CN Systems

ASTRO-NAVIGATION
DEAD RECKONING
ROUTE PLANNING

CN-2000 MODULE

+ SHARP

PC-1500 & PC-1500 A
POCKET COMPUTERS

Star List

NAME	NO.	MAG	SHA °	DEC °
ACAMAR	7	3.1	316	S 40
ACHERNAR	5	0.6	336	S 57
ACRUX	30	1.1	174	S 63
ADHARA	19	1.6	255	S 29
ALDEBARAN	10	1.1	291	N 16
ALIOTH	32	1.7	167	N 56
ALKAID	34	1.9	153	N 49
AL NA,IR	55	2.2	28	S 47
ALNILAM	15	1.8	276	S 1
ALPHARD	25	2.2	218	S 9
ALPHECCA	41	2.3	126	N 27
ALPHERATZ	1	2.2	358	N 29
ALTAIR	51	0.9	62	N 9
ANKAA	2	2.4	354	S 42
ANTARES	42	1.2	113	S 26
ARCTURUS	37	0.2	146	N 19
ATRIA	43	1.9	108	S 69
AVIOR	22	1.7	234	S 59
BELLATRIX	13	1.7	279	N 6
BETELGEUSE	16	0.1/1.2	271	N 7
CANOPUS	17	-0.9	264	S 53
CAPELLA	12	0.2	281	N 46
DENEB	53	1.3	50	N 45
DENEBOLA	28	2.2	183	N 15
DIPHDA	4	2.2	349	S 18
DUBHE	27	2.0	194	N 62
ELNATH	14	1.8	279	N 29
ELTANIN	47	2.4	91	N 51
ENIF	54	2.5	34	N 10
FOMALHAUT	56	1.3	16	S 30
GACRUX	31	1.6	172	S 57
GIENAH	29	2.8	176	S 17
HADAR	35	0.9	149	S 60
HAMAL	6	2.2	328	N 23
JUPITER	60			

NAME	NO.	MAG	SHA °	DEC °
KAUS AUST	48	2.0	84	S 34
KOCHAB	40	2.2	137	N 74
MARKAB	57	2.6	14	N 15
MARS	59			
MENKAR	8	2.8	315	N 4
MENKENT	36	2.3	149	S 36
MIAPLACIDUS	24	1.8	222	S 70
MIRFAK	9	1.9	309	N 50
MOONC	66			
MOONLL	65			
MOONUL	67			
NUNKI	50	2.1	76	S 26
PEACOCK	52	2.1	54	S 57
POLARIS	0	2.1	326	N 89
POLLUX	21	1.2	244	N 28
PROCYON	20	0.5	245	N 5
RASALHAGUE	46	2.1	96	N 13
REGULUS	26	1.3	208	N 12
RIGEL	11	0.3	282	S 8
RIGIL KENT	38	0.1	140	S 61
SABIK	44	2.6	103	S 16
SATURN	61			
SCHEDAR	3	2.5	350	N 56
SHAULA	45	1.7	97	S 37
SIRIUS	18	-1.6	259	S 17
SPICA	33	1.2	159	S 11
SUHAIL	23	2.2	223	S 43
SUNC	63			
SUNLL	62			
SUNUL	64			
TRANSFER	68			
VEGA	49	0.1	81	N 39
VENUS	58			
ZUBEN,UBI	39	2.9	137	S 16

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Program Construction

The CN-2000 Program is divided into sections, each of which may be accessed independently. To invoke any of the above sections press DEF and the appropriate key. If a prompt message appears in the display, the data is keyed in using the format given in the prompt message. The computer will not accept data whilst it is calculating as indicated by a BUSY sign in the display.

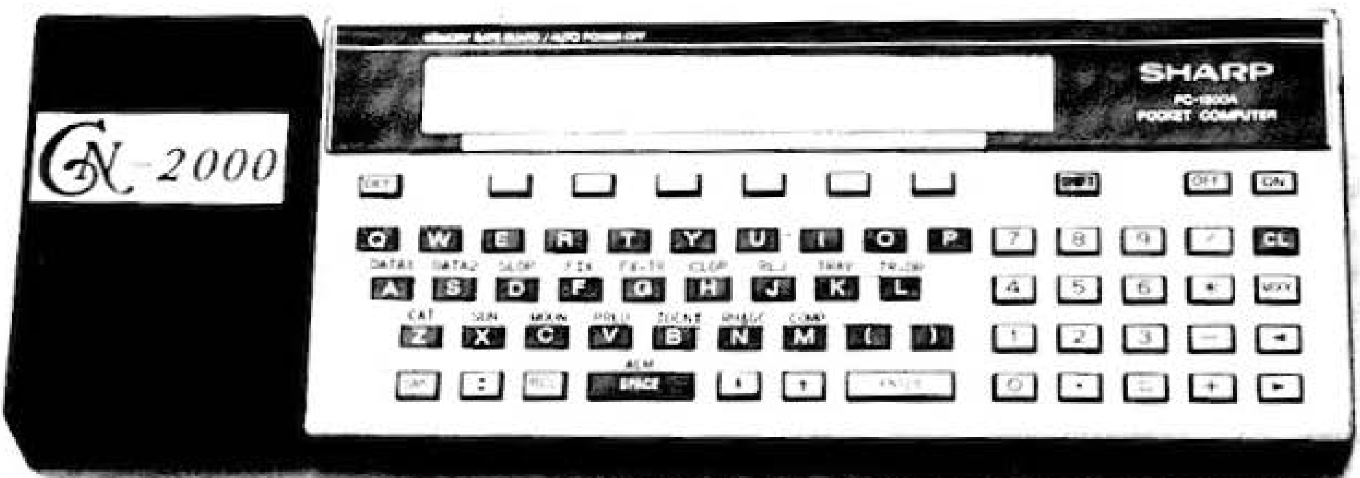
Output is prefixed by a descriptive label in the display or on the printed record. If the printer is not being used two courses of action are open. You may press ENTER to advance to the next stage in the section or you may transfer to another section by pressing DEF and the section key. The latter option is called branching. It is a feature of the CN-2000 Program that you are never "locked-in" to a particular section. You may branch at any time to another section.

The CN-2000 Module is compatible with these pocket computers:

Sharp PC-1500
Sharp PC-1500A
Tandy PC-2

Catalogue

CATALOGUE
0 POLARIS 2.1
1 ALPHERATZ 2.2
2 ANKAA 2.4
3 SCHEDAR 2.5
4 DIPHDA 2.2
5 ACHERNAR 0.6
6 HAMAL 2.2
7 ACAMAR 3.1
8 MENKAR 2.8
9 MIRFAK 1.9
10 ALDEBARAN 1.1
11 RIGEL 0.3
12 CAPELLA 0.2
13 BELLATRIX 1.7
14 ELNATH 1.8
15 ALNILAM 1.8
16 BETELGEUSE VAR
17 CANOPUS -0.9
18 SIRIUS -1.6
19 ADHARA 1.6
20 PROCYON 0.5
21 POLLUX 1.2
22 AVIOR 1.7
23 SUHAIL 2.2
24 MIAPLACIDUS 1.8
25 ALPHARD 2.2
26 REGULUS 1.3
27 DUBHE 2.0
28 DENEBOLA 2.2
29 GIENAH 2.8
30 ACRUX 1.1
31 GACRUX 1.6
32 ALIOTH 1.7
33 SPICA 1.2
34 ALKAID 1.9
35 HADAR 0.9
36 MENKENT 2.3
37 ARCTURUS 0.2
38 RIGIL KENT 0.1
39 ZUBEN,UBI 2.9
40 KOCHAB 2.2
41 ALPHECCA 2.3
42 ANTARES 1.2
43 ATRIA 1.9
44 SABIK 2.6
45 SHAULA 1.7
46 RASALHAGUE 2.1
47 ELTANIN 2.4
48 KAÙS AUST 2.0
49 VEGA 0.1
50 NUNKI 2.1
51 ALTAIR 0.9
52 PEACOCK 2.1
53 DENEB 1.3
54 ENIF 2.5
55 AL NA,IR 2.2
56 FOMALHAUT 1.3
57 MARKAB 2.6
58 VENUS
59 MARS
60 JUPITER
61 SATURN
62 SUNLL
63 SUNC
64 SUNUL
65 MOONLL
66 MOONC
67 MOONUL
68 TRANSFER



CN systems

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General description

The CN-2000 program for use with SHARP PC-1500 and PC-1500A Computers will provide data and solutions for all the practical problems which arise in astro-navigation and route planning. No almanac is required as all the astronomical data is generated by the program with an accuracy of +/-0.2'. The user may choose from a catalogue of 58 bright stars including Polaris, the Sun and Moon, and the four navigational planets, Venus, Mars, Jupiter and Saturn.

The timing of sights may be made automatically using the computer's internal clock. Corrections such as refraction, height of eye, semi-diameter, parallax etc. are automatically applied. Up to 40 sights may be reduced (Azimuth and Intercept) and the observer's position computed without any plotting. No averages of times and altitudes need be taken as individual sights can be processed. Thus mistakes or poor observations which may be concealed in averages are discovered and eliminated. In addition, the error of every sight is computed to provide a check on the quality of the position fix.

The program is completely self-contained in that prompt statements for data remind the operator of the format of the input. Sections on Planning (Prediction, Rise, Set etc. of the Sun and Moon), Identification etc. enable the navigator to plan, reduce and assess the quality of observations without the need of tables, graphs and almanacs.

Dead Reckoning (Traverse and Rhumb Line Calculations), Great Circle and Composite Sailing sections will assist in route planning, checking course plotting, navigating in high latitudes etc.

The navigator also has the choice of printing all the input and output of the program - an invaluable record for later reference.

Program Initialisation

SWITCH THE COMPUTER OFF BEFORE CONNECTING OR DISCONNECTING A PROGRAM MODULE. FAILURE TO DO SO MAY RESULT IN DAMAGE TO THE MODULE

1 Remove any program module from the computer module box.
2 Connect the NC-2000 module to the port at the left end of the computer or, if the computer is attached to the printer, connect the module to the port at the rear of the printer.
3 Switch the computer on. A message NEW0: CHECK? will appear in the display. Press CL, type NEW0 (figure zero not letter O) and press ENTER.
4 Press MODE (this will switch the computer from the PRO to the RUN mode).
5 Press DEF and then = (the equals key). The word BUSY will appear in the display for a few seconds, and then the prompt arrow will appear, indicating that the CN-2000 program is ready for use.

Program Execution

The program is to be executed in the RUN mode. Make sure that DEG also appears in the display. If it does not, type DEGREE and press ENTER.

Each section of the program is accessed by pressing DEF and then the appropriate letter key (A, S, D, F, etc.).

If whilst entering data a wrong value is keyed in, and provided ENTER has not been pressed, the correct data may be entered after pressing CL.

Basic Data

It is usual to start operations by keying in or reviewing BASIC DATA which consists of 13 items arranged in two sections labelled DATA 1 and DATA 2 and accessed by DEF A or DEF S. If only some items are to be entered or reviewed you can start at either DATA 1 or DATA 2, whichever is the quicker point of access. Note that the end of DATA 1 runs into the beginning of DATA 2.

DEF A
Prompt: PRINTER Y/N
You now choose whether you wish to print or display the input and output of the program. If your printer is connected you may enter Y(es) or (N)o but if the printer is not connected you must enter N. When you have made your choice and you do not wish to change it, simply press ENTER whenever the prompt PRINTER Y/N appears. This process, called skipping, is a feature of many sections of the CN-2000 program.

EXAMPLE: If your printer is attached, type Y, if not type N.

Prompt: UNITS M/F
You must now select, by entering M(etres) or F(eet) the units of length you wish to use when the Height of Eye is input later in the program. Once the units are selected all subsequent Heights of Eye will be calculated in those units until you change your selection. As in the previous section you may skip if you do not wish to change whatever has already been entered.

EXAMPLE: Type M and press ENTER.

Prompt: YEAR YYYY
Enter the year of observation. If you do not wish to change a previously entered value of the year, press ENTER and skip past this request. Now the stored value will be displayed (or printed) for you to check and a further pressing of ENTER allows you to proceed to the next data input. This latter process is called reviewing. Both skipping and reviewing may be used throughout the BASIC DATA section of the CN-2000 program.

EXAMPLE: Type 1985 and press ENTER.

Prompt: MONTH MMM
Enter the first three letters of the month of the year.

EXAMPLE: Type JAN and press ENTER.

Prompt: DAY DD
Enter the day of the month.

EXAMPLE: Type 7 and press ENTER.

WARNING - The CN-2000 program is designed to be used for any date between 1 March 1900 and 31 December 2099. Dates outside this range or impossible dates such as 29 February 1985 may produce incorrect results.

Prompt: WATCH ERROR F/SHH.MMSS
The error of the watch being used is input. E.g. F(ast) 1m 21s is input F.0121 or F0.0121.

When watch times or times taken from the computer's internal clock are entered later, this Watch Error is automatically applied. If the watch or clock being used is keeping correct time the input is a zero. In this case a preceding F or S is unnecessary.

EXAMPLE: Type F.0009 and press ENTER.

Prompt: TIME ZONE E/WHH.MM
The Time Zone, E(ast) or (W)est of the Greenwich Meridian, expressed in hours (and 30 minutes for half Zones) is entered. Standard Times, or Watch Times corrected for Watch Error, used in the program refer to this Time Zone. If GMT is being used a zero is to be entered and the prefix E or W may be omitted.

EXAMPLE: Type E11 and press ENTER. (The ship was keeping Australian Eastern Summer Time.)

The CN-2000 program now advances automatically into the second part of the BASIC DATA section (DATA 2).

DEF S
Prompt: LAT N/SDDMM.M
Just before this prompt appears in the display the additional prompt of DR is seen momentarily, reminding you that the Dead Reckoning Position is now required. Enter the latitude in the format N(orth) or S(outh) and then the degrees, minutes, decimal point and decimal minutes. A zero value without a preceding N of S is valid for an observer at the equator.

EXAMPLE: Type S3350.0 and press ENTER.

Prompt: LON E/WDDDMM.M
Enter the longitude in the format E(ast) or W(est) followed by degrees, minutes, decimal point and decimal minutes. As with latitude a zero value without a preceding letter is valid (observer on the Greenwich Meridian).

EXAMPLE: Type E15118.0 and press ENTER.

Prompt: COURSE(T) DDD.D
The course of the vessel during the period of celestial observations is entered. The True Course, not Magnetic, is required.

EXAMPLE: Type 108 and press ENTER.

Prompt: SPEED KK.K.
The speed in knots of the vessel whilst on the given course is now entered.

EXAMPLE: Type 9 and press ENTER.

Prompt: H OF E LL.L
The Height of Eye, in the units of length specified at the start of the BASIC DATA section, is now entered. After this entry the display will momentarily echo the chosen units. The printed output gives the Height of Eye and the units.

EXAMPLE: Type 3.1 and press ENTER.

Prompt: SEXT CORR +/-DDMM.M
The Sextant Correction (the correction to be applied to the observed altitude) is now entered. If the correction is negative the value must be prefixed by a minus sign but, if the correction is positive, a plus sign is optional.

EXAMPLE: Type 0 and press ENTER.

If you have entered the data as suggested in the previous Examples your printout should be identical with that shown below. If you are not using a printer, skip through and review the data in DEF A and DEF S (DATA 1 and DATA 2) and compare it also with the printout.

```
YEAR              1985
MONTH              JAN
DAY                  7
WATCH ERR F  0.0009
TIME ZONE     E11.00

DR
LAT            S3350.0
LON           E15118.0
COURSE(T)        108.0
SPEED              9.0
H OF E METRES      3.1
SEXT COR           0.0
```

NOTE: All the above data is stored permanently in the computer until new values are entered which overwrite the old ones.

The Table on page 5 summarises the BASIC DATA required for the various sections of the CN-2000 program.

Catalogue

DEF Z

The catalogue of 58 stars, 4 planets, the Sun and Moon (lower limb, centre and upper limb) may be accessed in one of three ways.

1 Enter the body number (prompt: BODY NO) and the response will be Number, Name and Magnitude of the star or Number and Name of the planet or Number, Name (including Limb) of the Sun or Moon. To continue, press ENTER and a prompt for another body number will be displayed.

2 If the body number is not known then skip the prompt BODY NO and the prompt BODY NAME will appear. If the name of the body is entered the response will be the same as 1 above. If the name is incorrectly entered the response NOT FOUND will be displayed after the catalogue has been searched.

It is not necessary to enter the full name of the body but only sufficient letters to uniquely identify it. For example the letters SI would be sufficient to identify SIRIUS. However the letters VE would result in the information for VEGA being given because the search routine finds VEGA before VENUS.

3 If the entire catalogue is required, skip through the prompts BODY NO and BODY NAME and the complete list of bodies is then output.

EXAMPLE: Access the program by pressing DEF and Z and skip through the prompts BODY NO and BODY NAME.

A printout of the CATALOGUE faces the Contents (Program Constuction) page.

Sun

DEF X

The data required for this section is shown in the Table on page 5. The results from this section will be found to be almost identical with those interpolated from the Nautical Almanac. All values given are for an observer at sea level with a clear horizon.

The Standard Time of upper transit (Meridian Passage) of the Sun is given first. Then the times of rise, morning civil and nautical twilight are given, followed by times of set etc.

Morning and afternoon azimuths are calculated for the instant when the Sun's centre appears to be level with the horizon. Rise and set is when the Sun's upper limb is seen to be touching the visible horizon.

In high latitudes the Sun may remain above the horizon for the whole of the day, in which case the the message ABOVE HOR is displayed or printed. If the Sun does not rise above an altitude of -12° the message NO PHENOM is displayed or printed. In intermediate cases when the Sun remains above altitude -6° or -12° (i.e. Civil or Nautical Twilight last all night) the additional message ALL NIGHT is displayed or printed.

EXAMPLE: Access the program by pressing DEF and X and press ENTER. The program will use the data entered in the previous Examples. The printed output is shown below.

```
SUN
TRANS     13.0057
RISE         5.52
AZ          117.7
CIV TW       5.23
NAU TW       4.48
SET         20.10
AZ          242.3
CIV TW      20.38
NAU TW      21.14
```

Moon

DEF C

The data required for this section is the same as for the Sun (see Table on page 5). The first output is the Moon's age in days, which is a measure of the elapsed time since new Moon. The time interval between new Moons is a synodical month (about 29.5 days). The times of upper and lower transit, rising and setting are then given in the order in which they occur.

In high latitudes, as with the Sun, the Moon may remain above or below the horizon for the whole of the day in which case the message ABOVE HOR or BELOW HOR is displayed or printed.

EXAMPLE: Access the program by pressing DEF and C and press ENTER. The output, based on the data entered in the previous Examples, is shown below.

Note that the calculations for the Moon are long and complicated - the total processing time is between 3 and 4 minutes. During the time the computer is calculating the BUSY symbol will appear in the display.

```
MOON
AGE              14
UPPER TRANS    0.33
SET            5.25
LOWER TRANS   13.02
RISE          20.37
```

Prediction

DEF V

Prompt: STD TIME HH.MMSS

The Table on this page shows the data required for this section.

The Standard Time at which the positions of celestial bodies are required for the planning of an observational program is keyed in. At first the LHA of the First Point of Aries is output. This may be of particular value if you wish to set a planisphere or star globe to see the approximate positions of bodies.

EXAMPLE: Type 20.38 and press ENTER. After a few seconds the computer will display or print LHA ARIES 4241.8 (i.e. 42°41'.8).

Prompt: LOWEST ALT DD

If you wish to limit the altitude range of bodies to be listed use this and the next prompt.

EXAMPLE: Type 25 and press ENTER. (You have elected to reject low altitude sights i.e. sights lower than 25°).

Prompt: HIGHEST ALT DD

This allows you to choose the highest altitude you wish to output.

EXAMPLE: Type 70 and press ENTER. (You have chosen to eliminate high altitude sights i.e. sights higher than 70°.)

Note that for both these prompts, degrees only are required (DD). The input of DDMM.M - degrees, minutes and decimals of minutes will result in a false output.

If you wish to predict all bodies that are above the horizon, skip through the above two prompts and the default values of 0° and 90° will be adopted automatically by the program.

Prompt: BODY NUMBER

If a Body Number is entered the output will be the body number, name, magnitude (if

TABLE - BASIC DATA REQUIRED FOR USE IN OTHER SECTIONS

BASIC DATA	SECTION					
	LOP	PRED	IDENT	SUN	MOON	ALM
DATE	YES	YES	YES	YES	YES	YES
WATCH ERROR	YES		YES			
TIME ZONE	YES	YES	YES	YES	YES	YES
DR POSITION	YES	YES	YES	YES	YES	YES*
COURSE & SPEED	YES					
HEIGHT OF EYE	YES	YES	YES			
SEXTANT CORR'N	YES	YES	YES			

* Required for the calculation of the Moon's co-ordinates.

appropriate), azimuth and altitude. The CN-2000 program will then be ready to accept another body number.

If you wish to predict positions for all the bodies in the catalogue, then skip past the prompt BODY NO and the catalogue will be searched for all available bodies in the chosen altitude range.

EXAMPLE: Skip past the Prompt BODY NO. Part of the printed output is shown below.

```
PREDICTION
STD TIME    20.3800
LHA ARIES    4241.8
LOWEST ALT       25
HIGHEST ALT      70

2 ANKAA 2.4
AZ            242.3
ALT          6029.2

4 DIPHDA 2.2
AZ            290.7
ALT          5727.8

5 ACHERNAR 0.6
AZ            202.3
ALT          6328.1

6 HAMAL 2.2
AZ            347.9
ALT          3152.9

8 MENKAR 2.8
AZ              4.3
ALT          5206.9

10 ALDEBARAN 1.1
AZ             30.5
ALT          3357.7

11 RIGEL 0.3
AZ             60.4
ALT          4822.5

13 BELLATRIX 1.7
AZ             49.5
ALT          3555.5
```

NOTE: If you request information for a body that is outside the chosen range of altitudes, the message OUT OF RANGE together with the body number will be displayed momentarily. The CN-2000 prediction program will only list bodies which are above the horizon.

The prediction routine may be used to advantage when an unknown body has been observed and it cannot be identified using the IDENTIFICATION section (see page 7) because the azimuth at the time of observation is not known. The catalogue is searched using a range between the lowest and highest altitude restricted to a "window" of (say) 1° or 2°, depending on the accuracy of the DR position. The output will be the azimuths and altitudes of all the bodies in the chosen altitude range.

EXAMPLE: At 20h34m you observed a bright body to have a sextant altitude of 38°54'. No azimuth was taken and subsequently you were unsure of the identity of the body. To identify it, access the PREDICTION section, enter 20.34 as the STD TIME, 38 as the LOWEST ALT and 40 as the HIGHEST ALT. Skip through BODY NO. The computer will search the catalogue and output:

```
PREDICTION
STD TIME    20.3400
LHA ARIES    4141.7
LOWEST ALT       38
HIGHEST ALT      40

15 ALNILAM 1.8
AZ             59.5
ALT          3855.3
```

Almanac

DEF SPACE

The data required for this section is shown in the Table on page 5. The first prompt is for a Standard Time. The output is the LHA of the First Point of Aries. Then a BODY NO is called for. The output is the SHA, DEC and LHA of the chosen body. If the body is either the Sun or Moon, the semi-diameter correction which is found in most almanacs is given together with its appropriate sign. In addition, for the Moon, the value of horizontal parallax is output.

As with the Prediction section, skipping the prompt BODY NO will result in the ouptut of data for the whole catalogue.

EXAMPLE: You wish to print the Almanac for 20h38m, 7 Jan 1985, for DR position S33°50' E151°18', Time Zone E11. If you have completed the previous Examples the Basic Data will reside in the computer. Otherwise you will have to enter it now.

Access the program by pressing DEF SPACE. On the prompt STD TIME, input 20.38. Skip through the prompt BODY NO and the entire Almanac will be calculated and output. Part of the output is shown below:

```
ALMANAC
STD TIME    20.3800
LHA ARIES    4241.8

0 POLARIS 2.1
SHA         32555.5
DEC         N8912.1
LHA           837.3

1 ALPHERATZ 2.2
SHA         35806.2
DEC         N2900.5
LHA          4048.0

2 ANKAA 2.4
SHA         35337.0
DEC         S4223.6
LHA          3618.9

3 SCHEDAR 2.5
SHA         35005.7
DEC         N5627.5
LHA          3247.5

4 DIPHDA 2.2
SHA         34917.7
DEC         S1804.3
LHA          3159.5

5 ACHERNAR 0.6
SHA         33542.6
DEC         S5719.1
LHA          1824.4

6 HAMAL 2.2
SHA         32825.3
DEC         N2323.6
LHA          1107.1
```

A NOTE on page 16 (see ACCURACY) shows how to compare the CN-2000 Almanac with the Nautical Almanac (N.P. 314).

Identification

DEF B

The data required for this section is shown in the Table on page 5.

Prompt: WATCH TIME HH.MMSS. Input the time. The next prompts are for sextant altitude SEXT ALT DDMM.M and azimuth (true bearing) AZ DDD.D. The output is the SHA and DEC of the body.

This section will be used mainly for calculating the co-ordinates of bodies which were not identified at the time of observation. If it is suspected that a star has been observed, the calculated co-ordinates may be compared with those in the Star Index (inside front and back covers). Otherwise the co-ordinates of the planets are generated using the ALMANAC section and a further comparison made.

EXAMPLE: Identify the body which had a sextant altitude of 38°54' and an approximate true bearing of 60°. The time of the observation was 20h34m on 7 Jan 1985, the DR position and Time Zone being those which have already been entered for the previous Examples. Access the program by DEF B and, on the prompt STD TIME, enter 20.34. For SEXT ALT enter 3854 and AZ enter 60. The output will be:

```
IDENTIFICATION
WATCH TIME 20.3400
SEXT ALT     3854.0
AZ             60.0
SHA         27553.9
DEC         S 127.6
```

Consult the Star Index. Alnilam (SHA 276° Dec S1°) is the only star which fits.

If the azimuth of the body is not known, the body may still be identified by using the PREDICTION section - see the Example on page 6.

Traverse

DEF K

The prompts LAT N/SDDMM.M and LON E/WDDDMM.M call for the initial co-ordinates of the traverse. These values are retained in the computer at all times until changed by entering or calculating new ones. If the stored values are required as starting co-ordinates of the traverse, this input may be skipped. The true Mercator course and distance (prompts COURSE(T) DDD.D and DIST MMMM.M) are entered and the latitude and longitude of the new position is displayed or printed. Pressing ENTER will prompt for a new course and distance etc.

EXAMPLE: A vessel, starting from S33°50' E151°18', steamed on a course of 100°T for a distance of 7.5 miles and then changed course to 108°T and steamed a further 49.8 miles. What was her DR position at the end of these runs?

Access the program by DEF K and process the information. Check your results with the printout below.

```
TRAVERSE
LAT          S3350.0
LON         E15118.0

COURSE(T)      100.0
DIST             7.5
LAT          S3351.3
LON         E15126.9

COURSE(T)      108.0
DIST            49.8
LAT          S3406.7
LON         E15223.8
```

Traverse → DR

DEF L

Frequently in the practice of navigation the final traverse co-ordinates are used as the DR co-ordinates for sight reduction. This can be performed simply by pressing DEF L. The message TRAV -> DR appears momentarily in the display to show that the co-ordinates have been transferred. If the printer is connected the message is printed as well.

EXAMPLE: If you have completed the previous Example, the TRAVERSE section should now contain the co-ordinates S3406.7 E15223.8. Press DEF L. The co-ordinates will be entered into the DATA 2 section. You may press DEF S and skip through the LAT and LON prompts to confirm that the DR position from the Traverse calculation has been transferred to the Basic Data section. Note that the initial co-ordinates in the TRAVERSE section remain unchanged.

Sight Reduction (SLOP)

It is usual to start operations by keying in or reviewing the DATA 1 and DATA 2 sections (DEF A and DEF S). If you have followed the Examples so far your Basic Data should be as shown on page 3 except that the DR co-ordinates (as derived from the TRAVERSE section) will now be S3406.7 E15223.8.

DEF D

This section is labelled SLOP which is short for Start Line of Position Calculations.

Sight reduction commences with the message OBS NO 1 appearing momentarily in the display followed by the prompt BODY NO. Immediately after the Body Number has been entered, the name of the body appears momentarily in the display and, if the printer is connected, the body name and number are printed. If the printer is not connected, it will be neccessary to press ENTER after each result is output.

For all bodies except transfers a watch time of observation and an observed sextant angle are called for. After this information has been entered the calculated azimuth and intercept, prefixed by T(oward) or A(way), are printed. The computer then momentarily displays the message OBS NO 2 and prompts for another BODY NO. If another observation has been made on the same body the input may be skipped. The procedure is repeated until all observational data is processed. Up to 40 sights may be reduced.

Occasionally it may happen during the course of entering a number of observations that a wrong body number or watch time etc. has been entered. Provided the value of the sextant altitude has not been entered, the mistake can be rectified immediately by branching to the CLOP (Continue Line of Position) section by pressing DEF H. Enter the data for that body again and carry on reducing more observations. Note that the previous observation number appears again.

It must be remembered that when beginning sight reductions with SLOP, the observation number counter is set to 1 and previous azimuths and intercepts are erased (internally). Therefore, when reducing a set of sights SLOP is only entered once.

If, during the course of sight reduction, it is found from the nature of the calculated azimuth and intercept that a poor observation has been made or data has been incorrectly entered, branch out, make the necessary correction and then, if necessary, return to the process of sight reduction using the CLOP section. In this way, previous results will be preserved.

Naturally it is not permitted to change the stored DR position, course and speed of the vessel during the reduction of a set of observations. Legitimate reasons for branching might be to change the Height of Eye, identify an unknown body, or inspect the Catalogue.

EXAMPLE: The navigator of the vessel we have been considering made the following observations at evening twilight on 7 Jan 1985. The Basic Data is as shown on page 3 except that the DR position is S34°06'.7 E152°23'.8 (the position by Traverse in the Example in the Traverse section). The Watch Time when the vessel's last position fix was made was 14h13m.

BODY NO	TIME	SEXT ALT
58	20h37m15s	24°45'
10	20h39m41s	34°05'
18	20h42m25s	37°04'
5	20h44m55s	63°01'

Access the program by DEF D and reduce the observations. Check with the printout alongside.

```
TRAV->DR

DR
LAT           S3406.7
LON          E15223.8

OBS NO              1
VENUS              58
WATCH TIME 20.3715
SEXT ALT       2445.0
AZ              272.8
INT          A    1.0

OBS NO              2
ALDEBARAN          10
WATCH TIME 20.3941
SEXT ALT       3405.0
AZ               28.8
INT          A   14.7

OBS NO              3
SIRIUS             18
WATCH TIME 20.4225
SEXT ALT       3704.0
AZ               85.6
INT          A    0.0

OBS NO              4
ACHERNAR            5
WATCH TIME 20.4455
SEXT ALT       6301.0
AZ              205.2
INT          T   13.9

FIX AT          20.37
LAT           S3423.1
LON          E15224.6
ERROR 1          -0.4
ERROR 2           0.7
ERROR 3          -0.5
ERROR 4           0.7

WT LAST FIX     14.13
SET             177.8
DRIFT             2.5
```

Fix

DEF F

When this is accessed the computer calculates the fix from the observations (up to 40 are permitted) which have been entered in the Sight Reduction section.

After the fix has been calculated the message FIX and the time of the fix are displayed. THE TIME OF THE FIX IS THE TIME OF THE OBSERVATION WHICH WAS FIRST PROCESSED. All other observations are automatically adjusted to that time. Observations may be processed in any time order.

The next output is the observed latitude and longitude of the vessel. The routine used in the program is based on the assumption that the observations are not affected by systematic errors and the most probable position is one for which the sum of the squares of the errors, as defined below, is a minimum. In cases where systematic errors are suspected it is best to plot the position lines and decide, on the basis of the geometry of the plot etc., where the most probable position lies.

If only one observation has been made the FIX corresponds to the intersection of the azimuth line drawn from the DR position (towards or away from the body) and the position line. If you wish to plot the position line, plot the observed position and draw a line through it at right angles to the azimuth of the body.

The errors of the observations are now displayed or printed. The error of an observation is the perpendicular distance from the position line to the observed position. If the observed sextant altitudes were corrected by these errors a perfect fix would be obtained, i.e. all the position lines would pass through the observed position.

Large error values often indicate poor observations. If it is decided that some observations should be excluded or others added, the REJ and/or CLOP sections may be used and a new observed position found. Note that the limit of 40 observations includes the rejected ones.

Finally the program prompts for WT LAST FIX HH.MM, i.e. watch time of the last fix. After this has been entered the Set in degrees and Drift in knots which affected the vessel between fixes is output. Note that the calculation will not be correct if the time between fixes exceeds 24 hours or the Time Zone or Watch Error has been changed.

EXAMPLE: Access the program by DEF F. The observations from the previous Example will be processed. (The Watch Time of Last Fix is 14h13m.) The printed output is shown on page 9.

Sight Rejection

If it is seen that the results of an observation (Azimuth and Intercept) are wrong and should be excluded from those stored in the computer, this may be done by calling up the Reject section.

DEF J

Prompt: REJECT OBS NO
Enter the observation number. If the printer is being used, the information is printed and the prompt repeated etc. In the non-printing mode, after pressing ENTER the prompt is also repeated. At the conclusion of this operation as with other sections such as IDENT, CAT etc. you may return to sight reduction using the CLOP section.

Sight Reduction (CLOP)

DEF H

This section is labelled CLOP which is short for Continue Line of Position Calculations.

CLOP should always be used to return to sight reduction when the sequence of entering sextant observations has been broken by branching to other sections.

When this section is invoked the numbering of observations is taken up where it was left off. The previously stored azimuths and intercepts are left intact and observations are now reduced as if the sequence of sight reductions had never been interrupted.

After entering the CLOP section do not skip the initial prompt BODY NO even though the body is the same as the one being processed prior to branching - the body number may have been overwritten in the meantime.

EXAMPLE: If, when working the previous example, by some mischance the sextant altitude for observation number 2 was entered and processed as 43°05' instead of 34°05', the output would include an intercept of T 525.6 which is obviously wrong. An examination of the data would indicate that the error arose from the incorrectly entered sextant altitude.

To recover from this error, branch to REJECT and eliminate the offending observation and then enter the observation again using CLOP. The correction may be made at any stage of the sight reduction process, even after the sights have been processed and a FIX obtained. If the correction is made after the FIX program has been run, obviously it will be necessary to re-run the FIX program.

The printout below shows the incorrect entry corrected at the end of the sequence of sight reduction and the subsequent Fix.

```
OBS NO             1
VENUS             58
WATCH TIME 20.3715
SEXT ALT     2445.0
AZ            272.8
INT         A   1.0

OBS NO             2
ALDEBARAN         10
WATCH TIME 20.3941
SEXT ALT     4305.0
AZ             28.8
INT         T 525.6

OBS NO             3
SIRIUS            18
WATCH TIME 20.4225
SEXT ALT     3704.0
AZ             85.6
INT         A   0.0

OBS NO             4
ACHERNAR           5
WATCH TIME 20.4455
SEXT ALT     6301.0
AZ            205.2
INT         T  13.8


REJECT OBS NO      2

OBS NO             5
ALDEBARAN         10
WATCH TIME 20.3941
SEXT ALT     3405.0
AZ             28.8
INT         A  14.7


FIX AT         20.37
LAT          S3423.1
LON         E15224.6
ERROR 1         -0.4
ERROR 3         -0.5
ERROR 4          0.7
ERROR 5          0.7
```

Fix → Traverse

DEF G

At the conclusion of sight reduction it will often be found convenient to transfer the observed position, as obtained by the FIX section, to the TRAVERSE section. This is achieved by pressing DEF G. The FIX co-ordinates are then stored and retained as the starting point for the next traverse calculation. The message FIX -> TRAV appears momentarily in the display to show that the co-ordinates have been transferred. If the printer is connected the message is printed as well.

EXAMPLE: Transfer the FIX co-ordinates resulting from the previous Example to the TRAVERSE section. You may access the TRAVERSE section and review the initial co-ordinates to confirm that the transfer has been made.

Running Up of Sights

Any fix based on a sequence of observations from a moving vessel is a running fix. Yet navigators tend to think of two types of fixes. The first is based on a number of observations of one body, e.g. the Sun, the sights often being separated by some hours. The second is based on observations of several bodies observed over a short period of time, e.g. a set of sights of stars and/or planets made at twilight. The latter type of fix is often treated as though the observations were made from a stationary vessel, which in many cases is incorrect. Both types of fixes are running fixes.

The CN-2000 sight reduction routines use the correct procedures for either "running up" and "running back" of sights or for transferring sights, thus obtaining the greatest possible accuracy.

When computing observations made over a short period of time (such as morning or evening stars) all sights are automatically "run up" or "run back" to THE TIME OF THE OBSERVATION WHICH WAS FIRST ENTERED INTO THE PROGRAM. The remaining observations may be entered in any order (not necessarily in the order in which they were made). The sight reduction is made as if the vessel were stopped at the time of the first entered observation and remained so for all the other observations. The "running up" (or "running back") routine uses the Course and Speed of the vessel stored in the Basic Data section and it assumes that these values remain constant during the period of the observations.

Transfers – Body No 68

When reducing a set of sights the SLOP and CLOP sections require a Body Number to be input. The Body Number and corresponding name of the celestial body are found in the CATALOGUE section. The time of observation and sextant altitude are then called for. The computer generates almanac data and reduces the sight, i.e. an Azimuth and Intercept are calculated. Finally the sight is automatically "run up" or "run back" to what it would have been had the sight been taken from the vessel's position at the time of the observation which is first entered in the computer. The vessel's course and speed are used in this latter process.

This routine is not suitable for observations extending over a long time, nor is it possible to take into account changes of course and speed during the period of observation. Therefore, for running fixes, such as Sun-run-Sun-run-Sun where some hours may separate the observations and the course or speed of the vessel may change, an alternative routine using transferred or double sights is used.

Each sight is reduced using the SLOP section of the program and the values of the Azimuths and Intercepts which are output are recorded. When a position fix is required the Azimuths and Intercepts of the previously reduced sights are entered using Body Number 68. The computer by-passes the sight reduction process and stores these values without further calculation. The FIX section is now invoked to complete the operation.

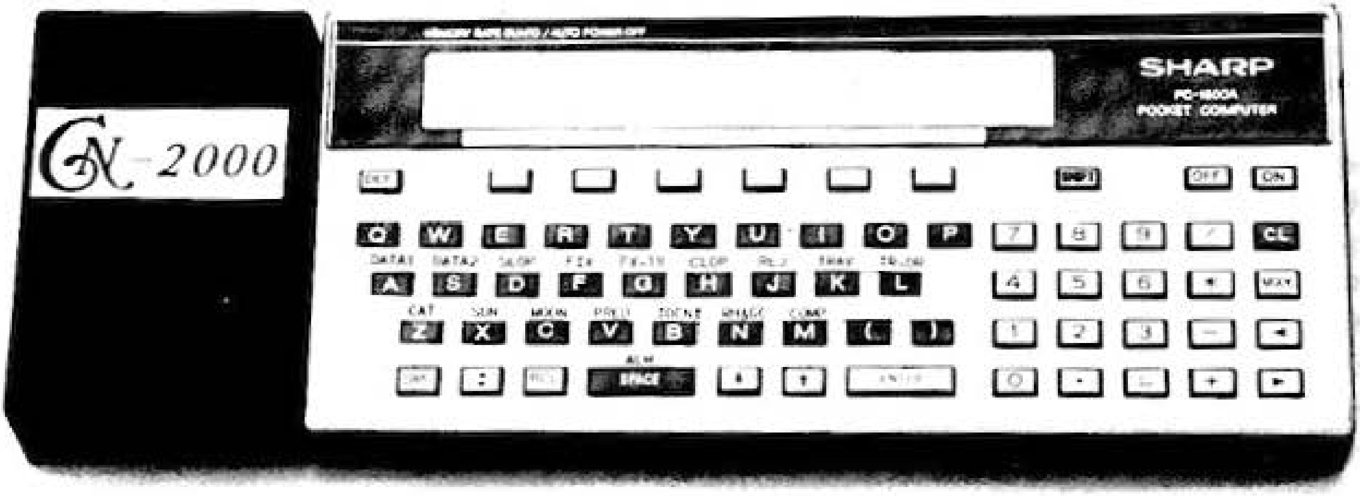
Transfers can, of course, be rejected by using the REJECT routine and, after branching from the SLOP section, sight reduction can be resumed by returning via CLOP and entering additional Transfers etc.

EXAMPLE: The following observations of the Sun (Lower Limb) were made during the morning of 7 January 1985. The Basic Data is the same as for the

```
DR
LAT              S3507.6
LON             E15128.7

OBS NO                 1
SUNLL                 62
WATCH TIME        7.5713
SEXT ALT          2337.0
AZ                 101.4
INT             A    6.5


DR
LAT              S3514.5
LON             E15159.8

OBS NO                 1
SUNLL                 62
WATCH TIME       11.1520
SEXT ALT          6345.0
AZ                  67.1
INT             A   12.4

OBS NO                 2
TRANSFER              68
AZ                 101.4
INT             A    6.5

FIX AT             11.15
LAT              S3525.5
LON             E15149.0
ERROR 1              0.0
ERROR 2             -0.0


DR
LAT              S3517.2
LON             E15212.1

OBS NO                 1
SUNLL                 62
WATCH TIME       12.3312
SEXT ALT          7529.0
AZ                  23.9
INT             A   21.9

OBS NO                 2
TRANSFER              68
AZ                 101.4
INT             A    6.5

OBS NO                 3
TRANSFER              68
AZ                  67.1
INT             A   12.4


FIX AT             12.33
LAT              S3535.8
LON             E15201.7
ERROR 1              1.5
ERROR 2              1.9
ERROR 3             -2.7
```

Catalogue

```
CATALOGUE
0 POLARIS 2.1
1 ALPHERATZ 2.2
2 ANKAA 2.4
3 SCHEDAR 2.5
4 DIPHDA 2.2
5 ACHERNAR 0.6
6 HAMAL 2.2
7 ACAMAR 3.1
8 MENKAR 2.8
9 MIRFAK 1.9
10 ALDEBARAN 1.1
11 RIGEL 0.3
12 CAPELLA 0.2
13 BELLATRIX 1.7
14 ELNATH 1.8
15 ALNILAM 1.8
16 BETELGEUSE VAR
17 CANOPUS -0.9
18 SIRIUS -1.6
19 ADHARA 1.6
20 PROCYON 0.5
21 POLLUX 1.2
22 AVIOR 1.7
23 SUHAIL 2.2
24 MIAPLACIDUS 1.8
25 ALPHARD 2.2
26 REGULUS 1.3
27 DUBHE 2.0
28 DENEBOLA 2.2
29 GIENAH 2.8
30 ACRUX 1.1
31 GACRUX 1.6
32 ALIOTH 1.7
33 SPICA 1.2
34 ALKAID 1.9
35 HADAR 0.9
36 MENKENT 2.3
37 ARCTURUS 0.2
38 RIGIL KENT 0.1
39 ZUBEN,UBI 2.9
40 KOCHAB 2.2
41 ALPHECCA 2.3
42 ANTARES 1.2
43 ATRIA 1.9
44 SABIK 2.6
45 SHAULA 1.7
46 RASALHAGUE 2.1
47 ELTANIN 2.4
48 KAÚS AUST 2.0
49 VEGA 0.1
50 NUNKI 2.1
51 ALTAIR 0.9
52 PEACOCK 2.1
53 DENEB 1.3
54 ENIF 2.5
55 AL NA,IR 2.2
56 FOMALHAUT 1.3
57 MARKAB 2.6
58 VENUS
59 MARS
60 JUPITER
61 SATURN
62 SUNLL
63 SUNC
64 SUNUL
65 MOONLL
66 MOONC
67 MOONUL
68 TRANSFER
```



CN Systems

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EXAMPLE- COMPOSITE SAILING- 3 LEGS ONLY: Using the same Departure and Arrival points as before and a Limiting Latitude of S60°00', calculate a single Rhumb Line Track and distance to the Limiting Latitude, along the Limiting Parallel of Latitude and from the Limiting Latitude to the Arrival point.

The printed output appears below.

```
COMPOSITE
DEPART
LAT          S4253.0
LON         E14721.0

ARRIVE
LAT          S5610.0
LON         W 6715.0
TRACK           98.1
DIST          5692.0
GC TRACK       161.0
GC DIST       4604.1

VERTEX
LAT          S7613.8

LIMITING
LAT          S6000.0


LAT          S6000.0
LON         W15504.5
TRACK          115.8
DIST          2363.0
GC TRACK       137.0
GC DIST       2292.4

LAT          S6000.0
LON         W 9746.9
TRACK           90.0
DIST          1726.2
GC TRACK       115.3
GC DIST       1664.3

LAT          S5610.0
LON         W 6715.0
TRACK           76.7
DIST           998.4
GC TRACK        90.0
GC DIST        985.8
```

Timing of Sights

When the CN-2000 program prompts for a watch time in the SLOP, CLOP or IDENTIFICATION sections, the time may be entered in one of two ways. Either the watch time is keyed in or ENTER is pressed at the time of observation. If the second method is used the time from the computer's internal clock is automatically entered into the calculation and displayed. If the printer is not being used, a further pressing of ENTER advances the program to the next prompt.

Before using the automatic timing feature the computer's internal clock must be set according to the Instruction Manual. It will be noted that when timing this way the months and days at the beginning of the time expression are suppressed in the output.

The rate of the computer clock should be periodically checked. If the clock has gained or lost it may be reset or this watch error entered in the Basic Data section.

Single-handed navigators who wish to take advantage of automatic timing face a practical difficulty because of the time delay between making an observation and getting to the computer to enter the time (the body number is input prior to the observation). The problem can be overcome by adopting a watch error equal to the time difference between taking a sight and pressing the ENTER key. For example, if it is found that generally 5 seconds elapses between making an observation and pressing ENTER, a watch error of F.0005 can be entered in the Basic Data section. This assumes that the internal clock is correctly set, otherwise the five second delay must be combined with the watch error.

WARNING: Standard Times and Watch Times (corrected for Watch Error) used in the program refer to the date (year month and day) entered in the Basic Data section. Therefore, if the date changes during a series of observations the date stored in DATA 1 should be changed. This can be avoided by adding 24 hours to the times of observations made after the date change.

Other Calculations

Apart from the normal running of the CN-2000 program, Sharp PC-1500 and PC-1500A computers can be used for any calculations whilst the CN-2000 module is connected provided the following storage registers are NOT used:

A	to Z	A0 to A9
E(0)	to E(40)	B0 to B9
A$	to Z$	C0 to C9
A$(0)	to A$(68)	D0 to D9
B$(0)		E0 to E2

The registers A to Z may be used on the understanding that data which has been entered as part of the program may be overwritten.

To guard against an error arising from any of the above, switch off the computer, withdraw the module and initialise the CN-2000 program (see page 2).

WARNING: The computer performs calculations to an accuracy of 10 decimal digits but the CN-2000 program displays the results of calculations with the last digit rounded off. Consequently values stored in the computer may differ from those displayed or printed by up to half of the last displayed digit. It follows that if some of the Examples given in this manual are re-worked using the printed output instead of values generated by the computer, the answers obtained may be slightly different from those shown.

Bubble Sextant

The CN-2000 program is intended primarily for use at sea with a marine sextant. However, it is possible to reduce observations made with a bubble sextant (or other instruments which do not use the visible horizon as an altitude reference) provided that zero is entered for the Height of Eye. For the Sun and the Moon the Body Numbers to be used are 63 and 66 respectively.

Figure of the Earth

Calculations in the TRAVERSE, RHUMB LINE & GREAT CIRCLE and COMPOSITE SAILING sections are based on the WGS 72 (World Geodetic System 1972) Spheroid with the exception of Great Circle calculations which are based on a sphere on the surface of which an angle of one minute of arc at the centre subtends one nautical mile.

Accuracy of Celestial Co-ordinates

If the celestial co-ordinates generated by the CN-2000 program are compared with those from an accurate almanac the maximum difference will not exceed about 0'.2, with the following two exceptions. In the case of the Moon a small correction has been applied to the Declination to allow for the shape of the Earth. For Venus the co-ordinates refer to the centre of light i.e. the centre of gravity of the light emanating from the planet.

It will be noticed that there are small differences between the values of stellar magnitude generated by the CN-2000 program and those tabulated in the Nautical Almanac. The reason for this is that the theory used in the CN-2000 program is the same as that used in the preparation of the Astronomical Almanac - the precise astronomical catalogue published by H.M. Nautical Almanac Office.

To compare CN-2000 almanac data with the Nautical Almanac, access DATA 1 and enter the date. Enter zero for TIME ZONE, DR LAT and DR LON. Access the ALMANAC section and enter the hour required. Select a Body Number or skip through for a complete output. Note that LHA's are now GHA's.

Input Formats

For a data entry where a decimal point is followed by a zero, both the decimal point and the trailing zero may be omitted. However if the figure or figures which precede the decimal point are zero, these must be entered.

E.g. 1 Latitude N17°12'.0
Enter either N1712.0 or N1712

E.g. 2 Longitude W009°00'.5
Enter either W00900.5 or W900.5

Note also that an arithmetical expression instead of a single numerical value may be used as input data.

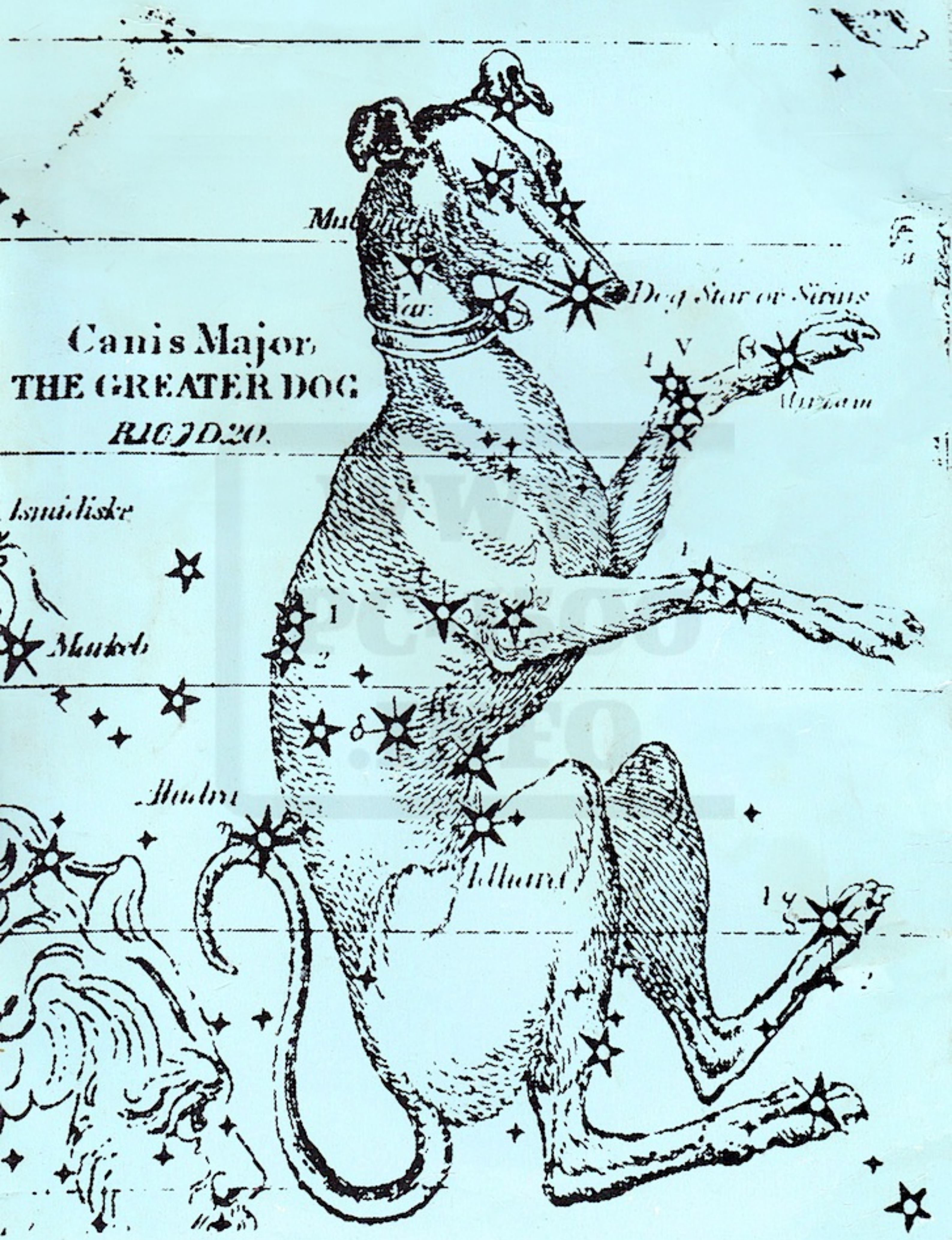
E.g. You are required to input the distance run by a ship steaming at 8.7 knots over a period of 50 minutes.

You may enter 8.7*50/60.

Star List

NO.	NAME	MAG	SHA °	DEC °
0	POLARIS	2.1	326	N 89
1	ALPHERATZ	2.2	358	N 29
2	ANKAA	2.4	354	S 42
3	SCHEDAR	2.5	350	N 56
4	DIPHDA	2.2	349	S 18
5	ACHERNAR	0.6	336	S 57
6	HAMAL	2.2	328	N 23
7	ACAMAR	3.1	316	S 40
8	MENKAR	2.8	315	N 4
9	MIRFAK	1.9	309	N 50
10	ALDEBARAN	1.1	291	N 16
11	RIGEL	0.3	282	S 8
12	CAPELLA	0.2	281	N 46
13	BELLATRIX	1.7	279	N 6
14	ELNATH	1.8	279	N 29
15	ALNILAM	1.8	276	S 1
16	BETELGEUSE	0.1/0.2	271	N 7
17	CANOPUS	-0.9	264	S 53
18	SIRIUS	-1.6	259	S 17
19	ADHARA	1.6	255	S 29
20	PROCYON	0.5	245	N 5
21	POLLUX	1.2	244	N 28
22	AVIOR	1.7	234	S 59
23	SUHAIL	2.2	223	S 43
24	MIAPLACIDUS	1.8	222	S 70
25	ALPHARD	2.2	218	S 9
26	REGULUS	1.3	208	N 12
27	DUBHE	2.0	194	N 62
28	DENEBOLA	2.2	183	N 15
29	GIENAH	2.8	176	S 17
30	ACRUX	1.1	174	S 63
31	GACRUX	1.6	172	S 57
32	ALIOTH	1.7	167	N 56
33	SPICA	1.2	159	S 11
34	ALKAID	1.9	153	N 49

NO.	NAME	MAG	SHA °	DEC °
35	HADAR	0.9	149	S 60
36	MENKENT	2.3	149	S 36
37	ARCTURUS	0.2	146	N 19
38	RIGIL KENT	0.1	140	S 61
39	ZUBEN,UBI	2.9	137	S 16
40	KOCHAB	2.2	137	N 74
41	ALPHECCA	2.3	126	N 27
42	ANTARES	1.2	113	S 26
43	ATRIA	1.9	108	S 69
44	SABIK	2.6	103	S 16
45	SHAULA	1.7	97	S 37
46	RASALHAGUE	2.1	96	N 13
47	ELTANIN	2.4	91	N 51
48	KAUS AUST	2.0	84	S 34
49	VEGA	0.1	81	N 39
50	NUNKI	2.1	76	S 26
51	ALTAIR	0.9	62	N 9
52	PEACOCK	2.1	54	S 57
53	DENEB	1.3	50	N 45
54	ENIF	2.5	34	N 10
55	AL NA,IR	2.2	28	S 47
56	FOMALHAUT	1.3	16	S 30
57	MARKAB	2.6	14	N 15
58	VENUS			
59	MARS			
60	JUPITER			
61	SATURN			
62	SUNLL			
63	SUNC			
64	SUNUL			
65	MOONLL			
66	MOONC			
67	MOONUL			
68	TRANSFER			


Canis Major
THE GREATER DOG
Dog Star or Sirius