Table 6 The complete prompting file, **equivellipse.PRO**, corresponding to the generic case called "equivellipse". This file is automatically created by "GENTEXT" once the GENOPT user has provided all variable names, one-line definitions, and “help” paragraphs during the entire “GENTEXT” interactive session. The variable names, the one-line definitions of the variables, and the “help” paragraphs, created by the GENOPT user during the GENTEXT interactive session, **will be seen by the “end” user.** If the GENOPT user has done his or her job well, the program system created by GENOPT (BEGIN, DECIDE, MAINSETUP, OPTIMIZE, CHOOSEPLOT, etc.), that is, the program system for the generic case, “**equivellipse**”, to be used later by the “end” user for specific cases (such as a specific case called “eqellipse”), will be user-friendly. The prompting numbers (e.g. 10) corresponding to each prompt for input data (e.g. “number of x coordinates: npoint”) are listed with the variable names (e.g. “npoint”) and one-line definitions (e.g. “number of x-coordinates”) in Table 2.

```
========================================================================
   5.0
       OPTIMUM DESIGN OF ISOGRID-STIFFENED ELLIPSOIDAL HEAD
       David Bushnell, retired (formerly with Lockheed Martin)
       ABSTACT: The externally pressurized head is elastic, has
       internal isogrid stiffening, and is attached to a short,
       unstiffened cylindrical shell of uniform thickness.
       The BIGBOSOR4 computer program is used for the structural
       analysis and GENOPT is used to set up the user-friendly
       optimization program. Please read the following papers
       for descriptions of BIGBOSOR4 and GENOPT:
       [1] Bushnell, D., "Automated optimum design of shells of
       revolution with application to ring-stiffened cylindrical
       shells with wavy walls", Proc. AIAA 41st SDM Meeting, AIAA
       Paper No. AIAA-2000-1663, April 2000. (Also see the Lockheed
       Martin report, LMMS P525674, November, 1999 for more details).
       [2] Bushnell, D., "GENOPT - a program that writes user-friendly
       optimization code", Int. J. Solids Structures, Vol. 26, No. 9/10
       pp. 1173-1210, 1990

  10.1 number of x-coordinates: npoint
  10.2
       The ellipse is simulated by a number of shell segments (try 10)
       each of which has constant meridional curvature (toroidal).
       npoint is the number of x-coordinates corresponding to the
       ends of the toroidal segments that make up the equivalent
       ellipse. You might try to simulate the ellipse by using 10
       toroidal segments. Then the value of npoint would be 11
       npoint includes the apex of the ellipse (x = 0) and the equator
       of the ellipse (x = a, in which a = semimajor axis length).

  15.1 Number Ixinpu  of rows in the array  xinput: Ixinpu
  20.1 x-coordinates for ends of segments: xinput
```

20.2
Please make sure to include x = 0 and x = a (equator) when
you provide values for xinput.

25.1 length of semi-major axis: ainput
25.2
ainput is the maximum "x=dimension" of the ellipse.
The equation for the ellipse is x^2/a^2 + y^2/b^2 = 1.0

30.1 length of semi-minor axis of ellipse: binput
30.2
binput is the y-dimension of the ellipse, the equation for which
is x^2/a^2 + y^2/b^2 = 1.0.

35.1 number of nodal points per segment: nodes
35.2
If you have about 10 segments, use a number less than 31.
Use an odd number, greater than or equal to 11

40.1 max. x-coordinate for x-coordinate callouts: xlimit
40.2
xlimit has two functions:
1. a delimiter for the definition of callouts:
for x < xlimit callouts are x-coordinates.
for x > xlimit callouts are y-coordinates.
Set xlimit equal to about a/2, where a = length of the
semi-major axis of the ellipse.
2. a delimiter for the boundary between Region 1
and Region 2, Design margins for maximum stress and
minimum buckling load in the shell skin and in the
isogrid stiffeners can be computed in two regions,
Region 1: 0 < x < xlimit, and
Region 2: xlimit < x < semi-major axis.

45.1 skin thickness at xinput: THKSKN
45.2
xinput is the vector of x-coordinate callouts for
thickness of the shell skin and height of the
isogrid stiffeners.

50.1 height of isogrid members at xinput: HIGHST
50.2
xinput is the vector of x-coordinate callouts for
thickness of the shell skin and height of the
isogrid stiffeners.

55.1 spacing of the isogrid members: SPACNG
55.2

SPACNG = altitude of the equilateral triangle between adjacent
isogrid members, measured to middle surfaces of isogrid members.
SPACNG = (length of side of triangle)*sqrt(3)/2.
SPACNG is constant over the entire shell.

60.1 thickness of an isogrid stiffening member: THSTIF
60.2
THSTIF is constant over the entire shell.

65.1 thickness of the cylindrical shell: THKCYL
70.1 radius of the cylindrical shell: RADCYL
75.1 length of the cylindrical segment: LENCYL
80.1 amplitude of the axisymmetric imperfection: WIMP
80.2
Use a positive value greater than zero.
For a perfect shell, use a value of WIMP that is
very, very small compared to the skin thickness.
The imperfections are in the shapes of the axisymmetric
buckling modes obtained from linear theory for the
PERFECT shell. The actual imperfections are equal to
WIMP*WSHAPE(i), i = 1,NUMB,
in which NUMB = number of nodes in a shell segment.
In the paper about optimization of ellipsoidal shells
the axisymmetric buckling modal imperfections are
called "mode 1", "mode 2", "mode 3", "mode 4",
corresponding to the number of the linear buckling
eigenvalue corresponding to axisymmetric buckling.
Optimization can be performed with the use of
two modes, "mode 1" and "mode 2" or with the use
of four modes, "mode 1", "mode 2", "mode 3", "mode 4".
The shell is optimized with the plus and minus
version of each axisymmetric buckling modal
imperfection present by itself. In other words,
the shell is optimized such that it will survive
if any ONE of up to eight axisymmetric buckling
modal imperfections of amplitude WIMP is present.
The plus and minus versions of the axisymmetric
buckling modal imperfections are processed as
different load sets "applied" to the shell:
Load set 1 has plus "mode 1" and plus "mode 2";
Load set 2 has minus "mode 1" and minus "mode 2";
Load set 3 has plus "mode 3" and plus "mode 4";
Load set 4 has minus "mode 3" and minus "mode 4.
Usually, optimization should be performed with use
of only "mode 1" and "mode 2" imperfection shapes.

85.1 elastic modulus: EMATL
90.1 Poisson ratio of material: NUMATL

95.1 mass density of material: DNMATL
95.2
For example, the mass density of aluminum in English units is
0.000259

100.1 strategy control for imperfection shapes: IMODE
100.2
IMODE governs the strategy used to generate axisymmetric
buckling modal imperfection shapes.
IMODE = 1 means use Strategy 1 (Do not use this)
IMODE = 2 means use Strategy 2 (Use this choice)

In Strategy 1 axisymmetric buckling modes are
scanned until a mode is found in which the normal
modal displacement amplitude at the apex of the shell
is at least 0.7. (All buckling modes are normalized so that
the maximum buckling modal displacement is 1.0. The
buckling modal imperfection is the user-specified amplitude,
WIMP, multiplied by the normalized buckling modal displacement
distribution WSHAPE along the meridian of the shell.)
The remaining n (n = 2 or n = 4) modes are selected without
regard to the imperfection amplitude at the apex.

In Strategy 2 the first n axisymmetric buckling
modes (n = 2 or n = 4) are selected regardless of their
amplitude at the apex of the shell.
It is best to try Strategy 2 first.

105.1 Number NCASES of load cases (environments): NCASES
110.1 uniform external pressure: PRESS
115.0 collapse pressure with imperfection mode 1: CLAPS1
120.1 allowable pressure for axisymmetric collapse: CLAPS1A
125.1 factor of safety for axisymmetric collapse: CLAPS1F
130.0 general buckling load factor, mode 1: GENBK1
135.1 allowable general buckling load factor (use 1.0): GENBK1A
135.2
GENBK1 is defined as a "buckling load FACTOR",
not as a "buckling LOAD". Therefore, you should
always use a value of the "allowable general buckling
load factor" equal to unity. This point holds for
the treatment of all buckling allowables in this
application.

140.1 factor of safety for general buckling: GENBK1F
140.2
Remember, this program already includes the effect of an
axisymmetric buckling modal imperfection. If you use an
imperfection amplitude, WIMP, significantly greater

```
      than zero you should accordingly use a factor of safety
      closer to unity than you would for an almost perfect
      shell.

145.1 Number JSKNBK1 of columns in the array, SKNBK1: JSKNBK1
150.0 local skin buckling load factor, mode 1: SKNBK1
155.1 allowable buckling load factor: SKNBK1A
160.1 factor of safety for skin buckling: SKNBK1F
165.0 buckling load factor, isogrid member, mode 1: STFBK1
170.1 allowable for isogrid stiffener buckling (Use 1.): STFBK1A
175.1 factor of safety for isogrid stiffener buckling: STFBK1F
180.0 maximum stress in the shell skin, mode 1: SKNST1
185.1 allowable stress for the shell skin: SKNST1A
190.1 factor of safety for skin stress: SKNST1F
195.0 maximum stress in isogrid stiffener, mode 1: STFST1
200.1 allowable stress in isogrid stiffeners: STFST1A
205.1 factor of safety for stress in isogrid member: STFST1F
210.0 normal (axial) displacement at apex, mode 1: WAPEX1
215.1 allowable normal (axial) displacement at apex: WAPEX1A
220.1 factor of safety for WAPEX: WAPEX1F
225.0 collapse pressure with imperfection mode 2: CLAPS2
230.1 allowable pressure for axisymmetric collapse: CLAPS2A
235.1 factor of safety for axisymmetric collapse: CLAPS2F
240.0 general buckling load factor, mode 2: GENBK2
245.1 allowable general buckling load factor (use 1.0): GENBK2A
250.1 factor of safety for general buckling: GENBK2F
250.2
      Remember, this program already includes the effect of an
      axisymmetric buckling modal imperfection. If you use an
      imperfection amplitude, WIMP, significantly greater
      than zero you should accordingly use a factor of safety
      closer to unity than you would for an almost perfect
      shell.

255.1 Number JSKNBK2 of columns in the array, SKNBK2: JSKNBK2
260.0 local skin buckling load factor, mode 2: SKNBK2
265.1 allowable skin buckling load factor (use 1.0): SKNBK2A
270.1 factor of safety for local skin buckling: SKNBK2F
275.0 buckling load factor for isogrid member, mode 2: STFBK2
280.1 allowable for isogrid stiffener buckling (Use 1.): STFBK2A
285.1 factor of safety for isogrid stiffener buckling: STFBK2F
290.0 maximum stress in the shell skin, mode 2: SKNST2
295.1 allowable stress for the shell skin: SKNST2A
300.1 factor of safety for skin stress: SKNST2F
305.0 maximum stress in isogrid stiffener, mode 2: STFST2
310.1 allowable stress in isogrid stiffeners: STFST2A
315.1 factor of safety for stress in isogrid member: STFST2F
320.0 normal (axial) displacement at apex, mode 2: WAPEX2
```

```
325.1 allowable normal (axial) displacement at apex: WAPEX2A
330.1 factor of safety for WAPEX: WAPEX2F
335.0 weight of the equivalent ellipsoidal head: WEIGHT
335.2
      You can get the weight of just the head (no cylindrical shell
      by setting the density of the cylindrical segment equal to 0.
      NOTE: This is done in SUBROUTINE BOSDEC for you.
999.0 DUMMY ENTRY TO MARK END OF FILE
===================================================================
```