can use MVENC to find out when the next suitable elongation will take place.
10. If you are interested in Mars and you have found out that it is visible, you can ascertain its distance and angular diameter by using MARSP. This program will also tell you when Mars will next be close to Earth at opposition.
11. If you plan to observe Jupiter, you can use JSATS to identify its large satellites.
12. SSTAR will tell you if there is a major meteor shower on the night of your observations.
13. When resetting the polar axis of an equatorial mount, you can find the direction and elevation of the pole by observing transits and elongations of Polaris. PSTAR will tell you the times to do this.
14. Searching for a faint nebula or other celestial object? Look up its right ascension and declination in your star atlas and then convert to the current epoch using EPOCH. By using TIMES to get sidereal time, you can then set the hour circle on your telescope and point to the correct right ascension and declination to bring the faint object within the field of view of a finder telescope.
15. If you want to use PHOTO to photograph one of the planets, you can find the angular diameter of Mercury and Venus from MERVE and that of Mars from MARSP. Angular diameters of Jupiter, Saturn, and Uranus are found by dividing 190, 158, and 68, respectively, by the distance of the planet in astronomical units, obtained from RADEC.
16. If you are planning to observe a solar eclipse, you can find out which planets and bright stars will be visible during the eclipse by running SKYSET/SKYPLT for the time and date of totality, changing the latitude and longitude to your observing site. Making a photograph of your monitor screen will provide a guide for you to identify objects surrounding the Sun.
17. Making a trip into another hemisphere? Learn the constellations in advance by using CONST and CONSH. Use SKYSET/SKYPLT to show you what the familiar constellations will look like from the opposite hemisphere, and in which direction to look for the planets.

Bibliography

The following books are recommended for further information about astronomical calculations. Some of them provide equations that can be used to obtain much greater precision of almanac data than that provided by the programs in this book. While the programs given here are sufficient for most practical purposes, more specialized routines are sometimes needed for predictions of stellar occultations by the Moon, close conjunctions of planets, or rigorous observations of celestial objects relative to star positions. If you need such precision in computations, many of the programs provided in this book can be upgraded within the limits of your computer's capability in handling numbers.

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An author, consultant, lecturer, and journalist, Eric Burgess's byline has appeared internationally in newspapers and magazines for over 40 years. He helped found the British Interplanetary Society in the 1930s and the International Astronautical Federation in the 1950s. He is a Fellow of the Royal Astronomical Society and has held official positions in several amateur astronomical societies. He has written extensively for NASA, providing educational materials and books on the missions and their results. He has recently become an enthusiastic participant in the personal computer revolution.