U.S. Department of Commerce
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
National Geodetic Survey

```
WW        W        WW   RRRRRRRRRR     KK         KK
WW       WWW       WW   RR       RR    KK       KK
 WW     WW WW     WW    RR        RR   KK     KK
 WW    WW   WW    WW    RR       RR    KK   KK
  WW   WW   WW   WW     RRRRRRRRRR     KK KK KK
  WW  WW     WW  WW     RR      RR     KKK     KK
   WW WW     WW WW      RR       RR    KK        KK
    WWW       WWW       RR        RR   KK          KK
```

Enhancement Programs

for

MTEN 3 or 4 SYSTEM

By:

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(Updated June 1988)
(Updated January 1992)

PREFACE

The WoRK (WRK) manual is documentation in support of a collection of utility programs determined to be the most useful for NOAA's Charting and Geodetic Services (C&GS) Hydrographic Operations. The manual's purpose is to be an instructional guide in the use of these utility programs by personnel working in the office and those engaged in geodetic and hydrographic field operations.

The materials presented herein by the WRK manual are the accumulated results from many smaller programs which were originally written for and programmed on hand-held calculators. The method of computation, program technique, and mathematical formulas are based on experiences obtained from the members of the geodetic and hydrographic operating elements of NOAA. All information has been taken freely from previously published manuals, namely, "Manual of Geodetic Triangulation", Special Publication No. 247 and the "Hydrographic Manual, Fourth Edition".

This WRK manual has been prepared under the direction of Mr. J.G. Gergen, Chief, Systems Development Branch, while the programs that are herein documented were prepared and written under the direction of Mr. D. B. Enabnit, Chief (Actg), Hydrographic Technology Programs (HTP). In the preparation of these "WRKnnn" (WRK) Programs, many hours of kind, understanding, and patient assistance were given by members of the HTP staff. In particular, NOAA Corps Officers CDR D. Seidel, LCDR A. Anderson, LCDR R. Floyd, LT V. Newell, and LT R. Mandzi all contributed advice and gave guidiance during the program development stage. A very special thanks goes to Mr. J. Gary Fredrick, Atlantic Marine Center; Mr. Danny Novak, Horizontal Network Branch; Mr. Dixon Hoyle, State Geodetic Advisor; and LT John Zabitchuck, NOAA Ship SURVEYOR; all of whom first used the WRK programs and then returned invaluable suggestions which were incorporated into the final versions.

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FOREWORD

Each "WRKnnn" (WRK) Program is a complete executable program with a primary filename equal to the "WRKnnn" name. Thus by just keying the "WRKnnn" name the operating system will load and execute the program. Each program was designed to operate on a console with a screen field size of 24 rows and 80 columns.

All programs and subroutines were written in Microsoft FORTRAN (MS-FORTRAN version 3.1) with one execption --- subroutine CONIN. This subroutine CONIN.ASM was written in assembler. Each program was compiled using Microsoft's MS-FORTRAN Compiler package and then combined with MS-LINK, the linking loader, to create the executable program. During the LINK step each WRK program was linked with both MTEN libraries and the Fortran library (FORTRAN.OBJ). The Fortran library used at runtime in all Links was the 8087 coprocessor library.

The actual screen display, as seen by the user, has a definite pattern. The basic pattern for each WRK program will be displayed by the following: Row 1 is the name of the current program in execution; Row 2 is a line of dashs to separate the WRK program from items which will be entered later; The middle rows (3 thru 20) are used to list entered data or listings. The last four rows (21 thru 24) are set aside for the entry of keyed information from the keyboard by the user. If an error is found during the execution of a WRK program, an error message will flash to the screen. The program will wait for the user to make a decision before it will continue.

The character subset used by WRK programs is restricted to only 47 characters. They are the alphabetic characters (letters A through Z), the numeric characters (numbers 0 through 9), and the eleven special characters (asterisk, blank, comma, period/decimal point, dollar sign, plus or minus sign, equal sign, slash, left and right parenthesis).

After each screen prompt statement and just before the actual location where the keyed data is entered, a data definition is provided along with the type of units that are required. The data definition has three basic types:

(1) (30A) -- alphanumeric characters -- a maximum of thirty allowed
(2) (LLL) -- alphabetic characters -- a maximum of three allowed
(3) (NNN) -- numeric characters -- a maximun of three allowed

The third, type (3), has several options beyond strictly numeric. If the data definition can be positive or negative, then a definition of (SNNN) with the letter "S" placed first in the format, is used to denote an optional "+" or "-" sign. If the data definition is a floating point number, the data must have a decimal character entered in the field and keyed as (SNNNN.NNN).

The data definition of (SNNNN.NNN) should be viewed as an example format and not as an exact representation of how the field should be keyed. The maximum field length for any entry is expressed on the screen by a line of dashes, "---------". In the above example (SNNNN.NNN) the decimal character, ".", can appear anywhere in the field length (e.g. 0.1, 223.4, -0.1456, -00.1, +20670. or 0.267321).

Some entries such as time and position require hours/degrees, minutes, and seconds, therefore, the data definition must include at least two commas and one decimal point and keyed in the following format (NNN,NN,NN.NNN). However, any leading zeros may be omitted, (i.e. zero degrees, minutes, and seconds) fully keyed would be as 000,00,00.000. It could be keyed as follows 0,0,0.0 without loss of accuracy. In addition to the data definition formats, help aids or examples for the data are flashed on-and-off to the screen for the user's examination before the field must be keyed. These aids are then removed from the screen at the conclusion of the prompt or current screen.

During execution of any WRK program, if an error is found, the program will display one of three types of error messages on rows 22, 23 and or 24. The first type will be a numbered message, e.g. "ERROR 061---- ...", and these messages are flashed only on row 23 and listed in the back of the "MTEN" Manual, Appendix C. The second type of error message, an unnumbered message e.g. "ERROR---- ...", will be displayed on row 23 of the current entry point screen. It will not have any additional information located in any of the other Appendixes and will usually terminate and exit the current entry point program. The third type of error message will provide immediate screen information by flashing additional messages for the user on rows 22 and 24. The user can, at this point, decide how to re-key or re-enter the current screen prompt information before continuing on with the program.

The characteristic pattern of all WRK programs is to use rows 22, 23, and 24 to prompt the user for data. Once the data entry has been completed with a <CR>, the information keyed will be reformatted and then reloaded on the screen display above at the approriate location. Since the WRK programs were designed to screen display all information and not use a printer (with exception of WRK001), the screen displays were setup so that they could be printed, therefore saving programming space which would have been required within the program to code and format a printed output listing. What was done within each program was to stop the program's execution, and then ask the user whether or not to print a copy of the screen. These stops were placed in every program so, whenever a screen display became full, the following message would flash to row 24 at the bottom of the screen:

DO YOU WANT TO PRINT THE CURRENT SCREEN (Y/N)? Y <CR>

A reply <CR>, the "NO" response, will force the program to continue without the option to print. If however, the reply Y <CR>, the "YES" response, is made the program will clear the message and reply by flashing the following message to the screen:

TOUCH <SPACE BAR + CR + SPACE BAR> -- PRINT SCREEN -- <CR>

At this point the user must touch the <SPACE BAR>, touch the <CR>, and then re-touch the <SPACE BAR> again. This will remove the "Cursor" image from the screen and when the screen is printed, by touching the "PRINT SCREEN" feature, the cursor image will not be part of the output that is printed. To continue, the user must again touch <CR> and the program will resume execution. Within the subroutine PRTSCN, which prompts the user with the above messages, the "GRAPHICS (Screen Print) Command" code to automatically invoke the system's screen print feature, was not used because: (1) not all users will have printers; and (2) not all users are equipped with keyboards that have a print screen key.

Additional prompts are flashed at the conclusion of every program entry point (on row 24) to allow the user to return to the program entry point or to just continue. Once the program entry point has been completed, and a new set of prompts have been displayed, the only way to return is to continue to the "MENU SCREEN" and then re-enter the program from the start.

The following message will be flashed to the screen on row 24 at the end of all WRK programs:

RETURN TO -- MENU SCREEN -- (Y/N)? <CR>

The <CR> reply, the "NO" response, will terminate program execution. The reply Y <CR>, the "YES" response, will force the program to re-enter at the very beginning.

1.0 WRK001 -- Tape Computations

To enter this program type WRK001 <CR>. The program will clear the screen and display the following entry points:

PROGRAM
(Y/N)?

STANDARD STEEL TAPE CORRECTIONS

TAPE STANDARDIZATION TABLE

Upon exiting either entry point, the program will display the following message:

RETURN TO --- MENU SCREEN --- (Y/N)?

This will allow the user to re-enter at the program level or to exit the program to DOS.

1.1 STANDARD STEEL TAPE CORRECTIONS

This program computes and applies the corrections required to reduce a taped distance to an horizontal distance and a geodetic distance on a selected ellipsoid. The computation is completed in five steps. They are (1) to determine the type of metal tape used and the overall observed distance, (2) to determine the tape's Coefficient of Expansion (COE) and to compute a temperature correction based on the observed temperature and COE, (3) to compute four more tape corrections (Tape+Catenary, Inclination, Setup, and Setback), (4) to allow the user to enter a reference ellipsoid (if one is needed) so the baseline measurement can be reduced to a geodetic length, and (5) to compute the final horizontal or geodetic distance by applying all the corrections to the observed distance and displaying the result on the screen.

Two examples will be used in order to demonstrate the use of this program. The first, EXAMPLE ONE, will be a reduction of a taped distance (slope) to a horizontal distance, i.e. the distance is measured from the instrument telescope axis set over the station mark to the surface of a nearby reference mark. The second, EXAMPLE TWO, will be a complete reduction of a short-traverse taped measurement, one "Bay", to a geodetic length on the selected ellipsoid. A "Bay" is the distance between the two tape ends disregarding the number of tape supports in between.

==================== (EXAMPLE ONE) ====================

Step one of this program determines the tape's metal type so it can be used to determine the correct COE to apply to the TEMPerature /TEMP/ Correction. The following data will be used for this example:

Observational Data

Tape (**)	/Steel/	30	Meters
Temperature		(?.?)	Unknown
Distance	HELD	23.61	Meters
Distance	CUT	8	mm
Tape End	/Height over Standpoint/	1.632	Meters
Zenith Distance	/DMS/	92,34,52	

(**) This tape is graduated at: 0.00 to 0.10 every mm and
0.10 to 30.0 every cm

In order to determine the tape's metal type, the program will prompt for the four possible types and ask the user to select one. The four prompts will recycle until a selection is made from the following messages:

```
TYPE OF METAL USED WAS "STEEL" (Y/N)?        Y <CR>
                       "INVAR"
                       "LOVAR"
                       "OTHER"
```

If the tape used for the measurement does not fit any of the first three classifications, the user must select "OTHER" and then later enter a COE for it. After the metal type has been selected, the program will load the screen with a "S, I, L or O" which corresponds to the type selected.

The second part of step one asks the user to enter the distance from the beginning mark on the tape to the ending mark on the tape (this is, the Distance "HELD" given with the observational data). The prompt for this distance is:

```
OBSERVED DISTANCE/BETWEEN TAPE MARKS/ (NNN.NNN)?  23.61 (M/F)? M <CR>
```

Once the prompt "(M/F)?" has been completed, the program will assume that all taping corrections that follow will be in the same measurement unit.

Step two prompts for the observed temperature. Using the selected metal type and the corresponding COE, the program will compute a TEMPerature /TEMP/ Correction for the observed temperature. The prompt for the temperature at the time of measurement is:

```
OBSERVED TEMPERATURE (NNN.N)?  20.0                  (C/F)? C <CR>
```

In this example the temperature was unknown so we have:

```
OBSERVED TEMPERATURE (NNN.N)?  <CR>
```

Since the observed temperature was unknown for this example, the reply of <CR> will allow the program to continue. However at this point the following prompt will appear on the screen:

```
CORRECTION FOR -- TEMPERATURE    /TEMP/     SKIP (Y/N)?          <CR>
```

If a reply of Y <CR>, the "YES" response, is made the program will continue and no futher computation will be made for the TEMPerature /TEMP/ Correction, and the screen display for the value of /TEMP/ will be left blank. However, if a <CR> reply, the "NO" response, is made the program (with no observed temperature entered) will assume an observed temperature of 20.0 Celsius, and computes a /TEMP/ Correction of zero, and loads the screen with it. A second message will also be loaded on the screen above the correction statement. That message is the COE in PPM (parts per million) that will be used with the selected metal type (e.g. the COE for steel equals 0.0000116 Meter / Meter / degree Celsius). To compute the /TEMP/ Correction:

```
PPM -- COEFFICIENT OF EXPANSION (M/M/C)   "STEEL"     11.6
```

or for the other types (I,L,O):

```
PPM -- COEFFICIENT OF EXPANSION (M/M/C)   "INVAR"      0.36
PPM -- COEFFICIENT OF EXPANSION (M/M/C)   "LOVAR"      3.96
PPM -- COEFFICIENT OF EXPANSION (M/M/C)   "OTHER"     xx.xx
```

If a metal type of "O" was selected, the user must enter a /TEMP/ Correction directly, since no COE is available for computation:

```
CORRECTION FOR -- TEMPERATURE    /TEMP/     x.xxxxx
```

The phrase "PAUSE (Y/N)?" will now appear at the bottom of the screen. It is displayed to allow the user time to examine the COE PPM message before the program clears the screen and continues with the next step.

Step three, the Tape+CATenary /TCAT/ Correction, prompts for a correction. The value must be entered by the user: METERS

```
CORRECTION FOR -- TAPE+CATENARY  /TCAT/ N.NNNNN  -0.00259 <CR>
```

A /TCAT/ Correction of -2.59 mm was used for this measurement. It was computed using the data taken from Figure (1.02).

Tape Length (m)	...	TCAT (2 points) (mm)
23		-2.27
	(23.61 = -2.59)	
24		-2.80

Another correction applied in step three, the INCLination /INCL/ Correction, computes a value and applies it to the observed distance. This correction reduces the observed distance to a horizontal measurement when the tape ends are not of equal height. The program will prompt the following statement:

```
CORRECTION FOR -- INCLINATION    /INCL/    SKIP (Y/N)?          <CR>
```

A reply of Y <CR>, the "YES" response, forces the program to skip the /INCL/ Correction, leave the screen display blank for it, and to continue to the next correction. However, if a <CR> reply, the "NO" response, is made the program will display another message in order to determine the method of computation for the correction:

```
ZENITH DISTANCE MEASURED (Y/N)?                              Y <CR>
```

A reply of Y <CR>, the "YES" response, will force the user to enter a zenith distance observation (see the above given data) in response to the next prompt:

```
ZENITH /DMS/ (NNN,NN,NN.N)?      92,34,52.0   PAUSE (Y/N)?        <C
```

At which point the computed correction will be loaded on the screen under the screen heading /INCL/. If however, a <CR> reply, the "NO" response, is made the program will then prompt with the following message:

```
ELEVATION DIFFERENCE MEASURED (Y/N)?                           <CR>
```

Here if the <CR> reply, the "NO" response, is made the program will continue without computing an /INCL/ Correction. A reply of Y <CR>, the "YES" response, will prompt the user to enter an observed difference of elevation. This computation will be described in EXAMPLE TWO.

The two remaining corrections for this step, /SETU/ and /SETB/, are addressed by the following set of program prompts and user replies:

```
                                                      METERS
CORRECTION FOR -- A SETUP       /SETU/ N.NNNNN                  <CR>

CORRECTION FOR -- A SETBACK     /SETB/ N.NNNNN   0.008 <CR>
```

A SETUp /SETU/ Correction is used when the (none in this example) end-of-tape mark falls short. Sometimes a short distance (a centimeter or two) is added to move the ending mark of the last measurement to a new point near the center of the chaining buck (support) in order to begin the current taping bay (thus an addition to this bay and not to the one just completed).

The entry Distance "CUT" (8 mm or 0.008 Meters) was given as part of the observational data. As a "NOTE" to the user, the program will always add the /SETU/ Correction and subtract the /SETB/ Correction to the observed distance.

Step four, the ELEVation /ELEV/ Correction, will not be discussed in this example (see EXAMPLE TWO). Therefore the user's reply to the prompt:

CORRECTION FOR -- ELEVATION /ELEV/ SKIP (Y/N)? Y <CR>

must be Y <CR>. This will leave a local horizontal distance from the station to the reference mark at the elevation of the station and reduce it to a geodetic length.

At this point, step five, the program computes the final length for the measurement and loads the value under the screen heading "REDUCED LENGTH" along with the character "M" or "F" to display the selected taping units. To complete this step the program prompts the user for changes to the current distance measurement and to the computed corrections, by the following statement:

RE-WORK THE CURRENT MEASUREMENT (Y/N)? <CR>

A <CR> reply, the "NO" response, allows the program to complete this step. A reply of Y <CR>, the "YES" response, will force the program to cycle through each of the above entries.

To complete EXAMPLE ONE, an additional prompt is made by the program. This prompt allows the user to enter a new measurement:

ENTER A NEW MEASUREMENT (Y/N)? <CR>

A reply of Y <CR>, the "YES" response, will return the program to step one and allow the user to enter another tape measurement. A reply of <CR> will return the user to the program's entry point level. A sample screen is given in Figure (1.01).

(EXAMPLE TWO)

This example of a short-traverse measurement between a station mark and another nearby mark uses the same data given in EXAMPLE ONE, however additional information is now available.

The first part of step one determines the metal type by:

TYPE OF METAL USED WAS "STEEL" (Y/N)? Y <CR>

The second part prompts the user to enter the overall distance between the beginning and ending tape marks with the prompt:

OBSERVED DISTANCE/BETWEEN TAPE MARKS/ (NNN.NNN)? 23.61 (M/F)? M <CR>

Step two prompts the user for the observed temperature at the time of measurement, so that the TEMPerature /TEMP/ Correction can be computed. The prompt is as follows:

```
OBSERVED TEMPERATURE (NNN.N)?  23.8                    (C/F)? C <CR>

CORRECTION FOR -- TEMPERATURE    /TEMP/            SKIP (Y/N)?   <CR>

                                                  PAUSE (Y/N)?   <CR>
```

Observational Data

Tape (**)	/Steel/ (NBS# 14412)	30.0	Meters
Temperature	(Mean of two readings)	23.8	Celsius
Distance	HELD	23.61	Meters
Distance	CUT	8.3	mm
Inclination	(Between ends-Forepoint lower)	1.064	Meters
Tape End	(Height above Standpoint)	1.632	Meters
Station	Elevation	10362	Feet
Station	Geoid Height	-26.0	Meters
Taping Latitude	/DMS/	40,01,10	North
Azimuth of Bay	/DMS/	317,10,16	(from North)
Datum	(Ellipsoid Clarke 1866)	NAD27	

(**) This tape is graduated at: 0.00 to 0.10 every mm and 0.10 to 30.0 every cm

Step three consists of four corrections, /TCAT/, /INCL/, /SETU/ and /SETB/. The first correction for /TCAT/ will be the same set of prompts given in EXAMPLE ONE or:

```
                                                   METERS

CORRECTION FOR -- TAPE+CATENARY  /TCAT/ N.NNNNN  -0.00259 <CR>
```

The INCLination /INCL/ Correction will answered by the user, and computed after responding to the following prompts:

```
CORRECTION FOR -- INCLINATION    /INCL/            SKIP (Y/N)?   <CR>

ZENITH DISTANCE MEASURED (Y/N)?                                  <CR>

ELEVATION DIFFERENCE MEASURED (Y/N)?                           Y <CR>

ELEVATION DIFFERENCE BETWEEN TAPE ENDS (NN.NNN)?  1.064 (M/F)? M <CR>

FOREPOINT (ABOVE/BELOW) STANDPOINT (A/B)?                      B <CR>
                                                  PAUSE (Y/N)?   <CR>
```

The SETUp /SETU/ and SETBack /SETB/ Corrections can be entered in either of two ways. If the user touches <CR> when prompted, the program will continue and leave the value for this correction as a blank field on the screen. However, if the user enters a 0.0 <CR>, the program will load the value 0.00 under the screen heading /SETU/ or /SETB/. The following prompts were used:

```
                                                                METERS
      CORRECTION FOR -- A SETUP        /SETU/ N.NNNNN                     <CR>

      CORRECTION FOR -- A SETBACK      /SETB/ N.NNNNN   0.0083 <CR>
```

Step four, the ELEVation /ELEV/ Correction, takes a horizontal tape measurement and reduces it to a geodetic length using the mid-point elevation of the "Bay". The correction will be computed by the program after the user answers the following set of statements:

```
      CORRECTION FOR -- ELEVATION      /ELEV/            SKIP (Y/N)?   <CR>

           LATITUDE /DMS/  (NN,NN,NN.NNN)?    40,01,10.0 <CR>

           AZIMUTH  /DMS/ (NNN,NN,NN.NN)?    317,10,16.0 <CR>
```

Since no ellipsoid information is available to the program, it will prompt the user to select one of the following ELLIPSOIDs by:

```
      USE GRS 1980      ELLIPSOID .. NAD83 ..       (Y/N)?
      USE CLARKE 1866   ELLIPSOID .. NAD27 ..       (Y/N)?
      USE WGS 1972      ELLIPSOID    .....          (Y/N)?
```

or select any user defined ELLIPSOID by:

```
      USE ELLIPSOID  (AAAAAAAAAA)?
      MAJOR AXIS   (NNNNNNN.NNNN)?
      FLATTENING "1/F" (NNN.NNNNNN)?
```

After the ellipsoid parameters have been selected, the "DATUM" abbreviation will be flashed to the screen in the upper right-hand corner.

STANDARD STEEL TAPE CORRECTIONS NAD27

MEASUREMENT TAPE	DISTANCE (M/F)	TEMP (C)	TAPE CORRECTIONS (millimeters/millifeet) TEMP	TCAT	INCL	SETU	SETB	ELEV	REDUCED LENGTH (M/F)
S	23.610			-2.59	-23.95		-8.00		23.5755 M
S	23.610	23.8 C	1.04	-2.59	-23.99		-8.30	-11.59	23.5646 M

Figure (1.01) ---- List of Taping Corrections

To continue, the program will partially clear the screen and then reload it with prompts for the user to enter the elevation of the station and the appropriate tape end heights:

```
ENTER STANDPOINT TAPE ELEVATION = (MARK HGT+GEOID HGT)+(TAPE END HGT)

     ELEVATION OF STATION MARK (SNNNN.NN)?      10362.  (M/F)? F <CR>

     GEOID HGT OF STATION MARK (SNN.NN)?          -26.0  (M/F)? M <CR>

     HEIGHT OF TAPE (ABOVE/BELOW) MARK (NN.NN)?   1.632  (M/F)? M <CR>

                   (ABOVE/BELOW)                         (A/B)? B <CR>

                                                  PAUSE (Y/N)?   <CR>
```

At this point, the program will automatically compute the mid-point height of the bay (over or below the Standpoint) by adding or subtracting one-half of the difference in elevation between the tape end points depending on whether or not the Forepoint tape end is "ABOVE or BELOW" the tape end for the Standpoint. This height difference will be added to the elevation of the Standpoint tape end in order to compute the /ELEV/ Correction. This correction will be loaded under the screen heading /ELEV/.

The final value for the measurement will be loaded under the screen heading "REDUCED LENGTH" along with the character "M" or "F" to display the taping units. A sample screen is given in Figure (1.01).

1.2 TAPE STANDARDIZATION TABLE

This program computes a Table of Tape + CATenery /TCAT/ Corrections for a given tape using the data found on a "Report of Length Calibration". The program computes the table in three steps. They are, (1) enter the tape's idenification information, (i.e. tape's ownership, serial number, calibration date, etc.), (2) enter the calibrated tape lengths from the report, and (3) provide the user with a printed listing.

The data listed below was taken from a "Report of Length Calibration" done by the National Bureau of Standards, December 9, 1971, on a 30-Meter tape (Serial Number 71-2).

REPORT OF LENGTH CALIBRATION

LUFKIN 30-METER STEEL TAPE NBS NO. 14412

THE AVERAGE "AE" VALUE FOR THIS TAPE IS 39894 KILOGRAMS

THE AVERAGE WEIGHT PER METER OF THIS TAPE IS 0.014927 KILOGRAMS

THE ASSUMED THERMAL EXPANSION OF THIS TAPE IS 0.00001160 M/M/DEG C

"THIS TAPE ON A HORIZONTAL FLAT SURFACE AND WITH TENSION APPLIED HAS BEEN COMPARED WITH THE STANDARDS OF THE UNITED STATES. THE DISTANCE BETWEEN THE TERMINAL POINTS OF THE INDICATED INTERVALS HAVE THE FOLLOWING LENGTHS AT 20 DEGREES CELSIUS:"

TENSION (Kilograms)	INTERVAL (Meters)	LENGTH (Meters)
5	0 to 1	0.99977
5	0 to 2	2.00028
5	0 to 3	3.00000
5	0 to 4	4.00022
5	0 to 5	5.00086
5	0 to 10	10.00085
5	0 to 15	15.00151
5	0 to 20	20.00201
5	0 to 25	25.00241
5	0 to 30	30.00281

Step one prompts the user for seven items of information. They will be used to properly identify the tape and the printed listing provided for the /TCAT/ Corrections. Each of the following prompts must be answered before the program will compute the table of corrections. The seven prompt are:

```
AGENCY NAME (35A)? -----------------------------------

AGENCY TAPE SERIAL NUMBER (10A)?                          NGS 71-02 <CR>

NATIONAL BUREAU OF STANDARDS NUMBER (10A)?                    14412 <CR>

DATE OF STANDARDIZATION /YYMMDD/ (NNNNNN)?                   711209 <CR>

AVERAGE WEIGHT OF THIS TAPE /Grams per Meter/ (NN.NNN)?      14.927 <CR>

STANDARDIZATION /at 20 Degrees Celsius/ TENSION (NN.NN)?      5.0   <CR>

LENGTH OF THIS TAPE /Meters/ (NNN)?                           30    <CR>
```

Step two prompts the user for the "FLAT" distance between terminal points (taken from the report data) for each meter interval of length (30 meters) starting with the first meter. Each meter prompt will be as follows:

```
FLAT TAPE LENGTH FOR "xx" METER(S) KNOWN (Y/N)?                 Y <CR>
```

The user must stop at each interval "xx" which corresponds to the calibration information given for that interval. To stop type Y <CR>, the "YES" response, and the program will change the entry line to:

```
FLAT TAPE LENGTH FOR "01" METER(S) (NNN.NNNNNN)?    0.99977 <CR>
```

From the given information the following nine entries were made:

```
FLAT TAPE LENGTH FOR "02" METER(S) (NNN.NNNNNN)?    2.00028 <CR>
                     "03"                           3.0     <CR>
                     "04"                           4.00022 <CR>
                     "05"                           5.00086 <CR>
                     "10"                          10.00085 <CR>
                     "15"                          15.00151 <CR>
                     "20"                          20.00201 <CR>
                     "25"                          25.00241 <CR>
                     "30"                          30.00281 <CR>
```

As each tape interval is flashed on the screen, the program computes a CATenary (2 support) Correction for the meter entry. This will be printed later in the table (see "Manual of Geodetic Triangulation", Special Publication No. 247, U.S. Department of Commerce, Captain F.R. Gossett, 1950, Revised Edition 1981, pages 226-227. After all "FLAT" tape values have been entered, the program will compute a Tape "T" value for each meter entry by linearly intrtpolating between the standardized points.

To compute the /TCAT/ Correction (2 points) for each meter entry in the table, two values "T" and "CAT" are simply added. To finish this step, the program will print a listing of the computed /TCAT/ corrections and then return to the program's "MENU" screen. A sample listing of the printed output is given in Figure (1.02).

NATIONAL GEODETIC SURVEY AGENCY NUMBER = NGS 71-02

NATIONAL BUREAU OF STANDARDS (NBS NUMBER) = 14412

DATE OF STANDARDIZATION (YYMMDD) = 711209

AVERAGE WEIGHT OF TAPE (Grams/Meter) = 14.927

STANDARDIZATION (20 Degrees Celsius) PULL (Kilograms) = 5.0

LENGTH OF TAPE (Meters) = 30

TAPE Corrn + CATENART Corrn = TCAT (Tape and CATenary Corrn)

Tape Length (M)	Tape Flat (mm)	+ CATenary 2 Supports (mm)	TCAT (2 points) (mm)
0	0.00	0.00	0.00
1	-0.23	0.00	-0.23
2	0.28	0.00	0.28
3	0.00	-0.01	-0.01
4	0.22	-0.02	0.20
5	0.86	-0.05	0.81
6	0.86	-0.08	0.78
7	0.86	-0.13	0.73
8	0.85	-0.19	0.66
9	0.85	-0.27	0.58
10	0.85	-0.37	0.48
11	0.98	-0.49	0.49
12	1.11	-0.64	0.47
13	1.25	-0.82	0.43
14	1.38	-1.02	0.36
15	1.51	-1.25	0.26
16	1.61	-1.52	0.09
17	1.71	-1.82	-0.11
18	1.81	-2.17	-0.36
19	1.91	-2.55	-0.64
20	2.01	-2.97	-0.96
21	2.09	-3.44	-1.35
22	2.17	-3.95	-1.78
23	2.25	-4.52	-2.27
24	2.33	-5.13	-2.80
25	2.41	-5.80	-3.39
26	2.49	-6.53	-4.04
27	2.57	-7.31	-4.74
28	2.65	-8.15	-5.50
29	2.73	-9.06	-6.33
30	2.81	-10.03	-7.22

Figure (1.02) -- Tape Standardization Table

2.0 WRK002 -- Eccentric Reductions

To enter this program type WRK002 <CR>. The program will clear the screen and the following entry points will be displayed:

```
PROGRAM
 (Y/N)?

       ECCENTRIC REDUCTION --- INSTRUMENT
       ECCENTRIC REDUCTION --- LIGHT/OBJECT
```

The only defaults to be initialized for this program are the ellipsoid parameters and the datum name. This is done by response to the prompt:

```
       ATTACH TO  --- "MTEN SYSTEM" ---  (Y/N)?
```

A reply of Y <CR>, the "YES" response, will require the user to complete the next two prompts:

```
       CHANGE DEFAULT DRIVE=C (Y/N)?  <CR>
       ENTER YOUR JOBCODE /JC/ (LL)?  JC <CR>
```

The program will then use the ellipsoid parameters that were initialized previously with ABSINX (See Manual Section 1).

If just a <CR>, the "NO" response, is made the "ATTACH TO ..." prompt, the program will execute independent of MTEN and all information must be entered from the keyboard.

With no datum information available, the program will ask the user to initialize the ellipsoid parameters by prompting for selection of one of the following:

```
       USE GRS 1980     ELLIPSOID .. NAD83 ..      (Y/N)?
       USE CLARKE 1866  ELLIPSOID .. NAD27 ..      (Y/N)?
       USE WGS 1972     ELLIPSOID    .....         (Y/N)?
```

or select another ellipsoid defined by:

```
       USE ELLIPSOID  (AAAAAAAAAA)?
       MAJOR AXIS    (NNNNNNN.NNNN)?
       FLATTENING "1/F" (NNN.NNNNNN)?
```

After the ellipsoid parameters have been selected or entered, the "DATUM" abbreviation display on the screen in the upper right-hand corner. At this point, entry points will flash to the screen and different screens will appear depending on the initial entry point selected. Upon the exit from each of the entry points, the program will prompt the user with the following:

```
       RETURN TO   --- MENU SCREEN ---  (Y/N)?
```

This will allow the user to re-enter at the program level or to exit.

2.1 ECCENTRIC INSTRUMENT

The purpose of this program is to compute an eccentric reduction for an instrument occupation which is eccentric to the true station /CENTER/. Upon successful completion of this program all observed data will appear as if the eccentric instrument occupation didn't exist and the observations will be configured as if the instrument was plumbed over the "TRUE" station. The actual data used for keyboard entries, will be that which was observed at the eccentric instrument occupation. After the reduction-to-center computation, the final reduced directions will be the reduced directions, as if they were observed at the "TRUE" station. The computation involves six steps, they are: (1) enter the name of the initial station, the eccentric instrument station name, and the true station /CENTER/ name, (2) enter the distance from the true station /CENTER/ to the initial station, (3) define the configuration of the clockwise reference angle measurement, (4) enter the reference angle and distance, (5) enter the directions to each observed object, and (6) compute the eccentric correction and display it and the reduced direction on the screen.

Two examples are given in order to demonstrate the use of this program entry point. The first, EXAMPLE ONE, was taken from "Manual of Geodetic Triangulation", Special Publication No. 247, U.S. Department of Commerce, Captain F.R. Gossett, 1950, Revised Edition 1981, pages (151-157). EXAMPLE TWO demonstrates the computational method used when the "MTEN SYSTEM" has been attached.

(EXAMPLE ONE)

Step one of the program requires the user to enter three station names and to define the geometric relationship between them. The three names --- the initial, eccentric, and true --- are prompted as follows (see Observational Data below):

```
1 - INITIAL USED ON ABSTRACT
2 - ECCENTRIC --- INSTRUMENT
3 - TRUE STATION /CENTER/

ENTER THE /SPN + NAME/ FOR ENTRY NBR " 1 " --- (Y/N)?   <CR>
ENTER STATION NAME: (30A)?   CENTRAL <CR>

ENTER THE /SPN + NAME/ FOR ENTRY NBR " 2 " --- (Y/N)?   <CR>
ENTER STATION NAME: (30A)?   CHASE (ECC) <CR>

ENTER THE /SPN + NAME/ FOR ENTRY NBR " 3 " --- (Y/N)?   <CR>
ENTER STATION NAME: (30A)?   CHASE <CR>
```

If a reply of <CR>, the "NO" response, is made the program will automatically prompt for the station name. However, a reply of Y <CR> will force the program to prompt the user to make a SPN assignment associated with the name entry. Note: SPN assignments are for the user's information only, because at this point in the program the "MTEN SYSTEM" files are unattached. After each entry has been completed, the program will reload the information onto the screen adjacent to the corresponding "NBR" line, i.e. see sample screen given by Figure (2.01).

```
-------------------------( Observational Data )---------------------------

          CENTRAL   +  1
                    .
                    .          ANGLE (1-2-3)  =   135 33 02 (Clockwise)
                    |
                    |          DISTANCE (3-2) =   10.987 Meters
                    |
                    |
                    |
   INSTRUMENT (ECC) O  2
                     .
                      .
                       .
                        .
                         .
                          .
          CHASE /CENTER/   +  3

                            STATION:   CHASE /Observed at CHASE (ECC)/
                            ABSTRACT:   1

                    OBSERVED     COMPUTED       OBSERVED
                    STATION      DISTANCE       DIRECTION
                  ----------------------------------------
                     Name        (Meters)      DDD-MM-SS.SS
                  ----------------------------------------
                    CENTRAL      25266.20        0 00 00.00
                    LITTLE       33058.26       18 20 10.78
                    LYONS        20237.65       24 34 53.00
                    BOSSING      31044.17      314 51 23.61
                    /CENTER/        10.987     135 33 02.
--------------------------------------------------------------------------
```

Step two of the program prompts the user for the geodetic distance from the initial station (NBR 1) to the true station /CENTER/ (NBR 3) by the following:

GEODETIC DISTANCE BETWEEN NBR(S)/1-3/ (NNNNN.NNN)? 25266.20 (M/F)? M <CR>

Once the geodetic distance /1-3/ has been entered, the screen will display the geometric configuration prompts and ask the user to define the clockwise measurement of the reference angle observation by:

```
WHICH STATION WAS USED TO  -- INITIAL ON "NBR" /1-2-3/ (N)?    1 <CR>
STATION REFERENCE ANGLE WAS  OBSERVED AT "NBR"   /2-3/ (N)?    2 <CR>
WHICH STATION WAS THE ANGLE -- TURNED TO "NBR" /1-2-3/ (N)?    3 <CR>
```

Step four will prompt the user for the clockwise value of the reference angle and then, the reference distance, i.e. the distance (3-2) from the true station /CENTER/ to the eccentric instrument. The prompts are:

```
REFERENCE ANGLE/DMS/ (NNN,NN,NN.N)?       135,33,02.0  <CR>
REFERENCE DISTANCE   (NNNN.NNN)?          10.987       (M/F)?  M <CR>
```

A sample screen is given in Figure (2.01).

```
  +---------------------------------------------------------------------------+
01|                    ECCENTRIC REDUCTION --- INSTRUMENT            NAD27    |
02|                  -------------------------------------                    |
03|                                                                           |
04| NBR  GEOMETRIC RELATIONSHIP        SPN                                    |
05|  1   INITIAL USED ON ABSTRACT            CENTRAL                          |
06|  2   ECCENTRIC --- INSTRUMENT            CHASE (ECC)                      |
07|  3   TRUE STATION /CENTER/               CHASE                            |
08|                                                                           |
09| GEODETIC DISTANCE BETWEEN NBR(S)/1-3/ (NNNNN.NNN)?  25266.20    (M/F)?  M |
10|                                                                           |
11|                                                                           |
12|      GEOMETRIC CONFIGURATION FOR ECCENTRIC --- INSTRUMENT                 |
13|      ---------------------------------------------------------            |
14|      WHICH STATION WAS USED TO     INITIAL ON "NBR" /1-2-3/ (N)? 1        |
15|      STATION REFERENCE ANGLE WAS  OBSERVED AT "NBR"   /2-3/ (N)? 2        |
16|      WHICH STATION WAS THE ANGLE    TURNED TO "NBR" /1-2-3/ (N)? 3        |
17|                                                                           |
18|      REFERENCE ANGLE/DMS/ (NNN,NN,NN.N)?       135,33,02.0     CLOCKWISE  |
19|      REFERENCE DISTANCE   (NNNN.NNN)?          10.987           (M/F)?  M |
20|                                                                           |
    ....
24|                                                                           |
  +---------------------------------------------------------------------------+
```

Figure (2.01) ---- Eccentric INSTRUMENT Configuration Screen

At this point the screen will clear and the program will go to the next screen display, the eccentric reduction computation. In step five the program allows the user to cycle through as many observed "OBJECTs" as are needed to complete all directions on a given abstract. Each "OBJECT" will require the user to complete three prompts. They are as follows: first, enter the "OBJECT" name, second, enter the geodetic distance from the true station /CENTER/ to the "OBJECT" station, and the third, enter the observed direction to the "OBJECT". A sample cycle set for one observed "OBJECT" is as follows:

```
ENTER OBJECT NAME:  LITTLE <CR>
ENTER OBJECT DISTANCE (NNNNN.NNN)?      33058.26         (M/F)?  M <CR>
ENTER OBJECT DIRECTION/DMS/ (NNN,NN,NN.NN)?  18,20,10.78 <CR>
```

When the third entry has been made, the program will compute the eccentric correction for the observed direction and then display the computed value for it and the "REDUCED DIRECTION" on the screen. A sample screen is given in Figure (2.02). NOTE: that upon reduction-to-center the true station as seen at the instrument (ECC) occupation, becomes the "OBJECT" seen from the true station plus 180 degrees. In most cases this flip-flop is left off the abstract since it is entered as the reference angle. To allow for additional observations to be entered, the following prompt will appear:

STOP OBSERVATION ENTRY (Y/N)? Y <CR>

A reply of <CR>, the "NO" response, will force the program to recycle and continue to prompt for additional observed directions. A reply of Y <CR>, the "YES" response, will stop the program and return to the program's "MENU" screen.

```
  +--------------------------------------------------------------------------+
01|                 ECCENTRIC REDUCTION --- INSTRUMENT          NAD27        |
02|               ------------------------------------                      |
03|                                                                          |
04|      OBSERVED                  DISTANCE  OBSERVED      CORRECTION  REDUCED   |
05| SPN  STATION NAME              (Meters)  DIRECTION         (")    DIRECTION |
06|                                                                          |
07|     CENTRAL                  25266.20 000-00-00.00       -62.81 359-58-57.19 |
08|     LITTLE                   33058.26 018-20-10.78       -60.96 018-19-09.82 |
09|     LYONS                    20237.65 024-34-53.00      -104.56 024-33-08.43 |
10|     BOSSING                  31044.17 314-51-23.61         0.88 314-51-24.49 |
11|     CHASE (ECC)                 10.99 315-33-02.00         0.00 315-33-02.00 |
12|                                                                          |
   ...
24|                                                                          |
  +--------------------------------------------------------------------------+
```

Figure (2.02) ---- Eccentric INSTRUMENT Screen

In order to convert a set of directions, so that the "INITIAL" direction has a direction equal to zero, the eccentric correction for the initial direction must be removed as shown below. This conversion is done automatically when attached to "MTEN" with the program ADJSTA. However, when unattached, it must be manualy computed by the user.

ECCENTRIC CORRECTION (")	REDUCED DIRECTION DDD-MM-SS.SS	INITIAL CORRN (")	DIRECTION WITH ZERO INITIAL
-62.81	359-58-57.19	+62.81	000-00-00.00
-60.96	018-19-09.82	+62.81	018-20-12.63
...	024-33-08.43	+62.81	024-34-11.24
	314-51-24.49	+62.81	314-52-27.30
	315-33-02.00	+62.81	315-34-04.81

—————————— (EXAMPLE TWO) ——————————

The first step of the program requires the user to enter the three SPNs used to define the eccentric relationship and to define the geometric relationship between them. Each of the SPNs for the initial, eccentric, and true stations will be prompted as follows (see Observational Data below):

-------------------------(Observational Data)--------------------------
At the (ECC) occupation

```
    BORO HALL (70)  +  1
                    .
 POUCH (71) + 3     .
  /CENTER/    .     .
               .    .          ANGLE (1-2-3)  =   326 43 06.5 (Clockwise)
                .   |
                 .  |          DISTANCE (3-2) =    2.639 Meters
 POUCH RM 4 (63) +  |
                  . |
                   .|          STATION :  POUCH /Observed at POUCH (ECC)/
                   .|          SPN     :  71
   POUCH (ECC)  (64) O  2      ABSTRACT:   4
                     .
                      .
                       .
                        .
                         .
                          .
      POUCH AZ MK 3 (60) +
```

OBSERVED STATION		OBSERVED DIRECTION
SPN	Name	DDD-MM-SS.SS
70	BORO HALL	0 00 00.00
60	POUCH AZ MK 3	146 43 06.50
63	POUCH RM 4	326 43 06.50
71	POUCH	326 43 06.50 /CENTER/

----

1 - INITIAL USED ON ABSTRACT
2 - ECCENTRIC --- INSTRUMENT
3 - TRUE STATION /CENTER/

ENTER THE /SPN + NAME/ FOR ENTRY NBR " 1 " --- (NNN)? 70 <CR>

ENTER THE /SPN + NAME/ FOR ENTRY NBR " 2 " --- (NNN)? 64 <CR>

ENTER THE /SPN + NAME/ FOR ENTRY NBR " 3 " --- (NNN)? 71 <CR>

After each SPN entry is completed (note there has to be a SPN assigned also for the "ECC" instrument even though the abstract data will be reduced to the true station), the program will re-load the information onto the screen next to the correcponding "NBR" line, i.e. see sample screen given by Figure (2.03).

```
--------------------------( Observational Data )---------------------------
                           Seen at POUCH /CENTER/

     BORO HALL (70)  +  1
                     .
                     .
                     .
                     .
                     .          ANGLE (1-2-3)  =   326 43 06.5 (Clockwise)
                     |
                     |          DISTANCE (3-2) =    2.639 Meters
                     |
                     |
                     |
                     |
         POUCH  (71) +  3       STATION :  POUCH
          /CENTER/    .         SPN     :  71
                       .        ABSTRACT:   4
                        .
         POUCH RM 4 (63) +
                          .
                           .
                            .
            POUCH (ECC) (64) O 2
                              .
                               .
                                .
              POUCH AZ MK 3 (60)  +


                 OBSERVED        COMPUTED     OBSERVED
                 STATION         DISTANCE     DIRECTION
             ---------------------------------------------
              SPN   Name           (Meters)    DDD-MM-SS.SS
             ---------------------------------------------
               70  BORO HALL       2692.77       0 00 00.00
               60  POUCH AZ MK 3    516.37     146 43 06.50
               63  POUCH RM 4         2.000    326 43 06.50
               64  POUCH (ECC)        2.639    326 43 06.50
---------------------------------------------------------------------------
```

The data must be recorded as if the observations were made at the true station (POUCH), but the observed directions have not been reduced. The directions are still the observations made at POUCH (ECC) and will be changed after step six is completed. The following data represents the observed data listed above at POUCH (ECC), but recorded as seen at the true station (POUCH).

NOTE: The last observed direction is to the instrument (ECC), since the occupation of SPN=71 cannot see itself on the abstract, it will therefore be entered on the abstract and displayed on the screen as if POUCH (ECC) SPN=64 was seen.

Step two of the program automatically computes the geodetic distance (1-3) between the initial station (NBR 1) and the true station (NBR 3) and displays the distance on the screen.

At this point the program, will display the geometric configuration prompts and ask the user to define the clockwise measurement of the reference angle observation by:

```
WHICH STATION WAS USED TO  -- INITIAL ON "NBR" /1-2-3/ (N)?    1 <CR>
STATION REFERENCE ANGLE WAS  OBSERVED AT "NBR"   /2-3/ (N)?    2 <CR>
WHICH STATION WAS THE ANGLE -- TURNED TO "NBR" /1-2-3/ (N)?    3 <CR>
```

```
  +-------------------------------------------------------------------------+
01|                ECCENTRIC REDUCTION --- INSTRUMENT           NAD27       |
02|               -------------------------------------                     |
03|                                                                         |
04| NBR  GEOMETRIC RELATIONSHIP       SPN                                   |
05|  1   INITIAL USED ON ABSTRACT      70    BORO HALL                      |
06|  2   ECCENTRIC --- INSTRUMENT      64    POUCH (ECC)                    |
07|  3   TRUE STATION /CENTER/         71    POUCH                          |
08|                                                                         |
09| GEODETIC DISTANCE BETWEEN NBR(S)/1-3/ (NNNNN.NNN)?  2692.77             |
10|                                                                         |
11|                                                                         |
12|      GEOMETRIC CONFIGURATION FOR ECCENTRIC --- INSTRUMENT               |
13|      ---------------------------------------------------------          |
14|      WHICH STATION WAS USED TO     INITIAL ON "NBR" /1-2-3/ (N)? 1      |
15|      STATION REFERENCE ANGLE WAS  OBSERVED AT "NBR"   /2-3/ (N)? 2      |
16|      WHICH STATION WAS THE ANGLE    TURNED TO "NBR" /1-2-3/ (N)? 3      |
17|                                                                         |
18|      REFERENCE ANGLE/DMS/ (NNN,NN,NN.N)?      326,43,06.5    CLOCKWISE  |
19|      REFERENCE DISTANCE   (NNNN.NNN)?         2.639            (M/F)?  M |
20|                                                                         |
   ....
24|                                                                         |
  +-------------------------------------------------------------------------+
```

Figure (2.03) ---- SPN / Eccentric INSTRUMENT Configuration Screen

Step four will prompt the user to enter, the clockwise value for the reference angle and then the reference distance by:

```
REFERENCE ANGLE/DMS/ (NNN,NN,NN.N)?        326,43,06.5  <CR>
REFERENCE DISTANCE   (NNNN.NNN)?           2.639        (M/F)?  M <CR>
```

A sample screen is shown in Figure (2.03).

Now the screen will clear and the program will go to the next screen display, the computation of an eccentric correction and reduction. With the program in the attached mode, the observed "OBJECTs" will be taken from a previously entered abstract (ABSHZT). In order to determine to which abstract the eccentric reductions are to be applied, the program will prompt the user to select an abstract number by:

```
SET NUMBER /ABSTRACT/ (NN)?   4 <CR>
```

For this example, station SPN=71 and ABSTRACT=4 were used. The program will automatically cycle through each "OBJECT" on the selected abstract. Three items are required for each eccentric reduction computation, namely - the name, distance, and direction. The first, the name, will be loaded from the MTEN FILEGPNX.JC file. The second, the distance, will be computed from an inverse computation if possible. However, if it can not be computed, the program will search the MTEN FILEDATX.JC file for a measured distance and if a distance can be found, it will be used. When a distance cannot be computed or found, the program will prompt the user to enter the distance from the true station /CENTER/ to the "OBJECT" station by:

```
ENTER OBJECT DISTANCE (NNNNN.NNN)?  2.00                (M/F)? M <CR>
```

The third item, the observed direction, will be loaded from the abstract. If the observed direction has had a previous eccentric correction applied to it, the program will flash the value (3.636 seconds) to the screen under the heading "CORRECTION", and just below this number the current computed correction for this direction will be shown.

SPN	OBSERVED STATION NAME	DISTANCE (meters)	OBSERVED DIRECTION	CORRECTION (")
70	BORO HALL	2692.77	000-00-00.00	3.626 110.928

Here, the program will ask the user to do one of the following with the currently computed eccentric correction:

```
DIRECTION HAS AN ECCENTRIC CORRECTION --- REPLACE (Y/N)?
ADD THE TWO "ECCENTRIC" CORRECTIONS   --- ADD (Y/N)?
LEAVE THIS DIRECTION "UNCHANGED"      --- (Y/N)?
```

If the "REPLACE (Y/N)?" is answered with a Y <CR>, the "YES" response, the program will erase the existing 3.626 seconds value and replace it with the 110.928 seconds value. A reply of <CR> will force the program to the second prompt. If the second prompt "ADD (Y/N)?" is answered with a Y <CR>, the "YES" response, the program will add (3.626 + 110.926) and then replace this as the new eccentric correction of 114.552 seconds. A <CR> response to the third question " --- (Y/N)?" will force the program to recycle starting with "REPLACE" again. A reply of Y <CR>, the "YES" response, to the third prompt will leave the eccentric correction as it was found at 3.626 seconds and continue to the next observed direction on the abstract. Where did the eccentric correction of 3.626 seconds come from? This small correction was the result of an eccentric LIGHT/OBJECT shown at the Forepoint SPN to the Standpoint SPN station, thus making the direction a double eccentric observation.

As the program steps through each observed direction, step six computes the eccentric correction for the observed direction and then displays the "REDUCED DIRECTION" on the screen. A sample screen is given in Figure (2.04). The values for the reduced directions have not been converted to a set of directions with an "INITIAL" direction of zero. This conversion will be done automatically by the program ADJSTA when all abstracts are combined into a single combined "LST".

```
+----------------------------------------------------------------------------+
|                 ECCENTRIC REDUCTION --- INSTRUMENT             NAD27       |
|               -------------------------------------                      |
|                                                                            |
|     OBSERVED                   DISTANCE  OBSERVED     CORRECTION   REDUCED |
| SPN  STATION NAME             (Meters)  DIRECTION        (")     DIRECTION |
|                                                                            |
|  70 BORO HALL                  2692.77 000-00-00.00       114.55 000-01-54.55 |
|  60 POUCH AZ MK 3               516.37 146-43-06.50         0.00 146-43-06.50 |
|  63 POUCH RM 4                    2.00 326-43-06.50         0.00 146-43-06.50 |
|  64 POUCH (ECC)                   2.64 326-43-06.50         0.00 146-43-06.50 |
|                                                                            |
 ...
|                                                                            |
+----------------------------------------------------------------------------+
```

Figure (2.04) ---- SPN / Eccentric INSTRUMENT Screen

2.2 ECCENTRIC LIGHT/OBJECT

This entry point computes an eccentric reduction for a light/object shown to other observing stations (NOTE: unless unavoidable, do not use an eccentric object for an initial). The treatment of all data referring to this eccentric light/object will be such that it didn't exist. Therefore, all abstracts (entered using "MTEN SYSTEM" files) will have the final direction keyed or (for "MTEN SYSTEM" data) the observed direction to the eccentric light/object plus an eccentric correction to reduce the direction to /CENTER/. In no case, should a SPN and Name be created for the eccentric light/object, unless other types of observational data will be abstracted, e.g. ABSHZT, ABSEDM, ABSZEN, etc. In this case it should be treated as another control point (with a SPN) and not as an eccentric point. The computation has six steps, they are: (1) enter the initial station used to sight on, the eccentric light/object, and the true station /CENTER/ name, (2) define the configuration of the reference angle measurement, (3) enter the reference angle and distance, (4) enter the date of the eccentric light/object, (5) enter each station which observed the light/object on the given date, and (6) compute the "ECCENTRIC DIRECTION" and display it and the eccentric "CORRECTION" to be applied at the observing stations on the screen.

Two examples are given in order to demonstrate the use of this program entry point. The first, EXAMPLE ONE, was taken from "Manual of Geodetic Triangulation", Special Publication No. 247, U.S. Department of Commerce, Captain F.R. Gossett, 1950, Revised Edition 1981, pages (151-157). EXAMPLE TWO, demonstrates the computational method used when the "MTEN SYSTEM" has been attached.

——————————— (EXAMPLE ONE) ———————————

Step one of the program requires the user to enter three names and to define the geometric relationship between them. The three names --- the combined "LST" initial, eccentric light/object, and true station --- are prompted as follows (see Observational Data below):

```
1  - INITIAL ON COMBINED "LST"
2  - ECCENTRIC --- LIGHT/OBJECT
3  - TRUE STATION /CENTER/

ENTER THE /SPN + NAME/ FOR ENTRY NBR " 1 " --- (Y/N)?   <CR>
ENTER STATION NAME: (30A)?    BLANK  <CR>

ENTER THE /SPN + NAME/ FOR ENTRY NBR " 2 " --- (Y/N)?   <CR>
ENTER STATION NAME: (30A)?    LITTLE (ECC LT) <CR>

ENTER THE /SPN + NAME/ FOR ENTRY NBR " 3 " --- (Y/N)?   <CR>
ENTER STATION NAME: (30A)?    LITTLE <CR>
```

If a reply of <CR>, the "NO" response is made, the program will automatically prompt for the station name. However, a reply of Y <CR> will force the program to prompt the user to make a SPN assignment to be associated with the name entered (NOTE: the SPN assignments are for the user's information only, because at this point in the program the "MTEN SYSTEM" files are unattached). After each entry has been completed, the program will reload the information onto the screen adjacent to corresponding "NBR" line, i.e. see sample screen in Figure (2.05).

```
--------------------------( Observational Data )---------------------------

            BLANK   +  1
                    .
                    .
                    .          ANGLE (2-3-1)  =   229 46 00 (Clockwise)
                    |
                    |          DISTANCE (3-2) =    0.062 Meters
                    |
                    |
                    |
                    |
             LITTLE +  3
            /CENTER/  .
                       .
                        .
                         .
                          .
                           .
        LIGHT/OBJECT (ECC)  0  2
```

Combined "LST" of Directions
at
STATION: LITTLE

OBSERVED STATION	COMPUTED DISTANCE	OBSERVED DIRECTION
Name	(Meters)	DDD-MM-SS.SS
BLANK	22650.82	0 00 00.00
JONES	31111.88	24 16 16.82
CHASE	33058.26	44 54 09.61
BILLIE	3562.02	92 18 26.37
BEAN	25373.81	274 27 36.82
RUTLEDGE	15034.45	357 59 50.24

Step two displays the geometric configuration prompts and ask the user to define the clockwise measurement of the reference angle observation by:

```
WHICH STATION WAS USED TO  -- INITIAL ON "NBR"   /1-2/ (N)?   2 <CR>
STATION REFERENCE ANGLE WAS  OBSERVED AT "NBR"     /3/ (N)?   3 <CR>
WHICH STATION WAS THE ANGLE -- TURNED TO "NBR"   /1-2/ (N)?   1 <CR>
```

Following the geometric configuration, step three prompts the user to enter the clockwise value for the reference angle and then, the reference distance, i.e. the distance from the true station /CENTER/ to the eccentric "LIGHT/OBJECT". The prompts are:

```
REFERENCE ANGLE/DMS/ (NNN,NN,NN.N)?      229,46,00.0  <CR>
REFERENCE DISTANCE   (NNNN.NNN)?         0.062        (M/F)?  M <CR>
```

A sample screen is given in Figure (2.05).

```
  +----------------------------------------------------------------------------+
01|                 ECCENTRIC REDUCTION --- LIGHT/OBJECT          NAD27        |
02|               ------------------------------------                         |
03|                                                                            |
04| NBR  GEOMETRIC RELATIONSHIP       SPN                                      |
05|  1   INITIAL USED ON COMBINED "LST"     BLANK                              |
06|  2   ECCENTRIC --- LIGHT/OBJECT         LITTLE (ECC LT)                    |
07|  3   TRUE STATION /CENTER/              LITTLE                             |
08|                                                                            |
11|                                                                            |
12|      GEOMETRIC CONFIGURATION FOR ECCENTRIC --- LIGHT/OBJECT                |
13|      ------------------------------------------------------------          |
14|      WHICH STATION WAS USED TO     INITIAL ON "NBR"   /1-2/ (N)? 2         |
15|      STATION REFERENCE ANGLE WAS  OBSERVED AT "NBR"     /3/ (N)? 3         |
16|      WHICH STATION WAS THE ANGLE   TURNED TO "NBR"    /1-2/ (N)? 1         |
17|                                                                            |
18|      REFERENCE ANGLE/DMS/ (NNN,NN,NN.N)?      229,46,00.0     CLOCKWISE    |
19|      REFERENCE DISTANCE   (NNNN.NNN)?         0.062             (M/F)?  M  |
    ....
24|                                                                            |
  +----------------------------------------------------------------------------+
```

Figure (2.05) ---- Eccentric LIGHT/OBJECT Configuration Screen

At this point the screen will clear and the program will go to the next screen display for the eccentric reduction computation. In step four the program prompts the user to enter a date for the eccentric light/object. The use of the date will be described in EXAMPLE TWO where the dates of observation are used to determine which eccentric corrections will be applied to which SPNs on abstracts.

The user will be allowed in step five to enter all stations that are on the combined "LST" for the station LITTLE, the true station, or to select only those stations from the combined "LST" which actually observed the eccentric light/object on the date it was eccentric. The program will allow the user to cycle through as many stations as are needed to complete the eccentric reduction computation.

There are three prompts per station: the object's station name, the geodetic distance from the true station to the "OBJECT" station, and the observed direction at the true station to the "OBJECT" station. A sample cycle set for one "OBJECT" station is as follows:

ENTER COMBINED "LST" OBJECT NAME: JONES <CR>
ENTER OBJECT DISTANCE (NNNNN.NNN)? 31111.88 (M/F)? M <CR>
ENTER OBJECT DIRECTION/DMS/ (NNN,NN,NN.NN)? 24,16,16.82 <CR>

After the third entry for each "OBJECT" has been made, step six computes the "ECCENTRIC DIRECTION" and the "CORRECTION" in seconds of arc for that combined "LST" observed direction and display the computed value on the screen. A sample screen is given in Figure (2.06). To allow for additional "OBJECTs" to be entered, the following prompt will appear:

STOP OBSERVATION ENTRY (Y/N)? Y <CR>

A reply of <CR>, the "NO" response, will force the program to recycle and to continue to enter additional objects. A reply of Y <CR>, the "YES" response, will stop the program and return to the program's "MENU" screen.

```
  +---------------------------------------------------------------------------+
01|                ECCENTRIC REDUCTION --- LIGHT/OBJECT          NAD27        |
02|              ------------------------------------                         |
03|                                                                           |
04|    OBSERVED                 DISTANCE   OBSERVED    ECCENTRIC    CORRECTION |
05| SPN  STATION NAME           (Meters)   DIRECTION   DIRECTION       (")    |
06|                                                                           |
07|     BLANK                   22650.82 000-00-00.00 049-46-00.00     0.431  |
08|     JONES                   31111.88 024-16-16.82 074-02-16.82     0.395  |
09|     CHASE                   33058.26 044-54-09.61 094-40-09.61     0.385  |
10|     BILLIE                   3562.02 092-18-26.37 142-04-26.37     2.206  |
11|     BEAN                    25373.81 274-27-36.82 324-13-36.82    -0.294  |
12|     RUTLEDGE                15034.45 357-59-50.24 047-45-50.24     0.629  |
   ...
24|                                                                           |
  +---------------------------------------------------------------------------+
```

Figure (2.06) ---- Eccentric LIGHT/OBJECT Screen

(EXAMPLE TWO)

With the "MTEN SYSTEM" attached, step one of the eccentric LIGHT/OBJECT entry point, will prompt the user to enter SPNs for the stations and define the geometric relationship between them. The SPN entries are required only for the combined "LST" initial and true station /CENTER/. The eccentric LIGHT/OBJECT (if a SPN and name were entered with STRSPN) can be entered with a SPN entry, or in most cases, if a SPN was not entered, it can be entered by name only. The three stations will be prompted as follows (see Observational Data below):

1 - INITIAL ON COMBINED "LST"
2 - ECCENTRIC --- LIGHT/OBJECT
3 - TRUE STATION /CENTER/

ENTER THE /SPN + NAME/ FOR ENTRY NBR " 1 " --- (NNN)? 84 <CR>
YOU SURE THIS STATION IS THE COMBINED "LST" INITIAL (Y/N)? Y <CR>

```
ENTER THE /SPN + NAME/ FOR ENTRY NBR " 2 " --- (NNN)?   <CR>
ENTER STATION NAME: (30A)?    BORO HALL (ECC LT) 800310 <CR>
ENTER THE /SPN + NAME/ FOR ENTRY NBR " 3 " --- (NNN)?   70 <CR>
```

After each entry has been completed (NOTE: no SPN entry was assigned to the eccentric LIGHT/OBJECT), the program will re-load the information onto the screen adjacent to the corresponding "NBR" line, i.e. see sample screen in Figure (2.07).

```
-------------------------( Observational Data )---------------------------

                  1 +  H 53 (84)
                     .
                     .          ANGLE (1-3-2)  =   274 06 01 (Clockwise)
                     |
                     |          DISTANCE (3-2) =    0.062 Meters
                     |
                     |
                  3  +  BORO HALL (70)
                    .     /CENTER/
                   .
                  .
                 .
                .
               .
           2  O  BORO HALL (ECC LT) 800310
```

Combined "LST" of Directions
at
STATION: BORO HALL
SPN: 70

OBSERVED STATION SPN	Name	COMPUTED DISTANCE (Meters)	OBSERVED DIRECTION DDD-MM-SS.SS
84	H 53	3986.92	0 00 00.00
...			
85	H 54	6383.10	28 16 34.62
83	H 52	3180.68	74 22 14.62
...			
76	FT WADSWORTH LH ECC	4472.22	134 11 17.50
75	FT WADSWORTH LH		134 12 33.38
...			
71	POUCH	2692.77	143 52 01.00

Step two will display the geometric configuration prompts and ask the user to define the clockwise measurement of the reference angle observation by:

```
WHICH STATION WAS USED TO  -- INITIAL ON "NBR"   /1-2/ (N)?   1 <CR>
STATION REFERENCE ANGLE WAS  OBSERVED AT "NBR"     /3/ (N)?   3 <CR>
WHICH STATION WAS THE ANGLE -- TURNED TO "NBR"   /1-2/ (N)?   2 <CR>
```

Following the geometric configuration prompts, the program will then prompt the user to enter the clockwise value for the reference angle and then the reference distance.

```
REFERENCE ANGLE/DMS/ (NNN,NN,NN.N)?      274,06,01.0  <CR>
REFERENCE DISTANCE   (NNNN.NNN)?         0.062        (M/F)?  M <CR>
```

A sample screen is given in Figure (2.07).

```
  +-------------------------------------------------------------------------+
01|                ECCENTRIC REDUCTION --- LIGHT/OBJECT         NAD27       |
02|               -------------------------------------                     |
03|                                                                         |
04| NBR  GEOMETRIC RELATIONSHIP           SPN                               |
05|  1   INITIAL USED ON COMBINED "LST"    84  H 53                         |
06|  2   ECCENTRIC --- LIGHT/OBJECT            BORO HALL (ECC LT) 800310    |
07|  3   TRUE STATION /CENTER/             70  BORO HALL                    |
08|                                                                         |
09|                                                                         |
10|                                                                         |
11|                                                                         |
12|      GEOMETRIC CONFIGURATION FOR ECCENTRIC --- LIGHT/OBJECT             |
13|      -------------------------------------------------------            |
14|      WHICH STATION WAS USED TO     INITIAL ON "NBR"   /1-2/ (N)? 1      |
15|      STATION REFERENCE ANGLE WAS  OBSERVED AT "NBR"     /3/ (N)? 3      |
16|      WHICH STATION WAS THE ANGLE    TURNED TO "NBR"   /1-2/ (N)? 2      |
17|                                                                         |
18|      REFERENCE ANGLE/DMS/ (NNN,NN,NN.N)?      274,06,01.0     CLOCKWISE |
19|      REFERENCE DISTANCE   (NNNN.NNN)?         0.062              (M/F)?  M |
20|                                                                         |
    ....
  +-------------------------------------------------------------------------+
```

Figure (2.07) ---- SPN / Eccentric LIGHT/OBJECT Configuration Screen

The screen will now clear and the program will go to the next screen display for the eccentric reduction computation. With the "MTEN SYSTEM" attached, the user must then enter a date for the eccentric LIGHT/OBJECT by:

```
ENTER ECCENTRIC --- LIGHT/OBJECT  DATE /YYMMDD/ (NNNNNN)?  800310 <CR>
```

This step will automatically be followed by step five of the program. The program will flash every station name found on the combined "LST" for the station BORO HALL (SPN=70). If a station on the "LST" is a landmark, or the station does not have ABSHZT's entered for it, the program will skip to the next name. When a station is found for which ABSHZTs have been entered, the following messages will automatically be flashed to the screen, to which, the user must make a response:

```
SELECT THE STATIONS WHICH SAW THE ECCENTRIC --- LIGHT/OBJECT

ENTER STATION:  H 53                               (Y/N)?  Y <CR>
ENTER STATION:  H 54                               (Y/N)?  Y <CR>
ENTER STATION:  H 52                               (Y/N)?  Y <CR>
ENTER STATION:  FT WADSWORTH LH ECC                (Y/N)?  <CR>
ENTER STATION:  POUCH                              (Y/N)?  Y <CR>
```

After each station name has been entered, the program will compute the "ECCENTRIC DIRECTION" and the "CORRECTION" and load both of them onto the screen. This loading will continue until all names on the combined "LST" have been displayed.

When the last name has been completed, the program will automatically go into an additional step with the "MTEN SYSTEM" attached. For every station name selected above, the program will parse thru all the ABSHZTs entered looking for the eccentric occupation date, i.e. 800310 for this example. When it has found a station with an abstract that has an observation date equal to the given eccentric date, it will stop searching, i.e. this example station POUCH, SPN=71, and ABSTRACT=1. The program will then parse thru all the directions on this abstract looking for the SPN of the true station (BORO HALL SPN=70). When it has found the true station on the abstract, it will stop again and prompt the user to do one of the following with the computed "CORRECTION":

```
CHECKING SPN =  71  ABSTRACT  1   CORRECTION =      110.928

DIRECTION HAS AN ECCENTRIC CORRECTION --- REPLACE (Y/N)?
ADD THE TWO "ECCENTRIC" CORRECTIONS   --- ADD (Y/N)?
LEAVE THIS DIRECTION "UNCHANGED"      --- (Y/N)?
```

If the "REPLACE (Y/N)?" is answered with a Y <CR>, the "YES" response, the program will erase the existing 110.928 seconds value and replace it with the 3.626 seconds value. A reply of <CR> will force the program to the second prompt. If the second prompt "ADD (Y/N)?" is answered with a Y <CR>, the "YES" response, the program will add (110.928 + 3.626) and then replace this as the new eccentric correction of 114.554 seconds. However, a <CR> response to the third question " --- (Y/N)?" will force the program to recycle starting with "REPLACE" again. A reply of Y <CR>, the "YES" response, will leave the eccentric correction as it was found at 110.928 seconds and continue to the next observed direction on the abstract. Where did the eccentric correction of 110.928 come from? This small correction was the result of an eccentric INSTRUMENT occupation at the Forepoint SPN station, thus making the direction a result of a double eccentric observation.

After this abstract has been completed, the program will continue to search the selected station name list until all names have been processed. The eccentric "CORRECTION" which was REPLACED/ADDED/OMITTED on the observed direction record on the abstract will automatically be added to the observed direction by the program ADJSTA when all abstracts are combined into a single combined "LST" for the station.

A sample screen is given in Figure (2.08).

```
  +--------------------------------------------------------------------------+
01|                  ECCENTRIC REDUCTION --- LIGHT/OBJECT         NAD27       |
02|                 -------------------------------------                     |
03|                        ECC DATE /YYMMDD/ =  800310                        |
04|     OBSERVED               DISTANCE   OBSERVED     ECCENTRIC    CORRECTION |
05| SPN  STATION NAME          (Meters)   DIRECTION    DIRECTION        (")    |
06|                                                                           |
07|  84 H 53                    3986.92 000-00-00.00  265-53-59.00      -3.199 |
08|  85 H 54                    6383.10 028-16-34.62  294-10-33.62      -1.828 |
09|  83 H 52                    3180.68 074-22-14.62  340-16-13.62      -1.357 |
10|  71 POUCH                   2692.77 143-52-01.00  049-46-00.00       3.626 |
11|                                                                           |
12|                                                                           |
   ...
24|                                                                           |
  +--------------------------------------------------------------------------+
```

Figure (2.08) ---- SPN / Eccentric LIGHT/OBJECT Screen

3.0 WRK003 -- Datum Transformation Computations

To enter this program type WRK003 <CR>. The program will clear the screen and prompt with the following display:

PROGRAM
(Y/N)?

- DATUM TRANSFORMATIONS

The data entries listed in Figure (3.01) and the datum shifts (DX,DY,DZ) listed elsewhere within the text are taken from the report "Applications of WGS Transformations to various Chart Datums for Plotting Satellite-Derived Positions", Muneendra Kumar and Randall B. Keener, Defense Mapping Agency, Washington, D.C. September 1983, Enclosure 1 to Annex A.

NN		YEAR	REFERENCE ELLIPSOID		SEMIMAJOR (Meters)	1/FLATTENING
01		1830	AIRY		6376563.396	299.324965
02		1830	EVEREST		6377276.345	300.8017
03		1841	BESSEL		6377397.155	299.152813
04		1866	CLARKE	NAD27	6378206.4	294.978698
05		1880	CLARKE		6378249.145	293.465
06		1906	HELMERT		6378200.	298.3
07		1910	INTERNATIONAL	INT24	6378388.	297.0
08		1940	KRASOVSKII		6378245.	298.3
09		1960	HOUGH		6378270.	297.0
10		1960	FISCHER		6378166.	298.3
11		1964	AUSTRALIAN NATIONAL		6378160.	298.25
12			EVEREST (MODIFIED)		6377304.063	300.801700
13		1965	AIRY (MODIFIED)		6377340.189	299.324959
14		1968	FISCHER		6378150.	298.3
15		1969	SOUTH AMERICAN		6378160.	298.250
16	WGS	1972	WORLD GEODETIC SYSTEM		6378135.	298.26
17	GRS	1980	GEODETIC REFERENCE SYSTEM	NAD83	6378137.	298.257222
18		??	NOT LISTED			

Figure (3.01) ---- Table of Common Hydrographic Chart Datums

The next prompt will allow the attachment of MTEN data files to the program so they can be used later if needed:

ATTACH TO --- "MTEN SYSTEM" --- (Y/N)?

A reply of Y <CR>, the "YES" response, will force the program to prompt the user to complete the next two prompts:

CHANGE DEFAULT DRIVE=C (Y/N)? <CR>
ENTER YOUR JOBCODE /JC/ (LL)? JC <CR>

The program will use the MTEN data files to load names and geographic positions, but the ellipsoid parameters that were initialized with the program ABSINX (See Manual Section 1) at the time the project was initialized will not be used. The user must identify the correct ellipsoid on which the geographic positions were entered and stored in the geographic position file (FILEGPNX.JC) by it's ellipsoid number (NN). A few commonly used hydrographic survey ellipsoids are provided in Figure (3.01).

A reply of <CR>, the "NO" response, will force the program to not use the existing MTEN data files. All computations will be done independent of MTEN and all information must be entered from the keyboard.

Upon exit from the program entry point, the program will prompt the user with the following:

```
RETURN TO   --- MENU SCREEN ---   (Y/N)?
```

This will allow the user to exit or to re-enter the program.

3.1 TRANSFORMATION -- DATUM to WGS72

The most common datum transfomation is to go from an established "Old" datum to the "New" World Geodetic System 1972 (WGS72). This transformation is selected automatically by the program whenever the user selects any ellipsoid number (NN) from Figure (3.01) other than the selection (NN) = 16. What this means is, that when the program prompts:

```
EXISTING GPS/MAP/CHART POSITIONS ON ELLIPSOID/OLD/ (NN)?  4 <CR>
```

and the user selects, e.g. the ellipsoid number (NN) = 4 (CLARKE 1866), the program will setup and compute the following transformation by:

```
DATUM (04) + SHIFT (DX,DY,DZ) =  WGS72 (16)
```

However, if the first ellipsoid number (NN) = 16 is selected and a second ellipsoid number (NN) = 4 is then selected, the program will setup and compute the following transformation (See Section 3.2):

```
WGS72 (16) + SHIFT (DX,DY,DZ) =  DATUM (04)
```

where the signs of the datum shifts (DX,DY,DZ) displayed on the screen will be set to a negative value for the transformation computation.

The computation is completed in four steps: (1) selection of the ellipsoid, (2) selection of the geographic area of interest, (3) entrance of the station information using the proper datum, and (4) computation of the datum transformation.

Step one will prompt for selection of the proper ellipsoid number

(NN). If the ellipsoid number selected is one of the above, i.e. see Figure (3.01), but not number (NN) = 18, the program will automatically load ellipsoid parameters AMAX (semimajor axis) and 1/F (inverse flattening) for program computation. If number (NN) = 18 is selected, the program prompt the user to provide ellipsoid parameters by:

```
REFERENCE ELLIPSOID -------------------------
SEMIMAJOR AXIS      xxxxxxx.xxx  (Meters)
1/FLATTENING        xxx.xxxxxxx
```

The screen will clear and next, a prompt to select the geographic area, will be displayed on the screen:

```
GEOGRAPHIC AREA --

    1   NORTH AMERICA
    2   PACIFIC OCEAN + ISLANDS
    3   ATLANTIC OCEAN + ISLANDS
    4   SOUTH AMERICA
    5   EUROPE
    6   AFRICA
    7   AUSTRALIA + NEW ZEALAND
    8   ASIA - MIDDLE EAST
    9   ASIA - SOUTH
   10   ASIA - FAR EAST
   11   ASIA - SOUTHEAST
   12   NOT LISTED

SELECT A GEOGRAPHIC AREA (NN)?  1 <CR>
```

Once the geographic area has been selected, the screen will be partialy cleared and then, on-by-one, all datums that are within the selected area will be displayed. The user must select a datum corresponding to the ellipsoid number (NN) selected above, e.g. if ellipsoid number (NN) = 18 and geographic area (NN) = 1 were selected, the following prompts would appear:

```
GEOGRAPHIC AREA --   NORTH AMERICA       -- CLARKE 1866
                                         -- FISCHER 1960
                                         -- FISCHER 1968
                                         -- GEODETIC REFERENCE SYSTEM
                                         -- (User Defined Ellipsoid)
```

The last entry, a User Defined Ellipsoid, must be selected if the ellipsoid number (NN) = 18 was previously selected.

```
SELECT THIS DATUM (Y/N)?  <CR> <CR> <CR> <CR> Y <CR>
```

For example suppose the user selected, ellipsoid number (NN) = 3 (BESSEL) and geographic area (NN) = 10 (ASIA - FAR EAST), then the screen will display the following information:

GEOGRAPHIC AREA -- ASIA - FAR EAST	DATUM + (DX,DY,DZ) = WGS72 -- BESSEL DX	DY	DZ
KOREA	-132	510	679
JAPAN + OKINAWA	-136	512	677
NOT LISTED			

the user verifies the selection of this datum by answering:

SELECT THIS DATUM (Y/N)? Y <CR>

At this point, a datum has been selected. The program then will allow the user to select one of the datum shifts listed on the screen or enter a new set of datum shifts from the keyboard. This is done by selecting "NOT LISTED". For this example, the city of Tokyo (BESSEL Ellipsoid -- JAPAN Datum) will be used. However, the datum shifts listed

DX	DY	DZ
-136	512	677

will not be used, but rather a new set of datum shifts that were theoretically determined by additional observations will be used. They are as follows:

DX = -135.98 DY = 512.01 DZ = 676.97

To enter this new set of datum shifts move the "(Y/N)?" prompt for a datum to the "NOT LISTED" line. The program will allow the user to enter a new datum name. It then prompts for the three datum shifts by:

```
                    SHIFT=( NEW - OLD )                METERS

ENTER " DX " SHIFT=(WGS72-DATUM) (SNNN.N)?  -135.98 <CR>
ENTER " DY " SHIFT=(WGS72-DATUM) (SNNN.N)?   512.01 <CR>
ENTER " DZ " SHIFT=(WGS72-DATUM) (SNNN.N)?   676.97 <CR>
```

After the three datum shifts have been entered, the program will again partially clear the screen.

Next the "STATION" display information will appear on the screen. The user must enter the station name, the latitude, the longitude, the elevation, and the geoid height of the station by answering the following prompts:

```
STATION NAME (30A)?   TOKYO CITY <CR>
LATITUDE /DMS/  (NN,NN,NN.NNNN)?  35,40,11.08      (N/S)? N <CR>
LONGITUDE/DMS/ (NNN,NN,NN.NNNN)? 139,32,28.22      (E/W)? E <CR>
ELEVATION (SNNN.NNN)?            58.0              (M/F)? M <CR>
GEOID HEIGHT (SN.NN)?            -0.16             (M/F)? M <CR>
```

As the "STATION" information is entered, it will be displayed on the screen below the heading "OLD DATUM", see Figure (3.02).

```
  +-----------------------------------------------------------------------------+
01| DATUM TRANSFORMATION                       DATUM  +  SHIFT    =  WGS72       |
02| GEOGRAPHIC AREA --  ASIA - FAR EAST          -- BESSEL                       |
03|                                                                             |
04|                               LONGITUDE   "East" (+) ... "West" (-)         |
05|   STATION NAME              OLD   DATUM        SHIFT       NEW   DATUM      |
06|                           (DD MM SS.SSS)      (SS.SS)    (DD MM SS.SSS)     |
07|                                                                             |
08|   TOKYO CITY          LAT  35-40-11.08000 N   11.63601   35-40-22.71601     |
09|                       LON 139-32-28.22000 E  -11.98214  139-32-16.23786     |
10|                       HGT        57.840   M   33.377           91.217       |
11|                                                                             |
    ...
  +-----------------------------------------------------------------------------+
```

Figure (3.02) ---- DATUM + SHIFT = WGS72 Screen

```
STATION ---------+-------------------+-------------------+-----
 (HGT)           |                   |                   |
              Station             Elevation           Station
              Height              of                  Height
              above               Station             above
              Bessel              above               WGS72
              Ellipsoid           Geoid               Ellipsoid
              57.840 m            58.000 m            91.217 m
                 |                   |                   |
                 |                   |                   |
Bessel           |                   |                   |
Ellipsoid -------+------+---         |                   |
                        |            |                   |
                     Bessel          |                   |
                     Geoid           |                   |
                     Height          |                   |
                     -0.160 m        |                   |
                        |            |                   |
Geoid                   |            |                   |
(Mean Sea Level) -------+------------+----------+---     |
                                                |        |
                                                |        |
                                             WGS72       |
                                             Geoid       |
                                             Height      |
                                            +33.217 m    |
                                                |        |
WGS72                                           |        |
Ellipsoid --------------------------------------+--------+-------
```

Figure (3.03) -- BESSEL/WGS72 Ellipsoid Heights

Step four, computation of the datum transformation, will be completed after all station items have been entered. The geographic position shifts for latitude (LAT), longitude (LON), and ellipsoid height (HGT) will be computed from the datum shifts (DX,DY,DZ) and will be listed below the heading "SHIFT". The new values for geographic position and ellipsoid height (for WSG72) will be listed under the heading "NEW DATUM". A sample WGS72 screen for Tokyo City is presented in Figure (3.02).

The following Figure (3.03) is provided in order to show the user the relationship between the two datums: the ellipsoid heights, the geoid heights, and the elevation of the Station.

For a second example using ellipsoid number (NN) = 4 (CLARKE 1866), and geographic area number (NN) = 1 (NORTH AMERICA). The following screen prompts would appear:

```
GEOGRAPHIC AREA --   NORTH AMERICA       -- CLARKE 1866
```

and

```
                                DATUM + (DX,DY,DZ) = WGS72
                                  -- CLARKE 1866
                                  DX        DY        DZ
                                --------------------------
   Y    USA (contiguous)         -22       157       177
        ALASKA                   -13       142       174
        CANADA                   -21       ...       ...
        etc.
```

With the "MTEN SYSTEM" attached and once a set of datum shifts (-22,157,177) have been selected, the program will partially clear the screen and display the following message:

```
USE "MTEN" SPNs (Y/N)?  Y <CR>
```

A Y <CR> reply, the "YES" response, will force the program to use SPN entries to identify which geographic positions are to be transformed. A reply of <CR>, the "NO" response, will allow the program to continue as described in example one. With the "MTEN" SPN's attached, the program will allow individual SPN's to be entered or a range of SPNs. This is done be responding to the following prompt:

```
USE "MTEN" SPNs SETUP A "MIN/MAX" RANGE (Y/N)? Y <CR>
```

and

```
                          BEGINNING /SPN/ (NNN)?  65 <CR>
                          END WITH  /SPN/ (NNN)?  75 <CR>
```

The program will now begins computing the geographic position shifts using the selected datum shifts (DX,DY,DZ) and displaying the results until the screen is full. Under this option, the station height above the ellipsoid will be computed by adding the station elevation and the geoid height for the station (if it has one). However, if no geoid height is available for the station, a mean geoid height for the project (entered with the ABSINX program) will be used. A sample screen where SPN's were used is given in Figure (3.04).

```
+------------------------------------------------------------------------+
| DATUM TRANSFORMATION                      DATUM  +  SHIFT    -  WGS72   |
| GEOGRAPHIC AREA --  NORTH AMERICA           -- CLARKE 1866              |
|                                                                         |
|                               LONGITUDE   "East" (+) ... "West" (-)    |
| SPN  STATION NAME              OLD   DATUM        SHIFT      NEW   DATUM |
|                             (DD MM SS.SSS)       (SS.SS)   (DD MM SS.SSS) |
|                                                                         |
|  69 POUCH AZ MK         LAT  40-37-08.38198 N    0.04376  40-37-08.42574 |
|                         LON  74-03-58.32148 W    0.93367  74-03-57.38781 |
|                         HGT          40.801  M  -33.273           7.528  |
|                                                                         |
|  70 BORO HALL           LAT  40-38-32.15600 N    0.04292  40-38-32.19892 |
|                         LON  74-04-35.58500 W    0.93279  74-04-34.65221 |
|                         HGT          59.103  M  -33.275          25.828  |
|                                                                         |
|  71 POUCH               LAT  40-37-07.89800 N    0.04378  40-37-07.94178 |
|                         LON  74-04-05.61200 W    0.93343  74-04-04.67857 |
|                         HGT          32.211  M  -33.274          -1.063  |
|                                                                         |
|  74 CONEY ISLAND LH     LAT  40-34-35.37300 N    0.04501  40-34-35.41801 |
|                         LON  74-00-43.82700 W    0.93938  74-00-42.88762 |
|                         HGT           2.399  M  -33.258         -30.859  |
|                                                                         |
|                                                                         |
+------------------------------------------------------------------------+
```

Figure (3.04) ---- SPN Datum Transformation Screen

3.2 TRANSFORMATION -- WGS72 to DATUM

Datum transfomations from the World Geodetic System 1972 (WGS72) to a selected ellipsoid number, (NN) = ??, will be done automatically by this program whenever the user selects ellipsoid number (NN) = 16 first.

EXISTING GPS/MAP/CHART POSITIONS ON ELLIPSOID/OLD/ (NN)? 16 <CR>

The program will prompt the user to select any ellipsoid number (NN) from Figure (3.01). What this means is that the program will re-prompt the user to enter a second (NN) value by:

CONVERT EXISTING POSITIONS --- TO ELLIPSOID/NEW/ (NN)? 3 <CR>

If the user selects the ellipsoid number (NN) = 3 (BESSEL), then the program will setup and compute the following transformation by:

WGS72 (16) + SHIFT (DX,DY,DZ) = DATUM (03)

where the signs of the shifts (DX,DY,DZ) displayed on the screen will be set to a negative value for the transformation computation.

The computation is donein four steps: (1) select the ellipsoids, (2) select the geographic area of interest, (3) enter the station information using the WGS72 datum, and (4) compute the datum transformation.

Step one will prompt the user to select the proper ellipsoid numbers (NN) = 16 and ??. If the second ellipsoid number selected is one of those shown on Figure (3.01), the program will automatically load the ellipsoid parameters AMAX (semimajor axis) and 1/F (inverse flattening) for program computation.

The screen will clear and step two, selection of the geographic area, will cause the following message to be displayed on the screen:

SELECT A GEOGRAPHIC AREA (NN)? 10 <CR>

Once a geographic area has been selected, i.e. for this example area (NN) = 10, the screen will partially clear and then, one-by-one, all datums within the selected area will be displayed on the screen. The user must stop the selection at the datum which corresponds to the ellipsoid number (NN) selected. In this case ellipsoid number (NN) = 3 (BESSEL) and geographic area (NN) = 10 (ASIA - FAR EAST), the screen will display the following:

	DATUM + (DX,DY,DZ) = WGS72		
GEOGRAPHIC AREA -- ASIA - FAR EAST--BESSEL	DX	DY	DZ
KOREA	-132	510	679
JAPAN + OKINAWA	-136	512	677
NOT LISTED			

NOTE: at this point the statement, "DATUM + (DX,DY,DZ) = WGS72)", is still backwards. As soon as the datum has been selected, the program will turn this statement around to the correct definition. Now user must select one of the possible datum shifts listed on the screen or select the "NOT LISTED" line which will allow the user to enter a new set of datum shifts from the keyboard. For this example, the city of Tokyo (BESSEL Ellipsoid - JAPAN Datum) will be used. However, as before the datum shifts (JAPAN + OKINAWA) listed will not be used. Instead the values given in Section 3.1 will be used:

```
DX  =  -135.98
DY  =   512.01
DZ  =   676.97
```

To enter this new set of datum shifts, move the "(Y/N)?" prompt for a datum to the "NOT LISTED" line. The program will allow the user to enter the new datum name and then prompt for the three datum shift parameters. After the three parameters have been entered, the program will again partially clear the screen and the datum transformation display on line one will be:

WGS72 + SHIFT = DATUM

Step three, "STATION" display information, will appear on the screen. For the WGS72 datum, the user must enter the station name, the latitude, the longitude, the elevation, and the geoid height of the station by answering the following prompts (see Figures (3.02) and (3.03)):

```
STATION NAME (30A)?   TOKYO CITY <CR>
LATITUDE /DMS/  (NN,NN,NN.NNNN)?  35,40,22.71601      (N/S)? N <CR>
LONGITUDE/DMS/ (NNN,NN,NN.NNNN)? 139,32,16.23786      (E/W)? E <CR>
ELEVATION (SNNN.NNN)?            58.0                 (M/F)? M <CR>
GEOID HEIGHT (SN.NN)?            33.217               (M/F)? M <CR>
```

```
  +---------------------------------------------------------------------------+
01| DATUM TRANSFORMATION                    WGS72  +  SHIFT    =  DATUM        |
02| GEOGRAPHIC AREA --  ASIA - FAR EAST        -- BESSEL                       |
03|                                                                            |
04|                             LONGITUDE   "East" (+) ... "West" (-)          |
05|   STATION NAME             OLD   DATUM        SHIFT       NEW   DATUM      |
06|                          (DD MM SS.SSS)      (SS.SS)   (DD MM SS.SSS)      |
07|                                                                            |
08|   TOKYO CITY       LAT  35-40-22.71601 N  -11.63601   35-40-11.08000       |
09|                    LON 139-32-16.23786 E   11.98214  139-32-28.22000       |
10|                    HGT         91.217  M  -33.377             57.840       |
11|                                                                            |
   ...
24|                                                                            |
  +---------------------------------------------------------------------------+
```

Figure (3.05) ---- WGS72 + SHIFT = DATUM Screen

As the "STATION" information is entered, it will be displayed on the screen below the heading "OLD DATUM", see sample screen given in Figure (3.05).

Step four, computation of the datum transformation, will be completed as soon as all station items have been entered. The geographic position shifts for latitude (LAT), longitude (LON), and ellipsoid height (HGT) will be computed from the datum shifts (DX,DY,DZ) and will be listed below the heading "SHIFT". The new values computed for the geographic position and ellipsoid height for the selected datum will be listed under the heading "NEW DATUM".

4.0 WRK004 -- Triangle Computations

To enter this program type WRK004 <CR>. The program will clear the screen and display the following program entry points on the screen:

PROGRAM
(Y/N)?

PLANE ...... TRIANGLES

SPHERICAL .. TRIANGLES

GEODETIC ... TRIANGLES

The user will be prompted to select a default set of units (to be used for screen display). The following message will be displayed on the screen:

DISTANCE UNITS /Meters or Feet/ (M/F)? M <CR>

Upon exiting each program entry point, the main program will display the following message. This will allow the user to re-enter the program or exit to DOS.

RETURN TO --- MENU SCREEN --- (Y/N)?

When the "GEODETIC" program entry point is selected, the user must furnish ellipsoid parameters and the datum name (i.e. the datum on which all geodetic computations will be computed using this program entry point).

The first screen prompt for the "GEODETIC" section is:

ATTACH TO --- "MTEN SYSTEM" --- (Y/N)?

If the user replies Y <CR>, the "YES" response, the program will force the user to complete two additional prompts:

CHANGE DEFAULT DRIVE=C (Y/N)? <CR>
ENTER YOUR JOBCODE /JC/ (LL)? JC <CR>

The program will use the ellipsoid parameters that were initialized with ABSINX (See Manual Section 1) at the time this project was first initialized.

If a <CR>, the "NO" response, was made to the prompt "ATTACH TO ...", then the program will not use the existing MTEN data files and all computations will be done independent of MTEN. All information must be entered by the user from the keyboard.

With the program now in the unattached mode and no ellipsoidal information available, the program will have to initialize ellipsoid parameters for geodetic computations by prompting the user to select one of the following:

```
USE GRS 1980      ELLIPSOID .. NAD83 ..      (Y/N)?
USE CLARKE 1866   ELLIPSOID .. NAD27 ..      (Y/N)?
USE WGS 1972      ELLIPSOID    .....         (Y/N)?
```

or select another defined by:

```
USE ELLIPSOID  (AAAAAAAAAA)?
MAJOR AXIS   (NNNNNNN.NNNN)?
FLATTENING "1/F" (NNN.NNNNNN)?
```

After the ellipsoid parameters have been selected or entered, the "DATUM" abbreviation will flash to the upper right-hand corner of the screen.

4.1 PLANE

The program computes the unknown elements of a plane triangle (either RIGHT or OBLIQUE) given any combination of the following triangle elements A,B,C (the triangle vertices) and a,b,c (the triangle sides opposite the corresponding vertices). The computation is done in four steps: (1) determine whether or not the plane triangle computation will be a RIGHT or OBLIQUE triangle; (2) prompt the user to enter the plane triangle verticies (A,B,C); (3) prompt the user to enter the plane triangle sides (a,b,c); and (4) solve for the unknown elements and display the results on the screen.

Step one will determine which plane triangle OPTION (1 or 2) will be used by the following:

```
IS THIS A ... "RIGHT" ... TRIANGLE       (Y/N)? Y <CR>
```

A reply of Y <CR>, the "YES" response, will force the program to the RIGHT triangle computation (OPTION 1). A <CR> reply, the "NO" response, will force the program to continue to the next option (OPTION 2). The configuration for the six elements of a RIGHT triangle are shown on Figure (4.01).

================================ (OPTION 1) ================================

Step two of the program will prompt the user to enter one or none of the plane angles (A or B):

```
GIVEN: "A" /DMS/ (NNN,NN,NN.NN)?  44,00,0.0 <CR>
```

As the vertex angle "A" or "B" is entered, it will be loaded to the screen under the "GIVEN" heading for "ANGLES".

Step three will prompt the user to enter any of the three sides (a,b,c) using one or all of the following statements:

```
SIDE:  "a"     (NNNNN.NNN)?                      (Y/N)? <CR>
SIDE:  "b"     (NNNNN.NNN)?                      (Y/N)? <CR>
SIDE:  "c"     (NNNNN.NNN)?     450.062 <CR>
```

As each side "a", "b" or "c" is entered, the distance will be displayed on the screen under the "GIVEN" heading for "SIDES".

When sufficient data has been entered, the triangle will be solved and the unknown triangle elements displayed on the screen under the heading "SOLVE". A sample RIGHT triangle screen is given in Figure (4.01).

Upon completion of the RIGHT triangle computation, the following message will appear on the screen:

```
RE-ENTER ... "PLANE" ... TRIANGLES                 (Y/N)? <CR>
```

A reply of Y <CR>, the "YES" response, will allow the user to return to step one where OPTIONs (1 or 2) can be re-entered. A <CR> reply, the "NO" response, will exit the program entry level and return the user to the program "MENU" level.

```
  +--------------------------------------------------------------------------+
01|                 TRIANGLE COMPUTATIONS --- PLANE                           |
02|                ---------------------------------------                    |
03|                                                                           |
04|                                              GIVEN          SOLVE         |
05|                              B                                            |
06|                             +          ANGLES--------------/DMS/          |
07|                            . .    A     44-00-00.00                       |
08|                       -   .   .   B                  46-00-00.00          |
09|                         .     .   C     90-00-00.00                       |
10|                       .       .                                           |
11|                  c .          .                                           |
12|                    .          .a                                          |
13|                  .            .                                           |
14|                .              .                                           |
15|              .                .         SIDES------------/METERS/         |
16|            .                  .   a                        312.6393       |
17|          .                 --.    b                        323.7475       |
18|     + . . . . . . . . . . |..+    c         450.0620                      |
19|     A           b           C                                             |
20|                                                                           |
21|                                                                           |
22|                                                                           |
23|                                                                           |
24|       RE-ENTER ..."PLANE"... TRIANGLES                    (Y/N)?          |
  +--------------------------------------------------------------------------+
```

Figure (4.01) ---- Plane RIGHT Triangle Screen

(OPTION 2)

The remaining portion of this section follows the same program steps described above except this option allows for computation of an OBLIQUE triangle. In order to allow the user to exit the plane triangle computations, the following prompt was inserted:

IS THIS AN ... "OBLIQUE" ... TRIANGLE (Y/N)? Y <CR>

A <CR> reply, the "NO" response, will allow the user to return to step one where OPTIONs (1 or 2) can be re-determined. A reply of Y <CR>, the "YES" response, will force the program to enter the plane OBLIQUE triangle computation. The configuration for the six OBLIQUE triangle elements is shown in Figure (4.02).

Step two will begin by prompting the user to enter one, two or none of the triangle angles (A, B, C):

```
GIVEN:  "A" /DMS/ (NNN,NN,NN.NN)?  40,00,00.0 <CR>
GIVEN:  "B" /DMS/ (NNN,NN,NN.NN)?                  (Y/N)? <CR>
GIVEN:  "C" /DMS/ (NNN,NN,NN.NN)?                  (Y/N)? <CR>
```

If vertices "A", "B" or "C" are entered, they will be displayed on the screen under the "GIVEN" heading for "ANGLES".

Step three will prompt the user to enter one, two or three of the triangle sides (a, b, c):

```
SIDE:  "a"        (NNNNN.NNN)?     450.062 <CR>
SIDE:  "b"        (NNNNN.NNN)?                      (Y/N)? <CR>
SIDE:  "c"        (NNNNN.NNN)?     400.026 <CR>
```

If the plane triangle sides "a", "b" or "c" are entered, they will be displayed on the screen under the "GIVEN" heading for "SIDES".

When sufficient data has been entered, the triangle will be solved and the unknown elements displayed on the screen below the heading "SOLVE". A sample OBLIQUE triangle screen is given in Figure (4.02).

```
  +---------------------------------------------------------------------------+
01|                   TRIANGLE COMPUTATIONS --- PLANE                          |
02|                 --------------------------------------                     |
03|                                                                            |
04|                                                GIVEN          SOLVE        |
05|                       C                                                    |
06|                      +                    ANGLES--------------/DMS/        |
07|                                         A   44-00-00.00                    |
08|                    .   .                B                 97-52-16.89      |
09|                                         C                 38-07-43.10      |
10|                  .       .                                                 |
11|           a                                                                |
12|           .             .b                                                 |
13|                                                                            |
14|        .                  .                                                |
15|                                           SIDES------------/METERS/        |
16|     .                       .           a      450.0620                    |
17|                                         b                    641.7853      |
18|  +  .  .  .  .  .  .  .  +             c      400.0260                    |
19| B              c          A                                                |
20|                                                                            |
  ...
24|                                                                            |
  +---------------------------------------------------------------------------+
```

Figure (4.02) ---- Plane OBLIQUE Triangle Screen

4.2 SPHERICAL

This program computes the unknown elements (angles or sides) of a spherical triangle given a sufficient number of angles (A,B,C) and sides (a,b,c) opposite the corresponding angles. The computation is done in four steps: (1) determine whether or not the triangle computation will be a SPHERICAL or a NZP (Astronomical) triangle, (2) prompt the user to enter the spherical triangle verticies (A,B,C), (3) prompt the user to enter the spherical triangle sides (a,b,c), and (4) solve for the unknown elements and display the results on the screen.

Step one of this program determines which spherical triangle OPTION (1 or 2) will be used froma response to the following:

```
IS THIS A ... NZP (Astronomical Triangle) ...   (Y/N)?  <CR>
```

A <CR> reply, the "NO" response, will allow the program to continue and to compute a SPHERICAL triangle (OPTION 1). A reply of Y <CR>, the "YES" response, will force the program to compute a NZP (Astronomical Triangle -- OPTION 2). The configuration for the six elements of a SPHERICAL triangle are shown in Figure (4.03).

==================================== (OPTION 1) ====================================

Step two will prompt the user to enter one, two, three or none of the SPHERICAL angles (A,B,C):

```
GIVEN: "A" /DMS/ (NNN,NN,NN.NN)?  61,00,0.0 <CR>
GIVEN: "B" /DMS/ (NNN,NN,NN.NN)?  61,00,0.0 <CR>
GIVEN: "C" /DMS/ (NNN,NN,NN.NN)?  61,00,0.0 <CR>
```

As the vertcies "A", "B" or "C" are entered, they will be displayed on the screen under the "GIVEN" heading for "ANGLES".

Step three will prompt the user to enter one, two, three or none of the SPHERICAL triangle sides (a,b,c in degrees minutes seconds):

```
SIDE:  "a" /DMS/ (NNN,NN,NN.NN)?             (Y/N)? <CR>
SIDE:  "b" /DMS/ (NNN,NN,NN.NN)?             (Y/N)? <CR>
SIDE:  "c" /DMS/ (NNN,NN,NN.NN)?             (Y/N)? <CR>
```

As each of the spherical triangle sides "a", "b" or "c" are entered, they will be displayed on the screen under the "GIVEN" heading for "SIDES".

When sufficient data has been entered, the SPHERICAL triangle will be solved and the unknown triangle elements displayed on the screen under the heading "SOLVE". A sample SPHERICAL triangle screen is given in Figure (4.03).

Upon completion of the SPHERICAL triangle computation, the following message will appear on the screen:

RE-ENTER ... "SPHERICAL" ... TRIANGLES (Y/N)? <CR>

A reply of Y <CR>, the "YES" response, will allow the user to return to step one where OPTIONs (1 or 2) can be re-entered. A <CR> reply, the "NO" response, will exit this level and return the user to the program "MENU" level.

```
  +------------------------------------------------------------------------+
01|                TRIANGLE COMPUTATIONS --- SPHERICAL                     |
02|              ---------------------------------------                   |
03|                     C                                                  |
04|                   . +                GIVEN          SOLVE              |
05|                 .   .                                                  |
06|               .                    ANGLES--------------/DMS/           |
07|                        .         A  61-00-00.00                        |
08|             .                    B  61-00-00.00                        |
09|        a                .        C  61-00-00.00                        |
10|        .                                                               |
11|                          .                                             |
12|      .                    b                                            |
13|                          .                                             |
14|    .                                                                   |
15|                          .         SIDES---------------/DMS/           |
16|  B +                             a               19-46-29.05           |
17|      .                  .        b               19-46-29.05           |
18|          .                       c               19-46-29.05           |
19|            c  .        .                                               |
20|                  .                                                     |
21|                     +                                                  |
22|                     A                                                  |
23|                                                                        |
24|      RE-ENTER ... "SPHERICAL" ... TRIANGLES              (Y/N)?        |
  +------------------------------------------------------------------------+
```

Figure (4.03) ---- SPHERICAL Triangle Screen

(OPTION 2)

The remaining portion of this section follows the same program steps described above except this option allows for computation of a NZP Astronomical Triangle. In order to display the proper configuration on the sreen, the user must define the location of the "STAR/OBJECT" by responding to the following prompt:

IS THE STAR/OBJECT ... "EAST" ... OF OBSERVER (Y/N)? Y <CR>

A reply of Y <CR>, the "YES" response, will display the star's vertex angle

(P) to the right (East side) of the observer's vertex angle (Z). Whereas, a <CR> reply, will display the star's vertex angle to the left (West side) of the observer's vertex angle, i.e. see Figure (4.04) for this configuration.

```
             NORTH
             POLE
              (N)
               |
               |
               |      "East"
               |     * STAR
               |    /   (P)
               |   /
               |  /
               | /
               |/
               +
           OBSERVER
              (Z)
```

Step two will begin by prompting the user to enter one, two or none of the NZP angles (N or Z):

```
                                    h  -- HOUR ANGLE
GIVEN: "N" /DMS/ (NNN,NN,NN.NN)?                           (Y/N)? <CR>

                                  AZI -- From "NORTH" -- (0 to 360)
GIVEN: "Z" /DMS/ (NNN,NN,NN.NN)?                           (Y/N)? <CR>
```

As the vertcies "N" or "Z" are entered, they will be displayed on the screen under the "GIVEN" heading for NZP "ANGLES".

Step three prompts the user to enter one, two or three of the NZP triangle sides (a,b,c in degrees minutes seconds):

```
                                   ZENITH DISTANCE/ALTITUDE --
SIDE:  "a" /DMS/ (NNN,NN,NN.NN)?  62,1,56.9     (Z/A)? Z <CR>

                                   OBSERVERS LATITUDE       --
SIDE:  "b" /DMS/ (NNN,NN,NN.NN)?  39,58,46.889 (N/S)? N <CR>

                                   STAR/OBJECT DECLINATION  --
SIDE:  "c" /DMS/ (NNN,NN,NN.NN)?  48,16,44.68   (N/S)? N <CR>
```

As each NZP triangle side "a", "b" or "c" is entered, it will be displayed on the screen under the "GIVEN" heading, below the second "ANGLES" label. When entries are made for the latitude of the observer, the declination of the star, and the altitude of the star, the program will automatically compute the co-latitude, the co-declination, the zenith distance, and reload these values to the screen.

After sufficient data entries are made, the NZP triangle will be solved and the unknown triangle elements displayed on the screen under the heading "SOLVE". A sample NZP triangle screen is given in Figure (4.04).

```
  +---------------------------------------------------------------------------+
01|                  TRIANGLE COMPUTATIONS --- SPHERICAL                      |
02|                ----------------------------------------                   |
03|                       N                                                   |
04|                    . +                   GIVEN         SOLVE              |
05|                  .    .                                                   |
06|                .    h                ANGLES--------------/DMS/            |
07|                         .         N                 91-11-27.67526        |
08|         CO- .                     P                 60-09-31.83194        |
09|         LAT              .        Z                 48-52-49.59979        |
10|          .  b                                                             |
11|                           .                                               |
12|       .                 c  CO-                                            |
13|                           .DEC                                            |
14|     .                                                                     |
15|                           .          ANGLES--------------/DMS/            |
16|  Z + AZI                          a   62-01-56.90000                      |
17|       .                  .        b   50-01-13.11100                      |
18|           . a                     c   41-43-15.32000                      |
19|               .         .                                                 |
20|        ZEN=CO-    .                                                       |
21|            ALT        +                                                   |
22|                        P                                                  |
23|                                                                           |
24|                                                                           |
  +---------------------------------------------------------------------------+
```

Figure (4.04) ---- NZP (Astronomical) Triangle Screen

4.3 GEODETIC

This program computes a GEODETIC triangle where three angles (1,2,3), or in the case of an intersection station where only two angles (2,3), are observed; and the geodetic distance between vertex stations 2 and 3 is known. The program computation is done in four steps: (1) enter a mean latitude in order for the program to compute a constant for spherical excess computation, (2) prompt the user to enter the vertex angles (1,2,3), (3) enter the geodetic distance between vertex station 2 and 3, and (4) solve the triangle, compute the lengths for the sides (1-3) and (1-2), and display the results on the screen.

Step one of this entry point prompts the user to enter a mean latitude for the GEODETIC triangle computation. The latitude entered will be used to compute the spherical excess for all following triangle computations until it is changed. The program will prompt by displaying the following message:

```
MEAN LATITUDE /DMS/ (NN,NN,NN.NNNN)?  40,40,0.0   (N/S)? N <CR>
```

Step two prompts the user to enter the observed angles for the vertices (1,2,3) in one or two ways. The first way, with the "MTEN SYSTEM" unattached, will force the user to enter each angle in turn by responding to the following statements:

```
GIVEN: -1- /DMS/ (NNN,NN,NN.NN)?  74,0,40.5 <CR>
GIVEN: -2- /DMS/ (NNN,NN,NN.NN)?  62,4,43.38 <CR>
GIVEN: -3- /DMS/ (NNN,NN,NN.NN)?  43,54,33.26 <CR>
```

If the "MTEN SYSTEM" has been attached, the program will display the following prompt on the screen asking the user to enter only the SPNs for the three vertex angles (1,2,3):

```
                                        VERTEX     1    2    3

ENTER THE THREE  "MTEN" SPNs (NNN)?  84   85   83
```

The program will automatically go to the combined "LST" (if it exists) for each SPN selected and take out the observed angle. If an angle does not exist, the user will be prompted to enter it from the keyboard.

In either of the above cases, the program will display each angle as it is entered under the "GIVEN" heading for "ANGLES".

Step three prompts the user to enter the geodetic distance between vertices 2 and 3. Two ways are possible, the first, in the unattached mode, forces the user to enter the distance directly from the keyboard:

```
SIDE:  2-3       (NNNNN.NNN)?    4764.6387 <CR>
```

Whereas the second way, in the attached mode, the user is allowed two options for entering the geodetic distance. Option one lets the program compute the geodetic inverse between the geographic position for stations 2 and 3 to get the distance, and option two lets the user enter it directly. To select one of these options the user must answer the following prompt:

COMPUTE A GEODETIC INVERSE FOR THE (2-3) SIDE ... (Y/N)? Y <CR>

A <CR> reply, the "NO" response, will change the program's mode to unattached and force the user to enter the required distance from the keyboard (option two). However if a reply of Y <CR>, the "YES" response is made, the program will compute the geodetic inverse between station 2 and 3 in order to obtain the geodetic distance.

Once the geodetic distance has been entered, the program will complete the GEODETIC triangle computation and display the results on the screen. The displayed results include: (1) the "SUM" of the three angles, (2) the sum of the spherical excess and the excess to be added to each angle, (3) the sum of the corrections and the amount to be applied to each observed angle to make it a spherical angle, and (4) the geodetic distance for the other two triangle sides (1-3) and (1-2). A sample screen for the GEODETIC triangle computation is given in Figure (4.05).

```
+--------------------------------------------------------------------------+
|                TRIANGLE COMPUTATIONS --- GEODETIC         NAD27           |
|              -------------------------------------                        |
|                                                                           |
|                                         GIVEN        SOLVE    SPHERICAL   |
|                     1                                           EXCESS    |
|                    +                ANGLES-------------/DMS/      (")     |
|                                  1   74-00-40.500      0.966      0.012   |
|                 .   .            2   62-04-43.380      0.966      0.012   |
|                                  3   43-54-33.260      0.966      0.012   |
|              .       .                                                    |
|        1-3                     SUM  179-59-57.140      2.897      0.037   |
|           .            .1-2                                               |
|                                                                           |
|        .                .                                                 |
|                                     SIDES-----------/METERS/              |
|     .                     .       2-3   4764.6387                         |
|                                   1-3              4379.4143              |
|   +  .  .  .  .  .  .  .  +       1-2              3437.3452              |
|  3          2-3           2                                              |
|                                                                           |
|                                                                           |
|                                                                           |
|                                                                           |
|    RE-ENTER WITH SAME .. MEAN LATITUDE                         (Y/N)?     |
+--------------------------------------------------------------------------+
```

Figure (4.05) ---- GEODETIC Triangle Screen

Upon completion of the GEODETIC triangle computation, the following two messages will appear on the screen. The first:

RE-ENTER WITH SAME .. MEAN LATITUDE (Y/N)? Y <CR>

A reply of Y <CR>, the "YES" response, will allow the program to continue using the same mean latitude, but a <CR> reply will force the user to enter a new mean latitude for the next computation. The second:

RE-ENTER ... "GEODETIC" ... TRIANGLES (Y/N)? <CR>

A reply of Y <CR>, the "YES" response, will allow the user to return to the program entry point and to continue. The <CR> reply will return the user to the program "MENU" level.

5.0 WRK005 -- Meteorological Data and EDM Observation Reduction

To enter this program type WRK005 <CR>. The program will clear the screen and the following display will flash to the screen:

```
METEOROLOGICAL DATA TABLE
-------------------------------
```

The user will be prompted to select a default set of distance units by the following message:

```
DISTANCE UNITS /Meters or Feet/  (M/F)?  M <CR>
```

The second program default is to select the ellipsoid parameters and the datum name to be used for all computations to be done by this program. The user is then prompted so that the program can draw information from MTEN files already loaded by:

```
ATTACH TO  --- "MTEN SYSTEM" ---  (Y/N)?
```

A reply of Y <CR>, the "YES" response, will cause the program to respond with the next two prompts:

```
CHANGE DEFAULT DRIVE=C (Y/N)?  <CR>
ENTER YOUR JOBCODE /JC/ (LL)?  JC <CR>
```

The program will then use the ellipsoid parameters that were initialized with ABSINX (See Manual Section 1).

If a reply of <CR>, the "NO" response, was made to the above "ATTACH TO ..." prompt, then the program will not use the existing MTEN data files but rather all computations will be made independent of MTEN with all information entered by the user from the keyboard.

With no datum information available, the program will ask the user to initialize the ellipsoid parameters by prompting for the selection of one of the following:

```
USE GRS 1980      ELLIPSOID .. NAD83 ..      (Y/N)?
USE CLARKE 1866   ELLIPSOID .. NAD27 ..      (Y/N)?
USE WGS 1972      ELLIPSOID    .....         (Y/N)?
```

or select another ellipsoid defined by:

```
USE ELLIPSOID  (AAAAAAAAAA)?
MAJOR AXIS   (NNNNNNN.NNNN)?
FLATTENING "1/F" (NNN.NNNNNN)?
```

After the ellipsoid parameters have been selected or entered, the "DATUM" abbreviation will display on the screen in the upper right-hand corner. At this point, the program will begin with the "METEOROLOGICAL DATA TABLE". Upon the exit from the program, the user will be prompted the following:

RETURN TO --- MENU SCREEN --- (Y/N)?

This will allow the user to re-enter at the program level or exit to DOS.

5.1 Meteorological Data

The purpose of this program is to compute an Electronic Distance Measurements (EDM) from a given Standpoint "INSTRUMENT" station to one or more Forepoint "REFLEX" stations all observed on the same date. The computation is broken up into two (2) parts. The first part (Section 5.1) has steps 1 thru 5 and the second part (Section 5.2) has steps 6 thru 17. The steps of the first part are; (1) to establish the Standpoint name and position; (2) to enter the date of observation; (3) to set the meteorological units for the Standpoint and Forepoint stations; (4) to enter the meteorological observation for the Standpoint "INSTRUMENT" station and the corresponding meteorological observation at the Forepoint "REFLEX" station for the same date; and (5) to convert all the meteorological observations (in the selected units) both at the Standpoint and Forepoint stations to metric equivalents for use in the EDM computations in the next part (Section 5.2).

Step 1, the establishment of the Standpoint "INSTRUMENT" station, is done in either of two ways. The first with the "MTEN SYSTEM" attached, the program will prompt the user to enter only the Standpoint SPN by the following:

```
    INSTRUMENT

STATION /SPN/ (NNN)?  6 <CR>
```

After the SPN entry, the program will load the Standpoint's station name, latitude, and longitude from the geographic position file (FILEGPNX.JC) and flash the information to the screen. However, the second way, with "MTEN" unattached, is for the program to prompt the user to complete the Standpoint "INSTRUMENT station information by:

```
    INSTRUMENT     NAME
STATION   BAYVIEW 1939 <CR>
```

and

```
    /DMS/        (NNN,NN,NN.NNNNN)

LATITUDE         48,29,32.74      N <CR>
LONGITUDE       122,28,54.00      W <CR>
```

------------------------(Observations: Padilla Bay)----------------------

STANDPOINT:	Latitude	Longitude	Elevation	Geoid
	DD MM SS.SS	DDD MM SS.SS	(M)	(M)
BAYVIEW 1939	48 29 32.74	122 28 54.00	0.60	0.0

Instrument Constant/Meters/ = +0.029 Height = 1.08
Assumed Index = 279.42
Wavelength /Microns/ = 0.8350

FOREPOINT (1):	Latitude	Longitude	Elevation	Geoid
	DD MM SS.SS	DDD MM SS.SS	(M)	(M)
PEW 1939	48 28 25.27	122 32 27.75	2.00	0.0

Reflex Constant/Meters/ = -0.028 Height = 1.525

Time	Measurement (Slope)	Reflex (Offset)	
1040	30.12/60/60	30.10/65/65	(P/D/W) ***
1044	4859.477	0.0	
1045	4859.351	0.125	Dialed /ppm/ = 110.0
1046	4859.604	-0.125	
1050	30.12/60/60	30.10/65/65	(P/D/W)

FOREPOINT (2):	Latitude	Longitude	Elevation	Geoid
	DD MM SS.SS	DDD MM SS.SS	(M)	(M)
CAVANAUGH 1886	48 29 08.91	122 32 48.95	3.00	0.0

Reflex Constant/Meters/ = -0.028 Height = 1.170

Time	Measurement (Slope)	Reflex (Offset)	
1110	30.10/62/61	30.08/62/61	(P/D/W)
1119	4880.761	0.0	
1120	4880.632	0.125	Dialed /ppm/ = 110.0
1122	4880.884	-0.125	
1123	4880.763	0.0	
1130	30.10/62/61	30.08/62/61	(P/D/W)

FOREPOINT (3):	Latitude	Longitude	Elevation	Geoid
	DD MM SS.SS	DDD MM SS.SS	(M)	(M)
MARCH POINT 2 1939	48 30 01.31	122 33 22.99	1.00	0.0

Reflex Constant/Meters/ = -0.028 Height = 1.775

Time	Measurement (Slope)	Reflex (Offset)	
1220	30.07/63/62	30.06/66/65	(P/D/W)
1224	5593.128	0.0	
1225	5593.006	0.125	Dialed /ppm/ = 110.0
1226	5593.258	-0.125	
1230	30.07/63/62	30.06/66/65	(P/D/W)

*** (P/D/W) = Pressure(Inches) / Dry temperature(F) / Wet bulb(F) after the Standpoint station's name has been entered, the program will ask the user if it is to be changed before proceeding to the entry of the station's position. When both the latitude and longitude have been entered, the position will be flashed on the screen and the user must verify it by answering the following question:

```
                          LAT  48-29-32.74000 N
                          LON 122-28-54.00000 W
      RE-ENTER THIS         GPN POSITION ...         (Y/N)?  <CR>
```

A reply of <CR>, the "NO" response, will allow the program to continue to step 2. A reply of Y <CR>, the "YES" response, will force the program to re-prompt the user to completely re-enter another geographic position for the Standpoint station.

The program's step 2, the date of observation, will prompt the user to enter the observation date which will be used to relate all meteorological data from both the Standpoint and all forepoints into a single table by the following prompt:

```
      ALL TABLE ENTRIES ARE FOR ONE      ...      DATE !

      DATE OF OBSERVATION /YYMMDD/?  840730 <CR>
```

after the date has been entered, it will be reloaded onto the screen in the upper left-hand corner as "DATE = 840730".

The program's step 3 will force the user to make 4 meteorological selections for the Standpoint "INSTRUMENT" station and also allow the same selections for the Forepoint "REFLEX" stations. The selections are for the INSTRUMENT station's units for the pressure, dry blub temperature, wet bulb temperature (if read), and (20 + 30)-foot temperature. After the INSTRUMENT units have been selected the user will be allowed to select the REFLEX units. The following set of screen prompts are given to show the INSTRUMENT unit entries:

```
                    +-- INSTRUMENT ----------------
                    |         -- TEMPERATURE(S) --
                    | PRESS   DRY   WET  20FT  30FT
                    |
                    +-----------------------------+
      STATION  ... INSTRUMENT   ... METEOROLOGICAL OBSERVATIONS

                                                               SELECT UNITS
                                                                  (Y/N)?
      PRESSURE IN .. (millimeters/inches) .. OF MERCURY        (MM)    N
                                                               (IN)    Y <CR>
NOTE -->PRESSURE IN .. (meters/feet)      .. ALTIMETER READING (MT)
                                                               (FT)
      PRESSURE IN .. (millibar/pascal)    .. READINGS          (MB)
                                                               (PA)
```

NOTE: NGS uses altimeters that have Sea Level (0 elevation) set to 1000 feet (see Smithsonian Meteorological Table 51). If your equipment records altitude in feet and doesn't have 1000 feet set at Sea Level, you will have to add an additional 1000 feet to your readings when using the above option. The NGS program WRK005 will automatically substract 1000 feet from all readings entered with the " ... (... /feet)" option.

```
TEMPERATURE READINGS  ..     /DRY BULB/  4 FT
TEMPERATURE IN  ..  (Celsius/Fahrenheit)  ..    DEGREES  (C)     N
                                                         (F)     Y <CR>

TEMPERATURE READINGS  ..     /WET BULB/
THEY  ...  WERE (Yes) / WERE NOT (No) ... OBSERVED               Y <CR>
TEMPERATURE IN  ..  (Celsius/Fahrenheit)  ..    DEGREES  (C)     N
                                                         (F)     Y <CR>

TEMPERATURE READINGS  ..     /20 + 30 FT/
THEY  ...  WERE (Yes) / WERE NOT (No) ... OBSERVED               <CR>
TEMPERATURE IN  ..  (Celsius/Fahrenheit)  ..    DEGREES  (C)
                                                         (F)
```

After the selection of the meteorological units for the INSTRUMENT station, the user may select the option to have units for the REFLEX station by the same set of prompts by:

```
+-- REFLEX --------------------
|          -- TEMPERATURE(S) --
| PRESS   DRY   WET   20FT  30FT
|
+-----------------------------+
```

```
STATION  ... REFLEX      ... METEOROLOGICAL OBSERVATIONS (Y/N)? Y <CR>
```

At this point, the program will re-cycle, at the REFLEX station, through each of the above listed prompts for selection of meteorological units.

Step 4 of the program will prompt the user to enter the meteorological observation(s) first for the Standpoint "INSRTUMENT" and then for the Forepoint "REFLEX" station (if selected) along with a time. Special NOTE to the user: the "METEOROLOGICAL TABLE" must have two entries for each EDM Observation which will be entered in the next part (Section 5.2), i.e. one meteorological observation with a time entry before and a second time entry that is after the actual EDM Observation time. The first prompt will be for the time of observation for the meteorological data by:

```
ENTER TIMES WITH A 24-HOUR CLOCK
OBSERVATION TIME /HHMM/ (NNNN)?  1040 <CR>
```

Next the program will prompt the user to enter the meteorological observations, with units selected, at the INSTRUMENT station and then at the REFLEX station:

```
                                                             INSTRUMENT

       ENTER ... PRESSURE IN        /INCHES/          (NNNNN.N)? 30.12 <CR>
       ENTER ... TEMPERATURE DRY    /FAHRENHEIT/      (NNN.N)?   60.0  <CR>
       ENTER ... TEMPERATURE WET    /FAHRENHEIT/      (NNN.N)?   59.99 <CR>

                                                               REFLEX

       ENTER ... PRESSURE IN        /INCHES/          (NNNNN.N)? 30.1  <CR>
       ENTER ... TEMPERATURE DRY    /FAHRENHEIT/      (NNN.N)?   65.0  <CR>
       ENTER ... TEMPERATURE WET    /FAHRENHEIT/      (NNN.N)?   64.99 <CR>
```

After each entry has been made, it will be re-loaded onto the screen under the appropriate "METEOROLOGICAL DATA TABLE" heading, see Figure (5.01). At the completion of each INSTRUMENT and REFLEX entry, the program will prompt the user the following:

```
       METEOROLOGICAL  ...       DATA ENTRY            (Y/N)?  STOP  !!
```

A reply of <CR>, the "NO" response, will allow the program to continue to prompt the user for additional meteorological observations (remember at least two per EDM Observation). A reply of Y <CR>, the "YES" response, will force the program to stop all meteorological data entry, and the ask the user if any of the "TABLE" entries need to be changed by:

```
       RE-ENTER .. ONE OF THE ABOVE ENTRIES ... (Y/N)?          <CR>
```

```
  +----------------------------------------------------------------------+
01|  DATE:   840730        METEOROLOGICAL  DATA  TABLE            NAD27    |
02|  NAME                  -------------------------------                 |
03|  BAYVIEW 1939                                                          |
04|                                                                        |
05|      +-- INSTRUMENT ---------------     +-- REFLEX ------------------- |
06|R     |          -- TEMPERATURE(S) --    |          -- TEMPERATURE(S) -- |
07|O TIME | PRESS    DRY    WET             | PRESS    DRY    WET          |
08|W     |  (IN)    (F)    (F)              |  (IN)    (F)    (F)          |
09|      +----------------------------+     +----------------------------+ |
10|                                                                        |
11|1 1040  30.120  60.0  60.0                30.100  65.0  65.0            |
12|2 1050  30.120  60.0  60.0                30.100  65.0  65.0            |
13|3 1110  30.100  62.0  61.0                30.080  62.0  61.0            |
14|4 1130  30.100  62.0  61.0                30.080  62.0  61.0            |
15|5 1220  30.070  63.0  62.0                30.060  66.0  65.0            |
16|6 1230  30.070  63.0  62.0                30.060  66.0  65.0            |
17|                                                                        |
    ....
  +----------------------------------------------------------------------+
```

Figure (5.01) ---- Observed Meteorological Table

A reply of <CR>, the "NO" response, will allow the program to continue. The Y <CR> response, will force the program to prompt the following:

ENTER WHICH .. ROW NUMBER .. TO BE CORRECTED (NN)?

When a "ROW" has been selected, the program will prompt the user one-by-one each item selected. To skip over those items which are correct and not to be changed, the user must touch <CR> for each one. Then at the item to be changed the user must re-type the correct value + <CR> and then continue to the end of that "ROW" before the change is completed.

At this point, after all meteorological data have been entered and corrected, step 5 will automatically re-format the METEOROLOGICAL DATA TABLE into metric equivalents, see Figure (5.02). This screen display for the metric table will complete the first part.

```
  +----------------------------------------------------------------------------+
01| DATE:   840730        METEOROLOGICAL  DATA  TABLE               NAD27     |
02| NAME                 --------------------------------                     |
03| BAYVIEW 1939                                                              |
04|                                                                           |
05|      +-- INSTRUMENT ---------------     +-- REFLEX ------------------    |
06|R     |        -- TEMPERATURE(S) --      |        -- TEMPERATURE(S) --    |
07|O TIME | PRESS   DRY   WET               | PRESS   DRY   WET               |
08|W     |  (MM)   (C)   (C)               |  (MM)   (C)   (C)              |
09|      +-----------------------------+     +-----------------------------+  |
10|                                                                           |
11|1 1040   765.0  15.6  15.6                 764.5  18.3  18.3               |
12|2 1050   765.0  15.6  15.6                 764.5  18.3  18.3               |
13|3 1110   764.5  16.7  16.1                 764.0  16.7  16.1               |
14|4 1130   764.5  16.7  16.1                 764.0  16.7  16.1               |
15|5 1220   763.8  17.2  16.7                 763.5  18.9  18.3               |
16|6 1230   763.8  17.2  16.7                 763.5  18.9  18.3               |
17|                                                                           |
   ....
  +----------------------------------------------------------------------------+
```

Figure (5.02) ---- Metric Meteorological Table

5.2 EDM Observation Computations

The second part of an EDM observation is completed by entering all Forepoint "REFLEX" Data required for each measurement. The computation required for part two has steps 6 thru 17. The steps are; (6) to enter the Forepoint "REFLEX" Station name and position; (7) to select or enter the "INSTRUMENT's" wavelength, constant, and assumed index; (8) to select or enter the "REFLEX" constant; (9) to enter the measured slope distance; (10) to enter the Index Rate Correction for the "INSTRUMENT" and "REFLEX" stations and the DIALED PPM; (11) Compute the meteorological correction; (12) to enter the Standpoint "INSTRUMENT" constants (Instrument Constant/Offset/Tilt); (13) to enter the Forepoint constants (Reflex Constant/Offset/Tilt); (14) to repeat steps 9 thru 13 for each additional slope measurement to the same Forepoint; (15) to display on the screen a summary of all entered slope measurements; (16) to compute the slope to geodetic reduction; and (17) to repeat steps 6 thru 16 in order to enter new Forepoint "REFLEX" stations which were observed on the same date from the Standpoint "INSTRUMENT" station.

Step 6, the establishment of the Forepoint "REFLEX" station, has two methods. The first method with the "MTEN SYSTEM" attached, is for the program to prompt the user to enter only the Forepoint SPN by:

```
            REFLEX

        STATION   /SPN/ (NNN)?   7 <CR>
```

After the SPN entry, the program will load the Forepoint's station name, latitude, and longitude from the geographic position file and flash the information to the screen. The other method with MTEN unattached, is for the program to prompt the user to complete the Forepoint "REFLEX" station information by:

```
            REFLEX      NAME

        STATION   PEW 1939 <CR>
```

and

```
          /DMS/       (NNN,NN,NN.NNNNN)

        LATITUDE        48,28,25.27     N <CR>
        LONGITUDE      122,32,27.75     W <CR>
```

After the Forepoint station's name has been entered, the program will ask the user if it is to be changed before proceeding to the entry of the station's position. When both the latitude and longitude have been entered, the position will displayed on the screen and the user must then verify it by answering the following question:

```
                    LAT  48-28-25.27000 N
                    LON 122-32-27.75000 W

     RE-ENTER THIS       GPN POSITION ...          (Y/N)?  <CR>
```

A reply of <CR>, the "NO" response, will allow the program to continue to step 7. A reply of Y <CR>, the "YES" response, will force the program to re-prompt the user to enter another geographic position for the Forepoint station.

Step 7 of the program will prompt the user to enter the Instrument's Wavelength, Constant, and Assumed Index. As an aid to the user, the following prompt will flash to the screen:

```
     EDM EQUIPMENT /Lightwave,Infrared,Microwave/ (L,I,M)?      I <CR>
```

Once a selection from (L,I,M) has been made, the program will display additional information on the screen for the user in order to help make the proper instrument selection. For this example, "I" was selected and the screen will appear as follows:

```
     SELECT
     (Y/N)?              WAVELENGTH     "N"
       N      INFRARED     0.8350     105.940    HP/3808,3820/
       N                   0.8400     105.925
       N                   0.8600     105.806    KERN/DM102/
       N                   0.8650     105.777
     . . .
       N                   0.9300     105.450    MA100
       Y      OTHER       (?.????)
```

For this example, the last item "OTHER" was used in order to show all prompts for the INSTRUMENT. If the first selection "0.8350" had been used, the program would not prompt the user for the Wavelength. All INSTRUMENT prompts are as follows:

```
                                                           INSTRUMENT

     ENTER ... WAVELENGTH /MICRONS/ (N.NNNN)                 0.835    <CR>
     ENTER ... EQUIPMENT CONSTANT /METERS/ (SN.NNNN)         0.029    <CR>
     ENTER ... ASSUMED REFRACTIVE INDEX /IN PPM/ (NNN.NN)? 279.42    <CR>
```

The ASSUMED REFRACTIVE INDEX of "279.42" which was entered will be used as the INSTRUMENT's PRESET value in the computation of Meteorological Corrections for both the Standpoint and Forepoint.

If the "MTEN SYSTEM" has been attached, the program will clear the lower section of the screen, search the system's Job Specific Instrument (JSI) file, and display on the screen all equipment associated with the selected (L,I,M) type. The user can then select from the JSI list or enter the appropriate INSTRUMENT if it is not found within the JSI list. While the program is making a search the message:

"WAIT!! ... CHECKING EQUIPMENT JSI FILE

will appear on the screen. When items of equipment are found within the JSI file, they will be displayed on the screen in the following format:

JSI	SERIAL NO.	MODEL	MANUFACTURER	CONSTANT	UNITS
531	2356	HP3808	HEWLETT-PACKARD	0.0320	METERS
536	100204	HP3808A	HEWLETT-PACKARD	0.0290	METERS

Program step 8 will prompt the user to enter, for this EDM observation, a constant for the equipment used at the Forepoint REFLEX station by the following:

REFLEX

ENTER ... EQUIPMENT CONSTANT /METERS/ (SN.NNNN) -0.028 <CR>

The same technique, as explained for the selection of an INSTRUMENT, is also used for the selection of the REFLEX equipment when the "MTEN SYSTEM" has been attached.

Then just before the actual EDM observations are entered, the program will prompt the user whether or not to apply "INDEX RATE" Corrections (see Meade, B. K., "Corrections for Refractive Index as Applied to Electro-Optical Distance Measurements," Sysposium on Electromagnetic Distance Measurement and Atmospheric Refraction, IAG, Boulder, CO, June 1969, 25 pages) to the INSTRUMENT and REFLEX Meteorological Corrections in PPM by:

APPLY ... "INDEX RATE" ... CORRECTIONS

TO INSTRUMENT/REFLEX "PPM" (Y/N)? <CR>

A reply of <CR>, the "NO" response, will turn off the INDEX RATE Correction. However, a reply of Y <CR>, the "YES" response, will force the program to prompt the user to enter values for both the INSTRUMENT and the REFLEX PPM Corrections.

At this point, step 9, the program will prompt the user to complete a series of prompts in order to enter an EDM observation to the Forepoint REFLEX station selected. The first prompt of the series will be the time of observation, i.e. so the program can parse the Metric Meteorological Table and find a time before and after the observation time. This time will be enter by the following prompt:

ENTER TIMES WITH A 24-HOUR CLOCK

OBSERVATION TIME /HHMM/ (NNNN)? 1044 <CR>

The second part of step 9 will prompt the user to enter the measured slope distance to the Forepoint REFLEX station by:

```
                                                                METERS

ENTER ... THE MEASURED SLOPE DISTANCE (NNNNN.NNNN)?   4859.477 <CR>
```

After the time and the slope distance have been entered, the program will display them on the screen under the approriate headings, see Figure (5.03).

Program step 10, the entry for INDEX RATE and DIALED PPM Corrections, will be prompted first for the Standpoint INSTRUMENT station and then for the Forepoint REFLEX station. If the INDEX RATE Correction is to be applied, the program will automatically stop under that heading "IX RATE" and wait for the user to enter a value for this correction. However, when the INDEX RATE is not to be applied, the program will stop only under the heading for the "DIALED" Correction. Here the user must make an entry if a meteorological correction was "DIALED" into the equipment in the field. Sample PPM Corrections for both the INSTRUMENT and REFLEX are given below respectively:

```
PRESET - (N*P/(273.2+T) - HUMIDITY + IX RATE) = PPM CORRN - DIALED

279.42 - ( 280.721       - 0.689    + 0.0    ) =  -0.611   - 110.0
279.42 - ( 277.861       - 0.814    + 0.0    ) =   2.373   - 110.0
```

After the PPM and DIALED Corrections have been entered, step 11, will compute the Meteorological Correction. The computed PPM values for the INSTRUMENT and REFLEX stations will be loaded onto the screen under the heading "MET(WX)". The Meteorological Correction (-0.5303) will be computed from the mean of the two PPM Corrections and loaded under the heading "ATMOS." in the CORRECTIONS table, see Figure (5.03).

Program step 12 will allow the user to enter constants which will change the slope distance measurement as a result of physical characteristics of the INSTRUMENT equipment. NOTE: the INSTRUMENT's constant of 0.029 meters is already displayed on the screen under the heading "CONST." in the table of CORRECTIONS. If the value is incorrect, it can be changed at this point or left as it is by touching <CR> and continuing on to the next item:

```
                                                    INSTRUMENT

ENTER ... CONSTANT IN  /METERS/          (SN.NNNN)?  <CR>
ENTER ... OFFSET   IN  /METERS/          (SN.NNNN)?  <CR>
ENTER ... TILT     IN  /METERS/          (SN.NNNN)?  <CR>
```

Program step 13 will allow the user to enter constants which will change the slope distance measurement as a result of physical characteristics for the REFLEX equipment. NOTE: the REFLEX's constant of -0.028 meters is already displayed on the screen under the heading "CONST." in the table of CORRECTIONS. If it is incorrect, it can be changed at this point by re-entering the value or it can be left as it is on the screen, by touching <CR> to continue to the next item:

```
                                                    REFLEX
ENTER ... CONSTANT IN  /METERS/         (SN.NNNN)?  <CR>
ENTER ... OFFSET   IN  /METERS/         (SN.NNNN)?  <CR>
ENTER ... TILT     IN  /METERS/         (SN.NNNN)?  <CR>
```

Program step 14 will add the Meteorological Correction (ATMOS.) to all the constants, offsets, and tilts for the INSTRUMENT and REFLEX to the measured slope distance in order to compute the corrected slope distance. The distance will be displayed under the heading "CORRECTED SLOPE", see Figure (5.03).

```
  +--------------------------------------------------------------------------+
01| DATE:   840730        EDM  OBSERVATIONAL  DATA                NAD27      |
02| NAME                 -----------------------------                       |
03| BAYVIEW 1939                            PEW 1939                         |
04|                                                                          |
05|      ASSUMED INDEX /PRESET/  279.42    WAVELENGTH /MICRONS/  0.8350      |
06|                                                                          |
07|               MEASURED          +--------- CORRECTIONS ----------+ CORRECTED |
08|TIME             SLOPE  MET(WX) |  ATMOS.  CONST.  OFFSET   TILT  |   SLOPE   |
09|                  (M)    (PPM)  |  (M)     (M)     (M)      (M)   |    (M)    |
10|1044 INSTR.  4859.477 -110.611    -.5303   .0290                    4858.9477 |
11|     REFLEX           -107.627            -.0280                              |
12|     ------------------------+--------------------------------+               |
13|1045 INSTR.  4859.351 -110.611    -.5302   .0290                    4858.9468 |
14|     REFLEX           -107.627            -.0280   .1250                      |
15|     ------------------------+--------------------------------+               |
16|1046 INSTR.  4859.604 -110.611    -.5303   .0290                    4858.9497 |
17|     REFLEX           -107.627            -.0280  -.1250                      |
18|     ------------------------+--------------------------------+               |
      ...
  +--------------------------------------------------------------------------+
```

Figure (5.03) ---- Forepoint (1): PEW 1939

When the corrected slope distance has been displayed on the screen, the program will prompt the user whether or not any of the above entries need to be corrected by:

```
CORRECT    ... THE ABOVE ENTRY ...     (Y/N)?   <CR>
```

A reply of <CR>, the "NO" response, will force the program to continue. A reply of Y <CR>, the "YES" response, will allow the user to change and will force the program to re-cycle through each item in the current EDM measurement.

If no changes are made to the current EDM measurement, the program will then prompt the user whether or not an additional "EDM SHEET" is to be entered for this EDM observation by:

```
EDM SHEET  ...       DATA ENTRY     (Y/N)?   <CR>   STOP !!
```

A reply of <CR>, the "NO" response, will allow the user to continue adding measurements to this EDM observation. The program will re-cycle starting with step 9 and continue working down to step 14 again. However, a reply of Y <CR>, the "YES" response, will force the program to stop "EDM SHEET ... DATA ENTRY", see Figure (5.03) where a total of three measurements (EDM SHEETs) have been entered.

At this point step 15 will automatically clear the screen and then display on the left hand side of the screen a summary of all entered measurements. If more than one (1) measurement has been entered, the program will compute and display the residuals (V), standard deviation (SD), and the standard error of the mean (MN) for this EDM observation. See Figure (5.04) for a sample screen.

```
+-----------------------------------------------------------------------------+
| DATE:   840730        EDM  OBSERVATIONAL  DATA                  NAD27      |
| NAME                  -----------------------------                         |
| BAYVIEW 1939                               PEW 1939                         |
|                                                                             |
|      ASSUMED INDEX /PRESET/  279.42    WAVELENGTH /MICRONS/  0.8350         |
|                                                                             |
|       DISTANCE          V        VV      HEIGHT       INSTRUMENT     REFLEX |
|         (M)           (MM)                                (M)          (M)  |
|       4858.9477       0.33      0.11    EQUIPMENT        1.080        1.525 |
|       4858.9468       1.32      1.74    STATION          0.600        2.000 |
|       4858.9497      -1.65      2.73    GEOID                               |
|      ------------------------------                                         |
|  MEAN 4858.9481                 4.58                                        |
|                       SD       1.51    SLOPE (MEAN)               4858.9481 |
|                       MN       0.87    2ND VELOCITY               4858.9480 |
|                                        MARK-TO-MARK               4858.9469 |
|                                        SEA LEVEL (GEOIDAL)        4858.9458 |
|                                        GEODETIC (ELLIPSOIDAL)     4858.9458 |
     ...
+-----------------------------------------------------------------------------+
```

Figure (5.04) ---- Forepoint (1): PEW 1939 -- Summary

Program step 16, the slope to geodetic reduction computation, will ask the user whether or not to continue by flashing the following message on the screen:

STOP ... THE EDM "REDUCTION" ... (Y/N)? <CR>

A reply of Y <CR>, the "YES" response, will force the program not to reduce the mean corrected slope distance to a geodetic distance. A reply of <CR>, the "NO" response, will allow the user to reduce the mean corrected slope distance to a geodetic distance by completing the following prompts:

```
 HEIGHT        INSTRUMENT (M)
EQUIPMENT          1.080 <CR>
STATION            0.600 <CR>
GEOID                    <CR>
```

and

HEIGHT	REFLEX (M)
EQUIPMENT	1.525 <CR>
STATION	2.00 <CR>
GEOID	<CR>

After the last HEIGHT prompt has been entered for the REFLEX station, the program will compute the "GEODETIC (ELLIPSOIDAL)" distance along with three other types of distances and display the results on the right hand side of the screen, see Figure (5.04).

The last program step prompts the user whether or not additional Forepoint REFLEX stations are to be entered for the current Standpoint INSTRUMENT station by the following:

CHANGE TO A NEW ... FOREPOINT ... (Y/N)? Y <CR>

A reply of Y <CR>, the "YES" response, will allow the use to continue entering new Forepoint REFLEX stations by forcing the program to re-enter at step 6 and then continue throught to step 16 again. (Remember the Meteorological Table must have had the weather observations entered for the new Forepoint REFLEX station.) A <CR> reply, the "NO" response, will force the program to stop all entry and prepare to exit.

Two additional Forepoint REFLEX stations, CAVANAUGH 1886 and MARCH POINT 2 1939, were entered and computed using the Observational Data provided. They are shown in the following Figures (5.05 and 5.06) respectively.

The last prompt flashed to the screen will allow the user to re-enter at the beginning of the program or exit by:

RETURN TO --- MENU SCREEN --- (Y/N)? <CR>

A reply of <CR>, the "NO" response, will exit to DOS, while the Y <CR> reply, the "YES" response, will allow the user to re-enter the program.

```
  +----------------------------------------------------------------------+
01| DATE:   840730       EDM  OBSERVATIONAL  DATA                NAD27    |
02| NAME                 -----------------------------                    |
03| BAYVIEW 1939                              CAVANAUGH 1886              |
04|                                                                       |
05|     ASSUMED INDEX /PRESET/  279.42    WAVELENGTH /MICRONS/  0.8350    |
06|                                                                       |
07|           MEASURED          +--------- CORRECTIONS ----------+ CORRECTED |
08|TIME          SLOPE  MET(WX) |  ATMOS.  CONST.  OFFSET  TILT  |   SLOPE  |
09|               (M)    (PPM)  |  (M)     (M)     (M)     (M)   |    (M)   |
10|1119 INSTR.  4880.761 -109.341   -.5332   .0290                4880.2288 |
11|     REFLEX           -109.155           -.0280                          |
12|     ------------------------+--------------------------------+          |
13|1120 INSTR.  4880.632 -109.341   -.5332   .0290                4880.2248 |
14|     REFLEX           -109.155           -.0280   .1250                  |
15|     ------------------------+--------------------------------+          |
16|1121 INSTR.  4880.884 -109.341   -.5332   .0290                4880.2268 |
17|     REFLEX           -109.155           -.0280  -.1250                  |
18|     ------------------------+--------------------------------+          |
19|1122 INSTR.  4880.763 -109.341   -.5332   .0290                4880.2308 |
20|     REFLEX           -109.155           -.0280                          |
21|     ------------------------+--------------------------------+          |
    ...
    ...

06|        DISTANCE        V        VV      HEIGHT     INSTRUMENT    REFLEX |
07|           (M)         (MM)                            (M)          (M)  |
08|        4880.2288     -1.00     1.00    EQUIPMENT     1.080        1.170 |
09|        4880.2248      2.99     8.92    STATION       0.600        3.000 |
10|        4880.2268      1.01     1.03    GEOID                            |
11|        4880.2308     -3.00     9.00                                     |
12|       -----------------------------                                     |
13|   MEAN 4880.2278              19.94                                     |
14|                     SD         2.58    SLOPE (MEAN)             4880.2278 |
15|                     MN         1.29    2ND VELOCITY             4880.2278 |
16|                                        MARK-TO-MARK             4880.2268 |
17|                                        SEA LEVEL (GEOIDAL)      4880.2250 |
18|                                        GEODETIC (ELLIPSOIDAL)   4880.2250 |
19|                                                                       |
    ...
  +----------------------------------------------------------------------+
```

Figure (5.05) ---- Forepoint (2): CAVANAUGH 1886

```
+----------------------------------------------------------------------------+
| DATE:   840730          EDM  OBSERVATIONAL  DATA                 NAD27      |
| NAME              -----------------------------                             |
| BAYVIEW 1939                             MARCH POINT 2 1939                 |
|                                                                             |
|      ASSUMED INDEX /PRESET/  279.42    WAVELENGTH /MICRONS/  0.8350         |
|                                                                             |
|                MEASURED          +--------- CORRECTIONS ----------+ CORRECTED |
|TIME                 SLOPE  MET(WX) |  ATMOS.  CONST.  OFFSET  TILT  |  SLOPE   |
|                      (M)    (PPM)  |  (M)     (M)     (M)     (M)   |   (M)    |
|1224 INSTR.  5593.128 -108.504    -.6020   .0290                    5592.5270 |
|     REFLEX           -106.745            -.0280                              |
|     ------------------------+--------------------------------+               |
|1225 INSTR.  5593.006 -108.504    -.6019   .0290                    5592.5301 |
|     REFLEX           -106.745            -.0280   .1250                      |
|     ------------------------+--------------------------------+               |
|1226 INSTR.  5593.258 -108.504    -.6020   .0290                    5592.5320 |
|     REFLEX           -106.745            -.0280  -.1250                      |
|     ------------------------+--------------------------------+               |
   ...
   ...
|         DISTANCE          V        VV       HEIGHT      INSTRUMENT     REFLEX  |
|           (M)           (MM)                                (M)          (M)   |
|         5592.5270        2.67     7.11    EQUIPMENT       1.080        1.525  |
|         5592.5301       -0.35     0.12    STATION         0.600        2.000  |
|         5592.5320       -2.32     5.38    GEOID                               |
|       -----------------------------                                          |
|   MEAN 5592.5297                 12.61                                       |
|                         SD        2.51    SLOPE (MEAN)              5592.5297 |
|                         MN        1.45    2ND VELOCITY              5592.5297 |
|                                           MARK-TO-MARK              5592.5283 |
|                                           SEA LEVEL (GEOIDAL)       5592.5278 |
|                                           GEODETIC (ELLIPSOIDAL)    5592.5278 |
|                                                                              |
    ...
+----------------------------------------------------------------------------+
```

Figure (5.06) ---- Forepoint (3): MARCH POINT 2 1939

6.0 WRK006 -- Special Computations

To enter this program type WRK006 <CR>. The program will clear the screen and display the following:

PROGRAM
(Y/N)?

```
3-POINT FIX  ... W/ANGLES

INTERSECTION  .. W/MULTI-AZIMUTHS

RESECTION   .... W/MULTI-DIRECTIONS
```

The program will prompt the user to select a default distance unit by flashing the following message to the screen:

```
DISTANCE UNITS /Meters or Feet/  (M/F)?  M <CR>
```

The next program defaults are the ellipsoid parameters and the datum name for all computations to be done by this program by. The user is prompted in order to give the ability to use data stored in MTEN files by:

```
ATTACH TO  --- "MTEN SYSTEM" ---  (Y/N)?
```

A reply of Y <CR>, the "YES" response, will cause the program to respond with the next two prompts:

```
CHANGE DEFAULT DRIVE=C (Y/N)?  <CR>
ENTER YOUR JOBCODE /JC/ (LL)?  JC <CR>
```

The program will then use the ellipsoid parameters that were initialized with ABSINX (See Manual Section 1).

If a <CR>, the "NO" response is made to the above prompt "ATTACH TO ...", the program will not use the existing MTEN data files. All computations will be made independent of MTEN and all information must be entered from the keyboard.

With no datum information available, the program will ask the user to initialize the ellipsoid parameters by selecting of one of the following:

```
USE GRS 1980      ELLIPSOID .. NAD83 ..      (Y/N)?
USE CLARKE 1866   ELLIPSOID .. NAD27 ..      (Y/N)?
USE WGS 1972      ELLIPSOID    .....         (Y/N)?
```

or select another defined by:

```
USE ELLIPSOID  (AAAAAAAAAA)?
MAJOR AXIS   (NNNNNNN.NNNN)?
FLATTENING "1/F" (NNN.NNNNNN)?
```

After the ellipsoid parameters have been selected or entered, the "DATUM" abbreviation will flash to the screen in the upper right-hand corner. At this point the entry points will be displayed on the screen. Different screens will appear depending on which entry point was selected. Upon exit from each entry point, the program will prompt the user with the following:

```
RETURN TO   --- MENU SCREEN ---  (Y/N)?
```

This will allow the user to re-enter at the program "MENU" level or to exit.

6.1 3-POINT FIX

This program computes the geographic position (Latitude and Longitude) of an occupied/instrument station using two angles (Left and Right), which were observed from the occupied/instrument station to three additional stations, whose geographic positions are known (Fixed stations). The program is structured to require: (1) entering the three fixed stations (LEFT,CENTRAL,RIGHT), (2) entering the two observed angles (LEFT and RIGHT), and (3) computing the observing station's geographic position.

There are two ways that the three fixed stations can be entered. If the "MTEN SYSTEM" is attached, then the user can enter the SPN for each station one-by-one. The program will prompt:

```
ENTER THE "MTEN" SPN (NNN)?  84 <CR>
```

The program will load the screen with each fixed station's SPN, Name, Latitude and Longitude from the geographic position file (FILEGPNXX.JC) and then flash it to the screen under the appropriate heading.

```
---LEFT MOST---
      84
H 53

LAT  040-40-32.84693 N
LON  074-03-34.84362 W
```

If the "MTEN SYSTEM" is not attached, the user is required to enter the following three items for each of the three fixed points:

```
STATION NAME (30A)?   H 53
LATITUDE  /DMS/  (NN,NN,NN.NNNN)?  40,40,32.84693    (N/S)? N <CR>
LONGITUDE /DMS/ (NNN,NN,NN.NNNN)?  74,3,34.84362     (E/W)? W <CR>
```

At the end of each fixed station entry the program will require the user to verify the input data by flashing the following message:

CHANGE THE CURRENT POSITION ENTERED .. (Y/N)?

A reply of <CR>, the "NO" change response, will cause the program to continue. A reply of Y <CR>, the "YES" response, will allow the user to re-enter the current fixed station.

The second portion of the keyboard entry requires the user to enter the "LEFT" and "RIGHT" angles one-by-one. At this point the screen will clear and display the (L) and (R) swinger angle limits for the three fixed points. That is, the angles which locate the occupied/instrumnet station on or near a circle which is coincident with a circumscribed circle through the three fixed points.

"LEFT" - ANGLE /DMS/ (NNN,NN,NN.N)? 28,16,34.5
"RIGHT" - ANGLE /DMS/ (NNN,NN,NN.N)? 94,00,53.0

Once the two angles have been entered, the program will solve for the geographic position of the occupied/instrument station if possible. The geographic position, the two angles, and the distance (DST) to the circle will be displayed on the screen. A positive (+) DST indicates that the occupied/instrument station is outside the circle. A negative (-) DST indicates the station is inside the circle. The actual value for DST is the shortest distance to the circumscribed circle from the station.

```
  +----------------------------------------------------------------------------+
01|                  SPECIAL COMPUTATIONS ---  3-POINT FIX                      |
02|                ----------------------------------------                     |
03|    ---LEFT MOST---          ---CENTRAL---              ---RIGHT MOST---     |
04|          84                       85                          74            |
05| H 53                     H 54                      CONEY ISLAND LH 1903     |
06|                                                                             |
07| LAT 040-40-32.84693 N    LAT 040-40-47.20435 N     LAT 040-34-35.37300 N    |
08| LON 074-03-34.84362 W    LON 074-01-09.69982 W     LON 074-00-43.82700 W    |
09|                                                                             |
10| POSITION ------------------------------------------------------------       |
11|                                                                             |
12|   LAT    040-38-32.15160                                                    |
13|   LON    074-04-35.58661                                                    |
14|                                                                             |
15| ANGLES --SWINGER LIMITS (L= 016-58-47.76  R= 077-22-20.67 )----------       |
16|                                                                             |
17|   LEFT   028-16-34.52                                                       |
18|   RIGHT  094-00-53.00                                                       |
19|                                                                             |
20| DST          -1694.1866                                                     |
    ...
24|                                                                             |
  +----------------------------------------------------------------------------+
```

Figure (6.01) --- 3-POINT FIX Screen

As each computation is completed, the program will prompt, first, for another computation with the same set of 3 fixed points by:

COMPUTE ANOTHER ... "3-POINT FIX" (Y/N)? <CR>

or remove the current set and replace them with a new set of fixed stations by:

RE-ENTER ... "3-POINT FIX" ... WITH/NEW STATIONS (Y/N)? <CR>

or third, to return to the program "MENU".

6.2 INTERSECTION

This program computes the geographic position (latitude and longitude) of a station by using the intersection of azimuths (converted from directions) from three or more occupied/instrument stations whose geographic positions are known (Fixed stations). The program computes the intersected position by requiring the user: (1) to enter the approximate position for the intersection station (to the nearest minute), (2) to enter three or more geographic positions for the occupied/instrument stations; (3) to establish an azimuth from the observed directions at each occupied/instrument station by either using an initial backsight and turning a clockwise angle to the intersection station, or by entering the azimuth directly from the occupied station to the intersection station. With this information, the program computes the geographic position of the intersection station by the method of least squares (variation of geodetic coordinates).

There are two ways that the intersection station and all the fixed observing stations can be entered. If the "MTEN SYSTEM" is attached, then the user can enter the SPN for each station one-by-one. The program will prompt:

```
                STATION
      INTERSECTION /SPN/ (NNN)?    81 <CR>
or    STANDPOINT   /SPN/ (NNN)?    84 <CR>
```

After the SPNs are entered, the program will load the screen with each station's SPN, NAME, Latitude, and Longitude from the geographic position file (FILEGPNX.JC) and flash the information to the screen for the appropriate SPN. However, if the "MTEN SYSTEM" is not attached, the user is required to enter the following three items one-by-one for the intersection station and for each of the fixed observing stations:

```
STATION NAME (30A)?
LATITUDE  /DMS/  (NN,NN,NN.NNNN)?
LONGITUDE /DMS/ (NNN,NN,NN.NNNN)?
```

After each entry is completed, the information will be reformatted and displayed on the screen. The user will be asked to verify the position or to completely change it by the following prompt:

RE-ENTER THIS GPN POSITION ... (Y/N)?

A reply of <CR>, the "NO" response, will cause the program to continue. A reply of Y <CR>, the "YES" response, will cause the program to prompt the user to completely re-enter all information for the station in question.

After each standpoint entry has been completed and the information displayed on the screen, the following message will appear:

ESTABLISH A BACKSIGHT ... THEN TURN AN ANGLE (Y/N)?

If a reply of Y <CR>, the "YES" response is made, the program will ask the user to enter the SPN or NAME as described above and the geographic position of the Backsight Station by the following prompt:

BACKSIGHT TO /SPN/ (NNN)? 86 <CR>

SPN	Station Name	Latitude (LAT)	Longitude (LON)
70	BORO HALL	40 38 32.156 N	74 04 35.585 W
71	POUCH	40 37 07.898 N	74 04 05.612 W
74	CONEY ISLAND LIGHTHOUSE	40 34 35.373 N	74 00 43.827 W
81	WORLD TRADE CENTER	40 42 43.27030 N	74 00 48.94544 W
82	BOLT	40 41 10.19899 N	74 01 36.23560 W
83	H 52	40 38 22.54453 N	74 02 20.81411 W
84	H 53	40 40 32.84693 N	74 03 34.84363 W
85	H 54	40 40 47.20435 N	74 01 09.69982 W
86	H 55	40 41 18.56257 N	74 02 39.82017 W
87	H 56	40 41 20.92814 N	74 00 45.97590 W

Figure (6.02) - Table of SPNs, Names, and Geodetic Positions

At this point, if the "MTEN SYSTEM" is attached, the program will go to the combined "LST" for the Standpoint SPN and take out the clockwise angle (BACKSIGHT-STANDPOINT-INTERSECTION), and then add this angle to the computed azimuth between the Standpoint and the Backsight Station in order to determine the azimuth from the Standpoint Station to the Intersection Station. However, if "MTEN SYSTEM" is not attached, the program will flash the following message to the screen and the user must enter the clockwise angle from the keyboard. The angles used for this example are listed in Figure (6.03):

```
/DMS/  (NNN,NN,NN.NN) CLOCKWISE
ANGLE   xxx,xx,xx.x <CR>
```

BACKSIGHT	STANDPOINT	INTERSECTION	ANGLE(Clockwise)
84	86	81	182 22 37.5
86	82	81	101 19 48.5
86	84	81	001 33 55.0
85	87	81	150 15 22.5
83	85	81	167 13 00.0
84	83	81	038 23 59.5

Figure (6.03) - Table of Intersection Observations

As each azimuth is computed and displayed on the screen, the user must verify the weight (WGT) furnished by the program. With the "MTEN SYSTEM" attached, the WGT will be computed from the observations found on the data file (FILEDATX.JC). However if "MTEN SYSTEM" is not attached, the user will be required to estimate a standard deviation for each azimuth and respond to the following message:

```
WGT = 1/VARIANCE     WHERE ... VARIANCE = (SD) * (SD)

ENTER STANDARD DEVIATION /SD/ (NN.NN)?    1.6 <CR>     SECONDS
```

The computed WGT will be loaded to the screen and the user will be prompted with the following:

```
RE-ENTER THE COMPUTED ... WEIGHT ...   (Y/N)? <CR>
```

If a reply of <CR>, the "NO" response is made, the program will compute the difference in seconds of arc (") between the computed and the observed (COMP-OBS) azimuths and flash the difference to the screen. However, if a reply of Y <CR>, the "YES" response is made, the program will allow the user to change the standard deviation. The program will recompute the weight (WGT) for the computed azimuth. The difference in seconds (COMP-OBS) is re-computed and the value is loaded onto the screen. If this value is greater than 3600 seconds (1 degree), the program will automatically flash "***" to the screen for the computed value and computed WGT for that observation will be changed to 0.01. This will allow the observation to remain as part of the adjustment, but its contribution to the solution will be minimal. However, if the user wants to remove this observation completely, the following message and response must be answered:

```
(COMPUTED-OBSERVED) OVER 1 DEGREE ... KEEP THIS ... OBSERVATION (Y/N)? <CR>
```

A reply of Y <CR>, the "YES" response, will leave the observation as it is seen on the screen and then continue to the next observation. A <CR> reply, the "NO" response, will cause the program to completely remove this observation from the solution and then to continue to the next observation.

When sufficient observations have been entered for the program to compute a solution, the following message will flash to the screen each time an additional new observation is to be entered:

STANDPOINT ... DATA ENTRY ... (Y/N) <CR> STOP !!

A reply of Y <CR>, the "YES" response, will cause the program to exit this set of prompts, while a reply of <CR>, the "NO" response, will cause the program to continue to prompt for additional observations until the screen is full (a maximum of 9 observations allowed). The next prompt allows the user to change his mind and continue if by chance, the user didn't really want to stop the observational data entry:

ARE YOU ... SURE ... YOU WANT TO STOP (Y/N)? Y <CR>

If a reply of Y <CR>, the "YES" response is made, the program will stop all data entry prompts for observations. A sample screen with six observations is given in Figure (6.04). A <CR> reply, the "NO" response, will cause the program to recycle in order to allow the user to enter another observation.

The intersection station's geographic position will be computed when the user has entered enough observations. The program will compute a least squares solution when sufficient data has been entered to have at least one degree of freedom.

The final screen will display five additional computed items: the first (1), under the heading "ADJUSTED" will be the adjusted geographic position of the Intersection Station; the second (2) under the heading "STD ERROR" will be the standard deviation for the latitude and longitude in seconds of arc (") of the adjusted position; the third (3), displayed at the bottom of the screen, are the "DEGREES FREEDOM", "VARIANCE UNIT WGT", and the standard deviation of "UNIT WGT"; the fourth (4) items are the individual residuals for the entered observations, displayed under the heading "RESIDUAL". On the first screen this heading was the difference in seconds between (COMP-OBS), however upon completion of the computation for the Intersection Station's geographic position, will be changed to "RESIDUAL" and the resulting residuals for each observation listed. For the given example on Figure (6.04) the following residuals were computed:

```
  ADJUSTED          STD ERROR                                    -------------
40-42-43.27118       0.00179                                        RESIDUAL
74-00-48.94398       0.00099                                          SS.SS
                                                                 -------------
                                                                    -0.775
DEGREES FREEDOM     =  4                                            -0.458
VARIANCE UNIT WGT   =  0.6289                                       -0.102
UNIT WGT            =  0.7930                                       -2.321
                                                                    -3.731
                                                                     1.611
```

The last items flashed to the screen are the "ERROR ELLIPSE" parameters for the adjusted geographic position. The parameter values given are the orientation azimuth of the maximum distortion for the ellipse (AZ) from North, the semi-major axis (MAX), and semi-minor axis (MIN) in millimeters.

```
(ERROR ELLIPSE)
AZ  = 015-43-56.2   (From North)
MAX =        57.2   (MM)
MIN =        17.9   (MM)
```

```
+---------------------------------------------------------------------------+
|                 SPECIAL COMPUTATIONS ---  INTERSECTION                    |
|               ------------------------------------------                  |
|                                ORIGINAL           ADJUSTED      STD ERROR |
|  81 WORLD TRADE CENTER    LAT 040-42-43.27030 N                           |
|                           LON 074-00-48.94544 W                           |
|                                                                           |
|                                                                           |
| ------------------------------------------------------------------------- |
| SPN STATION NAME                DISTANCE    WGT     AZIMUTH      COMP-OBS |
|                                 (METERS)          DDD-MM-SS.SS    SS.SS   |
|                               ------------------------------------------- |
|  86 H 55                        3688.222   0.11  044-52-53.51     -1.06   |
|  82 BOLT                        3078.100   0.11  021-08-20.79     -1.94   |
|  84 H 53                        5599.766   0.11  044-03-35.14     -0.31   |
|  87 H 56                        2540.899   0.11  358-25-46.05     -5.16   |
|  85 H 54                        3613.199   0.11  007-44-53.56      2.00   |
|  83 H 52                        8326.753   0.11  015-00-32.52      0.97   |
|                                                                           |
|                                                                           |
 ...
|                                                                           |
+---------------------------------------------------------------------------+
```

Figure (6.04) ---- INTERSECTION Screen

6.3 RESECTION

This program computes the geographic position (latitude and longitude) of an occupied station from the observed directions at that station to three or more fixed stations whose geographic positions are known. The program computes the resected position by requiring the user: (1) to enter the approximate position for the observing station (to the nearest minute), (2) to enter three or more geographic positions for the fixed stations; (3) to enter the directions observed at the unknown station to each fixed station. The program then computes the geographic position of the resection station by the method of least squares (variation of geodetic coordinates).

There are two ways that the resection station and the fixed stations can be entered. If the "MTEN SYSTEM" is attached, then the user can enter the SPN for each station. The program will prompt:

```
                STATION

      RESECTION    /SPN/ (NNN)?    70 <CR>
or    FOREPOINT    /SPN/ (NNN)?    85 <CR>
```

After the SPN entry, the program will load the screen with each station's SPN, NAME, Latitude, and Longitude from the geographic position file (FILEGPNX.JC) and flash the information to the screen for the appropriate SPN. However, if the "MTEN SYSTEM" is not attached, the user is required to enter the following three items one-by-one for the resection station and each of the fixed stations:

```
STATION NAME (30A)?
LATITUDE  /DMS/  (NN,NN,NN.NNNN)?
LONGITUDE /DMS/ (NNN,NN,NN.NNNN)?
```

After each entry is completed, the information will be reformatted and displayed on the screen. The user will be asked to verfiy the position or completely change it by the following prompt:

```
RE-ENTER THIS    GPN POSITION ...    (Y/N)?
```

A reply of <CR>, the "NO" response, will cause the program to continue. A reply of Y <CR>, the "YES" response, will cause the program to prompt the user to completely re-enter all information for the station in question.

After the resection station has been entered the program will establish an initial azimuth to one Forepoint SPN which is selected by the user. The following prompt will appear:

```
FOREPOINT ... IS IT THE "INITIAL" ON THE COMBINED LST (Y/N)? Y <CR>
```

If the Y <CR> reply, the "YES" response is made, the combined list offset direction will be zero (00-00-00.00). However if a reply of <CR>, the "NO" response is made, the program will prompt the user to complete the following screen prompt:

```
                                        /DMS/  (NNN,NN,NN.NN)
ENTER "FOREPOINT" DIRECTION         DIRECTION   28,16,34.62 <CR>
```

Hereafter, the combined list offset direction of 28-16-34.62 will be subtracted from each of the observed directions that are entered.

At this point, if the "MTEN SYSTEM" is attached, the program will go to the Standpoint combined "LST" for the observed direction to the Forepoint SPN, and subtract the combined list offset to the selected initial from each direction in order to compare the observation with the inverse azimuth which is computed between the resection station and the fixed station. However, if "MTEN SYSTEM" is not attached, the program will flash the following message to the screen and the user must enter the observed direction from the keyboard. A set of directions used for this example are listed in Figure (6.05):

```
                                        /DMS/  (NNN,NN,NN.NN)
                                    DIRECTION   xx,xx,xx.xx <CR>
```

As each azimuth is computed and loaded to the screen, the user must verify the weight (WGT) to be used in the computation. When the "MTEN SYSTEM" is attached, the WGT is computed from the observations found on the data file (FILEDATX.JC). However if the "MTEN SYSTEM" is not attached, then the user will be required to estimate the standard deviation for each azimuth and respond to the following message:

```
WGT = 1/VARIANCE     WHERE ... VARIANCE = (SD) * (SD)

ENTER STANDARD DEVIATION /SD/ (NN.NN)?    1.4 <CR>     SECONDS
```

The computed WGT will be loaded to the screen and the user will be prompted with the following:

```
RE-ENTER THE COMPUTED  ... WEIGHT ...    (Y/N)? <CR>
```

If a reply of <CR>, the "NO" response is made, the program will compute the difference in seconds of arc (") between the computed and the observed (COMP-OBS) azimuths and flash the difference to the screen. However, if a reply of Y <CR>, the "YES" response is made, the program will allow the user to re-enter a different value for the standard deviation and then recompute the weight (WGT) for that observed direction. The difference (COMP-OBS) in seconds is re-computed and the value loaded onto the screen. If this value is greater than 3600 seconds (1 degree), the program will automatically flash "***" to the screen for the computed value and the computed WGT for that observation will be changed to 0.01. This will allow the observation to remain as part of the adjustment, but its contribution to the solution will be minimal. However, if the user wants to remove this observation completely, the following message and response must be answered:

(COMPUTED-OBSERVED) OVER 1 DEGREE ... KEEP THIS ... OBSERVATION (Y/N)? <CR>

A reply of Y <CR>, the "YES" response, will leave the observation as it is seen on the screen and the program will continue to the next observation. A <CR> reply, the "NO" response, will cause the program to completely remove this observation from the solution and then continue to the next observation.

When sufficient observations have been entered for the program to compute a solution, the following message will flash to the screen each time an additional observation is to be entered:

FOREPOINT ... DATA ENTRY ... (Y/N) <CR> STOP !!

A reply of Y <CR>, the "YES" response, will cause the program to exit this set of prompts, while a reply <CR>, the "NO" response, will cause the program to continue to prompt for additional observations until the screen is full (a maximum of 9 observations allowed). The next prompt allows the user to change his mind and continue, if by chance, the user didn't really want to stop the observational data entry by:

ARE YOU ... SURE ... YOU WANT TO STOP (Y/N)? Y <CR>

If a reply of Y <CR>, the "YES" response is made, the program will stop all data entry prompts for observations. A sample screen with four observations is given in Figure (6.05). A <CR> reply, the "NO" response, will cause the program to recycle in order to allow the user to enter another observation.

SPN	STATION NAME	-DIRECTIONS-
84	H 53	00 00 00.00
85	H 54	28 16 34.62
74	CONEY ISLAND LIGHTHOUSE	122 17 25.88
71	POUCH	143 52 01.00

Figure (6.05) - List of Observed Directions at RESECTION Station

The resected station's geographic position will be computed when the user has entered enough observations. The program will compute a least squares solution when sufficient data has been entered to have at least one degree of freedom.

The final screen will display five additional computed items: the first (1), under the heading "ADJUSTED" will be the adjusted geographic position of the Resected Station; the second (2) under the heading "STD ERROR" will be the standard deviation for the latitude and longitude in seconds of arc (") of the adjusted position; the third (3), displayed at the bottom of the screen, are the "DEGREES FREEDOM", "VARIANCE UNIT WGT", and the standard deviation of "UNIT WGT"; the fourth (4) are the individual residuals for the entered observations, displayed under the heading "RESIDUAL". On the first screen this heading was the difference in seconds between (COMP-OBS), however upon completion of the computation for the Resected Station's geographic position, will be changed to "RESIDUAL" and the resulting residuals for each observation listed. The computed residuals for the above example are listed in Figure (6.06).

```
 ADJUSTED          STD ERROR                                    ------------
40-38-32.16124      0.01028                                       RESIDUAL
74-04-35.58501      0.00115                                         SS.SS
                                                                ------------
                                                                    1.218
DEGREES FREEDOM    =  1                                             1.182
VARIANCE UNIT WGT  =  3.0453                                       -0.927
UNIT WGT           =  1.7451                                       -1.508
```

The fifth (5) item flashed to the screen is the "ERROR ELLIPSE" parameters for the adjusted geographic position. The parameter values given are the orientation azimuth of the maximum distortion for the ellipse (AZ) from North, the semi-major axis (MAX), and semi-minor axis (MIN) in millimeters.

```
(ERROR ELLIPSE)
AZ  = 000-49-19.9   (From North)
MAX =       317.2   (MM)
MIN =        26.8   (MM)
```

```
  +--------------------------------------------------------------------------+
01|                 SPECIAL COMPUTATIONS ---  RESECTION                      |
02|               ----------------------------------------                   |
03|                              ORIGINAL          ADJUSTED      STD ERROR   |
04|  70 BORO HALL            LAT 040-38-32.15600 N                           |
05|                          LON 074-04-35.58500 W                           |
06|                                                                          |
08| -----------------------------------------------------------------------  |
09| SPN STATION NAME                 DISTANCE    WGT      AZIMUTH   COMP-OBS |
10|                                  (METERS)          DDD-MM-SS.SS  SS.SS   |
11|                               ---------------------------------------    |
12|  85 H 54                         6383.099    0.51  049-14-32.66   0.00   |
13|  74 CONEY ISLAND LIGHTHOUSE      9112.051    0.51  143-15-23.92   1.74   |
14|  71 POUCH                        2692.774    0.50  164-49-59.04  -1.40   |
15|  84 H 53                         3986.919    0.50  020-57-58.04  -1.77   |
16|                                                                          |
   ...
24|                                                                          |
  +--------------------------------------------------------------------------+
```

Figure (6.06) ---- RESECTION Screen

7.0 WRK007 -- Geodetic Computations

To enter this program type WRK007 <CR>. The program will clear the screen and the first set of program defaults, the ellipsoid parameters and the datum name, to be used by the program can be entered. The user is prompted to give the ability to the program to use loaded MTEN files by:

```
ATTACH TO --- "MTEN SYSTEM" --- (Y/N)?
```

A reply of Y <CR>, the "YES" response, will cause the program to respond with the next two prompts:

```
CHANGE DEFAULT DRIVE=C (Y/N)?  <CR>
ENTER YOUR JOBCODE /JC/ (LL)?  JC <CR>
```

The program will then use the ellipsoid parameters that were initialized previously with ABSINX (See Manual Section 1).

If a <CR>, the "NO" response, was made to the above prompt "ATTACH TO ...", then the program will not use the existing MTEN data files but rather all computations will be done independent of MTEN and all information must be entered by the user from the keyboard.

With no ellipsoid information available, the program will initialize the ellipsoid parameters for geodetic computations by prompting the user to select one of the following:

```
USE GRS 1980      ELLIPSOID .. NAD83 ..      (Y/N)?
USE CLARKE 1866   ELLIPSOID .. NAD27 ..      (Y/N)?
USE WGS 1972      ELLIPSOID    .....         (Y/N)?
```

or select another defined by:

```
USE ELLIPSOID  (AAAAAAAAAA)?
MAJOR AXIS   (NNNNNNN.NNNN)?
FLATTENING "1/F" (NNN.NNNNNN)?
```

After the ellipsoid parameters have been selected or entered the "DATUM" abbreviation will flash onto the screen in the upper right-hand corner.

The program will ask the user for a default set of distance units by flashing the following message on the screen:

```
DISTANCE UNITS /Meters or Feet/  (M/F)?  M <CR>
```

At this point, the program entry points will flash to the screen and different screens will appear depending on which entry point was selected.

PROGRAM
(Y/N)?

- GEODETIC GPN > XYZ

  GEODETIC INVERSE

  GEODETIC DIRECT

Upon exit from each of the program entry points, the program will prompt the user with the following:

RETURN TO --- MENU SCREEN --- (Y/N)?

This will allow the user to re-enter at the program entry level or exit. If an exit is made, MTEN files attached are dropped and the program will prompt:

REPEAT THIS ENTRY COMMAND --- (Y/N)?

This will allow the user to re-enter the program and attach different MTEN files or exit to DOS.

7.1 GPN > XYZ

This program takes the geographic position (Latitude and Longitude) of a Standpoint station along with an instrument height, elevation, and geoid fot the station and computes a space rectangular coordinates (X-Y-Z) for the position.

The first step of the program, entry of the Standpoint station, can be accomplished in two ways. The first, if the "MTEN SYSTEM" is attached, is for the user to enter just the SPN for the station:

```
                     STATION

        STANDPOINT   /SPN/ (NNNN)?  70 <CR>       BORO HALL
```

The program will load the Standpoint station's SPN, Name, Latitude, and Longitude from the geographic position file (FILEGPNX.JC) and display this information on the screen. A second option in the attached mode, allows the user to touch <CR> and the program will switch over and prompt as if it were in the unattached mode of entry.

If the "MTEN SYSTEM" is not attached, the user will be required to enter the following items for the beginning station:

```
                     STATION

        STANDPOINT   BORO HALL <CR>

and       /DMS/    (NNN,NN,NN.NNNNN)?

        LATITUDE     40,38,32.52722     N <CR>
        LONGITUDE    74,4,34.095        W <CR>
```

After this entry is completed, the information will be re-loaded into a triadic station group which will remain on the screen. The user will be asked to verify the geographic position loaded for the beginning station:

```
        RE-ENTER THE    ... GPN POSITION ...    (Y/N)? <CR>
```

A reply of <CR>, the "NO" response, will allow the program to continue. However, a Y <CR> reply, the "YES" response, will force the program to recycle and reprompt the user to re-enter all information for the Standpoint station.

Step two, the user is prompted whether or not to change the HEIGHTS at the Standpoint station. If this option is not selected, the program will use what is loaded on the screen. If the "MTEN SYSTEM" is attached, the program will load the information found in the geographic position file for only the elevation for the station and the geoid height. The user must select this option in order to change any of the screen entries:

CHANGE
(Y/N)?

Y STATION HEIGHT INFORMATION

A reply of <CR>, the "NO" response, will allow the program to compute the space rectragular coordinates for the Standpoint station. However, a Y <CR> reply, the "YES" response, will force the program to prompt the user to enter information as to the height of the instrument, station elevation, and geoid height by the following:

```
INSTRUMENT HEIGHT (SN.NNNN)?       1.234        UNITS (M/F)?  M <CR>

ELEVATION OF MARK (SNNN.NN)?      56.635        UNITS (M/F)?  M <CR>

GEOID HEIGHT      (SNNN.NN)?     -32.6          UNITS (M/F)?  M <CR>
```

At this point, the program will compute the space rectangular coordinates for the current geographic position and height information and display it on the screen. A sample screen display id given by Figure (7.01).

```
  +-----------------------------------------------------------------------+
01|                     GPN XYZ    COMPUTATIONS                           |
02|                   ----------------------------                        |
03| SPN   STATION NAME       GEOGRAPHIC POSITION    HEIGHTS     COORDINATES |
04|                            (DDD MM SS.SSS)      (METERS)        (METERS) |
05|                                                                       |
06|  70 BORO HALL          LAT 040-38-32.52722 N     1.234 I  1329704.2183 X |
07|                        LON 074-04-34.09500 W    56.635 E -4660595.0551 Y |
08|                        HGT          25.2687  M  -32.600 G  4132385.1552 Z |
09|                                                                       |
10|  71 POUCH              LAT 040-37-08.26991 N     1.234 I  1330840.4861 X |
11|                        LON 074-04-04.11915 W    29.742 E -4662009.5666 Y |
12|                        HGT          -1.6244  M  -32.600 G  4130395.1771 Z |
13|                                                                       |
14|                                                                       |
15|                                                                       |
     ...
23|                                                                       |
24|                                                                       |
  +-----------------------------------------------------------------------+
```

Figure (7.01) ---- GPN to Space Rectangular Coordinates X-Y-Z

7.2 INVERSE

This program computes a complete geodetic inverse between two fixed geographic positions (the Standpoint "FROM" station and the Forepoint "TO" station), and displays the geodetic distance, the foward azimuth (Standpoint station to the Forepoint), and the backward azimuth (Forepoint station to the Standpoint). The program requires the user to enter the geographic position for both stations, which is used to compute and display the final geodetic quantities.

When this program entry point is called, the character string "INVERSE" will appear on the screen on the top line near the center. In addition, each completed inverse computation will be labled with the following character string " -INVERSE- ". This program entry point identifier will be placed below the heading "AZIMUTH/DISTANCE" and between each pair of station names used in the computation.

Step one, each Standpoint "FROM" or Forepoint "TO" station can be entered in either the attached or unattached mode depending on the option selected by the user. If attached, the user will be required to enter only the SPN's of the "FROM" or "TO" stations by:

```
                 STATION
STANDPOINT       /SPN/ (NNN)?  70 <CR>       BORO HALL
FORESIGHT        /SPN/ (NNN)?  87 <CR>       H 56
```

or if unattached, to enter the names of the "FROM" and "TO" stations by the following:

```
                 STATION
STANDPOINT       BORO HALL <CR>
FOREPOINT        H 56 <CR>
```

After the attached SPN entry, the program will load the Standpoint/Forepoint station's SPN, Name, Latitude and Longitude from the geographic position file (FILEGPNX.JC) and flash this information to the screen. However, if only the name has been entered, then the following values will be required from the user:

```
   /DMS/   (NNN,NN,NN.NNNNN)?

LATITUDE    40,38,32.156        N <CR>
LONGITUDE   74,04,35.585        W <CR>
```

Upon the completion of each required "FROM" or "TO" entry, the program will reload the information and flash it to the screen below the heading "FROM" or "TO" as shown below:

```
STATION ... "FROM"                          STATION ... "TO"
BORO HALL                                   H 56

SPN  LAT  40-38-32.15600  N                 SPN  LAT  40-41-20.92814  N
 70  LON  74-04-35.58500  W                  87  LON  74-00-45.97590  W
```

The user will then be asked to verify the loaded geographic position for the Standpoint/Forepoint or to change it by:

RE-ENTER THE "FROM" GPN POSITION ... (Y/N)? <CR>

or

RE-ENTER THE "TO" GPN POSITION ... (Y/N)? <CR>

A reply of <CR>, the "NO" response, will allow the program to continue. A Y <CR> reply, the "YES" response, will force the program to recycle and to reprompt the user for the Standpoint/Forepoint station information again.

The geodetic inverse computation will be computed from the above entered entries for the latitude and longitude for the "FROM" and "TO" stations. Upon completion of the inverse computation, the inverse triad information will flash to the screen between the "FROM" and "TO" geographic positions; the first, "FWD" (the forward azimuth) from the Standpoint station to the Forepoint; second, "BCK" (the backward azimuth) from the Forepoint station to the Standpoint; and third "DST" (the geodetic distance) between the two stations. Each inverse triad will appear as follows:

```
     -INVERSE-
FWD  045-59-31.39694
BCK  226-02-01.02047
DST        7495.9927
```

An example screen for the geodetic inverse computation, Figure (7.02), is given below:

After each inverse computation has been completed, the following message will appear on the screen:

KEEP STANDPOINT (NAME/POSITION) (Y/N)?

A reply of <CR>, the "NO" response, will allow the program to continue. However, a reply of Y <CR>, the "YES" response, will force the program to retain all information for the Standpoint and to reload it for the next inverse computation. With this option, the user needs only to enter the next Forepoint station.

The last prompt by the program at this level is:

REPEAT THIS COMPUTATION (Y/N)? Y <CR>

This will allow the program to continue with a Y <CR> reply or to exit the inverse computation with a simple <CR> response. This exit is will not be to the program "MENU" level but rather to the beginning of the inverse/direct subroutine. At this point, the user can change the current entry point from "INVERSE" to "DIRECT" or vice versa by the following:

RE-ENTER ... "GEODETIC" ... INVERSE/DIRECT (Y/N)? <CR>

```
  +----------------------------------------------------------------------+
01|                       INVERSE    COMPUTATIONS                NAD27   |
02|                     ------------------------------                   |
03|  STATION  ...  "FROM"      AZIMUTH/DISTANCE       STATION ...  "TO"  |
04|                                                                      |
05| BORO HALL                       -INVERSE-      H 56                  |
06|                             FWD 045-59-31.39694                      |
07| SPN LAT  40-38-32.15600 N  BCK 226-02-01.02047 SPN LAT  40-41-20.92814 N |
08|  70 LON  74-04-35.58500 W  DST       7495.9927  87 LON  74-00-45.97590 W |
09| -------------------------                      ------------------------- |
10| GREENWICH/EQUATOR               -INVERSE-      NEAR - INTL DATE LINE |
11|                             FWD 079-30-39.78226                      |
12|     LAT  00-00-00.00000 N  BCK 280-29-20.21774     LAT  00-00-00.00000 N |
13|     LON  00-00-00.00000 E  GEO   19970924.4488     LON 179-24-00.00000 E |
14| -------------------------  EQU   19970933.9481 ------------------------- |
15|                                                                      |
   ...
23|                                                                      |
24|                                                                      |
  +----------------------------------------------------------------------+
```

Figure (7.02) ---- INVERSE Computation Screen

Additional code has been built into the INVERSE computation to handle anti-nodal positions along the equator (e.g. when the geodesic distance is shorter over a pole than to go around the earth along the equator). This case will arise when an equatorial lognitudal difference between stations is greater than the LIFTOFF point (about 179 degrees 23 + minutes depending on the selected ellipsoid). If the longitudal difference exceeds the LIFTOFF point, the following message will appear on the screen:

LONGITUDE DIFF GREATER THAN LIFTOFF 179-23-xx.xxxx CONTINUE (Y/N)? Y <CR>

To continue the program, touch Y <CR>, the "YES" response. The forward and backward azimuths are then flashed to the screen. However, instead of the geodetic distance "DST" being loaded it is changed to "GEO" and then loaded. Just below the "GEO" distance, a new symbol "EQU" for the equatorial distance is loaded and flashed to the screen. If a reply of <CR>, the "NO" response, is made, the program will drop this INVERSE computation and continue to the next entry.

7.3 DIRECT

This program computes a complete geodetic forward (direct) computation from a fixed geographic position (the Standpoint "FROM" station) to a new geographic position (the Forepoint "TO" station), using the geodetic azimuth at the Standpoint to the Forepoint and the geodetic distance between the two stations. The program computes the geodetic direct problem by requirung the user: (1) to enter the fixed geographic position for the Standpoint station and the name of the Forepoint; (2) to establish the forward azimuth either by keyboard entry of the azimuth from the Standpoint to the Forepoint or by initialing on a Backsight station and turning a clockwise angle, at the Standpoint, to the direction of the Forepoint station; (3) to enter the geodetic distance either as a keyboard entry or by selecting it from the "MTEN SYSTEM" data files. Given this information, the program computes the geographic position for the new Forepoint station and flashs it to the screen.

When this program entry point is called, the character string "DIRECT" appears on the screen on the top line near the center. In addition, each completed direct computation will be labled with the following character string " -DIRECT- ". This program entry point identifier will be placed below the heading "AZIMUTH/DISTANCE" and between each pair of station names used in the computation.

Step one begins with the Standpoint "FROM" station entry, it can be entered in either the attached or unattached mode depending upon the option selected by the user. If attached, the user will be required to enter only the SPN of the "FROM" station by:

```
                STATION
STANDPOINT      /SPN/ (NNN)?  71 <CR>      POUCH
```

If unattached, to enter the name of the "FROM" station by the following:

```
                STATION
STANDPOINT      POUCH <CR>
```

With the "MTEN SYSTEM" attached and the SPN entry made, the program will load the Standpoint/Forepoint station's SPN, Name, Latitude and Longitude from the geographic position file (FILEGPNX.JC) and flash this information to the screen. However, if only the name has been entered, then the following entries will be required from the user:

```
  /DMS/   (NNN,NN,NN.NNNNN)?

LATITUDE     40,37,07,898        N <CR>
LONGITUDE    74,04,05.612        W <CR>
```

Upon the completion of each required "FROM" entry, the program will reload the information and flash it to the screen below the heading "FROM" as shown below:

```
STATION  ...  "FROM"
POUCH

SPN  LAT  40-37-07.89800  N
 71  LON  74-04-05.61200  W
```

The user will then be asked to verify the loaded geographic position for the Standpoint or change it by:

```
RE-ENTER THE "FROM"  GPN POSITION ...     (Y/N)? <CR>
```

A reply of <CR>, the "NO" response, will allow the program to continue. A Y <CR> reply, the "YES" response, will force the program to recycle and to reprompt the user for the Standpoint station information again.

If the option to attach the "MTEN SYSTEM" was selected, the program will prompt the user, before the Standpoint station information is entered, whether or not a Backsight station is to be used by:

```
ESTABLISH A BACKSIGHT ... THEN TURN AN ANGLE (Y/N)? Y <CR>
```

A reply of <CR>, the "NO" response, will allow the program to continue to the entry of the Standpoint station. A reply of Y <CR> however, the "YES" response, will force the user to enter sufficient information in order to establish the Backsight station by:

```
BACKSIGHT TO /SPN/ (NNN)? 70 <CR>        BORO HALL
```

The last item of information required under step one is the identification of the Forepoint "TO" station. This series of prompts is similar to the series of prompts for the Standpoint station except the Forepoint station name is the only item of information required. The prompt will appear as one of the following depending on which mode the user selects:

```
          STATION
FOREPOINT /SPN/ (NNN)?   69 <CR>     POUCH AZ MK
```

or

```
FOREPOINT     POUCH AZ MK <CR>
```

Step two is the identification of the forward azimuth from the Standpoint "FROM" station to the Forepoint "TO" station. This azimuth can be entered in one of two ways. The first, in the unattached mode, requires the user to enter the azimuth directly from the keyboard by:

/DMS/ (NNN,NN,NN.NN) FROM NORTH
AZIMUTH 85,1,13.96 <CR>

or the second, in the attached mode, forces the program to go to the Standpoint's combined "LST" (if it exists) and take out the clockwise angle (Backsight-Standpoint-Foresight). This angle will be added to the inverse azimuth from the Standpoint to the Backsight station in order to compute the forward azimuth to the Forepoint station. When a combined "LST" does not exist, the program will switch to the unattached mode and prompt as described above for the azimuth entry.

Upon completion of the forward azimuth entry, the program will display on the screen, between the "FROM" and "TO" geographic positions under the heading "AZIMUTH/DISTANCE", the information for the DIRECT triad as follows:

```
     -DIRECT-
FWD  85-01-13.96141
BCK
DST
```

Step three of the program consolidates all the measured distances between the Standpoint and the Forepoint stations, and then asks the user to select one, some, all, none of the distances or to enter a single distance from the keyboard. In the unattached mode, the program will flash the following message to the screen and force the user to make an entry by:

DISTANCE /METERS/ (NNNNN.NNNN)? 172.017 <CR>

However, if the program is in the attached mode and measured distances exist in the data files, the program will flash all distances measured from the Standpoint station first, then all distances measured from the Forepoint back to the Standpoint. The order of elimination is to exhaust all short traverse measurements first (LGH code), all electronic distance measurements (EDM code) second, and all reference object measurements (DST codes) last.

Each measured distance will be flashed to the bottom of the screen and the following message will appear (this example is a short traverse distance measured from the Standpoint to the Forepoint):

LGH ... MEASUREMENT 172.0160 USE IT (Y/N)? Y <CR>

The user can either keep the measurement by the replying Y <CR>, the "YES" response, or to not keep it by a simple replying <CR>, the "NO" response. If this measurement is kept, it will re-appear above the prompt line in a horizontal stack of selected measurements. The program will continue flashing measurements to the screen until the user has had a chance to keep or reject every measurement (e.g. a multi-measurement entry selection, where the LGH distance measurement, 172.0180, is from the Forepoint to the

Standpoint is given below):

172.016 172.018

```
LGH ... MEASUREMENT              172.0180   USE IT (Y/N)?  Y <CR>

EDM ... MEASUREMENT              172.0160   USE IT (Y/N)?  <CR>

DST ... MEASUREMENT  FEET  ONLY  172.2124   USE IT (Y/N)?  <CR>

DST ... MEASUREMENT  KMs   ONLY  173.0000   USE IT (Y/N)?  <CR>
```

In the above example, five measured distances were found in the data files, but only the two "LGH" code measurements were selected and added to the horizontal stack. The final distance to be used by the program will be the mean of all measurements within the stack.

Step four, computation of the geographic position of the Forepoint "TO" station, is now performed and the DIRECT triad information completed by using the geographic position of the Standpoint "FROM" station, the forward azimuth, and the meaned geodetic or entered distance. Upon completion of the computation, the triad information will appear in the center of the screen as follows:

```
        -DIRECT-
FWD  085-01-13.96141
BCK  265-01-18.70772
DST        172.0170
```

To complete the screen display, the geographic position of the Forepoint station will be loaded under the station heading "TO". An example screen for the geodetic direct computation is presented in Figure (7.03).

After each direct computation has been completed, the following message will appear on the screen:

KEEP STANDPOINT (NAME/POSITION) (Y/N)?

A reply of <CR>, the "NO" response, will allow the program to continue. However, a reply of Y <CR>, the "YES" response, will force the program to retain all information for the Standpoint and reload it for the next inverse computation. With this option, the user needs to enter only the next Forepoint position and any additional inverse computations will hold the Standpoint station constant. With this option selected, an additional prompt will appear on the screen which will allow the user to change the Backsight station by:

CHANGE THE BACKSIGHT (Y/N)? <CR>

A <CR> reply, "NO" change response, will let the program continue, whereas a reply of Y <CR>, the "YES" response, will force the program to re-prompt for all information required to establish a new Backsight station.

The last prompt at this level is:

REPEAT THIS COMPUTATION (Y/N)? Y <CR>

and will allow the program to continue with a Y <CR> reply or to exit the DIRECT computation with a simple <CR> response. This exit will not be to the program "MENU" level but rather to the beginning of the inverse/direct subroutine. At this point, the user can change the current entry point from "INVERSE" to "DIRECT" or vice versa by the following:

RE-ENTER ... "GEODETIC" ... INVERSE/DIRECT (Y/N)? <CR>

```
  +------------------------------------------------------------------------------+
01|                       DIRECT     COMPUTATIONS                NAD27           |
02|                    -----------------------------                             |
03|   STATION ... "FROM"      AZIMUTH/DISTANCE        STATION ...  "TO"          |
04|                                                                              |
05| POUCH                           -DIRECT-        POUCH AZ MK                  |
06|                          FWD 085-01-13.96141                                 |
07| SPN LAT  40-37-07.89800 N  BCK 265-01-18.70772  SPN LAT  40-37-08.38198 N    |
08|  71 LON  74-04-05.61200 W  DST        172.0170   69 LON  74-03-58.32148 W    |
09| ------------------------                        ------------------------     |
10|                                                                              |
   ...
23|                                                                              |
24|                                                                              |
  +------------------------------------------------------------------------------+
```

Figure (7.03) ---- DIRECT Computation Screen

8.0 WRK008 -- Solar Azimuth Computation

To enter this program type WRK008 <CR>. The program will clear the screen and display the following on the screen:

```
PROGRAM
 (Y/N)?

    -    SOLAR ........ OBSERVATIONS
```

Next, defaults must be initialized. The program needs ellipsoid parameters and the datum name for all computations. The user will be prompted:

```
        ATTACH TO  --- "MTEN SYSTEM" ---  (Y/N)?
```

A reply of Y <CR>, the "YES" response, will force the program to prompt the user to complete the next two prompts:

```
        CHANGE DEFAULT DRIVE=C (Y/N)?  <CR>
        ENTER YOUR JOBCODE /JC/ (LL)?  JC <CR>
```

The program then will use the ellipsoid parameters initialized with ABSINX (See Manual Section 1).

If a <CR>, the "NO" response, was made to the above prompt "ATTACH TO ...", then the program will not use the existing MTEN data files but rather all computations will be done independent of MTEN and all information must be entered directly from the keyboard.

With no ellipsoidal information available, the program will initialize the ellipsoid parameters for geodetic computations by prompting the user to select one of the following ELLIPSOIDs by:

```
        USE GRS 1980      ELLIPSOID .. NAD83 ..      (Y/N)?
        USE CLARKE 1866   ELLIPSOID .. NAD27 ..      (Y/N)?
        USE WGS 1972      ELLIPSOID    .....         (Y/N)?
```

or select any user defined ELLIPSOID by:

```
        USE ELLIPSOID  (AAAAAAAAAA)?
        MAJOR AXIS   (NNNNNNN.NNNN)?
        FLATTENING "1/F" (NNN.NNNNNN)?
```

After the ellipsoid parameters have been selected or entered, the "DATUM" abbreviation will be displayed on the screen in the upper right-hand corner.

Upon completion of the computation, the program will prompt the user the following:

RETURN TO --- MENU SCREEN --- (Y/N)?

This allows the user to re-enter at the program level or exit to DOS.

SOLAR OBSERVATIONS

This program computes an azimuth from a Occupied station (Standpoint) to a Mark station (Forepoint) using observations on the Sun for a given time, direction, and altitude. The method of azimuth computation follows the sequence outlined on the National Oceanic and Atmospheric Adminstration (NOAA), form 75-63 (Revision 7-74). This document, Sun Azimuths -- Observations and Computations, released as Photogrammetry Instructions No. 19 (revision No. 2), dated June 15, 1973, fully describes the method of observation and computation. These computations are developed within this program.

This program has ten discrete computational steps. They are as follows: (1) entry of the Greenwich Date and the Local Time, (2) entry of the Standpoint and Mark (Forepoint) stations, (3) entry of the mean temperature and pressure during the observational time span, (4) entry of a beginning and ending Greenwich Mean Time (GMT) and the corresponding Declination of the Sun for these times, (5) entry of repeated reverse and direct observations to the Mark (Forepoint) station, (6) entry of repeated reverse and direct GMTs for the observations on the Sun, (7) entry of repeated reverse and direct horizontal direction observations on the Sun corresponding to the GMTs, (8) entry of repeated reverse and direct zenith distance observations on the Sun corresponding to the above GMTs, (9) computation of the Refraction and Parallax (R+P) corrections to be applied to the above zenith observations, and (10) computation of the final mean observed azimuth for the above set of observations to the Mark station; displaying both the standard deviation of a single obsetvation and the mean of the observations on the screen.

The first step will establish both the date of observation (to compute the Sun's Declination /North or South/) and the local time (to assign the proper sign of the final observed azimuth). The date and time are prompted by:

```
ENTER THE... GREENWICH DATE    .../YYMMDD/  (NNNNNN)? 841017 <CR>
         ... LOCAL TIME        .../AM-PM/   (A/P)?    P <CR>
```

Step two prompts the user for the Occupied (Standpoint) and the Mark (Forepoint) stations. These entries can be made in either the attached or unattached modes. If attached mode is selected, the user will be required to enter just the SPN's of the Standpoint and Mark stations by:

```
ENTER STATION  /SPN/ (NNN)?   xx <CR>
MARK           /SPN/ (NNN)?   xx <CR>
```

If the unattached mode is selected, the user will have to enter the names of the two stations by responding to the following prompt:

```
ENTER STATION     FORTES <CR>
MARK              FORTESQUE LIGHTHOUSE <CR>
```

After the Standpoint station is entered, the program will reload the name on the screen next to the heading "NAME:" and the Mark station name next to the heading "MARK:". The Standpoint geographic position is required, When in the attached mode, it will be loaded automatically from the data file (FILEGPNX.JC) but in the unattached mode, the position will be prompted for by the following:

```
                                       /DMS/    (NNN,NN,NN.NNNNN)?
ENTER STATION  FORTES                 LATITUDE   39,14,32.421     N <CR>
                                      LONGITUDE  75,10,23.800     W <CR>
```

The user must verify the geographic position entered once it has been loaded by the following message:

```
RE-ENTER THIS      GPN POSITION ...  (Y/N)?  <CR>
```

A <CR> reply, the "NO" response, will allow the program to continue. A reply of Y <CR>, the "YES" response, will force the program to recycle prompting again for the above information.

Step three prompts the user for a mean temperature and pressure for use in the computation of corrections applied to the mean observed zenith distance. The temperature can be keyed in either Fahrenheit or Celsius:

```
ENTER THE... MEAN TEMPERATURE        ... (NNN.N)?  68    (C/F) F <CR>
```

If no entry is made, the program will assume a value of 20 degrees Celsius in order to determine a temperature correction factor. The second part of this step allows entry of the observed mean pressure:

```
                          /Inches, Millimeters/ OF MERCURY  (I/M)?
ENTER THE... PRESSURE                  ... (NNNN.N)?   760.0    M <CR>
```

If the pressure is unknown, the program will prompt the user to enter an approximate elevation of the Standpoint station. This elevation will be converted to a corresponding pressure assuming STP at sea level. The final meteorological values will be loaded to the screen adjacent to the headings "TEMPERATURE" and "PRESSURE".

Step four requires the entry of a beginning and ending GMTs and the corresponding Declinations of the Sun. Each beginning and ending entry is a pair of prompts as follows:

```
                                                      24-HOUR CLOCK

ENTER THE... GMT OF DECLINATION .../HMS/ (NN,NN,NN.N) 19,00,00.0 <CR>
             DECLINATION OF SUN .../DMS/ (NN,NN,NN.N) 9,31,30.0 S <CR>
```

As the paired entries are made, they will be reloaded to the screen. When both the first and second pairs of data have been completed, the following messages will be displayed and the user asked to change them:

```
  G M T        DECLINATION
19-00-00.0      9-31-30.0 S
20-00-00.0      9-32-24.0 S

CHANGE ANY OF THE ABOVE (Y/N)?  <CR>
```

The <CR> reply, the "NO" response, will allow the program to continue. A reply of Y <CR> will force the program to recycle through each pair and allow the user to make corrections or changes to the entered data.

Step five allows the user to enter four instrument pointings (two in direct and two in reverse) to the Mark (Forepoint) station. The field methods call for first taking a set of Mark observations (one in reverse and the other in direct) on the Mark before the first set of observations on the Sun. The second set of observations (one in direct and the other in reverse) on the Mark are taken immediatelly after the second set of observations on the Sun. The two sets of Mark observations are entered first, so that a computed mean value for the "INITIAL" can be computed and then subtracted from the following sets of horizontal directions to the Sun.

The first set of Mark observations will be entered by responding to the following:

```
                                         INSTRUMENT IN   REVERSE/DIRECT

ENTER THE... DIRECTION TO MARK .../DMS/ (NNN,NN,NN.N)? 180,0,19.0 <CR>
                               .../DMS/ (NNN,NN,NN.N)?   0,0,13.0 <CR>
```

As each of the four directions are completed, they will be reloaded and flashed to the screen below the heading "INITIAL". A second value, just to the right of the keyed entry, is the normalized direct value for all instrument direct and reversed pointings. When all four pointings are completed, the program will flash the following message to the screen and ask the user for changes to the data by:

```
      INITIAL
R  180-00-19.0   000-00-19.0
D  000-00-13.0   000-00-13.0
D  000-00-14.0   000-00-14.0
R  180-00-20.0   000-00-20.0
         MEAN  =  000-00-16.5
```

CHANGE ONE OF THE ABOVE (Y/N)? <CR>

A reply of <CR>, the "NO" response, will allow the program to continue. A reply of Y <CR>, will force the program to recycle through each Mark pointing one-by-one and allow the user to change it. At this point, the program will save the computed mean pointing for the Mark (INITIAL), so it can be subtracted later from all horizontal direction observations to the Sun.

Once step five is completed, steps six, seven, eight and nine are repeated twice in order to enter the following items: (1) the GMT of the observation on the Sun, (2) the horizontal direction to the Sun, (3) the zenith distance to the Sun, and (4) the refraction plus parallax correction applied to the zenith observation on the Sun. These two sets of observations on the Sun will be between the previously entered pointings on the Mark station.

Step six requires entering four GMT observations. Each time is entered by responding to the prompt:

INSTRUMENT IN DIRECT/REVERSE

ENTER THE... GMT OF OBSERVATION .../HMS/ (NN,NN,NN.N)? 19,40,27.0 <CR>

and it will be reloaded onto the screen. Upon the completion of the fourth entry, the program will compute the mean time and prompt the user for changes by:

```
              G M T
         D    19-36-24.0
         D    19-37-42.0
         R    19-39-18.0
         R    19-39-49.0
MEAN  =       19-38-18.2
```

CHANGE ONE OF THE ABOVE (Y/N)? <CR>

A reply of <CR>, the "NO" response, will allow the program to continue. A reply of Y <CR> will force the program to recycle through each GMT entry, one-by-one, allowing the user to change it. At this point the mean GMT will be loaded to the screen under the heading "GM TIME". Based on a computed mean GMT, a corresponding Declination of the Sun will be computed and displayed on the screen under the heading "DECLINATION". A second set of GMTs will be prompted for after the corresponding observations for the direction to the

Sun, the zenith distance, and the (R+P) corrections have been completed for this first set.

Step seven requires the user to enter four horizontal directions to the Sun. These observations are required by the observing schedule on NOAA Form 75-63. Each horizontal direction is entered by:

```
                                        INSTRUMENT IN  DIRECT/REVERSE

      ENTER THE... DIRECTION TO SUN  .../DMS/ (NN,NN,NN.N)? 310,46,44.0 <CR>
```

it will be displayed on the screen under the heading "SUN". Just to the right of each entry, the normalized direct value for reverse and direct pointings will also be displayed. Upon completion of all four entries, the program will compute a mean horizontal direction, display it on the screen, and prompt the user for changes:

```
           SUN
      D  310-46-44.0   310-46-44.0
      D  311-04-22.0   310-04-22.0
      R  131-25-45.0   311-25-45.0
      R  131-32-38.0   311-32-38.0
            MEAN  =    310-12-22.2

      CHANGE ONE OF THE ABOVE (Y/N)?  <CR>
```

A reply of <CR>, the "NO" response, will allow the program to continue. A reply of Y <CR> will force the program to recycle through each horizontal direction entry, one-by-one, allowing the user to change it. At this point the the correct mean angle to the Sun will be computed by subtracting the mean INITIAL value from the mean MARK station value as follows:

(311 12 22.2) - (00 00 16.5) = (311 12 05.7)

and this corrected angle will be displayed on the screen under the heading "HZT ANGLE". A second set of horizontal directions will be prompted for after the corresponding observations for the zenith distance, and the (R+P) corrections have been completed for this first set.

Step eight requires the user to enter four zenith distance observations on the Sun corresponding to the GMTs and directions entered. Each zenith distance is entered by responding to the prompt:

```
                                        INSTRUMENT IN  DIRECT/REVERSE

      ENTER THE... ZENITH DISTANCE   .../DMS/ (NN,NN,NN.N)?  62,45,51.1 <CR>
```

The zenith distance will be displayed on the screen under the heading

"ZENITH". Just to the right of each entry, the normalized direct zenith distance will also be displayed. Upon completion of all four entries, the program will compute the mean zenith distance, display it on the screen, and prompt the user for changes:

```
       ZENITH
D   62-45-51.1    62-45-51.1
D   62-57-31.0    62-57-31.0
R  296-48-38.0    63-11-22.0
R  296-44-22.0    63-15-38.0
         MEAN  =  63-02-35.5

CHANGE ONE OF THE ABOVE (Y/N)?  <CR>
```

A reply of <CR>, the "NO" response, will allow the program to continue. A reply of Y <CR> will force the program to recycle through each zenith distance entry, one-by-one, allowing the user to change it. At this point the the correct mean altitude to the Sun will be computed by substracting the mean zenith distance from 90 degrees:

(90 00 00.0) - (63 02 35.5) = (26 57 24.5)

This computed altitude will be displayed on the screen under the heading "ALTITUDE". A second set of zenith distances will be prompted for after the corresponding (R+P) corrections for this first set have been completed.

Step nine is the computation of the Refraction plus Parallax (R+P) correction. This correction will be computed using the mean zenith distance for each of the above entered sets. The correction (R+P) in seconds of arc will be displayed on the screen:

```
                    REFRACTION  +  PARALLAX  =  R+P /SS.S/

ENTER THE...           -109.6   +     7.8    =  -101.8  STOP (Y/N) <CR>
```

If the user replies <CR>, the "NO" response, the program continues by adding the correction (R+P) to the ALTITUDE. It then computes the azimuth to the MARK by using the mean computed values. The computed azimuth for each set will be displayed on the screen under the heading "-AZIMUTH-". A Y <CR> reply the "YES" response, will force the program to recycle through each of the following items in order to allow the user to make changes or to correct the different observational entries:

```
GMT OF OBSERVATION     CHANGE (Y/N)?  <CR>

DIRECTION TO SUN       CHANGE (Y/N)?  <CR>

ZENITH DISTANCE        CHANGE (Y/N)?  <CR>
```

CHANGE THIS DATA LINE (Y/N)? <CR>

A reply of Y <CR> to the "CHANGE THIS DATA LINE" prompt, will force the program to recycle through the associated items again, whereas, a <CR> reply, the "NO" response, will allow the program to continue. When set one of observations is completed, the program will automatically return to step six and begin to prompt for the GMT, the horizontal direction, and the zenith distance to the Sun.

Step ten, noted as, when "DATA ENTRY" has been completed, computes and displays the "MEAN OBSERVED AZIMUTH" to the MARK station and displays the corresponding residuals (under the heading "RES'L") for each of the azimuth observations. Two additional items of information, the "STANDARD DEVIATION" for a single and mean observation, will also be computed and displayed on the screen. An example solar observation is seen in Figure (8.01).

```
  +----------------------------------------------------------------------+
01| GM DATE = 841017        SOLAR    OBSERVATIONS        LOCAL TIME = PM  |
02| STATION                -----------------------------                  |
03|  NAME:  FORTES                        MARK:  FORTESQUE LIGHTHOUSE     |
04|         LAT  39-14-32.42100 N         TEMPERATURE/CELSIUS/ =    20.0  |
05|         LON  75-10-23.80000 W         PRESSURE   /MM HG  / =   760.0  |
06|                                                                       |
07|  GM TIME   DECLINATION  ALTITUDE    R + P  HZT ANGLE    --AZIMUTH--  RES'L |
08| HH-MM-SS.S DD-MM-SS.S   DD-MM-SS.S   SS.S DDD-MM-SS.S  DDD-MM-SS.S   SS.S |
09| 19-38-18.2  9-32-04.4 S 26-57-24.5 -101.8 311-12-05.7  277-53-40.5    1.2 |
10| 19-41-36.0  9-32-07.4 S 26-28-15.0 -104.0 311-55-54.7  277-53-41.8   -0.1 |
11| 19-46-07.0  9-32-11.5 S 25-47-55.5 -107.3 312-55-01.2  277-53-44.1   -2.5 |
12| 19-47-33.5  9-32-12.8 S 25-34-59.2 -108.4 313-37-58.5  277-53-35.4    6.2 |
13| 19-49-25.2  9-32-14.4 S 25-17-57.0 -109.9 313-37-58.5  277-53-42.0   -0.3 |
14| 19-50-40.7  9-32-15.6 S 25-06-31.7 -110.9 313-54-02.0  277-53-46.1   -4.5 |
15|                                                       -------------------  |
16|           MEAN OBSERVED AZIMUTH (FROM NORTH)         277-53-41.70         |
17|                                                                        |
18|           STANDARD DEVIATION (SINGLE OBSERVATION)           3.6         |
19|           STANDARD DEVIATION  (MEAN OBSERVATION)            1.5         |
    ...
24|                                                                        |
  +----------------------------------------------------------------------+
```

Figure (8.01) ---- Solar Observation Screen

9.0 WRK009 -- State Plane Coordinate Systems

To enter this program type WRK009 <CR>. The program will clear the screen and the following display will flash to the screen:

WRK009 <Version nn> ... YYMMDD

PROGRAM
(Y/N)?

- STATE PLANE COORDINATES

The program will then prompt the user to give the ability to draw data from the MTEN files already loaded by:

ATTACH TO --- "MTEN SYSTEM" --- (Y/N)? <CR>

If a <CR>, the "NO" response, was made to the above prompt, then the program will not use the existing MTEN data files but rather all computations will be done independently of MTEN and all information must be entered by the user from the keyboard.

A reply of Y <CR>, the "YES" response, will cause the program to respond with the next two prompts:

CHANGE DEFAULT DRIVE=C (Y/N)? <CR>
ENTER YOUR JOB CODE/JC/ (LL)? JC <CR>

The program will then use the ellipsoid parameters that were initialized previously with the program ABSINX (See Manual Section 1). At this time the program will load onto the screen the current project's Title, Datum, Ellipsoid, Semi-major axis, and the 1/Flattening values by the following:

PROJECT TITLE

DATUM	NAD 1983
ELLIPSOID	GRS 1980
SEMI-MAJOR AXIS	6378137.000 METERS
1/FLATTENING	298.25222101
UNITS	METERS

If by chance the current attached MTEN data files are non-NAD83, the program will ask the user to make the following replies:

DATUM	NAD 1927
ELLIPSOID	CLARKE 1866
SEMI-MAJOR AXIS	6378206.400 METERS
	6378137.000

DEFAULT & SELECTED .. EQUATORIAL RADII .. ARE UNEQUAL
DO YOU WANT TO CONTINUE (Y/N)? Y <CR>

```
1/FLATTENING                         294.9786982144
                                     298.257222101

DEFAULT & SELECTED .. 1/FLATTENING .. ARE UNEQUAL
DO YOU WANT TO CONTINUE (Y/N)?                            Y &lt;CR&gt;
```

At this point the user has two options; the first is to exit the program and re-enter the program ABSINX in order to change the current ellipsoid parameters to NAD83; or second, stay with the current parameter values and have the ellipsoid redefined later within WRK009.

If the current MTEN files are NAD83, then the user should continue with Section 9.1. However, if the MTEN data files are on a non-NAD83 datum, the user should skip to Section 9.2. Upon exit from either of these Sections, the program will prompt the user with the following messages:

```
REPEAT THIS ENTRY COMMAND (Y/N)?                            <CR>

RETURN TO --- MENU SCREEN --- (Y/N)?                        <CR>
```

These prompts will allow the user to repeat the Command, re-enter at the program level or exit to DOS.

9.1 NAD83

This section of the program uses geographic positions on the NAD83 Datum, Latitude and Longitude (LAT,LON), to compute the corresponding State Plane Coordinate Systems in meters, Northing and Easting (N,E), for the selected state and mapping projection.

The program will initialize by loading NAD83 Datum parameters and all State Plane Coordinate Systems (SPCS) projection constant tables, and will then flash the following messages on the screen to the user:

```
TABLES ARE LOADED --- USE ONLY "NAD83 POSITIONS"

SELECT ... (N,E) ... PROJECTION UNITS
                                          METERS (Y/N)? Y <CR>
```

The projection units for SPCS Northing and Easting are meters. If Y <CR>, the "YES" response is selected, the program will flash the "NAD83" Datum to the upper right-hand corner of the screen. However, the user may, at this point, select either US Survey or International feet to display the final (N,E) coordinates. The program will prompt the user this option by the following:

```
CHANGE THE ELLIPSOID (Y/N)?                                 <CR>
```

If the selection of this option is a Y <CR>, the user should skip to Section 9.2 where the user will be prompted to select an ellipsoid and a datum, and then to define the type of projection the program is to use.

The <CR>, the "NO" response, will allow the program to continue and prompt the user to select a state and one state Plane Coordinate Zone (PCZ) code within that state. The screen will clear below the second line and the following information will flash to the sereen:

```
ENTER   ZONE
STATE   CODE
(LL)?  (NAD83)

 TX N   4201
 TXNC   4202
 TX C   4203
 TXSC   4204
 TX S   4205
```

In the above case the State of Texas, TX, was selected to answer the prompt "ENTER STATE (LL)?" and the program will search its tables to provide all "Zone Codes" associated with the State of Texas. Now that all the Zones are displayed, the user must select one.

```
ENTER        ... "ZONE CODE" ...

ZONES /4-DIGITS/ (NNNN)      4201 <CR>
```

Once the state Zone Code has been selected, it will be re-displayed for the user in the upper left-hand corner of the screen. If by chance the Zone Code is entered incorrectly, the program will ask the user to re-enter it by:

```
ZONE NOT FOUND IN TABLE
RE-ENTER  ... "ZONE" ...  (Y/N)?                         Y <CR>
```

If the Zone Code is not re-entered correctly, the program will proceed as described in Section 9.2 where the user must re-define the datum and projection to be used.

Another option available is to display on the screen the geographic position from which the (N,E) coordinates were computed by the following prompt:

```
DISPLAY THE  ...  "GEOGRAPHIC POSITIONS"  ...   (Y/N)?      <CR>
```

If this option is selected, the geographic positions will be displayed on the right-hand side of the screen under the headings "CONVERGENCE" and "SCALE", so as to leave the computed projection coordinates (N,E) unobstructed on the screen display.

```
                                                   LAT  DD-MM-SS.SSSSS N
                                                   LON DDD-MM-SS.SSSSS W
```

If MTEN was not attached, the program will prompt the user for each entry, one-by-one, until the screen is full:

```
NAME
LATITUDE   /DMS/   (NN,NN,NN.NNNNN)?                 (N/S)?
LONGITUDE  /DMS/  (NNN,NN,NN.NNNNN)?                 (E/W)?
```

The above prompts can be repeated by a Y <CR> response to the following:

DO YOU WANT TO CONTINUE (Y/N)? <CR>

A sample screen display for the Texas (North Zone 4201) is given by Figure (9.01), using the following geographic position data:

Name	Zone	Latitude	Longitude
ORIGIN	TX N	34 00 00.00 N	101 30 00.00 W
LOWER PARALLEL	TX N	34 39 00.00 N	101 30 00.00 W
UPPER PARALLEL	TX N	36 11 00.00 N	101 30 00.00 W

```
+-------------------------------------------------------------------------------------+
|     ZONE 4201                 STATE PLANE COORDINATES                 NAD83          |
|                         ---------------------------------                           |
|     STATION NAME        ZONE    NORTH(Y)       EAST(X)     CONVERGENCE   SCALE      |
|                         ----------------(METERS)------------------------------     |
| ORIGIN                  TX N  1000000.0000  200000.0000 +0,00,00.00 1.0002140       |
| LOWER PARALLEL          TX N  1072110.3322  200000.0000 +0,00,00.00 1.0000000       |
| UPPER PARALLEL          TX N  1242220.8692  200000.0000 +0,00,00.00 1.0000000       |
|                                                                                     |
   ...
|                                                                                     |
+-------------------------------------------------------------------------------------+
```

Figure (9.01) ---- NAD83 State Plane Coordinates -- TX (North Zone)

However, when MTEN data files are attached, the program will prompt the user for a SPN range by the following:

SELECT A RANGE OF SURVEY POINT NUMBERS /SPNs/

SPN WHERE TO BEGIN (NNN) ---
SPN WHERE TO END (NNN) ---

The program will then compute the (N,E) coordinates for the selected range, if possible. If the program is attached to MTEN and (N,E) coordinates were not displayed on the screen, the user must exit WRK009 and re-enter STRSPN at the program entry point "STRNAM". Each SPN which was not previously coded with a PCZ, must be modified to insert a PZC for it before WRK009 can be re-run. After the program has computed the (N,E) coordinates for the user's selected range, the following message will appear:

SELECT ANOTHER SPN RANGE (Y/N)? <CR>

A response Y <CR>, the "YES" response, will cause the program to re-enter at the selection of another SPN range. However, a <CR> response, the "NO" response, will allow the user to exit at this program level.

The NAD83 (SPCS) coordinates are in METERS. However, they maybe converted and displayed in FEET also, but this brings up the question of what type of FEET? There are two types of FEET in use, the U.S. Survey and the International. Each is derived from a relationship to the international meter standard. The following information shows the relationship:

```
METERS  *  (Conversion)     =      FEET
-------------------------------------------

METERS  *  (39.37/12.00)    =   U.S. SURVEY

METERS  *  (100.0/30.48)    =   INTERNATIONAL
```

To show the difference in the projection coordinates (N,E), where the FEET option was selected, Figure (9.02) has the Texas (North Zone 4201) displayed with both types of FEET. These (N,E) coordinates were computed using the same geographic position as used for Figure (9.01).

```
  +----------------------------------------------------------------------------+
01|    ZONE 4201               STATE PLANE COORDINATES                 NAD83   |
02|                      --------------------------------                      |
03|    STATION NAME       ZONE    NORTH(Y)      EAST(X)     CONVERGENCE   SCALE |
04|                      ------------(US SURVEY FEET)------------------------   
05| ORIGIN                TX N  3280833.333   656166.667  +0,00,00.00 1.0002140|
06| LOWER PARALLEL        TX N  3517415.315   656166.667  +0,00,00.00 1.0000000|
07| UPPER PARALLEL        TX N  4075519.635   656166.667  +0,00,00.00 1.0000000|
08|                                                                            |
    ...
04|                      ----------(INTERNATIONAL FEET)----------------------  |
05| ORIGIN                TX N  3280839.895   656167.979  +0,00,00.00 1.0002140|
06| LOWER PARALLEL        TX N  3517422.350   656167.979  +0,00,00.00 1.0000000|
07| UPPER PARALLEL        TX N  4075527.786   656167.979  +0,00,00.00 1.0000000|
08|                                                                            |
    ...
23|                                                                            |
24+----------------------------------------------------------------------------+
```

Figure (9.02) ---- US SURVEY + INTERNATIONAL FEET -- TX (North Zone)

9.2 OTHER

This section of the program uses geographic positions from a user defined datum (this datum could be NAD27) to compute the corresponding projection coordinates in feet, Northing and Easting (N,E), for the selected mapping projection.

The program will initialize as in Section 9.1 by loading NAD83 Datum parameters and all NAD83 State Plane Coordinate Systems (SPCS) projection constant tables, and will then flash the following messages on the screen to the user:

```
        TABLES ARE LOADED --- USE ONLY "NAD83 POSITIONS"

        SELECT ... (N,E) ... PROJECTION UNITS
                                                METERS (Y/N)?  N <CR>
```

The user <<< must..not..select.."METERS" >>> at this point will be asked by the program to change the ellipsoid and select the type of "FEET" to be displayed by the program on the screen:

```
        CHANGE THE ELLIPSOID (Y/N)?                            Y <CR>

                                    U.S. SURVEY     FEET  (Y/N)?  Y <CR>
                                    INTERNATIONAL   FEET  (Y/N)?  <CR>
```

With this datum information change, the program will ask the user to initialize the program's ellipsoid parameters by prompting for the selection of one of the following:

```
                                    "DATUM"
        USE GRS 1980     ELLIPSOID .. NAD83 ..      (Y/N)?        <CR>
        USE CLARKE 1866  ELLIPSOID .. NAD27 ..      (Y/N)?      Y <CR>
        USE WGS 1972     ELLIPSOID    ....
```

or select an "OTHER" ellipsoid defined by:

```
        USE ELLIPSOID  (AAAAAAAAAA)?
        MAJOR AXIS   (NNNNNNN.NNNN)?
        FLATTENING "1/F" (NNN.NNNNNN)?
```

After the ellipsoid parameters have been selected or entered, the "DATUM" abbreviation will display on the screen in the upper right-hand corner.

The program will prompt the user to select a state and one state Plane Coordinate Zone (PCZ) code within that state. The screen will clear below the second line and the following information will flash to the sereen:

```
        ENTER   ZONE
        STATE   CODE
        (LL)?  (NAD83)

         NE     2600
```

In the above case, the State of Nebraska, NE, was selected to answer the prompt "ENTER STATE (LL)?" and the program will search its tables to provide all ZONE CODEs associated with the State of Nebraska. If by chance the wrong state was entered, the program will prompt with the following:

```
?? STATE (LL) ... NOT FOUND TRY AGAIN (Y/N)? <CR>
```

A Y <CR>, the "YES" response, allows the user to reenter a new (LL) state. However, a <CR> reply, the "NO" response, will force the program to continue and will assume the state code (LL), as entered, is correct and use it.

Now that all the state zones (if they were found) are displayed, the user must enter, via the keyboard, one of them:

```
ENTER            ... "ZONE CODE" ...

ZONES /4-DIGITS/ (NNNN)      2601 <CR>
```

Once the state ZONE CODE has been selected, it will be re-displayed for the user in the upper left-hand corner of the screen. If by chance the Zone Code is entered incorrectly, the program will ask the user to re-enter it by:

```
ZONE NOT FOUND IN TABLE
RE-ENTER ... "ZONE" ... (Y/N)?                    <CR>
```

If the wrong ZONE CODE (number 2601 is a NAD27 Zone Code) is not corrected, the program will proceed with the code as entered. The user's defined datum and mapping projection will assume it to be correct.

Now that the ZONE CODE has been entered, the program will prompt the user to select a projection from the following (only the first two are allowed):

```
LAMBERT CONIC (TWO PARALLELS)      (Y/N)?              Y <CR>
TRANSVERSE MERCATOR                (Y/N)?
OBLIQUE MERCATOR                   (Y/N)?
```

Once the user has selected a projection, the program will load onto the screen the "NAD83 CONSTANTS" in the type of "FEET" units selected and for the selected projection, if they exist. The user at this time must enter each new re-defined projection parameter one-by-one <<making sure they are the correct values which represent the new projection>>.

```
LONGITUDE (CENTRAL MERIDIAN) /DMS/   100,00,00.0   (E/W)?  W <CR>
FALSE EASTING (C.M.)                 2000000.0               <CR>
FALSE NORTHING                       0.0                     <CR>

LATITUDE (LOWER) PARALLEL    /DMS/   41,51,00.0    (N/S)?  N <CR>
LATITUDE (UPPER) PARALLEL    /DMS/   42,49,00.0    (N/S)?  N <CR>
LATITUDE (FALSE NORTHING)    /DMS/   41,20,00.0    (N/S)?  N <CR>
```

At the end of these entries, the user will be asked to change any of the above items by:

```
                                RE-ENTER CONSTANTS (Y/N)?   <CR>
```

The last option, whether or not to display the geographic position from which the (N,E) coordinates were computed, is prompted by:

```
DISPLAY THE ... "GEOGRAPHIC POSITIONS" ... (Y/N)?      <CR>
```

If this option is selected, the geographic positions will be displayed on the right-hand side under the headings "CONVERGENCE" and "SCALE", so as to leave the computed projection coordinates (N,E) unobstructed on the screen.

```
                                        LAT  DD-MM-SS.SSSSS N
                                        LON DDD-MM-SS.SSSSS W
```

Again, as in Section 9.1, the user will either enter a MTEN SPN range to be computed or enter, from the keyboard, each station name and geographic position depending on whether or not MTEN data files have been attached. A sample screen display for the Nebraska (North Zone 2601) is given by Figure (9.03) using the following geographic position data:

Name	Zone	Latitude	Longitude
ORIGIN	NE	41 20 00.00 N	100 00 00.00 W
LOWER PARALLEL	NE	41 51 00.00 N	100 00 00.00 W
UPPER PARALLEL	NE	42 49 00.00 N	100 00 00.00 W

```
  +-----------------------------------------------------------------------+
01|     ZONE 2601          STATE PLANE COORDINATES              NAD27      |
02|                  ------------------------------                        |
03|     STATION NAME   ZONE    NORTH(Y)      EAST(X)    CONVERGENCE   SCALE |
04|                  -----------(US SURVEY FEET)-------------------------  |
05| ORIGIN                          0.000  2000000.000  +0,00,00.00 1.0001157|
06| LOWER PARALLEL             188273.461  2000000.000  +0,00,00.00 1.0000000|
07| UPPER PARALLEL             540546.863  2000000.000  +0,00,00.00 1.0000000|
08|                                                                        |
    ...
23|                                                                        |
24+-----------------------------------------------------------------------+
```

Figure (9.03) ---- NAD27 State Plane Coordinates -- NE (North Zone)

The last example, Figure (9.04), is a user defined keyboard scenario using a MTEN selected SPN Range to compute projection coordinates (N,E) from the geographic positions (on the NAD27 Datum) which were stored within MTEN Data files.

```
ATTACH TO --- "MTEN SYSTEM" ---  (Y/N)?                    Y <CR>

CHANGE DEFAULT DRIVE-C (Y/N)?     <CR>
ENTER YOUR JOB CODE/JC/ (LL)?      RS <CR>
```

```
                 UPPER NEW YORK BAY --G 18345--NY

DATUM                                       NAD 1927
ELLIPSOID                                   CLARKE 1866
SEMI-MAJOR AXIS                              6378206.400  METERS
1/FLATTENING                                 294.978698214
UNITS                                       FEET (US)

TABLES ARE LOADED --- USE ONLY "NAD83 POSITIONS"
SELECT ... (N,E) ... PROJECTION UNITS         METERS (Y/N)? N <CR>

CHANGE THE ELLIPSOID (Y/N)?                                  Y <CR>
                         U.S. SURVEY      FEET  (Y/N)? Y <CR>

USE CLARKE 1866  ELLIPSOID .. NAD27 ..         (Y/N)?        Y <CR>

ENTER
STATE
(LL)?

 NY <CR>

NY E   3101
NY C   3102
NY W   3103
NY L   3104

ENTER                   ... "ZONE CODE" ...
ZONES /4-DIGITS/ (NNNN)      3104 <CR>

LAMBERT CONIC (TWO PARALLELS)        (Y/N)?                  Y <CR>

                                         "DATUM"             NAD27
LONGITUDE (CENTRAL MERIDIAN) /DMS/      74,00,00.0   (E/W)?  W <CR>
FALSE EASTING (C.M.)                   2000000.0               <CR>
FALSE NORTHING                         100000.0                <CR>

LATITUDE (LOWER) PARALLEL    /DMS/     40,40,00.0    (N/S)?  N <CR>
LATITUDE (UPPER) PARALLEL    /DMS/     41,02,00.0    (N/S)?  N <CR>
LATITUDE (FALSE NORTHING)    /DMS/     40,30,00.0    (N/S)?  N <CR>

                              RE-ENTER CONSTANTS (Y/N)?     <CR>

DISPLAY THE  ...  "GEOGRAPHIC POSITIONS"  ...   (Y/N)?      <CR>

SELECT A RANGE OF SURVEY POINT NUMBERS /SPNs/

SPN WHERE TO BEGIN (NNN)          70 <CR>
SPN WHERE TO END   (NNN)          89 <CR>

SELECT ANOTHER SPN RANGE  (Y/N)?  <CR>

REPEAT THIS ENTRY COMMAND (Y/N)?                              <CR>

RETURN TO --- MENU SCREEN --- (Y/N)?                          <CR>
```

Note that only the stations within the selected SPN range and with the selected ZONE CODE will be computed and displayed on the screen, see Figure (9.04). If the other ZONE CODEs are required, the user must re-enter the program for each additional zone required.

```
  +------------------------------------------------------------------------+
01|      ZONE 3104              STATE PLANE COORDINATES             NAD27   |
02|                        UPPER NEW YORK BAY --G 18345-- NY                |
03|SPN  STATION NAME       ZONE   NORTH(Y)      EAST(X)    CONVERGENCE  SCALE |
04|                          -----------(US SURVEY FEET)------------------------ |
05| 70 BORO HALL          NY L  151839.281   1978754.821 -0,03,00.26 1.0000014|
06| 71 POUCH 1931         NY L  143310.447   1981058.834 -0,02,40.65 1.0000030|
07| 74 CONEY IS LIGHTHSE  NY L  127867.797   1996617.993 -0,00,28.67 1.0000062|
08| 75 FT WADSWORTH LH    NY L  138516.137   1984903.597 -0,02,08.02 1.0000040|
09| 77 CONEY IS BKLYN GAS NY L  129712.213   2005362.482 +0,00,45.46 1.0000058|
10| 78 ROBINS REEF LIGHT  NY L  157300.558   1981750.679 -0,02,34.87 1.0000005|
11| 79 STATUE OF LIBERTY  NY L  168885.400   1987530.539 -0,01,45.87 0.9999988|
12| 80 EMPIRE STATE BLDG  3101                                              |
13| 81 WORLD TRADE CENTER 3101                                              |
14| 82 BOLT               NY L  167825.174   1992585.962 -0,01,02.95 0.9999990|
15| 83 H 52 NY            NY L  150859.738   1989144.036 -0,01,32.10 1.0000016|
16| 84 H 53 NY            2900                                              |
17| 85 H 54 NY            NY L  165497.559   1994629.777 -0,00,45.59 0.9999993|
18| 86 H 55 NY            3101                                              |
19| 87 H 56 NY            NY L  168910.132   1996458.092 -0,00,30.07 0.9999988|
20| 88 H 57 NY            3101                                              |
21| 89 H 05 NY 79         NY L  129435.621   2000132.695 +0,00,01.12 1.0000059|
22| 90 H 05 NY 79 PTA     NY L  129426.052   2000147.704 +0,00,01.25 1.0000059|
23| 91 UNIDENTIFIED BLDG  3101                                              |
24+------------------------------------------------------------------------+
```

Figure (9.04) ---- MTEN with Selected SPN Range -- NY (Long IS Zone)

10.0 WRK010 -- Geodetic Traverse Computations

To enter this program type WRK010 <CR>. The program will clear the screen and the first set of program defaults, the ellipsoid parameters and the datum name, to be used by the program can be entered. The user is prompted to give the ability to the program to use loaded MTEN files by:

```
ATTACH TO --- "MTEN SYSTEM" --- (Y/N)?
```

A reply of Y <CR>, the "YES" response, will cause the program to respond with the next two prompts:

```
CHANGE DEFAULT DRIVE=C (Y/N)?  <CR>
ENTER YOUR JOBCODE /JC/ (LL)?  JC <CR>
```

The program will then use the ellipsoid parameters that were initialized previously with ABSINX (See Manual Section 1).

If a <CR>, the "NO" response, was made to the above prompt "ATTACH TO ...", then the program will not use the existing MTEN data files but rather all computations will be done independent of MTEN and all information must be entered by the user from the keyboard.

With no ellipsoid information available, the program will initialize the ellipsoid parameters for geodetic computations by prompting the user to select one of the following:

```
USE GRS 1980     ELLIPSOID .. NAD83 ..     (Y/N)?
USE CLARKE 1866  ELLIPSOID .. NAD27 ..     (Y/N)?
USE WGS 1972     ELLIPSOID    .....        (Y/N)?
```

or select another defined by:

```
USE ELLIPSOID  (AAAAAAAAAA)?
MAJOR AXIS   (NNNNNNN.NNNN)?
FLATTENING "1/F" (NNN.NNNNNN)?
```

After the ellipsoid parameters have been selected or entered the "DATUM" abbreviation will flash onto the screen in the upper right-hand corner.

The program will ask the user for a default set of distance units by flashing the following message on the screen:

```
DISTANCE UNITS /Meters or Feet/  (M/F)?  M <CR>
```

At this point, the program entry points will flash to the screen and different screens will appear depending on which entry point was selected.

PROGRAM
(Y/N)?

- GPN ... TRAVERSE ... COMPUTATION

Upon exit from the program entry point, the program will prompt the user with the following:

RETURN TO --- MENU SCREEN --- (Y/N)?

This will allow the user to re-enter at the program entry level or exit. If an exit is made, MTEN files attached are dropped and the program will prompt:

REPEAT THIS ENTRY COMMAND --- (Y/N)?

This will allow the user to re-enter the program and attach different MTEN files or exit to DOS.

GPN ... TRAVERSE

This program computes the geographic position (Latitude and Longitude) of a Forepoint station using horizontal angles observed at the Standpoint station and measured distances between the Standpoint and or Forepoint. The program requires the user: (1) to enter the beginning Standpoint station position (Fixed), (2) to establish orientation for the forward traverse azimuth (i.e. either by computing an inverse azimuth to a Backsight station or by entering a beginning azimuth from the keyboard), (3) to loop through as many Forepoint stations as needed until the ending station is reached, (4) to terminate the last forward traverse azimuth (i.e. either by comparing the last azimuth to the computed inverse azimuth to the final Forepoint station or by entering an ending azimuth from the keyboard). The program will provide a tablation of discrepancies in azimuth, latitude, and longitude.

The first step of the program, entry of the Standpoint station, can be accomplished in two ways. The first, if the "MTEN SYSTEM" is attached, is for the user to just enter the SPN for the station:

STATION

BEGINNING AT /SPN/ (NNN)? 70 <CR> BORO HALL

The program will load the beginning station's SPN, Name, Latitude, and Longitude from the geographic position file (FILEGPNX.JC) and display this information on the screen. A second option in the attached mode, allows the user to touch <CR> and the program will switch over and prompt as if it were in the unattached mode of entry.

If the "MTEN SYSTEM" is not attached, the user will be required to enter the following items for the beginning station:

```
                STATION

      BEGINNING AT BORO HALL <CR>

and     /DMS/    (NNN,NN,NN.NNNNN)?

      LATITUDE     40,38,32.156       N <CR>
      LONGITUDE    74,4,35.585        W <CR>
```

After this entry is completed, the information will be re-loaded into a triadic station group which will remain on the screen. The user will be asked to verify the geographic position loaded for the beginning station:

```
      CHANGE BEGINNING  "GPN"  POSITION...    (Y/N)? <CR>
```

A reply of <CR>, the "NO" response, will allow the program to continue. However, a Y <CR> reply, the "YES" response, will force the program to recycle and reprompt the user to re-enter all information for the beginning station.

Step two, the identification of a back azimuth station, can be entered two ways. The first way (the attached mode) is to just enter the SPN for the Backsight station by:

```
                STATION

      BACKSIGHT TO  /SPN/ (NNN)?   74 <CR>     CONEY ISLAND LH
```

The program will compute the geodetic inverse (if a geographic position has been entered for it), or the second way (when unattached), is for the user to enter the station name by:

```
      BACKSIGHT TO  CONEY ISLAND LH <CR>
```

This is followed by entering the azimuth from the Standpoint station to the Backsight station:

```
                                        /DMS/  (NNN,NN,NN.NN)    FROM NORTH
                                       AZIMUTH  143,15,25.66 <CR>
```

In either case, both the Backsight station name and the value for the back azimuth will be re-loaded and flashed to the screen on the "BCK" triad line. Depending on how the back azimuth was established, the character string "/INV/" (computed geodetic inverse) or "/AZI/" (keyboard entry) will also appear on this triad line.

Step two is looped through as many Standpoint stations as needed to reach the end of the traverse. The first prompt will identify the FORESIGHT (Forepoint station) associated with this Standpoint by a SPN entry for the attached mode and name entry for the unattached mode:

```
                    STATION

FORESIGHT TO  /SPN/ (NNN)?  71 <CR>
FORESIGHT TO   POUCH <CR>
```

Once the Forepoint station has been furnished to the program, two new options are provided. Option one (the attached mode) is for the program to automatically go to the Standpoint's stored combined "LST" and take-out the angle from the Backsight station clockwise to the Forepoint station. In the unattached mode or if the program can not find an angle from the "LST" in the attached mode, the program will jump to option two which requires the user to repond with a keyboard entry and furnish the observed angle at the Standpoint:

```
ANGLE /DMS/ (NNN,NN,NN.NN)?  21,34,35.12 <CR>   CLOCKWISE
```

As a check on the entered angle, the program will prompt the user to verify that the angle entered was measured clockwise from the Backsight station to the Foresight station:

```
WAS THE BACKSIGHT USED AS THE INITIAL   (Y/N)?  Y <CR>
```

At this point, the angle which was either found automatically or entered in response to the prompt, will be flashed to the screen on the "ANGLE" triad line. The forward traverse azimuth "FWD" will be computed by adding the angle to the "BCK" azimuth. The computed forward traverse azimuth will be flashed to the screen on the "FWD" triad line.

The third prompt under step two of the attached mode asks the user to select one, some, all or none of the measured distances found in the data file between the Standpoint and or the Forepoint stations by the following:

```
EDM ... MEASUREMENT            2692.8191  USE IT (Y/N)? <CR>
```

If a reply of Y <CR>, the "YES" response is made, the program will retain the selected distance and flash it to a screen line above the prompt. However, if <CR>, the "NO" response is made, the program will skip this distance and continue to the next one if it exists. If more than one distance is selected, the program will compute the mean of all selected distances for use with the forward computation. If no distances are selected, or if the program is being run in the unattached mode the program will force the user to enter a single distance by:

```
DISTANCE /METERS/ (NNNNN.NNNN)?  2692.8191 <CR>
```

At this point the program will flash the distance and the name of the Foresight station to the screen on the bottom line of the station triad. One additional item is computed (if possible) and displayed for the user on a line just below the station triad: if in attached mode and if a position exists for the Forepoint station in the geographic position file, the program will compute the discrepancies in both latitude (DLAT) and longitude (DLON) in the units selected (either Meters or Feet) and flash it to the screen in the following format:

DLAT/DLON -0.081 -0.021

This single line of information will be erased when the next Forepoint station triad is started.

The last prompt for any given Forepoint station triad is the following:

WILL THIS ... "FOREPOINT" ... BE THE LAST STATION (Y/N)? <CR>

If a reply of <CR>, the "NO" response is made, the program will recycle, starting with step three described above. A reply of Y <CR>, the "YES" response, will force the program to exit the Forepoint station triad loop and continue.

The ending station entry follows the exact procedures set forth for the beginning station described above. The only difference seen on the screen is that the ending station appears rather than the beginning station.

Working in the attached mode, the program will automatically use the geographic position file to make the final position comparisons and then display the DLAT and DLON values on the screen. Once these values have been flashed to the screen, the program will prompt:

RE-ENTER ENDING "GPN" POSITION ... (Y/N)? <CR>

If a reply of <CR>, the "NO" response is made, the program will continue. However, if a reply of Y <CR>, the "YES" response is made, the program will force the user to enter a latitude and longitude for the current station from the keyboard. The values of DLAT and DLON will be recomputed and again reloaded and flashed to the screen.

In order to terminate the ending forward traverse azimuth, one last set of prompts must be answered. The first, in the attached mode, is to identify the Foresight station to which the final angle will be turned by:

STATION

FORESIGHT TO /SPN/ (NNN)? 75 <CR> FT WADSWORTH LH or in the unattached mode by:

    FORESIGHT TO   FT WADSWORTH LH <CR>

As explained previously, the second prompt tells the program whether to compute an azimuth or to expect the user to enter the azimuth to the above Foresight station.

The fifth and last step will display the final information line to the screen. The display will give the geographic position closure for the traverse, in the units selected, and the ratio of the closure to the length of the traverse. For an example of the final screen display, see Figure (10.01).

```
  +------------------------------------------------------------------------+
01|                       TRAVERSE   COMPUTATIONS   FOR POSITION CLOSURE   |
02|                    -----------------------------                       |
03| SPN   STATION NAME         DISTANCE            AZIMUTHS        LATITUDE |
04|                             METERS                            LONGITUDE |
05|     CONEY ISLAND LH             /INV/ BCK  143-15-25.663                |
06|  70 BORO HALL                       ANGLE  021-34-35.119  40-38-32.15600 |
07|                          2692.8191    FWD  164-50-00.783  74-04-35.58500 |
08|                                                                         |
09|                                       BCK  344-50-20.300                |
10|  71 POUCH                           ANGLE  062-04-48.770  40-37-07.89624 |
11|                          3371.6759    FWD  046-55-09.070  74-04-05.61318 |
12|                                                                         |
13|                                       BCK  226-56-17.312                |
14|  83 H 52                            ANGLE  331-59-42.331  40-38-22.54320 |
15|     FT WADSWORTH LH                   FWD  198-55-59.643  74-02-20.81255 |
16| DLAT/DLON =     -0.008   -0.088   /INV/     198-56-07.976       -8.333   |
17| CLOSURE   =      0.088 /  6.06 KM            ONE PART IN        69000    |
18|                                                                         |
19|                                                                         |
    ...
23|                                                                         |
24|                                                                         |
  +------------------------------------------------------------------------+
```

Figure (10.01) ---- GPN Traverse Computation Screen

At this point the program will prompt the user to continue computation by:

    RE-COMPUTE TRAVERSE FOR AZIMUTH CLOSURE ... (Y/N)?

If a <CR>, the "NO" response, is made to the above prompt the program will exit to DOS. A "YES" response will clear the screen and flash the following information to the screen:

```
INSTRUMENT ERROR .. ANGLES  /SECONDS/ (NNN.NN)         2.0000

INSTRUMENT ERROR .. CONSTANT /METERS/   (N.NNNN)       0.0040

INSTRUMENT ERROR .. PPM                 (NNN.NN)       5.0000

DO YOU WANT TO MODIFY THE INSTRUMENT ERRORS            (Y/N)?
```

After the instrument errors have been modified, the complete traverse will be re-computed with the angles adjusted for azimuth closure. The display will give the geographic position closure for the traverse, in the units selected, and the new ratio for the closure in length of the traverse. For an example of the screen display, see Figure (10.02).

```
                        TRAVERSE   COMPUTATIONS   FOR AZIMUTH CLOSURE
                     -----------------------------
SPN   STATION NAME            DISTANCE             AZIMUTHS          LATITUDE
                               METERS                                LONGITUDE
   CONEY ISLAND LH                   /INV/ BCK  143-15-25.663
 70 BORO HALL                            ANGLE  021-34-37.896   40-38-32.15600
                            2692.8191     FWD  164-50-03.560   74-04-35.58500

                                          BCK  344-50-23.076
 71 POUCH                                ANGLE  062-04-51.548   40-37-07.89593
                            3371.6759     FWD  046-55-14.624   74-04-05.61467

                                          BCK  226-56-22.868
 83 H 52                                 ANGLE  331-59-45.108   40-38-22.54105
   FT WADSWORTH LH                        FWD  198-56-07.977   74-02-20.80991
DLAT/DLON =     -0.074    -0.026   /INV/       198-56-07.976
CLOSURE   =      0.078 /  6.06 KM               ONE PART IN          78000

   ...
```

Figure (10.02) ---- GPN Traverse Azimuth Closure

Once the azimuth closure computation is complete, the program will iterate to a solution. As the iterations are computed, the results are flashed to the screen by the following display:

```
SUM OF WEIGHTED RESIDUALS  =       6.6421
VARIANCE OF UNIT WEIGHT    =       2.2140
STD ERROR OF UNIT WEIGHT   =       1.4880
```

Next the screen will clear, and the adjusted observations will be displayed.

The last screen displayed is the adjusted geographic positions for the traverse computation. A sample screen is given by Figure (10.03).

```
  +----------------------------------------------------------------------------+
01|                      TRAVERSE   COMPUTATIONS    ADJUSTED GPN POSITIONS     |
02|                   -----------------------------                            |
03| STA    LATITUDE      SE LAT      LONGITUDE      SE LON      MAX   MIN   AZ |
04| NBR DDD-MM-SS.SSSSS  (")      DDD-MM-SS.SSSSS  (")         (MM) (MM) (DDD.DD)|
05|                                                            - ERROR ELLIPSE -|
06|   1 040-38-32.15600           074-04-35.58500                              |
07|   2 040-37-07.89688  .00004   074-04-05.61137  .00007       1.7  1.1   99.85|
08|   3 040-38-22.54344           074-02-20.80882                              |
09|                                                                            |
10|                                                                            |
11|                                                                            |
12|                                                                            |
     ...
24|                                                                            |
  +----------------------------------------------------------------------------+
```

Figure (10.03) ---- Adjusted GPN Traverse Geographic Positions

Correction Sheet

WRK003 Page 3-6 line 28 attached ans

attached and

WRK005 Page 5-4 line 51 See NOTE: 890106

Reference:

PRESSURE IN .. (... /feet) .. ALTIMETER READINGS (MT)

NGS uses altimeters that have Sea Level (0 elevation) set to 1000 feet (see Smithsonian Meteorological Table 51). If your equipment records altitude in feet and doesn't have 1000 feet set at Sea Level, you will have to add an additional 1000 feet to your readings when using the above option. The NGS program WRK005 will automatically subtract 1000 feet from all readings entered with the " ... (... /feet)" option.

RWS

WRK008 Page 8-6 line 47 refraction plus parallax (R+P)

Refraction plus Parallax (R+P)

Page 8-7 line 4 -". A

-". A

WRK009 Page 9-8 Figure (9.03) all 200000.000 should be

2000000.000 FEET