THE OBSERVATORY™

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LIGHTSPEED SOFTWARE

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Introduction

I know you don't want to read the introduction, nobody ever does. I know you don't want to read the manual either. You could skip it and probably get by with just Appendix A. On the other hand, you might enjoy the manual's guided tour of The Observatory. It won't take long, you only have to do it once and forever afterwards you will get most of the information you need by looking it up in Appendix A or B.

The Observatory is a simulation of the sky, making astronomy as simple and as informative as a picture. It places at your fingertips a powerful software telescope with which you can explore an electronic celestial sphere. You can set up this telescope anywhere on the Earth and pick any moment of time within a range of 10,000 years. The celestial atlas includes more than 400 stellar objects plus all the major members of the solar system, and a few minor ones as well (see Appendix F for the complete listing). The Observatory will show you the constellations of tonight's sky, the moons of Jupiter, the position of Halley's Comet, the Virgo Cluster of galaxies, Venus crossing the bright disk of the Sun, and a lot more.

Yet despite all its powerful capabilities, The Observatory is very simple to operate. The keyboard is your control panel and a single keystroke is usually all it takes to accomplish what you want. Many of the keys are setup as simple ON/OFF switches; type it once and it's ON, press it again and it's OFF. Every computer program takes some getting used to. You will find that The Observatory is both quick to learn and easy to use.

The next section will get you started. The following sections will lead you through all the commands and then in Appendix C you will find a few exercises to sharpen your skill at operating this amazing instrument.

Starting The Observatory

Almost every software manual begins by saying, "first boot the system" or "boot the disc and . . . ", etc. Boot? That one word really means:

Turn the computer's power switch OFF. Put The Observatory's *disc in Drive 1, label side up. Push it (gently) all the way in, close the drive's door and turn the computer's power switch ON.*

The Observatory will then load itself into your machine's memory by its own bootstraps. It takes awhile, it's a big program. When all the behind-the-scenes activity is finished, The Observatory will ask you two questions, neither of which you have to answer truthfully:

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1. *What is your location on the Earth?*
2. *What time is it?*

The next two sections of this manual will tell you all about how to answer these questions. Once The Observatory has this information, it can calculate and draw a high-resolution map of the sky.

Incidentally, your answers will be recorded on the disc and the next time you "boot the system", you will be greeted with the same location and time. That way, if you are particularly fond of some point in the space-time continuum, such as your backyard, The Observatory will be there when you boot.

Location on Earth

The Observatory will display a page entitled "Location on Earth" which shows you the current latitude and longitude. A simple globe or map is all you really need to determine your latitude and longitude. It is rarely necessary to specify these numbers to the full accuracy of degrees, minutes, and seconds; getting within a degree or two of their correct values is adequate for most purposes.

As you type, the cursor will move from position to position in such a way that you will only be able to change the numbers, North/South (N/S) and East/West (E/W). Furthermore, you can only type numbers in the number positions, only N or S at the end of latitude, and only E or W after longitude. Numbers can be erased by pressing the space bar. You can skip the cursor along by typing the "←" or "→" key. Also you will notice that the cursor automatically jumps to the next (or previous) line whenever it falls off the end or beginning of the current line. You can amuse yourself with this effect by holding down the REPEAT key and pressing either the "←" or "→" key.

You can make mistakes any time you want. Bizarre and meaningless locations, such as 647°W longitude, can be entered. When the cursor jumps to the next line, or when you press the RETURN key, The Observatory will process your entry, make what sense it can of it, and retype the line just as if you had not typed anything bizarre and meaningless. For example, 97°N latitude will be processed to 90°N. The Observatory never issues an error message; it would rather fix things up than complain about them.

When you are finished typing in the location, press the RETURN key. This will write the latitude and longitude in the lower left corner of the display (see Fig. 1). You have now established the location of your observatory on the earth.

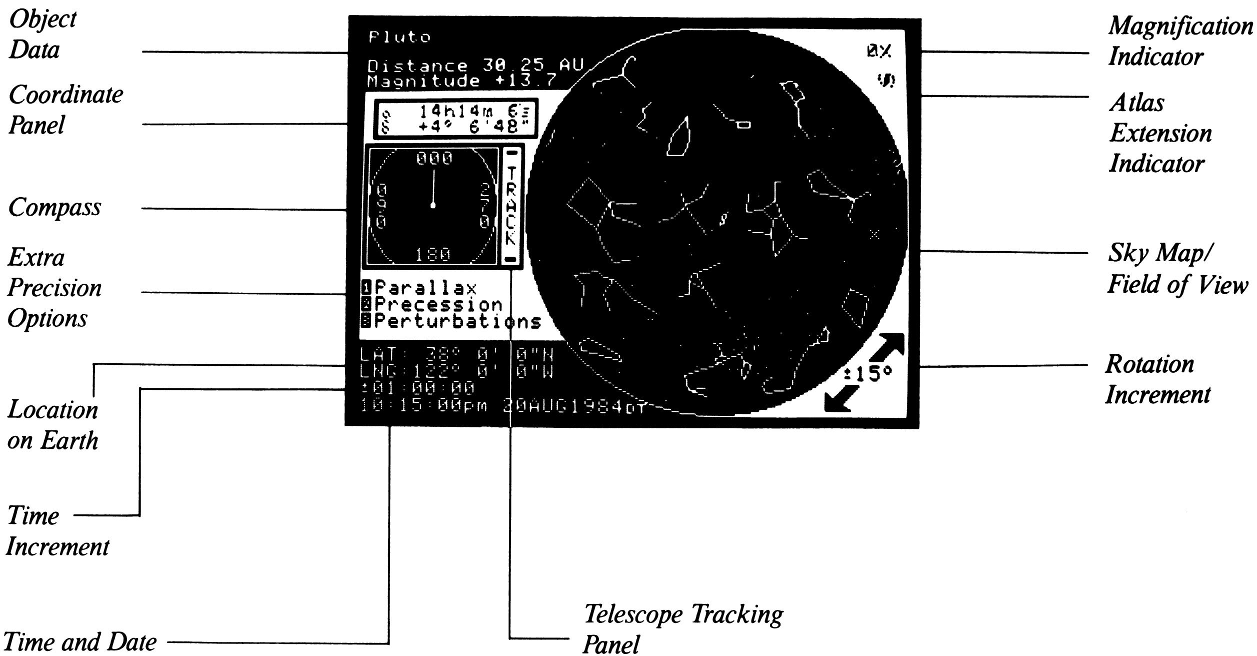

Figure 1. The Display

Time and Date

The Observatory will display a page with a title of either "Local Time" or "Universal Time". The time on your watch is Local Time. The time in Greenwich, England is Universal Time. You can switch back and forth between Local and
= Universal Time by typing the "=" key. The Observatory will accept and display either time.

All astronomical calculations are done according to Universal Time. If you select Universal Time, you and The Observatory will be in agreement. If you use Local Time, The Observatory will check your longitude and estimate Universal Time. The calculations will then proceed according to that estimate. In most cases the estimate is accurate, but near the edges of time zones, where political boundaries influence the time on your watch, errors as great as one hour may occur. If you decide to enter Local Time and are curious about The Observatory's estimate of Universal Time, type the "=" key and you will see what The Observatory thinks is the time in Greenwich.

As you type in the time and date the cursor will move to allow you to change the numbers and letters. Type "A" for am; "P" for pm. Midnight is 12:00:00am and noon is 12:00:00pm. Months are entered as the first three letters (SEP for September, etc.) You have quite a selection of years to choose from, 0 to 9999 AD in fact. If you type "86", that means "86 AD" not "1986". The exact range of time within which The Observatory operates can be found in Appendix D.

As the cursor moves along your entries are processed and, since The Observatory issues no error messages, what you typed will either be figured out or ignored. For example, try entering "XXX" for the month.

If you are entering Local Time you have the option of specifying Daylight Saving Time which is usually in effect during the summer.

When you are finished, press the RETURN key. The time and date will be displayed in the lower left corner of the screen (see Fig. 1) with UT, LT, or DT signifying Universal, Local or Daylight Saving Time.

The Sky Map

The Observatory must carry out an enormous number of calculations before drawing a map of the sky as it is seen from the location you have specified and for the time you have selected. Consult Appendix D for a brief discussion on calculation speed.

When the calculations are in progress, a graph will appear in the upper left corner of the display. The ever-shrinking indicator shows you an estimate of the percent of calculations remaining to be executed. What it really tells you is that your computer is still alive and working like crazy. When the indicator shrinks to zero, the graph will vanish and the sky map will appear.

On the sky map will be plotted the locations of hundreds of celestial objects. Each of these will appear as a single dot of light. The Observatory's sky map duplicates other maps published in astronomy books and magazines. The center of the map is the zenith, the point directly above you. The edge of the map is the horizon running all around. North, south, east and west can be read from the compass located to the left of the sky map (see Fig. 1). The compass needle always points toward north at 0°, east is at 90°, south is at 180°, and west is at 270°.

C Press the "C" key (Constellation lines). The Observatory will draw lines connecting the stars making up the constellations. If there are any stray dots of light left, they are usually solar system objects. Turning on the constellation lines is an excellent way to separate the stars from other objects plotted by The Observatory. Now press the "C" key again. The lines will disappear and you are back to a sky full of stars.

A Press the "A" key (Atlas Extension). The calculation graph will reappear in the upper left corner and a small galaxy symbol will appear in the upper right corner. The Observatory is now determining the positions of more than a hundred extra objects including star clusters, dust clouds, galaxies, even a quasar. Most of these extra objects are from the famous Messier Catalogue (see Appendix F). When the calculations are finished, more bright points will be plotted on the sky map marking the locations of these distant objects. Press the "A" key again and they will be removed from the map.

Again type the "A" key and they will reappear without the calculation process. Once calculations have been executed for a specific time and location, they do not have to be repeated unless you change either the time or the location.

The flashing sky cursor cannot have escaped your attention. There are a lot of things you can do with that little cursor. Check the next section to find out.

Cursor Moves

The Observatory will not respond to anything you type unless a cursor is visible on the display. During calculations, for example, the cursor is nowhere to be seen and any command you type will be ignored. The one exception to this rule is during the Search function described in the next section.

* By the way, if you can't stand things that constantly blink, you can steady the cursor by typing the "*" key. To start it blinking again, type "*" again.

The sky cursor is an X with the central dot missing. Type the "I" key and the sky cursor will move up one position. Press "M" and it moves down. The "J" and "K" keys move it left and right. To move the sky cursor in diagonal directions, press "U", "O", "N", or ",". If you hold down the REPEAT key while pressing any one of these keys, the cursor will move smoothly across the sky in the chosen direction. Figure 2 summarizes the keys which move the sky cursor.

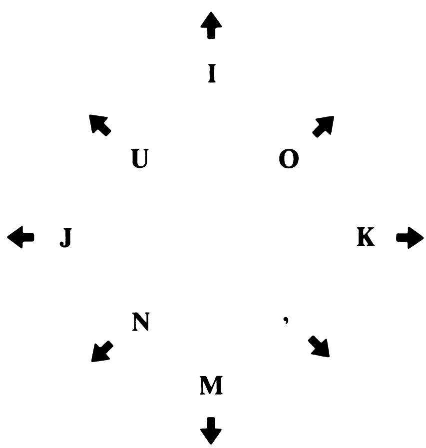

Figure 2. Moving the Sky Cursor

Q Center (exactly) a star in the sky cursor. Now press the "Q" key (Question). In the upper left corner of the display will appear the name of the object, including its common name if it has one. The distance to the object, if it is known, will be listed along with its visual magnitude, if known. For stars and other objects which lie beyond the solar system, the distance will be given in light-years (ly). There are almost 6 trillion miles in one light-year. If the object is within the solar system, the distance will be given in astronomical units (AU). One astronomical unit is the distance from the Earth to the Sun, about 93 million miles. Finally, the coordinate panel, which is located between all this data and the compass (see Fig. 1), will display the object's astronomical position in Right Ascension (α) and Declination (δ).

CTRL Q Now hold down the CONTROL (CTRL) key and at the same time press the "Q" key again. You get almost the same information. The one difference is in the coordinate panel, which now displays the object's Altitude (h) above the horizon and its Azimuth (A), or compass heading.

Move the sky cursor so that nothing is centered in the X and press either "Q" or "CTRL Q". The coordinate panel will tell you the Right Ascension, Declination or the Altitude, Azimuth of that point on the celestial sphere.

You probably are not thrilled with the prospect of having to move the sky cursor around amongst hundreds of tiny bright dots searching for the one you really want to see. The next section will tell you how to get the computer to search for you.

Searching for Something

S

At anytime you can ask The Observatory to show you the location of a celestial object. To start this process, press the "S" key (Search). The Observatory will then display a page entitled "Search". On the page you will see an alphabetical list of all the objects The Observatory knows about. Actually there are two such lists, one with and one without the objects in the Atlas Extension (see the "A" command, Appendix A). By pressing the appropriate numbers you can select from the list the object you wish to see. If the number you type has a name associated with it, The Observatory will search for that object. If the number you press has a blank next to it, The Observatory will show you a new, more refined alphabetical list beginning with the name above the number you pressed and ending with the name below the number you typed.

For example, suppose you wanted to see the bright, nearby star Procyon. When you press "S" (Search), you will be presented with a list like the following:

---

1. 41 ARI
2.
3. Beta TRA
4.
5. Gamma CAS
6.
7. Omicron PER
8.
9. Zosma

Stars are listed by both their common names, such as Procyon, and by their official designations, such as Alpha CMI, where CMI is the abbreviation for the star's constellation: Canis Minor. Consult Appendix E for the list of constellation names and abbreviations. A few stars are listed by catalogue designations (41 ARI, SAO 119234, etc.). Stars whose names begin with catalogue numbers will appear at the beginning of the alphabetical list.

Since Procyon is alphabetically between Omicron PER and Zosma, you would next press "8" and a new list would appear such as:

---

1. Omicron PER
2.
3. Rho PER
4.
5. Theta AQL
6.
7. Xi GEM
8.
9. Zosma

If you are like me and cannot spell, you may soon find yourself wandering down the wrong path. Press any key other than a meaningful number and you will cancel the Search and can then start over. Continue typing the appropriate numbers until you see Procyon. Press its number and one of two things will happen:

(a) If Procyon is present in the current field of view, The Observatory will center the cursor on it and display the star's data in the upper left corner.

(b) If Procyon is not visible in the current field of view, The Observatory will tell you so in the upper left corner.

CTRL S You can force The Observatory to show you any object, including any which it says are not in view. You can do this by pressing "CTRL S" (Force Search). Again you will see a page with an alphabetical list on it, only this one will be labeled "Force Search". Whatever you select from this list will be shown to you. The Observatory will now go to any lengths to bring what you want into view. It may cancel telescope pointing and the current magnification (described in the next section). It may change the time and recalculate the sky map. And, as a last resort, it may even change your latitude. In any event, Force Search never fails.

The Telescope

Z X

When you look at The Observatory's sky map, you are in fact looking through a telescope; it just happens to be pointed straight up and has a terrific field of view. Press the "Z" key (Zoom). The magnification indicator in the upper right corner will change from 1x to 2x. You have just magnified the portion of the sky above your head by a factor of two. Continue typing the "Z" key. You can magnify the scene in steps of 2 all the way up to 512x, in the process you will probably blow every visible star right off the edge of the screen. To de-magnify the image press the "X" key.

P

By now you are aware that any telescope which only points straight up is pretty useless. Bring the magnification down to 1x and move the cursor all the way over to the right or left of the sky map. Press the "P" key (Point). You have just pointed the telescope! It is now centered on the cursor at the edge of the sky map. Since the field of view is so wide at 1x, you can see the sharp curve of the horizon line. At 1x the view through the telescope is similar to looking through a fish-eye lens.

L R

However, you expect the horizon to be flat at your feet, or horizontal. Type the "L" key (Left Rotate) and the entire field of view will rotate to the left (counterclockwise). Press the "R" key (Right Rotate) and the rotation will take place to the right (clockwise). Each time you type "L" or "R" the field of view will rotate by the number of degrees specified in the Rotation Increment in the lower right corner (see Fig. 1).

In the next section you will learn how to alter the Rotation Increment to a value more to your liking. But for now try using the P (Point), L, R (Left, Right Rotate), Z (Zoom), and X (De-magnify) keys to get a scene where the horizon is horizontal. You will notice that the compass will change to reflect each rotation and, as you type the "Z" key, the horizon will gradually straighten out. You may also discover that the telescope will not swivel below the horizon. You are not allowed to bash the telescope into the floor of The Observatory.

At any time and at any level of magnification you can re-point the telescope by moving the cursor to the region of interest and typing "P". If some object should drift away from the center of view as you magnify, just move the cursor over to the object and re-point the telescope.

CTRL C You can quickly return to the original, unmagnified, unrotated sky map by simply holding down the CONTROL (**CTRL**) key and pressing "C" (Re-Center).

In the next section you will learn some easy ways to change the time, among other things. As time changes, the sky changes. Stars rise in the east, drift across the sky and disappear below the western horizon. Through all this the telescope will remain stupidly pointed in the same direction. If you magnify some interesting region of the sky and then decide to change the time, the objects you are looking at may move out of your field of view. You will have to find them again, usually by de-magnifying the scene and re-pointing the telescope.

CTRL P If, however, you point the telescope with a "CTRL P", you will also turn on Tracking. The word "TRACK" will appear vertically in the panel between the compass and the sky map/field of view (see Fig. 1). Pointing the telescope using just the "P" key will turn off Tracking. With Tracking turned on the telescope will follow a point on the celestial sphere as you change the time. Tracking does *not* follow objects. The moon, for example, travels at a different speed than the celestial sphere and can move out of your field of view even with Tracking on. Also, if you change the time such that the point you are following ends up below the horizon, Tracking will automatically be canceled. See Appendix C for a nice example of using Tracking to follow the different stages of an eclipse.

Changing Things

As you discovered in the beginning of this manual, The Observatory only needs to know two things to calculate the map of the sky—your location and the time. There are several ways to change either or both of these.

T To alter the time, press the "T" key (Time). The page titled either "Local Time" or "Universal Time" will then be displayed. The cursor will be positioned under the current time, although you can of course move it to alter the date also. If **D** you press the "D" key (Date), you will be given the same page with the cursor under the date.

E To change your location, type the "E" key (Earth). The page entitled "Location on Earth" will appear and you can then enter any latitude and longitude you like.

@ If you wish to change *both* your location and the time, press the "@" key. This will cause The Observatory to ask you in succession your location and the time, just as it did when you started the program.

In the lower left corner of the display, beneath longitude and above the time and date, you will notice a strange number which in Figure 1 is labeled "Time Increment". When you start The Observatory it looks like: ±01:00:00. It means: plus/minus 1 hour, 0 minutes, 0 seconds. If you press the **F** "F" key (Forward), the Time Increment will be added to the current time and the sky will be recalculated for the new time. With one keystroke you will have jumped forward in **B** time. If you type the "B" key (Backward), the Time Increment will be subtracted from the current time and, after the recalculation, you will have jumped backward in time.

CTRL B **CTRL F** **CTRL D** **CTRL T** By holding down the CONTROL (CTRL) key and pressing the "B", "F", "D", or "T" key, The Observatory will display a page titled "Increments" and the cursor will be positioned for changing the Time Increment. The other increment on the page, the Rotation Increment, can also be changed if you **CTRL L** **CTRL R** like. If you had pressed "CTRL L" or "CTRL R" you would have gotten the Increments page with the cursor positioned for changing the current Rotation Increment. You can enter any numbers you like for both increments, but The Observatory will process you entries so that they make sense.

For example, a Rotation Increment of 987° will be processed to 180°. A Time Increment of 99 seconds will become 1 minute, 39 seconds (±00:01:39). When you press the RETURN key, the Time Increment will be written in the lower left corner and the Rotation Increment will appear between the two big arrows in the lower right corner (see Fig. 1). The page will disappear, replaced by the sky.

If you bring any of these pages onto the display but do not change anything, when you press the RETURN key the page will be erased and you will be back with the unaltered image of the sky.

Extra Precision

The Observatory gives you three separate calculations for increasing the accuracy of the sky map:

1. Parallax

1 The first time you press the "1" key the word "Parallax" will appear below the compass in the list of extra-precision options (see Fig. 1) and The Observatory will execute a series of calculations to account for geocentric parallax. If you press the "1" key again, a calculation will take place to remove the effect of the parallax.

Astronomical calculations usually are conducted with the assumption that you, the observer, are located at the center of the earth. Geocentric parallax corrects for the fact that you are at some latitude on the earth's surface almost 4,000 miles from the center. For such distant objects as stars and galaxies, that 4,000 mile difference is insignificant. But for objects close to the earth, especially the moon, it is important. The "1" key applies only to the handful of solar system objects and only takes a few seconds. See Appendix C for an example of the effect of geocentric parallax when viewing an eclipse.

2. Precession

2 If you press the "2" key the word "Precession" will appear in the list of extra-precision options (see Fig. 1) and The Observatory will execute a lengthy calculation to account for the slow precession of the earth's axis. If you type the "2" key again, a calculation will take place to remove the effect of precession.

The positions of the stars change as the axis of the earth slowly wobbles or precesses. All of the stars and other distant objects in The Observatory's celestial atlas (see Appendix F) have positions accurate for 12am January 1, 2000. The "2" key will correct these positions for the exact time and date you have selected. See Appendix C for an exercise in watching the precession of the axis over the 10,000 year range of The Observatory.

3. Perturbations

3 If you press the "3" key the word "Perturbations" will appear in the list of extra-precision options (see Fig. 1) and The Observatory will execute a series of calculations to account for many of the principal planetary perturbations. If you press the "3" key again, you will set off a calculation to remove the effect of the perturbations.

The planets circle the sun in a very complex dance. They are continually pushing and pulling each other around with their gravitational fields, especially the giant outer plants; Jupiter, Saturn, Uranus and Neptune. Their simple elliptical orbits are thereby somewhat perturbed. The "3" key adds several seconds to the time it takes to calculate the positions of the objects in the solar system, but you can often see an obvious effect on the outer big four. Less of an effect is apparent on the inner planets and no perturbations are done for Pluto and Halley's Comet. These two objects travel through such a complex gravitational environment that to keep track of all the deviations from purely elliptical motion would make the computer intolerably slow. See Appendix C (Galileo's Sighting of Neptune) for an example of the importance of accounting for the perturbations.

For your convenience you can turn on all of the extra-
precision calculations (1, 2, and 3) all at once by pressing the
9 "9" key. Also you can turn them off all at once by typing the
0 "0" (zero) key.

To make it easier to see the full extent of the moon, particularly a new or eclipsing moon, it is drawn with an outline.

(For a more realistic view of the moon, you can eliminate the outline by typing the "(" key. Pressing it again will bring the outline back.

Some telescopes give you a mirror image of the sky with left and right switched. You can duplicate this effect with The

CTRL M Observatory by holding down the CONTROL (CTRL) key and pressing the "M" key (Mirror Image). Everything in the field of view will flip left to right. Pressing "CTRL M" again will flip the scene back. The compass will of course follow all these maneuvers. Also, pressing the RETURN key does the same thing as "CTRL M" since both send the same signal to the computer.

Finally, there will come a time when you will want to quit,

CTRL Y stop, halt, exit, finish. You have two choices. Press "CTRL Y" or remove the disc and turn the power OFF.

From now on you will probably only need to consult Appendix A and Appendix B to refresh your memory of the keyboard commands. For some specific demonstrations of the power of The Observatory, you might consider Appendix C. Not only will you see some astronomy, you will also improve what you have already learned about operating The Observatory.

Key Stroke	Command	Page
A	*Atlas Extension ON/OFF* The first time you press the "A" key, The Observatory will calculate and plot the positions of the more than 100 extra celestial objects listed in the Atlas Extension in Appendix F. If you type the "A" key a second time the extra objects will be removed from the display. Once the calculations have been done for a particular time and location, they do not have to be repeated. Therefore further typing of the "A" key brings the extra objects rapidly on and off the display. When the Atlas Extension is on, a small galaxy symbol will appear in the upper right hand corner of the display (see Fig. 1). With the Extension turned on, calculations of the sky map (as happens when you alter the time, for example) take longer. With the Extension turned off, the sky map is a more realistic view of what you would see with the un-aided eye since most of the objects in the Atlas Extension are too faint to be seen without a small telescope. For that reason the Atlas Extension might better be called the Amateur Astronomer's Menagerie.	*7*
B	*Back in Time* Each time you press the "B" key, the Time Increment (displayed in the lower left corner, see Fig. 1) will be subtracted from the current time and date and a new map of the sky will be calculated. To change the Time Increment, see CTRL B.	*15*
C	*Constellation Lines ON/OFF* The first time you press the "C" key, The Observatory will draw lines connecting the stars making up the different constellations. Pressing the "C" key again will erase the lines. Turning on the constellation lines makes it easier to pick out the objects of the solar system.	*7*
D	*Change the Date* Pressing the "D" key drops you in the page labeled "Local Time" or "Universal Time" with the cursor positioned for changing the date.	*15*

E	*Change the Location on Earth* Pressing the "E" key drops you in the page labeled "Location on Earth" where you can change your latitude and longitude.	*15*
F	*Forward in Time* Each time you press the "F" key, the Time Increment (displayed in the lower left corner, see Fig. 1) is added to the current time and date and a new map of the sky is calculated. To change the value of the Time Increment, see CTRL F.	*15*
I	*Cursor Up* Pressing the "I" key will move the sky cursor up. Holding down the REPEAT key and pressing "I" will move the cursor smoothly upward.	*9*
J	*Cursor Left* Pressing the "J" key will move the sky cursor to the left.	*9*
K	*Cursor Right* Pressing the "K" key will move the sky cursor right.	*9*
L	*Left Rotate* Each time you press the "L" key the current sky map/field of view will be rotated to the left (counterclockwise) by the number of degrees specified by the Rotation Increment displayed in the lower right corner (see Fig. 1). To change the value of the Rotation Increment, see CTRL L.	*13*
M	*Cursor Down* Pressing the "M" key will move the sky cursor down. If you press the REPEAT key at the same time, it will move smoothly downward.	*9*
N	*Cursor Down and Left* Pressing the "N" key will move the sky cursor diagonally down and to the left.	*9*

Key Stroke	Command	Page
O	*Cursor Up and Right* Pressing the "O" key will move the sky cursor diagonally up and to the right.	*9*
P	*Point Telescope/Tracking OFF* Pressing the "P" key will point the telescope at (centered on) the current position of the cursor. The "P" key also turns off Tracking so that if you alter the current time the telescope will remain blindly pointing in the same direction. See CTRL P for turning on Tracking.	*13*
Q	*Question the Cursor* Pressing the "Q" key will cause The Observatory to report on the current position of the sky cursor. If the cursor is not centered on or within any object, the Right Ascension (α) and Declination (δ) of the cursor will appear in the coordinate panel above the compass (see Fig. 1). If, however, the cursor is centered on or within some object, The Observatory will also list in the upper left corner any data on the object in question, such as its name or names, distance, and/or magnitude. See also CTRL Q.	*10*
R	*Right Rotate* Each time you press the "R" key the current sky map/field of view will be rotated to the right (clockwise) by the number of degrees specified by the Rotation Increment displayed in the lower right corner (see Fig. 1). To change the Rotation Increment, see CTRL R.	*13*
S	*Search* If you want The Observatory to show you where the object of your desires is, press the "S" key. You will be presented with the Search page. By pressing the appropriate number or numbers, you can select from the alphabetical list the name of the object you wish to be shown. If the object you are searching for is not currently in the field of view, The Observatory will so inform you. For a more powerful, surefire search, see CTRL S.	*11*

T	*Change the Time* Pressing the "T" key drops you in the page labeled "Local Time" or "Universal Time" with the cursor positioned for changing the time.	*15*
U	*Cursor Up and Left* Pressing the "U" key will move the sky cursor diagonally up and to the left.	*9*
X	*De-Magnify* Each time you press the "X" key the current field of view will be de-magnified by 2x until 1x is reached.	*13*
Z	*Zoom (Magnify)* Each time you press the "Z" key the current field of view will be magnified by 2x until 512x is reached. Use "P" or "CTRL P" to properly center the telescope during magnification.	*13*
0	*All Extra-Precision OFF* Pressing the "0" (zero) key turns off the extra-precision switches, 1, 2, and 3 all at once. See also "9".	*18*
1	*Geocentric Parallax ON/OFF* The first time you press the "1" key, The Observatory will execute a series of calculations to account for geocentric parallax. If you type the "1" key again, a calculation will take place to remove the effect of the parallax.	*17*
2	*Precession ON/OFF* The first time you press the "2" key, The Observatory will execute a lengthy calculation to account for the slow precession of the earth's axis. If you type the "2" key again, a calculation will be done to remove the effect of precession.	*17*
3	*Perturbations ON/OFF* The first time you type the "3" key, The Observatory will execute a series of calculations to account for many of the principal planetary perturbations. If you press the "3" key again, a calculation will take place to remove the effect of the perturbations.	*18*

Key Stroke	Command	Page
9	*All Extra-Precision ON* Pressing the "9" key turns on the extra-precision switches 1, 2, and 3 all at once. See also "0" (zero).	*18*
,	*Cursor Down and Right* Pressing the "," key will move the sky cursor diagonally down and to the right.	*9*
*	*Blink Cursor ON/OFF* Pressing the "*" key will change the cursor from blink to non-blink or vice versa.	*9*
(	*Moon Outline ON/OFF* Pressing the "(" key will turn on (or off) the outline of the moon. Turning the outline off creates a graphically more accurate picture of the moon. Turning the outline on makes it easier to see the full extent of the moon, particularly if the moon is new.	*19*
@	*Change Location and Time/Data* Pressing the "@" key will cause The Observatory to display for changing both the "Location on Earth" page followed by the "Local/Universal Time" page.	*15*
=	*Switch Time* Pressing the "=" key will change the displayed time from Local/Daylight Saving Time to Universal Time or vice versa.	*6*
←	*Page Cursor Left* Pressing the "←" key moves the cursor on any of the change pages (Location, Time, or Increments) to the left.	*4*
→	*Page Cursor Right* Pressing the "→" key moves the cursor on any of the change pages (Location, Time, or Increments) to the right.	*4*
CTRL B	*Change the Time Increment* Pressing the "CTRL B" keys drops you in the Increments page with the cursor positioned for changing the Time Increment.	*15*

CTRL C	*Re-Center Display* Pressing the "CTRL C" keys causes The Observatory to return to the sky map with no magnification, tracking turned off, mirror image and any rotation canceled.	*14*
CTRL D	same as CTRL B	*15*
CTRL F	same as CTRL B	*15*
CTRL L	*Change the Rotation Increment* Pressing the "CTRL L" keys drops you in the Increments page with the cursor positioned for changing the Rotation Increment.	*15*
CTRL M	*Mirror Image* Every time you press the "CTRL M" (or RETURN) keys, the sky display and the compass will flip left to right. This allows you to duplicate the view through a telescope which optically flips the image.	*19*
CTRL P	*Point Telescope/Tracking ON* Pressing the "CTRL P" keys does the same thing as typing "P" except that Tracking is turned on. With Tracking on, the telescope will follow a point on the celestial sphere as the time is changed.	*14*
CTRL Q	*Question Cursor* Pressing the "CTRL Q" keys does the same as typing "Q" except that the coordinates displayed will be Altitude (h) and Azimuth (A).	*10*
CTRL R	same as CTRL L	*15*
CTRL S	*Force Search* Pressing the "CTRL S" keys does the same as typing "S" except that Force Search will display the object you want no matter what. If necessary, Force Search will cancel the magnification, and/or change the time, and/or alter the latitude to bring the object into view. Since the Time and Location may be changed, a recalculation of the sky map may take place.	*12*
CTRL T	same as CTRL B	*15*
CTRL Y	*Exit The Observatory* Pressing the "CTRL Y" keys will end the observing session.	*19*

Command	Key	Page
Atlas Extension ON/OFF	**A**	*7*
Back in Time	**B**	*15*
Blink Cursor ON/OFF	*	*9*
Center Display	**CTRL C**	*14*
Change Increments	**CTRL B, CTRL D, CTRL F, CTRL L, CTRL R, or CTRL T**	*15*
Change Location	**E**	*15*
Change Location AND Time/Date	**@**	*15*
Change Time/Date	**T or D**	*15*
Constellation Lines ON/OFF	**C**	*7*
Cursor Blink ON/OFF	*	*9*
Cursor Down	**M**	*9*
Cursor Down and Left	**N**	*9*
Cursor Down and Right	**,**	*9*
Cursor Left	**J**	*9*
Cursor Question	**Q and CTRL Q**	*10*
Cursor Right	**K**	*9*
Cursor Up	**I**	*9*
Cursor Up and Left	**U**	*9*
Cursor Up and Right	**O**	*9*
Date Change	**D**	*15*
De-Magnify	**X**	*13*
Edit Location	**E**	*15*
Edit Location AND Time/Date	**@**	*15*
Edit Rotation Increment	**CTRL L or CTRL R**	*15*
Edit Time and Date	**T or D**	*15*

Edit Time Increment	**CTRL B, CTRL D, CTRL F, or CTRL T**	*15*
Exit	**CTRL Y**	*19*
Extra-Precision OFF	**0 (zero)**	*18*
Extra-Precision ON	**9**	*18*
Finish	**CTRL Y**	*19*
Force Search	**CTRL S**	*12*
Forward in Time	**F**	*15*
Halt	**CTRL Y**	*19*
Increments Change	**CTRL B, CTRL D, CTRL F, CTRL L, CTRL R, or CTRL T**	*15*
Left Cursor	**J**	*9*
Left Rotate	**L**	*13*
Local Time/Universal Time Switch	**=**	*6*
Location Change	**E**	*15*
Magnify/De-Magnify	**Z/X**	*13*
Mirror Image	**CTRL M or RETURN**	*19*
Moon Outline ON/OFF	**(**	*19*
ON/OFF 1, 2, and 3	**9 (ON) 0 (OFF)**	*18*
ON/OFF Atlas Extension	**A**	*7*
ON/OFF Blink Cursor	*****	*9*
ON/OFF Constellation Lines	**C**	*7*
ON/OFF Moon Outline	**(**	*19*
ON/OFF Parallax	**1**	*17*
ON/OFF Perturbations	**3**	*18*
ON/OFF Precession	**2**	*17*

Command	Key	Page
ON/OFF Telescope Tracking	**CTRL P (ON)** **P (OFF)**	*14/13*
Parallax ON/OFF	**1**	*17*
Perturbations ON/OFF	**3**	*18*
Point Telescope, Tracking OFF	**P**	*13*
Point Telescope, Tracking ON	**CTRL P**	*14*
Precession ON/OFF	**2**	*17*
Question Cursor	**Q and** **CTRL Q**	*10*
Quit	**CTRL Y**	*19*
Re-Center Display	**CTRL C**	*14*
Right Cursor	**K**	*9*
Right Rotate	**R**	*13*
Rotate Left	**L**	*13*
Rotation Increment Change	**CTRL L or** **CTRL R**	*15*
Search/Force Search	**S/CTRL S**	*11/12*
Stop	**CTRL Y**	*19*
Time Change	**T**	*15*
Time Increment Change	**CTRL B,** **CTRL D,** **CTRL F, or** **CTRL T**	*15*
Time Switch	**=**	*6*
Tracking OFF	**P**	*13*
Tracking ON	**CTRL P**	*14*
Universal Time/Local Time Switch	**=**	*6*
Zoom (Magnify)	**Z**	*13*

The following exercises are designed to demonstrate some of the capabilities of The Observatory as well as increase your skill at operating this unique astronomical instrument.

1. The Eclipse of March 16, 1485

The Observatory can simulate both total and annular solar eclipses. For example, a total eclipse of the sun was visible in Austria on March 16, 1485. If you do not have The Observatory running, start it up (boot it) as described at the beginning of this manual. If, however, it is currently running, just type the "@" key. On the Location page enter the coordinates of Vienna, Austria (48°N, 16°E). On the Time page get into Local Time if you are not there already (the "=" key) and enter: 4:55:00pm 16MAR1485, no Daylight Saving.

After the calculations you will be in Old Vienna with something strange happening to the sun. Press "S" (Search) and type the appropriate numbers to select the sun from the alphabetical list. The cursor will reveal it near the western horizon. Press "P" (Point) and then press "R" (Right Rotate) a few times to turn the map so that the earth is below and the sky is above. Now type "Z" (Zoom) several times to magnify the scene. As you do so you will soon see (around 8x) the disks of the sun and the new moon. Continue magnifying up to about 64x. Then press the "1" key to correct the scene for geocentric parallax. For greater realism you can remove the lunar outline by typing "(". If you would like to see different stages of the eclipse, set the Time Increment (CTRL T) to something like 15 minutes, turn on Tracking (CTRL P) and type "F" or "B" to go forward or backward in time. If you like, turn the outline of the moon back on (the "(" key).

Since you are now so good at doing eclipses, press the "@" key, set yourself up off the coast of Africa (2°N, 7°W) and bring into view the annular eclipse of 12:25pm Dec. 4, 1983 LT. During an annular eclipse the moon is relatively smaller than the sun and you will see a ring of fire in the sky.

2. Galileo's Sighting of Neptune

In the winter of 1612/1613 Galileo Galilei was making detailed observations of the moons of Jupiter. On the night of Jan. 28, 1613 he recorded in his notebook the positions of Jupiter, its moons Europa, Ganymede and Callisto, a faint star we now refer to affectionately as SAO 119234, and another faint "star" now known to have been the planet Neptune. The positions drawn by Galileo are in disagreement with our knowledge of the solar system's complex gravitational dynamics. Modern calculations do not duplicate exactly what Galileo saw. This disagreement adds support to the speculation that our knowledge is incomplete (not a bad speculation) and that perhaps an undiscovered planet is perturbing Neptune. You can see The Observatory's simulation of this historic sighting by executing the following commands:

(a) Change your location and time (type the "@" key) to northern Italy (44°N, 11°E) at 11pm on 28JAN1613 LT.
(b) Search for Jupiter (type "S", etc.).
(c) Point the telescope and zoom in to 256x ("P" and "Z").
(d) Turn on Precession (type "2") to bring SAO 119234 into view.
(e) Turn on Perturbations (type "3") to bring Jupiter and Neptune into alignment.

For more details about this remarkable event, read the article "Galileo's Sighting of Neptune" by Drake and Kowal, *Scientific American*, December, 1980.

3. Watching the Precession of the Earth's Axis

The earth is not quite a perfect sphere. It has a slight equatorial bulge. The moon and the sun exert a force on that small imperfection and thereby cause the spinning earth to wobble or precess. The precession is very slow; taking almost 26,000 years for the earth's axis to draw a complete circle against the background of fixed stars. The Observatory can show you a 10,000 year segment of that circle.

Set your location to the North Pole (90°N, the longitude can be anything) and set the time to 12pm Jan. 1, 0000. Do not move the cursor away from the center of the map since it marks the point at which the north axis of the earth intersects the celestial sphere. The cursor will in effect mark points along the circular path of the precession.

Set the Time Increment to 1,000 years (999y365d) and turn on Precession (the "2" key). When the calculation finishes you will be on the North Pole in the year 0 A.D. The cursor will mark a point between the Big and Little Dippers about which the earth/sky revolve. Now press "F" and increment forward in time. Continue jumping forward in 1,000 year increments. The center of the sky map, marked by the cursor, will show you points along the arc of the earth's precession, including the star Polaris in our time.

4. Searching 2004 for the Venus Transit

On rare occasions the planet Venus can be seen crossing the disk of the sun. The next such transit will take place sometime in the year 2004. Your task is to show it happening.

When Venus crosses the solar disk it will be passing between the earth and sun, an alignment known as inferior conjunction. The method of the search is to check different dates during the year for a time when Venus is both near to the earth in distance (a small AU) and close to the sun in the sky. Then the search can be repeated within a smaller interval for the exact time of the transit.

To start your search establish yourself near the equator and set the time to 12pm on Jan. 1, 2004. After the calculations search for the sun and Venus. Check how close they are to each other as well as the distance to Venus. Now set the Time Increment (CTRL T) to 30 days and go forward in time (press "F"). Watch how the sun and Venus change positions and note the distance to Venus. Go forward another 30 days. Not only are you watching Venus swing in its orbit about the sun, you are also watching the seasons change as the sun moves.

Eventually you will find a time when Venus is closest to the sun in the sky and closest to the earth in distance. Now change the Time Increment to a much smaller interval, say 2 days, and go either forward or backward in time, searching for that day when Venus crosses the solar disk. To witness the event you will have to narrow the time down to an interval of a few hours, and you may have to change your longitude. At high magnification you can actually see the black disk of Venus against the illuminated face of the sun. Using telescope tracking and a short Time Increment, you can watch the entire transit from beginning to end.

Other up and coming transits are due in 2012 and 2247. The last four Venus transits occurred in the years 1761, 1769, 1874 and 1882. Finally, transits by Mercury occur much more frequently, eleven this century, with one visible from Europe in 1986.

Technical Information about The Observatory

Appendix D

Memory Usage: 64K RAM

Program Language: Machine Instruction Set

Time Range (UT): 12:00:00 Jan. 1, 0000 A.D.
to
10:59:59 Dec. 31, 9999 A.D.

Location Range: Any Latitude and Longitude specified to 1 second of arc.

Magnification: 9 levels from 1x to 512x in steps of 2x. (The Observatory's 32x is about the same as human perception.)

Calculation Speed: Bottled up in the computer's hardware is the genie of speed. Software written in "higher level" languages such as BASIC and PASCAL can waste significant amounts of time as a result of various internal compromises. The Observatory makes no compromises when it comes to calculation speed. From its very conception the software has been designed and written to be the fastest astronomical calculator in the business. It is written in machine language, it sacrifices enormous amounts of memory to win more speed, it has its own specially designed arithmetic and its own custom tailored mathematical functions. As a result The Observatory executes an extraordinary number of equations very efficiently. Undoubtedly no one will be satisfied with this. After all, we are not even satisfied with the speed limit imposed by God on the entire universe. Nevertheless, like the speed of light, The Observatory succeeds in running at the speed limit imposed by the hardware on the electronic universe of your computer.

AND *Andromeda*
AQR *Aquarius* (Water Bearer)
AQL *Aquila* (Eagle)
ARI *Aries* (Ram)
AUR *Auriga* (Charioteer)
BOO *Boötes* (Herdsman)
CMA *Canis Major* (Big Dog)
CMI *Canis Minor* (Little Dog)
CAR *Carina* (Ship's Keel)
CAS *Cassiopeia*
CEN *Centaurus* (Centaur)
CEP *Cepheus*
CET *Cetus* (Whale)
CRU *Crux* (Southern Cross)
CYG *Cygnus* (Swan)
ERI *Eridanus* (River Eridanus)
GEM *Gemini* (Twins)
GRU *Grus* (Crane)
HER *Hercules*
HYA *Hydra* (Water Snake)
HYI *Hydrus* (Water Snake)
IND *Indus* (Indian)
LEO *Leo* (Lion)
LIB *Libra* (Scales)
LYR *Lyra* (Harp)
OCT *Octans* (Octant)
ORI *Orion*
PEG *Pegasus*
PER *Perseus*
PHE *Phoenix*
PSA *Piscis Austrinus* (Southern Fish)
SGR *Sagittarius* (Archer)
SCO *Scorpius* (Scorpion)
TAU *Taurus* (Bull)
TRA *Triangulum Australe* (Southern Triangle)
UMA *Ursa Major* (Big Bear)
UMI *Ursa Minor* (Little Bear)
VEL *Vela* (Ship's Sails)
VIR *Virgo* (Virgin)

	Orbital Period (years)	Semimajor Axis (AU)	Orbital Eccentricity	Orbital Inclination (degrees)	Diameter (km)	Surface Gravity (Earth=1)
The Sun	—	—	—	—	1,392,000	27.9
Mercury	0.24084	0.3871	0.2056	7.01	4,878	0.38
Venus	0.61515	0.7233	0.0068	3.39	12,104	0.89
Mars	1.8808	1.5237	0.0934	1.85	6,794	0.38
Jupiter	11.862	5.2028	0.0483	1.31	142,796	2.54
Saturn	29.456	9.5388	0.0560	2.49	120,000	1.07
Uranus	84.07	19.1914	0.0461	0.81	52,290	0.8
Neptune	164.81	30.0611	0.0100	1.77	48,600	1.2
Pluto	248.53	39.5294	0.2484	17.15	3,000-3,600	?
Halley's Comet	76.0081	17.9435	0.9673	162.24	?	?
The Moon	27d 7h 43m	384,500 km	0.055	18-29	3,476	0.17
Io	1d 18h 28m	422,000 km	0.000	0	3,632	0.19
Europa	3d 13h 14m	671,000 km	0.000	0.5	3,126	0.15
Ganymede	7d 3h 43m	1,070,000 km	0.001	0.2	5,276	0.17
Callisto	16d 16h 32m	1,885,000 km	0.01	0.2	4,820	0.13

Name	*h*	*m*	*s*	°	′	″		Mag
α AND	0	8	23.2	29	5	26	N	2.06
β CAS	0	9	10.6	59	8	59	N	2.27
ϵ PHE	0	9	24.6	45	44	51	S	3.88
γ PEG	0	13	14.1	15	11	1	N	2.83
ι CET	0	19	25.6	8	49	26	S	3.56
β HYI	0	25	45.3	77	15	16	S	2.80
α PHE	0	26	17.0	42	18	22	S	2.39
α CAS	0	40	30.4	56	32	15	N	2.23
η PHE	0	43	21.2	57	27	47	S	4.36
β CET	0	43	35.3	17	59	12	S	2.04
γ CAS	0	56	42.4	60	43	0	N	2.47
β PHE	1	6	5.0	46	43	8	S	3.31
ζ PHE	1	8	23.0	55	14	45	S	3.92
η CET	1	8	35.3	10	10	56	S	3.45
θ CET	1	24	1.3	8	11	1	S	3.60
δ CAS	1	25	48.9	60	14	7	N	2.68
γ PHE	1	28	21.9	43	19	6	S	3.41
δ PHE	1	31	15.0	49	4	22	S	3.95
α ERI	1	37	42.9	57	14	12	S	0.46
τ CET	1	44	4.0	15	56	15	S	3.50
ζ CET	1	51	27.5	10	20	6	S	3.73
γ ARI	1	53	31.8	19	17	37	N	4.75
ϵ CAS	1	54	23.6	63	40	13	N	3.38
β ARI	1	54	38.3	20	48	29	N	2.64
χ ERI	1	55	57.4	51	36	32	S	3.70
α HYI	1	58	46.2	61	34	12	S	2.86
υ CET	2	0	0.2	21	4	40	S	4.00
α ARI	2	7	10.3	23	27	45	N	2.00
ϕ ERI	2	16	30.6	51	30	44	S	3.56
o CET	2	19	20.7	2	58	39	S	3.04
δ HYI	2	21	45.1	68	39	34	S	4.09
κ ERI	2	26	59.1	47	42	14	S	4.25
ξ CET	2	28	9.5	8	27	36	N	4.28
α UMI	2	31	50.5	89	15	51	N	2.02
δ CET	2	39	28.9	0	19	43	N	4.07

ε HYI	2	39	35.5	68	16	1	S	4.11
ι ERI	2	40	40.0	39	51	19	S	4.11
γ CET	2	43	18.0	3	14	9	N	3.47
π CET	2	44	7.3	13	51	32	S	4.25
μ CET	2	44	56.5	10	6	51	N	4.27
41 ARI	2	49	59.0	27	15	38	N	3.63
η PER	2	50	41.8	55	53	44	N	3.76
θ ERI	2	58	15.6	40	18	17	S	3.42
π PER	2	58	45.6	39	39	46	N	4.70
ε ARI	2	59	12.6	21	20	25	N	4.63
λ CET	2	59	42.8	8	54	27	N	4.70
α CET	3	2	16.7	4	5	23	N	2.53
γ PER	3	4	47.7	53	30	23	N	2.93
ρ PER	3	5	10.5	38	50	25	N	3.39
β PER	3	8	10.1	40	57	21	N	2.12
δ ARI	3	11	37.7	19	43	36	N	4.35
τ ERI	3	19	30.9	21	45	28	S	3.69
α PER	3	24	19.3	49	51	41	N	1.79
δ PER	3	42	55.4	47	47	15	N	3.01
ο PER	3	44	19.1	32	17	18	N	3.83
γ HYI	3	47	14.5	74	14	21	S	3.24
η TAU	3	47	29.0	24	6	18	N	2.87
ζ PER	3	54	7.9	31	53	1	N	2.85
ε PER	3	57	51.2	40	0	37	N	2.89
λ TAU	4	0	40.8	12	29	25	N	3.47
λ PER	4	6	35.0	50	21	5	N	4.29
48 PER	4	8	39.6	47	42	45	N	4.04
μ PER	4	14	53.8	48	24	34	N	4.14
γ TAU	4	19	47.5	15	37	39	N	3.65
δ TAU	4	22	56.0	17	32	33	N	3.76
ε TAU	4	28	36.9	19	10	49	N	3.53
υ ERI	4	35	33.0	30	33	45	S	3.82
α TAU	4	35	55.2	16	30	33	N	0.85
ι AUR	4	56	59.6	33	9	58	N	2.69
ε AUR	5	1	58.1	43	49	24	N	2.99

Name	h	m	s	°	′	″		Mag
η AUR	5	6	30.8	41	14	4	N	3.17
β ORI	5	14	32.2	8	12	6	S	0.12
α AUR	5	16	41.3	45	59	53	N	0.08
γ ORI	5	25	7.8	6	20	59	N	1.64
β TAU	5	26	17.5	28	36	27	N	1.65
δ ORI	5	32	0.3	0	17	57	S	2.23
λ ORI	5	35	8.2	9	56	3	N	3.66
ι ORI	5	35	25.9	5	54	36	S	2.77
ϵ ORI	5	36	12.7	1	12	7	S	1.70
ζ TAU	5	37	38.6	21	8	33	N	3.00
σ ORI	5	38	44.7	2	36	0	S	3.81
ζ ORI	5	40	45.5	1	56	34	S	2.05
κ ORI	5	47	45.3	9	40	11	S	2.06
α ORI	5	55	10.3	7	24	25	N	0.50
β AUR	5	59	31.7	44	56	51	N	1.90
θ AUR	5	59	43.2	37	12	45	N	2.62
η GEM	6	14	52.6	22	30	24	N	3.28
ζ CMA	6	20	18.7	30	3	48	S	3.02
β CMA	6	22	41.9	17	57	22	S	1.98
μ GEM	6	22	57.6	22	30	49	N	2.88
α CAR	6	23	57.2	52	41	44	S	-0.72
γ GEM	6	37	42.7	16	23	57	N	1.93
ϵ GEM	6	43	55.9	25	7	52	N	2.98
α CMA	6	45	8.9	16	42	58	S	-1.46
ξ GEM	6	45	17.3	12	53	44	N	3.36
ϵ CMA	6	58	37.5	28	58	20	S	1.50
γ CMA	7	3	45.4	15	38	0	S	4.12
ζ GEM	7	4	6.5	20	34	13	N	3.79
δ CMA	7	8	23.4	26	23	35	S	1.84
δ GEM	7	20	7.3	21	58	56	N	3.53
η CMA	7	24	5.6	29	18	11	S	2.45
β CMI	7	27	9.0	8	17	21	N	2.90
α GEM	7	34	35.9	31	53	18	N	1.58
α CMI	7	39	18.1	5	13	30	N	0.38
β GEM	7	45	18.9	28	1	34	N	1.14

γ VEL	8	9	31.9	47	20	12	S	1.78
ϵ CAR	8	22	30.8	59	30	34	S	1.86
δ HYA	8	37	39.3	5	42	13	N	4.16
η HYA	8	43	13.4	3	23	55	N	4.30
δ VEL	8	44	42.2	54	42	30	S	1.96
ϵ HYA	8	46	46.5	6	25	8	N	3.38
ζ HYA	8	55	23.6	5	56	44	N	3.11
λ VEL	9	7	59.7	43	25	57	S	2.21
β CAR	9	13	12.1	69	43	2	S	1.68
θ HYA	9	14	21.8	2	18	51	N	3.88
ι CAR	9	17	5.4	59	16	31	S	2.25
κ VEL	9	22	6.8	55	0	38	S	2.50
α HYA	9	27	35.2	8	39	31	S	1.98
ψ VEL	9	30	41.9	40	28	0	S	3.60
ι HYA	9	39	51.3	1	8	34	S	3.91
ϵ LEO	9	45	51.0	23	46	27	N	2.98
υ CAR	9	47	6.1	65	4	18	S	2.96
υ HYA	9	51	28.6	14	50	48	S	4.12
μ LEO	9	52	45.8	26	0	25	N	3.88
ϕ VEL	9	56	51.7	54	34	4	S	3.54
η LEO	10	7	19.9	16	45	45	N	3.52
α LEO	10	8	22.3	11	58	2	N	1.35
λ HYA	10	10	35.2	12	21	15	S	3.61
ω CAR	10	13	44.3	70	2	16	S	3.32
ζ LEO	10	16	41.3	23	25	2	N	3.44
γ LEO	10	19	58.3	19	50	30	N	2.61
μ HYA	10	26	5.4	16	50	11	S	3.81
θ CAR	10	42	57.4	64	23	40	S	2.76
μ VEL	10	46	46.1	49	25	12	S	2.69
ν HYA	10	49	37.4	16	11	37	S	3.11
β UMA	11	1	50.4	56	22	56	N	2.37
α UMA	11	3	43.6	61	45	3	N	1.79
δ LEO	11	14	6.4	20	31	25	N	2.56
θ LEO	11	14	14.3	15	25	46	N	3.34
ξ HYA	11	33	0.1	31	51	27	S	3.54

Name	h	m	s	°	′	″		Mag
β LEO	11	49	3.5	14	34	19	N	2.14
β VIR	11	50	41.6	1	45	53	N	3.61
β HYA	11	52	54.5	33	54	28	S	4.28
γ UMA	11	53	49.8	53	41	41	N	2.44
SAO 119234	12	8	0.5	0	37	16	N	7.10
δ CEN	12	8	21.5	50	43	20	S	2.60
δ CRU	12	15	8.6	58	44	56	S	2.80
δ UMA	12	15	25.5	57	1	57	N	3.31
η VIG	12	19	54.3	0	40	0	S	3.89
α CRU	12	26	35.9	63	5	56	S	1.58
γ CRU	12	31	9.9	57	6	47	S	1.63
γ CEN	12	41	30.9	48	57	34	S	2.17
γ VIR	12	41	39.5	1	26	58	S	2.75
β CRU	12	47	43.3	59	41	19	S	1.25
ϵ UMA	12	54	1.7	55	57	35	N	1.77
δ VIR	12	55	36.1	3	23	51	N	3.38
ϵ VIR	13	2	10.5	10	57	33	N	2.83
γ HYA	13	18	55.2	23	10	18	S	3.00
ι CEN	13	20	35.7	36	42	44	S	2.75
ζ UMA	13	23	55.5	54	55	31	N	2.27
α VIR	13	25	11.5	11	9	41	S	0.98
80 UMA	13	25	13.4	54	59	17	N	4.01
ζ VIR	13	34	41.5	0	35	46	S	3.37
ϵ CEN	13	39	53.2	53	27	59	S	2.30
τ BOO	13	47	15.7	17	27	24	N	4.50
η UMA	13	47	32.3	49	18	48	N	1.86
υ BOO	13	49	28.5	15	47	52	N	4.07
ν CEN	13	49	30.2	41	41	16	S	3.41
μ CEN	13	49	36.9	42	28	26	S	3.04
η BOO	13	54	41.0	18	23	52	N	2.68
ζ CEN	13	55	32.3	47	17	18	S	2.55
β CEN	14	3	49.4	60	22	22	S	0.61
π HYA	14	6	22.2	26	40	56	S	3.27
θ CEN	14	6	40.8	36	22	12	S	2.06
α BOO	14	15	39.6	19	10	57	N	-0.04

δ OCT	14	26	54.8	83	40	4	S	4.32
ρ BOO	14	31	49.7	30	22	17	N	3.58
γ BOO	14	32	4.6	38	18	29	N	3.03
η CEN	14	35	30.3	42	9	28	S	2.31
α CEN	14	39	36.2	60	50	7	S	-0.01
π BOO	14	40	43.5	16	25	6	N	4.94
ζ BOO	14	41	8.8	13	43	42	N	4.43
ϵ BOO	14	44	59.1	27	4	27	N	2.70
β UMI	14	50	42.2	74	9	20	N	2.08
α LIB	14	50	52.6	16	2	31	S	2.75
κ CEN	14	59	9.6	42	6	15	S	3.13
β BOO	15	1	56.6	40	23	26	N	3.50
σ LIB	15	4	4.1	25	16	55	S	3.29
δ BOO	15	15	30.1	33	18	53	N	3.47
β LIB	15	17	0.3	9	22	59	S	2.61
γ TRA	15	18	54.6	68	40	46	S	2.89
γ UMI	15	20	43.6	71	50	2	N	3.05
γ LIB	15	35	31.5	14	47	22	S	3.91
ζ UMI	15	44	3.3	77	47	40	N	4.32
β TRA	15	55	8.4	63	25	50	S	2.85
π SCO	15	58	51.0	26	6	51	S	2.89
δ SCO	16	0	19.9	22	37	18	S	2.32
β SCO	16	5	26.1	19	48	19	S	2.62
κ HER	16	8	4.4	17	2	49	N	5.00
ϕ HER	16	8	46.1	44	56	6	N	4.26
η UMI	16	17	30.2	75	45	19	N	4.95
τ HER	16	19	44.3	46	18	48	N	3.89
σ SCO	16	21	11.2	25	35	34	S	2.89
γ HER	16	21	55.1	19	9	11	N	3.75
α SCO	16	29	24.4	26	25	55	S	0.96
β HER	16	30	13.1	21	29	22	N	2.77
τ SCO	16	35	52.9	28	12	58	S	2.82
ζ HER	16	41	17.1	31	36	10	N	2.81
η HER	16	42	53.7	38	55	20	N	3.53
ϵ UMI	16	45	57.8	82	2	14	N	4.23

Name	h	m	s	°	′	″		Mag
α TRA	16	48	39.9	69	1	40	S	1.92
ϵ SCO	16	50	9.7	34	17	36	S	2.29
ζ SCO	16	54	34.9	42	21	41	S	3.62
ϵ HER	17	0	17.3	30	55	35	N	3.92
η SCO	17	12	9.1	43	14	21	S	3.33
α HER	17	14	38.8	14	23	25	N	3.48
δ HER	17	15	1.8	24	50	21	N	3.14
π HER	17	15	2.7	36	48	33	N	3.16
υ SCO	17	30	45.7	37	17	45	S	2.69
δ UMI	17	32	12.5	86	35	11	N	4.36
λ SCO	17	33	36.4	37	6	13	S	1.63
θ SCO	17	37	19.0	42	59	52	S	1.87
ι HER	17	39	27.8	46	0	23	N	3.80
κ SCO	17	42	29.1	39	1	48	S	2.41
μ HER	17	46	27.5	27	43	15	N	3.42
ι SCO	17	47	35.0	40	7	37	S	3.03
θ HER	17	56	15.1	37	15	2	N	3.86
ξ HER	17	57	45.8	29	14	52	N	3.70
γ SGR	18	5	48.4	30	25	27	S	2.99
η SGR	18	17	37.5	36	45	42	S	3.11
δ SGR	18	20	59.6	29	49	41	S	2.70
ϵ SGR	18	24	10.3	34	23	5	S	1.85
λ SGR	18	27	58.1	25	25	18	S	2.81
α LYR	18	36	56.2	38	47	1	N	0.03
ζ LYR	18	44	46.3	37	36	18	N	4.36
ϕ SGR	18	45	39.3	26	59	27	S	3.17
β LYR	18	50	4.7	33	21	46	N	3.45
δ LYR	18	54	30.1	36	53	56	N	4.30
σ SGR	18	55	15.8	26	17	48	S	2.02
ξ SGR	18	57	43.7	21	6	24	S	3.51
γ LYR	18	58	56.5	32	41	22	N	3.24
ϵ AQL	18	59	37.3	15	4	6	N	4.02
ζ SGR	19	2	36.6	29	52	49	S	2.60
ο SGR	19	4	40.9	21	44	30	S	3.77
ζ AQL	19	5	24.5	13	51	48	N	2.99

λ	AQL	19	6	14.8	4	52	57	S	3.44
τ	SGR	19	6	56.3	27	40	14	S	3.32
π	SGR	19	9	45.7	21	1	25	S	2.89
β	SGR	19	22	38.2	44	27	32	S	4.01
α	SGR	19	23	53.0	40	36	58	S	3.97
δ	AQL	19	25	29.8	3	6	53	N	3.36
ι	CYG	19	29	42.2	51	43	47	N	3.79
β	CYG	19	30	43.2	27	57	35	N	3.08
δ	CYG	19	44	58.4	45	7	51	N	2.87
γ	AQL	19	46	15.5	10	36	48	N	2.72
α	AQL	19	50	46.9	8	52	6	N	0.77
η	AQL	19	52	28.3	1	0	20	N	3.90
ι	SGR	19	55	15.5	41	52	6	S	4.13
β	AQL	19	55	18.7	6	24	24	N	3.71
η	CYG	19	56	18.3	35	5	0	N	3.89
θ	SGR	19	59	44.1	35	16	35	S	4.37
θ	AQL	20	11	18.2	0	49	17	S	3.23
γ	CYG	20	22	13.6	40	15	24	N	2.20
α	IND	20	37	34.0	47	17	29	S	3.11
α	CYG	20	41	25.8	45	16	49	N	1.25
ϵ	CYG	20	46	12.6	33	58	13	N	2.46
ϵ	AQR	20	47	40.5	9	29	45	S	3.77
β	IND	20	54	48.5	58	27	15	S	3.65
ζ	CYG	21	12	56.1	30	13	37	N	3.20
α	CEP	21	18	34.7	62	35	8	N	2.44
θ	IND	21	19	51.9	53	26	59	S	4.39
β	CEP	21	28	39.5	70	33	39	N	3.23
β	AQR	21	31	33.4	5	34	16	S	2.91
ν	OCT	21	41	28.6	77	23	24	S	3.76
ϵ	PEG	21	44	11.1	9	52	30	N	2.39
κ	PEG	21	44	38.6	25	38	42	N	4.13
ι	PSA	21	44	56.7	33	1	33	S	4.34
θ	PSA	21	47	44.1	30	53	54	S	5.01
γ	GRU	21	53	55.6	37	21	54	S	3.01
δ	IND	21	57	55.0	54	59	34	S	4.40

Name	h	m	s	°	′	″		Mag
α AQR	22	5	46.9	0	19	11	S	2.96
ι AQR	22	6	26.1	13	52	11	S	4.27
ι PEG	22	7	0.6	25	20	42	N	3.76
α GRU	22	8	13.9	46	57	40	S	1.74
π PEG	22	9	59.2	33	10	42	N	4.29
θ PEG	22	10	11.9	6	11	52	N	3.53
ζ CEP	22	10	51.2	58	12	5	N	3.35
θ AQR	22	16	49.9	7	47	0	S	4.16
γ AQR	22	21	39.3	1	23	14	S	3.84
δ GRU	22	29	16.1	43	29	45	S	3.97
β PSA	22	31	30.3	32	20	46	S	4.29
η AQR	22	35	21.3	0	7	3	S	4.02
ϵ PSA	22	40	39.3	27	2	37	S	4.17
ζ PEG	22	41	27.6	10	49	53	N	3.40
β GRU	22	42	40.0	46	53	5	S	2.10
η PEG	22	43	0.1	30	13	17	N	2.94
β OCT	22	46	3.3	81	22	54	S	4.15
λ PEG	22	46	31.8	23	33	56	N	3.95
ϵ GRU	22	48	33.2	51	19	1	S	3.49
ι CEP	22	49	40.7	66	12	2	N	3.52
λ AQR	22	52	36.8	7	34	47	S	3.74
δ AQR	22	54	38.9	15	49	15	S	3.27
δ PSA	22	55	56.8	32	32	23	S	4.21
α PSA	22	57	39.0	29	37	20	S	1.16
β PEG	23	3	46.4	28	4	58	N	2.42
α PEG	23	4	45.6	15	12	19	N	2.49
ι GRU	23	10	21.5	45	14	48	S	3.90
ϕ AQR	23	14	19.3	6	2	56	S	4.22
ι PHE	23	35	4.5	42	36	55	S	4.71
γ CEP	23	39	20.8	77	37	57	N	3.21
π PHE	23	58	55.7	52	44	45	S	5.13

Name	h	m	°	′		Mag	Description
M1	5	34.5	22	1	N	11.3	Crab Nebula
M2	21	33.5	0	49	S	6.3	Globular cluster
M3	13	42.2	28	23	N	6.2	Globular cluster
M4	16	23.6	26	31	S	6.1	Globular cluster
M5	15	18.5	2	5	N	6.0	Globular cluster
M6	17	40.0	32	12	S	6.0	Open cluster
M7	17	54.0	34	49	S	5.0	Open cluster
M8	18	3.7	24	23	S		Lagoon Nebula
M9	17	19.2	18	31	S	7.6	Globular cluster
M10	16	57.2	4	6	S	6.4	Globular cluster
M11	18	51.1	6	16	S	7.0	Open cluster
M12	16	47.2	1	57	S	6.7	Globular cluster
M13	16	41.7	36	28	N	5.8	Globular cluster
M14	17	37.6	3	15	S	7.8	Globular cluster
M15	21	30.0	12	10	N	6.3	Globular cluster
M16	18	18.9	13	47	S	7.0	Open cluster
M17	18	20.8	16	10	S	7.0	Omega Nebula
M18	18	19.9	17	8	S	7.0	Open cluster
M19	17	2.6	26	16	S	6.9	Globular cluster
M20	18	2.4	23	2	S		Trifid Nebula
M21	18	4.7	22	30	S	7.0	Open cluster
M22	18	36.4	23	54	S	5.2	Globular cluster
M23	17	56.9	19	1	S	6.0	Open cluster
M24	18	18.4	18	25	S	6.0	Open cluster
M25	18	31.7	19	14	S	6.0	Open cluster
M26	18	45.2	9	24	S	9.0	Open cluster
M27	19	59.6	22	43	N	8.2	Dumbbell Nebula
M28	18	24.6	24	52	S	7.1	Globular cluster
M29	20	24.0	38	31	N	8.0	Open cluster
M30	21	40.4	23	11	S	7.6	Globular cluster
M31	0	42.7	41	16	N	3.7	Andromeda Galaxy
M32	0	42.7	40	52	N	8.5	Elliptical galaxy
M33	1	33.8	30	39	N	5.9	Spiral galaxy
M34	2	42.0	42	47	N	6.0	Open cluster
M35	6	8.8	24	20	N	6.0	Open cluster

Name	h	m	°	′		Mag	Description
M36	5	36.3	34	8	N	6.0	Open cluster
M37	5	53.0	32	33	N	6.0	Open cluster
M38	5	28.7	35	50	N	6.0	Open cluster
M39	21	32.3	48	26	N	6.0	Open cluster
M40	12	22.2	58	5	N	9.0	Double star
M41	6	47.0	20	44	S	6.0	Open cluster
M42	5	35.3	5	23	S		Orion Nebula
M43	5	35.5	5	16	S		Orion Nebula
M44	8	40.0	20	0	N	4.0	Praesepe
M45	3	47.5	24	7	N	2.0	Pleiades
M46	7	41.8	14	49	S	7.0	Open cluster
M47	7	36.6	14	29	S	5.0	Open cluster
M48	8	13.8	5	48	S	6.0	Open cluster
M49	12	29.8	8	0	N	8.9	Elliptical galaxy
M50	7	3.0	8	21	S	7.0	Open cluster
M51	13	29.9	47	12	N	8.4	Whirlpool Galaxy
M52	23	24.2	61	36	N	7.0	Open cluster
M53	13	12.9	18	10	N	7.7	Globular cluster
M54	18	55.1	30	28	S	7.7	Globular cluster
M55	19	40.0	30	57	S	6.1	Globular cluster
M56	19	16.6	30	11	N	8.3	Globular cluster
M57	18	53.6	33	2	N	9.0	Ring Nebula
M58	12	37.7	11	49	N	9.9	Spiral galaxy
M59	12	42.0	11	39	N	10.3	Elliptical galaxy
M60	12	43.7	11	33	N	9.3	Elliptical galaxy
M61	12	21.9	4	28	N	9.7	Spiral galaxy
M62	17	1.2	30	7	S	7.2	Globular cluster
M63	13	15.8	42	2	N	8.8	Spiral galaxy
M64	12	56.7	21	41	N	8.7	Spiral galaxy
M65	11	18.9	13	6	N	9.6	Spiral galaxy
M66	11	20.3	13	0	N	9.2	Spiral galaxy
M67	8	51.3	11	48	N	7.0	Open cluster
M68	12	39.5	26	45	S	8.0	Globular cluster
M69	18	31.4	32	21	S	7.7	Globular cluster
M70	18	43.2	32	17	S	8.2	Globular cluster

M71	19	53.7	18	47	N	6.9	Globular cluster
M72	20	53.5	12	32	S	9.2	Globular cluster
M73	20	59.0	12	38	S		Open cluster
M74	1	36.7	15	47	N	9.5	Spiral galaxy
M75	20	6.1	21	55	S	8.3	Globular cluster
M76	1	42.2	51	34	N	11.4	Planetary nebula
M77	2	42.7	0	1	S	9.1	Spiral galaxy
M78	5	46.7	0	4	N		Emission nebula
M79	5	24.2	24	31	S	7.3	Globular cluster
M80	16	17.0	22	59	S	7.2	Globular cluster
M81	9	55.8	69	4	N	6.9	Spiral galaxy
M82	9	56.2	69	42	N	8.7	Irregular galaxy
M83	13	37.7	29	52	S	7.5	Spiral galaxy
M84	12	25.1	12	53	N	9.8	Eliptical galaxy
M85	12	25.4	18	11	N	9.5	Spiral galaxy
M86	12	26.2	12	57	N	9.8	Elliptical galaxy
M87	12	30.8	12	23	N	9.3	Elliptical galaxy
M88	12	32.0	14	25	N	9.7	Spiral galaxy
M89	12	35.7	12	33	N	10.3	Elliptical galaxy
M90	12	36.8	13	10	N	9.7	Spiral galaxy
M91	12	35.4	14	30	N	9.5	Spiral galaxy
M92	17	17.1	43	8	N	6.3	Globular cluster
M93	7	44.6	23	53	S	6.0	Open cluster
M94	12	50.9	41	7	N	8.1	Spiral galaxy
M95	10	44.0	11	42	N	9.9	Barred spiral galaxy
M96	10	46.8	11	49	N	9.4	Spiral galaxy
M97	11	14.9	55	1	N	11.1	Owl Nebula
M98	12	13.8	14	54	N	10.4	Spiral galaxy
M99	12	18.8	14	25	N	9.9	Spiral galaxy
M100	12	22.9	15	49	N	9.6	Spiral galaxy
M101	14	3.5	54	21	N	8.1	Spiral galaxy
M103	1	33.1	60	42	N	7.0	Open cluster
M104	12	40.0	11	42	S	8.0	Sombrero Galaxy
M105	10	47.9	12	43	N	9.5	Elliptical galaxy
M106	12	19.0	47	18	N	9.0	Spiral galaxy

Name	h	m	°	′		Mag	Description
M107	16	32.5	13	3	S	9.0	Globular cluster
M108	11	11.6	55	40	N	10.5	Spiral galaxy
M109	11	57.7	53	22	N	10.6	Barred spiral galaxy
3C273	12	29.1	2	3	N	12.8	Quasar

Greek Alphabet

α Alpha
β Beta
γ Gamma
δ Delta
ε Epsilon
ζ Zeta
η Eta
θ Theta
ι Iota
κ Kappa
λ Lambda
μ Mu
ν Nu
ξ Xi
ο Omicron
π Pi
ρ Rho
σ Sigma
τ Tau
υ Upsilon
φ Phi
χ Chi
ψ Psi
ω Omega

Saving & Printing the Display

Since The Observatory loads as much astronomy as possible into the Apple's 64K of memory, there is no room left for DOS, the Disk Operating System. However, the following five steps will allow you to save copies of The Observatory's display onto any floppy disk formatted by either DOS 3.3 or ProDos.

1) When you have produced a scene which you would like to save, remove The Observatory disk from the drive and type:

> **CTRL Y**
> This will drop you into BASIC.

2) From the "]" cursor in BASIC type the following:

> **CALL - 151 RETURN**
> This will drop you into the MONITOR.

3) From the "*" cursor in the MONITOR type the following:

> **6000<2000.3FFFM RETURN**
> Don't forget the "M" after "FFF". This moves High Resolution Page 0 (The Observatory's display), located in the range of memory from $2000 to $3FFF, to a safe area of memory located at address $6000.

4) Insert a copy of either a DOS 3.3 Master Disk or ProDos into Drive 1 and, since you're still in the MONITOR, at the "*" cursor type:

> **6 CTRL K RETURN**
> where the "6" stands for the slot number of your disk controller card. The above command is identical to entering "PR#6" if you were in BASIC, i.e., it causes the disk drive to boot the DOS disk.

5) After DOS finishes loading and you're at the "]"

5) After DOS finishes loading and you're at the "]" cursor in BASIC, save The Observatory's display onto an appropriately formatted DOS disk by typing the following:

BSAVE FILENAME, A$6000, L$2000 RETURN

As a consequence of all this activity, especially the loading of DOS, large sections of The Observatory's computer code have been overwritten in memory. You will have to re-boot The Observatory in order to get back into the program.

There are several ways to get printed copies of The Observatory's display. Print cards such as **PRINT-IT** from Texprint will, at the push of a button, interface with many different dot-matrix printers. Alternatively there is software which can handle the major models of dot-matrix printers. For example, **TRIPLE-DUMP** from Beagle Bros. can be used to manipulate and printout images saved according to the above instructions. For other hardware and software options, check with your local computer dealer.

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