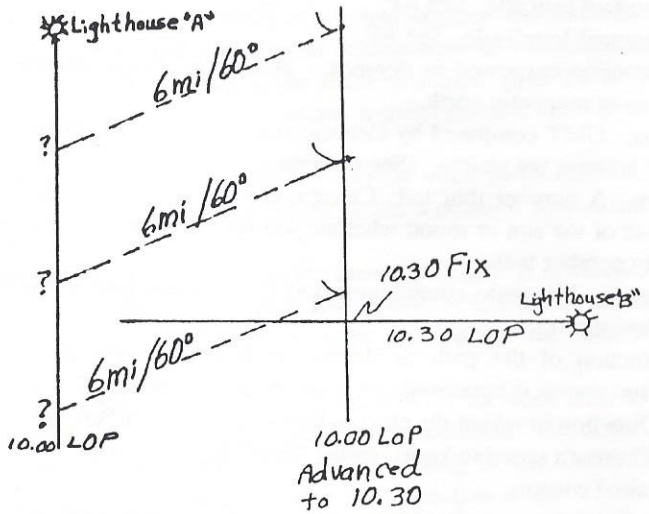
2. He chooses a chart position near his best known position (You call this his assumed position or AP.) and works out the sextant height (HC or computed height) he would actually read if he were at that position. He also computes the direction from the AP to the sun's GP at shot time.
3. He now has two sextant angles: The one he measured with the sextant, and the one he computed for the AP. Suppose they are the same. Can he say to himself: "Aha! the two angles agree. Therefore I am actually at the AP."? No, it's not quite that simple. Any observer at the same distance from the GP would measure his angle. So the AP is just one point on a circle of distance.

To show all possible positions he would need to draw a circle completely around the sun's GP. Fortunately that isn't necessary because he knows he is near the AP. He needs only to draw that part of the circle nearby. Moreover it is such a big circle that he can show his small part of it as a straight line without error.
The computed direction of the sun (called ZN) is like the spoke of a wheel pointing from his spot on the rim toward the GP.
4. He draws a dashed line (the ZN) pointing through his AP toward the sun's GP. That's the spoke.
5. Next he draws a solid line at right angles to the ZN. That is his LOP. In this case because the difference between his computed height and measured height was zero the LOP also passes through his AP. Now he can say: "Aha! I am somewhere on that LOP." Why not: "Aha! I am at the AP."? Remember he *measured the height of the sun, but not it's bearing.* (There is no practical way to measure such a bearing at sea with the needed accuracy.)
6. What does he do if the sextant angle doesn't match the computed angle (the usual case)? He reasons like this: If my actual position is closer to the GP than the AP the sun will appear to be higher and my sextant angle will be greater. For each minute the actual angle is greater than the computed I am one sea mile closer and for each minute the measured angle is less I am one mile farther from the GP. So I can measure TO or AWAY from the GP using the AP as the zero point. There I will draw my LOP at right angles to the ZN, and that will be my true LOP. Fine, that'sone LOP. But it takes two LOPs crossing to make a fix. For the fix to be perfect both LOPs would have to measured at exactly the same time if the ship is moving. That's a practical impossibility so I must adjust for the ship's travel between sights..

To illustrate the problem let's suppose that you are powering at 12 knots in a fog on a course of 60 degrees. At 10.00 the fog breaks and you sight a known light house due north, distance unknown. The fog closes in and you continue on course. At 10.30 the fog breaks again and you sight another known lighthouse due east, distance unknown again. How can you fix your position?

ADJUSTING LOPs FOR SHIP'S TRAVEL

The 10.00 sighting told you that you were somewhere on a line due south of lighthouse A. But at 10.30, when you sighted lighthouse B, you were about 6 miles east-northeast of your 10.00 position, whatever that was. Crossing the two lines makes no sense at all. What to do?
Why not take three of the possible points on line A and draw your distance and course--6nm/60deg-- from each of the three points. If you connect the points you will find that they make a straight line parallel to the north-south line from lighthouse A. Are you somewhere on that line at 10.30? If you are right about your speed and course you must be. And now you have two lines of position valid at 10.30. Where they cross you are--a fix.



LOPs can be advanced, as you just did, or retired. You could have advanced line A 15 minutes to 10.15 and retired line B by measuring back 15 minutes worth of ship's travel and made a fix for 10.15. When Celesticomp computes LOPs it does this for you automatically making all LOPs valid for the fix time you chose. A little thought will tell you that it would be impossible to get a daytime fix from the sun only without doing this.

This phenomenon, sometimes called "motion of the observer" is generally ignored in star fixes since the LOPs are close in time and the ship's movement small. But when the ship has moved a mile or more between the first and last LOP ignoring the motion of the observer can cause a significant error. 15 minutes between star sights is not uncommon. A tanker traveling 24 knots moves 6 miles in that time. He doesn't need a 6 miles motion error. Happily, with Celesticomp, he doesn't get one.

For a daytime running fix on the sun the time between LOPs is often several hours.

Here it is important that the inputs of course and speed be as accurate as possible. A one knot speed error over 5 hours is a five mile error. That would put you LOP five miles out. Moral: When difference between fix time and shot time is large make course and speed inputs very accurate.

GLOSSARY

AP or assumed position. Expressed in latitude and longitude. The navigator chooses this position as a base for computing and plotting his LOPs. Also used by the FIX program to compute the lat/lon of the fix from the LOPs.

A LAT or assumed latitude. See AP.

A LON or assumed longitude. See AP.

Azimuth. Direction expressed in degrees. Here it is always measured clockwise from either true or magnetic north.

Best star time. GMT computed by Celesticomp in the middle of the period when both stars and horizon are visible. (See twilight.)

Body number. A number that tells Celesticomp which celestial body you "shot", and, in the case of the sun or moon whether you shot the lower or upper edge of the disk. See body number lists.

Compass course. Magnetic course corrected for compass errors due to the ship's magnetism (deviation).

Course. Direction of the path or desired path to be made good by the ship. Direction of true course is measured clockwise from true north. (TC, TR CSE)

CUR DIR. Direction in which the current flows. Also called "set."

CUR VEL. Current's speed in knots, called "drift" in some texts.

DES CS. Desired course.

DEV or deviation. Amount the ship's compass deviates from a reading made where the compass is only affected by the earth's magnetic field.

DP Departure point.

DR or dead reckoning. Means of finding ship's position by extending a vector representing course and distance made good from best known previous position. Vital to all good navigation no matter what fixing method is used because DR enables the navigator to estimate his position at all times. The accuracy achieved depends on the accuracy of inputs of speed, course, and time. Good log-keeping is essential for accurate DR.

Eye height or HE. The height in feet that the observers eye is above the water level when the sight is made. The angle measured increases with height of eye and must be corrected by Celesticomp. To convert meters to feet multiply by 3.3.(At prompt EYE HT0.0? input value*3.3.--You get a star when you press the multiply key.)

FIX. Position determined by measurement. If measurements are accurate it is better than a DR position.

FIX TIME. The GMT time and date for which all LOPs of a given fix are valid. It

also provides a reference for shot date. (This date is adjusted when the shot is on a date earlier or later than fix time/date, but within 12 hours of fix time.)

GMT or Greenwich Mean Time. The time and date at Greenwich, England. It uses the 24 hour clock and is used for all celestial navigation. Your navigation will be much simpler if you do all of your navigation in GMT. For our purposes it is the same as UMT or Universal Mean Time.

Great Circle, GR CIR or GC. On the surface of a globe the shortest distance between two points. On a chart a line connecting the points through which a great circle passes. Great circles are significantly shorter than rhumb line (Mercator) courses on east west courses in high latitudes. The greater the distance saving the more they curve poleward when compared to rhumbline courses. This often takes them away from favoring trade winds and into bad weather and rough seas. They are more valuable to aviators and commercial vessels than to cruising men. Because great circles curve poleward they cross each meridian (line of longitude) at a different angle. Thus, for practical reasons, a great circle course is broken into a series of rhumbline (Mercator) courses.

HC. Computed height of a body above the horizon when viewed from a certain time and place. Valuable for predicting a planet or star's position so you can preset your sextant and find it easily.

Intercept. The distance from the AP to the measured LOP. It is measured along the ZN TO or AWAY. An away intercept is always shown as a minus value. If you use the CANCEL branch of the FIX program be sure to use the minus sign where needed.

I.C. or index correction. Correction in minutes of arc for scale error in the sextant. This error is determined by taking a "sight" on the horizon. The angle between the horizon and itself should be zero. If the actual reading is, say, 00.02 (2 minutes of arc) the sextant reading is 2 minutes high so the correction is -2.

LAN or local apparent noon. The GMT at which the sun crosses your meridian--passes due north or south of your longitude.

Lat/lon. Latitude/longitude.

LHA (local hour angle.) of Aries. This value tells you the "star time" at your longitude. It is used in starfinders to find which stars are up, how high, and in what direction. The STARLIST program does the same thing with more accuracy. (However STARLIST only lists stars between 30 and 70 degrees above the horizon--the best ones for shooting.)

LOP or line of position. If you are on Main Street but don't know the block you have an LOP. See the section: Theory of the Line of Position.

Lower limb. When you sight on the sun or moon you match either the lower or upper edge of the disk with the horizon instead of the center. This makes your sextant altitude false by about 15 minutes of arc. You must tell Celesticomp which you used so it can comppute the proper correction. Sun shots are almost always on the lower limb, but the phase of the moon sometimes requires you to use its upper

limb.

Knot or kt. A speed unit. One knot=one nautical mile per hour.

MAG CS or magnetic course. A course measured clockwise from magnetic north.

Mercator or rhumb line course. These courses appear on Mercator charts as straight lines so are easy to measure and steer. Most mariners use Mercator charts.

Nautical mile or nm. Used by sea navigators because it is one minute of latitude long. A change in sextant angle of one minute will affect the LOP by one nm. 6080 feet long on average.

N LAT or noon latitude. Also near point or estimated position (EP). This program always gives the lat/lon of the point on the LOP that is closest to the chosen AP. When the body lies within 3 or so degrees due north or south at shot time (ZN 0, 360, or 180 +/- 3) the latitude gives an accurate noon latitude. With other ZNs it gives you only the near point which some call an estimated position because it is slightly more likely than your DR to be an accurate position. Use with caution.

RL TR CS. Rhumb line true course.

Rhumb line. See Mercator course.

Sea mile. See nautical mile.

Sextant Altitude. The height of a body above the visible horizon measured in degrees, minutes, and tenths of minutes. (Hs for height by sextant.)

Shadow bearing. Bearing of the sun's shadow.

Sight or shot. Sextant altitude paired with exact GMT, and body name or number.

Shottime. GMT at the exact moment sextant altitude was measured.

TP. Turn point. See waypoint.

True course or TC or TR CS. See course.

Twilight. Sun below the horizon by .6 to 12 degrees. Celesticomp gives the time of civil twilight. (Sun 6 degrees below the horizon.) When the sun is between 6 and 12 degrees below the horizon both stars and the horizon are visible.

UNKNOWN STAR. More properly "unidentified star" but that name is too long to fit in Celesticomp's window.

Upper limb. See lower limb.

VAR or variation. The amount a compass affected only by earth magnetism varies from true north.

Vertex. If a great circle course is extended clear around the earth it will have vertexes at its northernmost and southernmost points. Vertex is included in the great circle program for students at maritime universities and has no application for the rest of us.

Waypoint (WP). A point along the intended track of a vessel where a turn or similar action is intended.

Zenith. The moment at which a body reaches its highest point above the horizon.

ZN. Computed azimuth at which a body will bear from the AP at shottime. No relation to zenith.

BODY LISTS

SHORT LIST

-10 LHA ARIES
-9 STARLIST
-8 UNKNOWN STAR
-7 SATURN
-6 JUPITER
-5 MARS
-4 VENUS
-3 MOON UP LIMB
-2 MOON LOW LIMB
-1 SUN UP LIMB
0 SUN LOW LIMB
27 ACAMAR
5 ACHERNAR
30 ACRUX
19 ADHARA
10ALDEBEBARAN
32 ALIOTH
34 ALKAID
55 AL NA'IR
15 ALNILAM
25 ALPHARD
41 ALPHECCA
1 ALPHERATZ
51 ALTAIR
2 ANKAA
42 ANTARES
37 ARCTURUS
43 ATRIA
22 AVIOR
13 BELLATRIX
16 BETELGUESE
17 CANOPUS
12 CAPELLA
53 DENEB
28 DENEBOLA
4 DIPHDA
27 DUBHE
14 ELNATH
47 ELTANIN
54 ENIF
56 FOMALHAUT
31 GACRUX
29 GIENAH
35 HADAR
6 HAMAL
48 KAUS AUST.
40 KOCHAB
57 MARKAB
8 MENKAR
36 MENKENT
24 MIAPLACIDUS
9 MIRFAK
50 NUNKI
52 PEACOCK
68 POLARIS
21 POLLUX
20 PROCYON
46 RASALHAGUE
26 REGULUS
11 RIGEL
38 RIGEL KENT.
44 SABIK
3 SCHEDAR
45 SHAULA
18 SIRIUS
33 SPICA
23 SUHAIL
49 VEGA
39 ZUBEN'UBI

COMPLETE STARLIST

1 ALPHAERATZ
3 SCHEDAR
4 DIPHDA
5 ACHERNAR
6 HAMAL
7 ACAMAR
8 MENKAR
9 MIRFAK
10 ALDEBARAN
11 RIGEL
12 CAPELLA
13 BELLATRIX
14 ELNATH
15 ALNILAM
16 BETELGUESE
17 CANOPUS
18 SIRIUS
19 ADHARA
20 PROCYON
21 POLLUX
22 AVIOR
23 SUHAIL
24 MIAPLACIDUS
25 ALPHARD
26 REGULUS
27 DUBHE
28 DENEBOLA
29 GIENAH
30 ACRUX
31 GACRUX
32 ALIOTH
33 SPICA
34 ALKAID
35 HADAR
36 MENKENT
37 ARCTURUS
38 RIGIL KENT.
39 ZUBEN'UBI
40 KOCHAB
41 ALPHECCA
42 ANTARES
43 ATRIA
44 SABIK
45 SHAULA
46 RASALHAGUE
47 ELTANIN
48 KAUS AUSTRALIS
49 VEGA
50 NUNKI

51 ALTAIR
52 PEACOCK
53 DENEB
54 ENIF
55 AL NA'IR
56 FAMALHAUT
57 MARKAB
58 CAPH
59 ALGENIB
60 b HYDRI
61 y CASSIOPEIAE
62 MIRACH
63 RUCHBAH
64 SHERATAN
65 a HYDRI
66 ALMAK
67 b TRIANGULI
68 POLARIS
69 ALGOL
70 ALCYONE
71 z PERSEI
72 e PERSEI
73 y ERIDANI
74 i AURIGAE
75 b ERIDANI
76 b LEPORIS
77 d ORIONIS
78 a LEPORIS
79 i ORIONIS
80 z TAURI
81 PHACT
82 ALNITAK
83 k ORIONIS
84 MENKALINAN
85 O AURIGAE
86 MIRZAM
87 ALHENA
88 t PUPPIS
89 o CANIS MAJORIS
90 WEZEN
91 p PUPPIS
92 n CANIS MAJORIS
93 b CANIS MINORIS
94 a PUPPIS
95 CASTOR
96 z PUPPIS
97 p PUPPIS
98 y VELORUM
99 d VELORUM
100 i URSA MAJORIS
101 i CARINAE
102 k VELORUM
103 N VELORUM
104 e LEONIS
105 ALGEIBA
106 o CARINAE
107 u VELORUM
108 MERAK
109 ps VELORUM
110 d LEONIS
111 PHECDA
112 d CENTAURI
113 b CORVI
114 a MUSCAE
115 MUHLIFAIN
116 y VIRGINIS
117 MIMOSA
118 COR CAROLI
119 e VIRGINIS
120 i CENTAURI
121 MIZAR
122 e CENTAURI
123 n BOOTIS
124 z CENTAURI
125 y BOOTIS
126 n CENTAURI
127 a LUPI
128 e BOOTIS
129 b LUPI
130 b LIBRAE
131 y TRIANGULI AUST.
132 y URSAE MINORIS
133 y LUPI
134 a SERPENTIS
135 b TRIANGULI AUST.
136 p SCORPII
137 DSCHUBBA
138 b SCORPII
139 d OPHIUCHI
140 n DRACONIS
141 b HERCULIS
142 r SCORPII
143 z OPHUICHI
144 z HERCULIS
145 e SCORPII
146 z ARAE
147 a HERCULIS
148 b ARAE
149 v SCORPII
150 b DRACONIS
151 a ARAE
152 o SCORPII
153 k SCORPII
154 b OPHIUCHI
155 y SAGITTARII
156 d SAGITTARII
157 y SAGITTARII
158 z SAGITTARII
159 z AQUILAE
160 p SAGITTARII
161 ALBIREO
162 d CYGNI
163 y AQUILAE
164 y CYGNI
165 a INDI
166 e CYGNI
167 ALDERAMIN
168 b AQUARII
169 d CAPRICORNI
170 a TUCANAE
171 b GRUIS
172 SCHEAT
173 y CEPHEI

PRACTICE ASHORE

You may want to reduce sights made on land using a substitute reference for the horizon. Celesticomp makes all the proper corrections for such sights except one: height of eye. **If you don't use the sea horizon in your sights you must make the EYE HT correction zero.**

The best way to practice ashore is to find a lake or pond where you can use an opposite shore at least a quarter of a mile away as your horizon. Then you consult a "dip short" table (There is one in Bowditch.) to get your correction. You can then include this correction with your Index Correction at the IC prompt. For example if the IC is 2.5 and the dip short a minus 3.2 you would respond to the IC prompt with: 2.5-3.2 ENTER. **For HE enter zero.**

Here is an abbreviated dip short table:
Corrections are in minutes of arc. Subtract all corrections.

	Shore Distance in Miles						
	0.2	0.4	0.6	0.8	1	1.5	2
Eye Ht(Feet)	**Dip Short Correction (minutes).**						
5	14.2	7.2	5.0	3.9	3.2	2.5	2.2
10	28.4	14.3	9.7	7.4	6.1	4.4	3.7

CHANGING BATTERIES

1. Battery type: CR2032. Available in most Radio Shack type stores.
2. Turn POWER OFF.
3. Remove the program card. (Release the EJECT latch.)
4. Unscrew the two retaining screws on the back and remove cover.
5. Depress the battery cover latch and slide the cover off.
6. Clean the two new CR 2032 cells and insert with the polarity shown on the cover.

AFTER YOU REPLACE THE BATTERIES YOU MAY GET A "BUSY" ON THE SCREEN OR YOU MAY GET AN ERROR SIGNAL WHEN YOU START A PROGRAM. IF YOU GET EITHER OF THESE YOU MUST DO A RESET.)

TROUBLE SHOOTING

An ERROR message stops all computation until cleared. The most bothersome error is ERROR 7. Practice clearing it and learn how, and how to avoid it. ERROR 7 occurs when you put too large a number in data that will be displayed in a prompt. It must cleared with the CLEAR ERROR#7 program or with the recessed ALL RESET button (back of the computer). Either erases your saved data, but doesn't affect your programs. Usually it only affects only one program, so you can clear it

with C-CE and run other programs before you RESET.

Induce the error and clear it:

PROMPT	REPLY/COMMENT
0	PLAN
GR CIR?Y/N	YES
DEP LAT 0?	24431 ENTER

You planted the error by omitting the decimal. Now press **ENTER** *until you see:*

REVIEW DATA	YES
ENTER ENTER ENTER	REVIEW DATA?Y/N YES
ERROR 7 IN 190	C-CE *Clears the screen.*

You can now run any program except the great circle or rhumb line.

	PLAN
GR CIR?Y/N	YES

Now you get ERROR 7 IN 190 (Or almost any line number.)

To Clear ERROR 7 you can do an ALL RESET or use the last program under the UTIL key. To use the program just key UTIl, say NO to all programs until you see: CLEAR ERROR 7?Y/N. If you say yes all of your inputs including the one that caused the error will be cleared, but the programs will be OK. You will have returned Celesticomp to the condition it had when it was new. An ALL RESET (see below) does exactly the same thing.

RESETTING CELESTICOMP V

(CAUTION:DO NOT RESET YOUR TRIM*3 CARD)

1. Find the hole on the back marked ALL RESET. With power on use a sharp, pointed instrument (some ball point pens are sharp enough) to press the RESET button deep in the hole. You will see: ** **.
2. Press the = key. You will see: *
3. Turn power off and back on. You will see: 0.
4. Select any program and check for normal operation. All saved data is erased, but the programs are OK. Celesticomp is in the condition it was when new.

OTHER ERRORS

ERROR 2. If a computation is impossible--i.e. dividing by zero--you get ERROR 2. Clear it with the C-CE key. Check the data inputs and recompute. If they don't change you will likely get the same error again. Usually changing the longitude or time input by .00001 will cure the problem.

Blank screen with power on. Turn power OFF, back ON. If this fails adjust the contrast. If that doesn't clear it you probably have a dead battery. **CAUTION: Don't use CA key to restore power as it will also erase saved data inputs.**

BUSY stays on screen or you get ERROR 4. This may occur after removal and replacement of program cartridge or batteries. You must do an ALL RESET.

Erratic operation may be caused by weak batteries. The symptoms are: Display fades, and you get unexplained error messages. If you have to turn the contrast control to full up to get a good display install new batteries.

APPARENT ERRORS: Celesticomp sight reduction computations have been compared with tabular solutions thousands of times and have always been proven correct. Some apparent errors are:

1. Failure to enter a FIX TIME. This is required even for a single LOP.
2. Using a FIX TIME that differs from SHOTTIME by more than 12 hours. This will cause Celesticomp to adjust to the wrong date.
3. Comparing intercepts computed by tables with Celesticomp computation when the AP for the two computations are different or when HO (the sextant reading corrected for dip, IC, refraction, HP, and semi-diameter) is entered into Celesticomp as the sextant reading. (You can zero the first two, but Celesticomp will always apply, where applicable, the last three.) When only HO is given in the textbook problem you must apply those corrections with reverse sign to get a sextant reading to give Celesticomp.
4. To get an LOP that is not advanced or retired you must use zero speed or make FIX TIME and SHOTTIME the same.

CARE: Give your Celesticomp the same protection you would a camera, ship's clock or similar device and it will reward you with a long and useful life. Protect it from moisture, shock, and temperature extremes. Keeping it in a drawer inside a ziplock bag while at sea is a good idea. (Don't put a drying agent in the bag with it because that may promote corrosion of the battery contacts.)

SERVICE: Service on the Sharp PC 1270 computer may be done through Celesticomp or directly through Sharp. Service on the Celesticomp program cartridge must be done through Celesticomp.

GUARANTEE: I guarantee that your Celesticomp V will perform as advertised or be repaired or replaced by one that will. It is not guaranteed against abuse. It must be returned in good condition. This guarantee is valid for one year from the date of purchase.

ASSISTANCE: If you would like help in using your new Celesticomp or in some other phase of celestial navigation please call or write me: (See page one.)