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# Programs for Skyline Planning

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## ABSTRACT

This paper describes four computer programs for the logging engineer's use in planning log harvesting by skyline systems. One program prepares terrain profile plots from maps mounted on a digitizer; the other programs prepare load-carrying capability and other information for single and multispan standing skylines and single span running skylines. In general. the three skyline programs prepare load paths. forces. and cable tension information from inputs of equipment specifications and anchoring geometry. Listings and explanations for all programs are included.



Keywords: Skyline logging. logging operations analysis/design, computer programs.


## CONTENTS

## INTRODUCTION

This paper presents four computer programs with specific application to skyline harvest unit layout: One program prepares terrain profiles from maps, and three programs express characteristics of load-carrying skylines.

The scope of this paper is limited to a simple and concise presentation of the programs without extensive interpretation of the information prepared by each. The mechanics of their use (i.e., details of input and output) are discussed thoroughly, but no attempt is made to explain the algorithms used.

## GENERAL INFORMATION

The programs are written in the American Standard Code for Information Interchange (ASCII) BASIC language common to many computer systems. They were developed on a Hewlett-Packard **9830** desk-top calculator/plotter/digitizer system (fig. **1)** at the Station's Forest Engineering Laboratory, Seattle, Washington.

**Figure 1.—Desk-top calculator system with digitizer, plotter, printer, and card reader.**

The configuration of this system can vary depending on the optional features included. The minimum calculator system configuration required to run the programs is:

I. Profile program
- BASIC MODEL 30 calculator with 3520 bytes of Read/Write Memory
- Additional Read Only Memories
  - Plotter control
  - Extended 1/O
- Plotter (9862A)
- Digitizer (9864A)
- Thermal page printer (9866A)

11. All skyline programs
- BASIC MODEL 30 calculator with (at least) 9000 bytes of Read/Write Memory
- Additional Read Only Memories
  - Plotter control
  - Extended 1/0
  - String variable (this requirement could be eliminated)
- Plotter (9862A)
- Thermal page printer (9866A)

Although these programs were prepared on a particular computer system and some familiarity with the mechanics of its operation is presumed, they are not limited to it. The ASCII BASIC language is a common computer code, and the programs can be executed on many other facilities. A listing of each program is included for use on other systems.

## SYSTEM OF UNITS

The programs presume the user is working with our traditional system of units. Length measurements are in feet or inches and forces or tensions, in pounds. However, the International System of Units (SI) could be accommodated. The user need only be consistent in the input and interpretation of output. The input and output label should be modified to eliminate confusion if other units will be used.

## VISUAL PROMPTERS

One goal in the development of these programs was to integrate a large portion of their documentation into the programs themselves. Ideally we expected to produce programs that, while they were being run in the machine, would provide enough instructions to lead a user through their execution. The approach was to request keyboard or digitizer inputs by display of interrogatory statement or other printed messages. These are called "visual prompters" for input. Their meaning is important to an understanding of each program, and consequently, the explanation of program use will focus on definitions for the visual prompters, which are in the tables.

## IALIZ \'

These programs reside on one magnetic tape cassette. The first file on the tape contains programs which load into the special function keys and are important to the execution of other programs. Therefore, the first step in the use of these programs is

LOADKEY 1, EXECUTE .

This will load several programs and/or instructions into the special function keys. These are labeled on the special function card (fig. 2). Keys $f_0$ through $f_4$ are part of the profile program and will be discussed in that section. The key fs provides a message (see fig. 3) about plotter precautions; keys $f_6$ through $f_9$ are for loading each main program from *the* magnetic tape cassette. The tape cassette should be rewound after executionof any of these special functions to minimize the chance of damage to tapes.

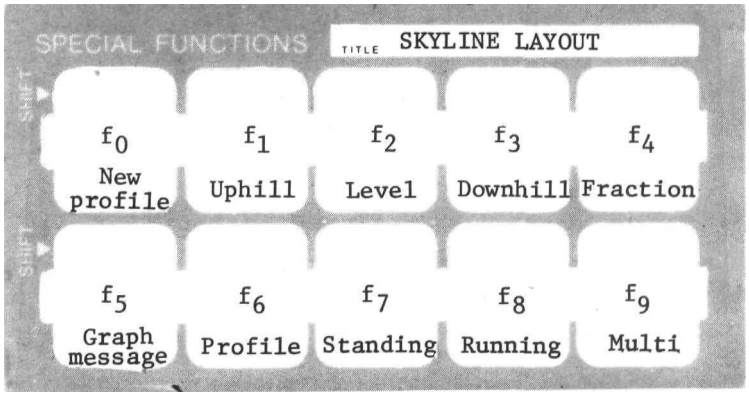



**Figure 2.—Special function card for skyline layout program.**

```
 THE PROGRAMS IN THIS PACKAGE USE THE HP9862A PLOTTER.
THEREFORE THE USER MUST ESTABLISH GRAPH LIMITS ON THE
PLOTTER AND SUPPLY SCALE FACTORS TO THE HP9830 COMPUTER.
THE GRAPH LIMITS ARE SET MANUALLY AS EXPLAINED IN THE PLOTTER
DOCUMENT.  THE SCALE FACTORS ARE ENTERED INTO THE COMPUTER
DURING PROGRAM EXECUTION FOLLOWING THE VISUAL PROMPTERS:
            (HORIZONTAL GRAPH LIMITS(FEET)?)
AND         (VERTICAL GRAPH LIMITS(FEET)?).
IT IS ALSO NECESSARY TO ESTABLISH THE PEN LOCATION FOR THE PLOTS
GENERATED BY EACH PROGRAM. THIS LOCATION IS MEASURED ON THE
PAPER WITH RESPECT TO THE LEFT GRAPH LIMIT WHICH IS REFERRED TO
AS THE ORIGIN.  EACH PROGRAM WILL REQUEST PEN LOCATION WITH
RESPECT TO THE ORIGIN AS IT REQUIRES IT.
```

**Figure 3.—The "GRAPH MESSAGE" program on the $f_5$ key.**

# SKYLINE PROFILE COMPUTER/PLOTTER/DIGITIZER PROGRAM

This program prepares a terrain profile on the plotter from information on a topographic map mounted on the system's digitizer. The program also prints span and elevation information.

## Description

The program is arranged as a main program and five subprograms recorded on the special function keys.

The main program establishes plot scale, records map scale and contour interval and also provides some operating instructions during execution in either the form of printed messages or requests for input (visual prompters) on the computer display.

The function key program on $f_0$ establishes plotter pen location and a number identification for the profile to be plotted, and calls for the coordinates of the first point on the profile.

The function key programs on $f_1$ through $f_3$ plot uphill, level, or downhill contours. Because a fractional contour is sometimes needed, a program is provided on $f_4$ to handle fractions of a contour interval.

## User Instructions

The following example demonstrates the program operation. Figure 4 is a map contrived to demonstrate all features of the program. The profile shown in figure 5 was produced from the contour map of figure 4.

Preliminary steps:

1. Press STOP and END to prepare for loading a program.
2. Press function key $f_6$ (or **LOAD 2,** EXECUTE).
3. Adjust graph limits on plotter.
4. Mount map on digitizer'surface.

Continue through entries in table 1 which relates the keyboard and digitizer inputs to the visual prompters on the computer display.

## output

This program prepares both plotted and printed output. The plotted results (fig. 5) present the profile of the terrain identified on the map. The horizontal distances and elevations are to the scale specified by the user.

The printed output is shown in figure 6. In addition to the initial entries for map scale and contour interval, the program prints some instructions to familiarize the user with the program operation; for each profile taken from a map, a tabulation of span and elevation for each digitized point is printed. The tabular entries are referenced to the first point in each series. Sections of the profile are labeled to identify uphill, downhill, or level terrain. These instructions are useful during operation of the program for the operator to check the accuracy of his work.

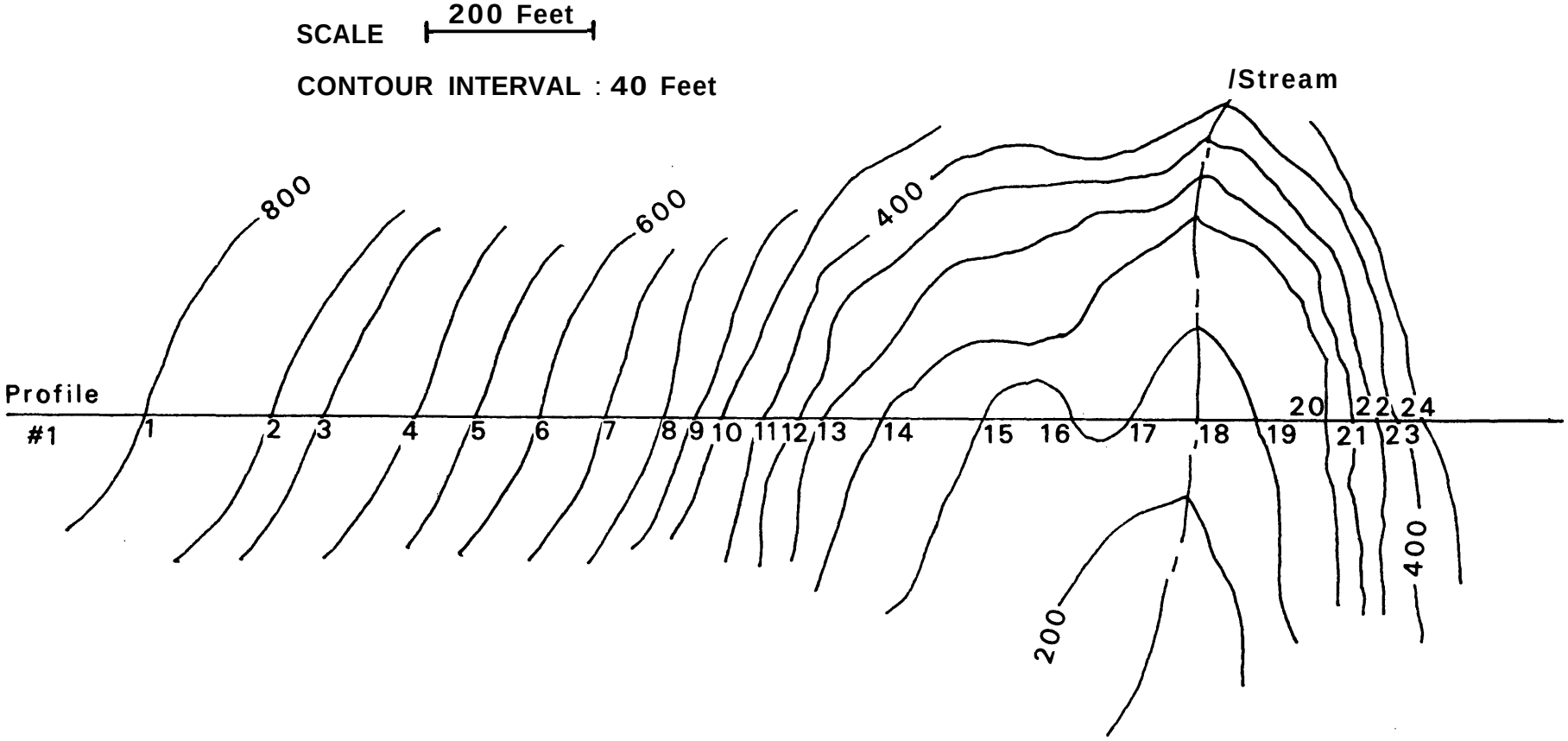



Figure 4.—Contour map.

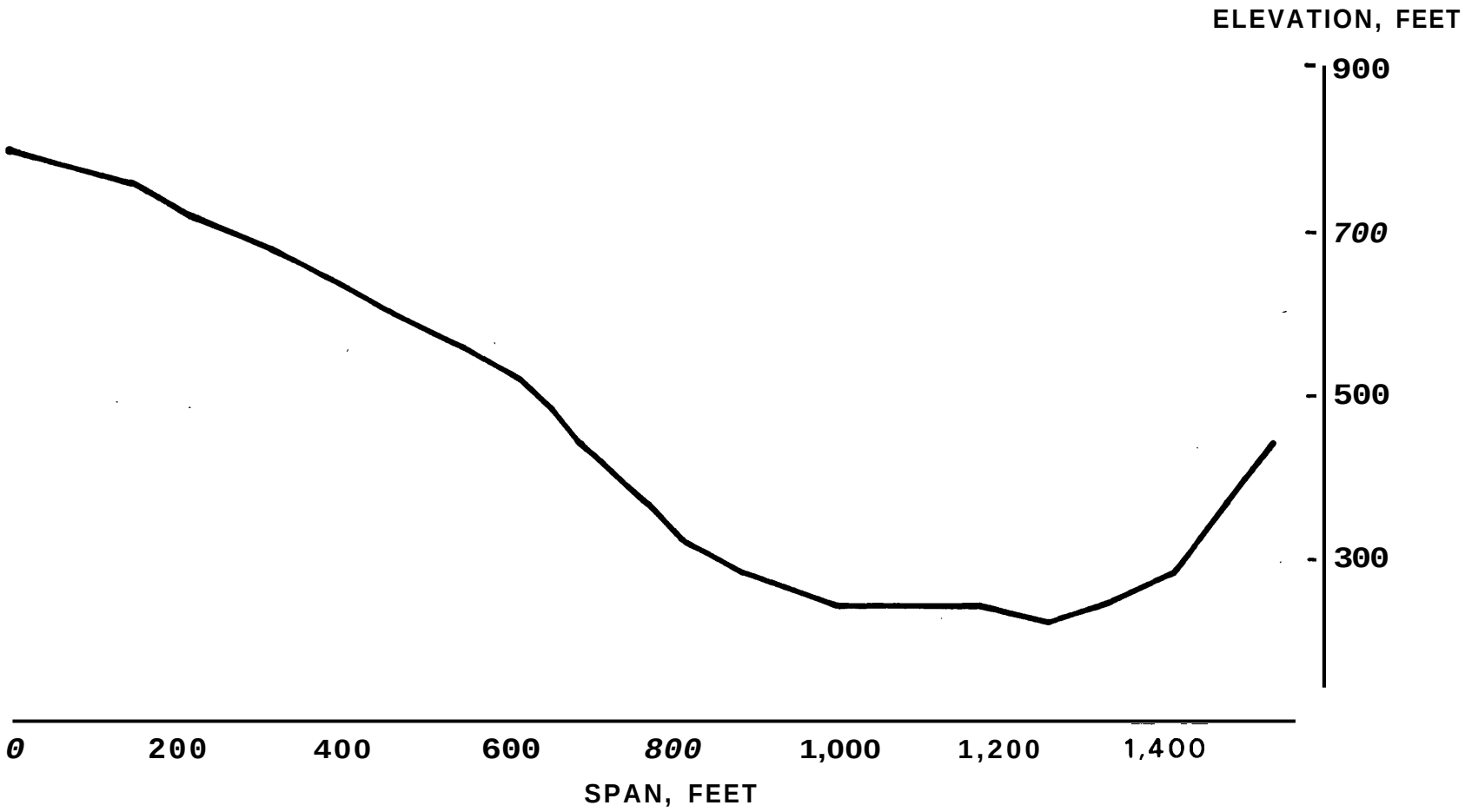



Figure 5.—Terrain profile developed on plotter.

**Table 1.--Input explanation for profile plot example**

| VISUAL PROMPTER ON DISPLAY | KEYBOARD RESPONSE | DESCRIPTION |
|---|---|---|
| HORIZONTAL GRAPH LIMITS (FEET)? | 2000 | Enters scale value for X-axis on plotter. |
| VERTICAL GRAPH LIMITS (FEET)? | 1400 | Enters scale value for Y-axis on plotter. |
| ***MAP*** SCALE (FEET/INCH)? | 200 | Enters scale of the map being used. |
| CONTOUR INTERVAL (FEET)? | 40 | Enters contour interval of the map being used. |
| PRESS - NEW PROFILE-FUNCTION **KEY.** | $f_0$ | Executes program on function key $f_0$. |
| HORZ. DIST.: ORIGIN TO 1ST POINT? | **100** | Enters horizontal distance from origin of the graph paper to the first point on the terrain profile plot. The origin is taken as the lower left graph limits set by the operator. |
| ELEV. DIST.: ORIGIN TO 1ST POINT? | **1100** | Enters the vertical distance from the origin to the first point on the terrain profile plot. |
| PROFILE NUMBER? | 1 | Enters number of profile to be plotted. |
| DIGITIZE FIRST POINT AFTER BEEP. | | (DIGITIZER RESPONSE): Set origin and digitize first point on the profile. |
| SELECT A SLOPE AND PROCEED. | | |
| | $f_3$ | Executes program on function key $f_3$ which anticipates downhill profile. |
| | | (DIGITIZER RESPONSE): Digitize all downhill points (2 through 15). |
| | STOP | |
| | $f_2$ | Executes program on function key $f_2$ which anticipates level profile. |
| | | (DIGITIZER RESPONSE): Digitize level section (points 16 and 17). |
| | STOP | |
| | $f_4$ | Executes program on function key $f_4$ which anticipates fractional contour interval. |
| FRACTION (+FOR UPHILL: -FOR DOWN)? | -.5 | (DIGITIZER RESPONSE): Digitize bottom of stream (point 18). |
| | STOP | |
| | $f_4$ | Executes $f_4$. |
| FRACTION **(+FOR** UPHILL: -FOR DOWN)? | +.5 | (DIGITIZER RESPONSE): Digitize next contour (point 19). |
| | STOP | |
| | $f_1$ | Executes program on function key $f_1$ which anticipates uphill profile. |
| | | (DIGITIZER RESPONSE): Digitize remaining uphill points (points 20 and 24). |
| | STOP | |

```
                    ***PROGRAM TO ENTER AND PLOT PROFILE***

NOTE:GRAPH LIMITS MUST BE ESTABLISHED ON PLOTTER
MAP SCALE = 200  FEET PER INCH
CONTOUR INTERVAL = 40    FEET

    ***SOME INSTRUCTIONS ON OPERATING THE PROGRAM***
          THE OPERATOR HAS 5 FUNCTION KEYS AVAILABLE FOR
        CONTROL OF THE PROGRAM. THESE ARE
          F0:NEW PROFILE - PRESS AT START OF EACH NEW PROFILE.
          F1:UPHILL - USED WHEN DIGITIZING AN UPHILL SECTION.
          F2:LEVEL - USED WHEN DIGITIZING A LEVEL SECTION.
          F3:DOWNHILL - USED WHEN DIGITIZING A DOWNHILL SECTION.
          F4:FRACTIONAL - FOR INCREMENTING A FRACTION OF THE CONTOUR.

          THE RATE OF DIGITIZING IS CONTROLLED BY AN AUDIBLE
        BEEP. AFTER EACH BEEP DIGITIZE A PROFILE POINT.

          FOR EACH NEW PROFILE THE PEN MUST BE LOCATED A DISTANCE
        TO THE RIGHT AND A DISTANCE UP FROM THE LOWER LEFT GRAPH LIMIT.

          TO BEGIN A PROFILE PRESS FUNCTION KEY F0.


PROFILE NUMBER
 POINT          SPAN      ELEV DIFF FROM PT1
                  A              0

                                          DOWNHILL SLOPE
  2               158           -40
  3               326           -80
  4               328           -120
  5               400           -160
  6               476           -200
  7               560           -240
  8               634           -280
  9               676           -320
  10              706           -360
  11              752           -400
  12              796           -440
  13              838           -480
  14              908           -520
  15              1028          -560
                                          LEVEL SLOPE
  16              1136          -560
  17              1206          -560
                                          FRACTIONAL INCREMENT=-20
  18              1286          -580
                                          FRACTIONAL INCREMENT= 20
  19              1356          -560
                                          UPHILL SLOPE
  20              1446          -520
  21              1472          -480
  22              1505          -440
  23              1533          -400
  24              1561          -360
```

**Figure 6.—Printed output from profile program.**

## PROFILE PROGRAM

There are six programs (the main program and five subprograms) in the skyline profile computer/plotter/digitizer program. Each program is relatively simple and, because of the **ASCII BASIC** language, self-explanatory. We include the listings here for those who may want to examine the algorithms or execute the programs on another facility.

LISTING OF MAIN PROFILE PROGRAM

```
10 PRINT TAB20"***PROGRAM TO ENTER AND PLOT PROFILE***"
20 PRINT TAB100"NOTE:GRAPH LIMITS MUST BE ESTABLISHED ON PLOTTER"
30 DISP "HORIZONTAL GRAPH LIMITS(FEET)";
40 INPUT G1
50 DISP "VERTICAL GRAPH LIMITS(FEET)";
60 INPUT G2
70 SCALE 0,G1,0,G2
80 REM ROUTINE TO TAKE PROFILES OFF CONTOUR MAPS
90 REM PROGRAM PRESUMES OPERATOR WILL SET GRAPH LIMITS TO AGREE WITH SCALE
100 FIXED 0
110 DISP "MAP SCALE(FEET/INCH)";
120 INPUT H
130 PRINT "MAP SCALE ="H"FEET PER INCH"
140 DISP "CONTOUR INTERVAL(FEET)";
150 INPUT C
160 PRINT "CONTOUR INTERVAL ="C" FEET"
170 PRINT
180 PRINT TAB3"***SOME INSTRUCTIONS ON OPERATING THE PROGRAM***"
190 PRINT TAB9"THE OPERATOR HAS 5 FUNCTION KEYS AVAILABLE FOR"
200 PRINT TAB8"CONTROL OF THE PROGRAM. THESE ARE"
210 PRINT TAB10"F0:NEW PROFILE - PRESS AT START OF EACH NEW PROFILE."
220 PRINT TAB10"F1:UPHILL - USED WHEN DIGITIZING AN UPHILL SECTION."
230 PRINT TAB10"F2:LEVEL - USED WHEN DIGITIZING A LEVEL SECTION."
240 PRINT TAB10"F3:DOWNHILL - USED WHEN DIGITIZING A DOWNHILL SECTION."
250 PRINT TAB10"F4:FRACTIONAL - FOR INCREMENTING A FRACTION OF THE CONTOUR."
260 PRINT TAB100,TAB9"THE RATE OF DIGITIZING IS CONTROLLED BY AN AUDIBLE"
270 PRINT TAB8"BEEP. AFTER EACH BEEP DIGITIZE A PROFILE POINT."
280 PRINT TAB100,TAB9"FOR EACH NEW PROFILE THE PEN MUST BE LOCATED A DISTANCE"
290 PRINT TAB8"TO THE RIGHT AND A DISTANCE UP FROM THE LOWER LEFT GRAPH LIMIT."
300 PRINT TAB100,TAB9"TO BEGIN A PROFILE PRESS FUNCTION KEY F0."TAB100,TAB100
310 DISP "GOTO -NEW PROFILE- FUNCTION KEY"
320 STOP
330 END
```

PROGRAM on $f_0$ **KEY**

```
10 PEN
20 DISP "HORZ.DIST.:ORIGIN TO 1ST POINT";
30 INPUT X0
40 DISP "ELEV.DIFF.:ORIGIN TO 1ST POINT";
50 INPUT Y0
60 OFFSET X0,Y0
70 PLOT 0,0,-2
80 PLOT 0,0,1
90 DISP "PROFILE NUMBER";
100 INPUT N5
110 CPLOT 0,-2
120 LABEL (4)N5
130 CPLOT 0,3
140 S1=E0=E1=N1=0
150 WRITE (15,160)"PROFILE NUMBER"N5
160 FORMAT F5.0,/," POINT          SPAN      ELEV DIFF FROM PT1"
170 DISP "DIGITIZE 1ST POINT AFTER BEEP"
180 WAIT 3000
190 WRITE (9,4)
200 ENTER (9,4)X1,Y1
210 N1=N1+1
220 PRINT N1,0,0
230 DISP "SELECT A SLOPE AND PROCEED"
240 STOP
250 END
```

PROGRAM on $f_1$ KEY

```
10 A1=1
20 PRINT TAB(40)"UPHILL SLOPE
30 WRITE (9,4)
40 ENTER (9,4)X2,Y2
50 N1=N1+1
60 X=X2-X1
70 Y=Y2-Y1
80 S=SQR(X*X+Y*Y)*H
90 S1=S1+S
100 E1=E1+A1*C
110 E=E1-E0
120 PRINT N1,S1,E
130 PLOT S1,E,2
140 X1=X2
150 Y1=Y2
160 GOTO 30
170 END
```

PROGRAM on $f_2$ **KEY**

```
10 A1=0
20 PRINT TAB40"LEVEL SLOPE"
30 WRITE (9,*)
40 ENTER (9,*)X2,Y2
50 N1=N1+1
60 X=X2-X1
70 Y=Y2-Y1
80 S=SQR(X*X+Y*Y)*H
90 S1=S1+S
100 E1=E1+A1*C
110 E=E1-E0
120 PRINT N1,S1,E
130 PLOT S1,E,2
140 X1=X2
150 Y1=Y2
160 GOTO 30
170 END
```

**PROGRAM on $f_3$ KEY**

```
10 A1=-1
20 PRINT TAB40"DOWNHILL SLOPE"
30 WRITE (9,*)
40 ENTER (9,*)X2,Y2
50 N1=N1+1
60 X=X2-X1
70 Y=Y2-Y1
80 S=SQR(X*X+Y*Y)*H
90 S1=S1+S
100 E1=E1+A1*C
110 E=E1-E0
120 PRINT N1,S1,E
130 PLOT S1,E,2
140 X1=X2
150 Y1=Y2
160 GOTO 30
170 END
```

**PROGRAM on $f_4$ KEY**

```
10 DISP "FRACTION(+FOR UPHILL;-FOR DOWN)";
20 INPUT A1
30 B1=A1*C
40 PRINT TAB40"FRACTIONAL INCREMENT="B1
50 WRITE (9,*)
60 ENTER (9,*)X2,Y2
70 N1=N1+1
80 X=X2-X1
90 Y=Y2-Y1
100 S=SQR(X*X+Y*Y)*H
110 S1=S1+S
120 E1=E1+A1*C
130 E=E1-E0
140 PRINT N1,S1,E
150 PLOT S1,E,2
160 X1=X2
170 Y1=Y2
180 GOTO 50
190 END
```

## SKYLINE PROGRAMS–GENERAL

There are three skyline programs––standing, running, and multispan. Organization and nomenclature are consistent for each program and can be discussed in general terms.

The primary purpose of each program is to develop a load path on the plotter. This load path is compared usually with a terrain profile which may have been generated by the profile program discussed in the previous section. It is important to recognize, however, that the profile may come from any source. The skyline programs operate independently of the terrain. They depend on the operator to describe plot scales and anchor point locations to properly aline the load paths with the profiles. The nomenclature is shown in figure 7.

The instructions for operating each program are an integral part of the program. They rely on the visual prompters that appear during program execution. Therefore, the format used to discuss program operation is the tabular arrangement of visual prompters with definitions and the numerical responses that will lead a user through an example.

The discussion of output is based on the results of the numerical example presented. These discussions describe the information provided by the program; but again, they do not purport to suggest the correct interpretation. Of course, the output information supports the skyline engineering layout task, but it is beyond the scope of this paper to discuss these activities extensively.

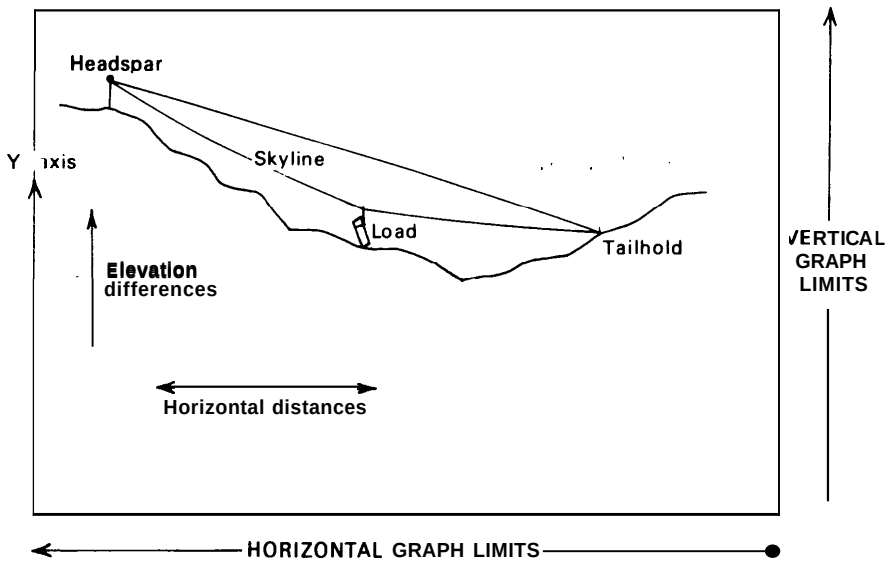



Figure 7.—Nomenclature.

## SINGLE SPAN TIGHT LINE AND SLACKLINE LOAD PATH PROGRAM

This program determines the tensions, loads, and deflections of a single span standing skyline cable configuration (fig. 8). The system consists of a skyline suspended between a headspar and tailhold and a main line which moves a load along the skyline toward the headspar. In two sections of the program ("Equipment Description" and Geometry Description" in table 2), the sizes and relative location of anchoring points of skyline and main line are entered as input. With this information, the program can compute either the load that can be supported at any point (trial load section), or the tensions and deflection resulting from a given line length and load (load path section).

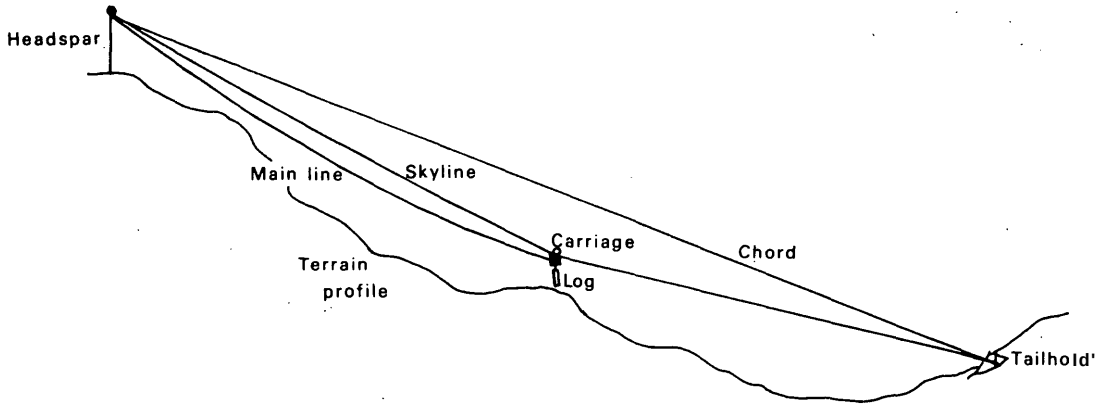



**Figure 8.—Single span standing skyline.**

### User Instructions

The following example demonstrates use of this program: First, load file 1 (i.e., LOADKEY 1, EXECUTE), then continue:

1. Press **STOP** and END to prepare for loading the program.
2. Press function key $f_7$ (or **LOAD 3,** EXECUTE).
3. Adjust graph limits on plotter.
4. Continue with the procedure outlined in table 2 by responding to the visual prompters with the numerical or alphanumeric entries indicated in the middle column. The DESCRIPTIONS should be read for an understanding of the process.

**Table 2.--Input explanation for standing skyline example**

| VISUAL PROMPTER ON DISPLAY | KEYBOARD RESPONSE | DESCRIPTION |
|---|---|---|
| HORIZONTAL GRAPH LIMITS (FEET)? | 2000 | Enters scale value for X-axis on plotter. |
| VERTICAL GRAPH LIMITS (FEET)? | 1400 | Enters scale value for Y-axis on plotter. |
| Equipment description | | |
| SKYLINE SIZE (LB/FOOT)? | 2.89 | Enters weight per foot of skyline. |
| SKYLINE WORKING TENSION (LB)? | 53300 | Enters allowable working tension of skyline. |
| MAIN LINE SIZE (LB/FOOT)? | 1.85 | Enters weight per foot of main line. |
| MAIN LINE WORKING TENSION (LB)? | 34500 | Enters allowable working tension of main line. |
| Geometry description | | |
| CORRIDOR NUMBER? | 1 | Enters number to identify skyline corridor. |
| HORZ. DIST.: HEADSPAR TO TAILHOLD? | 1500 | Enters skyline span. |
| ELEV. DIFF.: HEADSPAR TO TAILHOLD? | 500 | Enters vertical anchor point separation from top of headspar down to top of tailhold. |
| Trial load section | | |
| HORZ. DIST.: HEADSPAR TO LOAD? | 600 | Enters horizontal distance to first trial load location. |
| ELEV. DIFF.: HEADSPAR TO LOAD? | 350 | Enters vertical distance from top of headspar down to carriage location for first trial. |
| HORZ. DIST.: HEADSPAR TO LOAD? | 1200 | Enters horizontal distance to second trial load location. |
| ELEV. DIFF.: HEADSPAR TO LOAD? | 600 | Enters vertical distance from top of headspar down to carriage location for second trial. |
| HORZ. DIST.: HEADSPAR TO LOAD? | 0 | Causes program control to branch to the load path section of program. |
| Load path section | | |
| HORZ. DIST.: ORIGIN TO HEADSPAR? | 100 | Enters horizontal distance from origin to the top of the headspar. The origin is the lower left graph limit set by the operator. |
| ELEV. DIFF.: ORIGIN TO HEADSPAR? | 1200 | Enters vertical distance from origin to top of headspar. |
| TENSION DIAGNOSTIC REQUIRED? | NO | Provides some diagnostics about overstress if desired. If response is no, a plot of the load path is made automatically. |
| NEW LOAD PATH? | YES | Provides an opportunity to compute a load path for another load and line length. |
| LOAD? | 13000 | Enters load to be used for new load path. |
| LINE LENGTH? | 1594 | Enters the unstretched line length to be used for supporting the trial load. |
| TENSION DIAGNOSTIC REQUIRED? | YES | Provides diagnostics about line overstress. |
| DO YOU WANT A PLOT? | YES | Provides a plot of load path. |
| NEW LOAD PATH? | NO | Branches out of load path section. |
| NEW ANCHORING OR CORRIDOR? | NO | Terminates execution. |

## output

This program prepares both plotted and printed output. The plotted results (fig. 9) show the load path of the point of contact between the carriage and the skyline. Two paths are shown. Each path represents the trajectory of a point on the carriage support sheave as it moves over the fixed length of skyline and deflects under the load. The stretch of the skyline due to variable tensions is accounted for. The path is composed of nine points in the span and purposely does not include the anchor points.

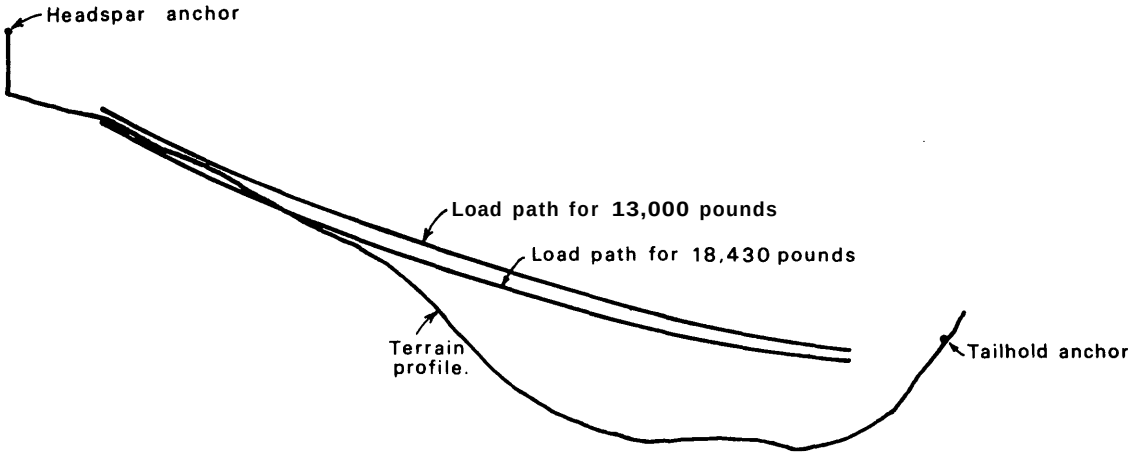



**Figure 9.—Standing skyline plotted results (profile from fig. 5).**

Figure 10 shows a sample of the printed output which summarizes input information and the tensions, line lengths, and forces in addition to the coordinates of points on the load path. Part A represents information that would be prepared while examining individual points in the skyline span for load capability. This part of the program, which provides load and line length from specified deflections, could be used to assess the capabilities of slack skyline. Part B, which gives the deflections and tensions associated with a fixed load and line length, could be used to investigate the potential for a tight skyline configuration.

```
                    ***STANDING SKYLINE PROGRAM***
SALE IDENTIFICATION- EXAMPLE #2
        EQUIPMENT DESCRIPTION.
              SKYLINE SIZE 2.89    POUNDS PER FOOT
              ALLOWABLE WORKING TENSION FOR SKYLINE 53300   POUNDS
              MAIN LINE SIZE 1.85    POUNDS PER FOOT
              MAIN LINE ALLOWABLE WORKING TENSION= 34500   POUNDS


 CORRIDOR NUMBER- 1
    HORIZONTAL DISTANCE FROM HEADSPAR TO TAILHOLD= 1500    FEET
    ELEVATION DIFFERENCE FROM HEADSPAR TO TAILHOLD= 500  FEET

 ---PART A : TRIAL LOAD LOCATIONS AND DEFLECTIONS.
    TRIAL LOAD LOCATED AT 600   WITH ELEVATION FROM HEADSPAR OF 350
          THE WEIGHT OF THE CARRIAGE PLUS LOAD 18430   POUNDS
          LENGTH OF THE SKYLINE BETWEEN SUPPORTS 1604.283   FEET

    TRIAL LOAD LOCATED AT 1200     WITH ELEVATION FROM HEADSPAR OF 600
          THE WEIGHT OF THE CARRIAGE PLUS LOAD 37243   POUNDS
          LENGTH OF THE SKYLINE BETWEEN SUPPORTS 1655.152   FEET


 ---PART B : LOAD PATH COORDINATES FOR LOAD OF 16430
            POUNDS AND AN UNSTRETCHED LINE LENGTH OF 1604.283   FEET.
   -DIST.:HEADSPAR TO LOAD-       -LINE TENSIONS-
     HORZ.      VERT.          MAIN LINE      SKYLINE AT HEADSPAR
      150        146            10008          31412
      300        225            8533           42645
      450        291            7672           49435
      600        350            7004           53418   *
      750        401            6393           55204   *
      900        446            5756           54948   *
      1050       485            5000           52295
      1200       516            3968           47155
      1350       534            2373           37832
      1500           END OF SPAN

 ---PART B : LOAD PATH COORDINATES FOR LOAD OF 13000
            POUNDS AND AN UNSTRETCHED LINE LENGTH OF 1594.000   FEET.
   -DIST.:HEADSPAR TO LOAD-       -LINE TENSIONS-
     HORZ.      VERT.          MAIN LINE      SKYLINE AT HEADSPAR
      150        121            6568           31678
      300        195            5782           41932
      450        259            5343           48071
      600        315            5008           52098
      750        367            4712           53549   *
      900        414            4405           53309   *
      1050       455            4033           50577
      1200       489            3524           45760
      1350       514            2652           36651
      1500           END OF SPAN
       DIAGNOSTIC OUTPUT ON SKYLINE OVERSTRESS
              *LOCATIONS WHERE SAFE SKYLINE TENSIONS WERE EXCEEDED

             DIST. OUT      T-MAX AT       LOAD WHICH WOULD
                            LEFT ANCHOR    PREVENT OVERSTRESS
              750            53549          12923
              900            53309          12997
```



**Figure 10.—Printed output from standing skyline program.**

## LISTING OF THE STANDING SKYLINE PROGRAM

```
10 REM PROGRAM TO AID IN THE LAYOUT OF STANDING SKYLINES.
20 DIM T$[30]
30 PRINT TAB100"NOTE:GRAPH LIMITS MUST BE ESTABLISHED ON PLOTTER."
40 DISP "HORIZONTAL GRAPH LIMITS(FEET)";
50 INPUT G1
60 DISP "VERTICAL GRAPH LIMITS(FEET)";
70 INPUT G2
80 SCALE 0,G1,0,G2
90 PLOT 0,0,1
100 PRINT TAB20"***STANDING SKYLINE PROGRAM***"
110 DISP "SALE IDENTIFICATION";
120 INPUT T$
130 PRINT "SALE IDENTIFICATION- "T$
140 REM***INPUT***
150 PRINT TAB9"EQUIPMENT DESCRIPTION."
160 DISP "SKYLINE SIZE(LB/FOOT)";
170 INPUT W1
180 PRINT TAB15"SKYLINE SIZE"W1"POUNDS PER FOOT"
190 DISP "SKYLINE WORKING TENSION(LB)";
200 INPUT T
210 PRINT TAB15"ALLOWABLE WORKING TENSION FOR SKYLINE"T"POUNDS"
220 DISP "MAIN LINE SIZE(LB/FOOT)";
230 INPUT W3
240 PRINT TAB15"MAIN LINE SIZE"W3"POUNDS PER FOOT"
250 DISP "MAIN LINE WORKING TENSION(LB)";
260 INPUT T5
270 PRINT TAB15"MAIN LINE ALLOWABLE WORKING TENSION="T5"POUNDS"
280 PRINT TAB100
290 DISP "CORRIDOR NUMBER";
300 INPUT T$
310 PRINT " CORRIDOR NUMBER- "T$
320 DISP "HORZ.DIST.:HEADSPAR TO TAILHOLD";
330 INPUT L
340 PRINT TAB4"HORIZONTAL DISTANCE FROM HEADSPAR TO TAILHOLD="L"FEET"
350 DISP "ELEV.DIFF.:HEADSPAR TO TAILHOLD";
360 INPUT H
370 IF H>0 THEN 400
380 DISP "MUST BE POSITIVE(I.E.DOWNHILL)";
390 INPUT H
400 PRINT TAB4"ELEVATION DIFFERENCE FROM HEADSPAR TO TAILHOLD="H"FEET"
410 E0=W=1000000
420 E1=3500000
430 REM***TRIALS OF LOAD POINTS.
440 PRINT TAB100," ---PART A : TRIAL LOAD LOCATIONS AND DEFLECTIONS."
450 DISP "HORZ.DIST.:HEADSPAR TO LOAD";
460 INPUT D1
470 IF D1=0 THEN 730
480 DISP "ELEV.DIFF.:HEADSPAR TO LOAD";
490 INPUT Y1
```

```
500 FIXED 0
510 PRINT TAB4"TRIAL LOAD LOCATED AT"D1" WITH ELEVATION FROM HEADSPAR OF"Y1
520 N=0
530 GOSUB 1440
540 S=S1+S2
550 PRINT TAB10"THE WEIGHT OF THE CARRIAGE PLUS LOAD"F1;"POUNDS"
560 FIXED 3
570 IF F1>0 THEN 590
580 PRINT "!!!!!NOTE!!!!!:NEGATIVE LOADS NOT ALLOWED. TRY NEW LOAD ARRANGEMENT."
590 PRINT TAB10"LENGTH OF THE SKYLINE BETWEEN SUPPORTS"S;"FEET"
600 PRINT
610 REM***GET MINIMUM LOAD AND LINE LENGTH.
620 W0=F1
630 IF W0>W THEN 670
640 IF F1<0 THEN 710
650 S0=S
660 W=W0
670 Y2=D1*H/L
680 E2=(Y1-Y2)/L
690 IF E2>E0 THEN 710
700 E0=E2
710 GOTO 450
720 REM*****************LOAD PATH PORTION OF PROGRAM**********************
730 I=J=K=I7=I8=I9=N=0
740 F1=W
750 S=S0
760 FIXED 0
770 PRINT TAB100," ---PART B : LOAD PATH COORDINATES FOR LOAD OF"F1
780 FIXED 3
790 PRINT TAB11" POUNDS AND AN UNSTRETCHED LINE LENGTH OF"S"FEET."
800 DISP "HORZ.DIST.:ORIGIN TO HEADSPAR";
810 INPUT X0
820 DISP "ELEV.DIFF.:ORIGIN TO HEADSPAR";
830 INPUT Y0
840 OFFSET X0,Y0
850 PLOT 0,0,1
860 PRINT "   -DIST.:HEADSPAR TO LOAD-        -LINE TENSIONS-"
870 PRINT "      HORZ.      VERT. ","MAIN LINE","SKYLINE AT HEADSPAR"
880 N=N+1
890 FIXED 0
900 D1=N/10*L
910 IF N=10 THEN 1340
920 Y1=D1*H/L+L*E0*3/4
930 Y4=Y1
940 GOSUB 1440
950 S4=S-(S1+S2)
960 IF ABS(S4)<S/10000 THEN 1000
970 Y5=Y1+L*E0/2
980 Y1=Y5
990 GOSUB 1020
```

```
1000 K=K+1
1010 M[K]=D1
1020 N[K]=Y1
1030 IF INT(H3)<0 THEN 1100
1040 T4=T1+W1*Y1
1050 T6=T3+W3*Y1
1060 IF INT(T4)>T THEN 1120
1070 IF INT(T6)>T5 THEN 1230
1080 PRINT TAB5,D1,Y1,T6,T4
1090 GOTO 880
1100 PRINT TAB5,D1,Y1,"H3="H3,T1;"HAULBACK REQ'D"
1110 GOTO 880
1120 PRINT TAB5,D1,Y1,T6,T4"*"
1130 I8=1
1140 K1=R2*(Y1-H)/(2*(L-D1))
1150 K2=((Y1-H)/(L-D1))↑2+1
1160 H2=(K1+SQR(K1↑2-K2*(((R2/2)↑2)-(T-W1*Y1)↑2)))/K2
1170 F2=H2*((Y1/D1)+(Y1-H)/(L-D1))-(R1+R2+R3)/2
1180 I=I+1
1190 A[I]=D1
1200 B[I]=T4
1210 C[I]=F2
1220 GOTO 880
1230 PRINT TAB5,D1,Y1,T6"**",T4
1240 I9=1
1250 B7=R3/2*(Y1/D1)
1260 B8=SQR(B7↑2-(1+(Y1/D1)↑2)*((R3/2)↑2-(T5-W3*Y1)↑2))
1270 H4=(B7+B8)/(1+(Y1/D1)↑2)
1280 F3=F1*H4/H3
1290 J=J+1
1300 E[J]=D1
1310 F[J]=T6
1320 G[J]=F3
1330 GOTO 880
1340 PRINT TAB5,L,TAB20"END OF SPAN"
1350 IF (I8+I9)=0 THEN 1430
1360 DISP "TENSION DIAGNOSTICS REQUIRED";
1370 INPUT T$
1380 IF T$="NO" THEN 1430
1390 GOSUB 2020
1400 DISP "DO YOU WANT A PLOT";
1410 INPUT T$
1420 IF T$="NO" THEN 2360
1430 GOTO 2270
1440 REM***SUB1***DETERMINES RELATIONSHIP BETWEEN GEOMETRY,LOAD,AND TENSION.
1450 R1=SQR(D1↑2+Y1↑2)*W1
1460 R2=SQR((L-D1)↑2+(Y1-H)↑2)*W1
1470 R3=SQR(D1↑2+Y1↑2)*W3
1480 B1=R1*Y1/2/D1
1490 B2=(Y1/D1)↑2+1
```

```
1500 IF N#0 THEN 1550
1510 B4=R2/2*(Y1-H)/(L-D1)
1520 B5=((Y1-H)/(L-D1))↑2+1
1530 GOSUB 1670
1540 GOTO 1560
1550 GOSUB 1740
1560 D0=D1*W1/2/H1
1570 A2=(EXP(D0)-EXP(-D0))/2
1580 A3=SQR(Y1↑2+((2*H1/W1)*A2)↑2)
1590 D3=1+1/3*D0↑2-1/45*D0↑4+2/945*D0↑6
1600 S1=A3-H1/(E1*W1↑2)*(1+(1+(Y1/A3)↑2)*D3/(D1/A3)↑2)*D1/2
1610 D0=(L-D1)*W1/2/H2
1620 A5=(EXP(D0)-EXP(-D0))/2
1630 A6=SQR((Y1-H)↑2+((2*H2/W1)*A5)↑2)
1640 D3=1+1/3*D0↑2-1/45*D0↑4+2/945*D0↑6
1650 S2=A6-H2/(E1*W1↑2)*(1+(1+((Y1-H)/A6)↑2)*D3/((L-D1)/A6)↑2)*(L-D1)/2
1660 RETURN
1670 REM***SUB2***DETERMINES LOAD FROM GEOMETRY AND TENSION.
1680 B3=(R1/2)↑2-(T-W1*Y1)↑2
1690 H1=(B1+SQR(B1↑2-B2*B3))/B2
1700 B6=(R2/2)↑2-(T-W1*Y1)↑2
1710 H2=(B4+SQR(B4↑2-B5*B6))/B5
1720 F1=H2*(Y1/D1+(Y1-H)/(L-D1))-(R1+R2+R3)/2
1730 RETURN
1740 REM***SUB3***DETERMINES TENSIONS FROM LOAD AND GEOMETRY.
1750 H2=(F1+(R1+R2+R3)/2)/(Y1/D1+(Y1-H)/(L-D1))
1760 T1=SQR((H2*(Y1-H)/(L-D1)-R2/2)↑2+H2↑2)
1770 B3=(R1/2)↑2-T1↑2
1780 H1=(B1+SQR(B1↑2-B2*B3))/B2
1790 H3=H2-H1
1800 T3=SQR(H3↑2*B2-H3*R3*Y1/D1+(R3/2)↑2)
1810 RETURN
1820 REM***SUB4***ITERATION FOR DEFLECTION WITH SECANT METHOD
1830 N9=1
1840 GOSUB 1440
1850 S5=S0-(S1+S2)
1860 IF ABS(S5)<0.2 THEN 2010
1870 D9=(Y5-Y4)*S5/(S5-S4)
1880 Y4=Y5
1890 Y5=Y5-D9
1900 IF Y5>0 THEN 1950
1910 N9=N9+1
1920 Y5=Y5+D9
1930 D9=D9/2
1940 GOTO 1890
1950 Y1=Y5
1960 S4=S5
1970 DISP "POINT"N;"ITERATION"N9
1980 N9=N9+1
1990 IF N9<20 THEN 1840
```

```
2000 PRINT "CONVERGENCE PROBLEM IN DEFLECTION ROUTINE AT D1="D1
2010 RETURN
2020 REM***SUB5***PRINTS OUT DIAGNOSTICS ABOUT OVERTENSIONS UPON REQUEST.
2030 IF I8=0 THEN 2140
2040 I7=1
2050 PRINT TAB7"DIAGNOSTIC OUTPUT ON SKYLINE OVERSTRESS"
2060 PRINT TAB18;"*LOCATIONS WHERE SAFE SKYLINE TENSIONS WERE EXCEEDED"
2070 PRINT
2080 PRINT TAB15;"DIST. OUT";"T-MAX AT";"LOAD WHICH WOULD"
2090 PRINT TAB30"LEFT ANCHOR";"PREVENT OVERSTRESS"
2100 Z=I
2110 FOR I=1 TO Z
2120 PRINT TAB15;A[I],B[I],C[I]
2130 NEXT I
2140 IF I9=0 THEN 2250
2150 I7=1
2160 PRINT TAB7"DIAGNOSTIC OUTPUT FOR MAIN LINE OVERSTRESS"
2170 PRINT TAB17;"**LOCATIONS WHERE SAFE MAIN LINE TENSIONS WERE EXCEEDED"
2180 PRINT
2190 PRINT TAB15;"DIST. OUT";"T-MAX AT";"LOAD WHICH WOULD"
2200 PRINT TAB30"LEFT ANCHOR";"PREVENT OVERSTRESS"
2210 V=J
2220 FOR J=1 TO V
2230 PRINT TAB15;E[J],F[J],G[J]
2240 NEXT J
2250 PRINT TAB100;TAB100
2260 RETURN
2270 REM***PLOT OF LOAD PATH.
2280 PLOT 0,0,-2
2290 PLOT 0,0,1
2300 FOR K=1 TO 9
2310 PLOT M[K],-N[K],-2
2320 NEXT K
2330 PLOT L,-H,1
2340 PLOT L,-H,2
2350 PEN
2360 DISP "NEW LOAD PATH";
2370 INPUT T$
2380 IF T$#"YES" THEN 2510
2390 DISP "LOAD";
2400 INPUT W
2410 DISP "LINE LENGTH";
2420 INPUT S0
2430 I=J=K=I7=I8=I9=N=0
2440 F1=W
2450 S=S0
2460 FIXED 0
2470 PRINT TAB100," ---PART B : LOAD PATH COORDINATES FOR LOAD OF"F1
2480 FIXED 3
2490 PRINT TAB11" POUNDS AND AN UNSTRETCHED LINE LENGTH OF"S"FEET."
2500 GOTO 850
2510 DISP "NEW ANCHORING OR CORRIDOR";
2520 INPUT T$
2530 IF T$#"NO" THEN 280
2540 END
```

## RUNNING SKYLINE LOAD PATH PROGRAM

This program determines tensions, loads, and deflections of a running skyline cable configuration (fig. 11). The system consists of a haulback, which serves also as the skyline, and a main line and slack-pulling line. In two sections of the program ("Equipment Description" and "Geometry Description" in table 3), the sizes and relative location of anchoring points for these lines are entered as input. The operating tension of the haulback, which is assumed to be nearly constant during yarding, is entered also. With this information, the program can compute either the path of a load held free of the ground or the path of a load with one end supported by the ground. For the log-dragging situation, the user must also specify the angle of drag (see fig. 12) and the friction coefficient between the log and the ground. The information provided by the program can be used in judging the capabilities of the running skyline.

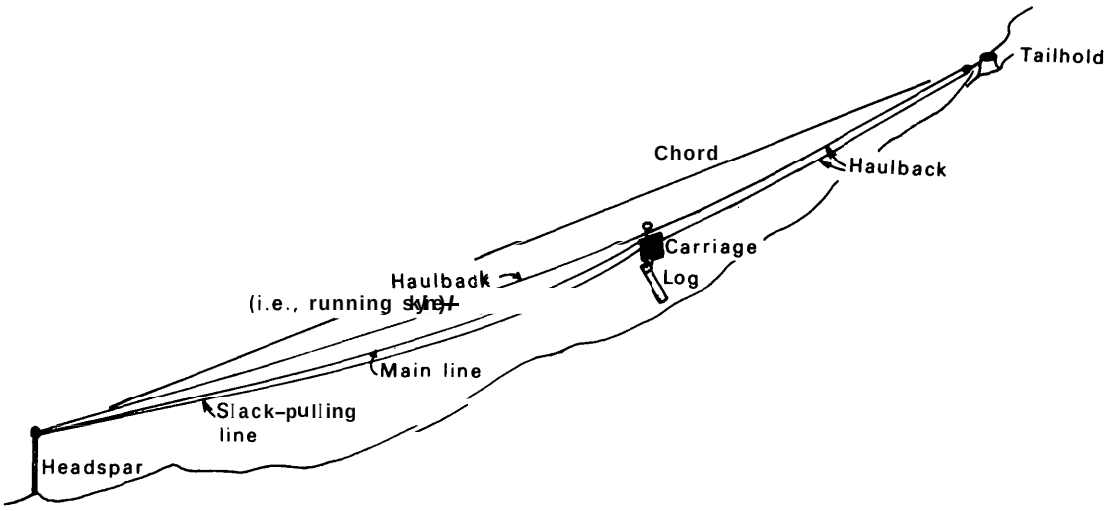



**Figure 11.—Running skyline.**

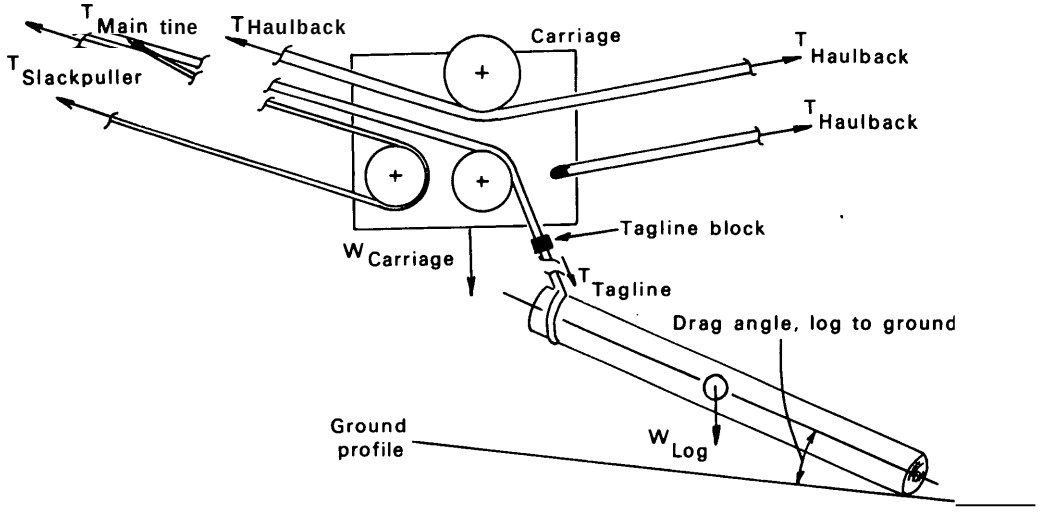



**Figure 12.—Running skyline carriage configuration.**

## User Instructions

The following example demonstrates use of this program. The first step is to load file 1 (i.e., LOADKEY 1, EXECUTE) and then continue through the following procedure:

1. Press **STOP** and END to prepare for loading the program.
2. Press function key $f_8$ (or LOAD 4, EXECUTE).
3. Adjust graph limits on plotter.
4. Continue with the procedure outlined in table 3 by responding to the visual prompters with the numerical or alphanumeric entries indicated in the middle column. The DESCRIPTIONS should be read for an understanding of the process.

**Table 3.--Input explanation for running skyline example**

| VISUAL PROMPTER ON DISPLAY | KEYBOARD RESPONSE | DESCRIPTION |
|---|---|---|
| HORIZONTAL GRAPH LIMITS (FEET)? | 2000 | Enters scale value for X-axis on plotter. |
| VERTICAL GRAPH LIMITS (FEET)? | 1400 | Enters scale value for Y-axis on plotter. |
| Equipment description | | |
| HAULBACK WEIGHT (LB/FOOT)? | 1.04 | Enters weight per foot of the haulback (i.e., the running skyline). |
| HAULBACK WORKING TENSION (LB)? | 19600 | Enters the tension held in the haulback line by the interlock mechanism. |
| MAIN + SLACKLINE WEIGHT (LB/FOOT)? | 1.44 | Enters the combined weight of the main and slack-pulling lines. |
| CARRIAGE WEIGHT (LB)? | 1200 | Enters the carriage weight. |
| Geometry description | | |
| CORRIDOR NUMBER? | 3 | Enters number to identify skyline corridor. |
| HORZ. DIST.: HEADSPAR TO TAILHOLD? | 1500 | Enters skyline span. |
| ELEV. DIFF.: HEADSPAR TO TAILHOLD? | -600 | Enters vertical anchor point separation from top of headspar down to top of tailhold. |
| Load path section | | |
| HORZ. DIST.: ORIGIN TO HEADSPAR? | 100 | Enters horizontal distance from origin to the top of the headspar. The origin is the lower left graph limits set by the operator. |
| ELEV. DIFF.: ORIGIN TO HEADSPAR? | *400* | Enters vertical distance from origin to top of the headspar. |
| ANTICIPATED LOAD SIZE (POUNDS)? | 10000 | Enters trial load value. |
| LOG DRAGGING (RESPOND YES OR NO)? | NO | Indicates the load path will be computed for the load suspended free of the ground. |
| DO YOU WANT A PLOT? | YES | Will provide a plot of the load path. |
| TRY ANOTHER PAYLOAD? | YES | Provides an opportunity to compute a load path for another load arrangement. |
| ANTICIPATED LOAD SIZE (POUNDS)? | 10000 | Enters trial load value. |
| LOG DRAGGING (RESPOND YES OR NO)? | YES | Indicates the load path will be computed for one end of the log dragging on the ground. |
| DRAG ANGLE, LOG TO GROUND (DEGS.)? | 20 | The angle the log makes with the ground in degrees (see fig. 12). |
| COEFFICIENT OF FRICTION? | 0.6 | The coefficient of friction between the ground and the dragging log. |
| DO YOU WANT A PLOT? | YES | Will provide a plot of the load path. |
| TRY ANOTHER PAYLOAD? | NO | Terminates computation on this configuration. |

## output

This program prepares both plotted and printed output. The plotted results (fig. **13)** show the load path of the point of contact between the haulback (running skyline) and the carriage. Two paths are shown in figure **13,** one for a log dragging situation, the other for the log load carried free of the ground. Each represents a trajectory of the carriage–skyline contact point as the load is moved from tailhold to headspar.

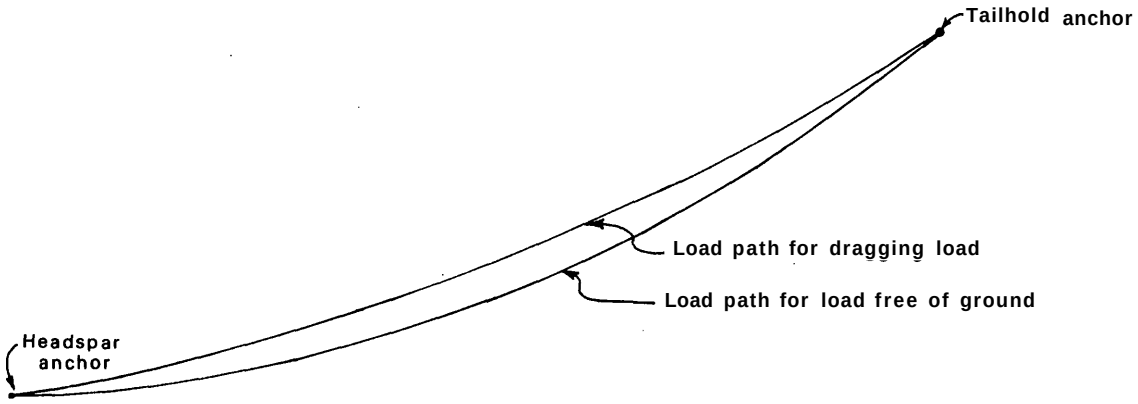



**Figure 13.—Plotted results for running skyline (no profile shown).**

Figure **14** shows the printed output which summarizes input information, line tensions, and forces in addition to the coordinates of points on the load path. There are four columns of line tension information for each load path point. Figure 12 shows the carriage configuration that was assumed to compute these tensions. Actually, the TAGLINE tension and the MAIN+SLACK tensions are independent of this specific configuration; however, the last two columns report special cases that may arise in the carriage shown. The MIN. MAIN tension would occur if the tagline block were not against the carriage and the slack-pulling line was tensioned to pick up a share of the MAIN+SLACK tension requirement. The amount it would share is in the last column, MAX. SLACK. The other likely operating mode is for the tagline block to be against the carriage, in which case the main line would carry the majority of the load up to a **maximum** of the MAIN+SLACK amount. Therefore the tensions in the printed output provide the extremes that could be encountered.

```
                    ***RUNNING SKYLINE PROGRAM***
SALE IDENTIFICATION- EXAMPLE #3

DESCRIBE THE EQUIPMENT.


     HAULBACK WEIGHT PER FOOT  1.04    POUNDS/FOOT
     ALLOWABLE WORKING TENSION FOR HAULBACK  19600   POUNDS
     WEIGHT OF MAIN PLUS SLACK-PULLING LINE 1.44    POUNDS/FOOT
     WEIGHT OF CARRIAGE 1200    POUNDS

CORRIDOR NUMBER 3
     HEADSPAR AND TAILHOLD ANCHOR SPAN 1500    FEET
     HEADSPAR TO TAILHOLD VERTICAL SEPARATION-600  FEET
     ANTICIPATED SIZE OF LOAD 10000   POUNDS    FREE OF GROUND
   LOAD PATH COORDINATES AND LINE TENSIONS
*DIST.:HEADSPAR TO LOAD*                    *LINE TENSIONS*
    HORZ.      VERT.            TAGLINE    MAIN+SLACK  MIN.MAIN  MAX.SLACK
     150        -12              10000       17039       13519       3519
     300        -34              10000       16699       13350       3350
     450        -65              10000       16380       13190       3190
     600       -106              10000       16081       13040       3040
     750       -158              10000       15804       12902       2902
     900       -221              10000       15553       12776       2776
    1050       -296              10000       15328       12664       2664
    1200       -383              10000       15132       12566       2566
    1350       -484              10000       14969       12484       2484
    1500       -600         TAILHOLD LOCATION
     ANTICIPATED SIZE OF LOAD 10000.00   POUNDS    DRAGGING
     DESIRED ANGLE OF LOG LOAD WITH RESPECT TO GROUND 20.00   DEGREES
     COEFFICIENT OF FRICTION 0.60
   LOAD PATH COORDINATES AND LINE TENSIONS
*DIST.:HEADSPAR TO LOAD*                    *LINE TENSIONS*
    HORZ.      VERT.            TAGLINE    MAIN+SLACK  MIN.MAIN  MAX.SLACK
     150        -30              5176        19031       12104       6928
     300        -66              5126        18860       11993       6867
     450       -109              5083        18701       11892       6809
     600       -158              5045        18554       11800       6755
     750       -213              5014        18421       11718       6703
     900       -276              4991        18300       11646       6655
    1050       -346              4976        18194       11585       6609
    1200       -423              4969        18102       11536       6566
    1350       -508              4972        18025       11499       6527
    1500       -600         TAILHOLD LOCATION
```

**Figure 14.—Printed output from the running skyline program.**

LISTING OF **THE** RUNNING **SKYLINE** PROGRAM

```
10 REM PROGRAM TO AID IN THE LAYOUT OF A RUNNING SKYLINE.
20 DIM T$[30]
30 PRINT TAB100"NOTE:GRAPH LIMITS MUST BE ESTABLISHED ON THE PLOTTER"
40 DISP "HORIZONTAL GRAPH LIMITS(FEET)";
50 INPUT G1
60 DISP "VERTICAL GRAPH LIMITS(FEET)";
70 INPUT G2
80 SCALE 0,G1,0,G2
90 PLOT 0,0,1
100 PRINT TAB20"***RUNNING SKYLINE PROGRAM***"
110 DISP "SALE IDENTIFICATION";
120 INPUT T$
130 PRINT "SALE IDENTIFICATION- "T$
140 PRINT TAB100"DESCRIBE THE EQUIPMENT."TAB100,TAB100
150 DISP "HAULBACK WEIGHT (LB/FOOT)";
160 INPUT W1
170 W2=W1
180 PRINT TAB5"HAULBACK WEIGHT PER FOOT "W1;"POUNDS/FOOT"
190 DISP "HAULBACK WORKING TENSION(LB)";
200 INPUT T
210 PRINT TAB5"ALLOWABLE WORKING TENSION FOR HAULBACK "T;"POUNDS"
220 DISP "MAIN+SLACKLINE WEIGHT(LB/FOOT)";
230 INPUT W3
240 PRINT TAB5"WEIGHT OF MAIN PLUS SLACK-PULLING LINE"W3;"POUNDS/FOOT"
250 DISP "CARRIAGE WEIGHT(LB)";
260 INPUT W6
270 PRINT TAB5"WEIGHT OF CARRIAGE"W6;"POUNDS",TAB100
280 DISP "CORRIDOR NUMBER";
290 INPUT T$
300 PRINT "CORRIDOR NUMBER "T$
310 DISP "HORZ.DIST.:HEADSPAR TO TAILHOLD";
320 INPUT L
330 PRINT TAB5"HEADSPAR AND TAILHOLD ANCHOR SPAN"L"FEET"
340 DISP "ELEV.DIFF.:HEADSPAR TO TAILHOLD";
350 INPUT H
360 PRINT TAB5"HEADSPAR TO TAILHOLD VERTICAL SEPARATION"H"FEET"
370 DISP "HORZ.DIST.:ORIGIN TO HEADSPAR";
380 INPUT X0
390 DISP "ELEV.DIFF.:ORIGIN TO HEADSPAR";
400 INPUT Y0
410 OFFSET X0,Y0
420 PLOT 0,0,-2
430 DEG
440 DISP "ANTICIPATED LOAD SIZE(POUNDS)";
450 INPUT W
460 DISP "LOG DRAGGING(RESPOND YES OR NO)";
470 INPUT T$
480 IF T$="YES" THEN 520
490 I1=0
```

```
500 PRINT TAB5"ANTICIPATED SIZE OF LOAD"W;"POUNDS    FREE OF GROUND"
510 GOTO 600
520 PRINT TAB5"ANTICIPATED SIZE OF LOAD"W;"POUNDS    DRAGGING"
530 I1=1
540 DISP "DRAG ANGLE,LOG TO GROUND(DEGS.)";
550 INPUT B1
560 PRINT TAB5"DESIRED ANGLE OF LOG LOAD WITH RESPECT TO GROUND"B1;"DEGREES"
570 DISP "COEFFICIENT OF FRICTION";
580 INPUT M1
590 PRINT TAB5"COEFFICIENT OF FRICTION"M1
600 PRINT "   LOAD PATH COORDINATES AND LINE TENSIONS"
610 PRINT "*DIST.:HEADSPAR TO LOAD*                    *LINE TENSIONS* "
620 PRINT "    HORZ.     VERT.",TAB5,"TAGLINE    MAIN+SLACK  MIN.MAIN  MAX.SLACK
630 E1=2
640 REM LOOP FOR CARRIAGE POSITION
650 N=I=0
660 N=N+1
670 D1=L*N/10
680 REM LOOP FOR DEFLECTIONS
690 REM INITIAL GUESS
700 H2=T*L/SQR(H↑2+L↑2)
710 REM CONVENIENT GUESS AT Y1
720 Y1=H/L*D1
730 R1=W1*SQR(Y1↑2+D1↑2)
740 R3=W3*SQR(Y1↑2+D1↑2)
750 R2=W2*SQR((Y1-H)↑2+(L-D1)↑2)
760 R4=R1+R3+2*R2
770 GOTO 910
780 Y1=(W4+W6+2*H2*H/(L-D1)+R4/2)/(W5/D1+2*H2/(L-D1)+2*H2/D1)
790 F1=SQR(H2↑2*(1+((Y1-H)/(L-D1))↑2)+H2*R2*(Y1-H)/(L-D1)+R2↑2/4)
800 F3=ABS(T-W1*Y1-F1)
810 IF F3<0.01 THEN 860
820 F2=(T-W1*Y1)/F1*H2
830 FIXED 2
840 H2=F2
850 GOTO 730
860 FIXED 2
870 GOSUB 1050
880 WRITE (15,890)D1,Y1,T5,T3,T6,T7
890 FORMAT F8.0,F10.0,7X,2F11.0,3X,F9.0,F10.0
900 GOTO 1130
910 REM AN ESTIMATE OF GROUND ANGLE BASED ON DEFLECTION GEOMETRY IS MADE.
920 A1=0.5*(Y1/D1-(Y1-H)/(L-D1))*180/3.14159
930 C1=COS(A1)
940 S1=SIN(A1)
950 IF I1=1 THEN 1000
960 REM THE LOAD SUSPENDED OPTION.
970 W4=W
980 W5=0
990 GOTO 1030
```

```
1000 N2=TAN(B1)
1010 W4=W*(1-(C1-S1*N2)/E1/(1+M1*N2)*(C1-M1*S1))
1020 W5=W*(C1-S1*N2)/E1/(1+M1*N2)*(S1+M1*C1)
1030 T5=SQR(W4↑2+W5↑2)
1040 GOTO 780
1050 REM COMPUTING COMBINED MAIN AND SLACK-PULLING LINE TENSIONS.
1060 A1=(R1*Y1/D1)↑2-4*(1+(Y1/D1)↑2)*(R1*R1/4-T↑2)
1070 H1=(R1*Y1/D1+SQR(A1))/2/(1+(Y1/D1)↑2)
1080 H3=2*H2+W5-H1
1090 T3=SQR(H3↑2+(H3*Y1/D1)↑2-H3*Y1/D1*R3+R3*R3/4)
1100 T6=(T3+T5)/2
1110 T7=(T3-T5)/2
1120 RETURN
1130 I=I+1
1140 M[I]=D1
1150 N[I]=Y1
1160 IF N<9 THEN 660
1170 WRITE (15,890)L,H," TAILHOLD LOCATION"
1180 DISP "DO YOU WANT A PLOT";
1190 INPUT T$
1200 IF T$="NO" THEN 1270
1210 PLOT 0,0,-2
1220 FOR K=1 TO 9
1230 PLOT M[K],-N[K],-2
1240 NEXT K
1250 PLOT L,-H,2
1260 PEN
1270 DISP "TRY ANOTHER PAYLOAD";
1280 INPUT T$
1290 IF T$="YES" THEN 440
1300 PRINT TAB100,TAB25"***************NEW PATH. RELOCATE PEN"
1310 PRINT TAB25"************************************",TAB100
1320 GOTO 280
1330 END
```

## MULTISPAN SKYLINE LOAD PATH PROGRAM

This program examines the tensions, loads, and deflections of a multispan skyline such as the one shown in figure 15. The system consists of a skyline anchored at a headspar and tailhold with additional intermediate supports at selected points between the anchors. In two sections of the program ("Equipment Description" and "Geometry Description" in table 4), the skyline size and the geometry of the anchoring and intermediate support locations are entered as input. With this information, the program can compute either the load that can be supported at any point (trial load section) or the tensions and deflections resulting from a given line length and load (load path section). In both these sections, the loading at intermediate supports is determined. This information can be used to determine the feasibility of the multispan skyline configuration which can be extremely sensitive to proper placement of anchors and supports, length of lines, and size of loads.

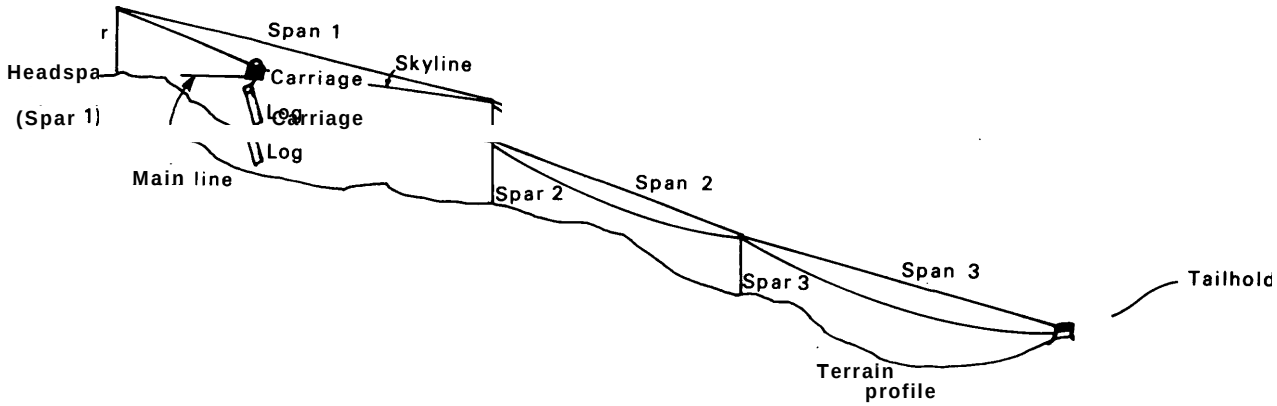



**Figure 15.—Multispan skyline.**

### User Instructions

The following example demonstrates use of this program. The first step is to load file 1 (i.e., LOADKEY 1, EXECUTE) and then continue through the following procedure:

1. Press STOP and END to prepare for loading the program.
2. Press function key $f_9$ (or LOAD 5, EXECUTE).
3. Adjust graph limits on plotter.
4. Continue with the procedure outlined in table 4 by responding to the visual prompters with the numerical or alphanumeric entries indicated in the middle column. The DESCRIPTIONS should be read for an understanding of the process.

**Table 4.--Input explanation for multispan skyline example**

| VISUAL PROMPTER ON DISPLAY | KEYBOARD RESPONSE | DESCRIPTION |
|---|---|---|
| HORIZONTAL GRAPH LIMITS (FEET)? | 2000 | Enters scale value for X-axis on plotter. |
| VERTICAL GRAPH LIMITS (FEET)? | 1400 | Enters scale value for Y-axis on plotter. |
| 'Equipment description | | |
| SKYLINE SIZE (LB/FOOT)? | 2.89 | Enters weight per foot of skyline. |
| ALLOWABLE WORKING TENSION (LB)? | 53300 | Enters allowable working tension of skyline. |
| Geometry description | | |
| CORRIDOR NUMBER? | *4* | Enters number to identify skyline corridor. |
| HORZ. DIST.: HEADSPAR TO TAILHOLD? | *1500* | Enters overall skyline span. |
| ELEV. DIFF.: HEADSPAR TO TAILHOLD? | *450* | Enters vertical anchor point separation from top of headspar down to top of tailhold. |
| HORZ. DIST.: HEADSPAR TO SPAR 2? | 600 | Enters horizontal distance to first intermediate spar. |
| ELEV. DIFF.: HEADSPAR TO SPAR 2? | 150 | Enters vertical distance from top of headspar down to jack on first intermediate spar. |
| HORZ. DIST.: HEADSPAR TO SPAR 3? | 1000 | Enters horizontal distance to second intermediate spar. |
| ELEV. DIFF.: HEADSPAR TO SPAR 3? | *300* | Enters vertical distance from top of headspar down to jack on second intermediate spar. |
| HORZ. DIST.: HEADSPAR TO SPAR 4? | *0* | Causes program control to branch to trial load section of program. |
| Trial load section | | |
| HORZ. DIST.: HEADSPAR TO LOAD? | 300 | Enters horizontal distance to first trial load location. |
| ELEV. DIFF.: HEADSPAR TO *LOAD?* | 150 | Enters vertical distance from top of headspar down to carriage location for first trial. |
| HORZ. DIST.: HEADSPAR TO LOAD? | 800 | Enters horizontal distance to second trial load location. |
| ELEV. DIFF.: HEADSPAR TO LOAD? | 300 | Enters vertical distance from top of headspar down to carriage location for second trial. |
| HORZ. DIST.: HEADSPAR TO LOAD? | 1300 | Enters horizontal distance to third trial load location. |
| ELEV. DIFF.: HEADSPAR TO LOAD? | *450* | Enters vertical distance from top of headspar down to carriage location of third trial. |
| HORZ. DIST.: HEADSPAR TO LOAD? | *0* | Causes program control to branch to the load path section of program. |
| Load path section | | |
| HORZ. DIST.: ORIGIN TO HEADSPAR? | 100 | Enters horizontal distance from origin *to* the top of the headspar. The origin is lower left graph limits set by the operator. |
| ELEV. DIFF.: ORIGIN TO HEADSPAR? | 1000 | Enters vertical distance from origin to top of the headspar. |
| NUMBER OF POINTS TO BE EXAMINED? | 3 | Establishes the number of data points that will be examined in each intermediate span (in addition to a point in the immediate vicinity of each support). |

Table 4.--Input explanation for multispan skyline example (Continued)

| VISUAL PROMPTER ON DISPLAY | KEYBOARD RESPONSE | DESCRIPTION |
|---|---|---|
| NEW LOAD PATH? | YES | Transfers program control to section for computing a second load path over this same arrangement of anchors and spars. |
| LINE LENGTH? | 1570 | Enters unstretched line length for second load path. |
| LOAD? | 10000 | Enters load to be used for new load path. |
| NUMBER OF POINTS TO BE EXAMINED? | 3 | Same as above. |
| NEW LOAD PATH? | NO | Branches out of load path section. |
| NEW ANCHORING OR SPAR GEOMETRY? | NO | Branches to next query. |
| MARK BOTTOM OF LOAD? | YES | Branches to section for load labeling. |
| CLEARANCE REQUIRED: CABLE TO GRD? | 60 | Enters length required to provide clearance for the carriage, chokers, and logs between the skyline cable and the ground. After labeling plot with arrows to represent this length, terminates program. |

## output

This program prepares both plotted and printed output. The plotted results (fig. 16) present the load path of the point of contact between the carriage and skyline. The number of points involved in this plot was selected during program execution.

Figure 17 shows a sample of printed output which summarizes the input information and the tensions, line lengths, and forces in addition to the coordinates of points on the load path. The forces and geometry at each load point and reactions at the intermediate spars are printed. Figure 18 shows how this information should be interpreted.

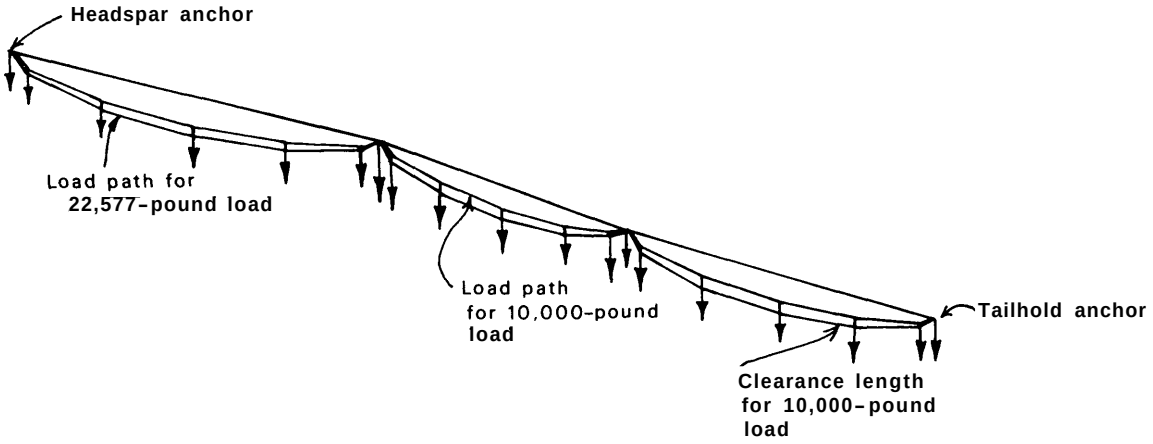
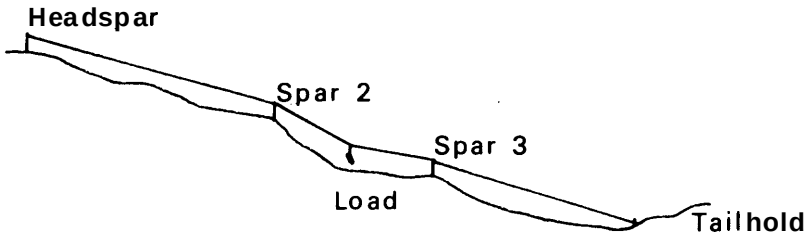



Figure 16.—Multispan skyline plotted results (no profile shown).

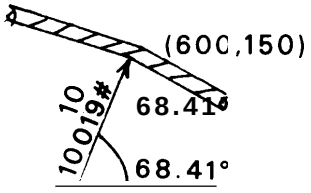
```
                    **** MULTISPAN PROGRAM. ****
SALE IDENTIFICATION- EXAMPLE #4
        EQUIPMENT DESCRIPTION.
              SKYLINE SIZE 2.89    POUNDS PER FOOT
              ALLOWABLE WORKING TENSION= 53300   POUNDS


 CORRIDOR NUMBER- 4
HORIZONTAL DISTANCE(D) FROM HEADSPAR TO TAILHOLD= 1500    FEET
ELEVATION DIFFERENCE(H) FROM HEADSPAR TO TAILHOLD= 450  FEET
     INTERMEDIATE SPAR 2    D 600  H 150
     INTERMEDIATE SPAR 3    D 1000    H 300
    TRIAL LOAD LOCATED AT  300 IN SPAN 1 WITH ELEVATION FROM HEADSPAR OF  150
        STRETCHED LENGTH 1584.630   UNSTRETCHED LENGTH 1576.383
             D        H     FORCE ANGLE    FORCE
           300      150        76.72        23448   LOAD= 22821
           600      150        79.64       -19860
          1000      300        71.29         2229
    TRIAL LOAD LOCATED AT  800 IN SPAN 2 WITH ELEVATION FROM HEADSPAR OF  300
        STRETCHED LENGTH 1590.487   UNSTRETCHED LENGTH 1582.209
             D        H     FORCE ANGLE    FORCE
           600      150        64.86       -22061
           800      300        71.57        32613   LOAD= 30939
          1000      300        81.41       -16228
    TRIAL LOAD LOCATED AT 1300 IN SPAN 3 WITH ELEVATION FROM HEADSPAR OF  450
        STRETCHED LENGTH 1581.081   UNSTRETCHED LENGTH 1572.853
             D        H     FORCE ANGLE    FORCE
           600      150        72.86        -7455
          1000      300        66.52        -6506
          1300      450        76.80        23190   LOAD= 22577
LOAD PATH BEING COMPUTED FOR LINE LENGTH OF 1572.853 AND LOAD OF  22577
    PREPARING FOR LOAD PATH BY EXAMINING 3    POINTS PER SPAN
          SPAR 1    D 0    H 0
          SPAR 2    D 600  H 150
          SPAR 3    D 1000    H 300
          SPAR 4    D 1500    H 450
    LOAD AT    30,DEFLECTED TO   38.6   ,HEADSPAR TENSION OF  39289
        SPAR LOADS    D        H    FORCE ANGLE     FORCE
                       30       39    57.83          26673 LOAD= 22579
                      600      150    74.37          -7828
                     1000      300    71.26           1286
    LOAD AT   150,DEFLECTED TO   97.7   ,HEADSPAR TENSION OF  54647
        SPAR LOADS    D        H    FORCE ANGLE     FORCE
                      150       98    69.92          24039 LOAD= 22578
                      600      150    76.45         -14367
                     1000      300    71.30           2319
    LOAD AT   300,DEFLECTED TO  143.3   ,HEADSPAR TENSION OF  57691
        SPAR LOADS    D        H    FORCE ANGLE     FORCE
                      300      143    76.59          23209 LOAD= 22577
                      600      150    79.01         -20166
                     1000      300    71.30           2524
```

**Figure 17.—Portion of printed output from multispan skyline program.**

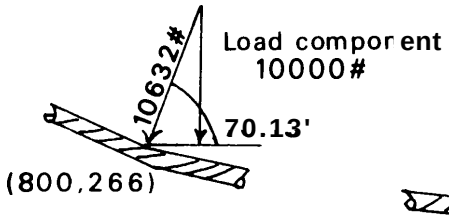



LOAD AT 800,DEFLECTED TO 266.4 ,HEADSPAR TENSION OF 32003

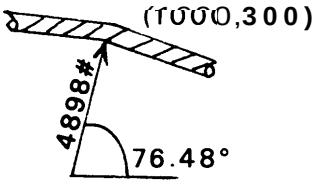
| SPAR LOADS | D | H | FORCE ANGLE | FORCE | |
|---|---|---|---|---|---|
| | 600 | 150 | 68.41 | -10019 | |
| | 800 | 266 | 70.13 | 10632 | LOAD= 10000 |
| | 1000 | 300 | 76.48 | -4898 | |




Load geometry at first intermediate spar (i.e., spar 2)




Load geometry at load point




Load geometry at second intermediate spar (i.e., spar 3)

Figure 18.—Interpretation of load path printout.

## **LISTING** OF **THE** MULTISPAN PROGRAM

```
10 REM PROGRAM TO AID IN THE LAYOUT OF A MULTISPAN SKYLINE.
20 DIM C[10],D[10],F[10],H[10],S[10],T[10],X[50],Y[50],T$[30]
30 PRINT TAB100"NOTE:GRAPH LIMITS MUST BE ESTABLISHED ON PLOTTER"
40 DISP 'HORIZONTAL GRAPH LIMITS(FEET)";
50 INPUT G1
60 DISP "VERTICAL GRAPH LIMITS(FEET)"
70 INPUT G2
80 SCALE 0,G1,0,G2
90 PLOT 0,0,1
100 PRINT TAB100,TAB20,"**** MULTISPAN PROGRAM. ****"
110 DISP "SALE IDENTIFICATION";
120 INPUT T$
130 PRINT "SALE IDENTIFICATION- "T$
140 REM*****CONTROLS*****
150 REM       I2 IDENTIFIES LOAD POINT.
160 REM      I3=1 LOAD IDENTIFIED AS SPAR
170 REM *****************LENGTH SEARCH PORTION OF PROGRAM *************
180 REM***INPUT***
190 PRINT TAB9"EQUIPMENT DESCRIPTION."
200 DISP "SKYLINE SIZE(LB/FOOT)";
210 INPUT W1
220 PRINT TAB15"SKYLINE SIZE"W1"POUNDS PER FOOT"
230 DISP "ALLOWABLE WORKING TENSION(LB)";
240 INPUT T
250 PRINT TAB15"ALLOWABLE WORKING TENSION="T"POUNDS"
260 PRINT TAB100
270 T1=T
280 DISP "CORRIDOR NUMBER";
290 INPUT T$
300 PRINT " CORRIDOR NUMBER- "T$
310 DISP "HORZ.DIST.:HEADSPAR TO TAILHOLD";
320 INPUT L1
330 PRINT "HORIZONTAL DISTANCE(D) FROM HEADSPAR TO TAILHOLD="L1"FEET"
340 DISP "ELEV.DIFF.:HEADSPAR TO TAILHOLD";
350 INPUT H1
360 PRINT "ELEVATION DIFFERENCE(H) FROM HEADSPAR TO TAILHOLD="H1"FEET"
370 E1=3500000
380 E0=S0=W=1000000
390 N=1
400 REM ENTER COORDINATES OF INTERMEDIATE SPARS.
410 N=N+1
420 DISP "HORZ.DIST.:HEADSPAR TO SPAR"N;
430 INPUT D[N]
440 IF D[N]=0 THEN 490
450 DISP "ELEV.DIFF.:HEADSPAR TO SPAR"N;
460 INPUT H[N]
470 PRINT "     INTERMEDIATE SPAR"N;"D"D[N];"H"H[N]
480 GOTO 400
490 REM ESTABLISH LEFT AND RIGHT ANCHOR POINTS.
500 D[1]=0
510 D[N]=L1
520 H[1]=0
```

```
530 H[N]=H1
540 I3=0
550 REM***TRIALS OF LOAD POINTS.
560 DISP "HORZ.DIST.:HEADSPAR TO LOAD";
570 INPUT X1
580 IF X1=0 THEN 930
590 DISP "ELEV.DIFF.:HEADSPAR TO LOAD";
600 INPUT Y1
610 GOSUB 1690
620 WRITE (15,630)X1,I1," WITH ELEVATION FROM HEADSPAR OF",Y1
630 FORMAT 4X,"TRIAL LOAD LOCATED AT",F5.0," IN SPAN",F2.0,F5.0
640 REM***GET SPAR LOADS
650 FOR I=2 TO N
660 GOSUB 2060
670 NEXT I
680 REM***GET TOTAL STRETCHED AND UNSTRETCHED LINE LENGTH.
690 GOSUB 2190
700 WRITE (15,710)S4,S2
710 FORMAT 9X,"STRETCHED LENGTH",F9.3,3X,"UNSTRETCHED LENGTH",F9.3
720 PRINT TAB10;"     D          H      FORCE ANGLE    FORCE"
730 FOR I=2 TO N
740 C1=C[I]*180/PI
750 IF I#I2 THEN 800
760 W0=F[I]*SIN(C[I])
770 WRITE (15,780)D[I],H[I],C1,F[I],W0
780 FORMAT 8X,2F8.0,5X,F8.2,F12.0,"   LOAD=",F6.0
790 GOTO 820
800 WRITE (15,810)D[I],H[I],C1,F[I]
810 FORMAT 8X,2F8.0,5X,F8.2,F12.0
820 NEXT I
830 REM***GET MINIMUM LOAD,LINE LENGTH AND DEFLECTION.
840 IF W0>W THEN 870
850 S0=S2
860 W=W0
870 Y2=H[I2-1]+(X1-D[I2-1])*(H[I2+1]-H[I2-1])/(D[I2+1]-D[I2-1])
880 E2=(Y1-Y2)/(D[I2+1]-D[I2-1])
890 IF E2>E0 THEN 910
900 E0=E2
910 GOSUB 2450
920 GOTO 550
930 REM****************LOAD PATH PORTION OF PROGRAM**************
940 WRITE (15,950)S0," AND LOAD OF",W
950 FORMAT "LOAD PATH BEING COMPUTED FOR LINE LENGTH OF",F9.3,F7.0
960 DISP "HORZ.DIST.:ORIGIN TO HEADSPAR";
970 INPUT X0
980 DISP "ELEV.DIST.:ORIGIN TO HEADSPAR";
990 INPUT Y0
1000 OFFSET X0,Y0
1010 PLOT 0,0,1
1020 DISP "NUMBER OF POINTS TO BE EXAMINED";
1030 INPUT N2
```

```
1040 PRINT "    PREPARING FOR LOAD PATH BY EXAMINING"N2;"POINTS PER SPAN"
1050 N0=N-1
1060 FOR I=1 TO N0
1070 PRINT "              SPAR"I;"D"D[I];"H"H[I]
1080 NEXT I
1090 REM***ESTABLISH SET OF POINTS FOR LOAD PATH COMPUTATIONS.
1100 X[1]=D[1]
1110 Y[1]=H[1]
1120 FOR J=2 TO N
1130 J1=(J-1)*(N2+3)+1
1140 X[J1]=D[J]
1150 Y[J1]=H[J]
1160 J2=J-1
1170 D8=D[J]-D[J-1]
1180 H8=H[J]-H[J-1]
1190 PLOT D[J2],-H[J2],2
1200 FOR K=1 TO (N2+2)
1210 I=(J-2)*(N2+3)+K+1
1220 IF K#1 THEN 1250
1230 X[I]=D[J-1]+0.05*D8
1240 GOTO 1290
1250 IF K#(N2+2) THEN 1280
1260 X[I]=D[J]-0.05*D8
1270 GOTO 1290
1280 X[I]=(D[J]-D[J-1])*(K-1)/(N2+1)+D[J-1]
1290 Y[I]=(X[I]-D[J-1])*H8/D8+H[J-1]+E0*D8
1300 NEXT K
1310 NEXT J
1320 M=(N-2)*(N2+3)+N2+4
1330 X[M]=D[N]
1340 Y[M]=H[N]
1350 PRINT TAB13"SPAR"N;"D"X[M];"H"Y[M]
1360 PLOT X[M],-Y[M],2
1370 PLOT 0,0,1
1380 REM***DETERMINE DEFLECTION AND LOAD AT EACH POSITION.
1390 FOR J=2 TO N
1400 J1=(J-1)*(N2+3)+1
1410 J2=J-1
1420 FOR K=1 TO (N2+2)
1430 J3=(J-2)*(N2+3)+K+1
1440 X1=X[J3]
1450 Y1=Y[J3]
1460 GOSUB 1830
1470 Y[J3]=H[I2]
1480 WRITE (15,1490)X[J3],Y[J3],";HEADSPAR TENSION OF"T1
1490 FORMAT 4X,"LOAD AT",F6.0,",DEFLECTED TO",F7.1,3X,F7.0
1500 PRINT TAB8"SPAR LOADS    D         H    FORCE ANGLE     FORCE"
1510 REM***DETERMINE SPAR LOADS AND ANGLES. ***
1520 FOR I=2 TO N
1530 GOSUB 2060
1540 C1=C[I]*180/PI
1550 C2=F[I]*SIN(C[I])
1560 IF I#I2 THEN 1600
1570 WRITE (15,1580)D[I],H[I],C1,F[I],C2
```

```
1580 FORMAT 17X,2F8.0,F9.2,F15.0," LOAD=",F6.0
1590 GOTO 1620
1600 WRITE (15,1610)D[I],H[I],C1,F[I]
1610 FORMAT 17X,2F8.0,F9.2,F15.0
1620 NEXT I
1630 IF I3=0 THEN 1650
1640 GOSUB 2450
1650 NEXT K
1660 NEXT J
1670 GOTO 2520
1680 REM***********SUBS FOR LOAD AND LENGTH ROUTINES*****************
1690 REM***SUB1***IDENTIFY LOAD SPAN AND REPRESENT LOAD AS SPAR.
1700 FOR I2=2 TO N
1710 IF X1<D[I2] THEN 1730
1720 NEXT I2
1730 FOR I1=N TO I2 STEP -1
1740 D[I1+1]=D[I1]
1750 H[I1+1]=H[I1]
1760 NEXT I1
1770 N1=N+1
1780 D[I2]=X1
1790 H[I2]=Y1
1800 I1=I2-1
1810 I3=1
1820 RETURN
1830 REM***SUB2***GETS DEFLECTION AND TENSIONS FROM LOAD AND LINE LENGTH.
1840 GOSUB 1690
1850 REM***ITERATE FOR DEFLECTION WITH SECANT METHOD.
1860 D8=D[I2+1]-D[I2-1]
1870 H[I2]=Y1-D8*E0/4
1880 GOSUB 2360
1890 GOSUB 2190
1900 Y1=H[I2]
1910 S5=S0-S2
1920 H[I2]=Y1+D8*E0/2
1930 N9=1
1940 GOSUB 2360
1950 GOSUB 2190
1960 S3=S0-S2
1970 IF ABS(S3)<0.2 THEN 2050
1980 Y2=(H[I2]-Y1)*S3/(S3-S5)
1990 S5=S3
2000 Y1=H[I2]
2010 H[I2]=H[I2]-Y2
2020 DISP "POINT"J3;"ITERATION"N9
2030 N9=N9+1
2040 GOTO 1940
2050 RETURN
2060 REM***SUB3***EVALUATE LOAD MAGNITUDE AND DIRECTION OF SPAR LOADS.
2070 G1=H[I+1]-H[I]
2080 G2=D[I+1]-D[I]
2090 G3=H[I]-H[I-1]
2100 G4=D[I]-D[I-1]
```

```
2110 T[I]=T1-W1*H[I]
2120 A1=ATN(-G1/G2)
2130 A2=PI-ATN(G3/G4)
2140 B1=W1/2/T[I]*G2
2150 B2=W1/2/T[I]*G4
2160 C[I]=0.5*(A1+A2+B2-B1)
2170 F[I]=2*T[I]*COS((A2-A1)/2+(B1+B2)/2)
2180 RETURN
2190 REM***SUB4***COMPUTE SEGMENT LENGTHS.
2200 S2=S4=0
2210 FOR I1=2 TO N1
2220 G3=H[I1]-H[I1-1]
2230 G4=D[I1]-D[I1-1]
2240 T[I1]=T1-W1*H[I1]
2250 A2=PI-ATN(G3/G4)
2260 B2=W1/2/T[I1]*G4
2270 M1=ABS(T[I1]*COS(A2+B2))
2280 S1=SQR(G3↑2+G4↑2*(1+(G4/M1)↑2/24)↑2)
2290 D0=G4/2/M1
2300 D3=1+1/3*D0↑2-1/45*D0↑4+2/945*D0↑6
2310 S[I1-1]=S1-M1/(E1*W1)*(1+(1+(G3/S1)↑2)*D3/(G4/S1)↑2)*G4/2
2320 S2=S2+S[I1-1]
2330 S4=S4+S1
2340 NEXT I1
2350 RETURN
2360 REM***SUB5***COMPUTE TENSION FROM GEOMETRY AND LOAD.
2370 G1=H[I2+1]-H[I2]
2380 G2=D[I2+1]-D[I2]
2390 G3=H[I2]-H[I2-1]
2400 G4=D[I2]-D[I2-1]
2410 A1=ATN(-G1/G2)
2420 A2=PI-ATN(G3/G4)
2430 T1=(W+W1/2*(G2*COS(A1)-G4*COS(A2)))/(SIN(A2)+SIN(A1))+W1*H[I2]
2440 RETURN
2450 REM***SUB6***RE-ESTABLISH SPAR COORDINATES.
2460 FOR I=I2 TO N
2470 D[I]=D[I+1]
2480 H[I]=H[I+1]
2490 NEXT I
2500 I3=0
2510 RETURN
2520 REM***PLOT OF LOAD PATH
2530 FOR J3=1 TO M
2540 PLOT X[J3],-Y[J3]
2550 NEXT J3
2560 PEN
2570 REM***RECOVERY PROCESS FOR NEW PASS
2580 IF I3=0 THEN 2600
2590 GOSUB 2450
2600 DISP "NEW LOAD PATH";
2610 INPUT T$
2620 IF T$#"YES" THEN 2700
2630 DISP "LINE LENGTH";
2640 INPUT S0
```

```
2650 DISP "LOAD";
2660 INPUT W
2670 WRITE (15,2680)S0," AND LOAD OF",W
2680 FORMAT "LOAD PATH BEING COMPUTED FOR LINE LENGTH OF",F9.3,F7.0
2690 GOTO 1010
2700 DISP "NEW ANCHORING OR SPAR GEOMETRY";
2710 INPUT T$
2720 IF T$="YES" THEN 260
2730 DISP "MARK BOTTOM OF LOAD";
2740 INPUT T$
2750 IF T$#"YES" THEN 2840
2760 REM MARK BOTTOM OF LOAD.
2770 DISP "REQUIRED CLEARANCE:CABLE TO GRD";
2780 INPUT C1
2790 FOR J3=1 TO M
2800 PLOT X[J3],-Y[J3],1
2810 LABEL (2820,C1/14,6,3.14159)126
2820 FORMAT B
2830 NEXT J3
2840 PRINT TAB100
2850 GOTO 180
2860 END
```



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The mission of the PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION is to provide the knowledge, technology, and alternatives for present and future protection, management, and use of forest, range, and related environments.

Within this overall mission, the Station conducts and stimulates research to facilitate and to accelerate progress toward the following goals:

1. Providing safe and efficient technology for inventory, protection, and use of resources.
2. Development and evaluation of alternative methods and levels of resource management.
3. Achievement of optimum sustained resource productivity consistent with maintaining a high quality forest environment.

The area of research encompasses Oregon, Washington, Alaska, and, in some cases, California, Hawaii, the Western States, and the Nation. Results of the research will be made available promptly. Project headquarters are at:

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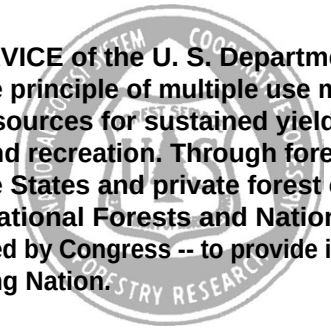

**The FOREST SERVICE of the U. S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress -- to provide increasingly greater service to a growing Nation.**