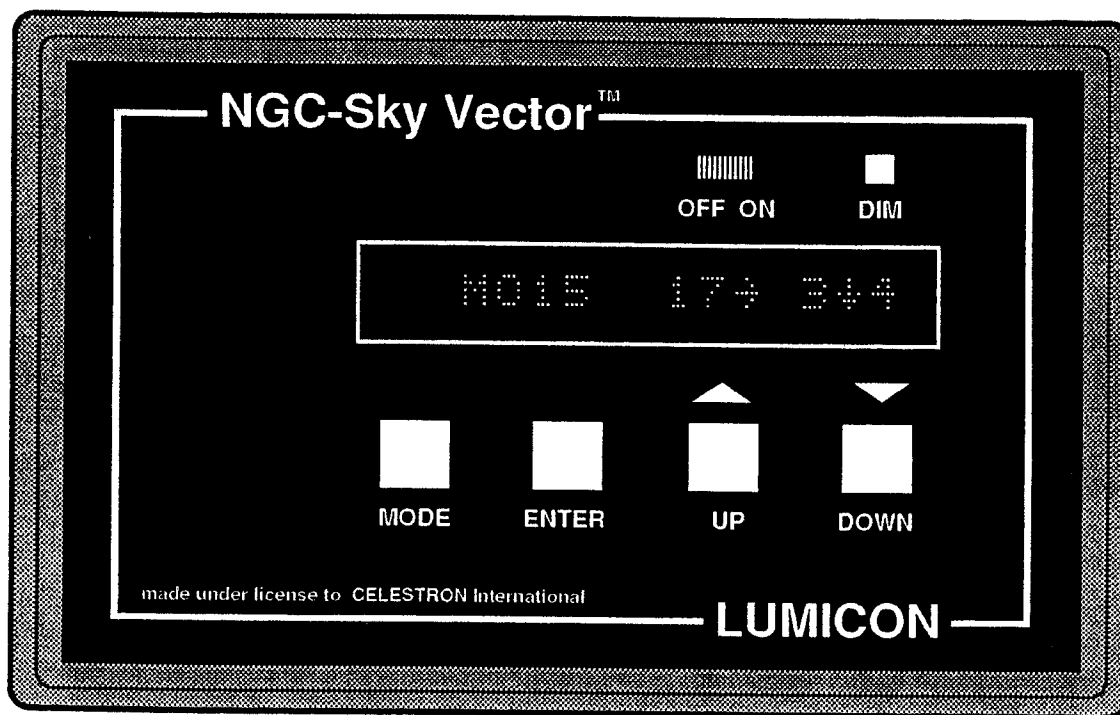


LUMICON
NGC Sky Vector™
Large Database Telescope Computer

INSTRUCTION MANUAL



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 Eratta for the Sky Vector v3.65

1.0 V3.65 FEATURES SUMMARY

The NGC Sky Vector is improved in many subtle ways by this v 3.65 software update. Compatible with extra high resolution encoders, New improved larger database, higher resolution display modes, live constellation calculation, live chart number calculation.

Encoder installation is simplified and more accurate as the encoder resolution is set directly in units of encoder steps per revolution. The display is simply RA +08192. This unit is now compatible with extra high resolution encoders of 8192 step resolution. Other high resolutions achieved by precision gearing can also be accommodated. The encoders are sampled more than twice as often as previous models.

The Right Ascension and Declination mode also shows the constellation name. When Extra resolution encoders are used the displays add additional digits to reflect this new resolution HH:MM.M +DD:MM. The guiding arrows can display with resolution up to 0.01°

The database has been increased to more than 12,000 objects with improved descriptive information. The star list now has most all double stars that might be separated by amateur telescopes. The increased non-stellar listing has selections for over a dozen lesser known catalogs. There are more selections from the Index catalog, UGC catalog and ESO catalog. The database is the best 12,000 objects in the sky.

The LED dot matrix display instrument has 5 brightness levels to not interfere with night adapted vision.

SECTION 2.3 Mode "RA DEC"

A continuous display of right ascension and declination is provided. The example shows a right ascension of 7 hours and 42 minutes, and a declination of north 28.1 degrees and the current constellation. Pressing the ENTER button will change the display to show the chart number of the Sky Atlas 2000.0, and the Uranometrial 2000 star chart that covers the part of the sky where the telescope is currently pointing. When extra resolution encoders or precision gearing provides resolution >6000 steps per revolution the display then shows more resolution.

Right Ascension and Declination and Constellation:

```
0742 +28.1 GEN
```

chart numbers and constellation:

```
SA=05 UA=139 GEN
```

Right Ascension and Declination high resolution display:

```
07:42.1 +28:06
```

SECTION 2.5 Mode "GUIDE"

The numbers will count down until the object is centered and the distance displayed is 0.0 degrees. If the distance to the object is greater than 10° the steering will be in whole 1 degree increments. Once the object is within 10° the instrument will display finer resolution steering directions up to 0.01 degrees. The following sequence of guiding displays shows how the guiding arrows and digits change as the object is approached.

far away: 6+7 12+

close by: 0+8 0+4

very close: +06 +20

centered: 0+0 0+0

Eratta for the Sky Vector v3.65

SECTION 2.9 MODE "ENCODER"

This allows verification that the encoders are functional and act with the proper sense of angular rotation. Encoder angles are displayed in degrees and tenths. Press "ENTER" to display the angles in encoder ticks the elemental unit of angle detected by the optical encoders. This is the same data that is reported to any personal computer connected to the RS232 port. The azimuth or right ascension encoder is displayed on the left digits. The range is 0.0° to 360.0°. The altitude or declination is displayed on the right. The range is ±180.0°. This display allows you to verify that both encoders function properly. Encoders may be connected backward, they will not function but are not damaged. The direction of encoder response may be verified.

encoder angles in degrees:

```
000.0 +000.0
```

encoder angles encoder ticks:

```
+0000 +0000
```

5.1 INSTALL Mode

The setup mode is used when the instrument is first installed on the telescope. The setup tells the instrument the date, what kind of telescope you are using, the desired scroll rate, and the resolution or gear ratio of the encoders. You may return to the mode selector at any time by pressing MODE. Select INSTALL from the mode selector and press ENTER. Continue to press the ENTER button to set through the settings. To make a change to one of the parameters, simply use the UP and DOWN arrow buttons, then press ENTER to advance to the next item.

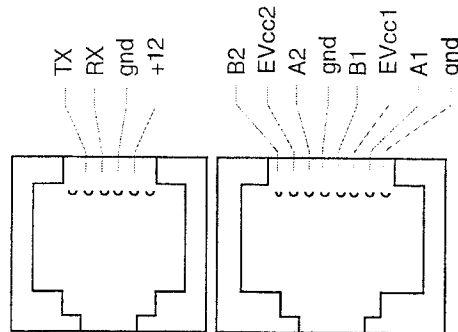
The order of the INSTALL procedure:

- 1. telescope mount
- 2. scroll rate:
- 3. chart number:
- 4. RA Encoder resolution, extra resolution encoder
- 5. Declination encoder resolution:

```
SCOPE EQ
SCROLL 5
CHART SA
AZ +00192
AL +04000
```

8.1 RS232 connections

A 6 position modular connector is used for the RS232 interface. There are a few computer accessories that have a compatible cable. The interface cable is available separately. The cable uses only three pins of the 6 position modular connector. Be careful to check the quality of a crimp when low cost crimpers are used. Make sure that all of the pins are down before inserting into the instrument as this can damage the wires of the connector.



You can make your own, only 3 wires used; TX, RX, gnd. You will have to check your computer manual for the connections on that end of the cable. The TX pin at the computer must connect to the RX pin on the NGC Sky Vector. The RX pin at the computer must connect to the TX pin on the Advanced Astro Master. The ground, gnd, pin is connected straight across. The communication is at 9600 baud, 8 data bits, 1 stop bit, no parity.

8.2 RS232 Commands

There are only two simple one letter requests. The "Q" query is answered with the encoder angles for both Right Ascension and Declination. The result is human readable decimal numbers with fixed format and leading zeros. The

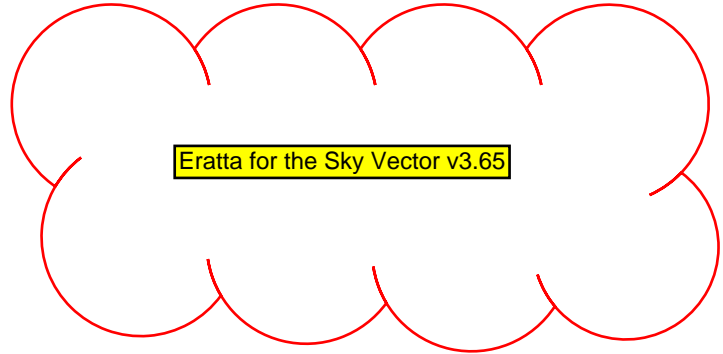
result will come back very quickly it will begin transmitting the result within 1 character frame of the query. The "P" command requests some status information and is not needed very often.

command: "Q" normal query

The response is in fixed format, two signed five digit numbers which correspond to the respective encoder angles. Encoder angles in the range of $+180^\circ$ to -180° are represented by values in the range of +04000 to -04000.

response :

data:	azimuth	altitude
format:	+00000<tab>+00000<cr>	
example:	+01234	-00123



1.0 Description

The NGC Sky Vector instrument will help you explore the sky quickly and easily. It will guide you to the best astronomical objects in the sky. This compact instrument is a complete telescope computer that performs complex transformations many times each second. It does the mathematics to make observing simple and efficient for you.

Finding an object is as easy as scrolling through the catalog. Select an object from one of the catalogs and tell the instrument to find it by using the guide function. The display will then give pointing instructions on how to move the telescope. It is especially useful under light polluted skies where few visible stars are available for star hopping to deep sky objects. **IMPORTANT:** Use only an **alkaline** battery for best operation.

Simply turn on the instrument, sight one or two stars, and let it guide you to deep sky objects. No need to polar align the telescope, no need to input latitude or longitude. It provides virtually any astronomical telescope, equatorial or altitude / azimuth, with a continuous, real-time digital readout of right ascension and declination coordinates. The unique method of alignment by two star sightings provides good pointing accuracy over the entire sky.

The alpha numeric display provides the names, coordinates, and descriptions in a simple, easy to read english scrolling text format. The LED dot matrix display emits a monochromatic red light which does not interfere with night adapted vision. The brightness of the display can be varied by pressing the DIM button. The instrument has 4 brightness levels.

The NGC Sky Vector instrument weighs 8 ounces, with the 9 volt battery installed. The instrument may be conveniently mounted near the eyepiece of the telescope without upsetting the balance. The instrument may be attached to the telescope by a strip of hook and loop fastening material such as Velcro or Scotch Dual Lock.

1.1 Operating Summary

Important: Verify initial setup, pages 16 to 21, before using the LUMICON NGC SKY VECTOR II for the first time. Be sure to read the detailed operation instructions, pages 4 to 11. Use only an **alkaline** 9 volt battery for best results.

1. "SET DEC=0" : set telescope declination to 0° for equatorial mounts, including Schmidt Cassegrain telescopes. Otherwise set optical axis horizontal for alt-azimuth (Dobsonian) telescopes. Press ENTER.
2. "STAR FIX" : Point telescope at a bright star. Press ENTER.
3. Press UP button to scroll to the correct name of the star.
4. Press ENTER to confirm the star sighting.
5. Point the telescope to a second bright star over 60° away.
6. Press UP button to scroll to the correct name of the second star.
7. Press ENTER to confirm the star sighting.
8. Press the MODE button.
9. Press UP to scroll through modes until "RA DEC" is displayed. Press ENTER to display RA & DEC coordinates.
10. (Optional) Press MODE. Press UP until "CATALOG" is displayed. Press ENTER to enter the Catalog mode.
11. Press UP to scroll through the catalog options M, ST ,NGC, IC, NS, PN, NEW, and PLANETS. When the desired catalog is named press ENTER.
12. Press UP to set the blinking digit, Press ENTER to set the desired object numbers one after another.
13. Press ENTER to finish the setting. Press ENTER once for coordinates, twice for description.
14. Press the MODE button. press UP to GUIDE mode. Press ENTER. Move until the displayed angles are zero.

2.0 Operation

SECTION 2.1 Display Modes

NGC Sky Vector has ten display modes, or functions. Pressing the MODE button returns to the mode selector menu, the user can then scroll through the list of functions. Each is described separately in the following text. The Up and Down arrow buttons are always used for scrolling through the lists. The UP arrow button advances through the list in a forward direction.

```

MODE   STAR   FIX
MODE   RA    DEC
MODE   CATALOG
MODE   GUIDE
MODE   IDENTIFY
MODE   ALIGN
MODE   TIMER
MODE   ENCODER
MODE   INSTALL

```

SECTION 2.2 Mode "STAR FIX"

This mode is used for the one or two star telescope alignment that must be performed at the start of an observing session. This mode automatically accesses a shortened star list of 28 named navigational stars to assist with the alignment operation. The display shows "(star name)". The first star in the list is Achernar, and is displayed after pressing the ENTER button. Pressing the UP arrow button advances through the alphabetical list of stars. The brightest stars from both the Northern and Southern hemispheres are included. These familiar bright stars cover the sky so that at least two are visible at any time. To perform the alignment operation, pick a bright familiar star and center it in the eyepiece. Chose the STAR FIX Mode and scroll through the star list to find the name of the star that is centered in the eyepiece. For the star Antares the display would show "ALIGN ANTARES". Verify the star is still centered in the eyepiece and press the ENTER button. Only one star is required for polar aligned telescopes. The first alignment step is now completed. Simply repeat this operation for the second star.

```

first star in list:   ALIGN   ACHERNAR
display of first choice star name: ALIGN   ANTARES
display of warp factor: WARP=+   0.2

```

After the instrument determines the transformation resulting from star alignment, it displays a measure of how well the alignment agrees with its star data. This space warp factor is given in degrees of error and is 0.0° for perfect alignment, but an acceptable range is $\pm 0.5^\circ$. The display will show the warp factor for about 2 seconds. For best results, use two stars that are at least 45° apart when aligning. See Section 2.7 describing the ALIGN mode which allows alignment on any object in any of the catalogs.

Note: Polaris should not be used as the first alignment star. It is too close to the celestial pole.

SECTION 2.3 Mode "RA DEC"

A continuous display of right ascension and declination is provided. The example below shows a right ascension of 7 hours and 42 minutes, and a declination of north 28 degrees and 10 minutes. Pressing the ENTER button will momentarily show the chart number of the Sky Atlas 2000.0 star chart that covers the part of the sky where the telescope is currently pointing.

```
Right Ascension and Declination:   RA=0742  DEC=+281
Sky Atlas 2000 chart number:      SA=08
```

SECTION 2.4 Mode "CATALOG"

This mode retrieves information from the database. Select CATALOG with the MODE button and press the ENTER button. Press the UP, DOWN arrow buttons to pick which group to chose from. There are eight different groups of astronomical objects in the database.

2.4.1 Choosing A Catalog

The Star (ST) catalog is the first choice and when you enter the CATALOG mode the display will show the catalog name of the most recent alignment star. Press the arrow buttons to select which of the three catalogs you wish to make a selection from. The display will bring up the choices as you press the button.

Example of the mode CATALOG displays for each object group:

```
Star catalog:      ST001
Messier catalog:   M001
NGC catalog:      NGC0001
IC catalog:       IC0001
Non-stellar catalog:  NS001

New catalog:      NEW01
Planets catalog:  PLANETS
```

2.4.2 The Star Catalog

The Star (ST) catalog contains many interesting stars, double stars and red stars including all of the alignment stars. First look up the object, select CATALOG mode, chose ST, and enter the star number using the arrow buttons to set the blinking digit, pressing ENTER to advance to the next digit to be set. Press ENTER after setting the last digit and the display will show the coordinates. The following information is displayed for Albiero:

Example of CATALOG display for selecting an object from the star (ST) list:

```
enter number:      ST182
coordinates:       1930+275
press ENTER for scrolling information:
  Star number:     ST182
  coordinates:     1930+275
  magnitude:       MAG=3.1
  size:            SIZE=34''
  name:            ALBIRO
  constellation:   CYGNUS
  description:     COLORED DOUBLE STAR
  chart number:    SA=08
```

2.4.3 The Messier Catalog

The MESSIER (M) list contains the full historical list of 110 Messier objects. Select CATALOG with the MODE button and press ENTER. If you are already in CATALOG, simply press the arrow buttons to switch between the catalogs, and press the ENTER button. The display will show "M001". Enter the desired value of the blinking digit using the arrow buttons and press ENTER to advance to the next digit. When the last digit has been set, press ENTER and the display will show the M number. Press ENTER again to show the coordinates for the selected object. Press ENTER again for a scrolling description which includes magnitude, popular name, description, and Sky Atlas 2000 chart number.

Example of CATALOG display for selecting an object from the Messier (M) list:

```
entering M catalog:  M001
enter M number choice:  M027
coordinates:  M027  1959+224
scrolling information:
  M number:  M027
  magnitude:  MAG=7.4
  size:  SIZE=480''
  name:  DUMBBELL NEBULA
  constellation:  VULPECULA
  description:  PLANETARY NEBULA IRREGULAR
  chart number:  SA=08
```

2.4.4 The NGC Catalog

The NGC catalog contains 7839 interesting non-stellar objects. The NGC identifier comes from the original index catalog of J. L. E. Dreyer. The NGC Sky Vector contains updated and corrected descriptions as compiled by Steve Gottleib using a 17" amateur telescope. To find an NGC object, select CATALOG mode, chose NGC, and enter the object's number using the arrow buttons to set the blinking digit. Press ENTER to advance to the next digit to be set. Press ENTER after setting the last digit for the display to show the coordinates. Press ENTER again to see the scrolling text information contained in the database for the selected object.

Example of CATALOG display for selecting an object from the NGC list:

```
entering NGC catalog:  NGC0001
enter selection:  NGC4565
coordinates:  NGC4565  1236+255
scrolling information:
  NGC number:  NGC4565
  magnitude:  MAG=9.6
  size:  SIZE=15
  name :
  constellation:  COMA BENICES
  description:  EDGE ON GALAXY DUSTY
  chart number:  SA=08
```

2.4.5 The IC Catalog

The Indexed Catalog (IC) contains 5332 objects that are not contained in the NGC catalog. These objects were missed in the Dreyer's original New General Catalog. The following example shows how to find the difficult Horsehead nebula, designated IC434, in the constellation Orion. Finding the Horsehead is easy with the NGC Sky Vector, but it may not be visible. The LUMICON H-Beta filter is needed for this object.

Example of CATALOG display for selecting an object from the IC list:

```

entering IC number      IC0001
enter selection:       IC0434
PressENTER for coordinates: IC0434  05+1-022
Press ENTER for scrolling information:
  IC number:          IC0434
  magnitude:          MAG=  ?
  size:              SIZE=59
  name :
  constellation:      ORION
  description:        NEBULA  LOW  BRIGHTNESS
  chart number:       SA=11

```

2.4.6 The Non-stellar (NS) Catalog

The Non-Stellar (NS) catalog contains those objects not included in either the popular NGC or IC catalogs. Multiple sources were used to compile this list of 268 interesting astronomical objects. The example shows how to find the object listed as TR2, an open cluster in Perseus.

Example of CATALOG display for selecting an object from the NS list:

```

entering NS number     NS001
enter selection:       NS047
PressENTER for coordinates: NS047  0237+555
Press ENTER for scrolling information:
  NS number:          NS047
  magnitude:          MAG= 5.9
  size:              SIZE=19
  name :              TR2
  constellation:      PERSEUS
  description:        OPEN  CLUSTER  RICH
  chart number:       SA=01

```

2.4.7 The NEW Catalog

The NEW catalog function allows the user to input coordinates for objects not in the database already, such as a new comet, or to create a custom star list for observing. The NEW catalog can store 32 objects, and the information is stored in non-volatile memory for future use. In the following example, the display comes up with NEW01 as the first item with coordinates 1234+123. To make a new entry under item 3, enter the object number as NEW03 as in all the other catalog object selections. Then set the coordinates. You can easily input the current coordinates by entering the first digit of RA as a digit other than 0,1,2. The current pointing coordinates will automatically be entered.

Example of CATALOG display for selecting an object from the NEW list:

enter NEW catalog: NEW01

enter selection: NEW03

Press ENTER to show current coordinates: NEW03 1234+123

Press ENTER again to change the coordinates: NEW03 1925+275

2.4.8 The PLANETS Catalog

The PLANETS catalog requires the entry of today's date, and the date will be the first item to come up. Press the UP and DOWN buttons to set the blinking digit, and press ENTER to advance to the next digit. Press the MODE button to exit without scrolling through the rest of the parameters. The order in which the planets are listed is organized by their distance to the sun. For historical planet positions you may enter any date from AD 0 to AD 2500 for the date entry in the SETUP mode. Highest accuracy occurs for AD 2000.

list of PLANETS: MERCURY

 VENUS

 MARS

 JUPITER

 SATURN

 URANUS

 NEPTUNE

 PLUTO

select Jupiter with UP arrow:

 JUPITER

Press ENTER to show current coordinates:

 JUPITER 1039+095

Press ENTER again to see the next planet's coordinates:

 SATURN 2108-170

SECTION 2.5 Mode "GUIDE"

The GUIDE mode provides steering directions to selected objects. It is the most fun and useful mode of operation. Select an object from the database, then press MODE to return the mode selector. Then select the function called "GUIDE" using the arrow buttons. Press ENTER to enter the GUIDE function. If you have not done a star alignment, the instrument will instruct you do so by displaying the message "ALIGN FIRST". To find M42, use the mode button to select the CATALOG, chose the M list and enter M042. Now press the Mode button and select the GUIDE mode. Press ENTER. The instrument will now display distance and direction from the nebula. Move the telescope as indicated to make the displayed deviation zero. The indication shows 6.4° right and 12° down. Press ENTER to obtain a scrolling description.

guide display arrows: M042 6.4 12.4

scrolling description: M042

 magnitude: MAG=4.0

```

size:          SIZE=63
name :        GREAT ORION NEBULA
constellation: ORION
description:  NEBULA
chart number: SA=11

```

The numbers will count down until the object is centered and the distance displayed is 0.0 degrees. If the distance to the object is greater than 10° the steering will be in whole 1 degree increments. Once the object is within 10° the instrument will display finer resolution steering directions of 0.1 degrees. The following sequence of guiding displays shows how the guiding arrows and digits change as the object is approached.

```

far away:      6÷7  12÷
close by:     0÷8  0÷4
centered:     0÷0  0÷0

```

The guide mode works in the axes of the telescope mounting. Thus an altitude azimuth telescope will be directed by the pointing arrows right, left and up, down. Motion in one axis will not cause the other deviation display to change.

The German equatorial guide mode works differently allowing for the two possible ways to point at an object. It will display the path from the current position that involves the least turning. Should the observer want to "flop" the telescope, it will give directions from the new position. The target object has coordinates α = declination and δ = right ascension. The observer may turn directly to these coordinates or to $\alpha_2 = \alpha + 180$ and $\delta_2 = 180 - \delta$.

SECTION 2.6 Mode "IDENTIFY"

The IDENTIFY mode provides another way of locating objects. Simply point the telescope at the object and ask the computer to search its database for an identity. This feature is useful when observing is restricted by cloud or sky conditions. The instrument also allows you to enter a selection criteria. The first search criteria is whether to search all of its catalogs, or by object type. The second search criteria is by magnitude. Selecting ANY and Magnitude 17 will search everything in the database. The display blinks every time it updates the search, so if you are moving around the sky while in the IDENTIFY mode it will provide information on the current, or nearest, object the telescope is pointed at. Each search takes about 3 seconds. The types of objects are as follows:

```

IDENTIFY choices:
any type of object:  FIND ANY  MAG 10
stellar objects:    FIND ST   MAG 10
globular cluster:   FIND GC   MAG 10
open cluster:       FIND OC   MAG 10
galaxy:              FIND GX   MAG 10
planetary nebula:   FIND PN   MAG 10
nebula:              FIND NB   MAG 10
double star:        FIND Z*   MAG 10
red or colored star: FIND R*   MAG 10
any non-stellar object: FIND NS   MAG 10

```

Press Enter to start the search, in this case we are looking for a star, magnitude 6:

```
search for star:      FIND ST  MAG 10
                     SEARCHING
                     FOUND ST068
```

Press ENTER for scrolling description:

```
ST068
MAG= 4.3
SIZE= 13''8
MONOCEROS
COLORED DOUBLE STAR
SA=12
```

SECTION 2.7 Mode "ALIGN"

You may use any object for an alignment fix by using the ALIGN mode. This function is useful for obtaining a new alignment fix during the middle of an observing session to correct small coordinate errors that may accumulate due to slight misalignments of the encoder installation.

For example, center the Messier object M42 in the eyepiece. Enter CATALOG mode and look up M42 in the M list, then switch to ALIGN mode. Press the ENTER button to chose this as a new alignment fix. Pressing ENTER again will show the "Warp" factor, which is the difference in degrees between the last two objects sighted and the actual measured angle from the encoders. A warp factor less than 0.5 would indicate a favorable alignment. For alignment on M42 this unit would display the following:

```
alignment mode display:  ALIGN  M042
pressing ENTER again:   WARP=+ 0.5
```

SECTION 2.8 Mode "TIMER"

The TIMER function is an elapsed time counter, useful for astrophotography or timed observations. Simply select the TIMER mode with the MODE button and press ENTER. Press ENTER again to START, STOP, and RESET. The display format is hours, minutes, seconds.

```
TIMER mode:           00 00 00
press ENTER to start:  START
counting:             00 00 01
press ENTER to stop:  STOP
35 minutes, 25 seconds: 00 35 25
press ENTER to reset:  RESET
                       00 00 00
```

SECTION 2.9 MODE "ENCODER"

This allows verification that the encoders are functional and act with the proper sense of angular rotation. Encoder angles are displayed in whole degrees. The angle of each encoder is displayed. The azimuth or right ascension encoder is displayed on the left three digits. The range is 0° to 360°. The altitude or declination is displayed on the right. The range is ±180°. This display allows you to verify that both encoders function properly. Encoders may be connected backward, they will not function but are not damaged. The direction of encoder response may be verified. Moving the telescope will change the encoder angles.

encoder angles for equatorial mounts:

```
ER=000  ED=+000
```

encoder angles for altitude/azimuth mounts:

```
AZ=000  AL=+000
```

SECTION 2.10 MODE "INSTALL"

This mode is generally used only when the instrument is first installed on a telescope. All settings are retained in non-volatile memory. Specific installation details such as scroll rate, encoder ratios, and type of telescope mount may be changed. See Sections 5.0 and 6.0 for instructions on how to perform the setup for equatorial and altitude/azimuth telescope mounts.

3.0 Initialization Alignment Operation for Equatorial Mount

3.1 DEC=0 Reminder

Turn on the NGC Sky Vector and the start up message will show "**LUMICON**". When the NGC Sky Vector is setup for use on an equatorial mount (EQ or GQ) it will display "**DEC=0**". This indicates that you need to move the telescope to zero in the declination axis. Press ENTER when the declination angle is zero. Press the ENTER button to enter the **ALIGN STAR** mode.

3.2 STAR FIX Mode

The NGC Sky Vector initially assumes that your equatorial telescope is properly polar aligned, in which case it is only necessary to sight a single star at the beginning of the observing session. Position the telescope so that a familiar bright star is centered in the eyepiece. Press ENTER and use the arrow buttons to scroll through the list of 28 stars until you find the name of the star that is in the eyepiece. Press the ENTER button again. The telescope is now aligned. Polar alignment is not required if you sight two stars. Choose a second star well separated from the first. The first star sighting should be at least 60° from the celestial pole, and the second star should be between 60° and 120° from the first star. You may use Polaris for the second star.

NOTE! German Equatorial mountings must have the encoder initialized with the declination axis set at the east of the meridian at zero declination. There are two zero settings, 0° on the western side of the meridian and 0° east of the meridian, on the declination axis. You must always use the same one.

For our example we will use Regulus, the bright star at the base of the backward question mark of Leo. In the STAR FIX mode the display will show the first star name in the list of 28 bright stars. The first star in the list is Achernar.

Achernar is first in the list: ALIGN ACHERNAR
Regulus selection : ALIGN REGULUS

We want to use the star Regulus for our first star sighting, so press down, and hold, the UP arrow button to advance through the list of star names. If you went past Regulus while scrolling, simply press the DOWN arrow button to back up. Release the button when the display reads "REGULUS." Verify that the star is still centered in the eyepiece and press the ENTER button to complete the alignment. The display will show the warp factor which is a measure of the amount of agreement (error in degrees) between the catalog angles and the measured angles between sighted stars. The acceptable range is $\pm 0.5^\circ$.

Warp factor: WARP=+ 0.1

Sighting a second star may improve accuracy, especially if there are any alignment errors in the polar mounting. After the first star sighting, simply press one of the arrow buttons to advance to another star name. To find Mizar, for example, press the UP arrow button until the display reads "MIZAR". Center Mizar in the eyepiece and press the ENTER button. The second star sighting is now complete. Press the MODE button to return to the mode selector.

Mizar selection : MIZAR
Warp factor: WARP=+ 0.2

Press the MODE button to chose the RA/DEC mode for display. NGC Sky Vector will now display the celestial coordinates for any telescope position. In our example the display now reads the coordinates for Mizar since that is where the telescope is currently pointed. The display reads "1323+545" which is a right ascension of 13 hours 23 minutes and declination of 54 degrees 50 minutes.

RA/DEC mode: RA = 1323+ DEC = +545

Swing the telescope around and observe how quickly the instrument tracks telescope position. The high resolution encoders are very sensitive to small motions. The instrument can track motions as great as 100° per second, which is faster than you would probably dare move a delicate optical instrument.

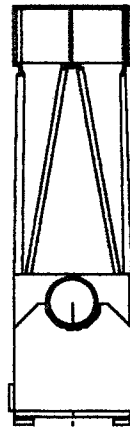
4.0 Two Star Alignment Operation for Altitude/Azimuth Mount

4.1 VERTICAL Reminder

When the instrument is turned on it will briefly display the startup message. The NGC Sky Vector will then display "VERTICAL". Position the telescope such that the optical axis is about vertical but **parallel** to the azimuth axis of rotation. A mechanical stop is very helpful for an accurate initialization. This operation initializes the altitude encode angle to 90°. This alignment must be carefully done as it will affect the accuracy of all subsequent operations. It is not important that the telescope base be leveled but only that the optical axis is parallel to the azimuth axis.

Vertical reminder:

VERTICAL

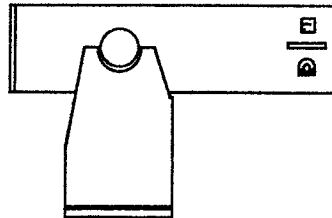


4.2 LEVEL ME Reminder

Alternatively the altitude encoder may be initialized to 0°. It will display the "LEVEL ME". Position the telescope such that the optical axis is **perpendicular** to both axes of rotation. For the Dobsonian this simply means leveling the tube. A mechanical stop or marks on the altitude bearings will help provide accurate operation. A carpenter's bubble level may be used the first time and a permanent mark placed on the altitude bearing for future use. Press the ENTER button to signal the completion of the level operation.

Level reminder:

LEVEL ME



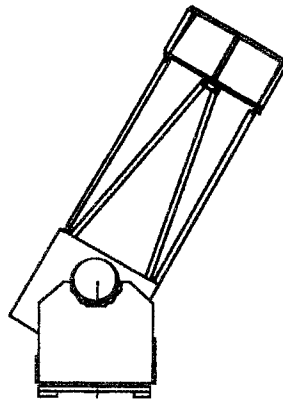
4.3 STAR FIX Operation

The STAR FIX mode is ready to use after the VERTICAL or LEVEL ME operations are complete. Find a bright star and center it in the eyepiece. Find the name of the star in the STAR FIX catalog using the arrow buttons to scroll through the list. Verify the star is still centered and press the ENTER button. A second star is needed, so find a second star (optimally 60° to 120° from the first star) and scroll through the list of star names again. Repeat the above steps for entering the second star fix. The warp factor is meaningful after the second star sighting. For best accuracy it should be in the range ± 0.5 . The telescope alignment is now completed.

STAR FIX mode: STAR FIX
beginning of list: ALIGN ACHERNAR

First star sighting:
first star choice: ALIGN MIZAR
meaningless warp factor: WARP=+47.5 (Ignore the warp factor for the first star)

Second star sighting:
second star choice: ALIGN SIRIUS
warp factor: WARP=+0.3



An altitude/azimuth telescope requires two star sightings at the beginning of an observing session before it can display right ascension and declination. **It is important that the altitude and azimuth axes be perpendicular to each other.**

SECTION 5.0 Equatorial Mount INSTALL

It is important to verify correct INSTALL parameters. Settings made in this mode are usually done only once, then remain correct for a given telescope. This one time operation stores the setup information in non-volatile memory.

5.1 INSTALL Mode

The INSTALL mode is used when the NGC Sky Vector is first installed on the telescope. The INSTALL tells the instrument the date, what kind of telescope you are using, the desired scroll rate, and the resolution or gear ratio of the encoders. You may return to the mode selector at any time by pressing MODE. Select INSTALL from the mode selector and press ENTER. Continue to press the ENTER button to set through the settings. To make a change to one of the parameters, simply use the UP and DOWN arrow buttons, then press ENTER to advance to the next item.

The order of the INSTALL procedure:

- | | |
|---------------------------------|------------|
| 1. today's date: | 03-16-1998 |
| 2. telescope mount | SCOPE EQ |
| 3. scroll rate: | SCROLL 5 |
| 4. chart number: | CHART 5A |
| 5. RA Encoder ratio display: | RA +8192 |
| 6. Declination encoder display: | DEC +4000 |

5.2 To Change Date

Select the install mode and press ENTER. The date is the first item in the INSTALL mode that is displayed. Use the UP/DOWN buttons to change the digits, then press ENTER to advance to the next digit. The instrument doesn't keep track of the current date when it is turned off, but it will remember the last date entered. After the date has been changed, press ENTER and the display will go the next item to be set. For historical planet positions you may enter any date from AD 0 to AD 2500.

- | | |
|---------------|------------|
| today's date: | 03-16-1998 |
| changed date: | 03-17-1998 |

5.3 To Select Type of Mount

The display will show the last type of telescope mount that was selected, and the letters will be blinking. To scroll through the choices of telescope mount, press the UP or DOWN button. After you have made a selection, press ENTER again and the instrument will make the change and go on to the next item to be set.

To change the type of mount, press arrow buttons to scroll through the choices. Press ENTER to set.

- | | |
|------------------------------------|----------|
| last mount selected: | SCOPE EF |
| change to EQ, equatorial mounting: | SCOPE EQ |

There are seven different types of telescope mounts to choose from. There are some computational differences between mounts, so it is important to make the appropriate selection.

Choices of telescope mount:

equatorial mount, perfect polar alignment (EP):	SCOPE	EP
GQ, german equatorial mounting:	SCOPE	GQ
GP, german equatorial mount, perfect polar alignment:	SCOPE	GP
AZ, Dobson mounting, horizontal initialization:	SCOPE	AZ
Dobson mounting, vertical initialization:	SCOPE	AV
Dobson, equatorial table:	SCOPE	ET
Equatorial mounting(includes Schmidt-Cass fork mount):	SCOPE	EQ

5.4 To Change The Display Scroll Rate

The scroll rate is the rate at which the characters advance horizontally across the display. This is most noticeable when the instrument is presenting the description for a catalog object. The speed of scrolling is a personal preference that varies with the individual, and the conditions of observing. The instrument comes set with a scroll rate of 5, which is a medium rate. There are 9 different scrolling speeds to choose from, where 9 is the fastest.

To change the scroll rate, press arrow buttons to select value. There are 9 scroll rates:

medium scroll rate:	SCROLL	5
faster scroll rate:	SCROLL	7
slower scroll rate:	SCROLL	3

Press ENTER again to go to the next step.

5.5 Selecting a Chart Number

The NGC Sky Vector database includes references to chart numbers in Wil Tirion's Sky Atlas 2000.0 and Uranometria 2000.0 by Tirion, Rappaport, and Lovi, volumes 1 and 2. The SETUP mode allows you to pick which sky atlas chart number you want the instrument to display during the object descriptions.

Atlas 2000 chart number:	CHART	SA
Uranometria chart number:	CHART	UA

Press ENTER again to go to the next step.

5.6 Equatorial Telescope Encoder Ratios

Many equatorial mountings will utilize gears to drive the optical encoders. This can increase resolution and make the installation more convenient. It is necessary to set the ratio of each encoder which is driven by gears. When standard resolution(2048 step) encoders are used with direct or 1:1 gear drive the encoder ratio should be 2048. The correct ratio for encoders is simply the number of pulses per revolution. For geared systems multiply the encoder pulses per revolution times the number of teeth of the gear on the shaft divided by the number of teeth of the gear on the encoder. The NGC Sky Vector can utilize standard (2048 step), high resolution (4000 step), or extra high resolution (8192) encoders. Most German equatorial mountings utilize gears to drive the optical encoders. The right ascension encoder is set first.

High resolution RA encoder: RA +4000

Next the declination encoder is set. For instance extra high resolution encoders would use a ratio of 8192.

Ex.high resolution Dec. encoder : DEC +8192

5.7 Encoder Direction Test for Equatorial Mount

Set the encoder ratio with both values as positive, "+" sign. The gears and orientation of the telescope can reverse the direction of motion. Changing the sign to either a "+" or a "-" will make the instrument respond in the opposite direction. To test the NGC Sky Vector for RA/DEC operation, turn on the instrument and orient the telescope to +0° declination. NGC Sky Vector will display "DEC =0". Press the MODE button. Select the ENCODER mode to display the encoder angles. The display should show "000 +000". Move the declination axis to approximately 60° north. The display should now show "000 +060" if the dec axis "sign" is correct. If it reads "000 -060", re-enter the gear ratio setup mode and change the sign to negative for the DEC axis.

To check the RA axis, re-enter the mode which displays the encoder angles as described for the DEC axis. Set the DEC axis to approximately +45°. Move the RA axis of the telescope in the direction of decreasing right ascension (for example, south to west, or clock-wise looking down at the telescope). The RA encoder angle should increase from 000°. If you rotate the telescope about 90 degrees and the left three display digits move in the correct direction, e.g. 090, the sign is correct. If not, e.g. 270, change the encoder ratio sign to a minus sign.

A problem can arise on some telescope mounts, such as the fork mount, where it possible to rotate the telescope 180° in both axes. This may confuse the computer under some situations. Simply reverse the rotations such that the RA knobs are on the observer's side.

The accuracy with which you can locate objects depends ultimately on how well the forks are aligned with the polar axis of the telescope. Check the geometric alignment of the telescope. Errors of this nature will show up as inconsistencies in locating objects in different parts of the sky .

SECTION 6.0 Altitude/Azimuth Mount INSTALL

It is important to verify correct INSTALL parameters. Settings made in this mode are usually done only once, then remain correct for a given telescope. This one time operation stores the install information in non-volatile memory.

6.1 INSTALL Mode

The INSTALL mode is used when the instrument is first installed on the telescope. The INSTALL tells the instrument the date, what kind of telescope you are using, the desired scroll rate, and the resolution or gear ratio of the encoders. You may return to the mode selector at any time by pressing MODE. Select INSTALL from the mode selector and press ENTER. Continue to press the ENTER button to set through the settings. To make a change to one of the parameters, simply use the UP and DOWN arrow buttons, then press ENTER to advance to the next item.

The order of the SETUP procedure:

- | | |
|-----------------------------------|------------|
| 1. today's date: | 03-16-1998 |
| 2. telescope mount | SCOPE EQ |
| 3. scroll rate: | SCROLL 5 |
| 4. chart number: | CHART SA |
| 5. Azimuth Encoder ratio display: | AZ +4000 |
| 6. Altitude encoder display: | AL +4000 |

6.2 To Change Date

Select the INSTALL mode and press ENTER. The date is the first item in the SETUP mode that is displayed. Use the UP/DOWN buttons to change the digits, then press ENTER to advance to the next digit. The instrument doesn't keep track of the current date when it is turned off, but it will remember the last date entered. After the date has been changed, press ENTER and the display will go the next item to be set. For historical planet positions you may enter any date from AD 0 to AD 2500.

- | | |
|---------------|------------|
| today's date: | 03-16-1998 |
| changed date: | 03-17-1998 |

6.3 To Select Type of Mount

The display will show the last type of telescope mount that was selected, and the letters will be blinking. To scroll through the choices of telescope mount, press the UP or DOWN button. After you have made a selection, press ENTER again and the instrument will make the change and go on to the next item to be set.

To change the type of mount, press arrow buttons to scroll through the choices. Press ENTER to set.

- | | |
|------------------------------------|----------|
| last mount selected: | SCOPE EF |
| change to AZ, equatorial mounting: | SCOPE AZ |

There are seven different types of telescope mounts to choose from. There are some computational differences between mounts, so it is important to make the appropriate selection.

Choices of telescope mount:

equatorial mount, perfect polar alignment (EP):	SCOPE	EP
GQ, german equatorial mounting:	SCOPE	GQ
GP, german equatorial mount, perfect polar alignment:	SCOPE	GP
AZ, Dobson mounting, horizontal initialization:	SCOPE	AZ
Dobson mounting, vertical initialization:	SCOPE	AV
Dobson, equatorial table:	SCOPE	ET
equatorial mounting (includes Schmidt-Cass fork mounts):	SCOPE	EQ

5.4 To Change The Display Scroll Rate

The scroll rate is the rate at which the characters advance horizontally across the display. This is most noticeable when the instrument is presenting the description for a catalog object. The speed of scrolling is a personal preference that varies with the individual, and the conditions of observing. The instrument comes set with a scroll rate of 5, which is a medium rate. There are 9 different scrolling speeds to choose from, where 9 is the fastest.

To change the scroll rate, press arrow buttons to select value. There are 9 scroll rates:

medium scroll rate:	SCROLL	5
faster scroll rate:	SCROLL	7
slower scroll rate:	SCROLL	3

Press ENTER again to go to the next step.

5.5 Selecting a Chart Number

The NGC Sky Vector database includes references to chart numbers in Wil Tirion's Sky Atlas 2000.0 and Uranometria 2000.0 by Tirion, Rappaport, and Lovi, volumes 1 and 2. The SETUP mode allows you to pick which sky atlas chart number you want the instrument to display during the object descriptions.

Atlas 2000 chart number:	CHART	SA
Uranometria chart number:	CHART	UA

Press ENTER again to go to the next step.

6.2 Altitude/Azimuth Telescope Mount Encoder Ratios

The Altitude Azimuth (Dobson) mounting utilizes direct drive optical encoders. The Azimuth encoder is set first. In the case of high resolution encoders use set to +4000. When extra high resolution encoders are used the effective encoder ratio is +8192. Adjust the blinking digit using the UP and DOWN buttons, when the digit is correctly set press ENTER to advance to the next digit.

Azimuth high resolution: AZ +4000 (LUMICON encoders are high resolution)

Next the altitude encoder is set. In the case of standard resolution encoders use set to +2048, high resolution encoders should use +4000. Adjust the blinking digit using the UP and DOWN buttons, when the digit is correctly set press ENTER to advance to the next digit.

Altitude high resolution: AL ++000

6.3 Encoder Direction Test for Altitude/Azimuth Mount

Set the encoder ratio with both values as positive, "+" sign. The side on which the altitude encoder is installed can reverse the encoder directional sense. Changing the sign to either a "+" or a "-" will make the instrument respond in the opposite direction.

To check Altitude/Azimuth telescope mounts, turn on the NGC Sky Vector and position the telescope as requested by the instrument. Select the ENCODER mode to display encoder angle and move the altitude axis down approximately 45° from vertical. Check that the display shows "000 +045". If the display is in agreement with the telescope position, then the altitude encoder polarity is correct and no change to the gear ratio setup is required. If not, use the setup mode to change the encoder ratio AL +/- sign.

Re-enter the mode for displaying encoder angles and move the telescope about the azimuth bearing from North towards East. The azimuth should increase from 0° to 90° if you rotate the telescope 90°. The display should now read "090 +045", where the 45° is from the test of the altitude axis. If not, then change the encoder ratio AZ +/- sign.

SECTION 7.0 Installation Problems

7.1 Encoder Cables

If the unit is not working correctly there are several installation items to check. If the RA and DEC do not change when the telescope is rotated, the encoder cables are most likely plugged in backwards. Make sure there is no binding on the cables and that the telescope moves freely without pulling on any of the encoder cables.

7.2 RA and DEC Coordinates

It is also possible that the star you had sighted in the eyepiece during the STAR FIX alignment procedure was not the same as the star displayed on the instrument readout. The warp factor will likely be large. If this is the case, turn the instrument off and on again, then proceed to mode STAR FIX and repeat the STAR FIX.

If the RA and DEC coordinates do not seem accurate, check the gear ratios in the INSTALL mode. The gear ratios entered in the INSTALL mode must be in agreement with the telescope mount on which the unit is installed.

A problem can arise on some telescope mounts, such as the fork mount, where it possible to rotate the telescope 180° in both axes. This may confuse the computer under some situations. Simply reverse the rotations such that the RA knobs are on the observer's side.

7.3 Low Battery

This is by far the most common operational problem with the instrument since many units are simply left on all night. A low battery condition will first appear as a message of erroneous encoder signal reception, and the display will show ENC ERR whenever there is a loss of signal. Other indications of a low battery condition might be a very dim display. A new 9 volt alkaline battery will last about 40 hours with the display at its lowest brightness level. **Alkaline batteries are required** as the instrument uses power in moderately high current pulses.

SECTION 8.0 Serial Computer Interface

8.1 Commands and format

The NGC Sky Vector can act as an interface between telescope and personal computer. It simply transmits the encoder angles at high resolution to your PC when requested. None of the complex transformations are performed, this is the "raw" data. It is expected that a PC can perform the transformations easily without introducing additional truncation error or delay. You can experiment with this function using a terminal program and manual typing the commands and moving the telescope.

You may write your own PC software, but LUMICON does not recommend it. To avoid difficulties, LUMICON highly recommends the software program "The Sky" available from Software Bisque as follows:

The Sky, Window I, 10,000 stars and deep-sky objects \$99.00

The Sky, Window II, 45,000 Stars and deep-sky objects \$129.00

The Sky, Window III, 272,000 stars and deep-sky objects \$199.00

In addition you will need to purchase a package with adapter cable, Link information and a disc with test software. This package costs about \$59.00, and is available from Software Bisque, 912 12th St., Suite A, Golden CO 80401; Ph. ~~303~~ 278 4428, FAX 303 278 0045 or 800-843-7599

Communication is RS232 serial ASCII at 9600 baud one stop bit no parity. The transmitter section uses the signal from the host computer for transmit power. Thus transmissions from the instrument may be garbled if the host transmits at the same time. The PC should wait for the response before sending additional commands.

There are only two one letter commands. The PC software must send a "Q" any time it needs to know the current position of the telescope. The "P" command will provide status information. The instrument initializes encoder angles to 000.0 and +090.0 when powered up. The telescope type will affect the initialization. If the telescope type is EP or GP star sightings will affect the encoder angles.

command: "Q" normal query

The response is in fixed format, two signed five digit numbers which correspond to the respective encoder angles. Encoder angles in the range of +180 to -180 are represented by values in the range of +16383 to -16384. Thus 90° is +8192.

response :

data:	azimuth	altitude
format:	±00000<tab>±00000<cr>	
example:	+01234	-00123

command: "P" status check

The "P" command provides a three digit status number, first digit is number of altitude encoder errors, second is the number of azimuth encoder errors, third is 0 for low battery and 1 for ok battery.

response :

format:	000 <cr>
example:	021

8.2 Serial Cable

Only four wires are required for the serial interface. Your PC may require other signals that are usually tied high or low. You will need to make a 6 position 4 pin modular connector. This is the same kind of connector on the line side of your telephone. This type of connector and an appropriate crimper is available at Radio Shack and other consumer electronics outlets.

The connections are listed in the order that they would appear with the gold contacts of the male connector facing toward you. Standard 4 conductor modular wire is recommended. The colors are for standard modular wire.

nc		no connection
+12 VDC	black	external power, optional
gnd	red	signal ground
RX	green	receive data
TX	yellow	transmit data
nc		no connection

The instrument may be powered by 6 to 28 volts DC using the communications connector. The input power is diode isolated and thus if it is at a lower voltage than the internal battery the battery will become discharged. The typical power consumption is only 18 ma.

SECTION 9.0 NGC Sky Vector Specifications

Dimensions	3.6 x 5.8 x 1.3
Weight	8 ounces, including 9v battery
Operating Temperature Range	-10°C to +50°C
Telescope mounting types	Equatorial Altitude/Azimuth (Dobsonian)
Display	Light emitting diode (LED), red color, 16 character alphanumeric
Display Dimming	5 step pushbutton dimming dimming range 10:1 from full bright to full dimmed.
Display Resolution	0.1m right ascension, 0.01 degree declination 0.01° in guide mode
Display Modes	STAR FIX function, alignment mode that uses short star list RA DEC function, right ascension and declination CATALOG, complete database of celestial objects from 7 sources GUIDE function, displays steering coordinates to object IDENTIFY function, compares target with database to find identity ALIGN function, alignment mode that uses complete catalog TIMER function, elapsed timer with start, stop, reset ENCODER function, shows encoder angles INSTALL, telescope installation setup
Database	Star catalog of 837 stars Complete list of 110 Messier objects NGC catalog of 7,840 objects IC catalog (141 selections) Non-stellar catalog of 778 objects Catalog of 306 planetary nebulae not in NGC or IC catalogues ESO Catalogue (1244 selections) UGC Catalogue (1026 selections) NEW catalog, a user defineable list of up to 27 objects Planets catalog - Select today's date or any date from AD 0 to AD 2500. Alignment star list of 28 bright, navigational stars Descriptions include magnitude, size, constellation, name, type, and chart Reference to Sky Atlas 2000.0 or Uranometria, Vol. 1 & 2, chart number
Equatorial Setup	Star based on 1 or 2 star sightings, polar alignment not required.
Alt/Azimuth Setup	Latitude, longitude, date, and time not required for alignment. Requires 2 star alignment and orthogonal positioning of encoder axes. No input for latitude, longitude, date, or time required for alignment.
Customization	Retained without electrical power in non-volatile memory
Coordinate Epoch	AD 2000
Sensing Method	Optical encoders, quadrature
Encoder Resolution	high resolution 4000 step, 0.09° encoders(supplied with all LUMICON Sky Vectors as standard equipment) extra high resolution, 8192 step, 0.04 degree encoders standard resolution 2048 step, 0.17° encoders
Sampling Rate	0.2 millisecond
Maximum Slew Rate	360° per second (high resolution)
Encoder gearing	any number of steps per revolution from 1000 to 10,000
Angle representation	16 bits
Vector representation	48 bits
Sidereal Clock accuracy	0.05 %
Power Requirements	5.1 to 12 volts DC 17 mA, display fully dimmed, typical 48 mA, display maximum brightness, typical Reverse polarity protected
Battery Recommended	Duracell, 9 volt alkaline 1604 battery
Battery Life	may be operated on external 12 VDC power supply 35 hours with display fully dimmed

SECTION 10.0 The ALIGN STAR Star List

The ALIGN STAR mode contains a short list of 28 bright navigational stars which make the initial star alignment operation go very quickly. Objects from the other catalogs may also be used using the ALIGN mode. This short star list is arranged in alphabetical order by common name.

name	greek	con	h m s	° ' "	V	type
Achernar	alpha	Eri	1 37 42.9	-57 14 12	0.5	star
Albireo	beta	Cyg	19 30 43.1	27 57 35	3.1	dbl col
Aldebaran	alpha	Tau	4 35 55.2	16 30 33	0.9	dbl red
Alphard	alpha	Hya	9 27 35.2	-8 39 31	2.0	star
Alpha Centari	alpha	Cen	14 39 36.7	-60 50 02	0.0	dbl
Alpheratz	alpha	And	0 08 23.2	29 05 26	2.1	star
Altair	alpha	Aql	19 50 46.8	8 52 06	0.8	star
Antares	alpha	Sco	16 29 24.3	-26 25 5	1.0	dbl red
Arcturus	alpha	Boo	14 15 39.6	19 10 57	0.0	star
Betelgeuse	alpha	Ori	5 55 10.2	7 24 26	0.1	red
Canopus	alpha	Car	6 23 57.1	-52 41 44	-0.7	star
Capella	alpha	Aur	5 16 41.3	45 59 53	0.1	star
Castor	alpha	Gem	7 34 35.9	31 53 18	1.6	dbl
Deneb	alpha	Cyg	20 41 25.8	45 16 49	1.3	star
Denebola	beta	Leo	11 49 03.5	14 34 19	2.1	dbl col
Fomalhaut	alpha	PsA	22 57 38.9	-29 37 20	1.2	star
Mirfak	alpha	Per	3 24 19.3	49 51 40	1.8	star
Mizar	zeta	UMa	13 23 55.5	54 55 31	2.3	dbl
Navi	gamma	Cas	0 56 42.4	60 43 00	2.5	dbl
Polaris	alpha	UMi	2 31 50.4	89 15 51	2.0	dbl
Procyon	alpha	CMi	7 39 18.1	5 13 30	0.4	star
Rasalhague	alpha	Oph	17 34 55.9	12 33 36	2.1	star
Regulus	alpha	Leo	10 08 22.2	11 58 02	1.4	dbl
Rigel	beta	Ori	5 14 32.2	-8 12 06	0.1	dbl
Sirius	alpha	CMa	6 45 08.9	-16 42 58	-1.5	dbl
Spica	alpha	Vir	13 25 11.5	-11 09 41	1.0	star
Suhail	lambda	Vel	9 07 59.7	-43 25 57	2.2	star
Vega	alpha	Lyr	18 36 56.2	38 47 01	0.0	mpl

LONG WIRE IS DEC
SHORT WIRE IS RA