A

COMPLETE NAVIGATION PACKAGE FOR THE HP-75C

by Louis Valier

EduCALC

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Dear User of NAVA,

SUBJECT: ERRATA

In the program listing four corrections should be made to the print out so that it agrees with the program. I cannot figure how the errors appeared in the print out.The program itself works fine.

Line 390, "Gosub 3420" should read "Gosub 3410"
Line 410, same correction as above
Line 440, Last Gosub should be 3420 (not 3430)
Line 1440, Last Gosub should be 3430 (not 3450)

For those who use this program on a boat depending on battery power, here are some ideas which have worked well for me.

The HP 82162A Thermal Printer works very well with the HP-75C. If there is not a way to recharge the NICAD battery in the unit it is possible to open the case and connect a socket to the inside terminals. It is a good idea to connect a diode leading to the socket.The socket is screwed in a hole made in the back of the case above the other sockets. Then a plug with wires can be used to connect the printer to a 6 volt lantern battery such as Eveready # 731. Sockets and plugs can be bought at a Radio Shack store.A good one is a Coaxial DC Power Connector socket and plug such as their # 274-1565 and 274-1549. I made the outside of the plug + and inside -.

The same thing can be done with the HP 82161 A Digital Cassette Drive.This makes a very good combination for portable use.

One word of caution, the wire connecting the plug to the battery should be heavy enough to handle the current. My first try was ordinary small 110 AC lamp cord which would not handle the current and the printer would not work !.

I would suggest the cigarette lighter adaptor sold by EDUCALC to recharge the battery in the HP-75C from the boats 12 V. battery.

Believe that you will find this a great program. If you find any errors pleae make a note of the problem and let me know by mail. Thank You and GOOD LUCK !

Louis Valier

TABLE OF CONTENTS

HP-75C NAVPAC

A Complete NAVPAC
by Louis Valier

Here is a list of its features:

1. It is similar to the HP-41C Navigation Module but has more accuracy and is much faster.

2. It solves the conventional Line of Position problem after which it finds the Most Probable Position.

3. It finds a Latitude at Noon from the Sun and from Polaris at twilight.

4. There is a routine for advancing an L.O.P. to combine it with a Noon Latitude to give a Running Fix.

5. Another routine will advance one L.O.P. to an L.O.P. at a later time and combine the two to give a Running Fix. This has never appeared in any program before.

6. It does navigtion work for the Sun, Moon, Mercury, Venus, Mars, Jupiter and Saturn. Also the 57 Navigational Stars used in the Nautical Almanac plus Polaris.

7. One routine will find an L.O.P.or Longitude from the time of Sunrise or Sunset.

8. One routine will Dead Reckon from one position to another. Also find the distance and course to a destination from the present position.

9. Another routine allows entry of the coordinates of a telescopc object such as a galaxy, special star, etc with either its Rt. Ascension or Sidereal Hour Angle and its Declination and the program will find the time it rises and sets. If a given GMT is entered it will give its Altitude and Azimuth at the time. For telescope use it will furnish its Hour Angle so that it is easy to orient a telescope to view the object.

10. Another routine gives the time of morning or evening twilight and sunrise or sunset so that the time for taking star sights is known. By entering this time in routine "B" it will list the SHAs of the Planets and Moons, their altidudes and azimuths. Then it lists those of the 58 stars whose altitudes are 15 degrees or more above the horizon, their altitudes and azimuths so the sextant can be pre-set and the object sighted in the direction given.

11. A short program included is one for recording sextant sights. Most experienced navigators like to take several sights of each body. This little program is good for recording times of sights as well as the sextant altitudes to match. Later the navigator has the listings to choose from.

12. A third program is for Voyage Planning. It furnishes Great Circle distances and courses between places. In addition it shows the comparative Rhumb Line Distance and Course. There is an easy way to break a Great Circle route into segments for plotting and sailing.

Solutions are given for typical sights and other routines in the package.

RUNNING NAVPAC 75-C

Here are some general pointers in running the NAVPAC 75-C program. First of all it is a long program. NAVA is 15667 bytes; STAR,2838 and TIME,447. These three plus space needed to run them take up almost all the space with the extra memory module in place. There is only enough room for a short program or two. To run the Voyage Planning part of the package which is 3510 bytes NAVA will have to be stored elsewhere. "VP" is a program which would be run prior to any actual navigation work so this should work out. The HP75-C Manual states that the operating system requires another 2100 bytes. It takes about 30 seconds to initialze NAVA when RUN is touched. Detailed examples are given for each routine on the pages indicated.

Common to all routines, the first thing to appear when the program is run is the prompt for the "Year". Enter appropriate year such as 1985.

2 The next prompt is for the month number,"Month Nr." Enter the number instead of the name.

3 Next prompt is for day of the month, again the date, a number.

4 Then you are asked for the "LOG/ Place". At sea the reading of the log would be entered. Ashore you may wish to put the name of the city. After these four entries the program asks "Correct? Y" If the entries are correct, key in "Y" for yes. If it is desired to change any entry enter "N" and the program prompts to "Reenter Data".

5 Next the program prompts for your choice of what you want to do. Nine choices are offered:

```
Choose: B:Bodies,D: Day
DR: D.Rk., DRD: DR.Dest
F:Fix, L:Long, LA:Lat
P: LOP, RF: Run.Fix
B/D/DR/DRD/F/L/LA/P/RF
```

B for Bodies gives the SHA,Hc and Azimuth of the five visible planets.Then goes thru the list of 58 stars and lists those which are at least 15 degrees above the horizon at the selcted time.Example on page 6

D for Day for a given Lat.,Long. and Time Zone for whatever body is chosen, gives the time it rises, azimuth at rising, time of meridian passage,time the body sets and azimuth at setting.Example on page 9 or 10

DR for Dead Reckoning finds the Lat.and Long.of a destination when given the starting Lat. & Long. plus the Course Distance in Nautical Miles.Example on page 16 or 17.

DRD for Dead Reckoning to Destination. Finds the distance and course from a Lat.and Long.to the Lat.and Long.of the destination. Very useful after figuring a position to know how far to the destination as well as the true course.Example on page 15.

F for Fix finds the fix of two L.O.P.s for two bodies which have been found using the routine P for L.O.P.Example on page 22.

L for Longitude uses the Time Sight formula to find the Long. when the Lat. is known.Example on page 16 or 18.

LA for Latitude will find the Meridian Latitude for the body selected. If an L.O.P. has been found earlier, LA will move the earlier L.O.P. forward and cross it with the Lat. to give a running fix.Example on page 17.

P for L.O.P. gives the L.O.P. for whatever body is selected and stores data so the L.O.P. can be used later with a Lat. or another L.O.P. to give a running fix. If "L" and Long had been found first its data is stored and later advanced to a noon Lat. to give a running fix.Example page 17.

RF is for a running fix after a second L.O.P. has been found later than a first one. It combines the two and gives a Running Fix. See example on pqges 20,21

After making a selection and starting to run a routine the first prompts will be for the Lat. and Long. Enter as DMT, example 21° 17.1' is entered as 21.171. For South Lats and East Longs enter the quantities as minus. so that Long. 123°03.6 E is entered as -123.036. G.M.T of HHMMSS such as 18hr. 30min. 12sec. is enterred as 18.3012.

Depending on the selection, the program will ask for input of more data. When entered it will ask if the entries are "Correct? Y". As before enter "Y" if correct and program goes on to ask "WHICH BODY?" but if an error was made entering data, enter "N" for not correct and proram will ask that you reenter Lat., Long, etc. In choosing "WHICH BODY" care must be taken to key the name so that it matches the way it is listed in the program (see following) or else it will prompt to have the name reentered. The bodies are:

SunL (Lower Limb of Sun)
SunU (Upper Limb of Sun)
Sun used with D, Day
Mercury
Mars

Jupiter
Saturn
MoonL (Lower Limb of Moon)
MoonU (Used for D, Day data for Moon as well as Upper Limb of Moon)
Star, this opens up the list of stars and a particular star must be selected, using number or name.
Extra, this allows entry of an extra body or Astronomical Object.

Star numbers are same as in Nautical Almanac or Star list with this program. If the number is not used a 0 must first be entered then the name instead of the star number. Star names are entered with first six letters of the name. If the name has less than six letters like Enif periods must follow the last letter so Enif is entered as "Enif.." and same for other short names.

After a routine is completed more choices are offered:

```
Choose: DR:Dead Reck.
DRD:DR.Dest.  F:Fix
M:Mo Sights   LA:M.Lat
  RF:Run.Fix
S:Start,T:Tel.,N:None
DR/DRD/F/M/LA/RF/S/T/N ?
```

Most are the same as the first choices. New ones are explained below.

M for more sights. This is very useful. It allows finding data for more than a single sight without having to enter date, log, Lat.& Long. etc.

S for Start.Program starts at beginning without going thru the 39 sec. initializing period.

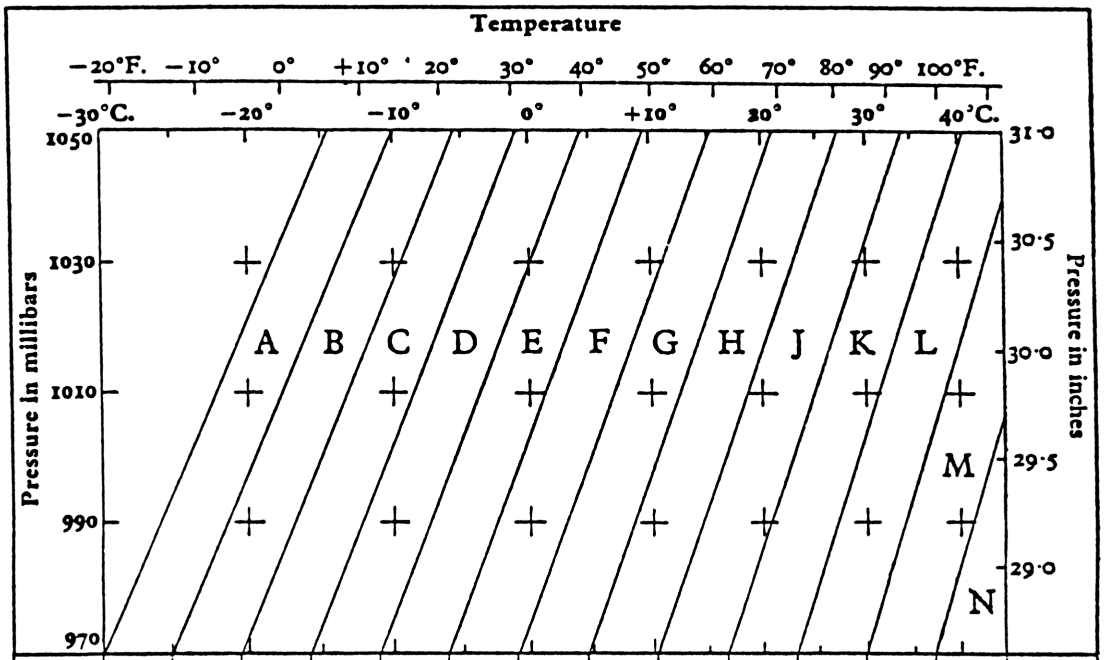
T for setting a telescope, gives the H.A. in Hours and Minutes next H.A. in degrees Minutes and tenths, then the Dec.Entries made with Rt. Asc or SHA and Dec.

N for none of the above in which case it displays "PAU" Hawaiian for finished and stops.

Page 26 has a sample with the timing of the limbs of the sun touching the horizon at sunset to obtain the Long.or an L.O.P. The same proceedure works for the rising sun in the morning Since no sextant is used it is easy to do. The altitude of the sun, Hs is entered as 0. The Ht. of Eye is important. Instead of an Index Corr. a correction for the Barometric Pressure and Temperature is entered. A chart with these corrections is on page 6.

of an Index Corr. a correction for the Barometric Pressure and Temperature is entered. A chart with these corrections is given below It is exactly the same as is done with the NAVPAC FOR YACHTSMEN and the HP 41-C.

ADDITIONAL REFRACTION CORRECTIONS FOR NON-STANDARD CONDITIONS



App. Alt.	A	B	C	D	E	F	G	H	J	K	L	M	N	App. Alt.
0° 00′	−6′·9	−5′·7	−4′·6	−3′·4	−2′·3	−1′·1	0′·0	+1′·1	+2′·3	+3′·4	+4′·6	+5′·7	+6′·9	0° 00′

This table is from the Nautical Almanac page A 4. It is to be used when finding the Long. from the Rising or Setting Sun. In such cases, due to extreme refraction at very low altitudes, greater accuracy can be had if this table is used. This means knowing the Barometric Pressure and the Temperature.

Example on page 26 when the time of Sunset is noted, the Barom. Press. is 29.98" and the Temp is 78°. Entering with these two arguments it puts us into the slanted column "J" This corr. is entered as an I.C., = +2.3'

SUBROUTINE "B"

This is a very useful routine for the navigator. For a given date, place and time it lists the positions of the five visible planets, their SHAs (so that they can be located on a star map), their altitudes and azimuths. (Negative altitudes mean below the horizon). It goes thru the list of 58 stars and selects those which are 15° or more above the horizon. These are suitable for sextant sights. It gives their altitudes and azimuths. A navigator can run this routine before twilight to plan which stars to use. The sextant can be set at the given altitude, aim the appropritate azimuth and the body will be there!

Useful for telescope viewing ashore.

```
Year?        1984
Month Nr.? 5
Day?         15
LOG/Place? Honolulu

 1984
 5
 15
Honolulu
Correct? Yy

Choose: B:Bodies,D: Day
DR: D.Rk.,   F :Fix
LA:Lat.,     L:Long
P: LOP,    RF: Run.Fix
B/D/DR/F/LA/L/P/RF B

Lat.?        21.17
Long.?       157.51
G.M.T.?      5.35
  B
   21.170
  157.510
   5.35
Correct? Yy

   Name ?  0
    MERCURY
   SHA =  331 D   6.6'
   HC = -32 D  48.5'
   Azimuth =   295.9
    VENUS
   SHA =  316 D   8.5'
   HC = -16 D  27.6'
   Azimuth =   294.7
    MARS
   SHA =  133 D   4.7'
   HC =  12 D  50.5'
   Azimuth =   115.3
    JUPITER
   SHA =  76 D  19.5'
   HC = -38 D  56.9'
   Azimuth =   102.5
    SATURN
   SHA =  139 D  25.9'
   HC =  20 D  33.3'
   Azimuth =   113.8
    MOON
   SHA =  126 D  54.8'
   HC =  7 D  31.6'
   Azimuth =   112.8
```

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```
 12 CAPELLA
HC =  21 D  49.5'
Azimuth =    312.5
 14 ELNATH
HC =  20 D  21.5'
Azimuth =    293.8
 16 BETELGEUSE
HC =  20 D  51.0'
Azimuth =    270.0
 18 SIRIUS
HC =  21 D  42.0'
Azimuth =    240.9
 19 ADHARA
HC =  17 D  18.1'
Azimuth =    228.3
 20 PROCYON
HC =  44 D   6.8'
Azimuth =    256.1
 21 POLLUX
HC =  50 D  35.5'
Azimuth =    288.7
 23 SUHAIL
HC =  22 D  12.5'
Azimuth =    197.2
 25 ALPHARD
HC =  55 D  37.1'
Azimuth =    211.4
 26 REGULUS
HC =  78 D  30.2'
Azimuth =    217.6
 27 DUBHE.
HC =  49 D  11.2'
Azimuth =      4.8
```

```
 28 DENEBOLA
HC =  71 D  38.0'
Azimuth =    108.1
 29 GIENAH
HC =  44 D  18.8'
Azimuth =    146.1
 32 ALIOTH
HC =  46 D  58.4'
Azimuth =     27.5
 33 SPICA.
HC =  37 D  31.9'
Azimuth =    124.0
 34 ALKAID
HC =  43 D   8.4'
Azimuth =     41.3
 37 ARCTURUS
HC =  38 D  54.3'
Azimuth =     81.9
 39 ZUBENUBI
HC =  17 D  28.4'
Azimuth =    115.6
 40 KOCHAB
HC =  27 D  30.1'
Azimuth =     15.9
 41 ALPHECA
HC =  22 D  43.2'
Azimuth =     68.8
 58 POLARIS
HC =  20 D  49.1'
Azimuth =    359.3
```

From Routine "B"
May 15 in Honolulu, Lat 21.17N , Long 157.51W
SHAs of Planets: MERCURY 331, VENUS 316, MARS 133, JUPITER 76, SATURN 139,MOON 127.
All on or very close to the ecliptic.

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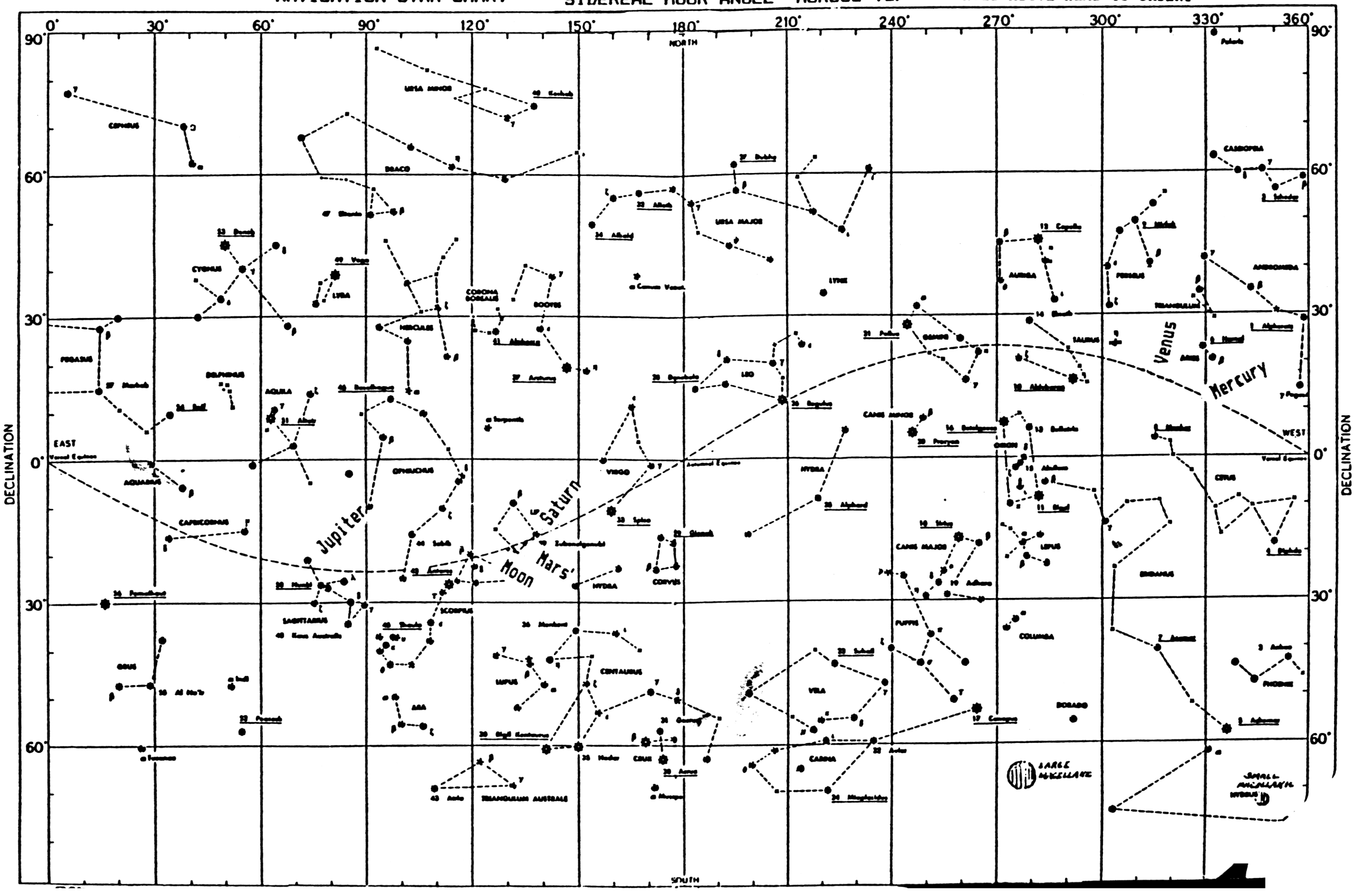
NAVIGATION STAR CHART SIDEREAL HOUR ANGLE ACROSS TOP HOLD ABOVE HEAD TO ORIENT



SUBROUTINE "D"

This routine is used to plan a day. It determines when a selected body will rise, be on the meridian and set. Also azimuths at rising and setting.

For the astronomer it gives the Longitude, Right Ascension, Sidereal Hour Angle and Declination. If coordinates are entered of an unlisted body such as a galaxy, etc. It will give the same data for the "Extra" entry. Then using routine "T" it will give the Hour Angle and Declination for setting circles on a telescope. See example on next page.

```
Year?      1985
Month Nr.? 7
Day ?      11
LOG/Place? Papeete

 1985
 7
 11
Papeete
Correct? Yy

Choose: B:Bodies,D: Day
DR: D.Rk.,  DRD: DR.Dest
F:Fix,  L:Long,  LA:Lat
P: LOP,  RF: Run.Fix
B/D/DR/DRD/F/L/LA/P/RF d

Lat.?      -17.32
Long.?     149.34
Time Zone? 10
  d
 -17.320
 149.340
 10
Correct? Yy

WHICH BODY? Sun
Sun
Long= 109 D  31.6'
R.A.= 7 H 24 M 32.3 S
GHA = 149 D  32.2'
SHA =  248 D  51.9'
Dec.=  22 D   1.3'
Dawn Twilt 5 H  39.1 M
Body Rises 6 H  30.5 M
Azimuth =    66.8
Mer. Pass  12 H   3.8 M
Body Sets  17 H  37.0 M
Azimuth =   293.2
Dusk Twilt 18 H  28.4 M
Another Body? Yy

WHICH BODY? MoonU
Long= 37 D  31.4'
R.A.= 2 H 21. M 42.7 S
GHA = 149 D  36.8'
SHA =  324 D  34.3'
Dec.=  13 D  17.3'
Body Rises 1 H   9.8 M
Azimuth =    76.1
Mer. Pass  7 H  2.0 M
Body Sets  12 H  54.1 M
Azimuth =   283.9
Another Body? Yy
```

```
WHICH BODY? Mercury
 MERCURY
Long= 227 D  23.7'
R.A.= 9 H 9 M 55.9 S
GHA = 151 D  22.0'
SHA =  222 D  31.0'
Dec.=  16 D  22.3'
Body Rises 8 H  11.6 M
Azimuth =    72.8
Mer. Pass  13 H  52.8 M
Body Sets  19 H  34.0 M
Azimuth =   287.2
Another Body? Yy

WHICH BODY? Venus
 VENUS
Long= 350 D   2.1'
R.A.= 4 H 14 M 26.1 S
GHA = 225 D  14.5'
SHA =  296 D  23.5'
Dec.=  18 D  31.4'
Body Rises 3 H  19.0 M
Azimuth =    70.5
Mer. Pass  8 H  57.3 M
Body Sets  14 H  35.6 M
Azimuth =   289.5
Another Body? Yy

WHICH BODY? Saturn
 SATURN
Long= 236 D  30.4'
R.A.= 15 H 19 M 18.4 S
GHA = 59 D   1.4'
SHA =  130 D  10.4'
Dec.= -16 D   1.2'
Body Rises 13 H  38.8 M
Azimuth =   106.8
Mer. Pass  20 H   2.2 M
Body Sets  2 H  25.5 M
Azimuth =   253.2
Another Body? Yn
```

An example using routine "D" in East Longitude.

Auckland, N.Z. is selected which tests use in southern latitudes as well. A N.Z. Almanac for that year verifies the Rising and Setting times of the Moon within a few minutes.

```
Year?       1981
Month Nr.? 6
Day ?       18
LOG/Place? Auckland

 1981
 6
 18
Auckland
Correct? Yy

Choose: B:Bodies,D: Day
DR: D.Rk.,  DRD: DR.Dest
F:Fix,  L:Long,  LA:Lat
P: LOP,  RF: Run.Fix
B/D/DR/DRD/F/L/LA/P/RF D

Lat.?       -36.51
Long.?      -174.46
Time Zone? -12
  D
 -36.510
-174.460
-12
Correct? Yy


WHICH BODY? MoonU
Long= 264 D  53.5'
R.A.= 17 H 38 M 15.3 S
GHA = 185 D   7.7'
SHA =  95 D  26.2'
Dec.= -20 D  12.6'
Prev.Day
Body Rises 16 H  58.0 M
Azimuth =   115.6
Mer. Pass  0 H  16.1 M
Body Sets  7 H  34.2 M
Azimuth =   244.4
Another Body? Yn

Choose: DR:Dead Reck.
DRD:DR.Dest.  F:Fix
M:Mo Sights   LA:M.Lat
  RF:Run.Fix
S:Start,T:Tel.,N:None
DR/DRD/F/M/LA/RF/S/T/N ?n

PAU
```

"Extra" used in routine "D".

Here we want to observe the Andromeda Galaxy known as M-31. We find the coordinates and they are entered. Routine "D" finds when it rises, is on the meridian and sets.

Then using routine "B" we enter the data at the GMT selected, here 8 hr. and it tells its Hc, Azimuth, Hour Angle in Hrs. and Min. also in Degrees and Minutes.

NOTE:
It is possible to make entries with either Rt. Asc. or SHA. When Rt. Asc. is not known, enter 0 and prgm will prompt for the SHA.

See examples on the right.

Routine "D"

```
Year?      1984
Month Nr.? 11
Day ?      1
LOG/Place? Honolulu

 1984
 11
 1
Honolulu
Correct? Yy

Choose: B:Bodies,D: Day
DR: D.Rk.,  DRD: DR.Dest
F:Fix,  L:Long,  LA:Lat
P: LOP,  RF: Run.Fix
B/D/DR/DRD/F/L/LA/P/RF D

Lat.?      21.17
Long.?     157.51
Time Zone? 10
  D
  21.170
 157.510
 10
Correct? Yy

WHICH BODY?
REENTER
WHICH BODY? Extra
Name ?  M-31
Rt.Asc.? .4154
DEC ?    41.11
Correct? Yy

Body Rises 15 H   8.2 M
Azimuth =    45.0
Mer. Pass  22 H  31.4 M
Body Sets  5 H  54.6 M
Azimuth =   315.0
Another Body? Ys

Choose: DR:Dead Reck.
DRD:DR.Dest.  F:Fix
M:Mo Sights   LA:M.Lat
  RF:Run.Fix
S:Start,T:Tel.,N:None
DR/DRD/F/M/LA/RF/S/T/N ?s
```

Routines "B" & "T"

```
Year?      1984
Month Nr.? 11
Day ?      1
LOG/Place? Honolulu

 1984
 11
 1
Honolulu
Correct? Yy

Choose: B:Bodies,D: Day
DR: D.Rk.,  DRD: DR.Dest
F:Fix,  L:Long,  LA:Lat
P: LOP,  RF: Run.Fix
B/D/DR/DRD/F/L/LA/P/RF B

Lat.?      21.17
Long.?     157.51
G.M.T.?    8
  B
  21.170
 157.510
  8
Correct? Yy

Name ?  M-31
Rt.Asc.? 0
DEC ?    41.11
SHA ?    349.315
Correct? Yy

HC =   69 D   6.4'
Azimuth =     16.1
  H.A.=  0 H  30.1 M
  H.A.=  7 D  31.8'
Dec.=  41 D  11.0'

Choose: DR:Dead Reck.
DRD:DR.Dest.  F:Fix
M:Mo Sights   LA:M.Lat
  RF:Run.Fix
S:Start,T:Tel.,N:None
DR/DRD/F/M/LA/RF/S/T/N ?T

  H.A.=  0 H  30.1 M
  H.A.=  7 D  31.8'
Dec.=  41 D  11.0'

Choose: DR:Dead Reck.
DRD:DR.Dest.  F:Fix
M:Mo Sights   LA:M.Lat
  RF:Run.Fix
S:Start,T:Tel.,N:None
DR/DRD/F/M/LA/RF/S/T/N ?N
```

PAU

This is from Mixter's PRIMER OF NAVIGATION
3rd Revised Edition. Revised by R.O. Williams
Solutions of the sights begins on page 16

30. DAYS WITH THE SUN

THE daily return of the sun to outshine the stars during half the hours of the year makes it the most often observed navigational body. Throughout each day it gives lines of position when visibility permits. It is the best of bodies for finding the compass error and is the natural measure of time. The navigator in turn must not only be able to determine a line of position from the sun but should understand the when and where of the sun's position and how best to utilize the various services of this great luminary.

Sun sights today give a line of position whenever the sun can be observed, in contrast to the limitations of the old navigation with its time sights for longitude and the noon sight for latitude. One method serves to work all sights, although surface navigators using the noon sight generally work it as a meridian altitude. Observing altitudes, the methods for working sights and plotting lines of position have been discussed in previous chapters. The purpose of this chapter is to further develop the various uses of the sun.

3001. A day at sea. The navigator at sea takes the sun in the morning, at noon, and should take it again in the afternoon as a further check of his longitude. Such a day with the sun is illustrated in Fig. 3001*a* which shows the plotting of problem P 1-30 as stated at the close of this chapter. The ship's position shortly before six in the morning is given. The problem, briefly stated, is to find its position at ten minutes after 3 P.M. To this end no two navigators would take exactly the same steps, and the work required in the detailed statement of the problem should be regarded as the minimum for a day with the sun.

The navigator's first step for the day was to observe Polaris at about 0550. Details of sight are found in Fig. 3001*b*. The latitude so found was 1′.8 south of the 0550 D.R. At 0840, the horizon having cleared, the sun was observed about 24° high. A detailed statement of this sight is given in (*c*) of P 1-30. After working the sight by H.O. 214, as in Fig. 3001*c*, the 0840 sun line was plotted and the Polaris line was advanced for the 0840 R. Fix shown on the plotting sheet. The dead reckoning, how[redacted]ever, was [redacted]ed f[redacted]rd f[redacted]he [redacted]D.R[redacted]l fu[redacted] inf[redacted]ion might warrant a move to the westward. After taking the noon sight at 1233, (Fig. 3001*d*) the 0840 sun line was advanced for a cross with the noon latitude line. The position so found apparently confirmed the error in the D.R. indicated at 0840. Accordingly the navigator shifted the course line to take departure from the 1233 R. Fix.

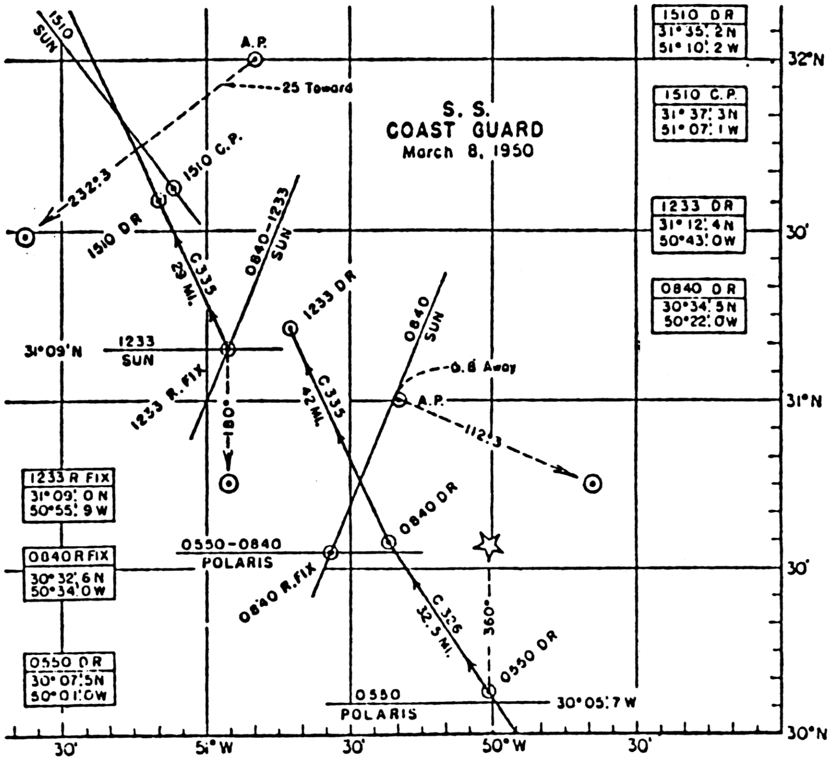
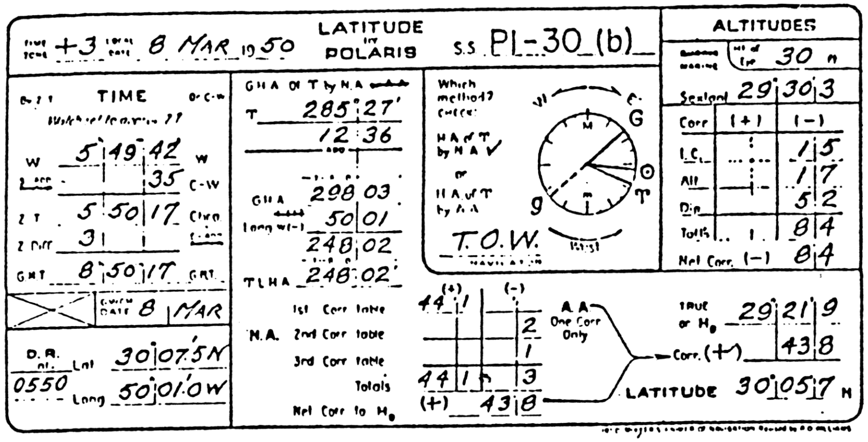


FIG. 3001*a*. A DAY WITH THE SUN.

The afternoon sun was taken at about 1510 for fear that clouds would prevent a later observation. The sight; worked by H.O. 214 as in Fig. 3001*e*, gave the 1510 sun line on which a perpendicular from the 1510 D.R. marked the most probable position of the ship at 1510 or 3:10 P.M. Details of the afternoon sight are given in (*g*) of P 1-30 and its solution is illustrated in Fig. 3001*e*.

To study the work discussed above, first read problem P 1-30, then again read the problem and note how every step is plotted. Having p
tured the situation, prepare a plotting sheet and work the proble
yourself in all its details. The student may work the sights fo
position by whatever method he is studying. As plotted in t



LATITUDE BY POLARIS S.S. PI-30 (b)

Time zone +3 Local date 8 MAR 19 50

TIME

W 5 49 42 W

C-W 35

Z.T. 5 50 17

Z Diff 31

GMT 8 50 17

Date 8 MAR

D.R. Lat 30 07.5 N

0550 Long 50 01.0 W

GHA of T by N.A.

T 285 27'

12 36

GHA 298 03

Long W(-) 50 01

248 02

TLHA 248 02

N.A. 1st Corr table, 2nd Corr table, 3rd Corr table, Totals, Net Corr to H_o

(+) 44 1 (−) 2 1 3; 44 1 3; (+) 43 8

A.A. One Corr Only

T.O.W.

ALTITUDES

Ht of Eye 30 ft

Sextant 29 30 3

I.C. (−) 1 5

Alt (−) 1 7

Dip (−) 5 2

Totals 1 8 4

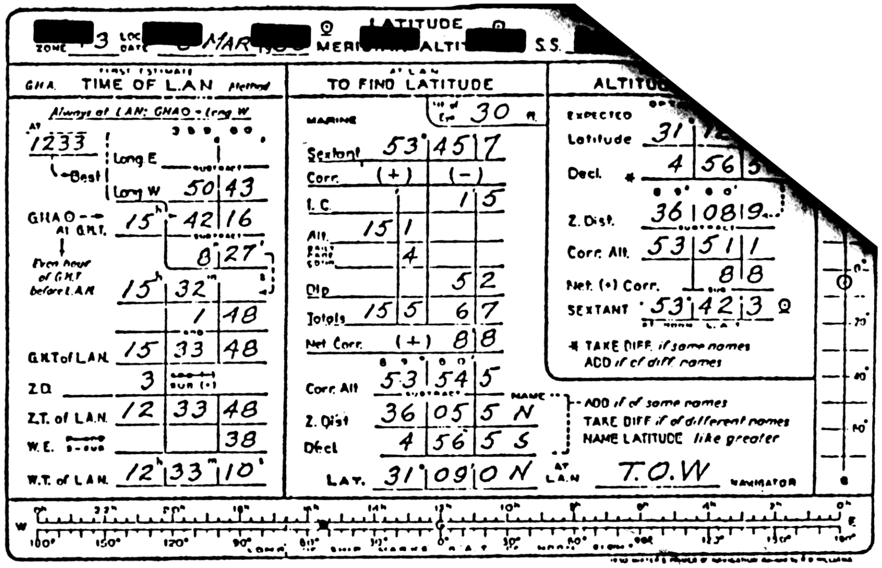
Net Corr. (−) 8 4

True or H_o 29 21 9

Corr. (+) 43 8

LATITUDE 30 05 7 N

Fig. 3001*b*. Polaris Sight.



ZONE [redacted] +3 LOC DATE [redacted] MAR [redacted] ⊙ LATITUDE ⊙ MERI[redacted]ALTI[redacted] S.S. [redacted]

TIME OF L.A.N.

Always at L.A.N.: GHAO = Long W

1233 Best; Long E; Long W 50 43

GHAO At G.M.T. 15h 42 16

8 27

Even hour of GMT before LAN 15h 32m

1 48

GMT of LAN 15 33 48

Z.D. 3

Z.T. of L.A.N. 12 33 48

W.E. 38

W.T. of L.A.N. 12h 33m 10s

TO FIND LATITUDE

Ht of Eye 30 ft

Sextant 53 45 7

I.C. (−) 1 5

Alt. 15 1

4

Dip (−) 5 2

Totals 15 5 6 7

Net Corr. (+) 8 8

Corr. Alt 53 54 5

Z. Dist 36 05 5 N

Decl 4 56 5 S

LAT. 31 09 0 N at L.A.N. T.O.W. Navigator

ALTITUDE

Expected Latitude 31

Decl. 4 56 5

Z. Dist. 36 08 9

Corr. Alt. 53 51 1

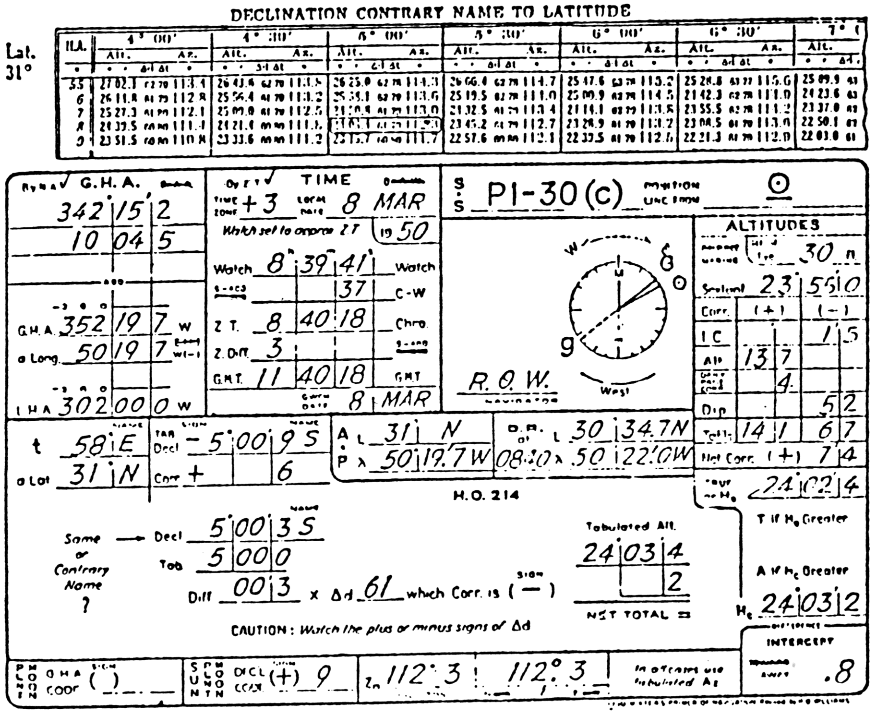
Net (+) Corr. 8 8

SEXTANT 53 42 3 ⊙

* TAKE DIFF. if same names, ADD if of diff. names

ADD if of same names, TAKE DIFF if of different names, NAME LATITUDE like greater

Fig. 3001*d*. Meridian Altitude.



DECLINATION CONTRARY NAME TO LATITUDE

Lat. 31°

S P1-30 (c) ⊙

G.H.A. 342 15 2; 10 04 5

G.H.A. 352 19 7 W

a Long. 50 19 7

L.H.A. 302 00 0 W

TIME: Time zone +3 Local date 8 MAR 19 50

Watch 8 39 41; C-W 37; Z.T. 8 40 18; Z. Diff 3; G.M.T. 11 40 18; 8 MAR

R.O.W. Navigator

ALTITUDES: Ht of eye 30 ft; Sextant 23 55 0; I.C. (−) 1 5; Alt 13 7; 4; Dip (−) 5 2; Totals 14 1 6 7; Net Corr. (+) 7 4; True H_o 24 02 4

t 58 E; a Lat 31 N

Tab Decl − 5 00 9 S; Corr + 6

A L 31 N; P λ 50 19.7 W

D.R. L 30 34.7 N; 08:20 λ 50 22.0 W

H.O. 214

Same or Contrary Name? Decl 5 00 3 S; Tab 5 00 0; Diff 00 3 x Δd 61 which Corr. is (−)

Tabulated Alt. 24 03 4; 2; NET TOTAL; H_c 24 03 2

T if H_o Greater; A if H_c Greater

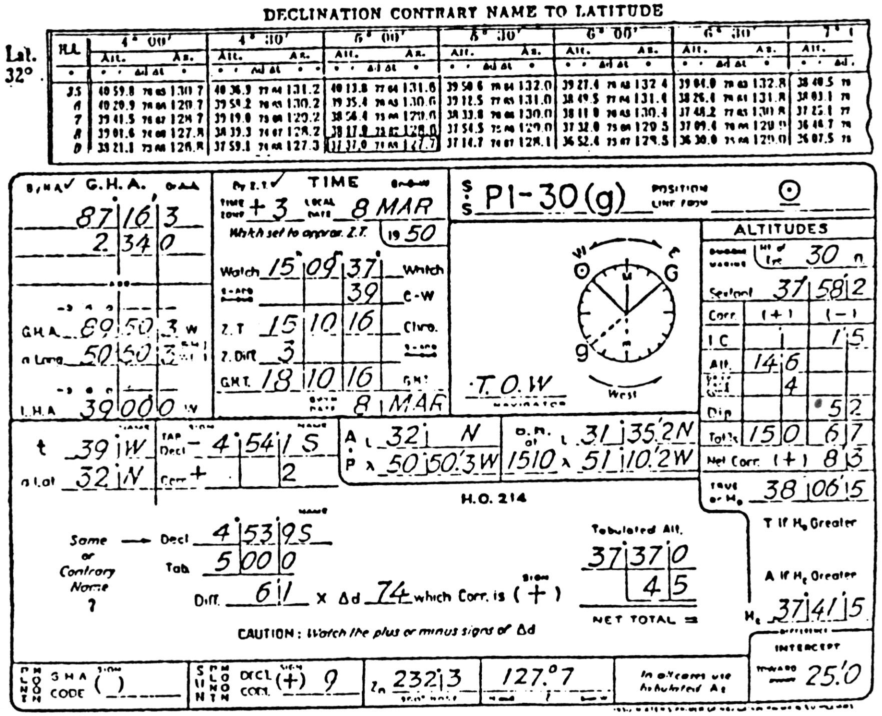
CAUTION: Watch the plus or minus signs of Δd

Decl Corr (+) 9; Z_n 112 3; 112° 3

In all cases use tabulated Az

INTERCEPT Away .8

Fig. 3001*c*. Morning Sun.



DECLINATION CONTRARY NAME TO LATITUDE

Lat. 32°

S P1-30 (g) ⊙

G.H.A. 87 16 3; 2 34 0

G.H.A. 89 50 3 W

a Long 50 50 3

L.H.A. 39 00 0 W

TIME: Time zone +3 Local date 8 MAR 19 50

Watch 15 09 37; C-W 39; Z.T. 15 10 16; Z. Diff 3; G.M.T. 18 10 16; 8 MAR

T.O.W. Navigator

ALTITUDES: Ht of eye 30 ft; Sextant 37 58 2; I.C. (−) 1 5; Alt. 14 6; 4; Dip (−) 5 2; Totals 15 0 6 7; Net Corr. (+) 8 3; True H_o 38 06 5

t 39 W; a Lat 32 N

Tab Decl − 4 54 1 S; Corr + 2

A L 32 N; P λ 50 50.3 W

D.R. L 31 35.2 N; 1510 λ 51 10.2 W

H.O. 214

Same or Contrary Name? Decl 4 53 9 S; Tab 5 00 0; Diff. 6 1 x Δd 74 which Corr. is (+)

Tabulated Alt. 37 37 0; 4 5; NET TOTAL; H_c 37 41 5

T if H_o Greater; A if H_c Greater

CAUTION: Watch the plus or minus signs of Δd

Decl Corr (+) 9; Z_n 232 3; 127° 7

In all cases use tabulated Az

INTERCEPT Toward 25.0

Fig. 3001*c*. Afternoon Sun.

tion the morning and afternoon sights were worked with H.O. 214 plotted from the A.P. at time of sight. Other methods will give practically the same lines.

In a textbook, problems in practical work must be punctuated with answers including the various D.R., A.P. and other positions. Thus it rests with both students and teachers to see that the plotting work is not neglected. Or any practical work series may be turned into a pure plotting problem by considering the results of working the sights as given data.

* * *

The work thus far discussed, and that found in problems P 2-30 and P 3-30 which are of similar scope, represents the minimum commonly required to complete junior courses in surface navigation. The following sections recite various other doings and uses of the sun of interest to navigators young and old.

3002. To best use the sun one should have some understanding of the altitudes and azimuths of that body to be expected during the coming day. Often the navigator must consider the time when the sun's altitude will afford a good first sight or when the sun will bear true east, the possibilities for a running fix, the maximum altitude at noon, and when conditions are favorable for swinging ship by the sun.

At sea, the navigator's knowledge of what the sun did yesterday is often sufficient to answer such questions as may arise. More exact answers require consideration of both the altitude and the azimuth of the sun. These quantities vary according to the sun's declination as determined by the date, the observer's latitude, and the local time of day.*

Altitudes of the sun. Observed from the equator when its declination is 0, the sun will rise at six o'clock and increase its altitude 15° each hour to a maximum of 90° at noon. Practically, this exact situation never occurs and the rise per hour, never exceeding 15°, will be greatest immediately after sunrise and least around noon. The difference in rate of rise is slight within the tropics, but from high latitudes while the sun hangs low at noon there is almost no change in altitude. If seen from either pole the sun would be visible throughout the entire 24 hours of the day with no perceptible change in altitude.

The sun's azimuth behaves in a reverse manner. To an observer at either pole, the sun, when visible, would appear to swing westward at a rate of 15° each hour. As one moves toward the equator it swings slower at sunrise and faster in midday. In the tropics the change in the sun's bearing may be slight until long after sunrise but may change very rapidly at noontime. The bearing of the sun is important to navigators for several reasons. It is used every day for compass correction and for plotting Sumner lines. It determines whether a line of position checks longitude, latitude, course, or speed (§1511). Less well understood are the opportunities for a running fix, or possibly a fix, which results from changes in the sun's azimuth as it swings westward.

Both the altitude and azimuth of the sun for any given declination, latitude and time may be read directly from H.O. 214. The H.A. column of the tables is entered with the hours and minutes of apparent time before or after noon, converted into arc, i.e. with the sun's meridian angle (*t*). Mariners, however, more often use a regular azimuth table when seeking a picture of prospective changes in the sun's azimuth or when swinging ship by the sun.

3003. Sunrise and sunset, as presently discussed, are the instants when the upper edge of the sun appears above or disappears below the sea horizon. The approximate times of these events may be taken from the almanacs.

In the *Nautical Almanac*, daily data section, is found Sunrise and Sunset *in various latitudes* for each day of the year. Simple interpolation between the latitude listings gives the minute of sunrise or sunset from 0° to 70° N or 60° S. Thus little more than an inspection of the tables gives L.M.T. of sunrise or sunset. For excerpts from these tables see Fig. 3210.

The *Air Almanac*, on each daily sheet, tabulates the L.M.T. of sunrise and sunset for the day in latitudes from 70° N to 60° S, from which the minute of these events may be interpolated by inspection. See Appendix VI.

3004. The sun does not rise true east except when its declination is 0 as when on the equator about March 21 and September 21. When the sun is north of the equator it will rise north of east in any latitude. When south of the equator it rises south of east. From a latitude of 60° the sun will rise 51° north of east about June 21 and 51° south of east about December 21. On the same dates, to an observer in latitude 40° the bearings of sunrise will be 31° from east, a figure which becomes 27° when the observer is in 30° N or S.

To check a small boat's compass by the bearing of sunrise or sunset requires an azimuth table except in the tropics. When within 30° of the equator, the bearing of the rising sun N or S of true east equals the sun's declination N or S of the equator, with a possible error of about ¼ point or less than 4° in extreme cases. Note that this gives a true bearing which must be corrected to magnetic by applying the local vari[illegible] before comparison with the compass reading.

---

* Many of the broad statements in this and following sections are made without reference to the effects of refraction, the equation of time, hourly change in declination, the sun's semidiameter, and differing definition of the exact time of sunrise, sunset, and twilight.

NAVIGATION ROUTINES "P",L.O.P. and "DRD"

On this and the next six pages are samples of a day's work at sea taken from Mixter's "PRIMER OF NAVIGATION". It starts with a dawn sight of POLARIS using routine "P" to find an L.O.P. and M.P.P.(Most Probable Position).The M.P.P. Latitude is the same as that which would be found with POLARIS by conventional means.

Please note the method of making entries: Degrees minutes and tenths (not seconds) are used.
So the sextant reading of 30°07.5' is entered as 30.075.
Time of 8 hr 50min 17sec is entered as 8.5017.

To the left is the L.O.P. and M.P.P. of POLARIS and below the routine "DRD" finds the distance from the M.P.P. to Hamilton, Bermuda (destination) at Lat. 32°15' N Long 64°50' W.

```
Year?       1950
Month Nr.? 3
Day ?       8
LOG/Place? Atlantic Oc.

 1950
 3
 8
Atlantic Oc.
Correct? Yy

Choose: B:Bodies,D: Day
DR: D.Rk.,  DRD: DR.Dest
F:Fix,  L:Lonq,  LA:Lat
P: LOP,  RF: Run.Fix
B/D/DR/DRD/F/L/LA/P/RF P

Lat.?       30.075
Long.?      50.01
G.M.T.?     8.5017
Sext.Alt?   29.303
Ht. Eye?    30
Ind.Corr.? -1.5
   P
   30.075
   50.010
   8.5017
   29.303
   30
  -1.5
Correct? Yy


WHICH BODY? Star
Star # or Name
Star #? 58
 58 POLARIS
Delay?  0

HC =   29 D  23.3'
HO =   29 D  21.8'
Mi. Away =     1.5
Azimuth =       .7
 M.P.P.:
LAT =   30 D   6.0'
LONG=   50 D   1.0'

Choose: DR:Dead Reck.
DRD:DR.Dest.   F:Fix
M:Mo Sights    LA:M.Lat
  RF:Run.Fix
S:Start,T:Tel.,N:None
DR/DRD/F/M/LA/RF/S/T/N ?DRD
```

```
Lat.?       30.06
Long.?      50.01
Dest?
Lat.?       32.15
Long.?      64.50
Correct? Yy

Tr. Co.=  279.6
 Dist.=  771.5 NMi.

Choose: DR:Dead Reck.
DRD:DR.Dest.   F:Fix
M:Mo Sights    LA:M.Lat
  RF:Run.Fix
S:Start,T:Tel.,N:None
DR/DRD/F/M/LA/RF/S/T/N ?n

PAU
```

USING ROUTINES "DR" and "LONG"

Dead Reckoning and Long.

This continues the day's work. First routine "DR" is used to advance the position on the course and distance sailed. After finding the new D.R. Lat and Long. they are used as a basis for the morning sight of the sun's lower limb. In this case the D.R. Lat. is quite accurate since it was advanced from the Lat. found by Polaris. Therefore we use routine "L" to find the Long. at the D.R. Lat.

```
Year?       1950
Month Nr.? 3
Day ?       8
LOG/Place? Atlantic Oc.

 1950
 3
 8
Atlantic Oc.
Correct? Yy

Choose: B:Bodies,D: Day
DR: D.Rk.,  DRD: DR.Dest
F:Fix,  L:Long,  LA:Lat
P: LOP,  RF: Run.Fix
B/D/DR/DRD/F/L/LA/P/RF DR

Lat.?       30.06
Long.?      50.01
Course?     326
NMi. Dist? 32.5
  DR
  30.060
  50.010
  326
  32.5
Correct? Yy

 D.R.:
LAT =  30 D  32.9'
LONG=  50 D  22.1'

Choose: DR:Dead Reck.
DRD:DR.Dest.  F:Fix
M:Mo Sights   LA:M.Lat
  RF:Run.Fix
S:Start,T:Tel.,N:None
DR/DRD/F/M/LA/RF/S/T/N ?n

PAU
```

```
Year?       1950
Month Nr.? 3
Day ?       8
LOG/Place? Atlantic Oc

 1950
 3
 8
Atlantic Oc
Correct? YL
Reenter Data
Year?       1950
Month Nr.? 3
Day ?       8
LOG/Place? Atlantic Oc

 1950
 3
 8
Atlantic Oc
Correct? Yy

Choose: B:Bodies,D: Day
DR: D.Rk.,  DRD: DR.Dest
F:Fix,  L:Long,  LA:Lat
P: LOP,  RF: Run.Fix
B/D/DR/DRD/F/L/LA/P/RF L

Lat.?       30.329
Long.?      50.221
Body in E. or W.?E
G.M.T.?     11.4018
Sext.Alt?   23.55
Ht. Eye?    30
Ind.Corr.? -1.5
  E
  L
  30.329
  50.221
  11.4018
  23.550
  30
 -1.5
Correct? Yy


WHICH BODY? LSunL
SunL
Delay?  0

LONG=  50 D  33.9'
```

USING THE ROUTINES "D.R." and "LA"

When it is approaching local noon the "D.R." is used to advance the morning position, found earlier, to the noon position. After sights of the noon sun are taken, using the highest sextant altitude found, the "LA" routine is used. It gives a good Meridian Latitude and a Meridian Longitude based on the morning Long. is advanced and crossed with the noon Latitude.

This completes the noon work so the 75 C can be turned off and used for something else.

```
Year?       1950
Month Nr.? 3
Day ?       8
LOG/Place? Atlantic Oc

 1950
 3
 8
Atlantic Oc
Correct? Yy

Choose: B:Bodies,D: Day
DR: D.Rk.,  DRD: DR.Dest
F:Fix,  L:Long,  LA:Lat
P: LOP,  RF: Run.Fix
B/D/DR/DRD/F/L/LA/P/RF DR

Lat.?       30.329
Long.?      50.339
Course?     335
NMi. Dist? 42
  DR
  30.329
  50.339
  335
  42
Correct? Yy

 D.R.:
LAT =  31 D  11.0'
LONG=  50 D  54.6'

Choose: DR:Dead Reck.
DRD:DR.Dest.  F:Fix
M:Mo Sights   LA:M.Lat
  RF:Run.Fix
S:Start,T:Tel.,N:None
DR/DRD/F/M/LA/RF/S/T/N ?Ls
```

```
Year?       1950
Month Nr.? 3
Day ?       8
LOG/Place? Atlantic Oc.

 1950
 3
 8
Atlantic Oc.
Correct? Yy

Choose: B:Bodies,D: Day
DR: D.Rk.,  DRD: DR.Dest
F:Fix,  L:Long,  LA:Lat
P: LOP,  RF: Run.Fix
B/D/DR/DRD/F/L/LA/P/RF LA

 Lat.?       31.11
 Long.?      50.546
 Sext.Alt?  53.457
 Ht. Eye?    30
 Ind.Corr.? -1.5
   LA
   31.110
   50.546
   53.457
   30
  -1.5
 Correct? Yy

 WHICH BODY? SunL
 SunL
 Delay?  0

  Meridian:
 LAT =  31 D   9.2'
 Prior Sight:LOP or Long? P,L or NL
 LONG=  50 D  55.4'
```

USING THE ROUTINES "D.R." and "L"

In the afternoon when another sight is to be taken, the "D.R." is used to advance the noon position. Then sights are taken on the sun and one is selected to be used. Since the D.R. Latitude is based on the known noon Latitude it is only necessary to find the Longitude to go with it.

```
Year?       1950
Month Nr.? 3
Day ?      8
LOG/Place? Atlantic Oc

 1950
 3
 8
Atlantic Oc
Correct? Yy

Choose: B:Bodies,D: Day
DR: D.Rk.,  DRD: DR.Dest
F:Fix,  L:Long,  LA:Lat
P: LOP,  RF: Run.Fix
B/D/DR/DRD/F/L/LA/P/RF DR

Lat.?       31.092
Long.?      50.554
Course?     335
NMi. Dist? 29
  DR
  31.092
  50.554
  335
  29
Correct? Yy

 D.R.:
LAT =  31 D  35.5’
LONG=  51 D   9.8’

Choose: DR:Dead Reck.
DRD:DR.Dest.  F:Fix
M:Mo Sights   LA:M.Lat
  RF:Run.Fix
S:Start,T:Tel.,N:None
DR/DRD/F/M/LA/RF/S/T/N ?n

PAU
```

```
Year?       1950
Month Nr.? 3
Day ?      8
LOG/Place? Atlantic Oc

 1950
 3
 8
Atlantic Oc
Correct? Yy

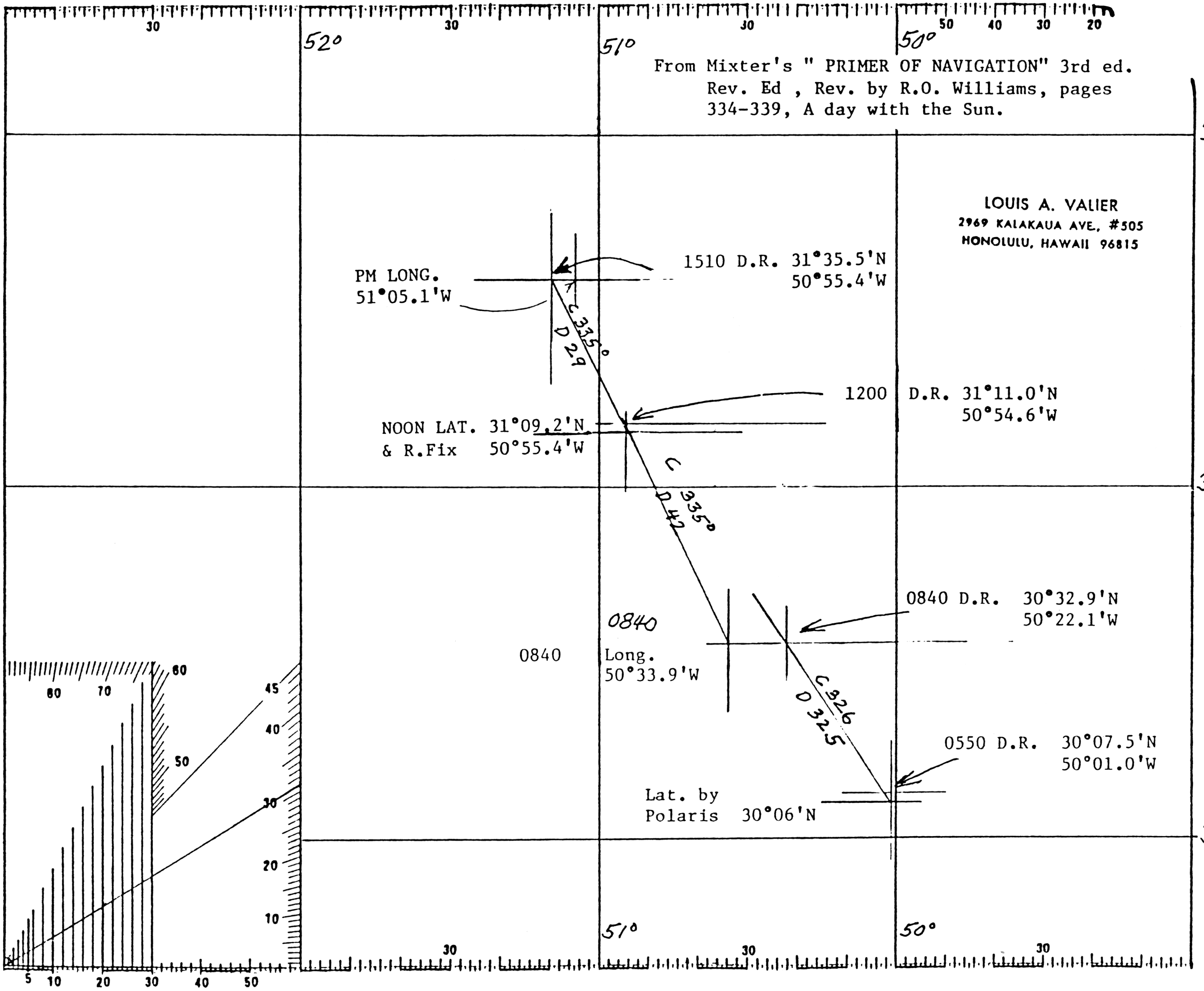
Choose: B:Bodies,D: Day
DR: D.Rk.,  DRD: DR.Dest
F:Fix,  L:Long,  LA:Lat
P: LOP,  RF: Run.Fix
B/D/DR/DRD/F/L/LA/P/RF L

Lat.?       31.355
Long.?      51.098
Body in E. or W.?W
G.M.T.?    18.1016
Sext.Alt?  37.582
Ht. Eye?   30
Ind.Corr.? -1.5
  W
  L
  31.355
  51.098
  18.1016
  37.582
  30
 -1.5
Correct? Yy


WHICH BODY? SunL
SunL
Delay?  0

LONG=  51 D   5.1’

Choose: DR:Dead Reck.
DRD:DR.Dest.  F:Fix
M:Mo Sights   LA:M.Lat
  RF:Run.Fix
S:Start,T:Tel.,N:None
DR/DRD/F/M/LA/RF/S/T/N ?s
```



From Mixter's " PRIMER OF NAVIGATION" 3rd ed.
Rev. Ed , Rev. by R.O. Williams, pages
334-339, A day with the Sun.

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HONOLULU, HAWAII 96815

USING THE ROUTINES "P","D.R." and "R.F."

Here is a good example of these routines with more details on the chart to the right.

```
Year?       1950
Month Nr.? 3
Day ?       8
LOG/Place? Atlantic Oc

 1950
 3
 8
Atlantic Oc
Correct? Yy

Choose: B:Bodies,D: Day
DR: D.Rk.,  DRD: DR.Dest
F:Fix,  L:Long,  LA:Lat
P: LOP,  RF: Run.Fix
B/D/DR/DRD/F/L/LA/P/RF P

Lat.?        30.329
Long.?       50.221
G.M.T.?      11.4018
Sext.Alt?   23.55
Ht. Eye?    30
Ind.Corr.? -1.5
  P
  30.329
  50.221
  11.4018
  23.550
  30
 -1.5
Correct? Yy


WHICH BODY? SunL
SunL
Delay?  0

HC =  24 D  11.6’
HO =  24 D   2.2’
Mi. Away =     9.4
Azimuth =   112.1
 M.P.P.:
LAT =  30 D  36.5’
LONG=  50 D  32.3’

Choose: DR:Dead Reck.
DRD:DR.Dest.  F:Fix
M:Mo Sights   LA:M.Lat
  RF:Run.Fix
S:Start,T:Tel.,N:None
DR/DRD/F/M/LA/RF/S/T/N ?DR
```

```
Lat.?       30.365
Long.?      50.323
Course?     335
NMi. Dist? 71
  DR
  30.365
  50.323
  335
  71
Correct? Yy

 D.R.:
LAT =  31 D  40.8’
LONG=  51 D   7.4’
```

```
 1950
 3
 8
Atlantic Oc
Correct? Yy

Choose: B:Bodies,D: Day
DR: D.Rk.,  DRD: DR.Dest
F:Fix,  L:Long,  LA:Lat
P: LOP,  RF: Run.Fix
B/D/DR/DRD/F/L/LA/P/RF RF

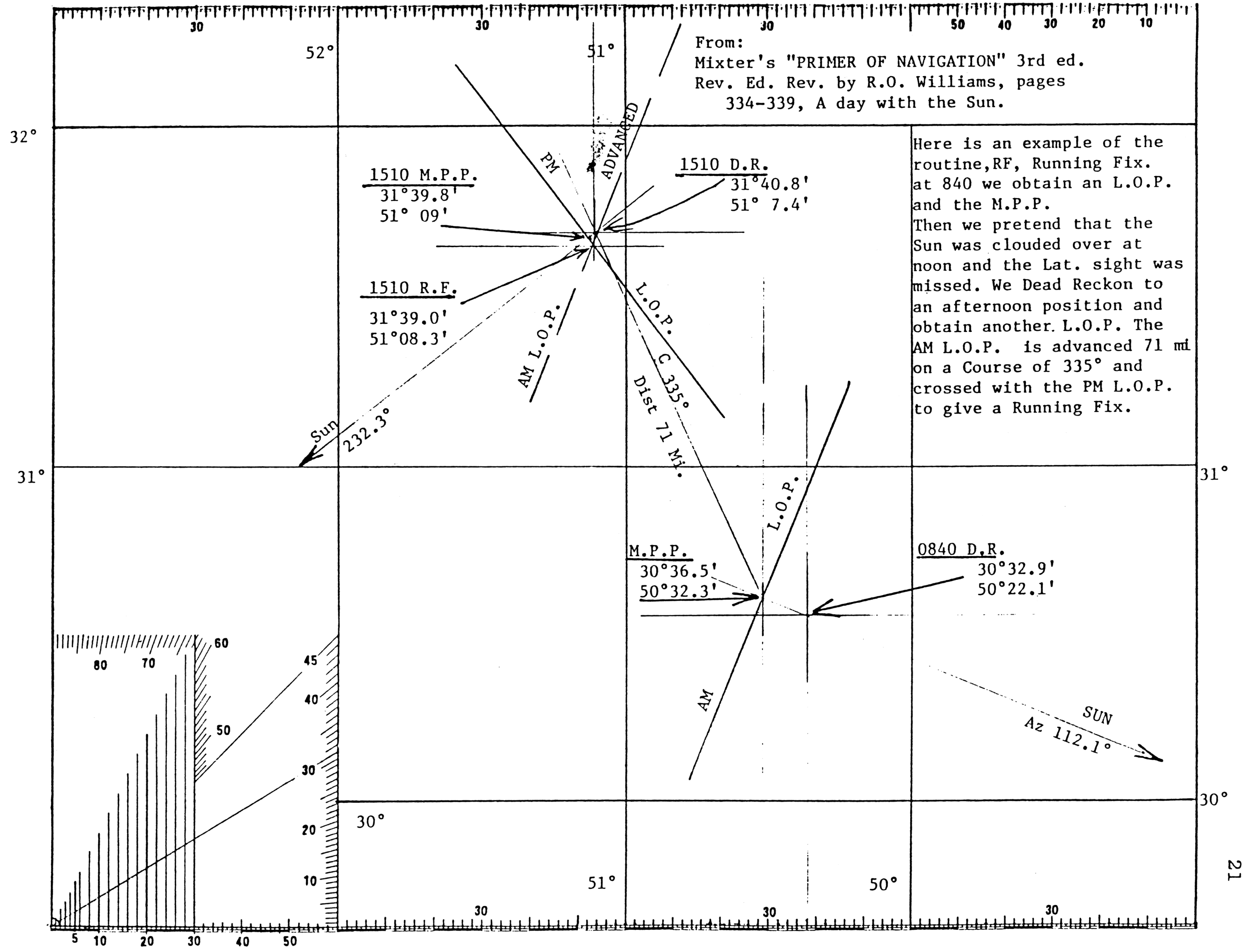
Lat.?       31.408
Long.?      51.074
G.M.T.?     18.1016
Sext.Alt?  37.582
Ht. Eye?   30
Ind.Corr.? -1.5
  RF
  31.408
  51.074
  18.1016
  37.582
  30
 -1.5
Correct? Yy


WHICH BODY? SunL
SunL
Delay?  0

HC =  38 D   4.6’
HO =  38 D   6.3’
Mi.Towards =   -1.7
Azimuth =   232.3
 M.P.P.:
LAT =  31 D  39.8’
LONG=  51 D   9.0’
 RUN FIX AT
LAT =  31 D  39.0’
LONG=  51 D   8.3’

Choose: DR:Dead Reck.
DRD:DR.Dest.  F:Fix
M:Mo Sights   LA:M.Lat
  RF:Run.Fix
S:Start,T:Tel.,N:None
DR/DRD/F/M/LA/RF/S/T/N ?n

PAU
```



From:
Mixter's "PRIMER OF NAVIGATION" 3rd ed.
Rev. Ed. Rev. by R.O. Williams, pages
334-339, A day with the Sun.

Here is an example of the routine, RF, Running Fix. at 840 we obtain an L.O.P. and the M.P.P. Then we pretend that the Sun was clouded over at noon and the Lat. sight was missed. We Dead Reckon to an afternoon position and obtain another. L.O.P. The AM L.O.P. is advanced 71 mi on a Course of 335° and crossed with the PM L.O.P. to give a Running Fix.

Here is another example of the speedy and excellent way this program will solve sights and obtain a fix from the Moon and a planet, Venus. This piece of work was used in the navigation class which I teach in Honolulu. The conventional method of solving the sights is shown on the plotting sheet. The sights are worked out with H.O. 249 Vol. II. Note how closely the Fixes are to each other by the two different methods.

```
Year?       1984
Month Nr.? 10
Day ?       5
LOG/Place? Pacific Oc.

 1984
 10
 5
Pacific Oc.
Correct? Yy

Choose: B:Bodies,D: Day
DR: D.Rk., DRD: DR.Dest
F:Fix, L:Long, LA:Lat
P: LOP, RF: Run.Fix
B/D/DR/DRD/F/L/LA/P/RF p

Lat.?       20.1
Long.?      156.3
G.M.T.?     4.18
Sext.Alt?   32.145
Ht. Eye?    11
Ind.Corr.? 0
  p
  20.100
 156.300
  4.18
  32.145
  11
  0
Correct? Yy

WHICH BODY? MoonU
 MOON
Long= 319 D  27.4'
R.A.= 21 H 34 M 13.4 S
GHA = 114 D  58.5'
SHA =  36 D  26.6'
Dec.= -19 D  47.0'
Delay?  0

HC =  32 D  59.9'
HO =  32 D  41.0'
Mi. Away =   18.8
Azimuth =   131.9
 M.P.P.:
LAT =  20 D  22.6'
LONG=  156 D  44.9'
```

```
Choose: DR:Dead Reck.
DRD:DR.Dest.  F:Fix
M:Mo Sights   LA:M.Lat
  RF:Run.Fix
S:Start.T:Tel..N:None
DR/DRD/F/M/LA/RF/S/T/N ?f

G.M.T.?    4.1930
Sext.Alt?  18.3
Ht. Eye?   11
Ind.Corr.? 0
  f
  20.100
 156.300
  4.193
  18.300
  11
  0
Correct? Yy

WHICH BODY? Venus
 VENUS
Long= 264 D  21.5'
R.A.= 14 H 36 M 33.3 S
GHA = 219 D  46.1'
SHA =  140 D  51.7'
Dec.= -15 D  33.5'
Delay?  0

HC =  18 D  19.1'
HO =  18 D  23.9'
Mi.Towards =
  -4.8
Azimuth =   245.0
 M.P.P.:
LAT =  20 D   8.0'
LONG=  156 D  34.7'
 FIX AT
LAT =  20 D  24.6'
LONG=  156 D  42.9'

Choose: DR:Dead Reck.
DRD:DR.Dest.  F:Fix
M:Mo Sights   LA:M.Lat
  RF:Run.Fix
S:Start.T:Tel..N:None
DR/DRD/F/M/LA/RF/S/T/N ?n

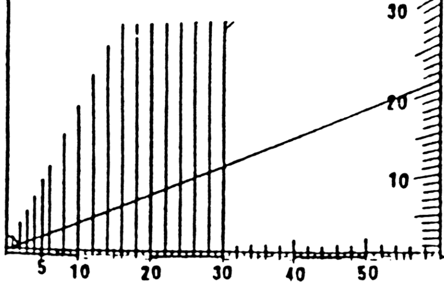
PAU
```

HOMEWORK This is a pair of evening sights: The Upper Limb of the MOON in the S.E. and the other of VENUS low in the S.W. Our text deals with the Moon and gives examples in Chapt. IX starting on page 58. Do not forget to use corrections for Alt. of Moon inside back cover of Naut. Almanac. Planets are covered in Chapt. VIII starting on page 50. from CELESTIAL NAVIGATION BY H.O.249 by Milligan

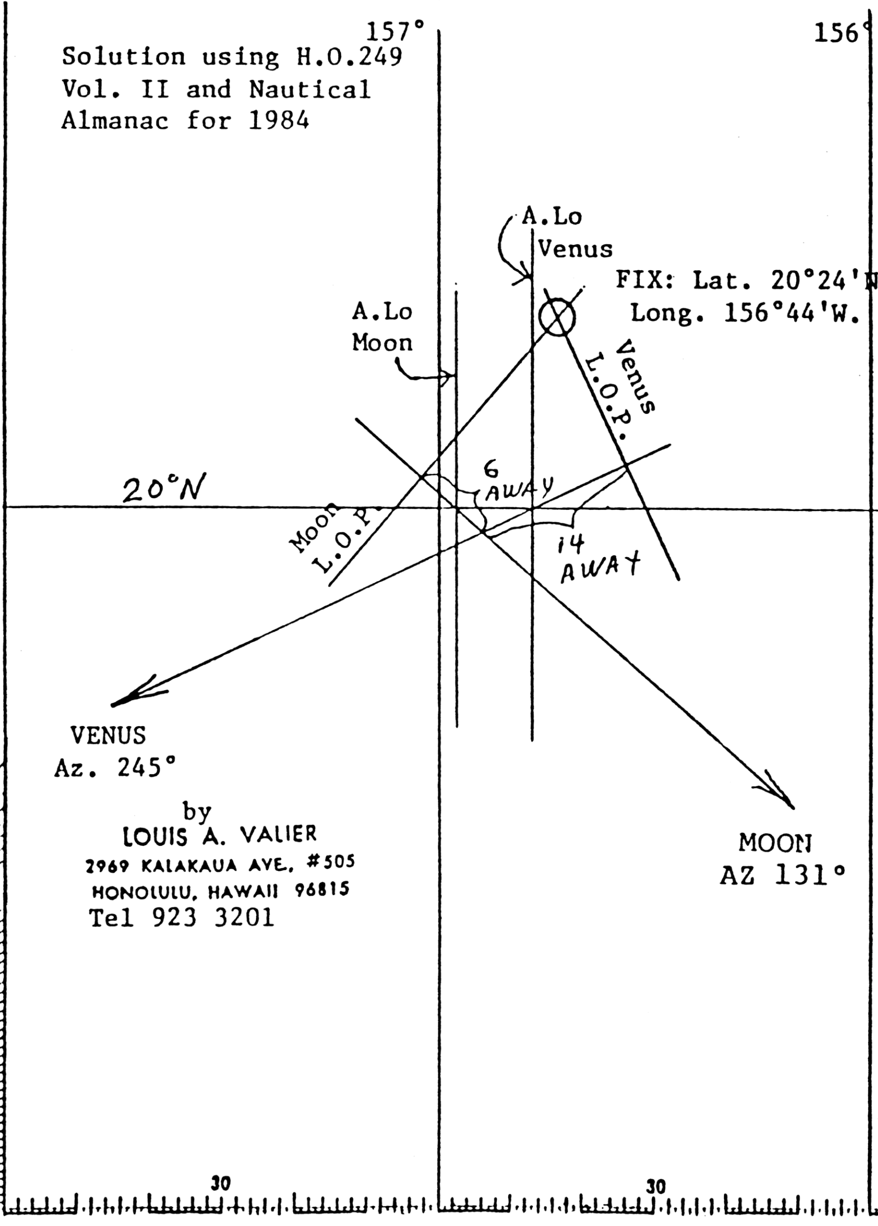
It is the evening of Oct. 4/5 at D.R. Lat. 20°10'N., Long. 156°30'W. Index. Corr. 0, H.E. is 11'

MOON

Date in Greenwich	5
Month	Oct
Year	1984
D.R. Lat.	20°10.0'N
D.R. Long	156°30.0'W
H.E.	11.0'
I.C.	0.0
Hs	32° 14.5'
GMT	4h18m00s
Dec @ Hr.	-19°50.0'
"d"	9.3'
DEC	-19° 47'
GHA @ Hr.	110°35.8'
"v"	13.0'
GHA	114°57.5'
Ass'd Long	156°57.5'
LHA	318°
Ass'd Lat	20°N
Hc	32°47'
Ho	-32°41'
Miles Away	6
Azimuth	131°



Solution using H.O.249
Vol. II and Nautical
Almanac for 1984



FIX: Lat. 20°24'N.
Long. 156°44'W.

by
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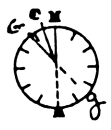
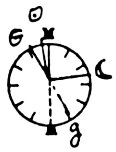
HONOLULU, HAWAII 96815
Tel 923 3201

20° N.

VENUS

Hs	18°30.0'
GMT	4h19m30s
Dec @ Hr.	-15°32.8'
"d"	-1.1
DEC	-15°33.2'
GHA @ Hr.	214°54.5'
"v"	-0.5'
GHA	219°46.8'
Ass'd Long	156°46.8'
LHA	63°
Ass'd Lat	20° N
Hc	18°38'
Ho	-18°24'
Miles Away	14
Azimuth	245°





Cus. ____________
Spd. ____________

BODY	☉	☾
DR L	33° 02'.8 N	33° 02'.8 N
DR λ	34° 05'.0 E	34° 05'.0 E
DATE (L)	25 APR. 69	25 APR 69
W		
WE		
ZT	13-01-26	12-55-43
ZD (+ or −)	(−) 2	(−) 2
GMT	11-01-26	10-55-43
DATE (G)	25 APR. 69	25 APR 69
v		13'.0
Tab. GHA	345° 30'.6	228° 02'.0
GHA incr'm't	21'.5	13° 17'.7
v corr./SHA		12'.0
GHA	345° 52'.1	241° 31'.7
aλ	34° 07.9 E	34° 28'.3 E
LHA	20° 00'.0	276° 00'.0
t (H.A.)	20° W	84° E
d (+ or −)	(+) 0'.8	(−) 10'.3
Tab. Dec.	13° 12'.7 N	21° 01'.6 N
d corr.	0'.0	(−) 9'.5
Dec.	13° 12'.7 N	20° 52'.1 N
H.P. ☾	+ −	+ 54'.9 −
IC	0	0
Dip (Ht 38 ')	(−) 6'.0	(−) 6'.0
Sum	(−) 6'.0	(−) 6'.0
hs	62° 53'.1	15° 19'.7
ha	62° 47'.1	15° 13'.7
Refr. Corr.	(−) 0'.5	(+) 62'.8
L/U ☾ ☉/♀ ♂	(+) 15'.9	(+) 1'.7 (−) 30'.0
TB (ha < 10°)		
Sum	+ 15'.9 (−) 0'.5	+ 64'.5 (−) 30'.0
Corr.	(+) 15'.4	(+) 34'.5
ha	62° 47'.1	15 13'.7
Ho	63° 02'.5	15 48.2
Dec. Diff.	12.7	7'.9
Δd (+ or −)	(+) .78	(−) .5
ht (Alt.)	62° 55'.5	16° 05'.0
corr.	(+) 9'.9	(−) 4'.0
Hc	63° 05'.4	16° 01'.0
Ho	63° 02'.5	15° 48'.2
a	A 2.9	A 12'.8
Az (see L & t)	N 132°.9 W	N 075°.1 E
Zn	227°.1	075°.1
aL	33° 00'.0 N	33° 00'.0 N
aλ	34° 07'.9 E	34 28'.3 E

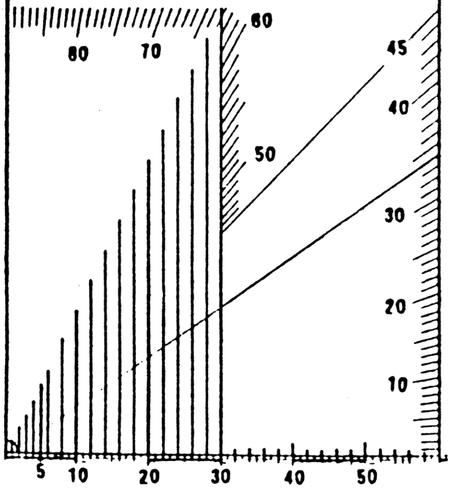
Celestial Navigation Sight Worksheet.

```
Year?        1969
Month Nr.? 4
Day ?        25
LOG/Place? East Long.

 1969
 4
 25
East Long.
Correct? Yy

Choose: B:Bodies,D: Day
DR: D.Rk.,  DRD: DR.Dest
F:Fix,  L:Long,  LA:Lat
P: LOP,  RF: Run.Fix
B/D/DR/DRD/F/L/LA/P/RF p

Lat.?        33.028
Long.?       -34.05
G.M.T.?      11.0126
Sext.Alt?    62.531
Ht. Eye?     38
Ind.Corr.? 0
 p
 33.028
-34.050
 11.0126
 62.531
 38
 0
Correct? Yy
```



```
WHICH BODY? [redacted]
SunL
Delay?  0

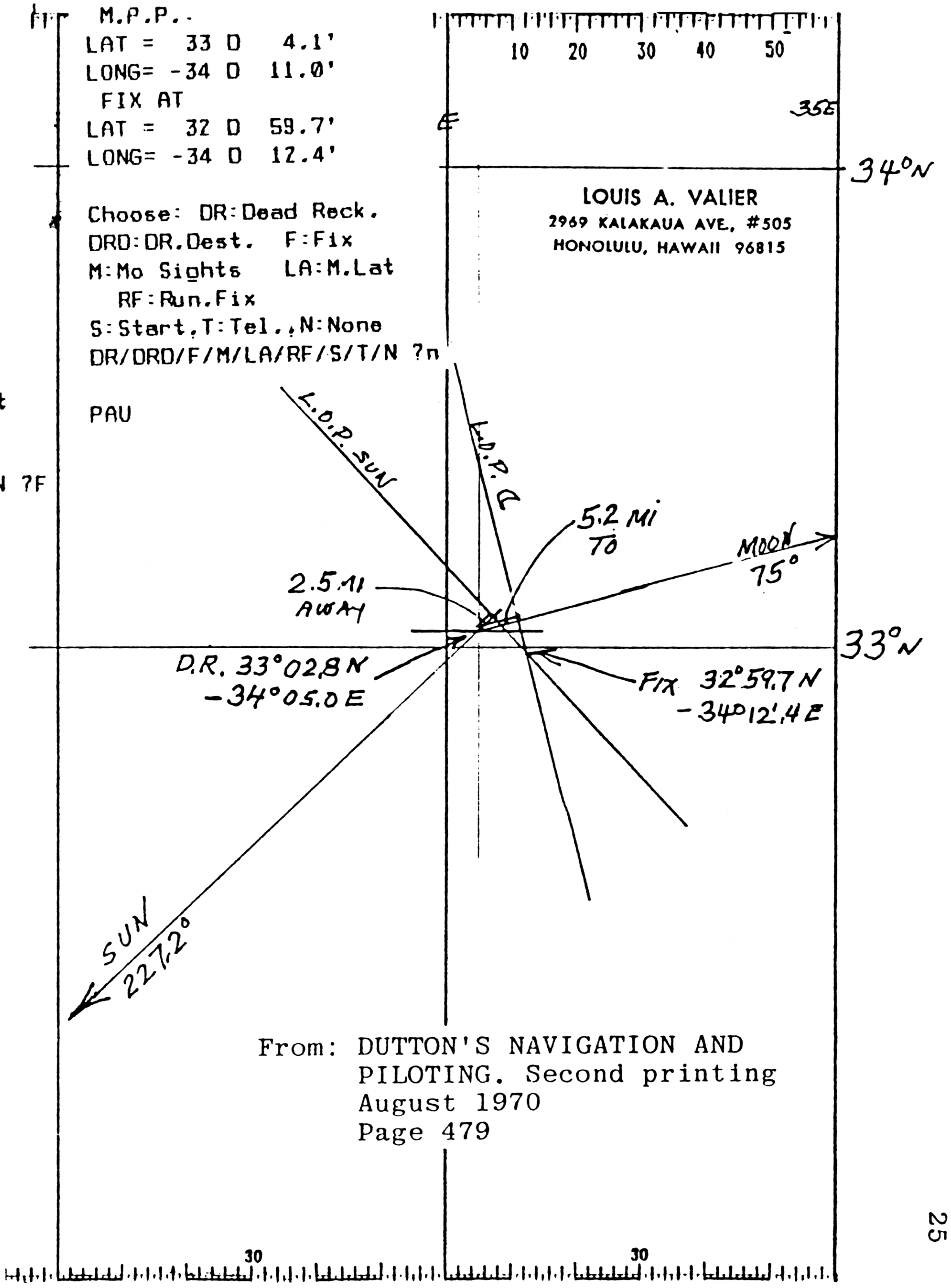
HC =   63 D   5.0'
HO =   63 D   2.5'
Mi. Away =     2.5
Azimuth =   227.2
  M.P.P.:
LAT =   33 D   4.5'
LONG= -34 D   7.1'

Choose: DR:Dead Reck
DRD:DR.Dest.   F:Fix
M:Mo Sights   LA:M.Lat
  RF:Run.Fix
S:Start,T:Tel.,N:None
DR/DRD/F/M/LA/RF/S/T/N ?F

G.M.T.?    10.5543
Sext.Alt?  15.197
Ht. Eye?   38
Ind.Corr.? 0
  F
  33.028
 -34.050
  10.5543
  15.197
  38
  0
Correct? Yy

WHICH BODY? MoonU
 MOON
Long= 132 D   4.0'
R.A.= 9 H 2 M 42.2 S
GHA = 241 D  32.0'
SHA =  224 D  19.4'
Dec.=  20 D  51.8'
Delay?  0

HC =   15 D  43.0'
HO =   15 D  48.2'
Mi.Towards =
  -5.2
Azimuth =    75.0
```



```
M.P.P..
LAT =   33 D   4.1'
LONG= -34 D  11.0'
 FIX AT
LAT =   32 D  59.7'
LONG= -34 D  12.4'

Choose: DR:Dead Reck.
DRD:DR.Dest.   F:Fix
M:Mo Sights   LA:M.Lat
  RF:Run.Fix
S:Start,T:Tel.,N:None
DR/DRD/F/M/LA/RF/S/T/N ?n

PAU
```

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From: DUTTON'S NAVIGATION AND
PILOTING. Second printing
August 1970
Page 479

FINDING A LONG or L.O.P. by TIMING A SUNSET.

Here is an unique way to obtain a Long or L.O.P. by timing when the Lower or Upper Limb of the sun just touches the horizon.If you have never done this it will be fun to try it out. use "0" as Sextant height, Correct Ht. of Eye. Instead of I.C. enter correction from table on page 6 for Temperature and Barom. Pressure. In this case Temp is 75° & Barom is 30.00" This gives a correction of +2.3'

```
Year?       1985
Month Nr.? 2
Day ?       10
LOG/Place? Honolulu

 1985
 2
 10
Honolulu
Correct? Yy

Choose: B:Bodies,D: Day
DR: D.Rk.,  DRD: DR.Dest
F:Fix,  L:Long,  LA:Lat
P: LOP,  RF: Run.Fix
B/D/DR/DRD/F/L/LA/P/RF L

Lat.?       21.171
Long.?      157.506
Body in E. or W.?w
G.M.T.?     4.2405
Sext.Alt?   0
Ht. Eye?    11
Ind.Corr.? 2.3
  L
  21.171
 157.506
  4.2405
   0.000
  11
  2.3
Correct? Yy

WHICH BODY? SunL
SunL
Delay?  0

LONG=  157 D  50.0'

Choose: DR:Dead Reck.
DRD:DR.Dest.  F:Fix
M:Mo Sights   LA:M.Lat
  RF:Run.Fix
S:Start,T:Tel.,N:None
DR/DRD/F/M/LA/RF/S/T/N ?s
```

```
Year?       1985
Month Nr.? 2
Day ?       10
LOG/Place? Honolulu

 1985
 2
 10
Honolulu
Correct? Yy

Choose: B:Bodies,D: Day
DR: D.Rk.,  DRD: DR.Dest
F:Fix,  L:Long,  LA:Lat
P: LOP,  RF: Run.Fix
B/D/DR/DRD/F/L/LA/P/RF p

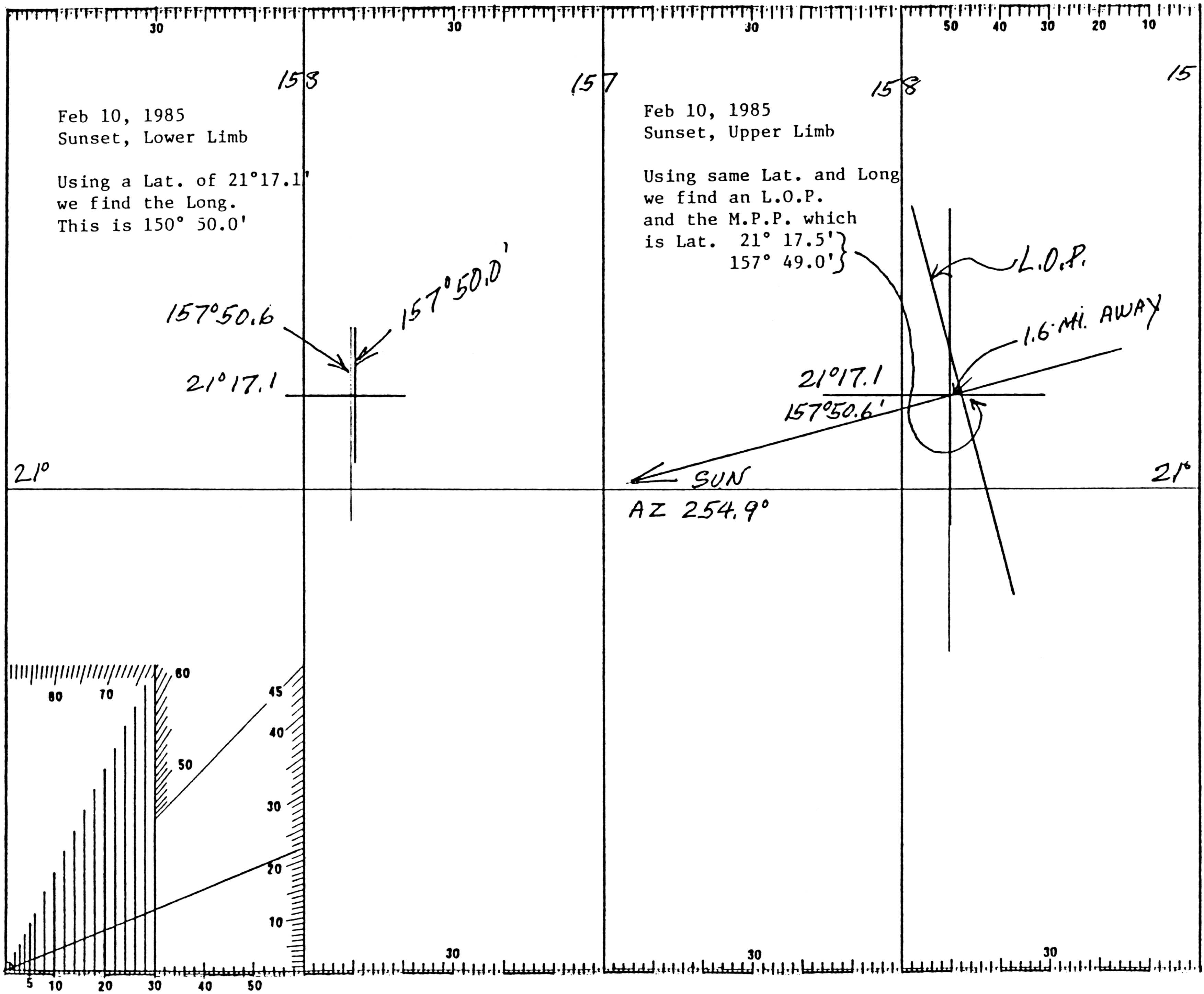
Lat.?       21.171
Long.?      157.506
G.M.T.?     4.2625
Sext.Alt?   0
Ht. Eye?    11
Ind.Corr.? 2.3
  p
  21.171
 157.506
  4.2625
   0.000
  11
  2.3
Correct? Yy

WHICH BODY? SunU
SunU
Delay?  0

HC =  0 D -50.0'
HO =  0 D -51.6'
Mi. Away =    1.6
Azimuth =   254.9
 M.P.P.:
LAT =  21 D  17.5'
LONG=  157 D  49.0'

Choose: DR:Dead Reck.
DRD:DR.Dest.  F:Fix
M:Mo Sights   LA:M.Lat
  RF:Run.Fix
S:Start,T:Tel.,N:None
DR/DRD/F/M/LA/RF/S/T/N ?n

PAU
```



Feb 10, 1985
Sunset, Lower Limb

Using a Lat. of 21°17.1'
we find the Long.
This is 150° 50.0'

Feb 10, 1985
Sunset, Upper Limb

Using same Lat. and Long
we find an L.O.P.
and the M.P.P. which
is Lat. 21° 17.5'
157° 49.0'

Here is a sample of the routine "TIME"

With a key assigned to "TIME$" and the HP 82162A Thermal Printer connected to the HP 75-C it is a simple and efficient way to record times and sights. In this case the sights were taken from our seaside apartment at 67' above sea level. In Honolulu local time is ten hours earlier than GMT, So, although the recorded date and time was Tues May 15 , in Honolulu the GMT time was Wed. 01 hrs GMT.

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```
TUE 05/15/1984 03:25:53
PM


Time? time$
Sext. 44.41
15:40:41  Hs 44.410
Time? time$
Sext. 44.325
15:41:20  Hs 44.325
Time? time$
Sext. 44.12
15:42:49  Hs 44.420
Time? time$
Sext. 43.33
15:45:42  Hs 43.330
Time? time$
Sext. 43.045
15:47:50  Hs 43.045
Time? time$
Sext. 42.51
→ 15:48:43  Hs 42.510
Time? time$
Sext. 42.37
→ 15:49:43  Hs 42.370
```

```
Year?        1984
Month Nr.? 5
Day?         16
LOG/Place? Apt. In HNL

 1984
 5
 16
Apt. In HNL
Correct? Yy
LOG/Place? Apt

 1984
 5
 16
Apt
Correct? Yy

Choose: B:Bodies,D: Day
DR: D.Rk.,   F :Fix
LA:Lat.,     L:Long
P: LOP,   RF: Run.Fix
B/D/DR/F/LA/L/P/RF p

Lat.?        21.158
Long.?       157.494
G.M.T.?      1.4843
Sext.Alt.? 42.51
Ht. Eye?     67
Ind.Corr.? 0
  p
  21.158
 157.494
  1.4843  ←
  42.510
  67
  0
Correct? Yy
```

```
WHICH BODY? SunL
SunL
Delay?  0

HC =   42 D  57.7'
HO =   42 D  57.9'
Mi.Towards =    -.2
Azimuth =    276.8
 M.P.P.:
LAT =  21 D  15.8'
LONG=  157 D  49.6'

Choose: DR:Dead Reck.
F:Fix, M:More Sights
LA:M.Lat. RF:Run.Fix
S:Start,  N:None
DR/F/M/LA/RF/S/None? m

G.M.T.?     1.4943
Sext.Alt.? 42.37
Ht. Eye?    67
Ind.Corr.? 0
  m
  21.158
 157.494
  1.4943  ←
  42.370
  67
  0
Correct? Yy

SunL
Delay?  0

HC =  42 D  43.8'
HO =  42 D  43.9'
Mi.Towards =    -.0
Azimuth =    276.8
 M.P.P.:
LAT =  21 D  15.8'
LONG=  157 D  49.4'
```

Another useful feature of the "TIME" program is that it finds the difference in time between two sights multiplied by speed of vessel gives distance between two sights. Very useful for running fixes.

```
Choose Sext.Sights
Or Time Diffs.
S or T T
1st GMT? 8.2403
2nd GMT? 8.4155
GMT Diff in Hrs=    .298
Knots? 20
NMi Sailed=    5.956
```

"VP"
LOUIS A. VALIER
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HONOLULU, HAWAII 96815

Samples from HP 41 C NAVIGATION PAC

page 12

```
Select Dead Reck.,Y
Otherwise Grt.Circ.
Dead Reck.? Yn
Starting Place
Lat.? 33.3101
Long.?118.385

Dest.
Lat.? 21.16
Long.?157.447
 33.311
 118.385
 21.16
 157.447
Correct? Yy

Co.=     260.6
Dist.= 2,193.8 NMi.

Vs. Rh. Ln. Co.=     250.6
Dist.= 2,209.0 NMi.

GC Plot ?Yn
PAU
```

page 13

```
Select Dead Reck.,Y
Otherwise Grt.Circ.
Dead Reck.? Yn
Starting Place
Lat.?      33.311
Long.?118.385

Dest.
Lat.? 21.16
Long.?157.447
 33.311
 118.385
 21.16
 157.447
Correct? Yy

Co.=     260.6
Dist.= 2,193.8 NMi.

Vs. Rh. Ln. Co.=     250.6
Dist.= 2,209.0 NMi.

GC Plot ?Yy
Long Incr.in Deg or NMi.
Nr.Deg. Long Incr? 0
Nr. NMi.Incr 52

START LAT= 33 d    31.1'
LONG= 118 d    38.5'

Co.=     260.4
Dist.=    52.0 NMi.

Pt. 1 :LAT= 33 d    22.4'
LONG= 119 d    39.9'
```

pages 14 and 15

```
Select Dead Reck.,Y
Otherwise Grt.Circ.
Dead Reck.? Yn
Starting Place
Lat.? 33.311
Long.?118.385

Dest.
Lat.? 21.16
Long.?157.447
 33.311
 118.385
 21.16
 157.447
Correct? Yy

Co.=     260.6
Dist.= 2,193.8 NMi.

Vs. Rh. Ln. Co.=     250.6
Dist.= 2,209.0 NMi.

GC Plot ?Yn
PAU
```

page 16

```
Select Dead Reck.,Y
Otherwise Grt.Circ.
Dead Reck.? Yy

From Pt.  A, with CO.
and Dist. find pt. B

Starting Place
Lat.? 33.311
Long.?118.385
True  Co.? 250.5
Dist./NMi.? 52

 33.311
 118.385
 250.5
 52
Correct? Yy

Dest.
LAT= 33 d    13.7'
LONG= 119 d    37.2'

PAU
```

Samples from HP 41 C NAVIGATION PAC

Pages 18 & 19   Los Angeles to Honolulu

LOUIS A. VALIER
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HONOLULU, HAWAII 96815

5° Increments

```
Select Dead Reck.,Y
Otherwise Grt.Circ.
Dead Reck.? Yn
Starting Place
Lat.? 33.311
Long.?118.385

Dest.
Lat.? 21.16
Long.?157.447
 33.311
 118.385
 21.16
 157.447
Correct? Yy

Co.=    260.6
Dist.= 2,193.8 NMi.

Vs. Rh. Ln. Co.=    250.6
Dist.= 2,209.0 NMi.

GC Plot ?Yy
Long Incr.in Deg or NMi.
Nr.Deg. Long Incr? 5

START LAT= 33 d    31.1'
LONG= 118 d    38.5'

Co.=    260.3
Dist.=    69.0 NMi.

Pt. 1 :LAT= 33 d    19.4'
LONG= 120 d     0.0'

Co.=    258.5
Dist.=   257.0 NMi.

Pt. 2 :LAT= 32 d    28.3'
LONG= 125 d     0.0'

Co.=    255.8
Dist.=   262.6 NMi.

Pt. 3 :LAT= 31 d    24.0'
LONG= 130 d     0.0'

Co.=    253.2
Dist.=   269.3 NMi.

Pt. 4 :LAT= 30 d     6.4'
LONG= 135 d     0.0'

Co.=    250.7
Dist.=   277.0 NMi.

Pt. 5 :LAT= 28 d    34.9'
LONG= 140 d     0.0'

Co.=    248.3
Dist.=   285.8 NMi.

Pt. 6 :LAT= 26 d    49.4'
LONG= 145 d     0.0'

Co.=    246.1
Dist.=   295.4 NMi.

Pt. 7 :LAT= 24 d    49.7'
LONG= 150 d     0.0'

Co.=    244.0
Dist.=   305.6 NMi.

Pt. 8 :LAT= 22 d    35.6'
LONG= 155 d     0.0'

Co.=    242.5
Dist.=   172.3 NMi.

Pt. 9 :LAT= 21 d    16.0'
LONG= 157 d    44.7'

Tot.Dist.= 2,194.0 NMi.
PAU
```

Sample from HP 41 C NAVIGATION PAC

pages 20 & 21   From Los Angeles to Honolulu

384 Mi. Increments

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HONOLULU, HAWAII 96815

```
Select Dead Reck.,Y
Otherwise Grt.Circ.
Dead Reck.? Yn
Starting Place
Lat.? 33.137
Long.?119.372

Dest.
Lat.? 21.16
Long.?157.447
 33.137
 119.372
 21.16
 157.447
Correct? Yy

Co.=    260.3
Dist.= 2,142.6 NMi.

Vs. Rh. Ln. Co.=    250.6
Dist.= 2,156.6 NMi.
```

```
GC Plot ?Yy
Long Incr.in Deg or NMi.
Nr.Deg. Long Incr? 0
Nr. NMi.Incr 384

START LAT= 33 d    13.7'
LONG= 119 d    37.2'

Co.=    258.3
Dist.=   384.1 NMi.

Pt. 1 :LAT= 31 d    55.7'
LONG= 127 d     3.5'

Co.=    254.4
Dist.=   384.1 NMi.

Pt. 2 :LAT= 30 d    12.5'
LONG= 134 d    15.4'

Co.=    250.9
Dist.=   384.1 NMi.

Pt. 3 :LAT= 28 d     6.6'
LONG= 141 d    11.0'

Co.=    247.7
Dist.=   384.1 NMi.

Pt. 4 :LAT= 25 d    40.6'
LONG= 147 d    49.3'

Co.=    244.9
Dist.=   384.1 NMi.

Pt. 5 :LAT= 22 d    57.4'
LONG= 154 d    10.8'

Co.=    117.1
Dist.=   222.6 NMi.

Pt. 6 :LAT= 21 d    16.0'
LONG= 157 d    44.7'

Tot.Dist.= 2,143.0 NMi.
PAU
```

Sample from HP 41 C NAVIGATION PAC
Pages 22 & 23 from Tokyo to Coos Bay

```
Select Dead Reck..Y
Otherwise Grt.Circ.
Dead Reck.? Yn
Starting Place
Lat.? 35.40
Long.?-139.45

Dest.
Lat.? 43.22
Long.?124.12
 35.4
-139.45
 43.22
 124.12
Correct? Yy

Co.=       50.2
Dist.= 4,214.2 NMi.

Vs. Rh. Ln. Co.=      84.1
Dist.= 4,469.7 NMi.

GC Plot ?Yy
Long Incr.in Deg or NMi.
Nr.Deg. Long Incr? 0
Nr. NMi.Incr 336

START LAT= 35 d    40.0'
LONG=-139 d    45.0'

Co.=       51.8
Dist.=    336.1 NMi.

Pt. 1 :LAT= 39 d      7.6'
LONG=-145 d    17.7'

Co.=       55.5
Dist.=    336.1 NMi.

Pt. 2 :LAT= 42 d    17.9'
LONG=-151 d    23.3'

Co.=       59.8
Dist.=    336.2 NMi.

Pt. 3 :LAT= 45 d      6.9'
LONG=-158 d     5.3'

Co.=       64.8
Dist.=    336.2 NMi.

Pt. 4 :LAT= 47 d    30.1'
LONG=-165 d    25.6'

Co.=       70.4
Dist.=    336.2 NMi.

Pt. 5 :LAT= 49 d    22.6'
LONG=-173 d    23.1'

Co.=       76.7
Dist.=    336.2 NMi.

Pt. 6 :LAT= 50 d    40.1'
LONG= 178 d     7.7'

Co.=       83.4
Dist.=    336.2 NMi.

Pt. 7 :LAT= 51 d    18.9'
LONG= 169 d    17.1'

Co.=       90.3
Dist.=    336.2 NMi.

Pt. 8 :LAT= 51 d    17.0'
LONG= 160 d    19.4'

Co.=       97.3
Dist.=    336.2 NMi.

Pt. 9 :LAT= 50 d    34.4'
LONG= 151 d    30.2'

Co.=      103.9
Dist.=    336.2 NMi.

Pt. 10 :LAT= 49 d    13.5'
LONG= 143 d     3.7'

Co.=      110.1
Dist.=    336.2 NMi.

Pt. 11 :LAT= 47 d    17.8'
LONG= 135 d     9.5'

Co.=      115.7
Dist.=    336.2 NMi.

Pt. 12 :LAT= 44 d    52.0'
LONG= 127 d    52.8'

Co.=      119.6
Dist.=    182.3 NMi.

Pt. 13 :LAT= 43 d    22.0'
LONG= 124 d    12.0'

Tot.Dist.= 4,216.5 NMi.
PAU
```

LOUIS A. VALIER
2969 KALAKAUA AVE., #505
HONOLULU, HAWAII 96815

Reverse direction of sample on previous page;
This is from Coos Bay to Tokyo

LOUIS A. VALIER
2969 KALAKAUA AVE., #505
HONOLULU, HAWAII 96815

```
Select Dead Reck.,Y
Otherwise Grt.Circ.
Dead Reck.? Yn
Starting Place
Lat.? 43.22
Long.?124.13

Dest.
Lat.? 35.40
Long.?-139.45
 43.22
 124.13
 35.4
-139.45
Correct? Yy

Co.=     300.8
Dist.= 4,213.6 NMi.

Vs. Rh. Ln. Co.=     264.1
Dist.= 4,469.0 NMi.

GC Plot ?Yy
Long Incr.in Deg or NMi.
Nr.Deg. Long Incr? 0
Nr. NMi.Incr 336

START LAT= 43 d     22.0'
LONG= 124 d     13.0'

Co.=     298.4
Dist.=   336.2 NMi.

Pt. 1 :LAT= 46 d      2.1'
LONG= 131 d      8.9'

Co.=     293.2
Dist.=   336.2 NMi.

Pt. 2 :LAT= 48 d     14.6'
LONG= 138 d     43.1'

Co.=     287.4
Dist.=   336.2 NMi.

Pt. 3 :LAT= 49 d     54.9'
LONG= 146 d     53.0'

Co.=     280.9
Dist.=   336.2 NMi.

Pt. 4 :LAT= 50 d     58.6'
LONG= 155 d     31.4'

Co.=     274.1
Dist.=   336.2 NMi.

Pt. 5 :LAT= 51 d     22.7'
LONG= 164 d     26.3'

Co.=     267.1
Dist.=   336.2 NMi.

Pt. 6 :LAT= 51 d      5.8'
LONG= 173 d     22.6'

Co.=     260.3
Dist.=   336.2 NMi.

Pt. 7 :LAT= 50 d      9.0'
LONG=-177 d     55.1'

Co.=     253.7
Dist.=   336.2 NMi.

Pt. 8 :LAT= 48 d     34.9'
LONG=-169 d     39.4'

Co.=     247.8
Dist.=   336.2 NMi.

Pt. 9 :LAT= 46 d     27.7'
LONG=-161 d     58.6'

Co.=     242.4
Dist.=   336.2 NMi.

Pt. 10 :LAT= 43 d     52.1'
LONG=-154 d     55.9'

Co.=     237.8
Dist.=   336.2 NMi.

Pt. 11 :LAT= 40 d     52.8'
LONG=-148 d     31.0'

Co.=     233.8
Dist.=   336.1 NMi.

Pt. 12 :LAT= 37 d     34.1'
LONG=-142 d     41.0'

Co.=     231.1
Dist.=   181.6 NMi.

Pt. 13 :LAT= 35 d     40.0'
LONG= 220 d     15.0'

Tot.Dist.= 4,215.9 NMi.
PAU
```

Sample problem from BOWDITCH ,AMERICAN PRACTICAL NAVIGATOR VOL. II. page 597 Great Circle and points every 5 degrees from Cape Town to New York City.

LOUIS A. VALIER
2969 KALAKAUA AVE. #505
HONOLULU, HAWAII 96815

```
Select Dead Reck.,Y
Otherwise Grt.Circ.
Dead Reck.? Yn
Starting Place
Lat.? -33.533
Long.?-18.231

Dest.
Lat.? 40.271
Long.?73.494
-33.533
-18.231
 40.271
 73.494
Correct? Yy

Co.=    304.5
Dist.= 6,762.7 NMi.

Vs. Rh. Ln. Co.=    308.9
Dist.= 7,099.5 NMi.

GC Plot ?Yy
Long Incr.in Deg or NMi.
Nr.Deg. Long Incr? 5

START LAT=-33 d    53.3'
LONG=-18 d    23.1'

Co.=    305.4
Dist.=   209.3 NMi.

Pt. 1 :LAT=-31 d    52.0'
LONG=-15 d     0.0'

Co.=    307.6
Dist.=   327.2 NMi.

Pt. 2 :LAT=-28 d    32.4'
LONG=-10 d     0.0'

Co.=    310.0
Dist.=   349.9 NMi.

Pt. 3 :LAT=-24 d    47.5'
LONG=-5 d     0.0'

Co.=    312.1
Dist.=   372.8 NMi.

Pt. 4 :LAT=-20 d    37.7'
LONG= 0 d     0.0'
```

```
Co.=    313.8
Dist.=   394.7 NMi.

Pt. 5 :LAT=-16 d     4.4'
LONG= 5 d     0.0'

Co.=    315.2
Dist.=   413.8 NMi.

Pt. 6 :LAT=-11 d    10.7'
LONG= 10 d     0.0'

Co.=    316.2
Dist.=   428.4 NMi.

Pt. 7 :LAT=-6 d     1.6'
LONG= 15 d     0.0'

Co.=    316.7
Dist.=   436.7 NMi.

Pt. 8 :LAT= 0 d   -43.9'
LONG= 20 d     0.0'

Co.=    316.8
Dist.=   437.7 NMi.

Pt. 9 :LAT= 4 d    35.0'
LONG= 25 d     0.0'

Co.=    316.4
Dist.=   431.3 NMi.

Pt. 10 :LAT= 9 d    47.2'
LONG= 30 d     0.0'

Co.=    315.5
Dist.=   418.4 NMi.

Pt. 11 :LAT= 14 d    45.6'
LONG= 35 d.    0.0'

Co.=    314.2
Dist.=   400.3 NMi.

Pt. 12 :LAT= 19 d    25.0'
LONG= 40 d     0.0'

Co.=    312.6
Dist.=   379.0 NMi.

Pt. 13 :LAT= 23 d    41.5'
LONG= 45 d     0.0'
```

```
Co.=    310.6
Dist.=   356.2 NMi.

Pt. 14 :LAT= 27 d    33.2
LONG= 50 d     0.0'

Co.=    308.3
Dist.=   333.4 NMi.

Pt. 15 :LAT= 30 d    59.7
LONG= 55 d     0.0'

Co.=    305.7
Dist.=   311.6 NMi.

Pt. 16 :LAT= 34 d     1.6
LONG= 60 d     0.0'

Co.=    302.9
Dist.=   291.5 NMi.

Pt. 17 :LAT= 36 d    40.0'
LONG= 65 d     0.0'

Co.=    299.9
Dist.=   273.5 NMi.

Pt. 18 :LAT= 38 d    56.5
LONG= 70 d     0.0'

Co.=    297.2
Dist.=   198.4 NMi.

Pt. 19 :LAT= 40 d    27.1
LONG= 73 d    49.4'

Tot.Dist.= 6,764.0 NMi.
PAU
```

From BOWDITCH Vol. II

1975 Edition

1010. A ship leaves Cape Town bound for New York City. The captain decides to use great-circle sailing from lat. 33°53'.3S, long. 18°23'.1E (near Green Point Light) to near Ambrose Light, lat. 40°27'.1N, long. 73°49'.4W.

Required.—(1) The initial great-circle course.

(2) The great-circle distance.

(3) The latitude and longitude of both vertices.

(4) The distance from the point of departure to each vertex.

(5) The latitude and longitude of points on the great circle at longitude 15°E and at each 5° of longitude thereafter to longitude 70°W.

Answers.—(1) C 304°.5. (2) D 6,762.7 mi. (3) L_v 46°49'.4S, λ_v 69°18'.8E; L_v 46°49'.4 N, λ_v 110°41'.2W. (4) D 2,407.5 mi. to eastern hemisphere vertex, 8,392.5 mi. to western hemisphere vertex. (5) L_1 33°53'.3S, λ_1 18°23'.1E (point of departure); L_x 31°52'.2S, λ_x 15°00'.0E; L_x 28°32'.5S, λ_x 10°00'.0E; L_x 24°47'.7S, λ_x 5°00'.0E; L_x 20°37'.8S, λ_x 0°00'.0; L_x 16°04'.5S, λ_x 5°00'.0W; L_x 11°10'.8S, λ_x 10°00'.0W; L_x 6°01'.7S, λ_x 15°00'.0 W; L_x 0°43'.9S, λ_x 20°00'.0W; L_x 4°35'.0N, λ_x 25°00'.0W; L_x 9°47'.2N, λ_x 30°00'.0W; L_x 14°45'.7N, λ_x 35°00'.0W; L_x 19°25'.0N, λ_x 40°00'.0W; L_x 23°41'.5N, λ_x 45°00'.0W; L_x 27°33'.3N, λ_x 50°00'.0W; L_x 30°59'.8N, λ_x 55°00'.0W; L_x 34°01'.7N, λ_x 60°00'.0W; L_x 36°40'.1N, λ_x 65°00'.0W; L_x 38°56'.6N, λ_x 70°00'.0W; L_2 40°27'.1N, λ_2 73°49'.4W (destination).

Same as preceeding page, reverse direction: New York City to Cape Town.

```
Select Dead Reck.,Y
Otherwise Grt.Circ.
Dead Reck.? Yn
Starting Place
Lat.? 40.271
Long.?73.494

Dest.
Lat.? -33.533
Long.?-18.231
 40.271
 73.494
-33.533
-18.231
Correct? Yy

Co.=    115.9
Dist.= 6,762.7 NMi.

Vs. Rh. Ln. Co.=    128.9
Dist.= 7,099.5 NMi.

GC Plot ?Yy
Long Incr.in Deg or NMi.
Nr.Deg. Long Incr? 5

START LAT= 40 d    27.1'
LONG= 73 d    49.4'

Co.=    118.7
Dist.=   472.2 NMi.

Pt. 1 :LAT= 36 d    40.0'
LONG= 65 d     0.0'

Co.=    122.9
Dist.=   291.5 NMi.

Pt. 2 :LAT= 34 d     1.6'
LONG= 60 d     0.0'

Co.=    125.7
Dist.=   311.6 NMi.

Pt. 3 :LAT= 30 d    59.7'
LONG= 55 d     0.0'

Co.=    128.3
Dist.=   333.4 NMi.

Pt. 4 :LAT= 27 d    33.2'
LONG= 50 d     0.0'

Co.=    130.6
Dist.=   356.2 NMi.

Pt. 5 :LAT= 23 d    41.5'
LONG= 45 d     0.0'

Co.=    132.6
Dist.=   379.0 NMi.

Pt. 6 :LAT= 19 d    25.0'
LONG= 40 d     0.0'

Co.=    134.2
Dist.=   400.3 NMi.

Pt. 7 :LAT= 14 d    45.6'
LONG= 35 d     0.0'

Co.=    135.5
Dist.=   418.4 NMi.

Pt. 8 :LAT= 9 d    47.2'
LONG= 30 d     0.0'

Co.=    136.4
Dist.=   431.3 NMi.

Pt. 9 :LAT= 4 d    35.0'
LONG= 25 d     0.0'

Co.=    136.8
Dist.=   437.7 NMi.

Pt. 10 :LAT= 0 d   -43.9'
LONG= 20 d     0.0'

Co.=    136.7
Dist.=   436.7 NMi.

Pt. 11 :LAT=-6 d     1.6'
LONG= 15 d     0.0'

Co.=    136.2
Dist.=   428.4 NMi.

Pt. 12 :LAT=-11 d    10.7'
LONG= 10 d     0.0'

Co.=    135.2
Dist.=   413.8 NMi.

Pt. 13 :LAT=-16 d     4.4'
LONG= 5 d     0.0'

Co.=    133.8
Dist.=   394.7 NMi.

Pt. 14 :LAT=-20 d    37.7'
LONG= 0 d     0.0'

Co.=    132.1
Dist.=   372.8 NMi.

Pt. 15 :LAT=-24 d    47.5'
LONG=-5 d     0.0'

Co.=    130.0
Dist.=   349.9 NMi.

Pt. 16 :LAT=-28 d    32.4'
LONG=-10 d     0.0'

Co.=    127.6
Dist.=   327.2 NMi.

Pt. 17 :LAT=-31 d    52.0'
LONG=-15 d     0.0'

Co.=    125.4
Dist.=   209.3 NMi.

Pt. 18 :LAT=-33 d    53.3'
LONG=-18 d    23.1'

Tot.Dist.= 6,764.3 NMi.
PAU
```

NAVA B 15667 Bytes

FLAGS USED IN PROGRAM

Q = 0 for L.O.P.
Q = 1 for "D" Data
Q = 2 for more "D" Data
Q = 3 for Moon "D" Data
Q = 4 for more Moon "D" Data
Q = 5 for Noon Latitude
Q = 6 for "B" Bodies

C = 7 for Longitude
Q = 8 for a Running Fix
Q = 9 forMore Sights,same body
Q0 = 0 for more "B" Bodies
P1 = 1 .for Moon Rise
P2 =1,2 for Moon M.P.
P3 = 1 for Moon Set

```
10 ! NAVIGATOR by L.A.'VALIER
20 DELAY 0 @ OPTION ANGLE DEGREES @ C,K,M2,Q,Q0,P1,P2,P3=0 @ N$='0' @ ASSIGN # 1
 TO 'STAR'
30 BEEP @ INPUT 'Year?       '; Y @ INPUT 'Month Nr.? '; M @ INPUT 'Day ?       ';
D
40 INPUT 'LOG/Place? '; A$ @ DISP
50 DISP '';Y @ DISP '';M @ DISP '';D @ DISP '';A$ @ GOSUB 3150
60 IF UPRC$(Y$)='Y' THEN 70 ELSE 20
70 IF Q)7 THEN 100 ELSE DISP 'Choose: B:Bodies,D: Day' @ DISP 'DR: D.Rk.,  DRD:
DR.Dest'
80 DISP 'F:Fix,  L:Long,  LA:Lat' @ DISP 'P: LOP,  RF: Run.Fix'
90 INPUT 'B/D/DR/DRD/F/L/LA/P/RF '; B$ @ DISP
100 IF Q(9 THEN GOSUB 1720 ELSE 160
110 IF UPRC$(B$)='L' THEN DISP 'Body in E. or W.?'; @ INPUT ''; C$ @ C=7
120 IF UPRC$(B$)='LA' THEN G1=0 @ Q=5 @ GOTO 200
130 IF UPRC$(B$)='DR' THEN 1730
140 IF UPRC$(B$)='DRD' THEN 1770
150 IF UPRC$(B$)='D' THEN Q=1 @ GOTO 220
160 INPUT 'G.M.T.?    '; G1 @ IF Q=9 THEN 200
170 IF UPRC$(B$)='B' THEN Q=6 @ Q0=0 @ GOSUB 250 @ DISP ' ';G1 @ GOSUB 3150
180 IF Q=0 OR C=7 THEN 200
190 IF Q=8 THEN 200 ELSE GOSUB 270 @ GOTO 290
200 INPUT 'Sext.Alt?  '; S3 @ INPUT 'Ht. Eye?   '; S1 @ INPUT 'Ind.Corr.? ';S2
210 IF Q=5 THEN 230 ELSE 290
220 INPUT 'Time Zone? '; Z9 @ GOSUB 250 @ DISP '';Z9 @ GOSUB 3150 @ GOSUB 270 @
GOTO 360
230 GOSUB 250 @ GOSUB 260 @ GOSUB 3150 @ GOSUB 270 @ GOTO 280
240 IMAGE DDDD.ddd
250 DISP '  ';B$ @ DISP USING 240 ; L2 @ DISP USING 240 ; L3 @ RETURN
260 DISP USING 240 ; S3 @ DISP ' ';S1 @ DISP ' ';S2 @ RETURN
270 IF UPRC$(Y$)='Y' THEN RETURN ELSE 100
280 IF Q=5 THEN 470
290 Z=G1 @ GOSUB 3420 @ G=Z @ IF Q=6 THEN 370
300 IF UPRC$(B$)='P' THEN 350
310 IF UPRC$(B$)='F' THEN Q=0 @ GOTO 350
320 IF UPRC$(B$)='RF' THEN Q=8 @ GOTO 350
330 IF C=7 THEN DISP '  ';C$ @ GOTO 350
340 IF UPRC$(B$)='M' THEN GOSUB 350 @ GOTO 480
350 GOSUB 250 @ DISP ' ';G1 @ GOSUB 260 @ GOSUB 3150 @ GOSUB 270
360 IF Q=1 THEN 470
370 GOSUB 2090 @ IF Q=6 THEN 380 ELSE 460
380 INPUT 'Name ?  '; E$ @ IF LEN(E$)(2 THEN 2410 ELSE INPUT 'Rt.Asc.? ';E4
390 IF E4=0 THEN 400 ELSE Z=E4 @ GOSUB 3420 @ E6=Z @ S=360-E6*15
400 INPUT 'DEC ?    '; E1 @ X2=E1 @ GOSUB 2000 @ D3=X2 @ IF E4=0 THEN 410 ELSE 4
20
410 INPUT 'SHA ?    '; E2 @ Z=E2 @ GOSUB 3420 @ S=Z
420 G9=S+G0 @ GOSUB 3150 @ IF UPRC$(Y$)='Y' THEN 430 ELSE 380
430 IF N$='Extra' THEN RETURN ELSE GOSUB 1300 @ GOSUB 1360
440 S5=N6 @ GOSUB 3170 @ Y4=N1/15 @ DISP '  H.A.= '; @ GOSUB 3430
450 X=N1 @ DISP '  H.A.= '; @ GOSUB 3340 @ GOSUB 3330 @ GOTO 1550
```

```
460 IF Q=9 THEN GOTO 480
470 DISP @ DISP 'WHICH BODY? '; @ INPUT '';N$
480 IF N$='SunL' THEN DISP 'SunL' @ GOTO 620
490 IF N$='SunU' THEN DISP 'SunU' @ S7=-S7 @ GOTO 620
500 IF N$='Sun' THEN GOSUB 1870 @ GOSUB 3290 @ GOTO 710
510 IF N$='Mercury' THEN GOSUB 1860 @ GOTO 2410
520 IF N$='Venus' THEN GOSUB 1860 @ GOTO 2470
530 IF N$='Mars' THEN GOSUB 1860 @ GOTO 2520
540 IF N$='Jupiter' THEN GOSUB 1860 @ GOTO 2590
550 IF N$='Saturn' THEN GOSUB 1860 @ GOTO 2710
560 IF N$='MoonL' THEN 2890
570 IF N$='MoonU' THEN 1900
580 IF N$='Star' THEN 950
590 IF N$='Extra' THEN 2070
600 DISP 'REENTER' @ GOTO 470
610 IF Q=1 THEN GOSUB 1860 @ GOTO 720 ELSE GOSUB 380 @ N$='0' @ GOSUB 1250 @ GOT
0 430
620 IF Q=1 THEN 600
630 IF Q=5 THEN GOTO 640 ELSE GOSUB 1230 @ GOTO 1360
640 G=0 @ GOSUB 2090 @ G=(L0-G9)/15 @ G=MOD(G,24)
650 GOSUB 2090 @ GOSUB 1230
660 Z6=90-S5 @ IF L1(D3 THEN L6=D3-Z6 ELSE L6=Z6+D3
670 IF K=0 OR 59 THEN 700 ELSE K=60 @ READ # 1,K ; N$,A(1),A(2) @ Z5=A(2)
680 IF Z5=0 THEN 700 ELSE 690
690 M0=(L1-L6)*TAN(Z5+90)/COS((L1+L6)/2) @ M2=L0+M0
700 M1=L6 @ DISP ' Meridian:' @ GOSUB 2010 @ GOTO 1550
710 IF UPRC$(B$)='D' THEN 720 ELSE 1220
720 N9=(L0-G9+G*15)/15-Z9 @ G5=15
730 IF N$='Sun' THEN S5=-12 @ GOSUB 3170 @ N3=N1 @ T6=N9-N1/G5 ELSE 760
740 IF T6(0 THEN T6=24+T6
750 Y4=T6 @ DISP 'Dawn Twilt'; @ GOSUB 3420
760 IF Q=2 THEN S5=-.575 @ GOTO 770 ELSE S5=-.8392
770 GOSUB 3170 @ T1=N9-N1/G5 @ IF T1(0 THEN 780 ELSE 790
780 IF Q=4 THEN P1=1 @ DISP 'Prev.Day '
790 T1=MOD(T1,24) @ Y4=T1 @ DISP 'Body Rises'; @ GOSUB 3420 @ A1=ACOS(SIN(D3)/CO
S(L1))
800 Z7=A1 @ GOSUB 3430 @ T2=N9+N1/G5 @ IF P2=1 THEN DISP 'Prev.Day'
810 IF P2=2 THEN DISP 'Next Day '
820 N9=MOD(N9,24) @ Y4=N9 @ DISP 'Mer. Pass '; @ GOSUB 3420 @ IF T2)24 THEN 830
ELSE 840
830 IF Q=4 THEN P3=1 @ DISP 'Next Day'
840 T2=MOD(T2,24) @ Y4=T2 @ DISP 'Body Sets '; @ GOSUB 3420 @ A2=360-A1 @ Z7=A2
@ GOSUB 3430
850 IF N$='Sun' THEN T9=N9+N3/G5 @ T9=MOD(T9,24) ELSE 870
860 Y4=T9 @ DISP 'Dusk Twilt'; @ GOSUB 3420
870 IF Q=2 OR 3 OR 4 THEN P1,P2,P3=0 @ GOTO 880 ELSE 1220
880 DISP 'Another Body? Y'; @ INPUT.''; Y$ @ IF UPRC$(Y$)='Y' THEN Q=1 @ GOTO 47
0 ELSE 1550
890 Q=3 @ G=0 @ GOSUB 2090 @ GOSUB 2900
900 D8=D9 @ G8=G9 @ 6=24 @ GOSUB 2090 @ GOSUB 2900 @ G=0 @ G7=G8-G9 @ IF G7(0 TH
EN G7=G7+360
910 G5=(360-G7)/24 @ G6=L0-G8 @ IF G6(0 THEN G6=G6+360
920 Q=4 @ S5=.1335 @ G=G6/G5 @ GOSUB 2090 @ GOSUB 2900
930 N9=G-Z9 @ IF N9(0 THEN P2=1 @ GOTO 770
940 IF N9)24 THEN P2=2 @ GOTO 770 ELSE 770
950 IF Q=1 THEN GOSUB 1860
960 IF Q=6 THEN 1010
970 DISP 'Star # or Name'
980 INPUT 'Star #? ';K0
990 IF K0)0 THEN 1010 ELSE 1000
```

```
1000 INPUT 'Star Name? '; K$ @ K$=K$[1,6]
1010 FOR K=1 TO 58
1020 READ # 1,K ; S$ @ S$=S$[1,6]
1030 IF Q=6 THEN GOSUB 1100
1040 IF Q=6 THEN K=K+1 @ GOTO 1030
1050 IF K=K0 THEN 1110
1060 IF K0)0 THEN 1080
1070 IF UPRC$(K$)=S$ THEN 1110 ELSE 1080
1080 NEXT K
1090 IF UPRC$(K$)#S$ THEN DISP 'Wrong Name,Reenter' @ GOTO 1000
1100 IF K)58 THEN 1550
1110 READ # 1,K ; S$,A(1),A(2),A(3),A(4)
1120 IF Q0#7 THEN DISP '';K;'';S$
1130 A0=A(1) @ T3=A(2) @ D0=A(3) @ T4=A(4) @ T5=(J-2433282)/36525
1140 P8=T3/36*T5-A0 @ P9=T4/36*T5+D0
1150 M6=(23042.5+13.96*.5+3.02*T5+.18*T5)*T5/36000 @ Z1=7.91/36000*T5^2+M6
1160 N=(20046.85-.08533*.5-4.26*T5-.42*T5^2)*T5/36000 @ R4=COS(P8+M6)*COS(P9)
1170 T7=R4*COS(N)-SIN(P9)*SIN(N) @ T8=SIN(P8+M6)*COS(P9) @ A9=ANGLE(T7,T8)+Z1
1180 A9=MOD(A9,360) @ S=360-A9
1190 D3=ASIN(R4*SIN(N)+SIN(P9)*COS(N))
1200 G9=S+G0 @ G9=MOD(G9,360) @ S7=0 @ IF Q=2 THEN 720
1210 IF Q=6 THEN GOSUB 1300 @ GOTO 1320 ELSE 1230
1220 S7=-S7
1230 IF S3=0 THEN 1240 ELSE 1250
1240 S5=(S2-.97*SQR(S1)-34.4)/60+S7 @ GOTO 1290
1250 S4=FP(S3)/.6+IP(S3) @ IF N$='MoonL' THEN 1260 ELSE 1270
1260 S7=ATN(1/R1)*COS(S4)+R5 @ GOTO 1280
1270 IF N$='MoonU' THEN S7=ATN(1/R1)*COS(S4)-R5
1280 S5=S4+.97*(TAN(S4-ATN(12*(S4+3)))-SQR(S1))/60+S2/60+S7 @ IF Q=9 THEN Q=0
1290 INPUT 'Delay?  '; D7 @ DELAY D7 @ DISP @ IF Q=5 THEN RETURN
1300 IF C=7 THEN GOSUB 3170 @ GOSUB 1920 @ GOTO 1930
1310 N6=ASIN(SIN(D3)*SIN(L1)+COS(D3)*COS(L1)*COS(G9-L0)) @ IF Q#0 THEN RETURN
1320 IF N6(15 THEN 1330 ELSE 1350
1330 IF Q0=7 THEN 1450
1340 IF Q0=0 THEN 1360
1350 IF Q0=7 THEN DISP '';K;'';S$
1360 X=N6 @ DISP 'HC = '; @ GOSUB 3340
1370 IF Q=6 THEN 1420
1380 X=S5 @ DISP 'HO = '; @ GOSUB 3340 @ I4=N6-S5 @ I5=60*IP(I4)+60*FP(I4)
1390 IMAGE dddd.d
1400 IF I5)0 THEN 1410 ELSE DISP 'Mi.Towards = '; @ DISP USING 1390 ; I5 @ GOTO
1420
1410 DISP 'Mi. Away = '; @ DISP USING 1390 ; I5
1420 Z2=COS(D3)*SIN(G9-L0)
1430 Z3=COS(D3)*SIN(L1)*COS(G9-L0)-SIN(D3)*COS(L1)
1440 Z4=ANGLE(Z3,Z2) @ Z5=180+Z4 @ Z7=Z5 @ GOSUB 3450
1450 IF Q=6 THEN RETURN
1460 D1=S5-N6 @ C0=Z5 @ GOSUB 1950
1470 IF UPRC$(B$)='F' THEN 1510
1480 IF Q=8 THEN 1510
1490 K=60 @ A(1)=I4 @ A(2)=Z5
1500 PRINT # 1,K ; N$,A(1),A(2) @ IF Q=0 OR 9 THEN 1510 ELSE 30
1510 DISP ' M.P.P.:' @ GOSUB 2010
1520 IF UPRC$(B$)='F' THEN 1540
1530 IF Q=8 THEN 1540 ELSE 1550
1540 K=60 @ READ # 1,K ; S$,A(1),A(2) @ GOTO 1670
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1550 DISP @ DISP 'Choose: DR:Dead Reck.' @ DISP 'DRD:DR.Dest.  F:Fix'
1560 DISP 'M:Mo Sights   LA:M.Lat' @ DISP '  RF:Run.Fix' @ DISP 'S:Start,T:Tel.,
N:None'
1570 INPUT 'DR/DRD/F/M/LA/RF/S/T/N ?'; B$ @ DISP
1580 IF UPRC$(B$)='DR' THEN GOSUB 1720 @ GOTO 1730
1590 IF UPRC$(B$)='DRD' THEN GOSUB 1720 @ GOTO 1770
1600 IF UPRC$(B$)='F' THEN Q=0 @ GOTO 160
1610 IF UPRC$(B$)='M' THEN Q=9 @ GOTO 160
1620 IF UPRC$(B$)='LA' THEN 100
1630 IF UPRC$(B$)='RF' THEN Q=8 @ GOTO 30
1640 IF UPRC$(B$)='S' THEN 20
1650 IF UPRC$(B$)='T' THEN 440
1660 IF UPRC$(B$)='N' THEN ASSIGN # 1 TO * @ DISP 'PAU' @ STOP
1670 IF Q=8 THEN A(1)=0
1680 M1=L1+(I4*SIN(A(2))-A(1)*SIN(Z5))/SIN(Z5-A(2))
1690 M2=L0+(I4*COS(A(2))-A(1)*COS(Z5))/(SIN(Z5-A(2))*COS(L1))
1700 IF Q=8 THEN DISP ' RUN';
1710 DISP ' FIX AT' @ GOSUB 2010 @ GOTO 1550
1720 GOSUB 1980 @ L2=X2 @ GOSUB 2000 @ L1=X2 @ GOSUB 1990 @ L3=X2 @ GOSUB 2000 @
 L0=X2
1730 IF UPRC$(B$)#'DR' THEN RETURN ELSE INPUT 'Course? .   ';C0
1740 INPUT 'NMi. Dist? '; D1 @ GOSUB 250 @ DISP ' ';C0 @ DISP ' ';D1 @ GOSUB 315
0
1750 IF UPRC$(Y$)='Y' THEN 1760 ELSE 1720
1760 D1=D1/60 @ GOSUB 1950 @ DISP ' D.R.:' @ GOSUB 2010 @ GOTO 1550
1770 W1=L1 @ W2=L0 @ DISP 'Dest? ' @ GOSUB 1980 @ GOSUB 2000 @ W3=X2 @ GOSUB 199
0
1780 GOSUB 2000 @ W4=X2 @ P7=W2-W4 @ GOSUB 3150
1790 IF UPRC$(Y$)='Y' THEN 1800 ELSE GOSUB 1720 @ GOTO 1770
1800 IF P7)180 THEN P7=P7-360
1810 IF P7(-180 THEN P7=P7+360
1820 P6=P7*COS((W3+W1)/2) @ C=ANGLE(W3-W1,P6) @ D2=60*SQR((W3-W1)^2+P6^2)
1830 IF C(0 THEN C=360+C
1840 DISP 'Tr. Co.= '; @ DISP USING 1390 ; C
1850 DISP ' Dist.= '; @ DISP USING 1390 ; D2; @ DISP ' NMi.' @ GOTO 1550
1860 S7=0 @ IF Q=1 THEN Q=2 @ GOTO 1880
1870 IF Q=1 THEN 1880 ELSE RETURN
1880 G=0 @ GOTO 2090
1890 IF Q=3 THEN 720 ELSE 1900
1900 IF Q=1 THEN 880 ELSE 2890
1910 G=0 @ Q=2 @ GOSUB 2090 @ RETURN
1920 IF UPRC$(C$)='E' THEN L4=G9+N1 @ L4=MOD(L4,360) @ RETURN ELSE L4=G9-N1 @ RE
TURN
1930 IF C=7 THEN M2=L4 @ GOSUB 2050 @ L1=L1+.1 @ Q=0 @ GOTO 1940 ELSE 1550
1940 GOSUB 3170 @ GOSUB 1920 @ K=59 @ A(1)=ABS(L4-M2) @ PRINT # 1,K ; N$,A(1) @
GOTO 1550
1950 M1=L1+D1*COS(C0) @ M5=-D1*SIN(C0)/COS(D1*COS(C0)/2+L1)
1960 M2=L0+M5 @ IF M2(-180 THEN M2=M2+360 @ RETURN
1970 IF M2)180 THEN M2=M2-360 @ RETURN ELSE M2=L0+M5 @ RETURN
1980 INPUT 'Lat.?        '; X2 @ RETURN
1990 INPUT 'Long.?       '; X2 @ RETURN
2000 X2=FP(X2)/.6+IP(X2) @ RETURN
2010 X=M1 @ DISP 'LAT = '; @ GOSUB 3340 @ IF UPRC$(B$)='LA' THEN 2020 ELSE 2040
2020 DISP 'Prior Sight:LOP or Long? P,L or N'; @ INPUT ''; P$ @ IF UPRC$(P$)='N'
 THEN 1550
2030 IF P$='P' THEN 2050 ELSE K=59 @ READ # 1,K ; N$,A(1) @ M2=10*A(1)*(L1-M1)+L
0
2040 IF M2=0 THEN RETURN
2050 IF M2)180 THEN M2=M2-360
```

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2060 X=M2 @ DISP 'LONG= '; @ GOSUB 3340 @ RETURN
2070 IF Q=1 THEN GOSUB 1860 @ GOSUB 380 @ GOTO 720 ELSE GOSUB 380 @ N$='0' @ GOS
UB 1250
2080 GOTO 430
2090 J=367*Y-7*(Y+(M+9)\12)\4+275*M\9+D+1721014+(G-12)/24
2100 T=J-2451545 @ U=T/36525+1 @ V=U-G/24/36525
2110 G0=RMD(99.69098325+RMD(V*(36000.76893+.000387083*V),360)+15.04106843*G,360)
2120 F1=360*FP(.606434+.03660110129*T) @ F2=360*FP(.374897+.03629164709*T)
2130 F3=360*FP(.259091+.0367481952*T) @ F4=360*FP(.827362+.03386319198*T)
2140 F5=360*FP(.347343-.00014709391*T) @ F7=360*FP(.779072+.00273790931*T)
2150 F8=360*FP(.993126+.0027377785*T) @ F9=360*FP(.700695+.011367714*T)
2160 H0=360*FP(.485541+.01136759566*T) @ H1=360*FP(.566441+.01136762384*T)
2170 H2=360*FP(.505498+.00445046867*T) @ H3=360*FP(.140023+.00445036173*T)
2180 H4=360*FP(.292498+.00445040017*T) @ H5=360*FP(.987353+.00145575328*T)
2190 H6=360*FP(.053856+.00145561327*T) @ H7=360*FP(.849694+.00145569465*T)
2200 H8=360*FP(.089608+.00023080893*T) @ H9=360*FP(.056531+.00023080893*T)
2210 J0=360*FP(.814794+.00023080893*T) @ J1=360*FP(.133295+.00009294371*T)
2220 J2=360*FP(.882987+.00009294371*T) @ J3=360*FP(.821218+.00009294371*T)
2230 J4=360*FP(.870169+.00003269438*T) @ J5=360*FP(.400589+.00003269438*T)
2240 J6=360*FP(.664614+.00003265562*T) @ J7=360*FP(.846912+.00001672092*T)
2250 J8=360*FP(.725368+.00001672092*T) @ J9=360*FP(.480856+.00001663715*T)
2260 K1=360*FP(.663854+.00001115482*T) @ K2=360*FP(.04102+.00001104864*T)
2270 K3=360*FP(.357355+.00001104864*T)
2280 P=6910*SIN(F8)+72*SIN(2*F8)-17*SIN(F8)-7*COS(F8-H9)-17*(U+SIN(F8))-7*COS(F8
-H9)
2290 P=P+6*SIN(F1-F7)+5*(SIN(4*F8-8*H6+3*H9)-COS(2*F8-2*H3))-4*(SIN(F8-H3)-COS(4
*F8-8*H6+H9))
2300 E=(84428-47*U+9*COS(F5))/3600 @ L=P/3600+F7 @ GOSUB 2400
2310 A3=ANGLE(COS(L),SIN(L)*COS(E)) @ D3=ASIN(SIN(E)*SIN(L)) @ B=0
2320 R=1.00014-.01675*COS(F8)-.00014*COS(2*F8)
2330 R7=R*COS(L) @ R8=R*SIN(L)*COS(E) @ R9=R*SIN(L)*SIN(E)
2340 G2=360-A3 @ G2=MOD(G2,360) @ A4=A3/15 @ IF A4(0 THEN A4=A4+24
2350 G9=G0-A3+360 @ G9=MOD(G9,360) @ A8=A4 @ S7=ATN(.00466/R)
2360 IF Q=1 THEN 2370 ELSE 2390
2370 DISP 'Sun ' @ G5=15 @ G=(L0-G9)/G5 @ IF G(0 THEN G=G+24 @ N9=G-Z9 @ N9=MOD(
N9,24)
2380 Q=2 @ GOTO 2090
2390 IF Q=2 THEN RETURN ELSE RETURN
2400 L=MOD(L,360) @ RETURN
2410 DISP ' MERCURY'
2420 P=84378*SIN(H0)+10733*SIN(2*H0)+1892*SIN(3*H0)-646*SIN(2*H1)+381*SIN(4*H0)
2430 L=(P-306*SIN(H0-2*H1))/3600+F9 @ GOSUB 2400
2440 B=24134*SIN(H1)+5180*SIN(H0-H1)+4910*SIN(H0+H1)+1124*SIN(2*H0+H1)+271*SIN(3
*H0+H1)
2450 B=B/3600 @ R=.39528-.07834*COS(H0)-.00795*COS(2*H0)
2460 GOSUB 3180 @ D3=D8 @ GOSUB 3220 @ GOSUB 3120
2470 DISP ' VENUS'
2480 P=2814*SIN(H3)-181*SIN(2*H4)-20*(SIN(H3)-U)+12*SIN(2*H3)-10*COS(2*F8-2*H3)
2490 L=(P+7*COS(3*F8-3*H3))/3600+H2 @ GOSUB 2400
2500 B=(12215*SIN(H4)+166*SIN(H3)*COS(H4))/3600 @ R=.72335-.00493*COS(H3)
2510 GOSUB 3180 @ D3=D8 @ GOSUB 3220 @ GOSUB 3120
2520 DISP ' MARS'
2530 P=38451*SIN(H6)+2238*SIN(2*H6)+181*SIN(3*H6)-52*SIN(2*H7)+37*(U+SIN(H6))
2540 P=P-22*COS(H6-2*H9)-19*SIN(H6-H9)+17*(COS(H6-H9)+SIN(4*H6))-16*COS(2*H6-2*H
9)
2550 L=(P+13*COS(F8-2*H6)-10*(SIN(H6-2*H7)+SIN(H6+2*H7)))/3600+H5 @ GOSUB 2400
2560 B=(6603*SIN(H7)+622*SIN(H6-H7)+615*SIN(H6+H7)+64*SIN(2*H6+H7))/3600
2570 R=1.53031-.1417*COS(H6)-.0066*COS(2*H6)-.00047*COS(3*H6)
2580 GOSUB 3180 @ A7=A7-.0137 @ D3=D8 @ GOSUB 3220 @ GOSUB 3120
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2590 DISP ' JUPITER'
2600 P=19934*SIN(H9)+5023*U+2511+1093*COS(2*H9-5*J2)+601*SIN(2*H9)-479*SIN(2*H9-
5*J2)
2610 P=P-185*SIN(2*H9-2*J2)+137*SIN(3*H9-5*J2)-131*SIN(H9-2*J2)+79*COS(H9-J2)
2620 P=P-76*COS(2*H9-2*J2)-74*(U+COS(H9))+68*(U+SIN(H9))+66*COS(2*H9-3*J2)
2630 P=P+63*COS(3*H9-5*J2)+53*COS(H9-5*J2)+49*SIN(2*H9-3*J2)-43*(U+SIN(2*H9-5*J2
))-37*COS(H9)
2640 P=P+25*(SIN(2*H8)+SIN(3*H9))-23*SIN(H9-5*J2)-19*(U+COS(2*H9-5*J2))-14*SIN(H
9-J2)
2650 L=(P+17*(COS(2*H9-4*J2)+COS(3*H9-3*J2))-13*SIN(3*H9-4*J2))/3600+H8 @ GOSUB
2400
2660 B=-4692*COS(H9)+259*SIN(H9)+227*(1-COS(2*H9))+30*(U+SIN(H9))+21*(U+COS(H9))
2670 B=(B+16*SIN(3*H9-5*J2)-13*SIN(H9-5*J2)-12*(COS(3*H9)+SIN(2*H9)))/3600
2680 R=5.20883-.25122*COS(H9)-.00604*COS(2*H9)+.0026*COS(2*H9-2*J2)-.0017*COS(3*
H9-5*J2)
2690 R=R-.00106*SIN(2*H9-2*J2)
2700 GOSUB 3180 @ A7=A7+.0252 @ D3=D8-.0019 @ GOSUB 3220 @ GOSUB 3120
2710 DISP ' SATURN'
2720 P=23045*SIN(J2)+5014*U-2689*COS(2*H9-5*J2)+2507+1177*SIN(2*H9-5*J2)
2730 P=P-826*COS(2*H9-4*J2)+802*SIN(2*J2)+425*SIN(H9-2*J2)-229*(U+COS(J2))
2740 P=P-153*COS(2*H9-6*J2)-142*(U+SIN(J2))-114*COS(J2)+101*(U+SIN(2*H9-5*J2))
2750 P=P-70*COS(2*J1)+67*SIN(2*J1)+66*SIN(2*H9-6*J2)+60*(U+COS(2*H9-5*J2))+41*SI
N(H9-3*J2)
2760 P=P+39*SIN(3*J2)+31*(SIN(H9-J2)+SIN(2*H9-2*J2))-29*COS(2*H9-3*J2)-28*SIN(2*
H9-6*J2+3*J5)
2770 P=P+22*(U+SIN(2*H9-4*J2)-SIN(J2-3*J5))+20*(SIN(2*H9-3*J2)+COS(4*H9-10*J2))
2780 P=P+19*(COS(2*J2-3*J5)+SIN(4*H9-10*J2))-17*(U+COS(2*J2))-16*COS(J2-3*J5)
2790 P=P-12*(SIN(2*H9-4*J2)-COS(H9)+SIN(2*J2-2*J5))-11*(U-SIN(2*J2)+COS(2*H9-7*J
2))
2800 L=P/3600+J1 @ GOSUB 2400
2810 B=8297*SIN(J2)-3346*COS(J2)+462*SIN(2*J2)-189*COS(2*J2)+185+79*(U+COS(J2))
2820 B=B-71*COS(2*H9-4*J2)+46*SIN(2*H9-6*J2)-45*COS(2*H9-6*J2)+29*SIN(3*J2)-20*C
OS(2*H9-3*J2)
2830 B=(B+18*(U+SIN(J2))-14*COS(2*H9-5*J2)-11*COS(3*J2-10*U))/3600
2840 R=9.55774-.53252*COS(J2)-.01878*SIN(2*H9-4*J2)-.01482*COS(2*J2)+.00817*SIN(
H9-J2)
2850 R=R-.00539*COS(H9-J2)-.00524*(U+SIN(J2))+.00349*SIN(2*H9-5*J2)+.00347*SIN(2
*H9-6*J2)
2860 R=R+.00328*(U+COS(J2))-.00225*SIN(J2)+.00149*COS(2*H9-6*J2)-.00126*COS(2*H9
-2*J2)
2870 R=R+.00104*COS(H9-J2)+.00101*COS(2*H9-5*J2)
2880 GOSUB 3180 @ A7=A7+.059 @ D3=D8-.0254 @ GOSUB 3220 @ GOSUB 3120
2890 DISP ' MOON'
2900 P=22640*SIN(F2)-4586*SIN(F2-2*F4)+2370*SIN(2*F4)+769*SIN(2*F2)-668*SIN(F8)
2910 P=P-412*SIN(2*F3)-212*SIN(2*F2-2*F4)-206*SIN(F2-2*F4+F8)+192*SIN(F2+2*F4)
2920 P=P+165*SIN(2*F4-F8)+148*SIN(F2-F8)-125*SIN(F4)-110*SIN(F2+F8)-55*SIN(2*F3-
2*F4)
2930 P=P-45*SIN(F2+2*F3)+40*SIN(F2-2*F3)-38*SIN(F2-4*F4)+36*SIN(3*F2)-31*SIN(2*F
2-4*F4)
2940 P=P+28*SIN(F2-2*F4-F8)-24*SIN(2*F4+F8)+19*SIN(F2-F4)+18*SIN(F4+F8)+15*SIN(F
2-2*F4-F8)
2950 P=P+14*(SIN(2*F2+2*F4)+SIN(4*F4))-13*SIN(3*F2-2*F4)-11*SIN(F2+16*F7-18*H2)
2960 P=P+10*SIN(2*F2-F8)+9*(SIN(F2-2*F3-2*F4)+COS(F2-16*F7-18*H2)-SIN(2*F2-2*F4+
F8))
2970 L=(P-8*(SIN(F2+F4)-SIN(2*F4-2*F8)+SIN(2*F2-F8))-7*SIN(2*F8))/3600+F1 @ GOSU
B 2400
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2980 B=18461*SIN(F3)+1010*SIN(F2+F3)+1000*SIN(F2-F3)-624*SIN(F3-2*F4)-199*SIN(F2
-F3-2*F4)
2990 B=B-167*SIN(F2+F3-2*F4)+117*SIN(F3+2*F4)+62*SIN(2*F2+F3)+33*SIN(F2-F3+2*F4)
3000 B=B+32*SIN(2*F2-F3)-30*SIN(F3-2*F4+F8)-16*SIN(2*F2+F3-2*F4)+15*SIN(F2+F3+2*
F4)
3010 B=B+12*SIN(F3-2*F4-F8)-9*SIN(F2-F3-2*F4+F8)-8*(SIN(F3+F5)-SIN(F3-2*F4-F8))
3020 B=(B-7*(SIN(F2+F3-2*F4)-SIN(F2+F3-F8)+SIN(F2+F3-4*F4)))/3600
3030 R=60.36298-3.27746*COS(F2)-.57994*COS(F2-2*F4)-.46357*COS(2*F4)-.08904*COS(
2*F2)
3040 R=R+.03865*COS(2*F2-2*F4)-.03237*COS(2*F4-F8)-.02688*COS(F2+2*F4)-.02358*CO
S(F2-2*F4+F8)
3050 R1=R-.0203*COS(F2-F8)+.01719*COS(F4)+.01671*COS(F2+F8)+.01247*COS(F2-2*F3)
3060 R=R1/23454.8 @ R5=.2725*ATN(1/R1)
3070 X4=R*COS(B)*COS(L) @ Y4=R*COS(B)*SIN(L)*COS(E)-R*SIN(B)*SIN(E) @ A7=ANGLE(X
4,Y4)
3080 X5=R*SIN(B)*COS(E)+R*COS(B)*SIN(L)*SIN(E) @ D9=ASIN(X5/SQR(X4^2+Y4^2+X5^2))
3090 D3=D9 @ GOSUB 3220
3100 IF UPRC$(B$)='D' THEN RETURN ELSE 3110
3110 GOSUB 3130 @ Q0=7 @ GOTO 950
3120 IF Q=2 THEN 720
3130 IF Q=6 THEN GOSUB 1300 @ GOTO 1360 ELSE 1230
3140 RETURN
3150 DISP 'Correct? Y'; @ INPUT ''; Y$ @ IF UPRC$(Y$)='Y' THEN DISP @ RETURN
3160 DISP 'Reenter Data' @ RETURN
3170 N1=ACOS((SIN(S5)-SIN(D3)*SIN(L1))/(COS(D3)*COS(L1))) @ RETURN
3180 X7=R7+R*COS(B)*COS(L) @ Y7=R8+R*COS(B)*SIN(L)*COS(E)-R*SIN(B)*SIN(E)
3190 A7=ANGLE(X7,Y7) @ Y8=SQR(X7^2+Y7^2)
3200 Y9=R*SIN(B)*COS(E)+R*COS(B)*SIN(L)*SIN(E)+R9
3210 D8=ASIN(Y9/SQR(Y8^2+Y9^2)) @ RETURN
3220 A8=A7/15 @ A8=MOD(A8,24)
3230 G2=360-A7 @ G2=MOD(G2,360) @ G9=G0+G2 @ G9=MOD(G9,360)
3240 IF Q=2 THEN GOSUB 3280 @ RETURN
3250 IF Q=3 THEN RETURN
3260 IF Q=4 THEN GOSUB 3280 @ RETURN
3270 IF Q=2 THEN DISP 'SUN' ELSE 3280
3280 IF Q=6 THEN 3320
3290 X=L @ DISP 'Long='; @ GOSUB 3340
3300 Y1=A8 @ DISP 'R.A.='; @ GOSUB 3390
3310 X=G9 @ DISP 'GHA ='; @ GOSUB 3340
3320 X=G2 @ DISP 'SHA = '; @ GOSUB 3340 @ IF Q=6 THEN RETURN
3330 X=D3 @ DISP 'Dec.= '; @ GOSUB 3340 @ RETURN
3340 IF IP(X)=0 THEN 3350 ELSE 3360
3350 IF FP(X)<0 THEN X1=60*FP(X) @ GOTO 3370
3360 X1=ABS(60*FP(X))
3370 DISP IP(X);'D'; @ DISP USING 1390 ; X1; @ DISP "'" @ RETURN
3380 IMAGE DD.D
3390 Y2=ABS(IP(60*FP(Y1))) @ Y3=ABS(60*FP(60*FP(Y1)))
3400 DISP IP(Y1);'H';IP(Y2);'M '; @ DISP USING 3380 ; Y3; @ DISP ' S' @ RETURN
3410 Z=IP(Z)+FP(FP(Z)*100)/36+IP(FP(Z)*100)/60 @ RETURN
3420 Y5=ABS(60*FP(Y4)) @ DISP IP(Y4);'H'; @ DISP USING 1390 ; Y5; @ DISP ' M' @
RETURN
3430 DISP 'Azimuth =  '; @ DISP USING 1390 ; Z7 @ RETURN
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STAR          B 2838 16:16 01/29/84

1 DATA 'ALPHERATZ',358.55083,.15,28.81444,-.16
2 DATA 'ANKAA.',354.04583,.27,-42.5755,-.4
3 DATA 'SHEDAR',350.58625,.09,56.26361,-.03
4 DATA 'DIPHDA',349.73,.24,-18.26083,.04
5 DATA 'ACHENAR',336.03667,.165,-57.49028,-.03
6 DATA 'HAMAL.',328.91292,.21,23.22694,-.15
7 DATA 'ACAMAR',315.90875,-.075,-40.50417,.03
8 DATA 'MENKAR',315.08417,-.015,3.89472,-.07
9 DATA 'MIRFAK',309.815,.045,49.685,-.02
10 DATA 'ALDEBARAN',291.737927,.075,16.41028,-.19
11 DATA 'RIGEL.',281.96667,0,-8.25806,0
12 DATA 'CAPELLA',281.75208,.12,45.94944,-.43
13 DATA 'BELLATRIX',279.38792,0,6.30611,-.01
14 DATA 'ELNATH',279.2175,.03,28.56722,-.18
15 DATA 'ALNILAM',276.5813,0,-1.23222,0
16 DATA 'BETELGEUSE',271.88417,.03,7.39944,.01
17 DATA 'CANOPUS',264.28958,.03,-52.66778,.02
18 DATA 'SIRIUS',259.26375,-.555,-16.64611,-1.21
19 DATA 'ADHARA',255.835,0,-28.90278,0
20 DATA 'PROCYON',245.82875,-.705,5.35444,-1.03
21 DATA 'POLLUX',244.435,-.705,28.14861,-.05
22 DATA 'AVIOR.',234.6275,-.06,-59.34806,.01
23 DATA 'SUHAIL',223.46125,-.03,-43.23,.01
24 DATA 'MIAPLACIDUS',221.83458,-.435,-69.51111,.1
25 DATA 'ALPHARD',218.7175,-.015,-8.44083,.03
26 DATA 'REGULUS',208.57208,-.255,12.21222,0
27 DATA 'DUBHE.',194.83542,-.255,62.02139,-.07
28 DATA 'DENEBOLA',183.3725,-.51,14.85167,-.12
29 DATA 'GIENAH',176.69208,-.165,-17.26444,.02
30 DATA 'ACRUX.',174.05,-.075,-62.82222,-.03
31 DATA 'GACRUX',172.90542,.045,-56.83361,-.27
32 DATA 'ALIOTH',167.04125,.21,56.23083,-.01
33 DATA 'SPICA.',159.36125,-.045,10.90111,-.04
34 DATA 'ALKAID',153.60708,-.18,49.56222,-.02
35 DATA 'HADAR.',149.93125,-.045,-60.13278,-.03
36 DATA 'MENKENT',149.06708,-.645,-36.125,-.52
37 DATA 'ARCTURUS',146.655,-1.17,19.44194,-2
38 DATA 'RIGIL KENT',140.95333,-7.35,-60.63028,.7
39 DATA 'ZUBENUBI',137.97292,-.105,-15.83528,-.07
40 DATA 'KOCHAB',137.29292,-.12,74.35972,.01
41 DATA 'ALPHECA',126.8575,.135,26.88167,-.1
42 DATA 'ANTARES',113.41583,-.015,-26.32278,-.03
43 DATA 'ATRIA.',109.1625,.06,-68.93889,-.04
44 DATA 'SABIK.',118.12292,.03,-15.66472,.09
45 DATA 'SHAULA',97.4475,0,-37.06944,-.03
46 DATA 'RASALHAGUE',96.84708,.12,12.595,-.23
47 DATA 'ELTANIN',91.13917,-.015,51.49389,-.02
48 DATA 'KAUS AUST',84.78667,-.045,-34.41028,-.13
49 DATA 'VEGA..',81.18875,.255,38.73583,.28
50 DATA 'NUNKI.',76.95875,.015,-26.36083,-.06
51 DATA 'ALTAIR',62.91417,.54,8.73472,.38
52 DATA 'PEACOCK',54.57417,.015,-56.89722,-.09
53 DATA 'DENEB.',50.06875,0,45.10083,0
54 DATA 'ENIF..',34.56792,.03,9.64472,0
55 DATA 'ALNAIR',28.7275,.18,-47.20417,-.15
56 DATA 'FOMALHAUT',16.27708,.375,-29.88778,-.16
57 DATA 'MARKAB',14.43292,.06,14.93583,-.04
58 DATA 'POLARIS',332.797917,2.715,89.028888,0
```

```
TIME        B  447 11:08 04/28/84

10 DELAY 0 @ DISP 'Choose Sext.Sights' @ DISP 'Or Time Diffs.'
20 INPUT 'S or T '; B$ @ IF UPRC$(B$)='S' THEN 30 ELSE 60
30 INPUT 'Time?  '; A$ @ A$=TIME$ @ INPUT 'Sext.? '; A @ IF A=0 THEN 60
40 IMAGE DDD.ddd
50 DISP '';A$;'  Hs'; @ DISP USING 40 ; A @ GOTO 30
60 INPUT '1st GMT? '; G1 @ Z=G1 @ GOSUB 100 @ G1=Z
70 INPUT '2nd GMT? '; G2 @ Z=G2 @ GOSUB 100 @ G2=Z
80 G3=G2-G1 @ DISP 'GMT Diff in Hrs='; @ DISP USING 40 ; G3
90 INPUT 'Knots? '; K @ K1=G3*K @ DISP 'Sailed= '; @ DISP USING 40 ; K1; @ DISP
' NMI' @ STOP
100 Z=IP(Z)+FP(FP(Z)*100)/36+IP(FP(Z)*100)/60 @ RETURN
```

```
VP        B 3510 19:36 01/14/84

10 DELAY 0 @ OPTION ANGLE DEGREES @ WIDTH INF @ M=0
20 DISP 'Select Dead Reck.,Y' @ DISP 'Otherwise Grt.Circ.'
30 INPUT 'Dead Reck.? ','Y'; Y$ @ IF UPRC$(Y$)='Y' THEN 40 ELSE 180
40 DISP @ DISP 'From Pt.  A, with CO.' @ DISP 'and Dist. find pt. B' @ DISP
50 GOSUB 990 @ INPUT 'True  Co.? '; CO @ INPUT 'Dist./NMi.? '; D2 @ DISP
60 DISP '';W @ DISP '';WO @ DISP '';CO @ DISP '';D2 @ GOSUB 1020
70 IF UPRC$(Y$)='Y' THEN 80 ELSE 50                   USES D.R. TO GO
80 L1=D2/60*COS(CO) @ L2=-D2/60*SIN(CO)/COS(L1/2+W1)  FROM PT A. USING
90 W3=L1+W1 @ W4=W2+L2 @ IF W4<-180 THEN W4=W4+360    CO.+DIST TO FIND PT.B
100 IF W4>180 THEN W4=W4-360
110 DISP 'Dest.' @ V7=W3 @ GOSUB 970 @ W3=Y @ V9=W4 @ GOSUB 980 @ W4=Y @ GO
TO 530
120 GOSUB 150 @ X=W @ GOSUB 740 @ W1=X @ GOSUB 170 @ X=WO @ GOSUB 740 @ W2=
X @ RETURN
130 IF UPRC$(Y$)='Y' THEN 140 ELSE 50          M is used as a flag.
140 GOSUB 840 @ GOSUB 940 @ GOTO 530           M = 1 for Westbound Sailings
150 DISP 'Starting Place'                      M= -1 for Eastbound Sailings
160 INPUT 'Lat.? '; W @ RETURN
170 INPUT 'Long.?'; WO @ RETURN
180 GOSUB 990 @ GOSUB 1000 @ IF UPRC$(Y$)='Y' THEN 190 ELSE 180
190 L1=W1 @ LO=W2 @ M3=W3 @ MO=M3 @ M4=W4 — FOR D.R.
200 W1=L1 @ W2=LO @ W3=M3 @ W4=M4 @ GOSUB 840
210 GOSUB 670 @ GOSUB 680 @ C=C1 @ D=D1 @ GOSUB 940— FOR G.C. CO.+DIST
220 DISP 'Vs. Rh. Ln. '; @ C=C2 @ D=D2 @ GOSUB 940 FOR D.R.
230 INPUT 'GC Plot ?','Y';Y$
240 IF UPRC$(Y$)='Y' THEN 250 ELSE 530
250 DISP 'Long Incr.in Deg or NMi.'
260 INPUT 'Nr.Deg. Long Incr? ';V6 — FOR DEG. INCR.
270 IF V6>0 THEN 300 ELSE 280
280 INPUT 'Nr. NMi.Incr ';V8
290 L1=W1 @ LO=W2 @ M3=W3 @ MO=M3 @ M4=W4
300 DISP @ DISP 'START '; @ V7=L1 @ GOSUB 970 @ V9=LO @ GOSUB 980
310 IF V6=0 THEN 320 ELSE 330
320 X3=1 @ D4=0 @ GOTO 550 - FOR NMI. INCR.
330 V9=IP((LO+V6)/10)*10 @ IF M<0 THEN V9=V9-V6
340 IF LO<0 THEN V9=V9-V6 ELSE 380                FOR INCRS.
350 IF M<0 THEN 380                               FIND NEXT LONG.
360 IF LO>0 THEN 370 ELSE 380
370 IF V9<LO THEN V9=V9+V6
380 V8=LO-V9 @ IF M<0 THEN V6=-V6 @ GOTO 420
390 IF M<0 THEN 400 ELSE 410
400 IF LO<0 THEN 420
410 IF M<0 THEN V9=V9-V6 @ V8=V9-LO @ V6=-V6
420 X3=1 @ D4=0 @ GOSUB 810 — FIND [illegible] T
430 W1=L1 @ W2=LO @ W3=V7 @ W4=V9 @ GOSUB 840 @ GOSUB 930 @ GOSUB 960
440 GOSUB 980
450 V9=W4+V6 @ GOSUB 810 @ GOSUB 820
460 IF ABS(W4)=180 THEN W4=-1*W4 @ GOTO 480
470 IF ABS(W4)>180 THEN W4=W4-360
480 V9=W4+V6 @ IF V9>180 THEN V9=V9-360
490 IF V9<-180 THEN V9=360+V9
500 IF ABS(W4-M4)<ABS(V6) THEN 510 ELSE 450
510 V7=M3 @ V9=M4 @ GOSUB 820
520 DISP 'Tot.Dist.='; @ DISP USING 750 ; D4; @ DISP ' NMi.'
530 DISP 'PAU' @ STOP
```

```
540 IF D3<V8 THEN 650
550 W3=ASIN(SIN(L1)*COS(V8/60)+COS(L1)*SIN(V8/60)*COS(C1)) @ W1=L1
560 P7=ATN(SIN(C1)/(COS(C1)*SIN(L1)-COS(L1)*COT(V8/60))) @ IF M<0 THEN P7=-
P7 ELSE P7=P7
570 W4=L0+P7 @ IF M<0 THEN W4=L0-P7 @ GOTO 610
580 IF M>0 THEN W4=L0+P7 @ GOTO 610
590 IF W4>0 THEN W4=L0+P7
600 IF W4<0 THEN W4=L0-P7
610 IF W4>180 THEN W4=W4-360
620 IF W4<-180 THEN W4=360+W4
630 W2=L0 @ GOSUB 840 @ GOSUB 930 @ V7=W3 @ GOSUB 960 @ V9=W4 @ GOSUB 980
640 L1=W3 @ L0=W4 @ GOSUB 670 @ GOSUB 680 @ GOTO 540
650 W1=W3 @ W2=W4 @ W3=M3 @ W4=M4 @ GOSUB 840 @ GOSUB 930 @ V7=W3 @ GOSUB 9
60
660 V9=W4 @ GOSUB 980 @ GOTO 520
670 D1=60*ACOS(SIN(L1)*SIN(M3)+COS(L1)*COS(M3)*COS(L0-M4)) @ D3=D1 @ RETURN
680 C1=ACOS((SIN(M3)-COS(D1/60)*SIN(L1))/(SIN(D1/60)*COS(L1)))
690 IF M>0 THEN C1=360-C1 @ RETURN
700 M6=360+M4 @ M7=360+L0
710 IF L0<0 THEN M7=360+L0
720 IF M4<0 THEN M6=360+M4
730 RETURN
740 X=FP(X)/.6+IP(X) @ RETURN
750 IMAGE DDcDDD.D
760 IF IP(Y)=0 THEN 770 ELSE 780
770 IF FP(Y)<0 THEN Y1=60*FP(Y) @ GOTO 790
780 Y1=ABS(60*FP(Y))
790 DISP IP(Y);'d'; @ DISP USING 750 ; Y1; @ DISP "'" @ RETURN
800 Y=IP(Y)+FP(FP(Y)*100)/36+IP(FP(Y)*100)/60 @ RETURN
810 V7=ATN((TAN(M3)*SIN(V9-L0)-TAN(L1)*SIN(V9-M4))/SIN(M4-L0)) @ RETURN
820 W1=W3 @ W2=W4 @ W3=V7 @ W4=V9 @ GOSUB 840 @ GOSUB 930 @ GOSUB 960
830 GOSUB 980 @ RETURN
840 P7=W2-W4 @ IF P7>180 THEN P7=P7-360
850 IF P7<-180 THEN P7=P7+360
860 P6=P7*COS((W3+W1)/2) @ C2=ANGLE(W3-W1,P6) @ D2=60*SQR((W3-W1)^2+P6^2)
870 IF C2<0 THEN C2=360+C2
880 IF C2<180 THEN 890 ELSE 900
890 IF M=0 THEN M=-1
900 IF C2>180 THEN 910
910 IF M=0 THEN M=1
920 C=C2 @ D=D2 @ RETURN
930 D4=D4+D2
940 DISP 'Co.= '; @ DISP USING 750 ; C
950 DISP 'Dist.='; @ DISP USING 750 ; D; @ DISP ' NMi.' @ DISP @ RETURN
960 DISP 'Pt.';'';X3;':'; @ X3=X3+1
970 Y=V7 @ DISP 'LAT='; @ GOSUB 750 @ RETURN
980 Y=V9 @ DISP 'LONG='; @ GOSUB 750 @ DISP @ RETURN
990 GOSUB 150 @ X=W @ GOSUB 740 @ W1=X @ GOSUB 170 @ X=W0 @ GOSUB 740 @ W2=
X @ RETURN
1000 W5=W @ W6=W0 @ DISP @ DISP 'Dest.' @ GOSUB 160 @ X=W @ GOSUB 740 @ W3=
X
1010 GOSUB 170 @ X=W0 @ GOSUB 740 @ W4=X @ DISP '';W5 @ DISP '';W6 @ DISP '
';W @ DISP '';W0
1020 INPUT 'Correct? ','Y'; Y$ @ IF UPRC$(Y$)='Y' THEN DISP @ RETURN
1030 DISP 'Reenter data' @ RETURN
```

FOR MI USING CO & DIST FINDS NEXT LAT AND ∆ LONG.

GT. C. FORMULAS: D1, C1.

FINDS GT. C CO + DIST FROM 1 PT TO DEST.

FINDS [illegible] LAT. FOR LONG.

USING PT. A + PT. B BY I.F. FINDS CO. + DIST.

VARIABLES FOR NAVA

A	A0 STAR	A1 R/S AZ	A2 SET AZ	A3 L	A4 = A8
	A.	A,	A' ANGLE	A8 RT. AS.	A9
B BETA PL	B0	B1	B2	B3	B4
	B5	B6	B7	B8	B9
C	C0 TR Co.	C1 MAG Co.	C2 Co.	C3 DR Co.	C4 GR⊙ Co
	C5	C6	C7	C8	C9
D DAY	D0 STAR	D1 MILES RUN	D2 DR. DIST	D3 DEC⊙ DD.D°	D4
	D5 SUM Mi	D6 = W1 + W2	D7 DELAY	D8 MOON DEC	D9 DEC
E ECLIPTIC	E0	E1 DEC DMT	E2 SHA-DMT	E3	E4 R.A. HHM
	E5	E6 R.A. DD.DD°	E7	E8 SHA DD.DD°	E9
F	F0	F1 PL	F2	F3	F4
	F5	F6 DATA	F7	F8	F9
G GMT	G0 GHA ♈	G1 GMT	G2 SHA	G3 GHA⊙	G4
	G5 °/HR	G6 L0-G8	G7 PA DATA	G8 MOON GHA	G9 GHA
H	H0 } PL	H1	H2	H3	H4
	H5 } DATA	H6	H7	H8	H9
I	I0	I1	I2	I3	I4 N6--S
	I5 INTERCEPT	I6 = I4	I7	I8	I9
J JUL. DAY	J0 } PL	J1	J2	J3	J4
	J5 } DATA	J6	J7	J8	J9
K	K0 STAR #	K1 = 1 for FIX	K2	K3	K4
	K5	K6 = 2 for R.F.	K7	K8	K9
L LONG (PL)	L0 IN LONG. DD°	L1 IN LA, D.D°	L2 = L1 INPUT LA	L3 L0 INPUT LO	L4 LONG
	L5	L6 M. LA.	L7 M LO	L8 LAT POL.	L9
M MONTH	M0 ΔLO MOON	M1 LA PT. 1	M2 LO PT. 1	M3 LA PT 2	M4 LO PT 2
	M5 in DR	M6 * PREC.	M7 FIX LA.	M8 FIX LO	M9
N * PREC	N0	N1 TIME SIGHT	N2 = L4 - M2 for LONG Δ	N3	N4
	N5	N6 LOP HC	N7	N8	N9 MP TIME
O LEN(G$)	O0	O1	O2	O3	O4
	O5	O6	O7	O8	O9
P PLON	P0	P1 FLAG MOON UP	P2 FLAG MOON RSE	P3 FLAG MOON SET	P4
	P5	P6 DR	P7 DR	P8 *	P9 *

VARIABLES FOR NAVA

Q	FLAG	Q0 FLAG	Q1 "D"	Q2 "D"	Q3 ☾	Q4 ☾
		Q5 LAT	Q6 "B"	Q7 LONG	Q8 R.F.	Q9 MORE SIGHTS
R	RP COEFF	R0	R1 RP COEFF ☾	R2	R3	R4
		R5 S.D. ☾	R6	R7 RP ☉	R8 RP☉	R9 RP☉
S	SHA *	S0	S1 H.E.	S2 I.C.	S3 Hs	S4 Hs ☉ Hs ☾
		S5 Ho	S6	S7 SD ☉	S8	S9
T		T0	T1 TIME RISE	T2 TIME SET	T3 STAR	T4 STAR
	TIME	T5 *	T6 DAWN TWI	T7 *	T8 *	T9 DUSK TWI
U	&	U0	U1	U2	U3	U4
	J.D.	U5	U6	7	U8	U9
V		V0	V1	V2	V3 ∠	V4 [illegible]
		V5	V6 [illegible]	V7	V8	V9
W	INP LA.	W0 INP LO	W1 DR LA #1	W2 DR LO #1	W3 DR LA #3	W'4 DR LO #
		W5	W6	W7	W8	W9
X	DD.DDDD to D.M.T.	X0	X1 = [illegible]	X2	X3 = COUNTER	X4
		X5	X6	X7 R7	X8	X9
Y	YEAR	Y0	Y1	Y2 H+M	Y3 H+M	Y4 H+M
		Y5 H+M	Y6	Y7 = R8	Y8 [illegible]	Y9 [illegible]
Z	HMS to HH.HHHH	Z0	Z1 *	Z2 Az	Z3 Az	Z4 Az
		Z5 Az	Z6 Z.D.	Z7 [illegible] Az	Z8	Z9 TIME ZONE

A$ LOG

B$ LOP/LA/LONG/DA

C$ LONG, E or W.

D$

N$ SELECTED BODY

Y$ YES