

STRENGTH OF SHIPS - ON THE NEUTRAL
AXIS LOCATION

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by

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ABSTRACT

This work is an attempt at determining the optimum neutral axis location in the midship section of a vessel, using as a model for the calculations a box girder, subject to several different conditions of sagging and hogging bending moments; several values of design stress are also considered and in the end what happens when lateral hydrostatic load is considered along with different values assigned to the design stress in tension and in compression is also analysed.

Thesis Supervisor: J. Harvey Evans

Title: Professor of Naval Architecture

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LIST OF SYMBOLS

| | |
|--------|--|
| a | - distance between transverse stiffening members |
| AL | - length of box girder or vessel |
| B | - beam |
| BOT | - thickness of the plating on the bottom |
| BM | - bending moment |
| D | - depth |
| DIBOT | - distance of the bottom from the neutral axis |
| DITOP | - distance of the top from the neutral axis |
| DSC | - design stress in compression |
| DST | - design stress in tension; also design stress without discrimination when DSC=DST |
| H | - head of sea water (lateral load) |
| HB | - head of sea water on the bottom |
| HM | - hogging bending moment |
| HT | - head of sea water on the top |
| I | - moment of inertia of the cross section with respect to the neutral axis (GMI in the program) |
| LBS | - longitudinal bending stress |
| S | - spacing of longitudinal stiffening members |
| SBCRIT | - critical stress on bottom |
| SBH | - stress on bottom due to hogging |
| SBS | - stress on bottom due to sagging |
| SM | - sagging bending moment |
| STCRIT | - critical stress on top |
| STH | - stress on top due to hogging |
| STR | - stress |

STR1 - primary stress = LBS
STR2 - secondary stress
STR3 - tertiary stress
STR3B - tertiary stress on bottom
STR3T - tertiary stress on top
STRCR - critical stress
STS - stress on top due to sagging
t - thickness of the plate
T - draft
TOP - thickness of the plating on the top
TS - thickness of the side plating
TSTH - total stress on top in hogging
TSTS - total stress on top in sagging
TSBH - total stress on bottom in hogging
TSBS - total stress on bottom in sagging

INTRODUCTION

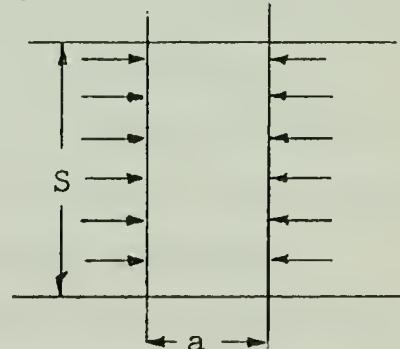
It is frequently found in the literature related with the strength of ships such statements as:

"In general the neutral axis is expected to be at 40% of the depth (D) above the base line ... a preliminary estimate of the thickness required for the bottom plating (BOT) can be obtained from

$$1.875 \left(\frac{0.4D}{0.6D} \right) 2240 \sqrt[3]{AL} = \frac{40300}{1 + \frac{1}{950} \left(\frac{S}{BOT} \right)}$$

where the Montgomerie's expression is being considered to determine the critical stress (SBCRIT psi) and the short edges are assumed far apart and simply supported.

$$SBCRIT = \frac{40300}{1 + \frac{1}{950} \left(\frac{S}{BOT} \right)}$$



a- distance between transverse stiffening members (inches)

1.875 accounts for a factor of safety

Tobin's expression was considered in the above formula to give the maximum permissible bending stress (LBS, psi)

$$LBS = 2240 \sqrt[3]{AL}$$

We see thus that this procedure allows for an estimate of the bottom thickness to be obtained after knowing the length and assuming a longitudinal frame spacing. What may be questioned here is the reason why one assumes the neutral axis 0.4D above the base line and also the reasons behind the choice of a frame spacing.

In the following a procedure to estimate the scantlings of longitudinal members is described; this procedure can also be found frequently in the literature dealing with the subject.

..."For a particular set of principal dimensions , general arrangement and frame spacing, plate panel thicknesses for one after another of the amidships longitudinally continuous elements are selected for an assumed position of the neutral axis at 40% of the depth above the keel. The composite midship section assemblage is then tested for the adequacy of its section modulus when ranged alongside some standard value, such as given by the Load Line Regulations or some function of it. Thus the modulus is judged sufficient to limit ship bending stresses to the value previously set and incorporated into the design equations.

For all but the deepest ships the modulus will undoubtedly need to be increased and a small arbitrary increment is added to the upper deck or bottom whichever happens still to be farther from the true neutral axis location found after the first design cycle. The shift of neutral axis resulting from the scantling increment requires a compensating increment in the opposite flan-

ge with the obvious outcome that the neutral axis is shifted in reverse with attendant effect on the scantling chosen first; a cyclic process is then begun. More trials will be necessary before the match of available to required section modulus is achieved."

From this transcript, we may again note the initial statement "...for a particular set of principal dimensions, general arrangement and frame spacing..." and question whether or not the frame spacing should be chosen as an input or rather be left as a variable and be obtained as a result of a structural design procedure. It is here acknowledged though that in these procedures an acceptable solution can be worked out and each new cycle is an improvement over the precedent ones. What may be questionable though is whether the first cycle, due to the assumptions made at its beginning, has or not a strong influence in the outcome leading to a solution among the various possible ones which in the end does not lead to "the optimum design" whatever its definition may be.

It seems that this trial procedure can be looked at as a "weakness" of the structural design procedure for the determination of scantlings and it is perhaps reasonable to make some effort in order to work out a process that could give the scantlings in a direct manner and be at the same time in agreement with what can be considered "the optimum design", (usually based on economic considerations).

Nowadays much concern is given to economics in ship design and naturally the strength calculations of a ship are also made with economical optimization in mind. With this respect, we can realize that in ships structures there is a desirability to minimize structural weight and some define structural efficiency as being the least weight structure capable of resisting the loads for which they are designed.

It should be clear that the cost of construction and of maintenance and repair are inter related factors together with least weight, to be considered when bringing economics into ship structural design. Also other matters such as accessibility, weldability and availability of material must be considered as well.

In the following sections an attempt is made to obtain without any interactions the scantlings for the plating of a box girder. It is hoped that through this simple model some helpful conclusions can be made in view of their application to a vessel's structure. Each of the different situations analyzed will be exhaustively explained in the following sections.

PRELIMINARY CALCULATIONS

The model used in this section and also throughout this work with only very small additional considerations is a box girder which cross section is pictured in figure 1.

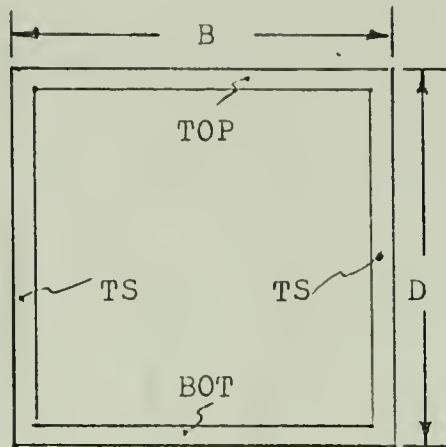


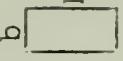
Fig. 1

As will be seen in the calculations of the following sections, the dimensional parameters used are of the order of magnitude of those considered in ship design.

This model was chosen due to its simplicity for the performance of the following calculations as can be understood immediately from its geometrically symmetrical cross section.

The objective of this section is to determine the necessary formulation to be used in future sections.

The formulation dealt with in this section is related only to the particular model chosen and the geometry of its cross section.

| MEMBER | SCANTLINGS inches (in) | AREA ² (in) | DISTANCE TO BOTTOM (ft) | A*d ² (in*ft) | A*d*d ² (in*ft) ² | WIDTH of member b (in) | HEIGHT OF MEMBER H (ft) |  $I = b * H^2 / 2$ (in*ft) ² | $\sum I =$ | |
|--------|---------------------------|---------------------------|----------------------------------|--------------------------------|---|---------------------------------|----------------------------------|---|--------------|---|
| | | | | | | | | | TOP | SIDE |
| TOP | B*TOP | B*TOP | D/12 | B*TOP*D/12 | B*TOP*(D/12) ² | B | - | - | | |
| SIDE | 2*TS*D | 2*TS*D | D/(2*12) | TS*D*D/12 | TS*D*(D/12)/12 ² | 2*TS | D/12 | 2*TS*(D/12) ³ | | |
| BOTTOM | B*BOT | B*BOT | - | - | - | b | - | - | | |
| | | | | | | | | | $\Sigma A =$ | $\frac{\Sigma (A * d * d)}{\Sigma I =}$ |
| | | | | | | | | | $I_{BOT} =$ | $-\sum A * (DIBOT')^2 =$ |

$$DIBOT = \frac{\sum(A*d)}{\sum A} * 12$$

$$DIBOT' = \frac{\sum(A*d)}{\sum A}$$

$$\sum A = B * TOP + 2 * TS * D + B * BOT = 2 * D * TS + B * (TOP + BOT)$$

DIBOT = Neutral axis location above bottom (in)

DIBOT' = " " " " " " " (ft)

I_{BOT} = Moment of inertia with respect to the bottom

I = " " " " " " " neutral axis

$$\sum(A*d) = (D/12) * (B * TOP + D * TS)$$

$$I = \sum(A*d*d) + \sum I - (\sum(A*d))^2 / (\sum A)$$

$$DIBOT = D * (B * TOP + D * TS) / (2 * D * TS + B * (TOP + BOT))$$

This formula will give DIBOT in inches if D and B are expressed in inches; it will give DIBOT in feet in the event that D and B are expressed in feet.

$$DITOP = D - DIBOT$$

$$DITOP = D * (B * BOT + D * TS) / (2 * D * TS + B * (TOP + BOT))$$

DITOP in units of inches or feet as explained for DIBOT

The following formula will give I in units of $(in*ft)^2$
for B and D given in inches.

$$I = \frac{(D/12)^2 * (3*B*B*TOP*BOT + (D*TS)^2 + 2*B*D*TS*(TOP+BOT))}{3*(2*D*TS+B*(TOP+BOT))}$$

Next formula gives I in units of $(in*ft)^2$ for B and D
given in feet.

$$I = \frac{4*D*D*(3*B*B*TOP*BOT + (D*TS)^2 + 2*B*D*TS*(TOP+BOT))}{2*D*TS+B*(TOP+BOT)}$$

These expressions will be used in most of the following
sections with B and D expressed in feet.

NOTE: TS which is defined as the thickness of the
side plating is considered throughout this work to be uniform
and will always be equal to the larger of the thicknesses obtained
for the top and for the bottom plating.

FORMULAS USED IN THE ANALYSIS

BEAM EQUATION

Assuming pure bending, the stresses in the cross section of the box girder are given by

$$\text{STR} = \frac{\text{BM} * y}{I}$$

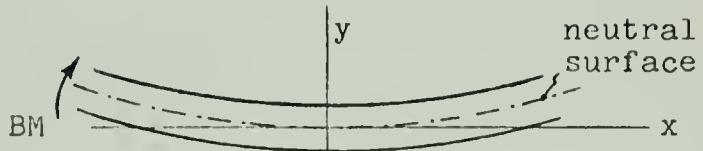


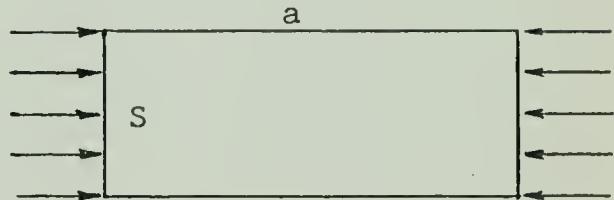
Fig. 2

where y is the distance from the neutral axis to the point where the stress is being determined.

The neutral surface indicated in fig. 2 is composed of all the points which are not subjected to any stress in pure bending.

BRYAN EQUATION - Plate under inplane load

$$\text{STRCR} = K * \frac{(\pi)^2 * E * (t)^2}{12 * (1 - (\text{POI})^2) * (S)^2}$$



When $a/S > 2$ then $K=4$

STRCR given in psi for t and S expressed in inches and E in psi.

$$\pi = 3.1416$$

PLATE UNDER LATERAL LOAD

$$\text{STR3} = 0.5 * K * \rho * H * \left(\frac{S}{t} \right)^2 * \frac{1}{144}$$

STR3 - tertiary stress

ρ - density of sea water (64 lb/ft³)

H - head of sea water (ft)

a - long dimension of plate (in)

S - short dimension of plate (in) = distance between
longitudinal stiffeners

t - plate thickness (in)

The stresses are more severe at points A and B but we are particularly interested in the stresses at point B because there they will combine with the stresses resulting from bending also called primary stresses.

Note that for a panel under lateral load, the direction of the stresses is, at the edges, perpendicular to them, so at B they are directed "longitudinally".

For $a/S > 2$ we have $K=0.685$

Replacing all the numbers in the above formula, we obtain

$$\text{STR3} = 0.152222 * H * \left(\frac{S}{t} \right)^2$$

BENDING STRESSES IN FLAT PLATES

WITH CLAMMED EDGES UNDER UNIFORM HYDROSTATIC LOAD

σ = Bending stress (lbs/sq in)

ρ = Density of sea water (64 lbs/cu ft)

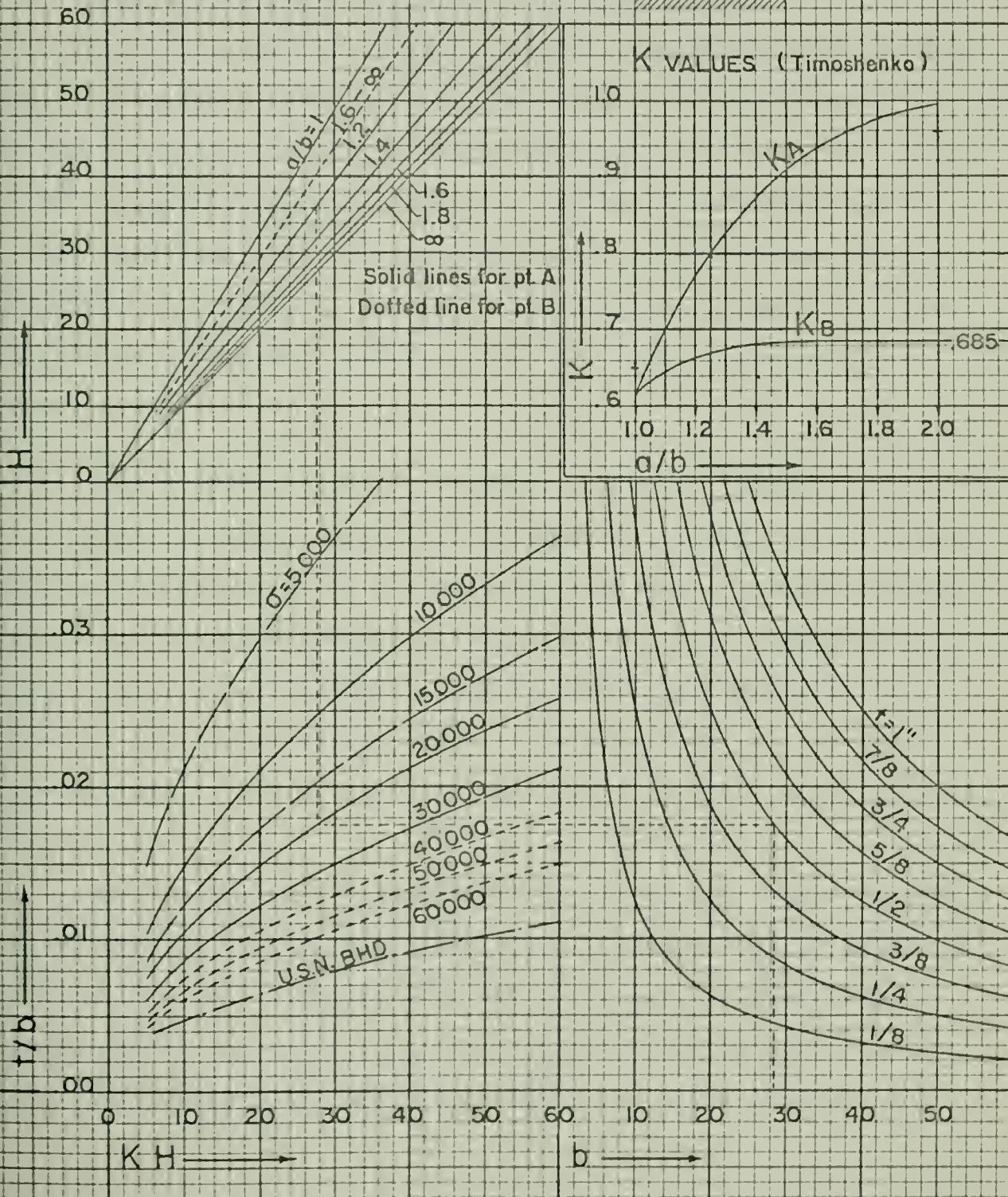
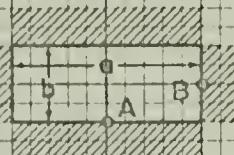
H = Head of sea wafer (feet)

q = Long dimension of plate panel (inches)

b = Short dimension of plate panel (inches)

t = Plate thickness (inches)

$$\text{Formula: } D = \frac{1}{2} K P H \left(\frac{b}{l}\right)^2 \frac{1}{144}$$



The following stress definitions and figures 3 and 4 will help understanding the reasons behind the calculations made in many of the following sections.

STRESS DEFINITIONS

STR1 - SHIP BENDING STRESS or PRIMARY STRESS

Since this stress is directly proportional to distance from the ship's neutral axis, it is substantially constant at any point on the cross section of the bottom or top plating when the vessel is in an upright attitude. For distinction, this stress may be termed a primary stress or an area stress in this location and under such a condition. While the longitudinal direction is implied in the foregoing comments, they are equally applicable transversely.

STR2 - GIRDER BENDING STRESS or SECONDARY STRESS

Girder bending stress arises from the reaction of a plating stiffener combination to a loading normal to the plating such as may be due to water pressure. Following the usual concept, the plating acts as one flange of the composite girder and so is stressed. Due to shear lag, this secondary stress in the plating is a maximum in way of the stiffener and diminishes with distance from it.

For the previous case of bottom plating and vessel upright, the transverse variation of fore and aft stress will be sensibly constant for some distance from the stiffener but will vary significantly through the plating thickness as the plate thickness is a substantial part of the distance to the neutral axis

of the plate stiffener combination. For convenience such a stress may be termed a line stress although for a wide spacing of stiffeners with consequently greater deviation from uniform distribution some inaccuracy of concept is introduced by using this term.

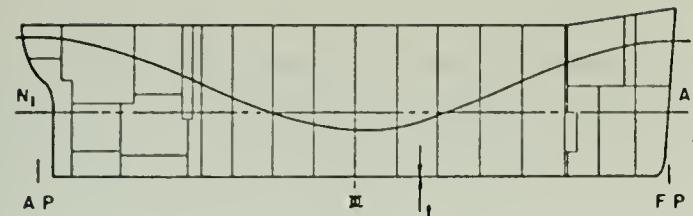
For girders continuous over several supports, such as transverse bulkheads, maximum bending moments occur at the supports and will readily be in the order of twice the field moment.

STR3 - PLATE BENDING STRESS - TERTIARY STRESS

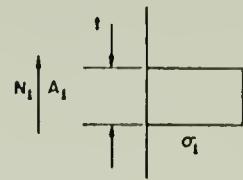
Proceeding in turn to ever more elemental portions of the ship's structure concludes with the simple plate panel supported on its four edges. In such a plate under lateral or normal loads, bending stresses are created which are variable from point to point on the panel and through its thickness with maxima occurring at one or the other surface. Since any such stress is effective at a point only, it may be called a point stress or tertiary stress.

Each elemental panel of ship's plating is generally one of a repeating pattern. Quite apart from any rotational restraint provided by the panel supports consisting of floors, frames, longitudinals, etc., there is the restraint afforded by the continuity of the plating and its loading. For practical purposes then, a condition of edge clamping exists with maximum stresses being found at the midlength of the longer panel edges and secondary maxima at the midlength of the shorter edges. In both cases these stresses are normal to their respective edges.

BENDING STRESSES IN SHIPS



STRESS DISTRIBUTION IN
BOTTOM SHELL AT
TRANSVERSE WEB FRAME



HULL BENDING STRESS

TYPICAL BOTTOM STRUCTURE
OF A
LONGITUDINALLY FRAMED SHIP

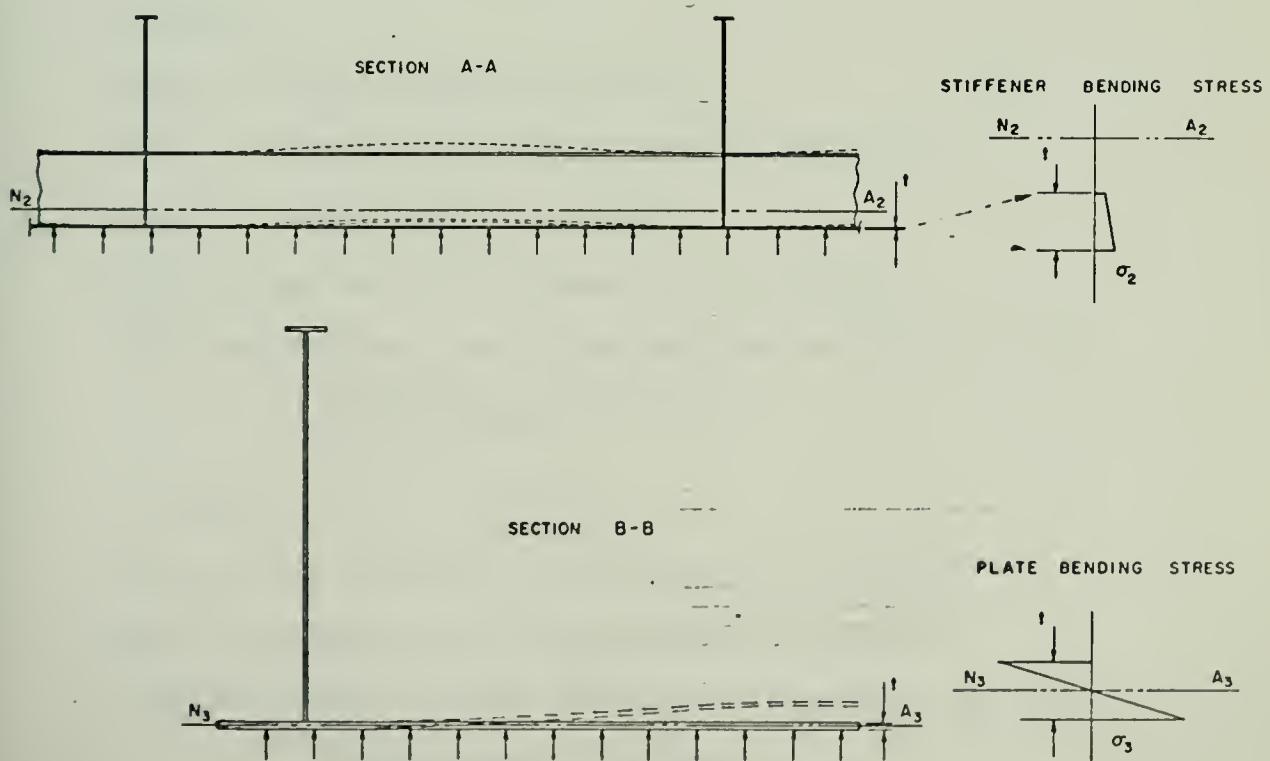
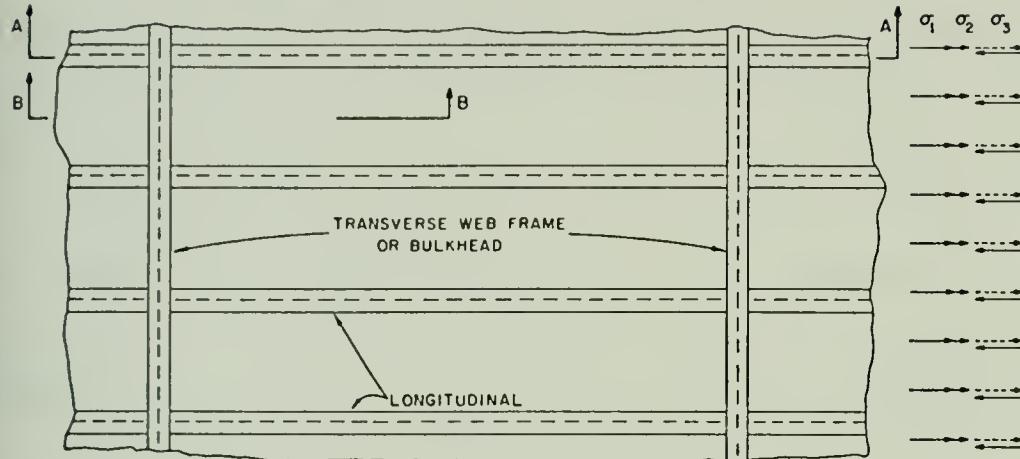


FIGURE 3

From the previous definitions and figure 3 we may summarize in figure 4 the effect of STR1, STR2 and STR3.

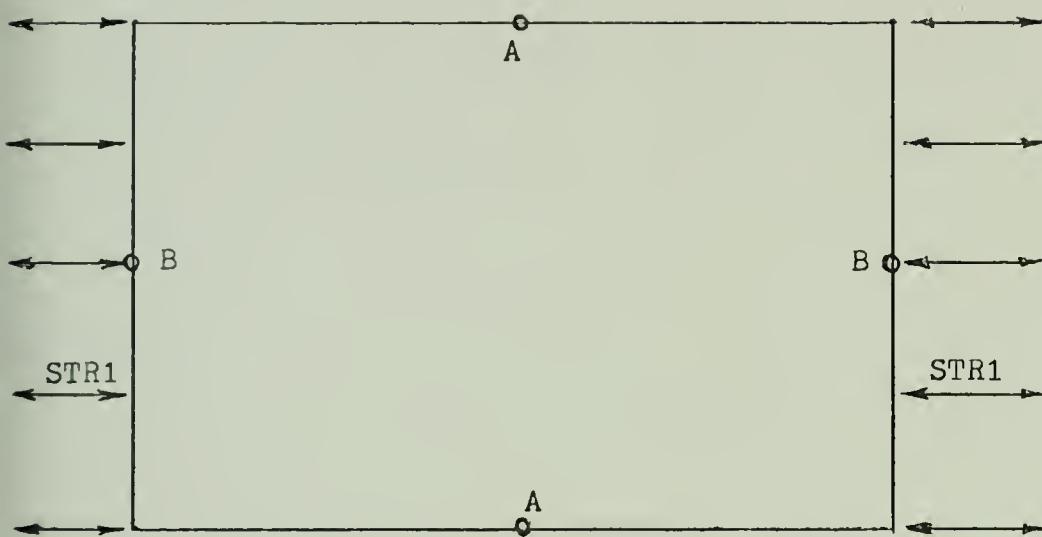


Fig. 4

At point A

STR2 is larger than at point B

STR2 is acting in the longitudinal direction

STR3 is larger than at point B

STR3 is acting in the transverse direction

STR1 and STR2 are here combined acting both in the
longitudinal direction

At point B

STR2 may be acting in the transverse direction

STR3 is acting in the longitudinal direction

STR1 and STR3 are here combined acting both in the
longitudinal direction.

Usually STR2 is attributed a constant value and can be taken into account by automatically decreasing the design stress by the value assigned to STR2.

THE BENDING MOMENT EQUATION

The bending moment equation used is derived from

$$BM = \Delta * AL / 35 \quad \text{ton*ft}$$

knowing that

$$\Delta = \nabla / 35 \quad \text{ton}$$

and that

$$\nabla = B * T * AL * C_b$$

and using

$$C_b = 0.75$$

we obtain

$$BM = \frac{0.75}{35 * 35} * B * T * AL * AL \quad \text{ton*ft}$$

where

AL = is the length in ft

B = is the beam in ft

T = is the draft in ft

C_b = is the block coefficient

or multiplying by 2240 we obtain

$$BM = 1.37143 * B * T * AL * AL \quad \text{lb*ft}$$

Note:

∇ is the displacement volume and Δ is the corresponding displacement weight.

MOMENT ACTING IN ONE DIRECTION

NO RESTRICTION IMPOSED ON THE COMPRESSION STRESS

Considering the box girder subjected to a bending moment acting in hogging BM, we will observe as a consequence that the top will be subjected to tension and the bottom to compression. These stresses are given by the already introduced formula

$$\text{STR} = \frac{\text{BM} * \text{Y}}{\text{I}}$$

or in this case, being interested on the top and bottom,

$$\text{STH} = \frac{\text{BM} * \text{DIBTOP}}{\text{I}}$$

$$\text{SBH} = \frac{\text{BM} * \text{DIBOT}}{\text{I}}$$

In this introductory study it was decided not to limit the value of the stress in compression. Only the value of the stress in tension, here STH will be requested to be equal to the value chosen for the design stress in tension (or smaller).

SBH will be a consequence of the value of DST and also of the S value chosen.

So, we will basically have 3 equations

$\text{DST} = \text{STH} \leftrightarrow \text{TOP}$ Bending equation

$S \leftrightarrow \text{SBH} \leftrightarrow \text{BOT}$ Bending equation + Bryan formula

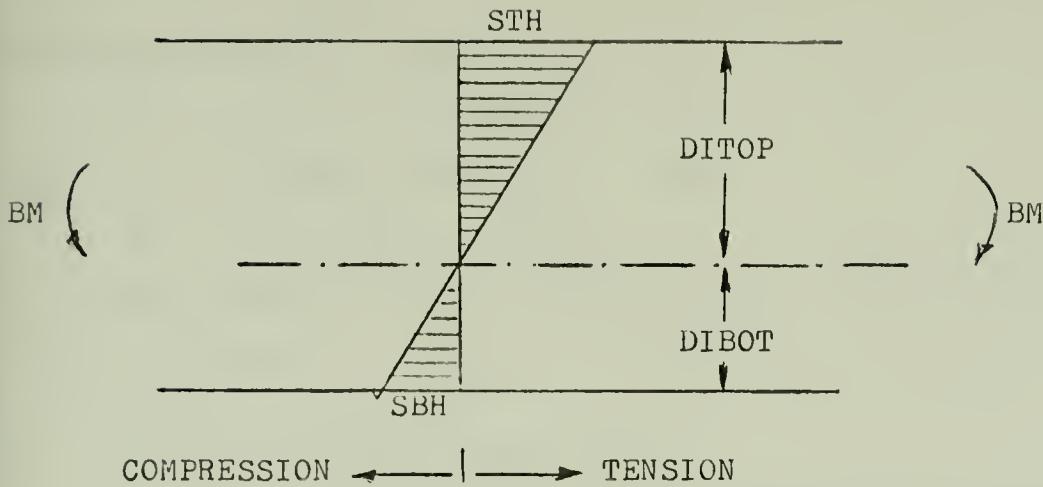


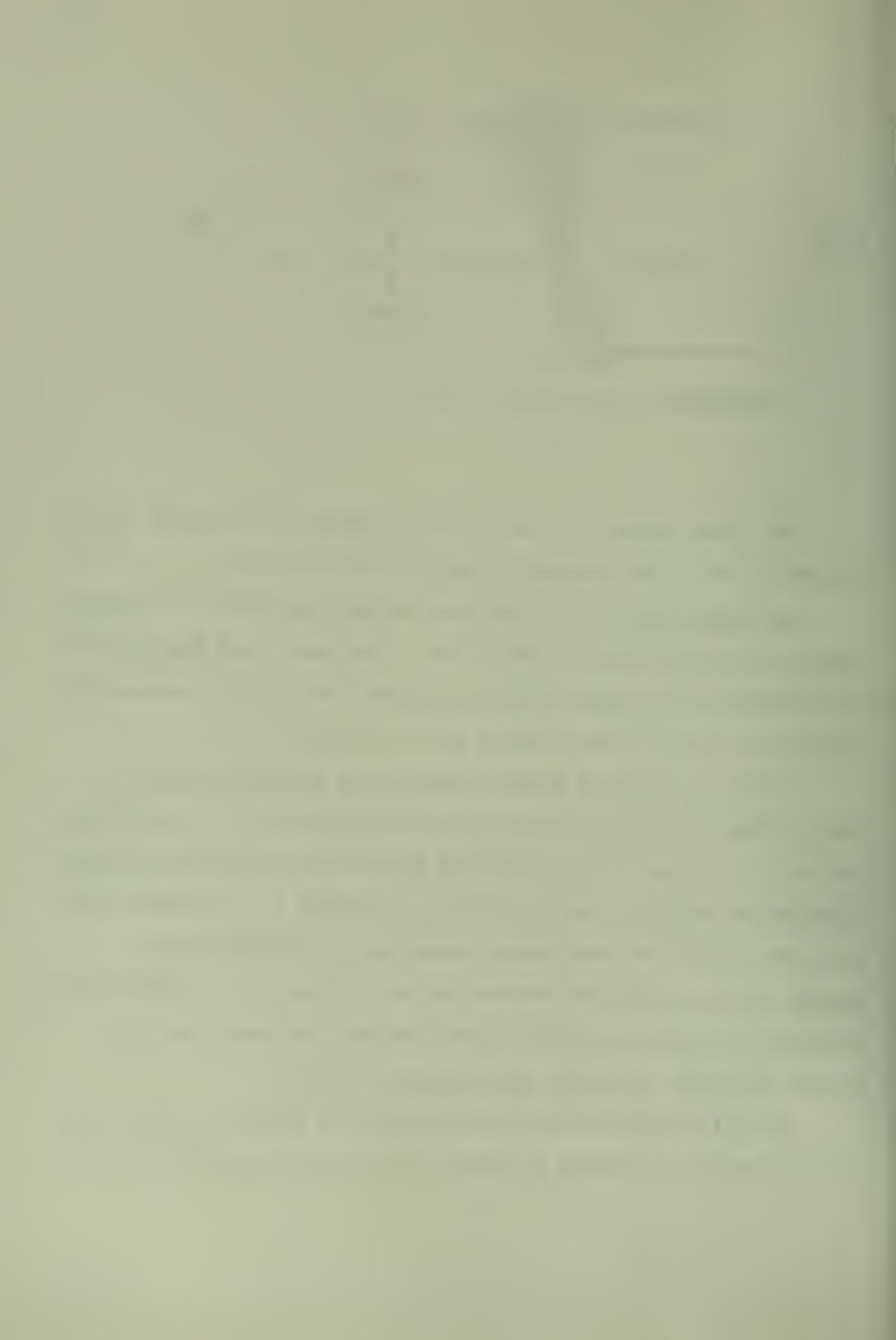
Fig. 5

The three equations that can be obtained will allow one to determine the three unknowns which are BOT, SBH, TOP.

By replacing in the equations already mentioned the expressions derived previously for DIBOT, DITOP and I and solving for BOT, TOP and SBH we obtain after a lengthy but simple process the equations in their final format as we will see.

Note here that in order to solve the three equations, the thickness of the side plates TS was made equal to the larger TOP or BOT; since TOP and BOT were not known and had to be determined after deciding on TS, the equations had to be solved twice. First the equations are solved assuming that $\text{TOP} > \text{BOT}$ this simply implying that the neutral axis is going to be chosen already closer to the top and $\text{TS} = \text{TOP}$. Second, the equations are solved assuming $\text{BOT} > \text{TOP}$ thus making $\text{TS} = \text{BOT}$.

As will be seen, only one solution is possible, the other being rejected by giving a result that does not agreee with the



assumption just mentioned.

TOP , BOT , S (inches)

B , D , DITOP , DIBOT , AL (ft)

DST , STH , SBH , E (psi)

BM (ton*ft)

I (in*ft)²

$$DST \geq STH = \frac{560 * BM * (B * BOT + D * TS)}{D * (3 * B * B * TOP * BOT + 2 * B * D * TS * (TOP + BOT) - (D * TS)^2)}$$

$$SBH = \frac{560 * BM * (B * TOP + D * TS)}{\text{Same denominator}}$$

$$BOT = \sqrt{G} \quad \sqrt{SBH}$$

$$G = 0.30396 * \frac{(S)^2 * (1 - (POI)^2)}{E}$$

$$\frac{DST}{SBH} = \frac{B * BOT + D * TS}{B * TOP + D * TS}$$

Making

$$A = \frac{9 * B * B * D}{140 * BM}$$

$$C = \frac{3 * B * D * D}{70 * BM}$$

$$F = \frac{3 * D * D * D}{140 * BM}$$

we will obtain, by assuming first TOP > BOT

$$DIBOT = \frac{D * (B+D) * TOP}{(2*D+B) * TOP + B * BOT}$$

$$DITOP = \frac{D * (B * BOT + D * TOP)}{\text{Same denominator}}$$

$$I = \frac{4 * D * D * \frac{(2 * B * D + D * D) * TOP * TOP + (2 * B * D + 3 * B * B) * TOP * BOT}{\text{Same denominator}}}{B * (BOT)^3}$$

$$TOP = \frac{(B+D)*G*DST-D*(BOT)^2}{(B+D)*G*DST-D*(BOT)^2}$$

$$BOT = \frac{TOP * (12*D - (C+F)*DST*TOP)}{DST*(A+C)*TOP - 12*B}$$

Before going to the equations obtained when $BOT > TOP$ is assumed, we call the attention of the reader to the fact that the values of BOT and TOP have to be obtained from the two above equations. Substitution of one into the other would result in an equation of degree higher than at least 5th degree, unsuitable for direct solution. As will be later exemplified, the solution is here obtained by assigning values to either one of BOT and TOP and through the two equations, we obtain the respective values for TOP and BOT. The plotting of these values BOT vs TOP will give one line for each of the two equations. The intersection of the two lines thus obtained allows the solution to be read from the plot.

This solution will be acceptable if the intersection lies in the sector $TOP > BOT$ otherwise the intersection must be rejected.

Assuming now $BOT > TOP$ we make $TS = BOT$ and obtain:

$$DIBOT = \frac{D * (B * TOP + D * BOT)}{(2 * D + B) * BOT + B * TOP}$$

$$DITOP = \frac{D * (B + D) * BOT}{\text{Same denominator}}$$

$$I = 4 * D * D * \frac{(2 * B * D + D * D) * (BOT)^2 + (2 * B * D + 3 * B * B) * TOP * BOT}{\text{Same denominator}}$$

$$TOP = \frac{(B + D) * (BOT)^3 - D * G * DST * BOT}{B * G * DST}$$

$$BOT = \frac{12 * (B + D) - (A + C) * DST * TOP}{(C + F) * DST}$$

In this form the equations can be used in a very simple computer program that will give the set of values TOP vs BOT suitable for plotting. At this stage we are hoping that if the intersection obtained in the situation where we assumed $TOP > BOT$ is acceptable, the two lines resulting from the case $BOT > TOP$ will not intersect or if they do that the intersection must be rejected due to the fact that they will violate the assumption from which they were derived.

As can be observed from the several cases run in the computer, the case where two acceptable solutions exist never happened and it can only happen if $TOP = BOT$ where then both solutions are acceptable and coincide as in the case of one of the following runs.

In the following pages the computer printouts are included. The first run is explained in detail to make the interested reader familiar with the problems encountered in determining the intersections and the respective thicknesses.

The other runs are here presented as well to serve as proof that a simple solution can always be obtained and also to give an idea of the range of thicknesses expected in each case.

In all runs only a bending moment acting in hogging was considered.

The program used is a direct application of the equations here derived to a particular set of values chosen as the input. From the results obtained, some conclusions were drawn that allowed for the improvements made in following sections.

No further explanation on the program shall here be given because it is self explanatory in the comment statements included.

STRENGTH OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE 1

```

204 C *AL* IS THE LENGTH
204 AL=502.
20C
218 C *DRA* IS THE DRAFT
218 DRA=8/3.
224 C D=AL/9.
2230 C *POI* IS THE POISSON'S RATIO OF THE MATERIAL
2230 FOR STEEL
2230 POI=0.3
2235 C *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
2235 FOR STEEL
2235 E=32.*17.***6
2240 C *DST* IS THE DESIGN STRESS
2240 DST=24000.
2154 C *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
2154 S=12.
2150 C *M* IS THE BENDING MOMENT
2150 M=(B*DRA*AL*AL*2.75)/(75.*35.)
2153 C E=7.3V396*S*(1.-POI*POI)/E
2154 A=E*B*D/(142.*BM)
2150 C D=3.**D*D/(72.*BM)
2154 F=D*D*D/(14.*BM)
2120 C THICKNESS OF TOP ASSUMED LARGER THAN BOTTOM THICKNESS
2120 WRITE(5,17)
2142 17 FORMAT('1',20X,'TOP ASSUMED LARGER THAN BOTTOM')
2157 C *TOP* IS THE THICKNESS OF THE TOP PLATING
2158 C *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
2158 BOT1=2.1
2175 11 TOP1=B*BOT1*BOT1*((B+D)*G*DST-D*BOT1*BOT1)
2175 WRITE(5,20)TOP1,BOT1
2159 20 FORMAT(' ',25X,'TOP1=1F9.4,5X,BOT1=1F9.4)
2201 20 BOT1=BOT1+2.25
2216 21 *F(BOT1.GT.0.2)GO TO 30
2223 GO TO 11
2230 30 TOP2=0.1
2234 31 BOT2=TOP2*((12.*D-(C+F)*DST)*TOP2)/(DST*(A+C)-TOP2-12.*B)
2240 WRITE(5,40)TOP2,BOT2
2246 40 FORMAT(' ',25X,'TOP2=1F9.4,5X,BOT2=1F9.4)
2250 TOP2=TOP2+2.25
2259 22 *F(TOP2.GT.1.1)GO TO 50
2261 GO TO 31
2266 50 CONTINUE
2266 C THICKNESS OF BOTTOM ASSUMED LARGER THAN TOP
2266 WRITE(5,40)
2212 60 FORMAT('1',20X,'BOTTOM ASSUMED LARGER THAN TOP')
2240 BOT3=0.1
2248 61 TOP3=((B+D)*BOT3*BOT3*BOT3-D*G*DST*BOT3)/(B*G*DST)
2248 WRITE(5,70)TOP3,BOT3
2258 70 FORMAT(' ',25X,'TOP3=1F9.4,5X,BOT3=1F9.4)
2250 BOT3=BOT3+2.25
2258 80 *F(BOT3.GT.1.1)GO TO 80
2260 GO TO 61

```


STRENGHT OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE 2

```

P402      80 TOP4=C+1
P40A      81 BOT4=(12.* (B+D)-(A+C)*DST*TOP4)/((C+F)*DST)
244E      WRITE(5,90)TOP4,BOT4
2472      90 FORMAT(1,1,24X,1TOP4='F9.4,5X,1BOT4='F9.4)
249A      TOP4=TOP4+1.15
24A6      +F(TOP4.GT.1.1GO TO 100
24E8      GO TO 81
24FC      100 CONTINUE
24BC      END
181(S)  •U    04C0(V) AL     04C8(V) B      04D0(V) DRA    04D8(V) D
181(V)  POI    04E8(V) E      04D0(S) •R     04F8(V) DST    0500(V) S
384(V)  RM     0518(V) G      0524(V) A      0520(V) C      0534(V) F
147(L)  12     0538(V) BOT1   0176(L) 11     0540(V) TOP1
152(L)  22     0554(V) TOP2   0234(L) 31     0558(V) BOT2
384(L)  40     0560(V) BOT3   0348(L) 61     0564(V) TOP2
370(V)  TOP3   0388(L) 70     0402(L) 80     0574(V) TOP4
370(V)  BOT4   0472(L) 90     0480(L) 100    0000(S) •V
' XEQ      L
108

```

PROGRAM LABELS:

| | | | | | |
|-------------|------------|------------|-----------|-------------|----------|
| 2870 •MAIN• | 2C0C •V | 2A3C •COMP | 2C1A •I | 25EC •R | 2B04 •ZE |
| 2A62 \$6 | 252C •A | 2B62 •MES | 29DE •W | 27E6 EXP | 296C AI' |
| 2D0E ALOG | 2AA4 •RARG | 2B22 •5 | 27E6 AEXP | 2B08 •ERCNT | 2AD6 \$8 |
| 2B08 •O | 2B0E •U | 3D36 | | | |

ENTRY-POINTS:

| | | | | | |
|------------|-------------|-----------|------------|----------|----------|
| 25EC •R | 262C •A | 260E ALOG | 27E6 AEXP | 27E6 EXP | 296C AI' |
| 29DE •W | 2A3C •COMP | 2A62 \$6 | 2AA4 •RARG | 2AD6 \$8 | 2B00 •S |
| 2B24 •ZERO | 2B08 •ERCNT | 2B2A •O | 2B60 •MES | 2B0A •U | 2C10 •V |
| 2C14 •I | | | | | |

COMMON-BLOCKS:

NONE

UNDEFINED SUBROUTINES:

NONE

TRANSFER ADDRESS 2070

EXECUTION BEGINS:

TOP ASSUMED LARGER THAN BOTTOM

| | | | |
|-------|----------|-------|---------|
| TOP1= | 0.2385 | BOT1= | 0.1000 |
| TOP1= | 0.2462 | BOT1= | 0.1250 |
| TOP1= | 0.0553 | BOT1= | 0.1100 |
| TOP1= | 2.2659 | BOT1= | 2.1150 |
| TOP1= | 2.2784 | BOT1= | 0.1200 |
| TOP1= | 0.0933 | BOT1= | 0.1250 |
| TOP1= | 0.1109 | BOT1= | 0.1300 |
| TOP1= | 2.1321 | BOT1= | 2.1350 |
| TOP1= | 0.1576 | BOT1= | 0.1400 |
| TOP1= | 2.1889 | BOT1= | 0.1450 |
| TOP1= | 0.2276 | BOT1= | 2.1500 |
| TOP1= | 2.2763 | BOT1= | 2.1550 |
| TOP1= | 0.3392 | BOT1= | 0.1600 |
| TOP1= | 0.4225 | BOT1= | 0.1650 |
| TOP1= | 2.5374 | BOT1= | 2.1700 |
| TOP1= | 2.7043 | BOT1= | 2.1750 |
| TOP1= | 0.9669 | BOT1= | 0.1800 |
| TOP1= | 1.4359 | BOT1= | 0.1850 |
| TOP1= | 2.5207 | BOT1= | 0.1900 |
| TOP1= | 2.1867 | BOT1= | 2.1950 |
| TOP1= | -11.0527 | BOT1= | 0.2000 |
| TOP2= | 0.1000 | BOT2= | -0.1738 |
| TOP2= | 0.1500 | BOT2= | -2.1758 |
| TOP2= | 0.2000 | BOT2= | -2.2808 |
| TOP2= | 0.2500 | BOT2= | -2.4765 |
| TOP2= | 2.3000 | BOT2= | -1.1361 |
| TOP2= | 0.3500 | BOT2= | 2.8493 |
| TOP2= | 0.4000 | BOT2= | 0.5282 |
| TOP2= | 0.4500 | BOT2= | 0.2263 |
| TOP2= | 0.5000 | BOT2= | 0.1925 |
| TOP2= | 0.5500 | BOT2= | 0.0287 |
| TOP2= | 0.6000 | BOT2= | -0.0534 |
| TOP2= | 0.6500 | BOT2= | -0.1244 |
| TOP2= | 0.7000 | BOT2= | -0.1487 |
| TOP2= | 0.7500 | BOT2= | -0.1888 |
| TOP2= | 0.8000 | BOT2= | -0.2260 |
| TOP2= | 0.8500 | BOT2= | -0.2612 |
| TOP2= | 0.9000 | BOT2= | -0.2950 |
| TOP2= | 0.9500 | BOT2= | -0.3276 |
| TOP2= | 1.0000 | BOT2= | -0.3593 |

BOTTOM ASSUMED LARGER THAN TOP

| | | | |
|-------|----------|-------|---------|
| TOP3= | 0.2135 | BOT3= | 0.1000 |
| TOP3= | 0.2124 | BOT3= | 0.1500 |
| TOP3= | 0.6417 | BOT3= | 0.2000 |
| TOP3= | 1.3783 | BOT3= | 0.2500 |
| TOP3= | 2.4900 | BOT3= | 0.3000 |
| TOP3= | 4.0807 | BOT3= | 0.3500 |
| TOP3= | 6.2001 | BOT3= | 0.4000 |
| TOP3= | 8.9341 | BOT3= | 0.4500 |
| TOP3= | 12.3596 | BOT3= | 0.5000 |
| TOP3= | 16.5533 | BOT3= | 0.5500 |
| TOP3= | 21.5920 | BOT3= | 0.6000 |
| TOP3= | 27.5527 | BOT3= | 0.6500 |
| TOP3= | 34.5121 | BOT3= | 0.7000 |
| TOP3= | 42.5470 | BOT3= | 0.7500 |
| TOP3= | 51.7342 | BOT3= | 0.8000 |
| TOP3= | 62.1501 | BOT3= | 0.8500 |
| TOP3= | 73.8731 | BOT3= | 0.9000 |
| TOP3= | 86.9784 | BOT3= | 0.9500 |
| TOP3= | 101.5434 | BOT3= | 1.0000 |
| TOP4= | 0.1000 | BOT4= | 0.0961 |
| TOP4= | 0.1520 | BOT4= | 0.0931 |
| TOP4= | 0.2000 | BOT4= | 0.0810 |
| TOP4= | 0.2520 | BOT4= | 0.0717 |
| TOP4= | 0.3000 | BOT4= | 0.0624 |
| TOP4= | 0.3500 | BOT4= | 0.0531 |
| TOP4= | 0.4000 | BOT4= | 0.0437 |
| TOP4= | 0.4500 | BOT4= | 0.0344 |
| TOP4= | 0.5220 | BOT4= | 0.0251 |
| TOP4= | 0.5500 | BOT4= | 0.0158 |
| TOP4= | 0.6000 | BOT4= | 0.0065 |
| TOP4= | 0.6500 | BOT4= | -0.0272 |
| TOP4= | 0.7200 | BOT4= | -0.1202 |
| TOP4= | 0.7500 | BOT4= | -0.2133 |
| TOP4= | 0.8000 | BOT4= | -0.363 |
| TOP4= | 0.8500 | BOT4= | -0.2993 |
| TOP4= | 0.9200 | BOT4= | -0.4923 |
| TOP4= | 0.9500 | BOT4= | -0.5254 |
| TOP4= | 1.0000 | BOT4= | -0.6784 |

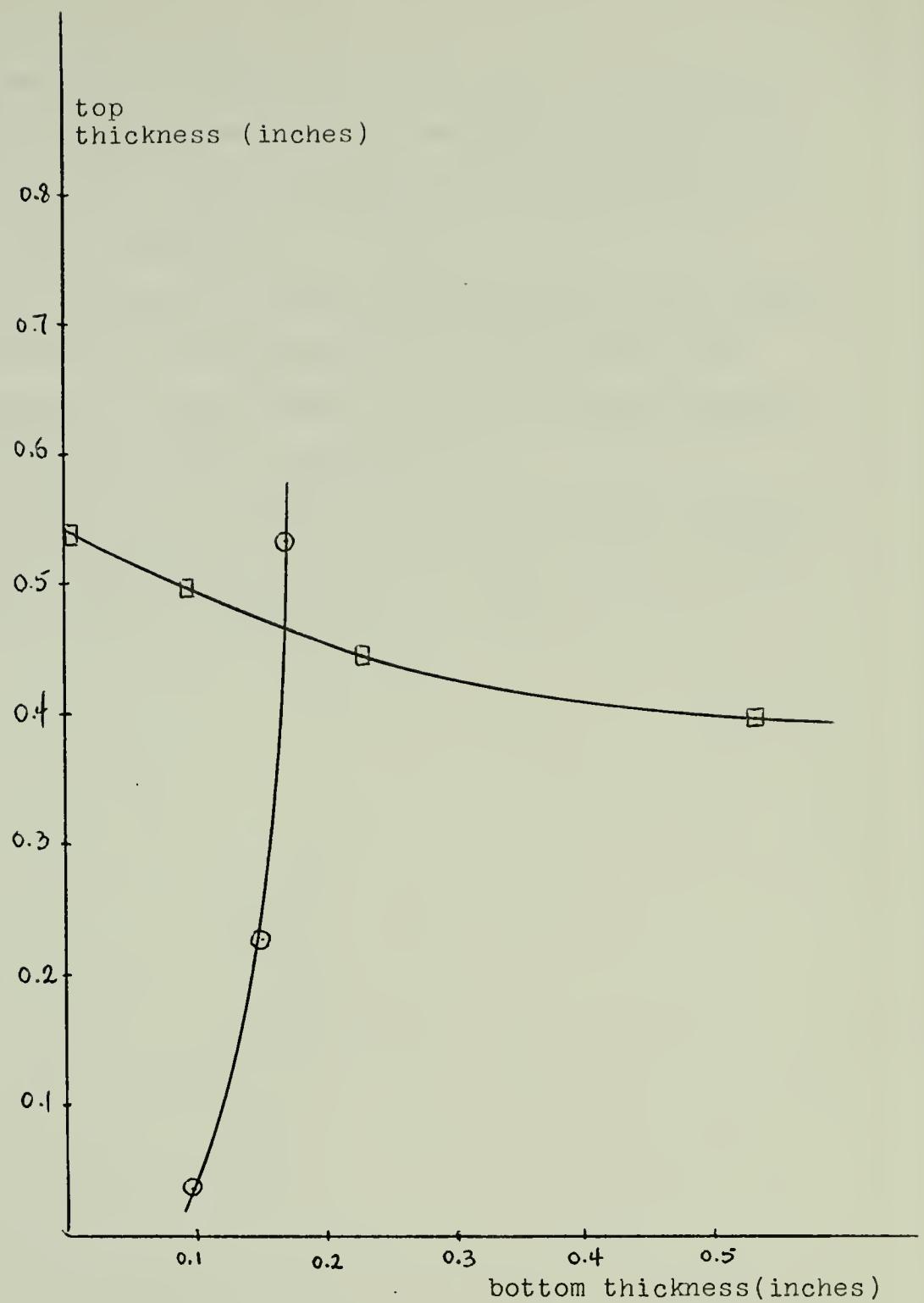
END

CF VIC OPERATING SYSTEM VERSION 1 REVISION 012 03/04/74 GENERATED 05/06/74

| | | |
|-----------------------|-----------------|-----|
| JOB HANDLING CHARGE | \$.35 / JOB | .35 |
| 175 LINES PRI.TED PR2 | \$ 1.25 / K LN | .22 |
| 67 CARDS READ | \$ 1.50 / K CD | .10 |
| 00 PLOTTER VECTORS | \$.25 / 1000 | .00 |
| 15 MODEL 70 SECONDS | \$25.00 / HOUR | .17 |
| 00 MODEL 80 SECONDS | \$12.50 / HOUR | .02 |
| | TOTAL CHARGE \$ | .77 |

PREIR 490 14731 LOGGED OUT 05/06/74 15:14. \$ 14.10 LEFT AFTER 17 LOGINS.

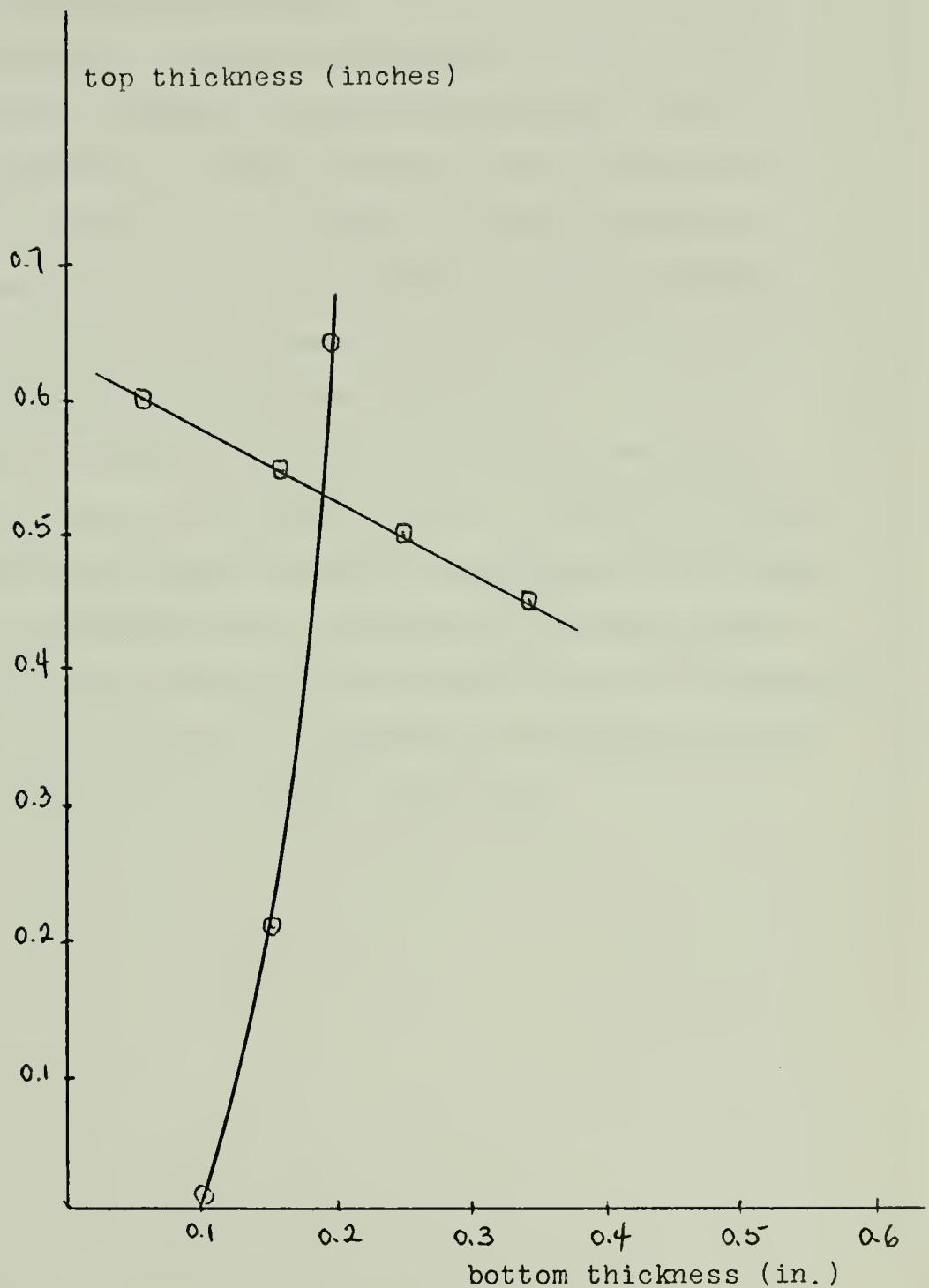
From these lists of thickness values printed by the computer, we can see that the acceptable ones are those marked with a || sign. Plotting these corresponding pairs of values properly, as is next exemplified, allows for one to read from the intersection of the two lines, which falls within the range set by the assumption that originated it, the values of thicknesses at the top and at the bottom which satisfy the model we started with.



We can see that the thickness values are easily read from the intersection obtained and they are acceptable because they fall within the range assumed to derive the formulas that originated them namely $\text{TOP} > \text{BOT}$.

Next will be plotted the case $\text{BOT} > \text{TOP}$ and as can be seen, again an intersection is obtained which in this case is not acceptable because it occurs within the range $\text{TOP} > \text{BOT}$ contrary to the assumed $\text{BOT} > \text{TOP}$ that originated it.

With a little more experience, this can be seen immediately from the computer printouts, thus avoiding loss of time doing a plot that will lead to a nonacceptable result.



Now having obtained the values for the thicknesses from the plots, we verify them through the use of the next program based on the formulation previously derived. As can be noted, we obtain an acceptable value for the stress at the top (since we are considering a hogging bending moment) which we said before in the derivation of the equations should not exceed the design stress in tension. In this case the design stress was DST=20000 psi and we see that the stress at the top STH=20037.5 the 37.5 coming possibly from inaccuracy when reading the thicknesses from the plot, and computer roundoffs.

Note that the stress at the bottom, since there was no limit placed on it except the Bryan formula to resist buckling caused by compressive inplane loading, is attaining a too large value which is unacceptable and unrealistic. Here again there should be no difference between SBH and SBCRIT and the difference that can be noted is also due to inaccuracy in reading the thicknesses from the plot and computer round-offs.

STRENGTH OF STIFFENED LONGITUDINAL AXES LOCATED

PAGE 1

```

0 24 C *L IS THE LENGTH
0 24
0 25 C L=91.0
0 25
0 26 C E=1178.
0 26
0 27 C D=12.70
0 27
0 28 C E=1178.
0 28
0 29 C *E0 IS THE MODULUS OF ELASTICITY OF THE MATERIAL
0 29
0 30 C E0=200000
0 30
0 31 C R0 IS THE YIELDING MODULUS OF THE MATERIAL
0 31
0 32 C E0=200000
0 32
0 33 C D=2.01*E0
0 33
0 34 C *S1 IS THE DESIGN STRESS
0 34
0 35 C S1=200000
0 35
0 36 C *S2 IS THE CRITICAL STRESS IN LONGITUDINAL STIFFENING MEMBERS
0 36
0 37 C S2=100000
0 37
0 38 C *M IS THE MOMENT OF INERTIA
0 38
0 39 C M=(4.0*100000000.0+25.0*1000.0)
0 39
0 40 C T0=2.01*E0*(1.0+0.01*E0)/E
0 40
0 41 C *T0 IS THE THICKNESS OF THE TOP PLATING
0 41
0 42 C *T1 IS THE THICKNESS OF THE BOTTOM PLATING
0 42
0 43 C T1=2.450
0 43
0 44 C S1*T1=0.100
0 44
0 45 C L=86.000 (EXACT PATTERN)
0 45
0 46 C M1=4.0*1000+T0*T0*2.01*3.0*T0*(TOP+BOT)+(BOT*T0*T0)
0 46
0 47 C *S1 IS THE STRESS ON TOP DUE TO LOGGING
0 47
0 48 C S1=1178.
0 48
0 49 C WRITE(F10.3)S1
0 49
0 50 C FORMAT(1X,1.2Y,1E10.3)
0 50
0 51 C *S2CRIT IS THE CRITICAL STRESS ON BOT
0 51
0 52 C S2CRIT=S1*BOT/E
0 52
0 53 C WRITE(F10.3)S2CRIT
0 53
0 54 C 112 FORMAT(1X,1.2Y,1E10.3)
0 54
0 55 C P=2.01*T0*(TOP+BOT)
0 55
0 56 C *D1TOP IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
0 56
0 57 C D1TOP=(P*T0)+(TOP*T0)/E
0 57
0 58 C WRITE(F10.3)D1TOP
0 58
0 59 C 420 FORMAT(1X,1.2Y,1E10.4)
0 59
0 60 C *D1BOT IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS
0 60
0 61 C D1BOT=(P*T0)+(BOT*T0)/E
0 61
0 62 C WRITE(F10.3)D1BOT
0 62
0 63 C 512 FORMAT(1X,1.2Y,1E10.4)
0 63
0 64 C E1L
0 64
0 65 C 6324(1)=L 6226(1)=R 6340(1)=DRA 6330(1)=D
0 65
0 66 C 6340(1)=R 6227(1)=R 6350(1)=DST 6364(1)=S
0 66
0 67 C 6370(1)=S 6228(1)=TCP 6351(1)=BOT 6333(1)=A
0 67
0 68 C 6388(1)=STL 6224(1)=S2 6352(1)=WT 6360(1)=C
0 68

```


STAB CUT OF SPINE AND LIVER WITH LOCATIONS

1 A 7E

RC [V] 5.0 172 [11] 100 204 [V] 500 [V] 102.3 [11] 116 130 [V] P
RC [V] 5.0 172 [11] 100 204 [V] 500 [V] 102.3 [11] 116 130 [V] P
RC [V] 5.0 172 [11] 100 204 [V] 500 [V] 102.3 [11] 116 130 [V] P

REGULATIONS:

N.Y.-P. 178.

2464 + 2 2476 + 2 2521 - 11 2638 - 100 2638 - 100 2638 - 100 2704 AT
 2530 + 2 2534 + 11 2535 - 5 2540 + 20 2540 + 20 2540 + 20 2718 +
 2550 + 2550 2561 + 11 2561 + 11 2562 + 11 2562 + 11 2562 + 11 2568 +
 2512 +

11

REFINE - CLOUD TIPPS:

11

EDWARD WILSON 670

E-I-I-8

| | |
|-----------|-------------|
| STL = | 3 327.6 + 9 |
| SAC = | 3 424.095 |
| ET (AT) = | 203.4 .372 |
| ET (TO) = | 22.1565 |
| ET (LO) = | 23.53 1 |

5

CE VIO REPORTING SYSTEM REQUESTED BY LEGISLATION 12 3/24/74 GENERATED 5/16/74

| | | | | | | | |
|----|-------------------|------|------|------------|------|--|------|
| 10 | HANDLING CHARGE | 1 | 0.25 | / | 0.25 | | 0.25 |
| 15 | LINES COPIED | 1 | 1.25 | / | 1.25 | | 1.25 |
| 54 | CARDS READ | 1 | 1.50 | / | 1.50 | | 1.50 |
| 20 | PLOTTED VECTORS | 1 | 0.25 | / | 0.25 | | 0.25 |
| 13 | MODEL IN SECONDS | 1.25 | 0.12 | / | 0.12 | | 0.12 |
| 20 | MODEL OUT SECONDS | 1.25 | 0.05 | / | 0.05 | | 0.05 |
| | | | | TOTAL TIME | 0.42 | | 0.42 |

R-512 422 14731 LOGGED 51 T 10/24/74 15:43 B 11.70 LEFT AFTER 20 LOGINS.

SUMMARY FOR THE PRECEDING CASE

Length = 500 ft
 Beam = $AL/8$
 Draft = $B/3$
 Depth = $AL/9$
 DST = 20000 psi
 S = 10 inches
 Material - STEEL
 TOP = 0.468 inches
 BOT = 0.166 inches
 STH = 20037.45
 SBH = 30434.89
 SBCRIT = 29886.80
 DITOP = 22.06 ft
 DIBOT = 33.50 ft

We can already notice here that the stress in the bottom is attaining a too large value due to the fact that, since no limit was imposed on it, it is dependent only on the chosen value for S and the respective capacity to resist buckling provided by S and BOT while at the same time stressing the top plate to its maximum allowed DST.

In the following two cases only the spacing S between the longitudinal stiffening members will be allowed to change and the results obtained are simply stated as previously exemplified and were determined in a similar way.

From the results obtained we can note the effect caused by the change of S.

STRENGHT OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE 1

```

0224 C *AL* IS THE LENGTH
0224 AL=522.
0225 C B=AL/8.
0218 C *DRA* IS THE DRAFT
0218 DRA=B/3.
0224 C D=AL/9.
0232 C *POI* IS THE POISSON'S RATIO OF THE MATERIAL
0232 FOR STEEL
0232 POI=C.3
0236 C *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
0236 FOR STEEL
0236 E=32.*10.*1000000.
0240 C *DST* IS THE DESIGN STRESS
0240 DST=21442.
0254 C *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
0254 S=24.
0256 C *BMR* IS THE BENDING MOMENT
0256  $BMR = (B \times DRA \times AL \times AL^2 \cdot 75) / (35 \cdot 35 \cdot 1)$ 
0258 G=9.30396*S*S*(1.-POI*POI)/E
0264 A=9.*B*8*D/(142.*BMR)
0264 D=3.*B*8*D/(72.*BMR)
0264 E=3.*D*D*D/(142.*BMR)
0266 C THICKNESS OF TOP ASSUMED LARGER THAN BOTTOM THICKNESS
0266 WRITE(5,17)
0269 10 FORMAT('1',25X,'TOP ASSUMED LARGER THAN BOTTOM')
0269 C *TOP* IS THE THICKNESS OF THE TOP PLATING
0269 C *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
0269 BOT1=0.1
0274 11 TOP1=B*BOT1*BOT1*BOT1/((B+D)*G*DST-D*BOT1*BOT1)
0275 WRITE(5,20)TOP1,BOT1
0279 20 FORMAT(' ',25X,'TOP1='F9.4,5X,'BOT1='F9.4)
0281 BOT1=BOT1+0.25
0285 25 IF(BOT1.GT.1.160 TO 30
0288 GO TO 11
0290 30 TOP2=0.1
0294 31 BOT2=TOP2*(12.*D-(C+F)*DST*TOP2)/(DST*(A+C)*TOP2-12.*B)
0298 WRITE(5,40)TOP2,BOT2
0304 40 FORMAT(' ',25X,'TOP2='F9.4,5X,'BOT2='F9.4)
0306 TOP2=TOP2+0.25
0308 45 IF(TOP2.GT.1.160 TO 50
0311 GO TO 31
0315 50 CONTINUE
0316 C THICKNESS OF BOTTOM ASSUMED LARGER THAN TOP
0316 WRITE(5,60)
0319 60 FORMAT('1',25X,'BOTTOM ASSUMED LARGER THAN TOP')
0320 BOT3=0.1
0324 61 TOP3=((B+D)*BOT3*BOT3*BOT3-D*G*DST*BOT3)/(B*G*DST)
0328 WRITE(5,70)TOP3,BOT3
0332 70 FORMAT(' ',25X,'TOP3='F9.4,5X,'BOT3='F9.4)
0334 BOT3=BOT3+0.25
0338 75 IF(BOT3.GT.1.160 TO 80
0341 GO TO 61

```


STRENGHT OF SHIPS-ON THE NEUTRAL AXIS LOCATION

```

0482      80 TOP4=0.1
248A      81 BOT4=(12.* (B+D)-(A+C)*DST*TOP4)/((C+F)*DST)
044E      WRITE(5,90)TOP4,BOT4
2472      90 FORMAT(' ',25X,'TOP4='F9.4,5X,'BOT4='F9.4)
249A      TOP4=TOP4+T*.75
24A6      IF(TOP4.GT.1.)GO TO 100
2488      GO TO 81
24BC      100 CONTINUE
24BC      END
'22[S] .U    04CA[V] AL    04C8[V] B     04D0[V] DRA    04D8[V] D
'E2[V] POI   04E8[V] E     0400[V] F     04F8[V] DST    0500[V] S
'24[V] BM    0518[V] G     0524[V] A     052C[V] C     0534[V] F
'42[L] 12    0538[V] BCT1   0176[L] 11    0542[V] TOP1
'E2[L] 22    0550[V] TCP2    0234[L] 31    0554[V] BOT2
'24[L] 42    0558[V] 40    0564[V] BOT3   0348[L] 61
'68[V] TOP3   0568[V] 70    056C[V] TOP4   040A[L] 81
'70[V] BCT4   0572[L] 90    0580[V] 120   0000[S] .V
' YEQ      L
'OF

```

PROGRAM LABELS:

| | | | | | |
|--------------|------------|------------|-----------|-------------|----------|
| 2H70 *MAIN,* | 2CP4 .V | 2A34 .COMP | 2C12 @I | 25E4 .R | 2AFC .ZF |
| 2A54 \$6 | 2624 .A | 2B58 .MES | 29D6 .W | 27DE EXP | 2964 AIM |
| 2606 ALOG | 2A9C .RARG | 2AF8 .5 | 27DE AEXP | 2B00 .ERCNT | 2ACE \$8 |
| 2B20 .0 | 2BD6 .U | 3D2E | | | |

NTRY-POINTS:

| | | | | | |
|------------|-------------|-----------|------------|----------|----------|
| 25E4 .R | 2624 .A | 26D6 ALOG | 27DE AEXP | 27DE EXP | 2964 AIM |
| 29D6 .W | 2A34 .COMP | 2A5A \$6 | 2A9C .RARG | 2ACE \$8 | 2AF8 .5 |
| 2AFC .ZERO | 2B00 .ERCNT | 2B22 .0 | 2B58 .MES | 2BE2 .U | 2C08 .V |
| -C12 @I | | | | | |

COMMON-BLOCKS:

ONE

REFINED SUBROUTINES:

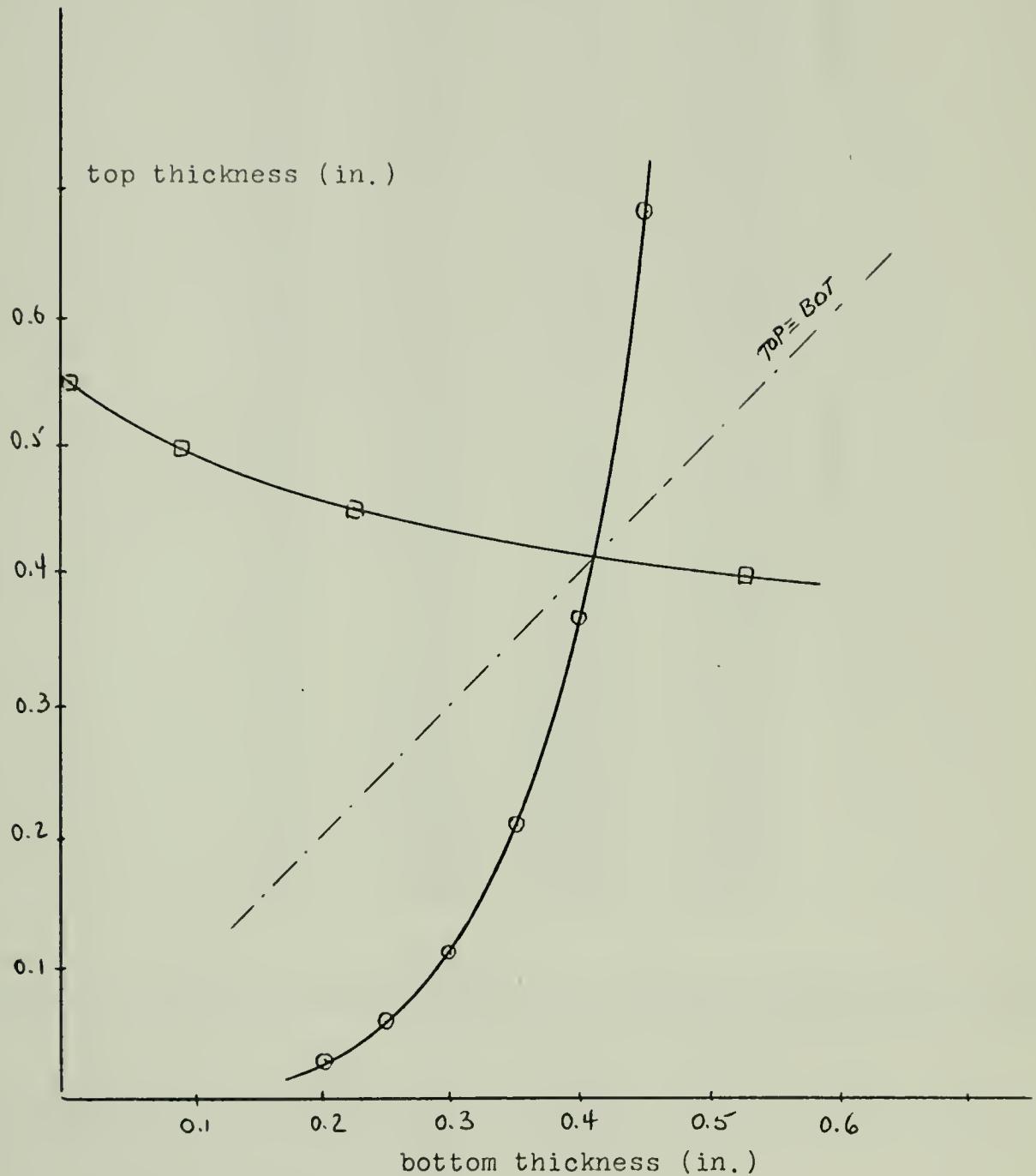
ONE

TRANSFER ADDRESS 2C72

EXECUTION BEGINS:

TOP ASSUMED LARGER THAN BOTTOM

| | | | |
|-------|----------|-------|----------|
| TOP1= | 2.2033 | BOT1= | 0.1200 |
| TOP1= | 2.2115 | BOT1= | 0.1500 |
| TOP1= | 2.2288 | BOT1= | 0.2200 |
| TOP1= | 2.2626 | BOT1= | 0.2500 |
| TOP1= | 2.1156 | BOT1= | 0.3200 |
| TOP1= | 2.2096 | BOT1= | 0.3500 |
| TOP1= | 2.3737 | BOT1= | 0.4700 |
| TOP1= | 2.6827 | BOT1= | 0.4522 |
| TOP1= | 1.3697 | BOT1= | 0.5200 |
| TOP1= | 3.7376 | BOT1= | 2.5522 |
| TOP1= | -32.1585 | BOT1= | 2.6102 |
| TOP1= | -4.4245 | BOT1= | 2.6522 |
| TOP1= | -2.8099 | BOT1= | 2.7122 |
| TOP1= | -2.2619 | BOT1= | 2.7522 |
| TOP1= | -2.7847 | BOT1= | 2.8122 |
| TOP1= | -1.8681 | BOT1= | 2.8522 |
| TOP1= | -1.7933 | BOT1= | 2.9222 |
| TOP1= | -1.7543 | BOT1= | 2.9502 |
| TOP1= | -1.7379 | BOT1= | 1.0200 |
| TOP2= | 2.1707 | BOT2= | -2.1738 |
| TOP2= | 2.1567 | BOT2= | -2.1758 |
| TOP2= | 2.2722 | BOT2= | -2.2808 |
| TOP2= | 2.2522 | BOT2= | -2.2765 |
| TOP2= | 2.3132 | BOT2= | -2.11361 |
| TOP2= | 2.2522 | BOT2= | 2.8493 |
| TOP2= | 2.4222 | BOT2= | 2.5222 |
| TOP2= | 2.4522 | BOT2= | 2.2263 |
| TOP2= | 2.5222 | BOT2= | 2.0925 |
| TOP2= | 2.5522 | BOT2= | 2.0287 |
| TOP2= | 2.6217 | BOT2= | -2.7534 |
| TOP2= | 2.6500 | BOT2= | -0.1744 |
| TOP2= | 2.7000 | BOT2= | -0.1487 |
| TOP2= | 0.7520 | BOT2= | -0.1888 |
| TOP2= | 0.8220 | BOT2= | -0.2260 |
| TOP2= | 0.8500 | BOT2= | -0.2612 |
| TOP2= | 0.9200 | BOT2= | -0.2950 |
| TOP2= | 0.9500 | BOT2= | -0.3276 |
| TOP2= | 1.0200 | BOT2= | -0.3593 |



BOTTOM ASSUMED LARGER THAN TOP

| | | | |
|-------|---------|-------|---------|
| TOP3= | -0.2775 | BOT3= | 0.1000 |
| TOP3= | -0.0949 | BOT3= | 0.1500 |
| TOP3= | -2.7867 | BOT3= | 0.2000 |
| TOP3= | -2.7444 | BOT3= | 0.2500 |
| TOP3= | 0.7406 | BOT3= | 0.3000 |
| TOP3= | 0.1769 | BOT3= | 0.3500 |
| TOP3= | 0.3729 | BOT3= | 0.4000 |
| TOP3= | 2.4371 | BOT3= | 0.4500 |
| TOP3= | 2.9782 | BOT3= | 0.5000 |
| TOP3= | 1.4047 | BOT3= | 0.5500 |
| TOP3= | 1.9250 | BOT3= | 0.6000 |
| TOP3= | 2.5478 | BOT3= | 0.6500 |
| TOP3= | 3.2816 | BOT3= | 0.7000 |
| TOP3= | 4.1349 | BOT3= | 0.7500 |
| TOP3= | 5.1162 | BOT3= | 0.8000 |
| TOP3= | 6.2348 | BOT3= | 0.8500 |
| TOP3= | 7.4970 | BOT3= | 0.9000 |
| TOP3= | 8.9137 | BOT3= | 0.9500 |
| TOP3= | 10.4925 | BOT3= | 1.0000 |
| TOP4= | 0.1000 | BOT4= | 0.9961 |
| TOP4= | 0.1500 | BOT4= | 0.9931 |
| TOP4= | 0.2000 | BOT4= | 0.9101 |
| TOP4= | 0.2500 | BOT4= | 0.7170 |
| TOP4= | 0.3000 | BOT4= | 0.6240 |
| TOP4= | 0.3500 | BOT4= | 0.5310 |
| TOP4= | 0.4000 | BOT4= | 0.4379 |
| TOP4= | 0.4500 | BOT4= | 0.3449 |
| TOP4= | 0.5000 | BOT4= | 0.2519 |
| TOP4= | 0.5500 | BOT4= | 0.1589 |
| TOP4= | 0.6000 | BOT4= | 0.0658 |
| TOP4= | 0.6500 | BOT4= | -0.0272 |
| TOP4= | 0.7000 | BOT4= | -0.1202 |
| TOP4= | 0.7500 | BOT4= | -0.2133 |
| TOP4= | 0.8000 | BOT4= | -0.3263 |
| TOP4= | 0.8500 | BOT4= | -0.3993 |
| TOP4= | 0.9000 | BOT4= | -0.4923 |
| TOP4= | 0.9500 | BOT4= | -0.5854 |
| TOP4= | 1.0000 | BOT4= | -0.6784 |

||

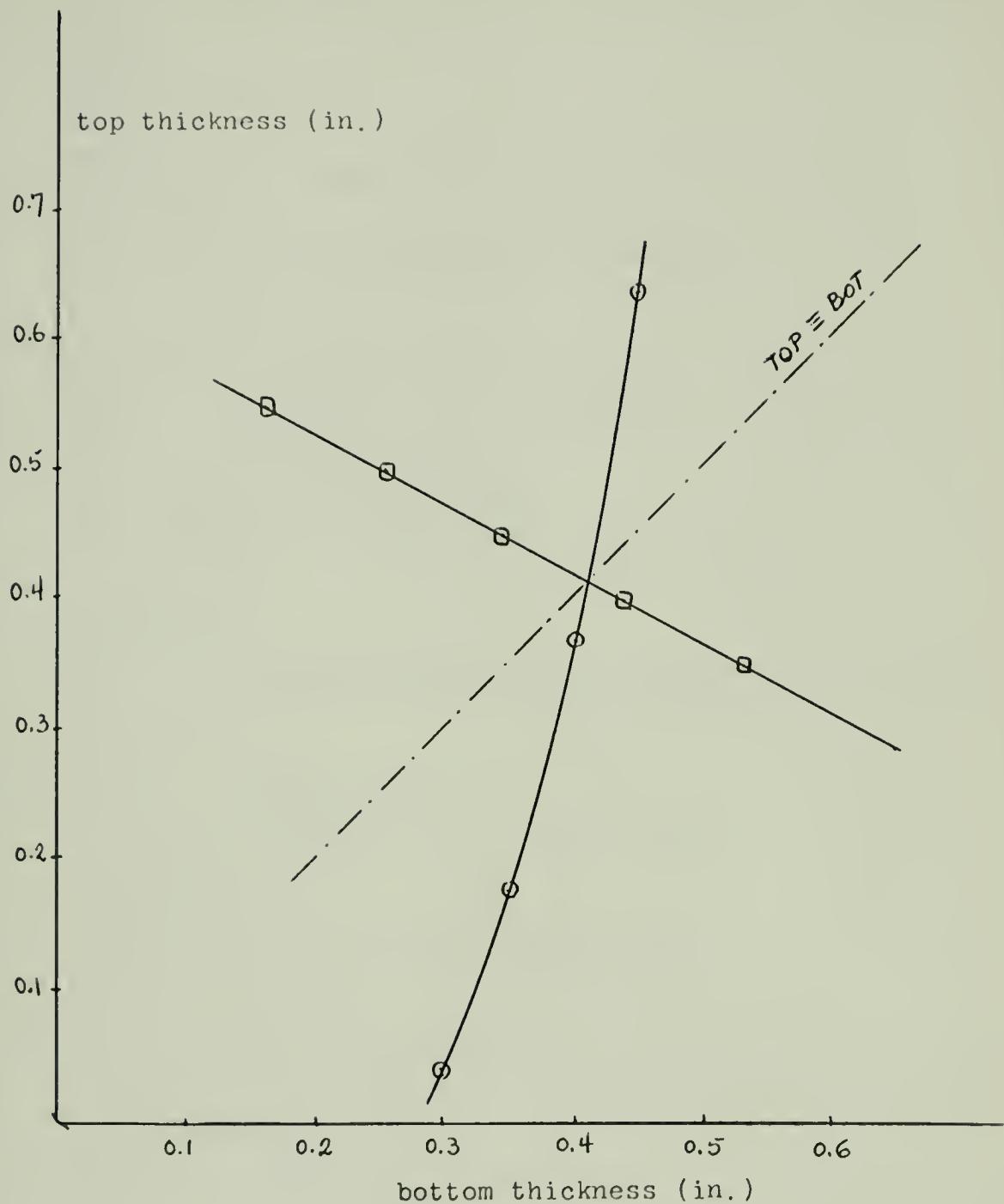
||

END

F VIO OPERATING SYSTEM VERSION 1 REVISION 012 03/04/74 GENERATED 05/06/74 0

| | | |
|----------------------|----------------|-----|
| 08 HANDLING CHARGE | \$.35 / JOB | .35 |
| 73 LINES PRINTED PR2 | \$ 1.25 / K LN | .22 |
| 67 CARDS READ | \$ 1.52 / K CD | .10 |
| 00 PLOTTER VECTORS | \$.25 / 1000 | .02 |
| 20 MODEL 70 SECONDS | \$25.47 / HOUR | .14 |
| 02 MODEL 80 SECONDS | \$12.57 / HOUR | .07 |
| TOTAL CHARGE \$ | | .81 |

REIR 490 14731 LOGGED OUT 25/06/74 15:20. \$ 13.29 LEFT AFTER 18 LOGINS.




```

0724 C *AL* IS THE LENGTH
0724 AL=500.
0770 D=AL/8.
0718 C *DRA* IS THE DRAFT
0718 DRA=B/3.
0724 D=AL/9.
0732 C *POI* IS THE POISSON'S RATIO OF THE MATERIAL
0732 FOR STEEL
0732 POI=0.3
0733 C *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
0733 FOR STEEL
0733 E=30.*10.*10.
0740 C *UST* IS THE DESIGN STRESS
0740 DST=20000.
0754 C *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
0754 S=32.
0750 C *BMM* IS THE BENDING MOMENT
0750 BM=(B*DRA*AL*V*75)/(35.*35.)
0756 G=2.32396*S*S*(1.-POI*POI)/E
0756 C *TOP* IS THE THICKNESS OF THE TOP PLATING
0756 C *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
0756 TOP=0.4125
0756 BOT=0.4125
0764 A=563.*BMM*(B*BOT+D*TOP)
0764 B=60*(3.*B*TOP*BOT+2.*B*B*TOP*(TOP+BOT)+(D*D*TOP*TOP))
0764 C *GTH* IS THE STRESS ON TOP DUE TO HOGGING
0764 GTH=A/DEN
0764 WRITE(5,60)GTH
0764 60 FORMAT(1.1,20X,'GTH=F12.3')
0764 C B=563.*BMM*(B*TOP+D*TOP)
0764 C *GPH* IS THE STRESS ON BOT DUE TO HOGGING
0764 GPH=C/DEN
0764 WRITE(5,90)GPH
0764 90 FORMAT(1.1,20X,'GPH=F12.3')
0764 C *SBCRIT* IS THE CRITICAL STRESS ON BOT
0764 SBCRIT=BOT*BOT/G
0764 WRITE(5,110)SBCRIT
0764 110 FORMAT(1.1,17X,'SBCRIT=F10.3')
0764 P=P.*D*TOP+B*(TOP+BOT)
0764 C *DITOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
0764 DITOP=D*(B*BOT+D*TOP)/P
0764 WRITE(5,42)DITOP
0764 42 FORMAT(1.1,18X,'DITOP=F10.4')
0764 C *DIBOT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS
0764 DIBOT=D*(B*TOP+D*TOP)/P
0764 WRITE(5,54)DIBOT
0764 54 FORMAT(1.1,18X,'DIBOT=F10.4')
0764 END
0765 U 0324[V] AL      0320[V] B      0334[V] DRA      0330[V] D
0765 V POI    0340[V] E      0000[S]  R      0350[V] DST      0364[V] S
0765 W BM     0370[V] G      0388[V] TOP     0390[V] BOT      0394[V] A
0765 X DEN    0384[V] ST      0174[L] 62      0000[S] @I      0388[V] C

```


STRENGTH OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE 2

| | | | | |
|------------|------------|----------------|-------------|------------|
| C[V] SBH | (1E2[L] 92 | 03C1[V] SBCRIT | 0228[L] 110 | 03C4[V] P |
| X[V] DITOP | (2A8[L] 40 | 03CC[V] DIBOT | 0304[L] 50 | 0000[S] •V |

>EQ L
F

OGRIN LABELS:

| | | | | | |
|-------------|------------|------------|-----------|-------------|----------|
| 2871 •MAIN• | 2A60 •V | 2890 •COMP | 2A6E •I | 2440 •R | 2958 •ZE |
| 288N \$6 | 2480 •A | 2884 •MES | 2832 •W | 263A EXP | 27C0 AIN |
| 2532 ALLOG | 28F8 •RARG | 2954 •5 | 263A AEXP | 295C •ERCNT | 292A \$8 |
| 295C •0 | 2A32 •U | 3B8A | | | |

TRY-POINTS:

| | | | | | |
|------------|-------------|------------|------------|----------|----------|
| 2441 •R | 2480 •A | 2532 ALLOG | 263A AEXP | 263A EXP | 27C0 AIN |
| 2831 •W | 2890 •COMP | 2886 \$6 | 28F8 •RARG | 292A \$8 | 2954 •5 |
| 295A •ZERO | 295C •ERCNT | 295F •0 | 2984 •MES | 2A3E •U | 2A64 •V |
| 2A61 •I | | | | | |

NO PBLOCKS:

.E

DEFINED SUBROUTINES:

.E

ANSWER ADDRESS 2070

CUTION BEGINS:

```

STH= 21037.113
SBH= 21037.113
SBCRIT= 215v5.348
DITOP= 27.7778
DIBOT= 27.7778

```

END

F VIO OPERATING SYSTEM VERSION 1 REVISION 012 03/04/74 GENERATED 05/06/74 V

| | | |
|----------------------|-----------------|-----|
| 08 HANDLING CHARGE | \$.35 / JOB | .35 |
| 85 LINES PRINTED PR2 | \$ 1.25 / K LN | .11 |
| 54 CARDS READ | \$ 1.50 / K CD | .08 |
| 20 PLOTTER VECTORS | \$.25 / 1200 | .00 |
| 13 MODEL 70 SECONDS | \$25.27 / HOUR | .29 |
| 20 MODEL 80 SECONDS | \$12.57 / HOUR | .20 |
| | TOTAL CHARGE \$ | .63 |

FEIR 492 14731 LOGGED OUT 25/06/74 15:46. \$ 11.16 LEFT AFTER 21 LOGINS.

SUMMARY

| | |
|----------|-------------|
| Length | = 500 ft |
| Beam | = AL/8 |
| Draft | = B/3 |
| Depth | = AL/9 |
| DST | = 20000 psi |
| S | = 30" |
| Material | - STEEL |
| TOP | = 0.4125" |
| BOT | = 0.4125" |
| STH | = 20037.11 |
| SBH | = 20037.11 |
| SBCRIT | = 20505.43 |
| DITOP | = 27.78' |
| DIBOT | = 27.78' |

Note that this is the case where two acceptable solutions exist although they end up being the same because TOP=BOT.

Note that the neutral axis is located half way between top and bottom and the stress is the same at the top and at the bottom, as it was expected beforehand.


```

1704 C *AL* IS THE LENGTH
1724 AL=500.
172C B=AL/8.
1718 C *DRA* IS THE DRAFT
1718 DRA=B/3.
1724 D=AL/9.
1730 C *POI* IS THE POISSON'S RATIO OF THE MATERIAL
1730 FOR STEEL
1730 POI=0.3
1738 C *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
1738 FOR STEEL
1735 E=32.*10.*1000000.
1740 C *DST* IS THE DESIGN STRESS
1740 DST=207.2.
1754 C *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
1754 S=120.
1760 C *BM* IS THE BENDING MOMENT
1760 BM=(B*DRA*AL*AL*2.75)/(35.*35.)
1783 C C=2.32396*S*S*(1.-POI*POI)/E
1784 A=9.*6.*B*D/(147.*BM)
1790 C B=3.*8.*D*D/(72.*BM)
1794 F=3.*D*D*D/(147.*BM)
1800 C THICKNESS OF TOP ASSUMED LARGER THAN BOTTOM THICKNESS
1800 WRITE(5,17)
1810 10 FORMAT('1',25X,'TOP ASSUMED LARGER THAN BOTTOM')
1815 C *TOP* IS THE THICKNESS OF THE TOP PLATING
1815 *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
1815 BOT1=1.
1820 11 TOP1=R*ROT1*BOT1*((B+D)*G*DST-D*BOT1*BOT1)
1820 WRITE(5,20)TOP1,BOT1
1825 20 FORMAT('1',25X,'TOP1='F9.4,5X,'BOT1='F9.4)
1830 ROT1=BOT1+0.25
1835 IF(BOT1.GT.2.)GO TO 30
1840 GO TO 11
1845 30 TOP2=0.02
1850 31 BOT2=TOP2*((12.*D*(C+F)*DST*TOP2)/(DST*(A+C)*TOP2+12.*B))
1850 WRITE(5,40)TOP2,BOT2
1855 40 FORMAT('1',25X,'TOP2='F9.4,5X,'BOT2='F9.4)
1860 TOP2=TOP2+0.02
1865 IF(TOP2.GT.1.)GO TO 52
1870 GO TO 31
1875 50 CONTINUE
1880 C THICKNESS OF BOTTOM ASSUMED LARGER THAN TOP
1880 WRITE(5,60)
1885 60 FORMAT('1',25X,'BOTTOM ASSUMED LARGER THAN TOP')
1890 BOT3=1.
1895 61 TOP3=((B+D)*ROT3*BOT3*BOT3-D*G*DST*BOT3)/(B*G*DST)
1900 WRITE(5,70)TOP3,BOT3
1905 70 FORMAT('1',25X,'TOP3='F9.4,5X,'BOT3='F9.4)
1910 BOT3=BOT3+0.25
1915 IF(BOT3.GT.2.)GO TO 80
1920 GO TO 61

```


STRENGHT OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE 2

```

1402      80 TOP4=0.02
140A      81 BOT4=(12.* (B+D)-(A+C)*DST*TOP4)/((C+F)*DST)
144E      WRITE(5,90)TOP4,BOT4
1472      90 FORMAT(1 1,2F8.4,1TOP4='F9.4,5X,1BOT4='F9.4)
149A      TOP4=TOP4+0.22
14A6      IF(TOP4.GT.1.)GO TO 100
14B8      GO TO 81
14BC      100 CONTINUE
14BC      END
0P[S] .U 04C0[V] AL    04C8[V] B     04D0[V] DRA   04D8[V] D
0P[V] POI 04E8[V] E     04F0[S] .R    04F8[V] DST   0500[V] S
08[V] BM  051C[V] G    0528[V] A     0530[V] C    0538[V] F
+0[L] 10  0000[S] @I   053C[V] BOT1  0176[L] 11   0540[V] TOP1
-2[L] 20  022C[L] 30   0554[V] TOP2  0234[L] 31   055C[V] BOT2
34[L] 40  02FE[L] 50   0312[L] 60   056C[V] BOT3  0348[L] 61
7V[V] TOP3 03B8[L] 70   0472[L] 80   0574[V] TOP4  040A[L] 81
78[V] BOT4 0472[L] 90   048C[L] 100  0000[S] .V
XEQ      L
DF

```

PROGRAM LABELS:

| | | | | | |
|-------------|------------|------------|-----------|-------------|----------|
| 2070 *MAIN* | 2C0C .V | 2A3C .COMP | 2C1A @I | 25EC .R | 2B04 .ZE |
| 2A62 \$6 | 262C .A | 2B60 .MES | 29DE .W | 27E6 EXP | 296C AIM |
| 26DE ALOG | 2AA4 .RARG | 2B00 .5 | 27E6 AEXP | 2B08 .ERCNT | 2AD6 \$8 |
| 2B05 .0 | 2BDE .U | 3D36 | | | |

ENTRY-POINTS:

| | | | | | |
|------------|-------------|-----------|------------|----------|----------|
| 25EC .R | 262C .A | 26DE ALOG | 27E6 AEXP | 27E6 EXP | 296C AIM |
| 29DF .W | 2A3C .COMP | 2A62 \$6 | 2AA4 .RARG | 2AD6 \$8 | 2B00 .5 |
| 2B04 .ZERO | 2B08 .ERCNT | 2B2A .0 | 2B60 .MFS | 2BEA .U | 2C10 .V |
| 2C1A @I | | | | | |

COMMON-BLOCKS:

ONE

DEFINED SUBROUTINES:

ONE

TRANSFER ADDRESS 2070

EXECUTION BEGINS:

TOP ASSUMED LARGER THAN BOTTOM

| | | | |
|-------|--------|-------|----------|
| TOP1= | 0.2423 | BOT1= | 1.0000 |
| TOP1= | 0.2868 | BOT1= | 1.0500 |
| TOP1= | 0.3378 | BOT1= | 1.1000 |
| TOP1= | 0.3960 | BOT1= | 1.1500 |
| TOP1= | 0.4626 | BOT1= | 1.2000 |
| TOP1= | 0.5385 | BOT1= | 1.2500 |
| TOP1= | 0.6253 | BOT1= | 1.3000 |
| TOP1= | 0.7245 | BOT1= | 1.3500 |
| TOP1= | 0.8382 | BOT1= | 1.4000 |
| TOP1= | 0.9688 | BOT1= | 1.4500 |
| TOP1= | 1.1191 | BOT1= | 1.5000 |
| TOP1= | 1.2929 | BOT1= | 1.5500 |
| TOP1= | 1.4947 | BOT1= | 1.6000 |
| TOP1= | 1.7375 | BOT1= | 1.6500 |
| TOP1= | 2.0078 | BOT1= | 1.7000 |
| TOP1= | 2.3366 | BOT1= | 1.7500 |
| TOP1= | 2.7305 | BOT1= | 1.8000 |
| TOP1= | 3.2081 | BOT1= | 1.8500 |
| TOP1= | 3.7959 | BOT1= | 1.9000 |
| TOP1= | 4.5327 | BOT1= | 1.9500 |
| TOP1= | 5.4783 | BOT1= | 2.0000 |
| TOP2= | 0.0200 | BOT2= | -0.0182 |
| TOP2= | 0.0400 | BOT2= | -0.0375 |
| TOP2= | 0.0700 | BOT2= | -0.0579 |
| TOP2= | 0.0800 | BOT2= | -0.0799 |
| TOP2= | 0.1000 | BOT2= | -0.1038 |
| TOP2= | 0.1200 | BOT2= | -0.1201 |
| TOP2= | 0.1400 | BOT2= | -0.1595 |
| TOP2= | 0.1600 | BOT2= | -0.1932 |
| TOP2= | 0.1800 | BOT2= | -0.2228 |
| TOP2= | 0.2000 | BOT2= | -0.2508 |
| TOP2= | 0.2200 | BOT2= | -0.2417 |
| TOP2= | 0.2400 | BOT2= | -0.2434 |
| TOP2= | 0.2600 | BOT2= | -0.2421 |
| TOP2= | 0.2800 | BOT2= | -0.2376 |
| TOP2= | 0.3000 | BOT2= | -0.2361 |
| TOP2= | 0.3200 | BOT2= | -0.24815 |
| TOP2= | 0.3400 | BOT2= | -0.29162 |
| TOP2= | 0.3600 | BOT2= | -0.36081 |
| TOP2= | 0.3800 | BOT2= | -0.38255 |
| TOP2= | 0.4000 | BOT2= | -0.3282 |
| TOP2= | 0.4200 | BOT2= | -0.3689 |
| TOP2= | 0.4400 | BOT2= | -0.2655 |
| TOP2= | 0.4600 | BOT2= | -0.1926 |
| TOP2= | 0.4800 | BOT2= | -0.1371 |
| TOP2= | 0.5000 | BOT2= | -0.0925 |
| TOP2= | 0.5200 | BOT2= | -0.0553 |
| TOP2= | 0.5400 | BOT2= | -0.0233 |
| TOP2= | 0.5600 | BOT2= | -0.0750 |
| TOP2= | 0.5800 | BOT2= | -0.0323 |
| TOP2= | 0.6000 | BOT2= | -0.02534 |
| TOP2= | 0.6200 | BOT2= | -0.0748 |
| TOP2= | 0.6400 | BOT2= | -0.02948 |
| TOP2= | 0.6600 | BOT2= | -0.1136 |
| TOP2= | 0.6800 | BOT2= | -0.1315 |

| | | | |
|-------|--------|-------|---------|
| TCP2= | 0.7000 | BOT2= | -0.1487 |
| TCP2= | 0.7200 | BOT2= | -0.1651 |
| TCP2= | 0.7400 | BOT2= | -0.1810 |
| TCP2= | 0.7600 | BOT2= | -0.1964 |
| TCP2= | 0.7800 | BOT2= | -0.2114 |
| TCP2= | 0.8000 | BOT2= | -0.2260 |
| TCP2= | 0.8200 | BOT2= | -0.2403 |
| TCP2= | 0.8400 | BOT2= | -0.2543 |
| TOP2= | 0.8600 | BOT2= | -0.2681 |
| TCP2= | 0.8800 | BOT2= | -0.2816 |
| TCP2= | 0.9000 | BOT2= | -0.2950 |
| TOP2= | 0.9200 | BOT2= | -0.3081 |
| TOP2= | 0.9400 | BOT2= | -0.3211 |
| TCP2= | 0.9600 | BOT2= | -0.3340 |
| TCP2= | 0.9800 | BOT2= | -0.3467 |
| TCP2= | 1.0000 | BOT2= | -0.3593 |

Note that in this case by simple inspection of the coordinates of the points to be plotted we can see that the intersection will occur outside the acceptable range.

Note also that in order to obtain the coordinates of the points within a range of interest where the intersection may occur, different ranges and increments are considered in each program. This could be improved if at that time these printouts were available and a better idea of the thicknesses that should be expected existed.

| BOTTOM | ASSUMED LARGER THAN TOP |
|---------------|-------------------------|
| TOP3= -0.1776 | BOT3= 1.0000 |
| TOP3= -0.1099 | BOT3= 1.0500 |
| TOP3= -0.0310 | BOT3= 1.1200 |
| TOP3= 0.0596 | BOT3= 1.1500 |
| TOP3= 0.1625 | BOT3= 1.2000 |
| TOP3= 0.2782 | BOT3= 1.2500 |
| TOP3= 0.4072 | BOT3= 1.3000 |
| TOP3= 0.5501 | BOT3= 1.3500 |
| TOP3= 0.7074 | BOT3= 1.4000 |
| TOP3= 0.8797 | BOT3= 1.4500 |
| TOP3= 1.0674 | BOT3= 1.5000 |
| TOP3= 1.2711 | BOT3= 1.5500 |
| TOP3= 1.4914 | BOT3= 1.6200 |
| TOP3= 1.7287 | BOT3= 1.6800 |
| TOP3= 1.9836 | BOT3= 1.7500 |
| TOP3= 2.2567 | BOT3= 1.8200 |
| TOP3= 2.5484 | BOT3= 1.8800 |
| TOP3= 2.8594 | BOT3= 1.9500 |
| TOP3= 3.1961 | BOT3= 2.0200 |
| TOP3= 3.5410 | BOT3= 2.0900 |
| TOP3= 3.9128 | BOT3= 2.1600 |
| TOP4= 0.12800 | BOT4= 1.145 |
| TOP4= 0.34000 | BOT4= 1.1878 |
| TOP4= 0.52600 | BOT4= 1.2715 |
| TOP4= 0.71800 | BOT4= 1.333 |
| TOP4= 0.91000 | BOT4= 0.9061 |
| TOP4= 1.12000 | BOT4= 0.9389 |
| TOP4= 1.34000 | BOT4= 0.9217 |
| TOP4= 1.56000 | BOT4= 0.8845 |
| TOP4= 1.78000 | BOT4= 0.8473 |
| TOP4= 2.00000 | BOT4= 0.8101 |
| TOP4= 2.22000 | BOT4= 0.7728 |
| TOP4= 2.44000 | BOT4= 0.7356 |
| TOP4= 2.66000 | BOT4= 0.6984 |
| TOP4= 2.88000 | BOT4= 0.6612 |
| TOP4= 3.10000 | BOT4= 0.6240 |
| TOP4= 3.32000 | BOT4= 0.5868 |
| TOP4= 3.54000 | BOT4= 0.5496 |
| TOP4= 3.76000 | BOT4= 0.5124 |
| TOP4= 3.98000 | BOT4= 0.4752 |
| TOP4= 4.20000 | BOT4= 0.4379 |
| TOP4= 4.42000 | BOT4= 0.4007 |
| TOP4= 4.44000 | BOT4= 0.3635 |
| TOP4= 4.46000 | BOT4= 0.3263 |
| TOP4= 4.48000 | BOT4= 0.2891 |
| TOP4= 4.50000 | BOT4= 0.2519 |
| TOP4= 4.52000 | BOT4= 0.2147 |
| TOP4= 4.54000 | BOT4= 0.1775 |
| TOP4= 4.56000 | BOT4= 0.1403 |
| TOP4= 4.58000 | BOT4= 0.1030 |
| TOP4= 4.60000 | BOT4= 0.0658 |
| TOP4= 4.62000 | BOT4= 0.0286 |
| TOP4= 4.64000 | BOT4= -0.0086 |
| TOP4= 4.66000 | BOT4= -0.0458 |
| TOP4= 4.68000 | BOT4= -0.0832 |

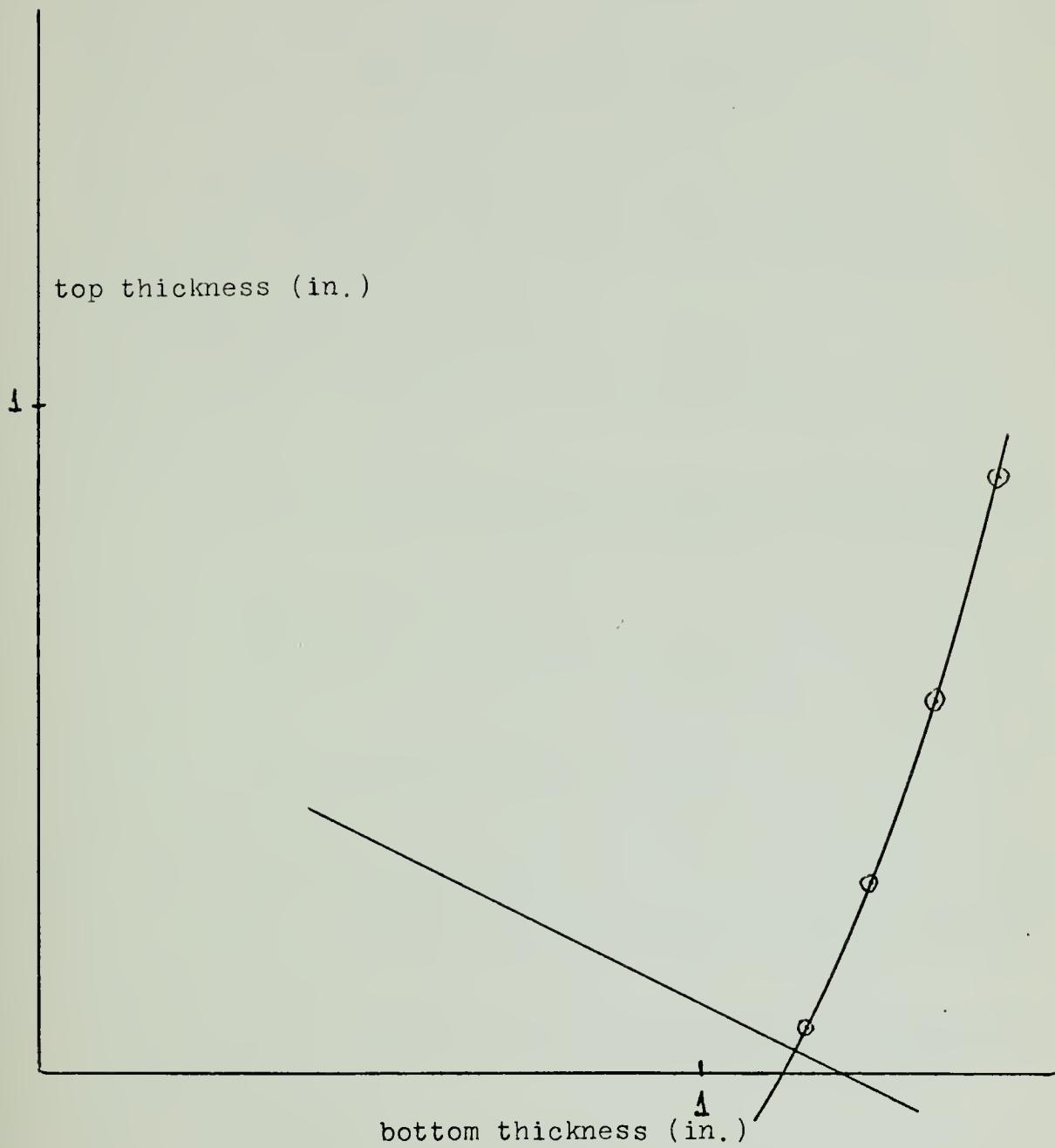
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| TCP4= | 2.7627 | BOT4= | -2.2219 |
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| TCP4= | 2.8627 | BOT4= | -2.4179 |
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| TCP4= | 2.9027 | BOT4= | -2.4923 |
| TCP4= | 2.9227 | BOT4= | -2.5295 |
| TCP4= | 2.9427 | BOT4= | -2.5668 |
| TCP4= | 2.9627 | BOT4= | -2.6042 |
| TCP4= | 2.9827 | BOT4= | -2.6412 |
| TCP4= | 1.0027 | BOT4= | -2.6784 |

END

CF VI0 OPERATING SYSTEM VERSION 1 REVISION 012 03/04/74 GENERATED 05/06/74 C

| | | |
|-----------------------|----------------|-----|
| JOB HANDLING CHARGE | \$.35 / JOB | .35 |
| 239 LINES PRINTED PR2 | \$ 1.25 / K LN | .30 |
| 67 CARDS READ | \$ 1.50 / K CD | .12 |
| 00 PLOTTER VECTORS | \$.25 / 1000 | .02 |
| 17 MODEL 70 SECONDS | \$25.00 / HOUR | .12 |
| 00 MODEL 80 SECONDS | \$12.50 / HOUR | .02 |
| TOTAL CHARGE \$ | | .87 |

IRFEIR 490 14731 LOGGED OUT 25/06/74 15:25. \$ 12.42 LEFT AFTER 19 LOGINS.



STRENGTH OF SHIPS ON THE NEUTRAL AXIS LOCATION

PAGE 1

64 C *ALF IS THE LENGTH
 65 ALFE =
 66 C=LL/S.
 67 C=LIS IS THE DR.
 68 L=EL/3.
 69 C=EL/S.
 70 C *E1 IS THE ELASTIC RATIO OF THE MATERIAL
 71 FOR STIFF.
 72 D1= .3
 73 C E1 IS THE YOUNG'S MODULUS OF THE MATERIAL
 74 FOR STIFF.
 75 S=30.0*1.0*1.6
 76 C *S2 IS THE MAXIMUM STRESS
 77 D2=2.0.
 78 C L2 IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
 79 S=12.0
 80 C *R1 IS THE LENGTH OF PLATE
 81 CR1=(L2*ALF+L1*EL)/ (3E1+3E2)
 82 C=L1=2.0*9.8*6.0/(1.0*301+61)*12
 83 C L1 IS THE TOTAL LENGTH OF THE TUBE PLATING
 84 C L2 IS THE THICKNESS OF THE TUBE PLATING
 85 D2=1.0
 86 D3T=1.0
 87 C PEEA = E1*(EXP(0.05*T))
 88 DFT=1.0*(1.0+0.1*T)+0.1*EXP(-0.1*T)*(TOP+BOT)+(D1*D2*BOT*BOT))
 89 C STRESS TO THE STIFFENING TOP DUE TO FOGGING
 90 C1T=1.0
 91 C PEEA*(1.0+0.1*T)
 92 C PEEA*(1.0+0.1*T)+(D1*D2*BOT)
 93 C STRESS TO THE STIFFENING BOT DUE TO FOGGING
 94 C2T=0.0
 95 C PEEA*(0.05*T)
 96 C SFCRIT=(1.0+0.1*T)*C1T=1.01*1.0
 97 C SFCRIT IS THE CRITICAL STRESS ON BOT
 98 CFCRIT=0.1*T
 99 C PEEA*(0.05*T)
 100 C PEEA*(0.05*T)+(D1*D2*BOT)
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 731 C631T=1.0
 732 C632T=1.0
 733 C633T=1.0
 734 C634T=1.0
 735 C635T=1.0
 736 C636T=1.0
 737 C637T=1.0
 738 C638T=1.0
 739 C639T=1.0
 740 C640T=1.0
 741 C641T=1.0
 742 C642T=1.0
 743 C643T=1.0
 744 C644T=1.0
 745 C645T=1.0
 746 C646T=1.0
 747 C647T=1.0
 748 C648T=1.0
 749 C649T=1.0
 750 C650T=1.0
 751 C651T=1.0
 752 C652T=1.0
 753 C653T=1.0
 754 C654T=1.0
 755 C655T=1.0
 756 C656T=1.0
 757 C657T=1.0
 758 C658T=1.0
 759 C659T=1.0
 760 C660T=1.0
 761 C661T=1.0
 762 C662T=1.0
 763 C663T=1.0
 764 C664T=1.0
 765 C665T=1.0
 766 C666T=1.0
 767 C667T=1.0
 768 C668T=1.0
 769 C669T=1.0
 770 C670T=1.0
 771 C671T=1.0
 772 C672T=1.0
 773 C673T=1.0
 774 C674T=1.0
 775 C675T=1.0
 776 C676T=1.0
 777 C677T=1.0
 778 C678T=1.0
 779 C679T=1.0
 780 C680T=1.0
 781 C681T=1.0
 782 C682T=1.0
 783 C683T=1.0
 784 C684T=1.0
 785 C685T=1.0
 786 C68

STRUCTURE OF CURRENT THE CULTURAL AXIS LOCATIONS

PAGE 2

| | | | |
|-----------|------------|----------------------------|-----------|
| •(V) S12 | 162(L1) 67 | 309(V) SECRET (203(L1) 110 | 3300(V) P |
| •(V) IT1C | 142(L1) 67 | 304(V) DIRECT (314(L1) 50 | 2030(S) V |
| •(V) IT1C | L | | |

✓ CRAFT LAYER :

| | | | | | |
|------------|-----------|--------------|-----------|-------------|---------|
| ✓ 70 •••I | 216 ••• | ✓ 14 •••PUPP | ✓ 76 I | 2448 •R | 2160 •I |
| ✓ E 14 | 242 •• | ✓ 30 •••S | ✓ 74 •• | 2642 EXP | 2708 AI |
| ✓ RA 11 50 | 209 •••PR | ✓ 50 ••S | ✓ 42 /EXP | 2964 •ERONT | 2132 •2 |
| ✓ 4 •• | 2170 •• | ✓ 10 | | | |

✓ KEY-UNITES:

| | | | | | |
|-----------|------------|------------|------------|----------|----------|
| ✓ 448 •• | 242 •• | ✓ 31 11 03 | ✓ 42 /EXP | 2642 EXP | 2708 ATI |
| ✓ 530 • | 250 •••NS | ✓ 31 06 | ✓ 10 ••ARG | 2932 \$4 | 2950 •4 |
| ✓ 411 ••T | 2564 ••C 1 | ✓ 16 ••0 | ✓ 10 ••F3 | 2646 •H | 2450 • |
| ✓ 676 • | | | | | |

✓ CRAFT LAYER :

✓

✓ FINISHED UNITS:

✓

✓ CRAFT-LOCATIONS 207

✓ LTI - CRAFT 51

✓ LTI = 19771.523
 ✓ LTI = 973.271
 ✓ CRAFT = 9732.023
 ✓ LTI = 37.4202
 ✓ LTI = 15.1223

✓ CRAFT OPERATING SYSTEM VERSION 1 REVISION 112 3/04/74 GENERATED 5/16/74

| | | |
|--------------------|----------------|------|
| ✓ 4 ••LTI •• CRAFT | ✓ 10 ••5 / 100 | ✓ 25 |
| ✓ 5 LTI •• CRAFT | ✓ 10 ••5 / 100 | ✓ 11 |
| ✓ 6 CRAFT •• | ✓ 10 ••5 / 100 | ✓ 25 |
| ✓ 7 PLATES 1501029 | ✓ 25 / 100 | ✓ 1 |
| ✓ 8 MDFL 7 SEC 000 | ✓ 10 ••5 / 100 | ✓ 11 |
| ✓ 9 MDFL 7 SEC 000 | ✓ 10 ••5 / 100 | ✓ 2 |
| | TOTAL CRAFT | ✓ 6 |

✓ EIR 402 14031 L707 ALT 5/14/74 15:40. ✓ 14:51 LEFT AFTER 72 LOGINS.

SUMMARY

Length = 500'
Beam = AL/8
Draft = B/3
Depth = AL/9
DST = 20000 psi
S = 120"
Material = STEEL
TOP = 0.03"
BOT = 1.14"
STH = 19771.88
SBH = 9579.87
SBCRIT = 9788.37
DITOP = 37.42'
DIBOT = 18.13'

Note in this case the large value chosen for S and associated with it the large value required for the thickness at the bottom to avoid buckling which nevertheless does not resist stresses larger than 9788 psi in compression.

If we look now at these three cases, all for the same material and set of dimensions (same bending moment) we can see how the thicknesses and neutral axis position changed as the value of S was changed.

| CASE | S inches | TOP inches | BOT inches | SBH psi | SBCRIT psi | DITOP ft | DIBOT ft |
|------|-------------|---------------|---------------|------------|---------------|-------------|-------------|
| 1 | 10 | 0.468 | 0.166 | 30000 | 30000 | 22.06 | 33.05 |
| 2 | 30 | 0.4125 | 0.4125 | 20000 | 20000 | 27.78 | 27.78 |
| 3 | 120 | 0.03 | 1.14 | 9700 | 9700 | 37.43 | 18.13 |

In this table, we can more readily make conclusions on the influence of the value chosen for S on the neutral axis location, and also a quick look at the resulting values for the thicknesses may give an idea of the weight associated with each case.

In the following cases the dimension parameters are changed (increased) and consequently the bending moment and the thicknesses of plating will be higher.


```

C *AL* IS THE LENGTH
C AL=1000.
C B=AL/5.75
C *DRA* IS THE DRAFT
C DRA=B/3.3
C D=AL/14.
C *POI* IS THE POISSON'S RATIO OF THE MATERIAL
C FOR STEEL
C POI=0.3
C *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
C FOR STEEL
C E=30.*10.**6
C *DST* IS THE DESIGN STRESS
C DST=187.12.
C *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
C S=32.
C *BM* IS THE BENDING MOMENT
C BM=(B*DRA*AL*0.75)/(35.*35.)
C G=0.3*396*S*S*(1.-POI+POI)/E
C A=9.*B*B*D/(147.*BM)
C C=3.*B*D*D/(74.*BM)
C F=3.*D*D*D/(147.*BM)
C THICKNESS OF TOP ASSUMED LARGER THAN BOTTOM THICKNESS
C WRITE(5,17)
10 FORMAT('1',25X,'TOP ASSUMED LARGER THAN BOTTOM')
C -TOP1+ IS THE THICKNESS OF THE TOP PLATING
C -BOT1+ IS THE THICKNESS OF THE BOTTOM PLATING
C BOT1=C+1
11 TOP1=S*BOT1*BOT1*((B+D)*G*DST-D*BOT1*BOT1)
C WRITE(5,20)TOP1,BOT1
20 FORMAT('1',25X,'TOP1='F9.4,5X,'BOT1='F9.4)
BOT1=BOT1+1.25
  IF(BOT1.GT.2.)GO TO 32
  GO TO 11
30 TOP2=1.
31 BOT2=TOP2*(12.+D-(C+F)*DST*TOP2)/(DST*(A+C)*TOP2-12.*B)
C WRITE(5,40)TOP2,BOT2
40 FORMAT('1',25X,'TOP2='F9.4,5X,'BOT2='F9.4)
TOP2=TOP2+1.5
  IF(TOP2.GT.15.)GO TO 50
  GO TO 31
50 CONTINUE
C THICKNESS OF BOTTOM ASSUMED LARGER THAN TOP
C WRITE(5,60)
60 FORMAT('1',25X,'BOTTOM ASSUMED LARGER THAN TOP')
BOT3=0.1
61 TOP3=((B+D)*BOT3*BOT3*BOT3-D*G*DST*BOT3)/(B*G*DST)
C WRITE(5,70)TOP3,BOT3
70 FORMAT('1',25X,'TOP3='F9.4,5X,'BOT3='F9.4)
BOT3=BOT3+1.25
  IF(BOT3.GT.3.)GO TO 80
  GO TO 61

```


STRENGHT OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE 2

```

.02      80 TOP4=1.
.0A      81 BOT4=(12.* (R+D)-(A+C)*DST*TOP4)/((C+F)*DST)
.4E      WRITE(5,90)TOP4,BOT4
.72      90 FORMAT(1,25X,'TOP4=1F9.4,5X,'BOT4=1F9.4)
.9A      TOP4=TOP4+.5
.46      IF(TOP4.GT.15.)GO TO 100
.68      GO TO 81
.5C      100 CONTINUE
.9C      END

```

| | | | | |
|----------|------------|--------------|--------------|--------------|
| [S] .U | 04C0[V] AL | 04C8[V] B | 04D0[V] DRA | 04D8[V] D |
| [V] POI | 04F8[V] E | 0000[S] R | 04F8[V] DST | 0500[V] S |
| [V] BM | 0518[V] G | 0524[V] A | 0530[V] C | 053C[V] F |
| [L] 12 | 0200[S] PI | 0540[V] BOT1 | 0176[L] 11 | 0548[V] TOP1 |
| [L] 20 | 0220[L] 30 | 0550[V] TOP2 | 0234[L] 31 | 0560[V] BOT2 |
| [L] 42 | 02FE[L] 50 | 0312[L] 62 | 0578[V] BOT3 | 0348[L] 61 |
| [V] TOP3 | 0300[L] 70 | 0402[L] 80 | 0580[V] TOP4 | 040A[L] 81 |
| [V] BOT4 | 0472[L] 90 | 048C[L] 100 | 0200[S] V | |

EQ L

PROGRAM LABELS:

| | | | | | |
|------------|------------|------------|-----------|-------------|----------|
| 07. *MAIN* | 2C18 .V | 2A48 .COMP | 2C26 @I | 25F8 .R | 2B10 .ZE |
| 2AE \$6 | 2638 .A | 2B6C .MES | 29EA .W | 27F2 EXP | 2978 AIM |
| 6EA ALOG | 2AB0 .RARG | 2B0C .5 | 27F2 AEXP | 2B14 .ERCNT | 2AE2 \$8 |
| 814 .O | 2BEA .U | 3D42 | | | |

HY-POINTS:

| | | | | | |
|-----------|-------------|-----------|------------|----------|----------|
| 5F8 .R | 2638 .A | 26EA ALOG | 27F2 AEXP | 27F2 EXP | 2978 AIM |
| 9EA .W | 2A48 .COMP | 2A6E \$6 | 2AB0 .RARG | 2AE2 \$8 | 2B0C .5 |
| 814 .ZERO | 2B14 .ERCNT | 2B16 .O | 2B6C .MES | 2BF6 .U | 2C1C .V |
| C26 @I | | | | | |

MON-BLOCKS:

E

DEFINED SUBROUTINES:

E

TRANSFER ADDRESS 2070

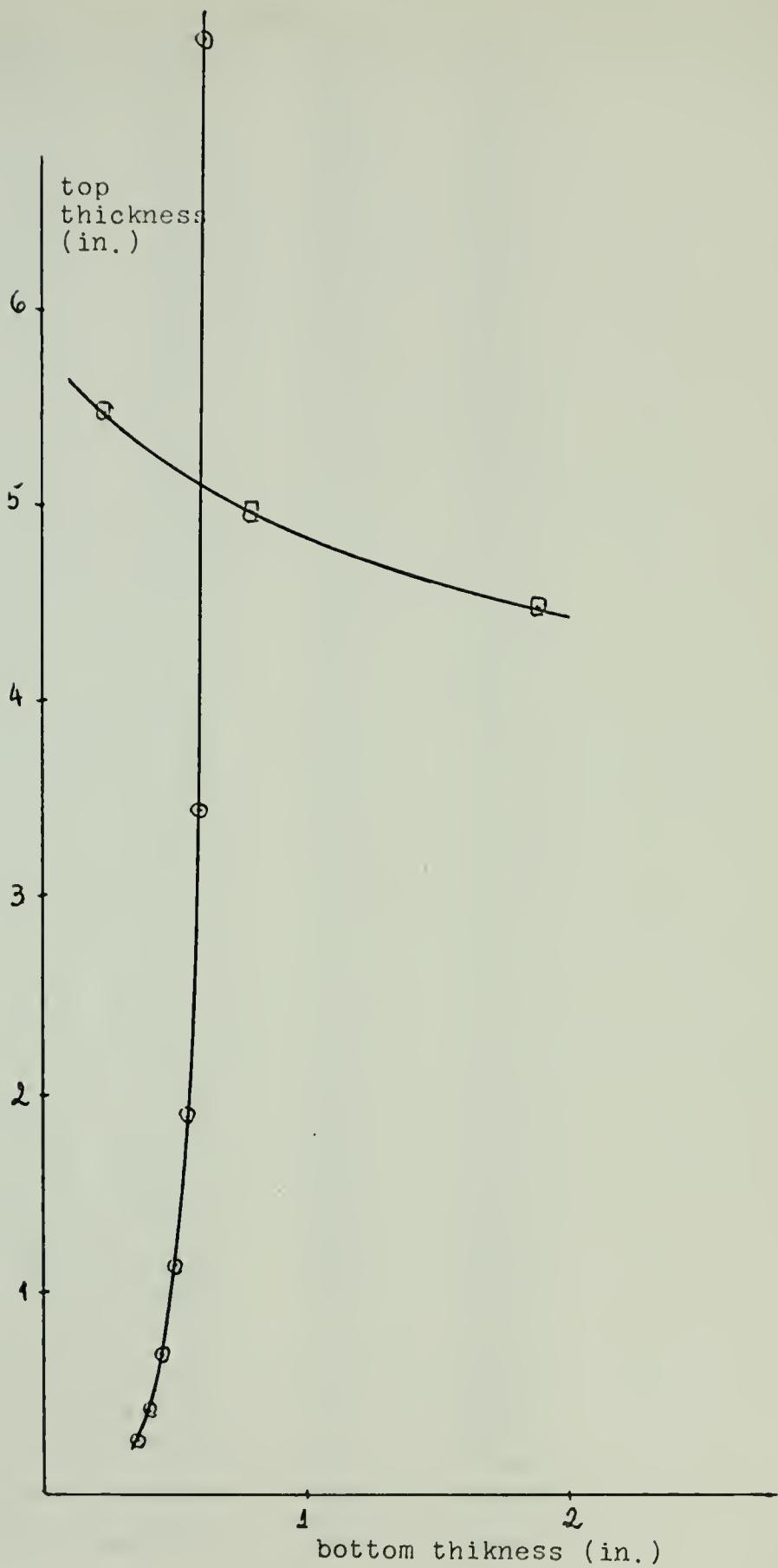
SECTION BEGINS:

TOP ASSUMED LARGER THAN BOTTOM

| | | | |
|-------|----------|-------|----------|
| TOP1= | 2.0048 | BOT1= | 0.1000 |
| TOP1= | 2.0168 | BOT1= | 0.1500 |
| TOP1= | 2.0412 | BOT1= | 0.2000 |
| TOP1= | 2.07844 | BOT1= | 0.2500 |
| TOP1= | 2.1554 | BOT1= | 0.3000 |
| TOP1= | 2.2673 | BOT1= | 0.3500 |
| TOP1= | 2.4414 | BOT1= | 0.4000 |
| TOP1= | 2.7145 | BOT1= | 0.4500 |
| TOP1= | 1.1570 | BOT1= | 0.5000 |
| TOP1= | 1.9240 | BOT1= | 0.5500 |
| TOP1= | 3.4364 | BOT1= | 0.6000 |
| TOP1= | 7.3849 | BOT1= | 0.6500 |
| TOP1= | 36.2430 | BOT1= | 0.7000 |
| TOP1= | -20.7688 | BOT1= | 0.7500 |
| TOP1= | -9.8191 | BOT1= | 0.8000 |
| TOP1= | -7.1387 | BOT1= | 0.8500 |
| TOP1= | -5.9771 | BOT1= | 0.9000 |
| TOP1= | -5.3601 | BOT1= | 0.9500 |
| TOP1= | -5.0020 | BOT1= | 1.0000 |
| TOP1= | -4.7816 | BOT1= | 1.0500 |
| TOP1= | -4.6498 | BOT1= | 1.1000 |
| TOP1= | -4.5747 | BOT1= | 1.1500 |
| TOP1= | -4.5388 | BOT1= | 1.2000 |
| TOP1= | -4.5313 | BOT1= | 1.2500 |
| TOP1= | -4.5450 | BOT1= | 1.3000 |
| TOP1= | -4.5748 | BOT1= | 1.3500 |
| TOP1= | -4.6173 | BOT1= | 1.4000 |
| TOP1= | -4.6700 | BOT1= | 1.4500 |
| TOP1= | -4.7309 | BOT1= | 1.5000 |
| TOP1= | -4.7986 | BOT1= | 1.5500 |
| TOP1= | -4.8720 | BOT1= | 1.6000 |
| TOP1= | -4.9502 | BOT1= | 1.6500 |
| TOP1= | -5.0325 | BOT1= | 1.7000 |
| TOP1= | -5.1183 | BOT1= | 1.7500 |
| TOP1= | -5.2071 | BOT1= | 1.8000 |
| TOP1= | -5.2986 | BOT1= | 1.8500 |
| TOP1= | -5.3924 | BOT1= | 1.9000 |
| TOP1= | -5.4883 | BOT1= | 1.9500 |
| TOP1= | -5.5860 | BOT1= | 2.0000 |
| TOP2= | 1.0002 | BOT2= | -0.4673 |
| TOP2= | 1.5002 | BOT2= | -0.7727 |
| TOP2= | 2.0002 | BOT2= | -1.1829 |
| TOP2= | 2.5002 | BOT2= | -1.8315 |
| TOP2= | 3.0002 | BOT2= | -3.2461 |
| TOP2= | 3.5222 | BOT2= | -11.8971 |
| TOP2= | 4.2220 | BOT2= | 5.8810 |
| TOP2= | 4.5020 | BOT2= | 1.8850 |
| TOP2= | 5.2020 | BOT2= | 0.8127 |
| TOP2= | 5.5020 | BOT2= | 0.2578 |
| TOP2= | 6.2220 | BOT2= | -0.1140 |
| TOP2= | 6.5020 | BOT2= | -2.4000 |
| TOP2= | 7.2220 | BOT2= | -4.6389 |
| TOP2= | 7.5222 | BOT2= | -0.8492 |
| TOP2= | 8.2222 | BOT2= | -1.2408 |
| TOP2= | 8.5222 | BOT2= | -1.2195 |



| | | | |
|-------|---------|-------|---------|
| TOP2= | 9.0000 | BOT2= | -1.3890 |
| TOP2= | 9.5000 | BOT2= | -1.5516 |
| TOP2= | 10.0000 | BOT2= | -1.7290 |
| TOP2= | 10.5000 | BOT2= | -1.8623 |
| TOP2= | 11.0000 | BOT2= | -2.0124 |
| TOP2= | 11.5000 | BOT2= | -2.1599 |
| TOP2= | 12.0000 | BOT2= | -2.3752 |
| TOP2= | 12.5000 | BOT2= | -2.4487 |
| TOP2= | 13.0000 | BOT2= | -2.5907 |
| TOP2= | 13.5000 | BOT2= | -2.7314 |
| TOP2= | 14.0000 | BOT2= | -2.8711 |
| TOP2= | 14.5000 | BOT2= | -3.0298 |
| TOP2= | 15.0000 | BOT2= | -3.1477 |



| BOTTOM | ASSUMED | LARGER THAN TOP |
|--------|----------|-----------------|
| TOP3= | -0.0316 | BOT3= 0.1000 |
| TOP3= | -0.0297 | BOT3= 0.1500 |
| TOP3= | -0.0066 | BOT3= 0.2000 |
| TOP3= | 0.449 | BOT3= 0.2500 |
| TOP3= | 0.1318 | BOT3= 0.3000 |
| TOP3= | 0.2612 | BOT3= 0.3500 |
| TOP3= | 0.4442 | BOT3= 0.4000 |
| TOP3= | 0.6758 | BOT3= 0.4500 |
| TOP3= | 0.9752 | BOT3= 0.5000 |
| TOP3= | 1.3455 | BOT3= 0.5500 |
| TOP3= | 1.7926 | BOT3= 0.6000 |
| TOP3= | 2.3268 | BOT3= 0.6500 |
| TOP3= | 2.9524 | BOT3= 0.7000 |
| TOP3= | 3.6764 | BOT3= 0.7500 |
| TOP3= | 4.5071 | BOT3= 0.8000 |
| TOP3= | 5.4511 | BOT3= 0.8500 |
| TOP3= | 6.5155 | BOT3= 0.9000 |
| TOP3= | 7.7174 | BOT3= 0.9500 |
| TOP3= | 9.0229 | BOT3= 1.0000 |
| TOP3= | 10.5021 | BOT3= 1.0500 |
| TOP3= | 12.1130 | BOT3= 1.1000 |
| TOP3= | 13.7917 | BOT3= 1.1500 |
| TOP3= | 15.5273 | BOT3= 1.2000 |
| TOP3= | 17.3330 | BOT3= 1.2500 |
| TOP3= | 20.2157 | BOT3= 1.3000 |
| TOP3= | 22.4826 | BOT3= 1.3500 |
| TOP3= | 25.3427 | BOT3= 1.4000 |
| TOP3= | 28.1972 | BOT3= 1.4500 |
| TOP3= | 31.0531 | BOT3= 1.5000 |
| TOP3= | 34.5334 | BOT3= 1.5500 |
| TOP3= | 38.274 | BOT3= 1.6000 |
| TOP3= | 41.7430 | BOT3= 1.6500 |
| TOP3= | 45.7024 | BOT3= 1.7000 |
| TOP3= | 49.8976 | BOT3= 1.7500 |
| TOP3= | 54.3427 | BOT3= 1.8000 |
| TOP3= | 59.0383 | BOT3= 1.8500 |
| TOP3= | 63.9990 | BOT3= 1.9000 |
| TOP3= | 69.0223 | BOT3= 1.9500 |
| TOP3= | 74.7329 | BOT3= 2.0000 |
| TOP3= | 80.4228 | BOT3= 2.0500 |
| TOP3= | 86.4022 | BOT3= 2.1000 |
| TOP3= | 92.9790 | BOT3= 2.1500 |
| TOP3= | 99.6624 | BOT3= 2.2000 |
| TOP3= | 106.6534 | BOT3= 2.2500 |
| TOP3= | 113.9652 | BOT3= 2.3000 |
| TOP3= | 121.6029 | BOT3= 2.3500 |
| TOP3= | 129.5735 | BOT3= 2.4000 |
| TOP3= | 137.0842 | BOT3= 2.4500 |
| TOP3= | 146.5416 | BOT3= 2.5000 |
| TOP3= | 155.5534 | BOT3= 2.5500 |
| TOP3= | 164.9265 | BOT3= 2.6000 |
| TOP3= | 174.4679 | BOT3= 2.6500 |
| TOP3= | 184.7845 | BOT3= 2.7000 |
| TOP3= | 195.2838 | BOT3= 2.7500 |
| TOP3= | 206.1726 | BOT3= 2.8000 |

| | | | |
|-------|----------|-------|----------|
| TOP3= | 217.4581 | BOT3= | 2.8500 |
| TOP3= | 229.1475 | BOT3= | 2.9200 |
| TOP3= | 241.2473 | BOT3= | 2.9500 |
| TOP3= | 253.7654 | BOT3= | 3.0700 |
| TOP4= | 1.00000 | BOT4= | 16.1639 |
| TOP4= | 1.50000 | BOT4= | 14.2342 |
| TOP4= | 2.00000 | BOT4= | 12.3744 |
| TOP4= | 2.50000 | BOT4= | 10.3746 |
| TOP4= | 3.00000 | BOT4= | 8.4448 |
| TOP4= | 3.50000 | BOT4= | 6.5150 |
| TOP4= | 4.00000 | BOT4= | 4.5852 |
| TOP4= | 4.50000 | BOT4= | 2.6554 |
| TOP4= | 5.00000 | BOT4= | 0.7256 |
| TOP4= | 5.50000 | BOT4= | -1.2742 |
| TOP4= | 6.00000 | BOT4= | -3.1340 |
| TOP4= | 6.50000 | BOT4= | -5.0438 |
| TOP4= | 7.00000 | BOT4= | -6.9936 |
| TOP4= | 7.50000 | BOT4= | -8.9234 |
| TOP4= | 8.00000 | BOT4= | -10.8532 |
| TOP4= | 8.50000 | BOT4= | -12.7829 |
| TOP4= | 9.00000 | BOT4= | -14.7127 |
| TOP4= | 9.50000 | BOT4= | -16.6425 |
| TOP4= | 10.00000 | BOT4= | -18.5723 |
| TOP4= | 10.50000 | BOT4= | -20.5021 |
| TOP4= | 11.00000 | BOT4= | -22.4319 |
| TOP4= | 11.50000 | BOT4= | -24.3617 |
| TOP4= | 12.00000 | BOT4= | -26.2915 |
| TOP4= | 12.50000 | BOT4= | -28.2213 |
| TOP4= | 13.00000 | BOT4= | -30.1511 |
| TOP4= | 13.50000 | BOT4= | -32.0808 |
| TOP4= | 14.00000 | BOT4= | -34.0106 |
| TOP4= | 14.50000 | BOT4= | -35.9404 |
| TOP4= | 15.00000 | BOT4= | -37.8702 |

ND

VIC OPERATING SYSTEM VERSION 1 REVISION 012 03/04/74 GENERATED 05/06/74 V

| | | |
|----------------------|-----------------|-----|
| 08 HANDLING CHARGE | \$.35 / JOB | .35 |
| 53 LINES PRINTED PR2 | \$ 1.25 / K LN | .32 |
| 67 CARDS READ | \$ 1.50 / K CD | .10 |
| 82 PLOTTER VECTORS | \$.25 / 1000 | .00 |
| 17 MODEL 70 SECONDS | \$ 25.00 / HOUR | .12 |
| 82 MODEL 80 SECONDS | \$ 12.50 / HOUR | .00 |
| | TOTAL CHARGE \$ | .89 |

EIR 490 14731 LOGGED OUT 25/06/74 17:26. \$ 9.62 LEFT AFTER 23 LOGINS.

STRENGTH OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE 1

```

0204 C *AL* IS THE LENGTH
0204 AL=1000.
0205 B=AL/5.75
0218 C *DRA* IS THE DRAFT
0218 DRA=B/3.3
0224 D=AL/14.
0232 C *POI* IS THE POISSON'S RATIO OF THE MATERIAL
0232 FOR STEEL
0232 POI=0.3
0238 C *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
0238 FOR STEEL
0238 E=30.*10.***6
0240 C *DST* IS THE DESIGN STRESS
0240 DST=18000.
0254 C *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
0254 S=30.
0255 C *BM* IS THE BENDING MOMENT
0255 BM=(B*DRA*AL*AL*0.75),(35.*35.)
0255 G=B*34396*S*S*(1.-POI+POI)/E
0264 C *TOP* IS THE THICKNESS OF THE TOP PLATING
0264 *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
0264 TOP=5.12
0264 BOT=0.62
0264 A=560.*BM*(B*BOT+D*TOP)
0264 DEN=D*(3.*B*B*TOP*BOT+2.*B*D*TOP*(TOP+BOT)+(D*D*TOP*TOP))
0264 C *STH* IS THE STRESS ON TOP DUE TO HOGGING
0264 STH=A/DEN
0268 WRITE(5,60)STH
0274 60 FORMAT(' ',20X,'STH='F10.3)
0280 C =560.*BM*(B*TOP+D*TOP)
0284 C *SBH* IS THE STRESS ON BOT DUE TO HOGGING
0284 SBH=C/DEN
0286 WRITE(5,90)SBH
0292 90 FORMAT(' ',20X,'SBH='F10.3)
0296 C *SBCRIT* IS THE CRITICAL STRESS ON BOT
0296 SBCRIT=BOT*BOT/G
0300 WRITE(5,110)SBCRIT
0308 110 FORMAT(' ',17X,'SBCRIT='F10.3)
0314 P=2.*D*TOP+B*(TOP+BOT)
0322 C *DITOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
0322 DITOP=D*(B*BOT+D*TOP)/P
0328 WRITE(5,40)DITOP
0334 40 FORMAT(' ',18X,'DITOP='F10.4)
0340 C *DIBOT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS
0340 DIBOT=D*(B*TOP+D*TOP)/P
0348 WRITE(5,50)DIBOT
0354 50 FORMAT(' ',18X,'DIBOT='F10.4)
0362 END

0205 [S] U 0324[V] AL      0320[V] B      0334[V] DRA      0330[V] D
0205 [V] POI 0340[V] E      0002[S] .R      0350[V] DST      0364[V] S
0205 [V] BM   0370[V] G      0388[V] TOP      0300[V] BOT      0398[V] A
0205 [V] DEN  0380[V] STH     0174[L] 60      0000[S] PI       0300[V] C

```


STRENGHT OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE 2

| | | | | |
|------------|------------|----------------|-------------|------------|
| 4(V) SRH | 01E2(L) 90 | 03C8(V) SBCRIT | 0228(L) 110 | 03CC(V) P |
| 0(V) DITOP | 02A8(L) 40 | 03D4(V) DIBOT | 03D4(L) 50 | 0000(S) .V |
| EQ | L | | | |
| DF | | | | |

PROGRAM LABELS:

| | | | | | |
|-------------|------------|------------|-----------|-------------|----------|
| 2270 *MAIN* | 2A68 .V | 2898 *COMP | 2A76 AI | 2448 *R | 2960 .Z |
| 288E \$6 | 2488 .A | 298C *MES | 283A .W | 2642 EXP | 27C8 AI |
| 253A ALOG | 2900 .RARG | 295C *5 | 2642 AEXP | 2964 *ERCNT | 2932 \$R |
| 2964 *O | 2A3A .U | 3B92 | | | |

TRY-POINTS:

| | | | | | |
|------------|-------------|------------|------------|----------|---------|
| 2448 .R | 2488 .A | 253A AI OG | 2642 AEXP | 2642 EXP | 27C8 AI |
| 283A .W | 2898 .COMP | 288E \$6 | 2900 .RARG | 2932 \$8 | 295C .H |
| 2960 .ZERO | 2964 *ERCNT | 2966 .O | 298C .MES | 2A46 .U | 2A6C .V |
| 2A76 AI | | | | | |

COMMON-BLOCKS:

NE

DEFINED SUBROUTINES:

NE

TRANSFER ADDRESS 2070

EXECUTION BEGINS:

```

STH= 18085.023
SBH= 47973.711
SBCRIT= 46323.625
DITOP= 19.5551
DIBOT= 51.8734
END

```

F VIO OPERATING SYSTEM VERSION 1 REVISION 012 03/04/74 GENERATED 05/06/74

| | | |
|----------------------|-----------------|-----|
| JOB HANDLING CHARGE | \$.35 / JOB | .35 |
| 85 LINES PRINTED PR1 | \$ 1.25 / K LN | .11 |
| 54 CARDS READ | \$ 1.50 / K CD | .08 |
| 20 PLOTTER VECTORS | \$.25 / 1024 | .00 |
| 13 MODEL 72 SECONDS | \$25.00 / HOUR | .09 |
| 02 MODEL 80 SECONDS | \$12.50 / HOUR | .06 |
| | TOTAL CHARGE \$ | .63 |

REIR 490 14731 LOGGED OUT 25/06/74 17:36. \$ 8.11 LEFT AFTER 25 LOGINS.

SUMMARY

| | |
|----------|-------------|
| Length | = 1000 ft |
| Beam | = AL/5.75 |
| Draft | = B/3.3 |
| Depth | = AL/14 |
| DST | = 18000 psi |
| S | = 30" |
| Material | - STEEL |
| TOP | = 5.12" |
| BOT | = 0.62" |
| STH | = 18085.02 |
| SBH | = 47973.71 |
| SBCRIT | = 46323.82 |
| DITOP | = 19.55' |
| DIBOT | = 51.87' |

We might say here that the value chosen for S is small and this accounts for the compression at the bottom to reach such a high value.

In the next case, the value chosen for S is increased to 60 inches.


```

2294 C *AL* IS THE LENGTH
2294 AL=1000.
2295 C B=AL/5.75
2295 DRA=B/3.3
2296 C D=AL/14.
2297 C *POI* IS THE POISSON'S RATIO OF THE MATERIAL
2298 C FOR STEEL
2298 POI=0.3
2299 C *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
2300 C FOR STEEL
2300 E=30.*10.**6
2301 C *DST* IS THE DESIGN STRESS
2302 DST=18000.
2303 C *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
2304 S=60.
2305 C *BM* IS THE BENDING MOMENT
2306 BM=(B*DRA*AL*AL*0.75)/(35.*35.)
2307 G=0.30396*S*S*(1.-POI*POI)/E
2308 A=9.*B*D/(140.*BM)
2309 C =3.*B*D*D/(70.*BM)
2310 F=3.*D*D*D/(140.*BM)
2311 C THICKNESS OF TOP ASSUMED LARGER THAN BOTTOM THICKNESS
2312 WRITE(5,10)
2313 10 FORMAT('1',25X,'TOP ASSUMED LARGER THAN BOTTOM')
2314 C *TOP* IS THE THICKNESS OF THE TOP PLATING
2315 C *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
2316 BOT1=0.02
2317 11 TOP1=B*BOT1*BOT1*((B+D)*G*DST-D*BOT1*POI)
2318 WRITE(5,20)TOP1,BOT1
2319 20 FORMAT(' ',25X,'TOP1=,F9.4,5X,',BOT1='F9.4')
2320 BOT1=BOT1+0.02
2321 IF(BOT1.GT.2.,GO TO 30
2322 GO TO 11
2323 30 TOP2=1.
2324 31 BOT2=TOP2*(12.*D*(C+F)*DST*TOP2)/(DST*(A+C)*TOP2-12.*B)
2325 WRITE(5,40)TOP2,BOT2
2326 40 FORMAT(' ',25X,'TOP2=,F9.4,5X,',BOT2='F9.4')
2327 TOP2=TOP2+0.2
2328 IF(TOP2.GT.6., GO TO 50
2329 GO TO 31
2330 50 CONTINUE
2331 C THICKNESS OF BOTTOM ASSUMED LARGER THAN TOP
2332 WRITE(5,60)
2333 60 FORMAT('1',25X,'BOTTOM ASSUMED LARGER THAN TOP')
2334 BCT3=0.4
2335 61 TOP3=((B+D)*BOT3*BOT3*BOT3-D*G*DST*BOT3)/(B*G*DST)
2336 WRITE(5,70)TOP3,BOT3
2337 70 FORMAT(' ',25X,'TOP3=,F9.4,5X,',BOT3='F9.4')
2338 BOT3=BOT3+0.02
2339 IF(BOT3.GT..85)GO TO 80
2340 80 TOP4=1.

```


STRENGHT OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE 2

```

1426      81 BOT4=(12.* (B+C)-(A+C)*DST*TOP4)/((C+F)*DST)
1444      WRITE(5,90)TOP4,BOT4
146E      90 FORMAT(' ',25X,'TOP4=,F9.4,5X,',BOT4='F9.4')
1496      TOP4=TOP4+0.2
1512      IF(TOP4.GT.5.5)GO TO 100
1524      GO TO 81
1548      100 CONTINUE
1568      END
1588      .S) .U    04BC[V] AL    04C4[V] B     04CC[V] DRA   04D4[V] D
1608      C[V] POI   04E4[V] E     0400[S] .R    04F4[V] DST   04FC[V] S
1628      .[V] BM    0518[V] G     0524[V] A     0530[V] C     053C[V] F
1648      P[L] 10    0540[S] @I   0540[V] BOT1  0176[L] 11   0548[V] TOP1
1668      P[L] 20    022C[L] 30   0558[V] TOP2  0234[L] 31   055C[V] BOT2
1688      P[L] 40    02FE[L] 50   0312[L] 60   0574[V] BOT3  0348[L] 61
1708      C[V] TOP3  0388[L] 70   03FE[L] 80   0584[V] TOP4  0406[L] 81
1728      .[V] BOT4  046E[L] 90   0488[L] 100  0000[S] .V
1748      L
1768

```

PROGRAM LABELS:

| | | | | | |
|-------------|------------|------------|-----------|-------------|-----------|
| 2270 *MAIN* | 2C20 .V | 2A50 .COMP | 2C2E @I | 2600 .R | 2B18 .7 |
| 2A76 \$6 | 2640 .A | 2B74 .MES | 29F2 .W | 27FA EXP | 2980 AI |
| 26F2 ALOG | 2AB8 .RARG | 2B14 .5 | 27FA AEXP | 2B1C .ERCNT | 2AEA \$.8 |
| 2B1C .0 | 2BF2 .U | 3D4A | | | |

TRY-POINTS:

| | | | | | |
|------------|-------------|-----------|------------|-----------|---------|
| 2600 .R | 2640 .A | 26F2 ALOG | 27FA AEXP | 27FA EXP | 2980 AI |
| 29F2 .W | 2A50 .COMP | 2A76 \$6 | 2AB8 .RARG | 2AEA \$.8 | 2B14 .5 |
| 2B18 .ZERO | 2B1C .ERCNT | 2B1E .0 | 2B74 .MES | 2BFE .U | 2C24 .V |
| 2C2E @I | | | | | |

MON-BLOCKS:

NE

DEFINED SUBROUTINES:

NE

TRANSFER ADDRESS 2070

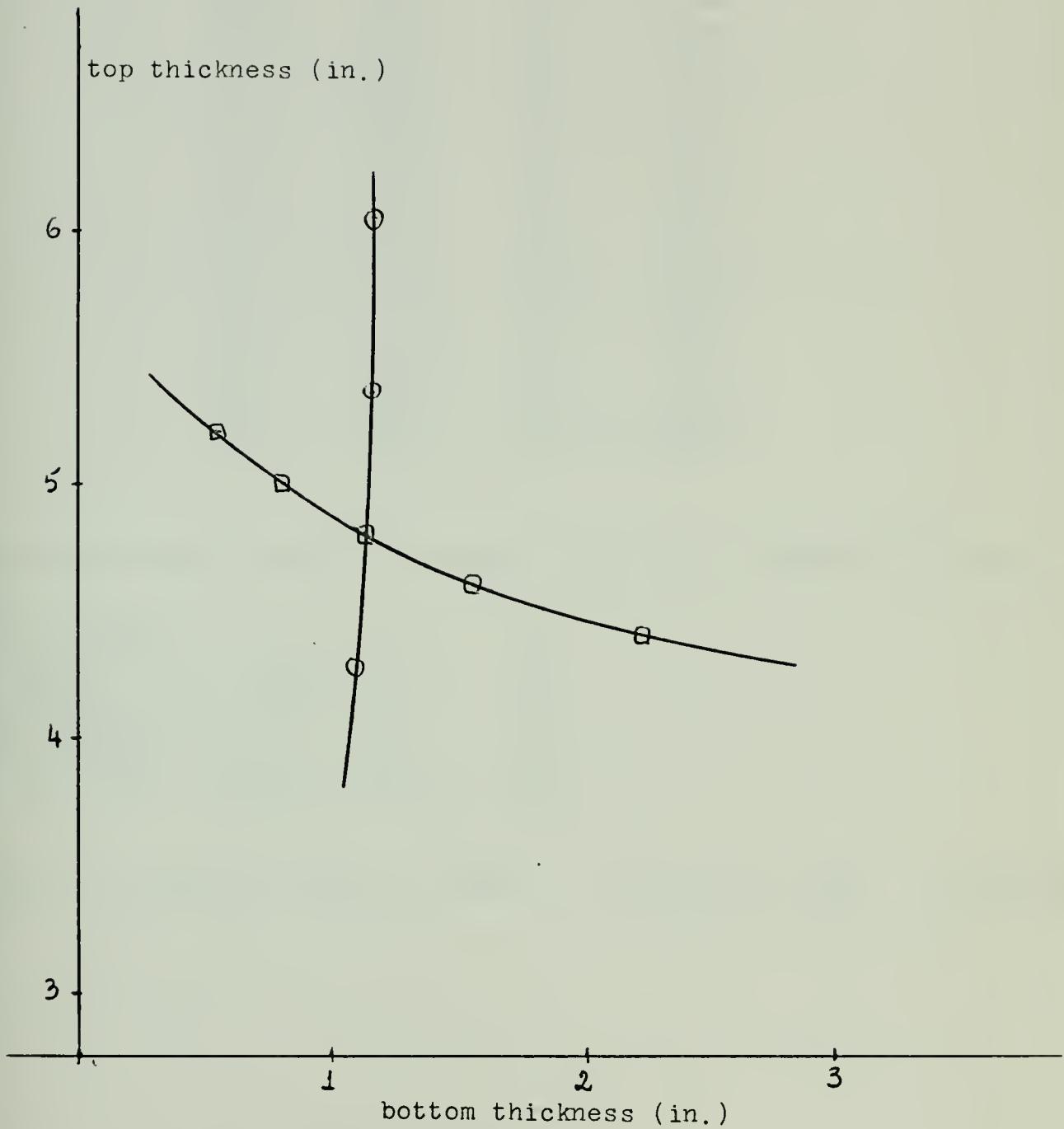
CUTION BEGINS:

TOP ASSUMED LARGER THAN BOTTOM

| | | | |
|-------|--------|-------|--------|
| TOP1= | 0.0000 | BOT1= | 0.0200 |
| TOP1= | 0.0001 | BOT1= | 0.0400 |
| TOP1= | 0.0003 | BOT1= | 0.0600 |
| TOP1= | 0.0006 | BOT1= | 0.0800 |
| TOP1= | 0.0012 | BOT1= | 0.1000 |
| TOP1= | 0.0021 | BOT1= | 0.1200 |
| TOP1= | 0.0033 | BOT1= | 0.1400 |
| TOP1= | 0.0049 | BOT1= | 0.1600 |
| TOP1= | 0.0070 | BOT1= | 0.1800 |
| TOP1= | 0.0097 | BOT1= | 0.2000 |
| TOP1= | 0.0129 | BOT1= | 0.2200 |
| TOP1= | 0.0169 | BOT1= | 0.2400 |
| TOP1= | 0.0216 | BOT1= | 0.2600 |
| TOP1= | 0.0271 | BOT1= | 0.2800 |
| TOP1= | 0.0335 | BOT1= | 0.3000 |
| TOP1= | 0.0409 | BOT1= | 0.3200 |
| TOP1= | 0.0494 | BOT1= | 0.3400 |
| TOP1= | 0.0591 | BOT1= | 0.3600 |
| TOP1= | 0.0700 | BOT1= | 0.3800 |
| TOP1= | 0.0824 | BOT1= | 0.4000 |
| TOP1= | 0.0942 | BOT1= | 0.4200 |
| TOP1= | 0.1116 | BOT1= | 0.4400 |
| TOP1= | 0.1288 | BOT1= | 0.4600 |
| TOP1= | 0.1478 | BOT1= | 0.4800 |
| TOP1= | 0.1689 | BOT1= | 0.5000 |
| TOP1= | 0.1921 | BOT1= | 0.5200 |
| TOP1= | 0.2178 | BOT1= | 0.5400 |
| TOP1= | 0.2459 | BOT1= | 0.5600 |
| TOP1= | 0.2769 | BOT1= | 0.5800 |
| TOP1= | 0.3108 | BOT1= | 0.6000 |
| TOP1= | 0.3479 | BOT1= | 0.6200 |
| TOP1= | 0.3886 | BOT1= | 0.6400 |
| TOP1= | 0.4330 | BOT1= | 0.6600 |
| TOP1= | 0.4816 | BOT1= | 0.6800 |
| TOP1= | 0.5346 | BOT1= | 0.7000 |
| TOP1= | 0.5925 | BOT1= | 0.7200 |
| TOP1= | 0.6558 | BOT1= | 0.7400 |
| TOP1= | 0.7248 | BOT1= | 0.7600 |
| TOP1= | 0.8003 | BOT1= | 0.7800 |
| TOP1= | 0.8828 | BOT1= | 0.8000 |
| TOP1= | 0.9730 | BOT1= | 0.8200 |
| TOP1= | 1.0717 | BOT1= | 0.8400 |
| TOP1= | 1.1799 | BOT1= | 0.8600 |
| TOP1= | 1.2985 | BOT1= | 0.8800 |
| TOP1= | 1.4289 | BOT1= | 0.9000 |
| TOP1= | 1.5724 | BOT1= | 0.9200 |
| TOP1= | 1.7306 | BOT1= | 0.9400 |
| TOP1= | 1.9054 | BOT1= | 0.9600 |
| TOP1= | 2.0900 | BOT1= | 0.9800 |
| TOP1= | 2.3141 | BOT1= | 1.0000 |
| TOP1= | 2.5537 | BOT1= | 1.0200 |
| TOP1= | 2.8218 | BOT1= | 1.0400 |
| TOP1= | 3.1229 | BOT1= | 1.0600 |
| TOP1= | 3.4626 | BOT1= | 1.0800 |
| TOP1= | 3.8480 | BOT1= | 1.1000 |

| | | | |
|-------|-----------|-------|---------|
| TOP1= | 4.2878 | BOT1= | 1.1200 |
| TOP1= | 4.7931 | BOT1= | 1.1400 |
| TOP1= | 5.3786 | BOT1= | 1.1600 |
| TOP1= | 6.0632 | BOT1= | 1.1800 |
| TOP1= | 6.8726 | BOT1= | 1.2000 |
| TOP1= | 7.8419 | BOT1= | 1.2200 |
| TOP1= | 9.0212 | BOT1= | 1.2400 |
| TOP1= | 10.4893 | BOT1= | 1.2600 |
| TOP1= | 12.3398 | BOT1= | 1.2800 |
| TOP1= | 14.7629 | BOT1= | 1.3000 |
| TOP1= | 18.0762 | BOT1= | 1.3200 |
| TOP1= | 22.8310 | BOT1= | 1.3400 |
| TOP1= | 30.2304 | BOT1= | 1.3600 |
| TOP1= | 43.2943 | BOT1= | 1.3800 |
| TOP1= | 72.4699 | BOT1= | 1.4000 |
| TOP1= | 194.7422 | BOT1= | 1.4200 |
| TOP1= | -339.7163 | BOT1= | 1.4400 |
| TOP1= | -95.4322 | BOT1= | 1.4600 |
| TOP1= | -57.1123 | BOT1= | 1.4800 |
| TOP1= | -41.5440 | BOT1= | 1.5000 |
| TOP1= | -33.1158 | BOT1= | 1.5200 |
| TOP1= | -27.8412 | BOT1= | 1.5400 |
| TOP1= | -24.2356 | BOT1= | 1.5600 |
| TOP1= | -21.6199 | BOT1= | 1.5800 |
| TOP1= | -19.6394 | BOT1= | 1.6000 |
| TOP1= | -18.0908 | BOT1= | 1.6200 |
| TOP1= | -16.8492 | BOT1= | 1.6400 |
| TOP1= | -15.8337 | BOT1= | 1.6600 |
| TOP1= | -14.9894 | BOT1= | 1.6800 |
| TOP1= | -14.2780 | BOT1= | 1.7000 |
| TOP1= | -13.6717 | BOT1= | 1.7200 |
| TOP1= | -13.1500 | BOT1= | 1.7400 |
| TOP1= | -12.6974 | BOT1= | 1.7600 |
| TOP1= | -12.3021 | BOT1= | 1.7800 |
| TOP1= | -11.9546 | BOT1= | 1.8000 |
| TOP1= | -11.6475 | BOT1= | 1.8200 |
| TOP1= | -11.3750 | BOT1= | 1.8400 |
| TOP1= | -11.1322 | BOT1= | 1.8600 |
| TOP1= | -10.9151 | BOT1= | 1.8800 |
| TOP1= | -10.7203 | BOT1= | 1.9000 |
| TOP1= | -10.5453 | BOT1= | 1.9200 |
| TOP1= | -10.3875 | BOT1= | 1.9400 |
| TOP1= | -10.2462 | BOT1= | 1.9600 |
| TOP1= | -10.1145 | BOT1= | 1.9800 |
| TOP1= | -10.0001 | BOT1= | 2.0000 |
| TOP2= | 1.0000 | BOT2= | -0.4673 |
| TOP2= | 1.2000 | BOT2= | -0.5810 |
| TOP2= | 1.4000 | BOT2= | -0.7055 |
| TOP2= | 1.6000 | BOT2= | -0.8440 |
| TOP2= | 1.8000 | BOT2= | -1.0009 |
| TOP2= | 2.0000 | BOT2= | -1.1829 |
| TOP2= | 2.2000 | BOT2= | -1.4002 |
| TOP2= | 2.4000 | BOT2= | -1.6693 |
| TOP2= | 2.6000 | BOT2= | -2.0190 |
| TOP2= | 2.8000 | BOT2= | -2.5045 |
| TOP2= | 3.0000 | BOT2= | -3.2460 |

| | | | |
|-------|--------|-------|----------|
| TOP2= | 3.2000 | BOT2= | -4.5652 |
| TOP2= | 3.4000 | BOT2= | -7.7108 |
| TOP2= | 3.6000 | BOT2= | -26.8087 |
| TOP2= | 3.8000 | BOT2= | 16.3226 |
| TOP2= | 4.0000 | BOT2= | 5.8811 |
| TOP2= | 4.2000 | BOT2= | 3.3945 |
| TOP2= | 4.4000 | BOT2= | 2.2560 |
| TOP2= | 4.6000 | BOT2= | 1.5888 |
| TOP2= | 4.8000 | BOT2= | 1.1408 |
| TOP2= | 5.0000 | BOT2= | 0.8127 |
| TOP2= | 5.2000 | BOT2= | 0.5572 |
| TOP2= | 5.4000 | BOT2= | 0.3490 |
| TOP2= | 5.6000 | BOT2= | 0.1733 |
| TOP2= | 5.8000 | BOT2= | 0.0210 |
| TOP2= | 6.0000 | BOT2= | -0.1140 |



BOTTOM ASSUMED LARGER THAN TOP

| | | | |
|-------|---------|-------|---------|
| TOP3= | -0.0122 | BOT3= | 0.4000 |
| TOP4= | 1.2000 | BOT4= | 16.1639 |
| TOP4= | 1.2000 | BOT4= | 15.3920 |
| TOP4= | 1.4000 | BOT4= | 14.6201 |
| TOP4= | 1.6000 | BOT4= | 13.8482 |
| TOP4= | 1.8000 | BOT4= | 13.0763 |
| TOP4= | 2.0000 | BOT4= | 12.3044 |
| TOP4= | 2.2000 | BOT4= | 11.5324 |
| TOP4= | 2.4000 | BOT4= | 10.7605 |
| TOP4= | 2.6000 | BOT4= | 9.9886 |
| TOP4= | 2.8000 | BOT4= | 9.2167 |
| TOP4= | 3.0000 | BOT4= | 8.4448 |
| TOP4= | 3.2000 | BOT4= | 7.6729 |
| TOP4= | 3.4000 | BOT4= | 6.9010 |
| TOP4= | 3.6000 | BOT4= | 6.1290 |
| TOP4= | 3.8000 | BOT4= | 5.3571 |
| TOP4= | 4.0000 | BOT4= | 4.5852 |
| TOP4= | 4.2000 | BOT4= | 3.8133 |
| TOP4= | 4.4000 | BOT4= | 3.0414 |
| TOP4= | 4.6000 | BOT4= | 2.2695 |
| TOP4= | 4.8000 | BOT4= | 1.4975 |
| TOP4= | 5.0000 | BOT4= | 0.7256 |
| TOP4= | 5.2000 | BOT4= | -0.0463 |
| TOP4= | 5.4000 | BOT4= | -0.8182 |

END

VIO OPERATING SYSTEM VERSION 1 REVISION A12 03/04/74 GENERATED 05/06/74

| | | |
|-----------------------|----------------|-----|
| JOB HANDLING CHARGE | \$.35 / JOB | .35 |
| 246 LINES PRINTED PR1 | \$ 1.25 / K LN | .31 |
| 66 CARDS READ | \$ 1.50 / K CN | .10 |
| 22 PLOTTER VECTORS | \$.25 / 1000 | .00 |
| 17 MODEL 72 SECONDS | \$25.00 / HOUR | .12 |
| 03 MODEL 80 SECONDS | \$12.50 / HOUR | .00 |
| TOTAL CHARGE \$ | | .88 |

PEIR 490 14731 LOGGED OUT 05/06/74 17:28. \$ 8.74 LEFT AFTER 24 LOGINS.

STRNGHT OF SHIPS=ON THE NEUTRAL AXIS LOCATION

PAGE 1

```

04 C *AL* IS THE LENGTH
04 AL=1000.
2C B=AL/5.75
18 C *DRA* IS THE DRAFT
18 DRA=B/3.3
24 D=AL/14.
32 C *POI* IS THE POISSON's RATIO OF THE MATERIAL
32 FOR STEEL
37 POI=0.3
38 C *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
38 FOR STEEL
38 E=30.*10.*10000.
4C C *DST* IS THE DESIGN STRESS
4C DST=180M0.
54 C *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
54 S=60.
5C C *BM* IS THE BENDING MOMENT
5C BM=(B*DRA*AL*AL*0.75)/(35.*35.)
82 G=0.30396*S*S*(1.-POI+POI)/E
84 C *TOP* IS THE THICKNESS OF THE TOP PLATING
84 C *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
84 TOP=4.79
8C BOT=1.15
C6 A=560.*BM*(B*BOT+D*TOP)
F8 DEN=D*(3.*B*B*TOP*BOT+2.*B*D*TOP*(TOP+BOT)+(D*D*TOP*TOP))
4C C *STH* IS THE STRESS ON TOP DUE TO HOGGING
4C STH=A/DEN
58 WRITE(5,60)STH
74 60 FORMAT(' ',20X,'STH='F10.3)
8E C=560.*BM*(B*TOP+D*TOP)
8A C *SBH* IS THE STRESS ON BOT DUE TO HOGGING
8A SBH=C/DEN
C6 WRITE(5,90)SBH
E2 90 FORMAT(' ',20X,'SBH='F10.3)
FC C *SBCRIT* IS THE CRITICAL STRESS ON BOT
FC SBCRIT=BOT*BOT/G
PC WRITE(5,110)SBCRIT
28 110 FORMAT(' ',17X,'SBCRIT='F10.3)
44 P=2.*D*TOP+B*(TOP+BOT)
62 C *DITOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
62 DITOP=D*(B*BOT+D*TOP)/P
8C WRITE(5,40)DITOP
PA 42 FORMAT(' ',18X,'DITOP='F10.4)
C4 C *DIBOT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS
C4 DIBOT=D*(B*TOP+D*TOP)/P
E8 WRITE(5,50)DIBOT
32 50 FORMAT(' ',18X,'DIBOT='F10.4)
22 END

(S) •U 0324[V] AL      032C[V] B      0334[V] DRA      033C[V] D
[V] POI 034C[V] E      00000[S] .R      035C[V] DST      0364[V] S
C[V] BM   0382[V] G      038C[V] TOP     0394[V] BOT      039C[V] A
C[V] DEN  03C0[V] STH    2174[L] 60      0000[S] PI      03C4[V] C

```


STRENGHT OF SHIPS=ON THE NEUTRAL AXIS LOCATION

PAGE 2

| | | | | |
|-------------|------------|----------------|-------------|------------|
| 05(V) SRH | 01E2(L) 90 | 03CC(V) SBCRIT | 0228(L) 110 | 03D0(V) P |
| 04(V) DITOP | 02A8(L) 40 | 03D8(V) DIBOT | 0304(L) 50 | 000V(S) .V |
| .XEQ L | | | | |
|)F | | | | |

PROGRAM LABELS:

| | | | | | |
|-------------|------------|------------|-----------|-------------|----------|
| 2270 *MAIN* | 2A6C .V | 289C .COMP | 2A7A .I | 244C .R | 2964 .Z |
| 28C2 \$6 | 248C .A | 29C0 .MES | 283E .W | 2646 EXP | 27CC AI |
| 253E ALOG | 2904 .RARG | 2960 .S | 2646 AEXP | 2968 .ERCNT | 2936 \$8 |
| 2968 .O | 2A3E .U | 3B96 | | | |

TRY-POINTS:

| | | | | | |
|------------|-------------|-----------|------------|----------|---------|
| 244C .R | 248C .A | 253E ALOG | 2A46 AEXP | 2646 EXP | 27CC AI |
| 283E .W | 289C .COMP | 28C2 \$6 | 2904 .RARG | 2936 \$8 | 2960 .S |
| 2964 .ZERO | 2968 .ERCNT | 296A .O | 29C8 .MES | 2A4A .U | 2A70 .V |
| 2A7A .I | | | | | |

MON-BLOCKS:

.E

DEFINED SUBROUTINES:

.E

TRANSFER ADDRESS 2070

CUTION BEGINS:

```

STH= 18017.242
SBH= 39055.434
SBCRIT= 39843.250
DITOP= 22.5492
DIBOT= 48.8793

```

END

F VIO OPERATING SYSTEM VERSION 1 REVISION 012 03/04/74 GENFRATED 05/06/74

| | | | |
|----------------------|--------------|--------|-----|
| JOB HANDLING CHARGE | \$.35 | / JOB | .35 |
| 85 LINES PRINTED PR1 | \$ 1.25 | / K LN | .11 |
| 54 CARDS READ | \$ 1.50 | / K CD | .08 |
| 20 PLOTTER VECTORS | \$.25 | / 10%a | .00 |
| 13 MODEL 72 SECONDS | \$25.00 | / HOUR | .09 |
| 00 MODEL 80 SECONDS | \$12.50 | / HOUR | .02 |
| | TOTAL CHARGE | \$.63 | |

FIR 490 14731 LOGGED OUT 05/06/74 17:37. \$ 7.48 LEFT AFTER 26 LOGINS.

SUMMARY

Length = 1000'
Beam = AL/5.75
Draft = B/3.3
Depth = AL/14
DST = 18000 psi
S = 60"
Material - STEEL
TOP = 4.79"
BOT = 1.15"
STH = 18017.24
SBH = 39055.43
SBCRIT = 39843.44
DITOP = 22.55'
DIBOT = 48.88'

Since sometimes it is desirable to use aluminum alloys in the structure of ships, due to their light weight, high corrosion resistance and non-magnetic characteristics, in the following runs, the material considered is aluminum. The necessary change is made in the input to account for the properties of this material.

When considering aluminum as the structural material, we must keep in mind that the aluminum hull will be more flexible than a corresponding steel ship. The modulus of elasticity of aluminum is about one third that of steel, and if scantlings were identical, the deflection of an aluminum ship, under a given load, would be three times those of a steel ship.

However, to obtain a factor of safety on ultimate strength equal to that in steel, the area of an aluminum member in direct stress, or the section modulus of an aluminum member in bending would be about 1.5 times that of the corresponding steel member (based on an ultimate strength of about 60000 psi in medium steel and of about 40000 psi across the welds of a welded aluminum structure).

A section modulus of 1.5 times that in steel, with the same depth being considered in both cases, would result in a deflection in aluminum about twice that in steel. However, the lower modulus of elasticity of aluminum reduces its ability to resist buckling , and for the same factor of safety both the section modulus and the moment of inertia in aluminum would in

general be somewhat more than 1.5 times those in steel, so that the deflection of the aluminum structure would in general be somewhat less than twice that of the steel structure.

The greater deflection would reduce the natural frequency of hull vibration, and so would affect the interaction of slamming stress and bending moment stress. It could also affect shaft bearing pressures. It has been proposed as an arbitrary basis of design that aluminum ships be designed for a deflection about 1.5 times that of steel ships. This would require a moment of inertia of twice the value of that in the steel hull girder, and would automatically result in a section modulus substantially more than 1.5 times that in steel, and a factor of safety correspondingly greater than in steel.


```

2004      C      *AL* IS THE LENGTH
204        AL=1000.
20C        B=AL/5.75
218      C      *DRA* IS THE DRAFT
218        DNA=B/3.3
224        D=AL/14.
238      C      *POI* IS THE POISSON'S RATIO OF THE MATERIAL
238      C      FOR ALUMINUM
238        PCI=0.33
238      C      *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
238      C      FOR ALUMINUM
238        E=10.*10.*6
240      C      *DST* IS THE DESIGN STRESS
240        DST=1800.
254      C      *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
254        S=10.
250      C      *BM* IS THE BENDING MOMENT
250        RM=(B*DHA*AL*AL*0.75)/(35.*35.)
258        G=V*3V2*6*S*S*(1.-PCI*POI)/E
258        A=9.*H*F*D/(140.*RM)
260        C=3.*B*1.*D/(70.*RM)
264        F=3.*D*1.*D/(140.*RM)
260      C      THICKNESS OF TOP ASSUMED LARGER THAN BOTTOM THICKNESS
260        WRITE(5,10)
264      10 FORMAT('1',25X,'TOP ASSUMED LARGER THAN BOTTOM')
266      C      *TOP1* IS THE THICKNESS OF THE TOP PLATING
266      C      *BOT1* IS THE THICKNESS OF THE BOTTOM PLATING
266        BOT1=0.2
276      11 TOP1=B*BOT1*BOT1/((B+D)*G*DST-D*BOT1*ROT1)
276        WRITE(5,20)TOP1,BOT1
276      20 FORMAT('1',25X,'TOP1='F9.4,5X,',BOT1='F9.4)
276        BOT1=BOT1+0.21
276        IF(BOT1.GT.2.4)GO TO 30
276        GO TO 11
276      30 TOP2=1.
276      31 BOT2=TOP2*(12.*D-(C+F)*DST*TOP2)/(DST*(A+C)*TOP2-12.*B)
276        WRITE(5,40)TOP2,BOT2
276      40 FORMAT('1',25X,'TOP2='F9.4,5X,',BOT2='F9.4)
276        TOP2=TOP2+0.2
276        IF(TOP2.GT.5.) GO TO 50
276        GO TO 31
276      50 CONTINUE
276      C      THICKNESS OF BOTTOM ASSUMED LARGER THAN TOP
276        WRITE(5,60)
276      60 FORMAT('1',25X,'BOTTOM ASSUMED LARGER THAN TOP')
276        BOT3=0.1
276      61 TOP3=((F+D)*BOT3*BOT3*BOT3-D*G*DST+BOT3)/(B*G*DST)
276        WRITE(5,70)TOP3,BOT3
276      70 FORMAT('1',25X,'TOP3='F9.4,5X,',BOT3='F9.4)
276        BOT3=BOT3+0.21
276        IF(BOT3.GT..24)GO TO 90
276        GO TO 61

```


STRENGTH OF SHIPS ON THE NEUTRAL AXIS LOCATION

PAGE 2

```

P4P2      PR TOP4=1.
P4P4      S1 BOT4=(12.* (B+C)-(A+C)*DST*TOP4)/((C+F)*DST)
P4E        WRITE(5,90)TOP4,BOT4
P472      P1 FORMAT(' ',25X,'TOP4='F9.4,5X,'BOT4='F9.4)
P49A      TOP4=TOP4+0.2
P4A6      IF(TOP4.GT.5.5)GO TO 100
P4B8      GO TO 81
P4C       10 CONTINUE
P4C       END
P (S)  •U  24C0[V] AL    P4C8[V] B     P4D0[V] DRA    04D8[V] D
P (V)  •I  24E8[V] E    P4D0[L] •R    P4F4[V] DST    04FC[V] S
P (V)  •L  2514[V] G    P520[V] A    P52C[V] C    0538[V] F
P (L)  17  P470[S] •I    P530[V] BOT1  P176[L] 11   0544[V] TOP1
P (L)  27  222C[L] 30   P550[V] TOP2  P234[L] 31   055C[V] BOT2
P (L)  47  22FE[L] 50   P310[L] 60   P570[V] BOT3  0348[L] 61
P (V)  TCP3  2335[L] 70   P400[L] 80   P580[V] TOP4  040A[L] 81
P (V)  4PT4  2472[L] 90   P4BC[L] 100  P6C3[S] •V

80      L
C

```

GRAPH LABELS:

| | | | | | |
|----------|------------|------------|-----------|-------------|----------|
| P70 •AI | 2C1C •V | 2A4C •COMP | 2C2A •I | 25FC •R | 2B14 •Z |
| 2A72 \$P | 263C •A | 2B70 •MES | 29EF •W | 27F6 EXP | 297C AI |
| 7FE ALUG | 2AB4 •RARG | 2B17 •S | 27F6 AEXP | 2B18 •ERCNT | 2AE6 \$8 |
| -B18 •C | 2BEE •U | 3D46 | | | |

NTRM-POINTS:

| | | | | | |
|------------|-------------|-----------|------------|----------|---------|
| SFC •Z | 263C •A | 26EE ALOG | 27F6 AEXP | 27F6 EXP | 297C AI |
| 29EE •Y | 2A4C •COMP | 2A72 \$6 | 2AB4 •RARG | 2AE6 \$8 | 2B10 •B |
| 2B14 •ZFF0 | 2B18 •ERCNT | 2B1A •O | 2B70 •MES | 2BFA •U | 2C20 •V |
| 2C2A •T | | | | | |

COMMON-BLOCKS:

C'E

REFINED SUBROUTINES:

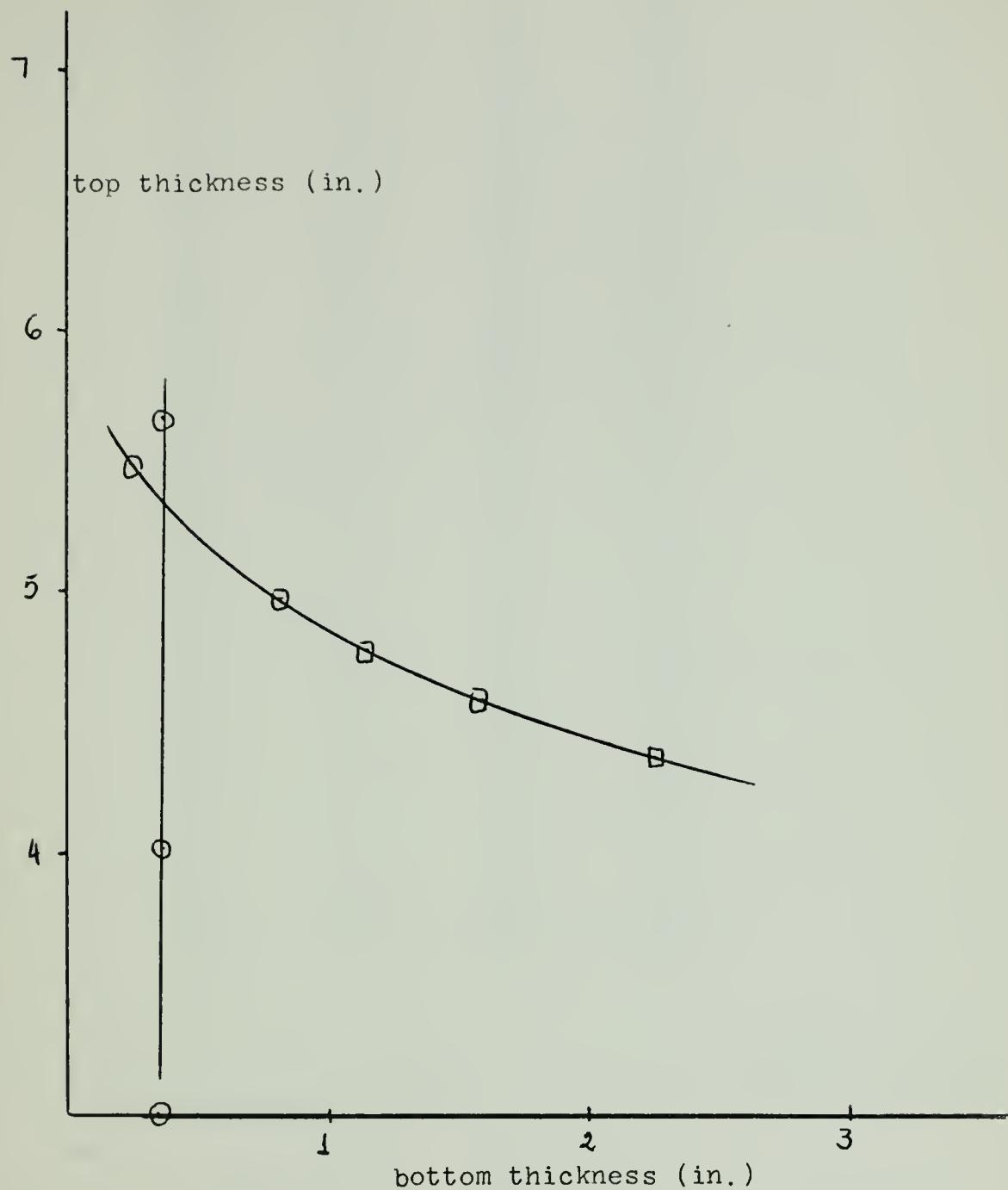
C'E

TRANSFER ADDRESS 2270

EXECUTION BEGINS:

TOP ASSUMED LARGER THAN BOTTOM

| | | | |
|-------|---------|-------|----------|
| TOP1= | 0.1558 | BOT1= | 0.2000 |
| TOP1= | 0.1858 | BOT1= | 0.2100 |
| TOP1= | 0.2177 | BOT1= | 0.2200 |
| TOP1= | 0.2596 | BOT1= | 0.2300 |
| TOP1= | 0.3124 | BOT1= | 0.2400 |
| TOP1= | 0.3624 | BOT1= | 0.2500 |
| TOP1= | 0.4225 | BOT1= | 0.2600 |
| TOP1= | 0.5128 | BOT1= | 0.2700 |
| TOP1= | 0.6121 | BOT1= | 0.2800 |
| TOP1= | 0.7123 | BOT1= | 0.2900 |
| TOP1= | 0.8427 | BOT1= | 0.3000 |
| TOP1= | 1.0144 | BOT1= | 0.3100 |
| TOP1= | 1.2243 | BOT1= | 0.3200 |
| TOP1= | 1.4941 | BOT1= | 0.3300 |
| TOP1= | 1.8452 | BOT1= | 0.3400 |
| TOP1= | 2.3218 | BOT1= | 0.3500 |
| TOP1= | 3.0023 | BOT1= | 0.3600 |
| TOP1= | 4.0236 | BOT1= | 0.3700 |
| TOP1= | 5.0921 | BOT1= | 0.3800 |
| TOP1= | 9.4016 | BOT1= | 0.3900 |
| TOP1= | 20.8821 | BOT1= | 0.4000 |
| TOP2= | 1.0144 | BOT2= | -0.4673 |
| TOP2= | 1.2243 | BOT2= | -0.5810 |
| TOP2= | 1.4941 | BOT2= | -0.7055 |
| TOP2= | 1.8452 | BOT2= | -0.8440 |
| TOP2= | 2.3218 | BOT2= | -1.0009 |
| TOP2= | 3.0023 | BOT2= | -1.1829 |
| TOP2= | 4.0236 | BOT2= | -1.4002 |
| TOP2= | 5.0921 | BOT2= | -1.6693 |
| TOP2= | 9.4016 | BOT2= | -2.0190 |
| TOP2= | 20.8821 | BOT2= | -2.5045 |
| TOP2= | 3.0023 | BOT2= | -3.2460 |
| TOP2= | 4.0236 | BOT2= | -4.5652 |
| TOP2= | 5.0921 | BOT2= | -7.7108 |
| TOP2= | 6.0628 | BOT2= | -26.8087 |
| TOP2= | 7.0328 | BOT2= | 16.3226 |
| TOP2= | 8.0028 | BOT2= | 5.8811 |
| TOP2= | 9.0728 | BOT2= | 3.3945 |
| TOP2= | 10.0428 | BOT2= | 2.2560 |
| TOP2= | 11.0128 | BOT2= | 1.5888 |
| TOP2= | 12.0828 | BOT2= | 1.1408 |
| TOP2= | 13.0528 | BOT2= | 0.8127 |
| TOP2= | 14.0228 | BOT2= | 0.2578 |



BOTTOM ASSUMED LARGER THAN TOP

| | | | |
|-------|---------|-------|---------|
| TOP3= | -0.0121 | BOT3= | 0.1000 |
| TOP3= | -0.0167 | BOT3= | 0.1100 |
| TOP3= | 0.0127 | BOT3= | 0.1200 |
| TOP3= | 0.0122 | BOT3= | 0.1300 |
| TOP3= | 0.0219 | BOT3= | 0.1400 |
| TOP3= | 0.0360 | BOT3= | 0.1500 |
| TOP3= | 0.0528 | BOT3= | 0.1600 |
| TOP3= | 0.0723 | BOT3= | 0.1700 |
| TOP3= | 0.0948 | BOT3= | 0.1800 |
| TOP3= | 0.1204 | BOT3= | 0.1900 |
| TOP3= | 0.1403 | BOT3= | 0.2000 |
| TOP3= | 0.1617 | BOT3= | 0.2100 |
| TOP3= | 0.2177 | BOT3= | 0.2200 |
| TOP3= | 0.2556 | BOT3= | 0.2300 |
| TOP3= | 0.3814 | BOT3= | 0.2400 |
| TOP4= | 1.0000 | BOT4= | 16.1639 |
| TOP4= | 1.2800 | BOT4= | 15.3920 |
| TOP4= | 1.4100 | BOT4= | 14.6201 |
| TOP4= | 1.6100 | BOT4= | 13.8482 |
| TOP4= | 1.8000 | BOT4= | 13.0763 |
| TOP4= | 2.0000 | BOT4= | 12.3044 |
| TOP4= | 2.2800 | BOT4= | 11.5324 |
| TOP4= | 2.4100 | BOT4= | 10.7605 |
| TOP4= | 2.6100 | BOT4= | 9.9886 |
| TOP4= | 2.8100 | BOT4= | 9.2167 |
| TOP4= | 3.0000 | BOT4= | 8.4448 |
| TOP4= | 3.2100 | BOT4= | 7.6729 |
| TOP4= | 3.4100 | BOT4= | 6.9010 |
| TOP4= | 3.6100 | BOT4= | 6.1290 |
| TOP4= | 3.8100 | BOT4= | 5.3571 |
| TOP4= | 4.0000 | BOT4= | 4.5852 |
| TOP4= | 4.2100 | BOT4= | 3.8133 |
| TOP4= | 4.4100 | BOT4= | 3.0414 |
| TOP4= | 4.6100 | BOT4= | 2.2695 |
| TOP4= | 4.8100 | BOT4= | 1.4975 |
| TOP4= | 5.0000 | BOT4= | 0.7256 |
| TOP4= | 5.2100 | BOT4= | -0.0463 |
| TOP4= | 5.4100 | BOT4= | -0.8182 |

END

F VIO OPERATING SYSTEM VERSION 1 REVISION 012 03/04/74 GENERATED 05/06/74

| | | |
|-----------------------|----------------|-----|
| JOB HANDLING CHARGE | \$.35 / JDF | .35 |
| 177 LINES PRINTED PR1 | \$ 1.25 / K LN | .22 |
| 67 CARDS READ | \$ 1.50 / K CR | .10 |
| 20 PLOTTER VECTORS | \$.25 / 1000 | .00 |
| 22 MODEL 72 SECONDS | \$25.00 / HOUR | .14 |
| 22 MODEL 84 SECONDS | \$12.50 / HOUR | .00 |
| TOTAL CHARGE \$ | | .81 |

-EIR 492 14731 LOGGED OUT 25/06/74 19:37. \$ 6.67 LEFT AFTER 27 LOGINS.

STRENGHT OF SHIPS-ON THE NEUTRAL AXIS LOCATION

```

1274 C *AL* IS THE LENGTH
1274 C AL=1000.
1274 C *DRA* IS THE DRAFT
1274 C DRA=8/3.3
1274 C DRA/14.
1274 C *POI* IS THE POISSON'S RATIO OF THE MATERIAL
1274 C FOR ALU INUM
1274 C POI=1.33
1274 C *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
1274 C FOR ALU INUM
1274 C E=10.*10.*10.
1274 C *DST* IS THE DESIGN STRESS
1274 C DST=180.0.
1274 C *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
1274 C S=10.
1274 C *BL* IS THE BENDING MOMENT
1274 C BL=(P*DRA*AL*L**2)/((35.*35.))
1274 C G=.3M39A*S*S*(1.-POI+POI)/E
1274 C *TOP* IS THE THICKNESS OF THE TOP PLATING
1274 C *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
1274 C TOP=5.35
1274 C BOT=0.363
1274 C A=56.1.*BL*(B*BOT+D*TOP)
1274 C DE=BL*(B.*B*TCP*BOT+2.*B*0*TOP*(TOP+BOT)+(D*D*TOP*TOP))
1274 C *STH* IS THE STRESS ON TOP DUE TO HOGGING
1274 C STH=A/LEN
1274 C WRITE(5,67)STH
1274 C 67 FORMAT(' ',22X,'STH='F10.3)
1274 C SBH=A.*BL*(B*TOP+D*TOP)
1274 C *SBH* IS THE STRESS ON BOT DUE TO HOGGING
1274 C SBH=C/LEN
1274 C WRITE(5,67)SBH
1274 C 67 FORMAT(' ',22X,'SBH='F10.3)
1274 C *SBCRIT* IS THE CRITICAL STRESS ON BOT
1274 C SBCRIT=BOT*BOT/G
1274 C WRITE(5,110)SBCRIT
1274 C 110 FORMAT(' ',17Y,'SBCRIT='F10.3)
1274 C F=2.*D*TOP+B*(TCP+BOT)
1274 C *DITOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
1274 C DITOP=F*(B*BOT+D*TOP)/P
1274 C WRITE(E,47)DITOP
1274 C 47 FORMAT(' ',18Y,'DITOP='F10.4)
1274 C *DIBOT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS
1274 C DIBOT=F*(B*TOP+D*TOP)/P
1274 C WRITE(5,5Y)DIBOT
1274 C 5Y FORMAT(' ',18Y,'DIBOT='F10.4)
1274 C END

```

| | | | | | |
|-----|------|-------------|-------------|-------------|-----------|
| (S) | 0.11 | 0324(V) AL | 0320(V) B | 0334(V) DRA | 033C(V) D |
| (V) | P=1 | 0340(V) C | 0312(S) .R | 0358(V) DST | 0360(V) S |
| (V) | D= | 0372(V) G | 0394(V) TOP | 038C(V) BOT | 0394(V) A |
| (V) | LEN | 0368(V) STH | 0174(L) 60 | 0000(S) @I | 03BC(V) C |

STRENGTH OF SHIPS ON THE NEUTRAL AXIS LOCATION

PAGE 2

| | | | | |
|-----------|------------|----------------|-------------|------------|
| [V] SRA | ,1E2[L] 82 | -3C4[V] SRCRIT | 0228[L] 110 | 03C8[V] P |
| [V] DITCR | 2A8[L] 40 | -3D7[V] DIBOT | 03C4[L] 50 | 000P[S] .V |
| EO | L | | | |

GRAM LABELS:

| | | | | | |
|------------|------------|------------|-----------|-------------|----------|
| 17E *N1TH* | 2A64 •V | 2B94 •COMP | 2A72 PI | 2444 •R | 295C •ZI |
| SRA SA | 2484 •S | 2983 •MES | 2B36 .W | 263E EXP | 27C4 AI |
| 536 AL CC | 2EFC •RARG | 2B52 •S | 263E AEXP | 296V •ERCNT | 292E \$8 |
| 982 •T | 2736 •U | 2B8F | | | |

BY-PORT TS:

| | | | | | |
|-----------|-------------|-----------|------------|----------|---------|
| 444 •P | 2484 •A | 2B36 AL06 | 263E AEXP | 263E EXP | 27C4 AI |
| 236 • | 2504 •COMP | 2B3A 9A | 28FC •RARG | 292F \$8 | 2958 •S |
| 7FC •ZERH | 2B61 •FRONT | 2B52 •S | 2938 •MES | 2A42 •U | 2468 •V |
| 472 M* | | | | | |

NO-BLOCKS:

E

DEFINED SUBROUTINES:

E

TRANSFER ADDRESS 2B7F

ITION BEGINS:

STH= 18111.119
 SBR= 53387.980
 SRCRIT= 48640.414
 DITCR= 18.0832
 DIBOT= 53.3253

ID

V10 OPERATING SYSTEM VERSION 1 REVISION 012 03/04/74 GENERATED 05/06/74

| | | |
|----------------------|-----------------|-----|
| 08 HANDLING CHARGE | \$.35 / JOB | .35 |
| 25 LINES PAINTED PR1 | 2 1.25 / K LN | .11 |
| 54 CARTS READ | 2 1.50 / K CN | .38 |
| 20 PLOTTED VECTORS | \$.25 / 1242 | .00 |
| 17 MODEL 72 SECONDS | \$25.00 / HOUR | .12 |
| 20 MODEL 92 SECONDS | \$12.50 / HOUR | .22 |
| | TOTAL CHARGE \$ | .66 |

TER 432 14731 LOGGED OUT 25/06/74 19:56. \$ 3.43 LEFT AFTER 31 LOGINS.

SUMMARY

Length = 1000'
Beam = AL/5.75
Draft = B/3.3
Depth = AL/14
DST = 18000 psi
S = 10"
Material = ALUMINUM
TOP = 5.35"
BOT = 0.363"
STH = 18111.11
SBH = 53387.98
SBCRIT = 48648.64
DITOP = 18.09'
DIBOT = 53.34'


```

014 C *AL* IS THE LENGTH
014 C AL=1000.
015 C B=AL/5.75
016 C *DRA* IS THE DRAFT
017 C DRA=B/3.3
018 C D=AL/14.
019 C *POI* IS THE POISSON'S RATIO OF THE MATERIAL
020 C FOR ALUMINUM
021 C POI=0.35
022 C *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
023 C FOR ALUMINUM
024 C E=10.*1.E+6
025 C *DST* IS THE DESIGN STRESS
026 C DST=18000.
027 C *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
028 C S=30.
029 C *BM* IS THE BENDING MOMENT
030 C BM=(B*DRA*AL*A+0.75)/(35.*35.)
031 C G=0.3*396*S*(1.-POI*POI)/E
032 C A=B+C*D/(140.*BM)
033 C C=3.*B+C*D/(70.*BM)
034 C F=3.*D+C*D/(140.*BM)
035 C THICKNESS OF TOP ASSUMED LARGER THAN BOTTOM THICKNESS
036 C WRITE(5,10)
037 C 10 FORMAT('1',25Y,'TOP ASSUMED LARGER THAN BOTTOM')
038 C *TOP* IS THE THICKNESS OF THE TOP PLATING
039 C *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
040 C BOT1=0.2
041 C TOP1=B*BOT1*BOT1*BOT1/((B+C)*G*DST-D*BOT1*BOT1)
042 C WRITE(5,20)TOP1,BOT1
043 C 20 FORMAT('1',25Y,'TOP1=1F9.4,5X,BOT1=1F9.4)
044 C BOT1=BOT1+0.1
045 C IF(BOT1.GT.2.5)GO TO 30
046 C GO TO 11
047 C 30 TOP2=1.
048 C 31 BOT2=TOP2*(12.*D+(C+F)*DST*TOP2)/(DST*(A+C)*TOP2+12.*B)
049 C WRITE(5,40)TOP2,BOT2
050 C 40 FORMAT('1',25Y,'TOP2=1F9.4,5X,BOT2=1F9.4)
051 C TOP2=TOP2+0.2
052 C IF(TOP2.GT.6. ) GO TO 50
053 C GO TO 31
054 C 50 CONTINUE
055 C THICKNESS OF BOTTOM ASSUMED LARGER THAN TOP
056 C WRITE(5,60)
057 C 60 FORMAT('1',25Y,'BOTTOM ASSUMED LARGER THAN TOP')
058 C BOT3=0.1
059 C 61 TOP3=((B+D)*BOT3+BOT3*BOT3-D*G*DST-BOT3)/(B*G*DST)
060 C WRITE(5,70)TOP3,BOT3
061 C 70 FORMAT('1',25Y,'TOP3=1F9.4,5X,BOT3=1F9.4)
062 C BOT3=BOT3+0.01
063 C IF(BOT3.GT.1.5)GO TO 80
064 C GO TO 61

```


STRENGTH OF SHIPS ON THE NEUTRAL AXIS LOCATION

PAGE 2

```

42      09 TOP4=1.
43      81 BOT4=(12.* (B+C)-(A+C)*DST*TOP4)/((C+F)*DST)
44      WRITE(5,90)TOP4,BOT4
45      FORMAT(1,25X,1TOP4=1E9.4,5X,1BOT4=1E9.4)
46      TOP4=TOP4+0.2
47      IF(TOP4>BT+5.5)GO TO 100
48      GO TO 81
49      100 CONTINUE
50      END
51      DATA AL 1408[V] B 04F0[V] DRA 04D8[V] D
52      DATA F 14E8[V] .R 04F4[V] DST 04FC[V] S
53      DATA G 0518[V] A 0534[V] C 053C[V] F
54      DATA BI 0540[V] BOT1 0176[L] 11 0548[V] TOP1
55      DATA BN 0550[V] TOP2 0234[L] 31 0560[V] BOT2
56      DATA EN 0312[L] 60 0574[V] BOT3 0348[L] 61
57      DATA T0P3 0349[L] 70 0402[L] 80 0584[V] TOP4 040A[L] 81
58      DATA BOT4 0472[L] 90 04F0[L] 100 0000[S] .V
59      END

```

GRAM LABELS:

| | | | | | |
|------------|------------|------------|-----------|-------------|----------|
| 170 •MATH* | 2C22 •V | 2A51 •COMP | 2C2E •I | 2600 •P | 2B18 •Z |
| A76 \$6 | 2641 •A | 2B74 •MES | 29F2 •W | 27FA EXP | 2980 AIN |
| 6F2 ALOG | 2A83 •RARG | 2B14 •S | 27FA AEXP | 2B1C •ERCNT | 2AEA \$8 |
| B1C •O | 2BF2 •U | 3C4A | | | |

RAM POINTERS:

| | | | | | |
|-----------|-------------|-----------|------------|----------|----------|
| 510 •R | 264V •Z | 26F2 ALOG | 27FA AEXP | 27FA EXP | 2980 AIN |
| 9F2 •Y | 2A51 •COMP | 2A76 •A | 2ABE •RARG | 2AEA \$8 | 2B14 •S |
| 518 •ZFEN | 2B1C •ERCNT | 2B1E •O | 2B74 •MES | 2BFE •U | 2C24 •V |
| C2E •T | | | | | |

NON-BLOCKS:

E

DEFINED SUBROUTINES:

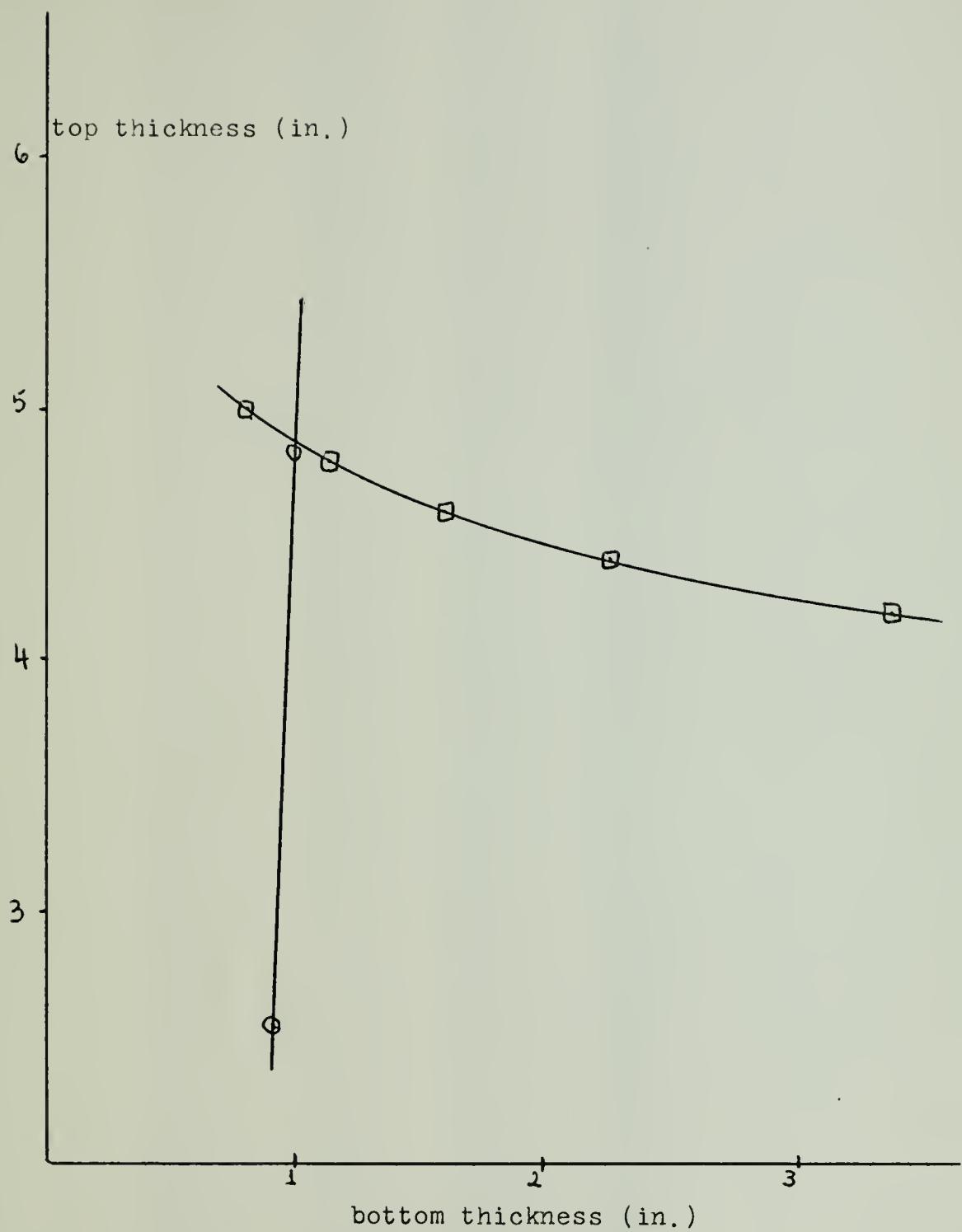
E

TRANSFER ADDRESS 2C70

SECTION BEGINS:

TOP ASSUMED LARGER THAN BOTTOM

| | | | |
|-------|----------|-------|----------|
| TOP1= | 0.0123 | BOT1= | 0.2000 |
| TOP1= | 0.0464 | BOT1= | 0.3000 |
| TOP1= | 0.1127 | BOT1= | 0.4000 |
| TOP1= | 0.2421 | BOT1= | 0.5000 |
| TOP1= | 0.4524 | BOT1= | 0.6000 |
| TOP1= | 0.8210 | BOT1= | 0.7000 |
| TOP1= | 1.4376 | BOT1= | 0.8000 |
| TOP1= | 2.5460 | BOT1= | 0.9000 |
| TOP1= | 4.8248 | BOT1= | 1.0000 |
| TOP1= | 10.0165 | BOT1= | 1.1000 |
| TOP1= | 22.6441 | BOT1= | 1.2000 |
| TOP1= | -29.2967 | BOT1= | 1.3000 |
| TOP1= | -14.7528 | BOT1= | 1.4000 |
| TOP1= | -11.7622 | BOT1= | 1.5000 |
| TOP1= | -9.4724 | BOT1= | 1.6000 |
| TOP1= | -8.6564 | BOT1= | 1.7000 |
| TOP1= | -8.1945 | BOT1= | 1.8000 |
| TOP1= | -7.9417 | BOT1= | 1.9000 |
| TOP1= | -7.8127 | BOT1= | 2.0000 |
| TOP1= | -7.7677 | BOT1= | 2.1000 |
| TOP1= | -7.7798 | BOT1= | 2.2000 |
| TOP1= | -7.8311 | BOT1= | 2.3000 |
| TOP1= | -7.9143 | BOT1= | 2.4000 |
| TOP1= | -8.0212 | BOT1= | 2.5000 |
| TOP2= | 1.0108 | BOT2= | -0.4673 |
| TOP2= | 1.208 | BOT2= | -0.5810 |
| TOP2= | 1.4108 | BOT2= | -0.7055 |
| TOP2= | 1.6108 | BOT2= | -0.8440 |
| TOP2= | 1.8108 | BOT2= | -1.0009 |
| TOP2= | 2.0108 | BOT2= | -1.1829 |
| TOP2= | 2.2108 | BOT2= | -1.4002 |
| TOP2= | 2.4108 | BOT2= | -1.6693 |
| TOP2= | 2.6108 | BOT2= | -2.0190 |
| TOP2= | 2.8108 | BOT2= | -2.5045 |
| TOP2= | 3.0108 | BOT2= | -3.2460 |
| TOP2= | 3.2108 | BOT2= | -4.5652 |
| TOP2= | 3.4208 | BOT2= | -7.7108 |
| TOP2= | 3.6108 | BOT2= | -26.8087 |
| TOP2= | 3.8108 | BOT2= | 16.3226 |
| TOP2= | 4.0208 | BOT2= | 5.8811 |
| TOP2= | 4.2208 | BOT2= | 3.3945 |
| TOP2= | 4.4208 | BOT2= | 2.2560 |
| TOP2= | 4.6208 | BOT2= | 1.5888 |
| TOP2= | 4.8208 | BOT2= | 1.1408 |
| TOP2= | 5.0208 | BOT2= | 0.8127 |
| TOP2= | 5.2208 | BOT2= | 0.5572 |
| TOP2= | 5.4208 | BOT2= | 0.3490 |
| TOP2= | 5.6208 | BOT2= | 0.1733 |
| TOP2= | 5.8208 | BOT2= | 0.0210 |
| TOP2= | 6.0208 | BOT2= | -0.1140 |



| BOTTOM ASSUMED LARGER THAN TOP | BOT3= | 0.1000 |
|--------------------------------|-------|--------|
| TCP3= -1.0349 | BOT3= | 0.1100 |
| TCP3= -1.0469 | BOT3= | 0.1200 |
| TCP3= -1.0477 | BOT3= | 0.1300 |
| TCP3= -1.0513 | BOT3= | 0.1400 |
| TCP3= -1.0567 | BOT3= | 0.1500 |
| TCP3= -1.0588 | BOT3= | 0.1600 |
| TCP3= -1.0595 | BOT3= | 0.1700 |
| TCP3= -1.0592 | BOT3= | 0.1800 |
| TCP3= -1.0584 | BOT3= | 0.1900 |
| TOP3= -1.1564 | BOT3= | 0.2000 |
| TOP3= -1.1565 | BOT3= | 0.2100 |
| TOP3= -1.1561 | BOT3= | 0.2200 |
| TOP3= -1.1563 | BOT3= | 0.2300 |
| TOP3= -1.1561 | BOT3= | 0.2400 |
| TOP3= -1.1524 | BOT3= | 0.2500 |
| TOP3= -1.1503 | BOT3= | 0.2600 |
| TOP3= -1.1476 | BOT3= | 0.2700 |
| TOP3= -1.1444 | BOT3= | 0.2800 |
| TOP3= -1.1407 | BOT3= | 0.2900 |
| TOP3= -1.1364 | BOT3= | 0.3000 |
| TOP3= -1.1315 | BOT3= | 0.3100 |
| TOP3= -1.1261 | BOT3= | 0.3200 |
| TOP3= -1.1226 | BOT3= | 0.3300 |
| TOP3= -1.1213 | BOT3= | 0.3400 |
| TOP3= -1.1215 | BOT3= | 0.3500 |
| TOP3= 1.1151 | BOT3= | 0.3600 |
| TOP3= 1.1219 | BOT3= | 0.3700 |
| TOP3= 1.1203 | BOT3= | 0.3800 |
| TOP3= 1.1035 | BOT3= | 0.3900 |
| TOP3= 1.0945 | BOT3= | 0.4000 |
| TOP3= 1.0852 | BOT3= | 0.4100 |
| TOP3= 1.0767 | BOT3= | 0.4200 |
| TOP3= 1.0760 | BOT3= | 0.4300 |
| TOP3= 1.0752 | BOT3= | 0.4400 |
| TOP3= 1.1151 | BOT3= | 0.4500 |
| TOP3= 1.1246 | BOT3= | 0.4600 |
| TOP3= 1.1408 | BOT3= | 0.4700 |
| TOP3= 1.1554 | BOT3= | 0.4800 |
| TOP3= 1.1770 | BOT3= | 0.4900 |
| TOP3= 1.1965 | BOT3= | 0.5000 |
| TOP3= 1.2170 | BOT3= | 0.5100 |
| TOP3= 1.2395 | BOT3= | 0.5200 |
| TOP3= 1.2610 | BOT3= | 0.5300 |
| TOP3= 1.2545 | BOT3= | 0.5400 |
| TOP3= 1.2760 | BOT3= | 0.5500 |
| TOP3= 1.2346 | BOT3= | 0.5600 |
| TOP3= 1.2313 | BOT3= | 0.5700 |
| TOP3= 1.2391 | BOT3= | 0.5800 |
| TOP3= 1.4186 | BOT3= | 0.5900 |
| TOP3= 1.4426 | BOT3= | 0.6000 |
| TOP3= 1.4762 | BOT3= | 0.6100 |
| TOP3= 1.5116 | BOT3= | 0.6200 |
| TOP3= 1.5451 | BOT3= | 0.6300 |
| TOP3= 1.5799 | BOT3= | 0.6400 |
| TOP3= 1.6159 | BOT3= | 0.6500 |

| | | | |
|-------|--------|-------|--------|
| TOP3= | 0.6572 | BOT3= | 0.6600 |
| TOP3= | 0.6918 | BOT3= | 0.6700 |
| TOP3= | 0.7316 | BOT3= | 0.6800 |
| TOP3= | 0.7728 | BOT3= | 0.6900 |
| TOP3= | 0.8152 | BOT3= | 0.7000 |
| TOP3= | 0.8551 | BOT3= | 0.7100 |
| TOP3= | 0.8943 | BOT3= | 0.7200 |
| TOP3= | 0.9309 | BOT3= | 0.7300 |
| TOP3= | 0.9929 | BOT3= | 0.7400 |
| TOP3= | 1.0443 | BOT3= | 0.7500 |
| TOP3= | 1.0902 | BOT3= | 0.7600 |
| TOP3= | 1.1515 | BOT3= | 0.7700 |
| TOP3= | 1.2153 | BOT3= | 0.7800 |
| TOP3= | 1.2676 | BOT3= | 0.7900 |
| TOP3= | 1.3175 | BOT3= | 0.8000 |
| TOP3= | 1.3769 | BOT3= | 0.8100 |
| TOP3= | 1.4369 | BOT3= | 0.8200 |
| TOP3= | 1.4974 | BOT3= | 0.8300 |
| TOP3= | 1.5655 | BOT3= | 0.8400 |
| TOP3= | 1.6263 | BOT3= | 0.8500 |
| TOP3= | 1.6917 | BOT3= | 0.8600 |
| TOP3= | 1.7508 | BOT3= | 0.8700 |
| TOP3= | 1.8205 | BOT3= | 0.8800 |
| TOP3= | 1.8909 | BOT3= | 0.8900 |
| TOP3= | 1.9711 | BOT3= | 0.9000 |
| TOP3= | 2.0404 | BOT3= | 0.9100 |
| TOP3= | 2.1206 | BOT3= | 0.9200 |
| TOP3= | 2.2040 | BOT3= | 0.9300 |
| TOP3= | 2.2842 | BOT3= | 0.9400 |
| TOP3= | 2.3663 | BOT3= | 0.9500 |
| TOP3= | 2.4511 | BOT3= | 0.9600 |
| TOP3= | 2.5358 | BOT3= | 0.9700 |
| TOP3= | 2.6254 | BOT3= | 0.9800 |
| TOP3= | 2.7129 | BOT3= | 0.9900 |
| TOP3= | 2.8143 | BOT3= | 1.0000 |
| TOP3= | 2.8976 | BOT3= | 1.0100 |
| TOP3= | 2.9928 | BOT3= | 1.0200 |
| TOP3= | 3.0962 | BOT3= | 1.0300 |
| TOP3= | 3.1802 | BOT3= | 1.0400 |
| TOP3= | 3.2925 | BOT3= | 1.0500 |
| TOP3= | 3.3957 | BOT3= | 1.0600 |
| TOP3= | 3.4906 | BOT3= | 1.0700 |
| TOP3= | 3.5943 | BOT3= | 1.0800 |
| TOP3= | 3.7127 | BOT3= | 1.0900 |
| TOP3= | 3.8273 | BOT3= | 1.1000 |
| TOP3= | 3.9419 | BOT3= | 1.1100 |
| TOP3= | 4.0567 | BOT3= | 1.1200 |
| TOP3= | 4.1747 | BOT3= | 1.1300 |
| TOP3= | 4.2948 | BOT3= | 1.1400 |
| TOP3= | 4.4171 | BOT3= | 1.1500 |
| TOP3= | 4.5417 | BOT3= | 1.1600 |
| TOP3= | 4.6685 | BOT3= | 1.1700 |
| TOP3= | 4.7975 | BOT3= | 1.1800 |
| TOP3= | 4.9288 | BOT3= | 1.1900 |
| TOP3= | 5.0624 | BOT3= | 1.2000 |
| TOP3= | 5.1994 | BOT3= | 1.2100 |
| TOP3= | 5.3326 | BOT3= | 1.2200 |

| | | | |
|-------|---------|-------|---------|
| TOP3= | 5.4772 | BOT3= | 1.2300 |
| TOP3= | 5.4872 | BOT3= | 1.2400 |
| TOP3= | 5.7656 | BOT3= | 1.2500 |
| TOP3= | 5.9124 | BOT3= | 1.2600 |
| TOP3= | 6.2626 | BOT3= | 1.2700 |
| TOP3= | 6.2123 | BOT3= | 1.2800 |
| TOP3= | 6.3714 | BOT3= | 1.2900 |
| TOP3= | 6.5260 | BOT3= | 1.3000 |
| TOP3= | 6.6892 | BOT3= | 1.3100 |
| TOP3= | 6.9518 | BOT3= | 1.3200 |
| TOP3= | 7.0170 | BOT3= | 1.3300 |
| TOP3= | 7.1848 | BOT3= | 1.3400 |
| TOP3= | 7.3552 | BOT3= | 1.3500 |
| TOP3= | 7.5221 | BOT3= | 1.3600 |
| TOP3= | 7.7757 | BOT3= | 1.3700 |
| TOP3= | 7.8819 | BOT3= | 1.3800 |
| TOP3= | 8.7628 | BOT3= | 1.3900 |
| TOP3= | 8.2464 | BOT3= | 1.4000 |
| TOP3= | 8.4326 | BOT3= | 1.4100 |
| TOP3= | 8.6216 | BOT3= | 1.4200 |
| TOP3= | 8.6123 | BOT3= | 1.4300 |
| TOP3= | 9.7778 | BOT3= | 1.4400 |
| TOP3= | 9.2051 | BOT3= | 1.4500 |
| TOP3= | 9.4751 | BOT3= | 1.4600 |
| TOP3= | 9.6120 | BOT3= | 1.4700 |
| TOP3= | 9.9157 | BOT3= | 1.4800 |
| TOP3= | 10.1723 | BOT3= | 1.4900 |
| TOP3= | 10.2327 | BOT3= | 1.5000 |
| TOP4= | 1.7620 | BOT4= | 16.1639 |
| TOP4= | 1.2720 | BOT4= | 15.3920 |
| TOP4= | 1.4120 | BOT4= | 14.6201 |
| TOP4= | 1.6120 | BOT4= | 13.8482 |
| TOP4= | 1.2220 | BOT4= | 13.0763 |
| TOP4= | 2.0220 | BOT4= | 12.3044 |
| TOP4= | 2.2120 | BOT4= | 11.5324 |
| TOP4= | 2.4120 | BOT4= | 10.7605 |
| TOP4= | 2.6120 | BOT4= | 9.9886 |
| TOP4= | 2.8120 | BOT4= | 9.2167 |
| TOP4= | 3.0220 | BOT4= | 8.4448 |
| TOP4= | 3.2220 | BOT4= | 7.6729 |
| TOP4= | 3.4220 | BOT4= | 6.9010 |
| TOP4= | 3.6220 | BOT4= | 6.1290 |
| TOP4= | 3.8220 | BOT4= | 5.3571 |
| TOP4= | 4.0220 | BOT4= | 4.5852 |
| TOP4= | 4.2220 | BOT4= | 3.8133 |
| TOP4= | 4.4220 | BOT4= | 3.0414 |
| TOP4= | 4.6220 | BOT4= | 2.2695 |
| TOP4= | 4.8220 | BOT4= | 1.4975 |
| TOP4= | 5.0220 | BOT4= | 0.7256 |
| TOP4= | 5.2220 | BOT4= | -0.1463 |
| TOP4= | 5.4220 | BOT4= | -0.8182 |

| | | |
|----------------------|----------------|-----|
| CR HANDLING CHARGE | \$.25 / JOB | .25 |
| 11 LINES PRINTED PR1 | \$ 1.25 / K LN | .39 |
| 67 CARDS READ | \$ 1.50 / K CD | .17 |
| 22 PLOTS OF VECTORS | \$.25 / 1000 | .00 |
| 22 MODEL 71 SECONDS | \$25.00 / HOUR | .15 |
| 22 MODEL 81 SECONDS | \$12.50 / HOUR | .00 |
| TOTAL CHARGE \$ | | .99 |

EIR 400 14731 LOGGED OUT 06/26/74 19:42. \$ 5.68 LEFT AFTER 28 LOGINS.

STRENGTH OF SHIPS ON THE NEUTRAL AXIS LOCATION

PAGE 1

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04 C *AL* IS THE LENGTH
24 AL=110.0
20 R=AL/5.75
18 C *DRA* IS THE DRAFT
18 DRA=H/3.3
24 R=AL/14.0
32 C *POI* IS THE POISSON'S RATIO OF THE MATERIAL
22 FOR ALUMINUM
32 POI=0.33
38 C *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
32 FOR ALUMINUM
32 E=10**10**6
40 C *DST* IS THE DESIGN STRESS
40 DST=150.0
54 C *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
54 S=34.0
50 C *B'M* IS THE BENDING MOMENT
50 BM=(R*DRA*AL*AL**1.75)/(35.0*35.0)
58 G=FV*37396*S*S*(1.0+POI+POI)/E
54 C *TCP* IS THE THICKNESS OF THE TOP PLATING
54 *BCT* IS THE THICKNESS OF THE BOTTOM PLATING
54 TCP=4.86
50 C ROT=1.0
50 A=56V.0*B'M*(B*TOT+D*TOD)
50 LEN=0*(2.0*B*TOD*ROT+2.0*B*D*TOD*(TOP+BOT)+(D*D*TOP*TOD))
140 C *STH* IS THE STRESS ON TOP DUE TO HOGGING
140 STH=A/LEN
158 C WRITE(B,6F)STH
174 A FORMAT(' ',20X,'STH='F10.3)
184 C F=56V.0*B'M*(B*TOD+D*TOD)
194 C *SBH* IS THE STRESS ON BOT DUE TO HOGGING
194 SBH=C/LEN
216 C WRITE(B,90)SBH
216 A FORMAT(' ',20X,'SBH='F10.3)
216 C *SBCRIT* IS THE CRITICAL STRESS ON BOT
216 SBCRIT=HOT*BOT/G
220 C WRITE(B,112)SBCRIT
228 C FORMAT(' ',17X,'SBCRIT='F10.3)
244 P=2.0*D*TOD+B*(TOP+BOT)
268 C *DITOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
268 DITOP=D*(B*BOT+D*TOP)/P
280 C WRITE(B,40)DITOP
288 A FORMAT(' ',18X,'DITOP='F10.4)
294 C *DIBOT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS
294 DIBOT=D*(B*TOP+D*TOP)/P
298 C WRITE(B,52)DIBOT
304 C FORMAT(' ',18X,'DIBOT='F10.4)
320 END
{S} .U 0324[V] AL      0320[V] B      0334[V] DRA      0330[V] D
{V} PCI 0340[V] E      0322[S] .R      0358[V] DST      0360[V] S
{V} BY   0370[V] G      0388[V] TOP      0300[V] BOT      0394[V] A
{V} DEM 0388[V] STH     /174[L] 60 ,    0000[S] @I      0380[V] C

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STRENGTH OF SHIPS ON THE NEUTRAL AXIS LOCATION

PAGE 2

| | | | | |
|-----------|------------|-----------------|-------------|------------|
| [V] SAB | 21E2[L] 97 | 13C4 [V] SBCRIT | 0228[L] 110 | 03C8[V. P |
| [V] DUTCR | 02A8[L] 49 | 3D0[V] DIPOT | 0374[L] 50 | 0007[S] .V |
| TEL | L | | | |

GRAM LABELS:

| | | | | | |
|-----------|------------|------------|-----------|-------------|----------|
| 27D *M1** | 2A64 .V | 2894 .COMP | 2A72 .I | 2444 .R | 295C .Z |
| 82A SA | 2484 .A | 2938 .MES | 2436 .W | 263F EXP | 27C4 AI |
| 536 ALOG | 28FC .RARG | 2953 .E | 263E AEXP | 296F .ERCNT | 292E \$9 |
| 362 .7 | 2A26 .W | 263F | | | |

HY-PCI T3:

| | | | | | |
|-----------|-------------|-----------|------------|----------|---------|
| 444 .- | 2424 .H | 2536 ALOG | 263E AEXP | 263E EXP | 27C4 AI |
| 336 . | 2854 .COMP | 2834 .E | 28FC .RARG | 292F \$8 | 2958 .5 |
| 55C .7-FN | 2960 .ERCNT | 2962 .W | 2988 .MES | 2A42 .U | 2468 .V |
| 472 .H | | | | | |

NON-BLOCKS:

E

REFINER SUBROUTINES:

E

TRANSFER ADDRESS 2870

ROUTINE REGISTERS:

```

STH= 18E62.194
SHF= 41334.957
SBCPIT= 41021.625
JITOP= 21.7217
DIBOT= 49.7269
END

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VIO OPERATING SYSTEM VERSION 1 REVISION 012 03/04/74 GENERATED 05/06/74

| | | |
|----------------------|-----------------|-----|
| CE HANDLING CHARGE | \$.25 / JOB | .35 |
| 85 LINES PRINTED PR1 | \$ 1.25 / K LN | .11 |
| 54 CARDS READ | \$ 1.50 / K CN | .08 |
| 72 PLTTER VECTORS | \$.25 / 1770 | .00 |
| 16 MODEL 72 SECONDS | \$25.00 / HOUR | .11 |
| 82 MODEL 80 SECONDS | \$12.50 / HOUR | .00 |
| | TOTAL CHARGE \$ | .65 |

TEIR 42 14731 LOGGED OUT 05/06/74 19:58. \$ 2.78 LEFT AFTER 32 LOGINS.

SUMMARY

Length = 1000'
Beam = AL/5.75
Draft = B/3.3
Depth = AL/14
DST = 18000 psi
S = 30"
Material - ALUMINUM
TOP = 4.86"
BOT = 1.00"
STH = 18063.18
SBH = 41334.96
SBCRIT = 41021.80
DITOP = 21.72'
DIBOT = 49.71'

STRENGTH OF SHIPS ON THE NEUTRAL AXIS LOCATION

PAGE 1

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2784 C *AL* IS THE LENGTH
2785 C AL=3000.
2786 C B=AL/5.75
2787 C *DRA* IS THE DRAFT
2788 C DRA=B/3.3
2789 C D=AL/14.
2790 C *POI* IS THE POISSON'S RATIO OF THE MATERIAL
2791 C FOR ALUMINUM
2792 C POI=2.33
2793 C *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
2794 C FOR ALUMINUM
2795 C E=10**11**6
2796 C *DST* IS THE DESIGN STRESS
2797 C DST=180.0.
2798 C *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
2799 C S=60.
2800 C *B* IS THE BENDING MOMENT
2801 C B=(P*D*A*AL+AL*(C+75))/(35.35.)
2802 C G=FV*2*3.96*S+S*(1.0POI+POI)/E
2803 C A=C+F+C/(140.+B)
2804 C C=G+F+C/(170.+B)
2805 C F=G+C*(C/(140.+B))
2806 C THICKNESS OF TOP ASSUMED LARGER THAN BOTTOM THICKNESS
2807 C WRITE(5,17)
2808 C 1, FORMAT('1',25X,'TOP ASSUMED LARGER THAN BOTTOM')
2809 C *TOP* IS THE THICKNESS OF THE TOP PLATING
2810 C *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
2811 C BOT1=1.
2812 C TCP1=(B+D)*BOT1*BOT1,((B+D)*G*DST-D*BOT1*BOT1)
2813 C WRITE(5,22)TOP1,BOT1
2814 C 2, FORMAT('1',25X,'TOP1=,F9.4,5X,,BOT1='F9.4)
2815 C BOT1=BOT1+0.1
2816 C IF(BOT1.GT.2.5)GO TO 30
2817 C GO TO 11
2818 C TOP2=3.5
2819 C 31 BOT2=TOP2*(12.*7-(C+F)*DST*TOP2)/(DST*(A+C)*TOP2-12.*B)
2820 C WRITE(5,40)TOP2,BOT2
2821 C 4, FORMAT('1',25X,'TOP2=,F9.4,5X,,BOT2='F9.4)
2822 C TOP2=TOP2+0.2
2823 C IF(TOP2.GT.6.0)GO TO 52
2824 C GO TO 31
2825 C 52 CONTINUE
2826 C THICKNESS OF BOTTOM ASSUMED LARGER THAN TOP
2827 C WRITE(5,60)
2828 C 6, FORMAT('1',25X,'BOT3 ASSUMED LARGER THAN TOP')
2829 C BOT3=0.7
2830 C 61 TCP3=((B+D)*BOT3-BOT3*BOT3-D*G*DST*BOT3)/(B*G*DST)
2831 C WRITE(5,72)TOP3,BOT3
2832 C 7, FORMAT('1',25X,'TOP3=,F9.4,5X,,BOT3='F9.4)
2833 C BOT3=BOT3+0.05
2834 C IF(BOT3.GT.1.5)GO TO 90
2835 C GO TO 61

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STRENGTH OF SHIPS=ON THE NEUTRAL AXIS LOCATION

PAGE 2

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4P2      80 TOP4=1.
4PA      91 P0T4=(14.* (B+n)-(A+C)*DST*TOP4)/((C+F)*DST)
4E       WRITE(5,92)TOP4,R0T4
72       92 FORMAT(' ',25X,'TOP4=,F9.4,5X,1BOT4='F9.4)
9A       TOP4=TOP4+0.2
9B       IF(TOP4>IT.E.) GO TO 100
9E       GO TO 91
9C       120 CONTINUE
9D       END

```

| | | | | |
|----------|-------------|---------------|---------------|---------------|
| [S] .01 | 24CP [V] AL | 14Ca [V] B | 04D1 [V] DRA | 04D8 [V] D |
| [V] P01 | 14F8 [V] E | 122 [S] .R | 04F4 [V] DST | 04FC [V] S |
| [V] F01 | 1518 [V] G | 1524 [V] A | 0530 [V] C | 053C [V] F |
| [L] 11 | 15P1 [S] .I | 1540 [V] BOT1 | 0176 [L] 11 | 0544 [V] TOP1 |
| [L] 21 | 15P2 [L] 30 | 1557 [V] TOP2 | 0234 [L] 31 | 0560 [V] BOT2 |
| [L] 41 | 15P3 [L] 30 | 1512 [L] AP | 0578 [V] BOT3 | 0348 [L] 61 |
| [V] TOP3 | 13-8 [L] 70 | 1412 [L] RV | 058C [V] TOP4 | 040A [L] 81 |
| [V] R0T4 | 1472 [L] 70 | 14PC [L] 100 | 0070 [S] .V | |

REG L

F

GRAPH LINES:

| | | | | | |
|------------|------------|------------|-----------|-------------|----------|
| -27W *MAT | 2028 .v | 2A58 .COMP | 2C36 .I | 2608 .R | 2B20 .ZI |
| -47E SA | 2648 .A | 2A7C .MES | 29FA .W | 2802 EXP | 2988 AI |
| 26FA AI OG | 2AC0 .RARG | 2B1C .S | 2B02 /EXP | 2B24 .ERCNT | 2AF2 \$8 |
| 2B24 .P | 2EFA .L | 3B52 | | | |

TRY-PUT, T0:

| | | | | | |
|------------|-------------|------------|------------|----------|---------|
| 2608 .P | 2648 .A | 26FA AI OG | 2B02 AEXP | 2802 EXP | 2988 AI |
| 29FA .Z | 2A58 .COMP | 2A7E %G | 2AC0 .RARG | 2AF2 \$8 | 2B1C .S |
| 2B20 .ZER0 | 2B24 .ERCNT | 2B24 .n | 2B7C .MES | 2C06 .U | 2C2C .V |
| EC36 .H | | | | | |

MON-BLOCKS:

E

DEFINED SUBROUTINES:

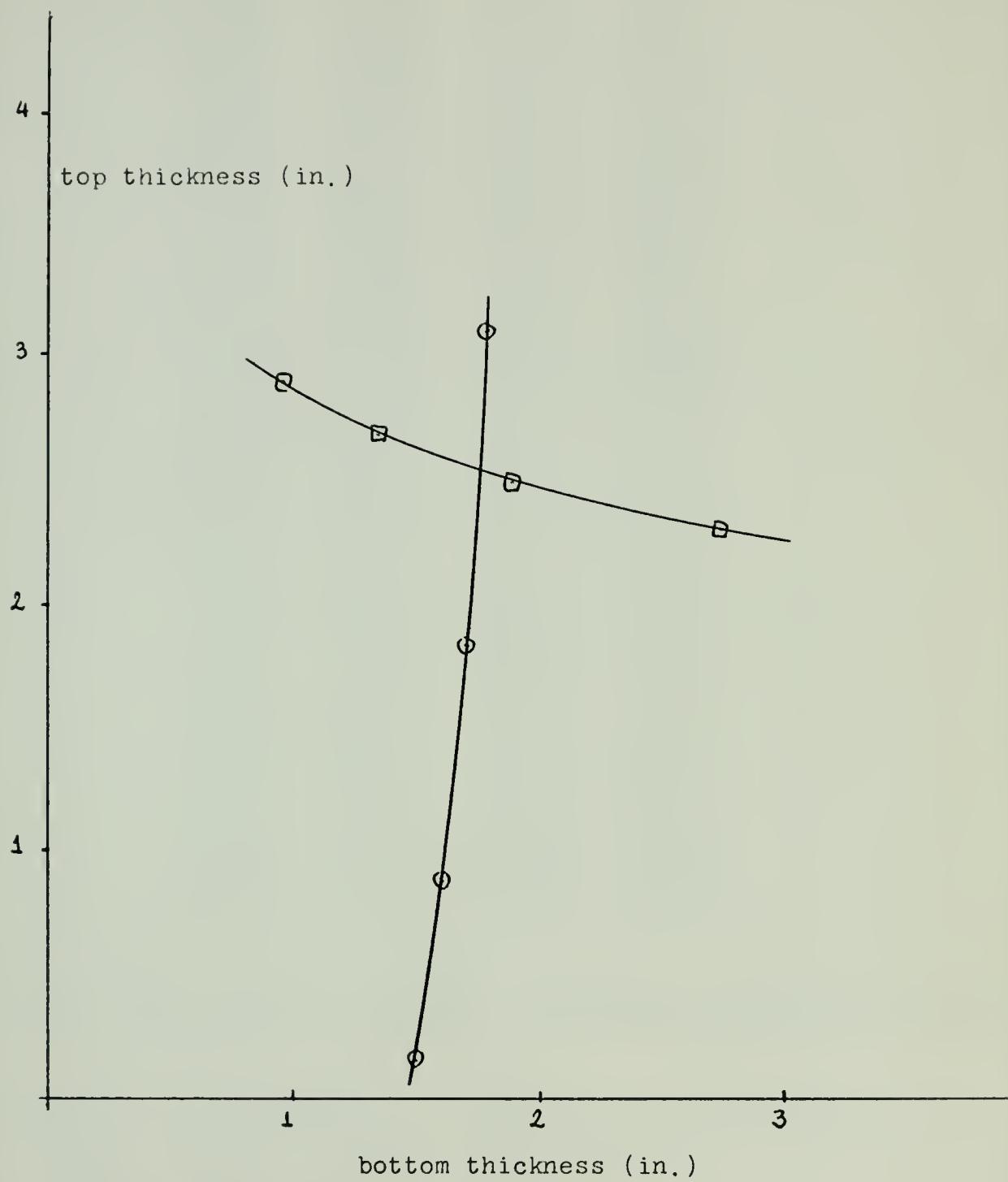
E

TRANSFER ADDRESS 237V

CUTION REGS:

TCP ASSUMED LARGER THAN BOTTOM

| | | | |
|-------|-----------|-------|----------|
| TCP1= | 1.4842 | BOT1= | 1.0000 |
| TCP1= | 1.6725 | BOT1= | 1.1700 |
| TCP1= | 1.9169 | BOT1= | 1.2900 |
| TCP1= | 1.9329 | BOT1= | 1.3000 |
| TCP1= | 1.4421 | BOT1= | 1.4000 |
| TCP1= | 2.1747 | BOT1= | 1.5000 |
| TCP1= | 2.2751 | BOT1= | 1.6000 |
| TCP1= | 3.8112 | BOT1= | 1.7000 |
| TCP1= | 5.0919 | BOT1= | 1.8000 |
| TCP1= | 6.9147 | BOT1= | 1.9000 |
| TCP1= | 9.6145 | BOT1= | 2.0000 |
| TCP1= | 13.0342 | BOT1= | 2.1000 |
| TCP1= | 21.8145 | BOT1= | 2.2000 |
| TCP1= | 47.1143 | BOT1= | 2.3000 |
| TCP1= | 125.2764 | BOT1= | 2.4000 |
| TCP1= | -171.9198 | BOT1= | 2.5000 |
| TCP2= | 3.5V2V | BOT2= | -11.8971 |
| TCP2= | 3.7~V | BOT2= | 91.0296 |
| TCP2= | 3.31~V | BOT2= | 8.7662 |
| TCP2= | 4.1~V | BOT2= | 4.3496 |
| TCP2= | 4.3~V | BOT2= | 2.7380 |
| TCP2= | 4.41~V | BOT2= | 1.8852 |
| TCP2= | 4.7V~V | BOT2= | 1.3454 |
| TCP2= | 4.9V~V | BOT2= | 0.9655 |
| TCP2= | 5.1V~V | BOT2= | 0.6778 |
| TCP2= | 5.2~V | BOT2= | 0.4483 |
| TCP2= | 5.5V~V | BOT2= | 0.2578 |
| TCP2= | 5.7~V | BOT2= | 0.1947 |
| TCP2= | 5.9V~V | BOT2= | -0.2484 |



BOTTOM ASSUMED LARGER THAN TOP

| | | | |
|-------|---------|-------|---------|
| TOP3= | -P.0118 | BOT3= | 0.7000 |
| TOP3= | 0.0310 | BOT3= | 0.7500 |
| TOP3= | 1.0829 | BOT3= | 0.8000 |
| TOP3= | 1.1445 | BOT3= | 0.8500 |
| TOP3= | 1.2143 | BOT3= | 0.9000 |
| TOP3= | 1.2909 | BOT3= | 0.9500 |
| TOP3= | 1.3824 | BOT3= | 1.0000 |
| TOP3= | 1.4822 | BOT3= | 1.0500 |
| TOP3= | 1.6107 | BOT3= | 1.1000 |
| TOP3= | 1.7521 | BOT3= | 1.1500 |
| TOP3= | 1.8924 | BOT3= | 1.2000 |
| TOP3= | 1.0524 | BOT3= | 1.2500 |
| TOP3= | 1.2319 | BOT3= | 1.3000 |
| TOP3= | 1.4220 | BOT3= | 1.3500 |
| TOP3= | 1.6325 | BOT3= | 1.4000 |
| TOP3= | 1.8548 | BOT3= | 1.4500 |
| TOP3= | 2.0925 | BOT3= | 1.5000 |
| TOP4= | 1.0116 | BOT4= | 16.1639 |
| TOP4= | 1.2724 | BOT4= | 15.3920 |
| TOP4= | 1.4126 | BOT4= | 14.6201 |
| TOP4= | 1.6120 | BOT4= | 13.8482 |
| TOP4= | 1.8120 | BOT4= | 13.0763 |
| TOP4= | 2.0120 | BOT4= | 12.3144 |
| TOP4= | 2.2120 | BOT4= | 11.5324 |
| TOP4= | 2.4120 | BOT4= | 10.7605 |
| TOP4= | 2.6120 | BOT4= | 9.9886 |
| TOP4= | 2.8120 | BOT4= | 9.2167 |
| TOP4= | 3.0120 | BOT4= | 8.4448 |
| TOP4= | 3.2120 | BOT4= | 7.6729 |
| TOP4= | 3.4120 | BOT4= | 6.9010 |
| TOP4= | 3.6120 | BOT4= | 6.1290 |
| TOP4= | 3.8120 | BOT4= | 5.3571 |
| TOP4= | 4.0120 | BOT4= | 4.5852 |
| TOP4= | 4.2120 | BOT4= | 3.8133 |
| TOP4= | 4.4120 | BOT4= | 3.0414 |
| TOP4= | 4.6120 | BOT4= | 2.2695 |
| TOP4= | 4.8120 | BOT4= | 1.4975 |
| TOP4= | 5.0120 | BOT4= | 0.7256 |

END

F VIO OPERATING SYSTEM VERSION 1 REVISION 12 03/04/74 GENERATED 05/06/74 1

| | | |
|-----------------------|----------------|-----|
| JOB HANDLING CHARGE | \$.25 / JOB | .35 |
| 164 LINES PRINTED PER | \$ 1.05 / K LN | .21 |
| 67 CARDS READ | \$ 1.50 / K CD | .10 |
| 20 PLOTTING VECTORS | \$.25 / 10.0 | .00 |
| 19 MODEL 7 SECONDS | \$25.00 / HOUR | .13 |
| 22 MODEL 21 SECONDS | \$12.50 / HOUR | .00 |
| TOTAL CHARGE | \$.79 | |

EIP 402 14731 LOGGED OUT 05/06/74 19:48. \$ 4.89 LEFT AFTER 29 LOGINS.

STRENGHT OF SHIPS ON THE NEUTRAL AXIS LOCATION

PAGE 1

```

214 C *AL* IS THE LENGTH
214 AL=100.0
215 C B=AL/5.75
216 C *DRA* IS THE DRAFT
216 DRA=B/3.3
217 C D=AL/14.
218 C *POI* IS THE POISSON'S RATIO OF THE MATERIAL
219 FOR ALUMINUM
220 C POI=0.33
221 C *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
222 FOR ALUMINUM
223 C E=10.*10.*10.
224 C *DST* IS THE DESIGN STRESS
225 DST=18422.
226 C *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
227 S=6.0
228 C *RM* IS THE BENDING MOMENT
229 RM=(B*DRA*AL*Z*7.75)/(35.*35.*)
230 C E=3.394*S*S*(1.+POI*POI)/E
231 C *TOP* IS THE THICKNESS OF THE TOP PLATING
232 C *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
233 C TOP=4.53
234 C BOT=2.74
235 C S=BOT+TOP
236 C DEF=D*(B+3.*TOP+BOT+2.*B*D*TOP*(TOP+BOT)+(D*D*TOP-TOP))
237 C *STH* IS THE STRESS ON TOP DUE TO HOGGING
238 STH=DEF/DEN
239 C WRITE(5,4C) STH
240 C FORMAT(' ',20X,'STH=F10.3)
241 C S=BOT+TOP+BOT
242 C *SPH* IS THE STRESS ON BOT DUE TO HOGGING
243 SPH=DEF/DEN
244 C WRITE(5,5D) SPH
245 C FORMAT(' ',20X,'SPH=F10.3)
246 C *SCRIT* IS THE CRITICAL STRESS ON BOT
247 SCRIT=BOT-BOT/G
248 C WRITE(5,1E) SCRIT
249 C 11W FORMAT(' ',17X,'SCRIT=F10.3)
250 C P=2.*D-TOP+B*(TOP+BOT)
251 C *DITOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
252 DITOP=D*(B*BET+D*TOP)/P
253 C WRITE(5,4F) DITOP
254 C 4C FORMAT(' ',18X,'DITOP=F10.4)
255 C *DIBOT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS
256 DIBOT=D*(B*TCP+D*TOP)/P
257 C WRITE(5,5D) DIBOT
258 C 5W FORMAT(' ',18X,'DIBOT=F10.4)
259 C END

```

| | | | | | |
|------|--------|-------------|-------------|-------------|-----------|
| 1324 | •U | W324[V] AL | 0320[V] B | 0334[V] DRA | 0330[V] D |
| 324 | V] POI | 0340[V] E | 0000[S] •R | 0358[V] DST | 0360[V] S |
| 325 | V] RM | W370[V] G | 238P[V] TOP | 0390[V] BOT | 0398[V] A |
| 326 | V] DEN | 0380[V] STH | 2174[L] 62 | 0000[S] @I | 03C0[V] C |

STRENGHT OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE 2

| | | | | |
|------------|------------|----------------|-------------|------------|
| 1(V) SRH | 01E2[L] 90 | 03CR[V] SBCRIT | 0228[L] 110 | 03CC[V] P |
| 1(V) DITOP | 02A8[L] 40 | 03D4[V] DIBOT | 0304[L] 50 | 00C9[S] •V |

L

F

PROGRAM LABELS:

| | | | | | |
|-------------|------------|------------|-----------|-------------|----------|
| 2A71 •MAIN• | 2A68 •V | 2898 •COMP | 2A76 •I | 2448 •R | 2960 •ZE |
| 258E \$6 | 2438 •A | 298C •MES | 283A •W | 2642 EXP | 27C8 A11 |
| 2534 ALLOG | 2974 •RARG | 295C •S | 2642 AEXP | 2964 •ERCNT | 2932 \$8 |
| 2964 •O | 2A3A •U | 3892 | | | |

RAY-POINTS:

| | | | | | |
|------------|-------------|------------|------------|----------|----------|
| 2448 •R | 2438 •A | 2534 ALLOG | 2642 AEXP | 2642 EXP | 27C8 A11 |
| 2A76 •W | 2898 •COMP | 288C \$4 | 2900 •RARG | 2932 \$8 | 295C •S |
| 2A68 •ZERO | 2964 •ERCNT | 2964 •O | 298C •MES | 2A46 •U | 2A6C •V |
| | | | | | |

2A76 •I

MONITOR BLOCKS:

1:

DEFINED SUBROUTINES:

N:

TRANSFER ADDRESS 2078

ENTRY BEGINS:

```

      STH= 18034•023
      SBH= 31831•496
      SBCRIT= 31767•121
      DITOP= 25•8324
      DIBOT= 45•5962
    END
  
```

F VIO OPERATING SYSTEM VERSION 1 REVISION 012 03/04/74 GENERATED 05/06/74 F

| | | |
|----------------------|-----------------|-----|
| 08 HANLING CHARGE | \$.35 / JOB | •35 |
| 25 LINES PRI TED PR2 | \$ 1.25 / K LY | •11 |
| 54 CARDS READ | \$ 1.57 / K CD | •08 |
| 12 PLOTTER VECTORS | \$.25 / 100Z | •00 |
| 14 MODEL 70 SECONDS | \$25.17 / HOUR | •10 |
| 47 MODEL 80 SECONDS | \$12.50 / HOUR | •00 |
| | TOTAL CHARGE \$ | •64 |

PEIR 490 14731 LOGGED OUT 25/05/74 20:01. \$ 2.14 LEFT AFTER 33 LOGINS.

SUMMARY

Length = 1000'
Beam = AL/5.75
Draft = B/3.3
Depth = AL/14
DST = 18000 psi
S = 60"
Material - ALUMINUM
TOP = 4.53"
BOT = 1.76"
STH = 18034.02
SBH = 31831.49
SBCRIT = 31767.27
DITOP = 25.83'
DIBOT = 45.60'

STRENGTH OF SHIPS ON THE NEUTRAL AXIS LOCATION

PAGE 1

```

  P4      C      *AL* IS THE LENGTH
  P4      C      AL=12000.
  /C      C      R=AL/5.75
  '18     C      *DRA* IS THE DRAFT
  18     C      DNA=D/3.3
  24     C      DFAL/14.
  34     C      *POI* IS THE POISSON'S RATIO OF THE MATERIAL
  37     C      FOR ALUMINUM
  38     C      PUI=V*.35
  38     C      *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
  38     C      FOR ALUMINUM
  38     C      E=10.*1.*10
  40     C      *DST* IS THE DESIGN STRESS
  40     C      DST=18000.
  54     C      *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
  54     C      S=120.
  50     C      *BM* IS THE BENDING MOMENT
  50     C      FM=(P*DFA*AL*AL*.75)/(36.*35.)
  58     C      C=V*.30396*S*S*(1.-POI*PUI)/E
  64     C      A=9.*R+D/(142.*RM)
  64     C      C=3.*R+L*D/(72.*RD)
  64     C      F=3.*D*L*D/(140.*RM)
  70     C      THICKNESS OF TOP ASSUMED LARGER THAN BOTTOM THICKNESS
  70     C      WRITE(5,10)
  74     10    FORMAT('1',25x,'TOP ASSUMED LARGER THAN BOTTOM')
  76     C      *TOP* IS THE THICKNESS OF THE TOP PLATING
  76     C      *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
  76     C      BOT1=2.
  76     11    TOP1=R*BOT1*BOT1*BOT1/((B+F)*G*DST+D*BOT1*BOT1)
  76     C      WRITE(5,20)TOP1,BOT1
  76     21    FORMAT(' ',25x,'TOP1=,F9.4,5X,',BOT1='F9.4')
  76     C      BOT1=BOT1+C*2
  76     22    IF(BOT1.GT.7.) GO TO 30
  76     23    GO TO 11
  76     24    TOP2=3.5
  76     25    BOT2=TOP2*(12.*D+(C+F)*DST*TOP2)/(DST*(A+C)*TOP2-12.*B)
  76     C      WRITE(5,40)TOP2,BOT2
  76     46    FORMAT(' ',25x,'TOP2=,F9.4,5X,',BOT2='F9.4')
  76     C      TOP2=TOP2+C*2
  76     47    IF(TOP2.GT.6.) GO TO 50
  76     48    GO TO 31
  76     49    CONTINUE
  76     C      THICKNESS OF BOTTOM ASSUMED LARGER THAN TOP
  76     C      WRITE(5,60)
  76     60    FORMAT('1',25x,'BOTTOM ASSUMED LARGER THAN TOP')
  76     C      BOT3=1.
  76     61    TOP3=((H+D)*BOT3+BOT3*BOT3+BOT3*D*G*DST*BOT3)/(P*G*DST)
  76     C      WRITE(5,70)TOP3,BOT3
  76     71    FORMAT(' ',25x,'TOP3=,F9.4,5X,',BOT3='F9.4')
  76     C      BOT3=BOT3+C*2
  76     72    IF(BOT3.GT.3.5) GO TO 80
  76     73    GO TO 61

```


STRENGTH OF SHIPS ON THE NEUTRAL AXIS LOCATION

```

472      A~ TOP4=1.
47A      S1 8014=(12.* (B+C)+(A+C)*DST*TOP4)/((C+F)*DST)
47E      XRITE(5,87)TOP4, TOP4
472      Q FORMAT(11,25Y,1TOP4=F9.4,5X,1BOT4=F9.4)
47A      TOP4=TOP4+0.2
476      IF(TOP4.GT.4.5)GO TO 100
47R      GO TO 81
47C      110 CONTINUE
47C      END
[S] •II 2400[V] AL    2400[V] B    2400[V] DRA   0408[V] D
[V] FCT  24E8[V] E    2400[R] R    24F4[V] DST   04FC[V] S
[V] •W  2518[V] G    2524[V] A    2520[V] C    053C[V] F
[L] 11  2000[S] I    2542[V] BOT1  2176[L] 11   0548[V] TOP1
[L] 21  2220[L] 3P    2550[V] TOP2  2224[L] 31   0564[V] BOT2
[L] 41  22FE[L] 5W    2312[L] 6W   2578[V] BOT3  0348[L] 61
[V] TMP3 2328[L] 7W    2402[L] 3P   2580[V] TOP4  040A[L] 81
[V] FCT4 2472[L] 90    2400[L] 100  200A[S] •V
EG      L

```

GRAN LABELS:

| | | | | | |
|-----------|------------|------------|-----------|-------------|----------|
| 2772 •MAT | 2010 •V | 2440 •COMP | 202A •I | 25FC •R | 2B14 •Z |
| 2A72 \$A | 263C •A | 2472 •MES | 26EE •W | 27F6 EXP | 297C AI |
| 6EE ALOG | 2A14 •RARG | 2H1A •S | 27F6 AEXP | 2B18 •ERCNT | 2AE6 \$8 |
| 2E13 •O | 2EEF •L | 3D46 | | | |

TRY-POINTS:

| | | | | | |
|-------------|-------------|-----------|------------|----------|---------|
| 2EFC •P | 263C •4 | 26EE ALOG | 27F6 AEXP | 27F6 EXP | 297C AI |
| 2EE •W | 2A4C •COMP | 2A72 \$A | 2AB4 •RARG | 2AE6 \$8 | 2B10 •S |
| 2E14 •ERCNT | 2E18 •ERCNT | 2H1A •O | 2B7F •MES | 2BFA •U | 2C20 •V |
| C2A •T | | | | | |

NON-BLOCKS:

E

DEFINED SUBROUTINES:

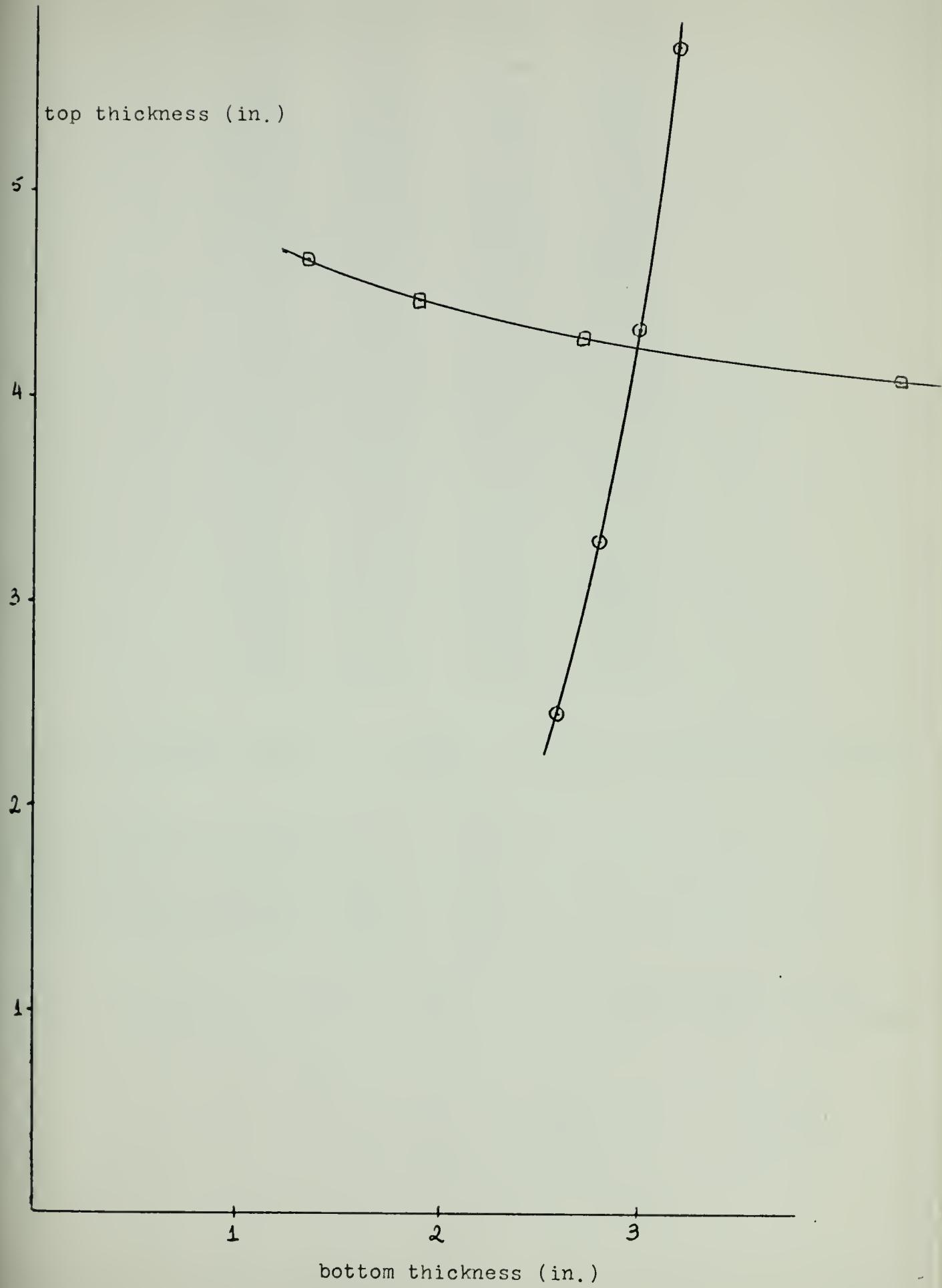
E

TRANSFER ADDRESS 2+78

EXECUTION BEGINS:

TOP ASSUMED LARGER THAN BOTTOM

| | | | |
|-------|-----------|-------|----------|
| TOP1= | 3.0684 | BOT1= | 2.7000 |
| TOP1= | 1.9451 | BOT1= | 2.8000 |
| TOP1= | 1.9328 | BOT1= | 2.4000 |
| TOP1= | 2.4658 | BOT1= | 2.6000 |
| TOP1= | 3.2242 | BOT1= | 2.8000 |
| TOP1= | 4.3464 | BOT1= | 3.0000 |
| TOP1= | 5.7523 | BOT1= | 3.2000 |
| TOP1= | 7.6255 | BOT1= | 3.4000 |
| TOP1= | 11.1159 | BOT1= | 3.6000 |
| TOP1= | 13.8165 | BOT1= | 3.8000 |
| TOP1= | 19.2122 | BOT1= | 4.0000 |
| TOP1= | 27.9616 | BOT1= | 4.2000 |
| TOP1= | 43.4722 | BOT1= | 4.4000 |
| TOP1= | 72.2119 | BOT1= | 4.6000 |
| TOP1= | 124.4668 | BOT1= | 4.8000 |
| TOP1= | -243.7314 | BOT1= | 5.0000 |
| TOP1= | -117.7242 | BOT1= | 5.2000 |
| TOP1= | -75.9876 | BOT1= | 5.4000 |
| TOP1= | -59.147 | BOT1= | 5.6000 |
| TOP1= | -49.8724 | BOT1= | 5.8000 |
| TOP1= | -44.2455 | BOT1= | 6.0000 |
| TOP1= | -40.6148 | BOT1= | 6.2000 |
| TOP1= | -37.9964 | BOT1= | 6.4000 |
| TOP1= | -35.9977 | BOT1= | 6.6000 |
| TOP1= | -34.4115 | BOT1= | 6.8000 |
| TOP1= | -33.5596 | BOT1= | 7.0000 |
| TOP2= | 3.6168 | BOT2= | -11.8971 |
| TOP2= | 3.7260 | BOT2= | 91.8296 |
| TOP2= | 3.9798 | BOT2= | 2.7662 |
| TOP2= | 4.1160 | BOT2= | 4.3496 |
| TOP2= | 4.2760 | BOT2= | 2.7380 |
| TOP2= | 4.5760 | BOT2= | 1.8850 |
| TOP2= | 4.7660 | BOT2= | 1.3454 |
| TOP2= | 4.9760 | BOT2= | 0.9655 |
| TOP2= | 5.1160 | BOT2= | 0.6778 |
| TOP2= | 5.3460 | BOT2= | 0.4483 |
| TOP2= | 5.5660 | BOT2= | 0.2578 |
| TOP2= | 5.7160 | BOT2= | 0.0947 |
| TOP2= | 5.9260 | BOT2= | -0.2484 |



| TOPDOWN ASSUMED LARGER THAN TOP | BOT3= | TOP |
|---------------------------------|-------|---------|
| TOP3= -1.2198 | BOT3= | 1.2000 |
| TOP3= -4.1456 | BOT3= | 1.2000 |
| TOP3= -5.0236 | BOT3= | 1.4000 |
| TOP3= 0.1659 | BOT3= | 1.6000 |
| TOP3= 4.4326 | BOT3= | 1.8000 |
| TOP3= 1.7841 | BOT3= | 2.0000 |
| TOP3= 1.2340 | BOT3= | 2.2000 |
| TOP3= 1.7928 | BOT3= | 2.4000 |
| TOP3= 2.4628 | BOT3= | 2.6000 |
| TOP3= 3.2510 | BOT3= | 2.8000 |
| TOP3= 4.1921 | BOT3= | 3.0000 |
| TOP3= 5.2720 | BOT3= | 3.2000 |
| TOP3= 6.4712 | BOT3= | 3.4000 |
| TOP4= 1.0146 | BOT4= | 16.1639 |
| TOP4= 1.2140 | BOT4= | 15.3920 |
| TOP4= 1.4138 | BOT4= | 14.6201 |
| TOP4= 1.6136 | BOT4= | 13.8482 |
| TOP4= 1.8134 | BOT4= | 13.0763 |
| TOP4= 2.0132 | BOT4= | 12.3044 |
| TOP4= 2.2130 | BOT4= | 11.5324 |
| TOP4= 2.4128 | BOT4= | 10.7605 |
| TOP4= 2.6126 | BOT4= | 9.9886 |
| TOP4= 2.8124 | BOT4= | 9.2167 |
| TOP4= 3.0122 | BOT4= | 8.4448 |
| TOP4= 3.2120 | BOT4= | 7.6729 |
| TOP4= 3.4118 | BOT4= | 6.9010 |
| TOP4= 3.6116 | BOT4= | 6.1290 |
| TOP4= 3.8114 | BOT4= | 5.3571 |
| TOP4= 4.0112 | BOT4= | 4.5852 |
| TOP4= 4.2110 | BOT4= | 3.8133 |
| TOP4= 4.4108 | BOT4= | 3.0414 |

END

© VIO OPERATING SYSTEM VERSION 1 REVISION A12 03/04/74 GENERATED 05/06/74

| | | |
|----------------------|-----------------|-----|
| CR HANDLING CHARGE | \$.35 / JOB | .35 |
| 67 LINES PRINTED PR1 | \$ 1.25 / K LN. | .21 |
| 67 CARDS READ | \$ 1.50 / K CR | .13 |
| VP PLOTTED VECTORS | \$.25 / 1000 | .02 |
| 20 MODEL 72 SECONDS | \$25.00 / HOUR | .14 |
| 92 MODEL 80 SECONDS | \$12.50 / HOUR | .06 |
| TOTAL CHARGE \$ | | .80 |

EIR 400 14731 LOGGED OUT 05/06/74 19:52 • \$ 4.00 LEFT AFTER 30 LOGINS.

STRENGTH OF SHIPS ON THE NEUTRAL AXIS LOCATION

PAGE 1

```

24 C *AL* IS THE LENGTH
25 AL=1000.
26 G=AL/5.75
27 *DRA* IS THE DRAFT
28 DRA=G/3.3
29 G=AL/14.
30 *POI* IS THE POISSON'S RATIO OF THE MATERIAL
31 FOR ALUMINUM
32 POI=0.33
33 *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
34 FOR ALUMINUM
35 E=10.**12.**6
36 *DST* IS THE DESIGN STRESS
37 DST=17.2*V.
38 *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
39 S=12.0
40 *BHD* IS THE BENDING MOMENT
41 BH=(E*POI*AL*AL*1.75)/(35.0*35.0)
42 BH=386.5*P*(1.0+POI*POI)
43 *TOP* IS THE THICKNESS OF THE TOP PLATING
44 *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
45 TOP=4.27
46 BOT=2.08
47 A=BH*1.0*(BOT+TOP)
48 B=DST*(3.0*P*TOP*TOP+12.0*BHD*TOP*(TOP+BOT)+(D*E*TOP*TOP))
49 *STH* IS THE STRESS ON TOP DUE TO HOGGING
50 STH=BDEN
51 WRITE(5,60)STH
52 FFORMAT('1.12V',18TH='F10.3')
53 C=6.0*P*(BOT+TOP)
54 *SPH* IS THE STRESS ON BOT DUE TO HOGGING
55 SPH=C/DEN
56 WRITE(5,80)SPH
57 FFORMAT('1.12V',18SPH='F10.3')
58 *SECPI* IS THE CRITICAL STRESS ON BOT
59 SECPI=BOT*BOT/G
60 WRITE(5,11)SECPI
61 FFORMAT('1.17V',18SECPI='F10.3')
62 P=2.0*P*TOP+P*(TOP+BOT)
63 *DITCP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
64 DITCP=P*(8*SECPI+P*TOD)/P
65 WRITE(5,42)DITCP
66 FFORMAT('1.18V',18DITCP='F10.4')
67 *DIBOT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS
68 DIBOT=P*(8*TOD+P*TOD)/P
69 WRITE(5,5V)DIBOT
70 FFORMAT('1.18V',18DIBOT='F10.4')
71 END
72
73 0324[V] AL      032C[V] B      0334[V] DRA      033C[V] D
74 034C[V] E      0360[S] .R      0358[V] DST      036A[V] S
75 037C[V] G      0368[V] TOP      0389[V] BOT      0398[V] A
76 03FC[V] STH     0174[1] 6P      0400[S] @I      03C0[V] C

```


STRENGTH OF SHIELDS IN THE NEUTRAL AXIS LOCATION

PAGE 2

| | | | | |
|-----------|------------|---------------|-------------|-----------|
| (V) SOR | PIE2[L] 90 | 300[V] SBCRIT | F228[L] 110 | 03CC[V] P |
| (V) FITCP | 1274[L] 40 | 3PA[V] DIPOT | F314[L] 50 | 0000[S] V |
| | L | | | |

RAM (APPLC):

| | | | | | |
|-----------|------------|------------|-----------|-------------|----------|
| 170 MATP | 2168 .V | 2198 •60NP | 2476 .I | 2448 •R | 2960 .2F |
| •E | 2448 .I | 298C •ES | 283A .W | 2642 EXP | 2708 AI |
| ERA AL NC | 2921 •FARG | 295C •S | 2642 /EXP | 2964 •ERCNT | 2932 \$8 |
| 64 •C | 2134 .U | 2192 | | | |

HYBRIT TSD:

| | | | | | |
|---------|-------------|------------|------------|----------|---------|
| 440 •F | 248 .A | 2131 11.00 | 2642 AEXP | 2642 EXP | 2708 AI |
| •CA • | 289 .CCFP | 212F 5A | 294C •RARG | 2932 \$3 | 295C •E |
| 92 •TFC | 2964 •ERCNT | 296A •D | 298C •MES | 2A46 •U | 2A4C •V |
| 16 •T | | | | | |

MATERIALS:

E

FINER SURFACES:

E

REF ID: 2276

INITIAL REGIONS:

```

SIH= 17952.723
SE= 22852.766
SPCFIT= 22759.1 9
FITCP= 31.4316
FIBCT= 39.9971

```

F VIO OPERATING SYSTEM VERSION 1 REVISION 012 03/04/74 GENERATED 5/26/74

| | | |
|----------------------|----------------|-----|
| 10 HAVING CHARGE | \$ •2E / JOE | •35 |
| 25 LINES PAINTED PR1 | \$ 1.2E / E LV | •11 |
| 54 CARDS READ | \$ 1.EC / E Ch | •28 |
| 70 PLATTED VECTORS | 3 •2E / 10.2 | •01 |
| 15 MODEL 71 SECONDS | \$25.7; / EPC | •11 |
| 6 MODEL 80 SECONDS | \$12.50 / Eoud | •02 |
| | TOTAL CHARGE | •65 |

ETR 49 14731 LOGGED OUT 25/05/74 20:03 • \$ 1.49 LEFT AFTER 34 LOGINS.

SUMMARY

Length = 1000'
Beam = AL/5.75
Draft = B/3.3
Depth = AL/14
DST = 18000 psi
S = 120"
Material = ALUMINUM
TOP = 4.27"
BOT = 2.98"
STH = 17958.79
SBH = 22852.76
SBCRIT = 22768.12
DITOP = 31.43'
DIBOT = 39.99' or 40.00'

Looking at the following table we can also observe for the aluminum the effect of changing S on the neutral axis location and the compressive stresses resulting on the bottom plating.

| CASE | S inches | TOP inches | BOT inches | SBH psi | SBCRIT psi | DITOP ft | DIBOT ft |
|------|-------------|---------------|---------------|------------|---------------|-------------|-------------|
| 1 | 10 | 5.35 | 0.363 | 53000 | 49000* | 18.09 | 53.34 |
| 2 | 30 | 4.86 | 1.00 | 41000 | 41000 | 21.72 | 49.71 |
| 3 | 60 | 4.53 | 1.76 | 32000 | 32000 | 25.83 | 45.60 |
| 4 | 120 | 4.27 | 2.98 | 23000 | 23000 | 31.43 | 40.00 |

(*) This difference may result from inaccuracy in reading the plot.

Here again the values of TOP and BOT may allow for a quick evaluation of the weight relationship between the four cases.

One run was also made in the case of the aluminum for AL=500 ft and the results are here included.

STRENGTH OF SHIPS ON THE NEUTRAL AXIS LOCATION

PAGE 1

```

164 C *AL* IS THE LENGTH
165 AL=50V.
166 R=AL/2.
167 C *DRA* IS THE DRAFT
168 DRA=B/3.
169 L=AL/9.
170 C *POI* IS THE POISSON'S RATIO OF THE MATERIAL
171 C FOR ALUMINUM
172 POI=.33
173 C *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
174 C FOR ALUMINUM
175 E=1.0E+10
176 C *UST* IS THE DESIGN STRESS
177 DST=1e3.0.
178 C *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
179 S=3V.
180 C *M* IS THE BENDING MOMENT
181 M=(D+B*A*AL+AL+L*ZF)/(35.+35.+)
182 G=(3.346*S+S*(1.-POI*POI))/E
183 A=9.0E+4*B/(147.+B**)
184 C=3.384*B/(7.0E+4)
185 F=3.3E+4*B/(147.+B**)
186 C THICKNESS OF TOP ASSUMED LARGER THAN BOTTOM THICKNESS
187 WRITE(5,10)
188 10 FORMAT('1',25X,'TOP ASSUMED LARGER THAN BOTTOM')
189 C *TOP* IS THE THICKNESS OF THE TOP PLATING
190 C *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
191 BOT1=0.1
192 11 TCP1=P*BOT1*BOT1/(B+C)*G*DST-D*BOT1*BOT1
193 WRITE(5,20)TOP1,BOT1
194 20 FORMAT('1',25X,'TOP1=1F9.4,5X,BOT1=1F9.4)
195 BOT1=BOT1+0.15
196 IF(BOT1.GT.1.0D-0) TO 30
197 GO TO 11
198 31 TOP2=0.1
199 32 BOT2=TOP2*(12.*C+(C+F)*DST*TOP2)/(FST*(A+C)*TOP2+12.*B)
200 WRITE(5,40)TOP2,BOT2
201 40 FORMAT('1',25X,'TOP2=1F9.4,5X,BOT2=1F9.4)
202 TOP2=TOP2+0.15
203 IF(TOP2.GT.1.0D-0) TO 50
204 GO TO 31
205 50 CONTINUE
206 C THICKNESS OF BOTTOM ASSUMED LARGER THAN TOP
207 WRITE(5,60)
208 60 FORMAT('1',25X,'BOTTOM ASSUMED LARGER THAN TOP')
209 BOT3=0.1
210 61 TOP3=((F+D)*BOT3*BOT3+BOT3*D*G*DST*BOT3)/(B*G*DST)
211 WRITE(5,70)TOP3,BOT3
212 70 FORMAT('1',25X,'TOP3=1F9.4,5X,BOT3=1F9.4)
213 BOT3=BOT3+0.15
214 IF(BOT3.GT.1.0D-0) TO 80
215 GO TO 61

```


STRENGTH OF SHIPS ON THE NEUTRAL AXIS LOCATION

PAGE 2

```

-42      R0  TOP4=0.1
-43      F1 BOT4=(12.*((E+F)-(A+C)).DST*TOP4)/((C+F)*DST)
-44      WRITE(6,32)TOP4,BOT4
-45      32  FORMAT(1X,2H4,1TOP4=F9.4,5X,1BOT4=F9.4)
-46      TOP4=TOP4+1.0
-47      IF(TOP4.GT.1.0)GO TO 100
-48      GO TO 51
-49      100 CONTINUE
-50      END
-51      .400 [V] AL    .400 [V] B    .400 [V] DRA   .400 [V] D
-52      .401 [V] E    .401 [V] R    .401 [V] DST   .401 [V] S
-53      .518 [V] C    .524 [V] A    .524 [V] C    .534 [V] F
-54      .527 [V] D    .532 [V] BOT1  .5176 [L] 11   .546 [V] TOP1
-55      .528 [V] E    .533 [V] TOP2  .5234 [L] 31   .5554 [V] BOT2
-56      .537 [V] F    .542 [V] B    .542 [V] BOT3  .5346 [L] A1
-57      .538 [V] G    .543 [V] C    .543 [V] TOP4   .440A [L] 81
-58      .539 [V] H    .544 [V] D    .544 [V] S    .544 [V] V
-59      .

```

BEAM TABLES:

| | | | | | |
|--------------|-------------|------------|-----------|-------------|----------|
| 170 .0001 .* | 2014 .* | 2A34 .001P | 2012 I | 25E4 .R | 2AFC .Z |
| AIA .00 | 2A24 .00 | 2150 .00ES | 2A06 .I | 27DF EXP | 2964 AI |
| 616 .0000 | 2A3C .00AFG | 2AF2 .00 | 27DF AEXP | 2B00 .0RCNT | 2AEC \$8 |
| 217 .00 | 2014 .00 | 2D2F | | | |

TIME-FACTORS:

| | | | | | |
|------------|-------------|------------|------------|----------|----------|
| 2E4 .00 | 2624 .00 | 2606 .0LOG | 27DE /EXP | 27DE EXP | 2964 AI |
| 2E5 .00 | 2A34 .00MP | 2A5A .06 | 2A9C .0ARG | 2ACE \$8 | 2AF8 .00 |
| AFC .0ZERO | 2B00 .0RCNT | 2E32 .00 | 2B58 .0MES | 2BEP .0U | 2C78 .0V |
| C12 .0I | | | | | |

NON-BLOCKS:

E

DEFINED SUBROUTINES:

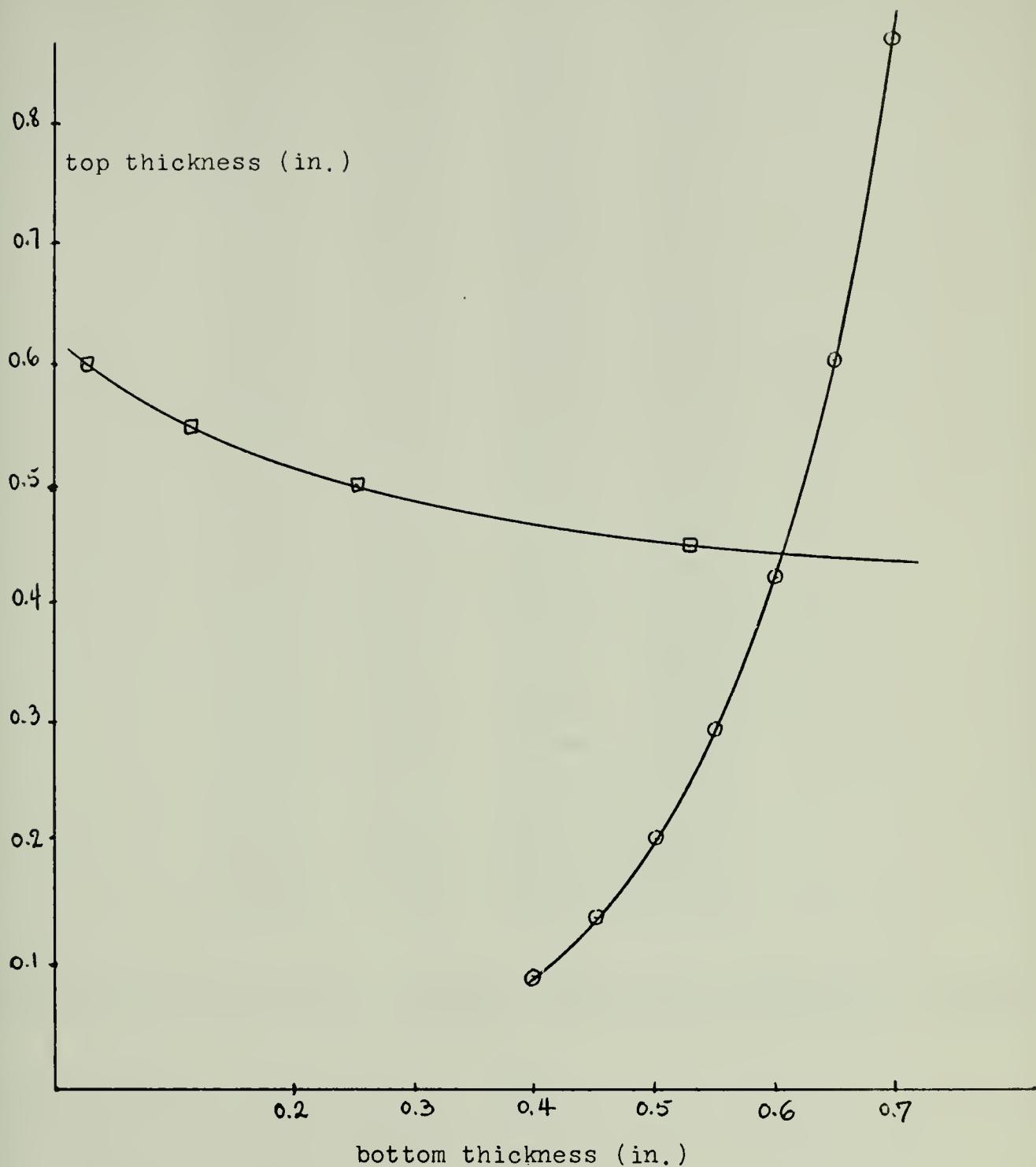
E

TRANSFER ADDRESS 2A70

SECTION BEGINS:

TOP ASSUMED LARGER THAN BOTTOM

| | | | |
|-------|----------|-------|---------|
| TOP1= | 4.0V12 | BOT1= | 0.1000 |
| TOP1= | 3.0V12 | BOT1= | 0.1500 |
| TOP1= | 3.0E161 | BOT1= | 0.2000 |
| TOP1= | 3.0E08 | BOT1= | 0.2500 |
| TOP1= | 3.0E21 | BOT1= | 0.3000 |
| TOP1= | 3.0E66 | BOT1= | 0.3500 |
| TOP1= | 3.0E52 | BOT1= | 0.4000 |
| TOP1= | 3.1414 | BOT1= | 0.4500 |
| TOP1= | 3.0E41 | BOT1= | 0.5000 |
| TOP1= | 3.0E71 | BOT1= | 0.5500 |
| TOP1= | 3.0E4646 | BOT1= | 0.6000 |
| TOP1= | 3.0E59 | BOT1= | 0.6500 |
| TOP1= | 3.0E72 | BOT1= | 0.7000 |
| TOP1= | 3.0E59 | BOT1= | 0.7500 |
| TOP1= | 3.0E67 | BOT1= | 0.8000 |
| TOP1= | 3.0E59 | BOT1= | 0.8500 |
| TOP1= | 3.0E43 | BOT1= | 0.9000 |
| TOP1= | 3.0E21 | BOT1= | 0.9500 |
| TOP1= | -16.6E11 | BOT1= | 1.0000 |
| TOP2= | 3.1416 | BOT2= | -0.1017 |
| TOP2= | 3.0E56 | BOT2= | -0.1687 |
| TOP2= | 3.0E57 | BOT2= | -0.2587 |
| TOP2= | 3.0E58 | BOT2= | -0.3997 |
| TOP2= | 3.0E59 | BOT2= | -0.6955 |
| TOP2= | 3.0E59 | BOT2= | -2.1234 |
| TOP2= | 3.0E59 | BOT2= | 1.7868 |
| TOP2= | 3.0E59 | BOT2= | 0.5333 |
| TOP2= | 3.0E59 | BOT2= | 0.2515 |
| TOP2= | 3.0E59 | BOT2= | 0.1143 |
| TOP2= | 3.0E59 | BOT2= | 0.0258 |
| TOP2= | 3.0E59 | BOT2= | -0.0403 |
| TOP2= | 3.0E59 | BOT2= | -0.0944 |
| TOP2= | 3.0E59 | BOT2= | -0.1413 |
| TOP2= | 3.0E59 | BOT2= | -0.1835 |
| TOP2= | 3.0E59 | BOT2= | -0.2224 |
| TOP2= | 3.0E59 | BOT2= | -0.2591 |
| TOP2= | 3.0E59 | BOT2= | -0.2941 |
| TOP2= | 3.0E59 | BOT2= | -0.3277 |



Intersection not accepted; assumed Top > Bot ended up
with Bot > Top.

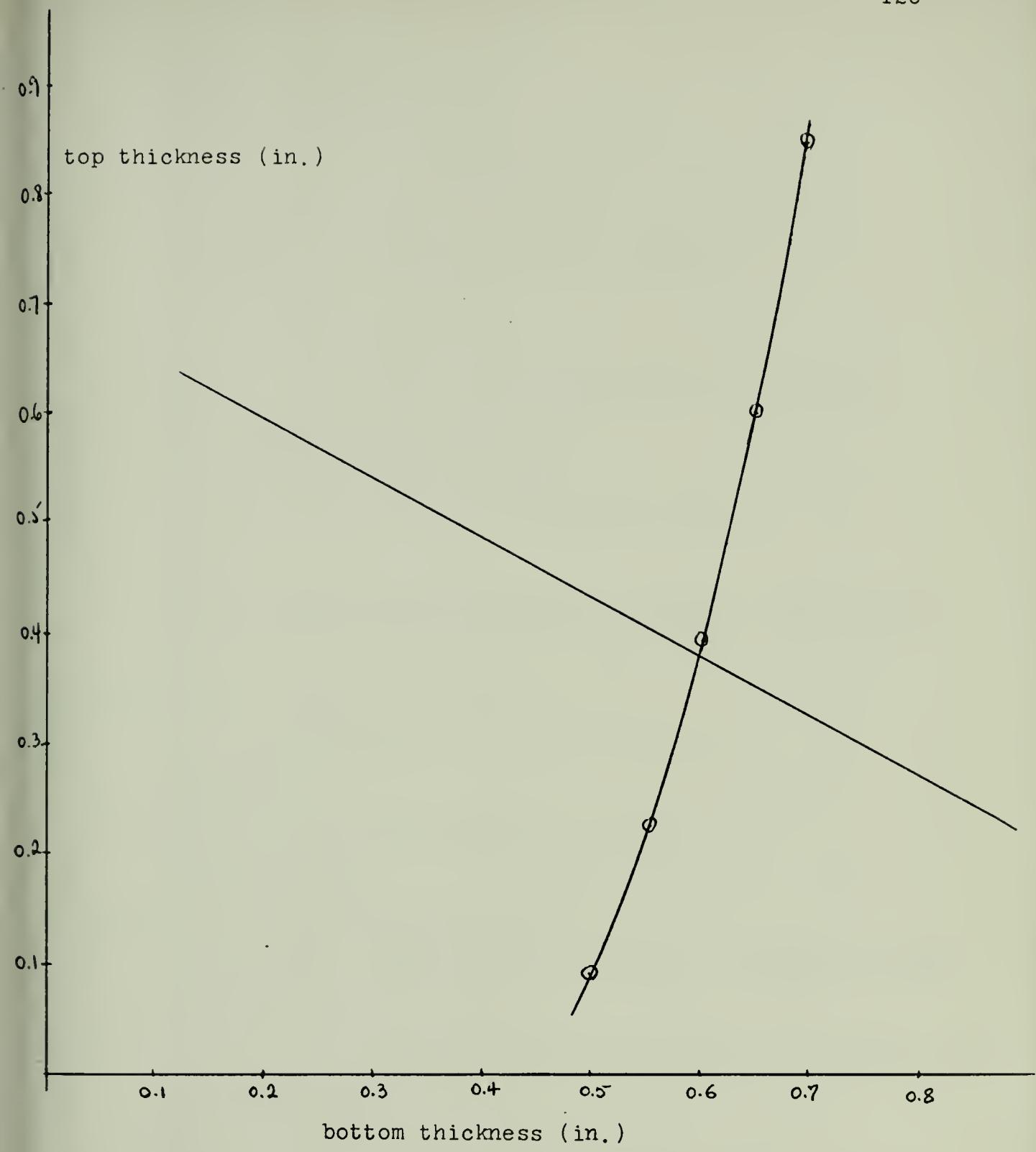
| BOTTOM ASSUMED LARGER THAN TOP | BOT3= | 0.1000 |
|--------------------------------|-------|---------|
| TOP3= -0.0484 | BOT3= | 0.1500 |
| TOP3= -0.1167 | BOT3= | 0.2000 |
| TOP3= -0.1493 | BOT3= | 0.2500 |
| TOP3= -0.1566 | BOT3= | 0.3000 |
| TOP3= -0.1584 | BOT3= | 0.3500 |
| TOP3= -0.1645 | BOT3= | 0.4000 |
| TOP3= -0.0181 | BOT3= | 0.4500 |
| TOP3= -0.0077 | BOT3= | 0.5000 |
| TOP3= 0.0556 | BOT3= | 0.5500 |
| TOP3= 0.2273 | BOT3= | 0.6000 |
| TOP3= 0.3945 | BOT3= | 0.6500 |
| TOP3= 0.4644 | BOT3= | 0.7000 |
| TOP3= 0.8543 | BOT3= | 0.7500 |
| TOP3= 1.1464 | BOT3= | 0.8000 |
| TOP3= 1.4929 | BOT3= | 0.8500 |
| TOP3= 1.8861 | BOT3= | 0.9000 |
| TOP3= 2.4021 | BOT3= | 0.9500 |
| TOP3= 2.8743 | BOT3= | 1.0000 |
| TOP3= 3.4168 | BOT3= | 1.0500 |
| TOP4= 0.1648 | BOT4= | 1.1275 |
| TOP4= 0.1846 | BOT4= | 1.1344 |
| TOP4= 0.2148 | BOT4= | 0.9414 |
| TOP4= 0.2848 | BOT4= | 0.2484 |
| TOP4= 0.3148 | BOT4= | 0.7554 |
| TOP4= 0.3548 | BOT4= | 0.6623 |
| TOP4= 0.4848 | BOT4= | 0.3693 |
| TOP4= 0.4948 | BOT4= | 0.4763 |
| TOP4= 0.5148 | BOT4= | 0.3832 |
| TOP4= 0.5448 | BOT4= | 1.2902 |
| TOP4= 0.6148 | BOT4= | 0.1972 |
| TOP4= 0.6548 | BOT4= | 0.1842 |
| TOP4= 0.7048 | BOT4= | 0.0111 |
| TOP4= 0.7548 | BOT4= | -0.0819 |
| TOP4= 0.8648 | BOT4= | -0.1749 |
| TOP4= 0.8548 | BOT4= | -0.2680 |
| TOP4= 0.9648 | BOT4= | -0.3610 |
| TOP4= 0.9548 | BOT4= | -0.4540 |
| TOP4= 1.0148 | BOT4= | -0.5470 |

END

F VIO OPERATING SYSTEM VERSION 1 REVISION 012 03/04/74 GENERATED 05/06/74

| | | |
|-----------------------|----------------|-----|
| JOB HANDLING CHARGE | \$.35 / JOB | .35 |
| 173 LINES PRINTED PR1 | \$ 1.25 / K LN | .22 |
| 67 CARDS READ | \$ 1.50 / K CR | .1 |
| 37 PLOTTER VECTORS | \$.25 / 1000 | .02 |
| 22 MODEL 7" SECONDS | \$25.00 / HOUR | .14 |
| 22 MODEL 8" SECONDS | \$12.50 / HOUR | .00 |
| TOTAL CHARGE \$ | | .81 |

EIR 49A 14731 LOGGED OUT 05/06/74 20:09. \$.68 LEFT AFTER 35 LOGINS.



STRENGTH OF SHIPS ON THE NEUTRAL AXIS LOCATION

PAGE 1

```

04      C      *AL* IS THE LENGTH
04      AL=500.
05      R=AL/8.
12      C      *DRA* IS THE DRAFT
13      DRA=R/3.
24      R=AL/9.
37      C      *POI* IS THE POISSON'S RATIO OF THE MATERIAL
38      FOR ALUMINUM
39      POI=.33
40      C      *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
41      FOR ALUMINUM
42      E=1E+11.*E
43      C      *DST* IS THE DESIGN STRESS
44      DST=12M.PA
54      C      *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
55      S=30.
56      C      *RM* IS THE BENDING MOMENT
57      RM=(E*DRA*AL*AL*0.75)/(35.*35.)
58      G=E*35326*S*S/(1.-POI+POI*POI)
59      C      *TOP* IS THE THICKNESS OF THE TOP PLATING
60      C      *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
61      TOP=4.0
62      BOT=7.0
63      A=S64.*RM*(B*BOT+D*BOT)
64      DEM=C*(C.*RM*B*TOP*BOT+2.*B*DEM*(TOP+BOT)+(D*B*BOT*BOT))
65      C      *STH* IS THE STRESS ON TOP DUE TO HOGGING
66      STH=A/DEM
67      WRITE(5,67)STH
68      67 FORMAT(1.1,2F4.1,1STH=F10.3)
69      C      C=S6V.*RM*(B*TOP+D*BOT)
70      SBH=C/DEM
71      C      *SBH* IS THE STRESS ON BOT DUE TO HOGGING
72      SBH=C/DEM
73      WRITE(5,73)SBH
74      73 FORMAT(1.1,2F4.1,1SBH=F10.3)
75      C      *SECRI* IS THE CRITICAL STRESS ON BOT
76      SECRI=BOT*BOT/A
77      WRITE(5,110)SECRI
78      110 FORMAT(1.1,17Y,1SECRI=F10.3)
79      P=2.*D*BOT+B*(TOP+BOT);
80      C      *DITOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
81      DITOP=D*(B*BOT+D*BOT)/P
82      WRITE(5,40)DITOP
83      40 FORMAT(1.1,18Y,1DITOP=F10.4)
84      C      *DIBOT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS
85      DIBOT=D*(B*TOP+D*BOT)/P
86      WRITE(5,50)DIBOT
87      50 FORMAT(1.1,18Y,1DIBOT=F10.4)
88      END

```

| | | | | |
|---------|-------------|-------------|-------------|-----------|
| [S] •II | 0324[V] AL | 0320[V] B | 0334[V] DRA | 0330[V] D |
| [V] POI | 0340[V] E | 0320[S] •R | 0358[V] DST | 0360[V] S |
| [V] BM | 0370[V] G | 0388[V] TOP | 0360[V] BOT | 0398[V] A |
| [V] DEM | 0388[V] STH | 0374[L] 60 | 0388[S] •I | 0380[V] C |

STRUCTURE OF SHIPS ON THE NEUTRAL AXIS LOCATION

| | | | | |
|-----------|------------|----------------|-------------|------------|
| (V) S84 | W1E2[L] 90 | 03C4[V] SBCRIT | 0228[L] 110 | 03C8[V] P |
| (V) DTTCP | 12A8[L] 40 | 03D0[V] DIFOT | 03D4[L] 50 | 03D8[S] .V |
| EU | L. | | | |

GRAM LABLES:

| | | | | | |
|------------|------------|------------|-----------|-------------|----------|
| 17E *MA1 • | 2A64 •V | 2894 •COMP | 2A72 •I | 2444 •R | 295C •ZE |
| 0NA \$6 | 2424 •A | 29B2 •MES | 2936 •N | 263F EXP | 27C4 AII |
| 26 AL 1G | 29FC •PAPG | 2959 •S | 263E AEXP | 2960 •ERCNT | 292E \$8 |
| 9AL •7 | 2A36 •U | 288E | | | |

SYSPRINT TQ:

| | | | | | |
|----------|------------|-----------|------------|----------|----------|
| 444 •2 | 2454 •- | 2536 W10G | 263E AEXP | 263F EXP | 27C4 AII |
| 236 • | 2894 •COMF | 242A 96 | 29FC •RARG | 292E \$8 | 2958 •5 |
| 0RC •2EF | 2964 •FC01 | 2962 •7 | 2938 •MES | 2A42 •U | 2A68 •V |
| 472 •T | | | | | |

INSTRUCTIONS:

E

DEFINED SUBROUTINES:

E

USER ADDRESS 2870

TIME UPDINS:

STH= 18E80,764
 SHH= 14570,137
 SBCRIT= 14767,777
 DITOP= 34,7137
 DIFOT= 24,7119

ND

MIO OPERATING SYSTEM VERSION 1 REVISION 012 03/04/74 GENERATED 65/26/74

| | | |
|----------------------|-----------------|-----|
| GE HANDLING CHARGE | \$ 1.25 / JNB | •35 |
| 55 LINES PRINTED PR1 | \$ 1.005 / K LN | •11 |
| 54 CARDS READ | \$ 1.00P / K CR | •08 |
| 41 PLOTTED VECTORS | \$ 1.25 / 1000 | •00 |
| 16 MODEL 70 SECONDS | \$25.00 / HOUR | •11 |
| 48 MODEL 50 SECONDS | \$12.50 / HOUR | •00 |
| | TOTAL CHARGE \$ | •65 |

ZIF 471 14731 LOGGED OUT 05/26/74 20:13 • \$ 003 LEFT AFTER 36 LOGINS.

SUMMARY

Length = 500'
Beam = AL/8
Draft = B/3
Depth = AL/9
DST = 18000 psi
S = 30"
Material = ALUMINUM
TOP = 0.38"
BOT = 0.6"
STH = 18089.66
SBH = 14578.14
SBCRIT = 14767.85
DITOP = 30.76"
DIBOT = 24.79"

HOGGING BENDING MOMENT=SAGGING BENDING MOMENT

DESIGN STRESS IN TENSION=DESIGN STRESS IN COMPRESSION

From the preceding section we can understand the need to put some limit on the value of the compressive stresses, and perhaps also the inefficiency of considering the value of S (the spacing between longitudinal stiffening members) as an input to the problem.

In this section we will consider a bending moment of the same magnitude in both hogging and in sagging and the stress in either tension or compression will have as upper limit the design stress.

Since the bending moment is the same, it is intuitive that the thickness required to resist tension on top and compression on bottom (buckling) when the hogging moment is acting will also be respectively the thicknesses to resist tension on bottom and buckling on top when we consider the sagging moment. We would end up then with a thickness on top required by the hogging moment TOPH , a thickness on bottom required by the hogging moment, as well as a thickness on top required by the sagging moment TOPS and a thickness on bottom required by the sagging moment BOTS .

Since $\text{HM} = \text{SM}$ we must obtain

$\text{TOPS} = \text{BOTH} = t_1$ and $\text{BOTS} = \text{TOPH} = t_2$

and we will end up considering the largest t_1 or t_2 , to be the thickness of the top and bottom simultaneously.

Assume for instance that $t_1 > t_2$ then if we decide on t_1 for

thickness of the top as well as at the bottom, we will verify that we have overdesigned because TOPS = t1 corresponds to BOTs = t2 which plugged into the expression for I gives a smaller value than using TOPS = t1 with BOTH = t1 that will give a larger value for I; this larger I value when used in

$$\text{STR} = \frac{\text{BM} * \text{Y}}{\text{I}}$$

will give a smaller STR value than the design stress and we could use a smaller thickness, may be between t1 and t2 for both the top and bottom and satisfy the DST requirement.

This means that we must incorporate in this analysis the fact already known that when BM (hogging) is equal to BM (sagging) we will have to consider the neutral axis half way between top and bottom which means that the thickness of the top shall be equal to the thickness of the bottom for a geometrically symmetrical cross section.

Let's determine the formulas that will best serve this case then:

$$\text{HM} = \text{SM} = \text{BM}$$

$$\text{DITOP} = \text{DIBOT} = \text{D} * (\text{B} * \text{t} + \text{D} * \text{t}) / (2 * \text{D} * \text{t} + \text{B} * (2 * \text{t}))$$

$$\text{t} = \text{TOP} = \text{BOT} = \text{TS}$$

$$\text{I} = \frac{3 * \text{B} * \text{B} + \text{D} * \text{D} + 4 * \text{B} * \text{D}}{2 * \text{D} * \text{D} * \text{t} * \frac{\text{D} + \text{B}}{\text{D} + \text{B}}}$$

$$\text{Now we can write } \text{STR} = \frac{\text{BM} * \text{DITOP}}{\text{I}} = \frac{\text{BM} * \text{DIBOT}}{\text{I}} = \text{DST}$$

and the instability formula

$$t = S^* \sqrt{0.30396 * \frac{1 - POI * POI}{E} * DST}$$

Where S is the spacing between longitudinals.

We see thus that we cannot have more than two equations and so we must seek for two variables. A quick inspection and one can see that knowing BM, B, D, the material properties and the design stress DST we have left to determine what should be the thickness of the plating (t) and the corresponding frame spacing (S). Solving the equations with this in mind, we obtain

$$BM = 1.37143 * B * T * AL * AL \quad lb*ft$$

and from $STR = \frac{BM * Y}{I}$ we obtain

$$DST = \frac{BM * (D + B)}{4 * D * t * (3 * B * B + D * D + 4 * B * D)}$$

which gives

$$t = \frac{BM * (D + B)}{4 * D * DST * (3 * B * B + D * D + 4 * B * D)}$$

and also

$$S = \sqrt{\frac{t}{0.30396 * (1 - POI * POI) * DST}}$$

These formulas will give for a prescribed set of dimensions (ft) and a particular material subject to bending BM (lb*ft) the thickness t (inches) and the spacing of longitudinal stiffening members S (inches) required.

HOGGING MOMENT AND SAGGING MOMENT OF
DIFFERENT MAGNITUDES
THE DESIGN STRESS IS THE SAME IN TENSION AND
IN COMPRESSION

Let's consider now the case where the magnitude of HM is different than the value for SM.

We have in this case:

$$DITOP = \frac{D * (B * BOT + D * TS)}{2 * D * TS + B * (TOP + BOT)}$$

$$DIBOT = \frac{D * (B * TOP - D * TS)}{\text{SAME DENOMINATOR}}$$

$$I = \frac{3 * B * B * TOP * BOT + (D * TS)^2 + 2 * B * D * TS * (TOP + BOT)}{4 * D * D * \text{SAME DENOMINATOR}}$$

$$STH = \frac{HM * DITOP}{I}$$

$$STS = \frac{SM * DITOP}{I}$$

$$SBH = \frac{HM * DIBOT}{I}$$

$$SBS = \frac{SM * DIBOT}{I}$$

$$BOT = \sqrt{G} \sqrt{SBH}$$

$$TOP = \sqrt{G} \sqrt{STS}$$

where $G = 0.30396 * \frac{S^2 * (1 - POI * POI)}{E}$

Looking at these equations, we know that the result obtained for the thicknesses is going to determine the value of DITOP, DIBOT and I. If furthermore we restrain the stresses from being larger than DST we will undoubtedly want them to end up being DST otherwise if they are smaller we are not using the material efficiently.

We thus have

$$DST = STH = HM \cdot K_1 \quad DST = STS = SM \cdot K_1 \quad \text{where } K_1 = DITOP/I$$

$$DST = SBH = HM \cdot K_2 \quad DST = SBS = SM \cdot K_2 \quad \text{where } K_2 = DIBOT/I$$

This tells us that if for instance $HM > SM$
we should be considering $DST = STH = HM \cdot K_1$

$$\text{and } DST = SBH = HM \cdot K_2$$

because the other two equations will determine lower stresses and are thus within the requirement of not exceeding the design stress, being automatically satisfied.

Now from these equations we can see that if the design stress required for the top, (in tension for the case of $HM > SM$; note that for the case $SM > HM$ the other two equations should be considered and the conclusions are similar), is going to be the same one as required for the bottom (in compression), we must have $K_1 = K_2$ and so $DITOP = DIBOT$ and the neutral axis will again end up being located halfway between top and bottom for a geometrically symmetrical cross section.

We can here use the same two equations derived in the previous section to determine (t) and (S). The moment to be considered here will be the larger of HM or SM instead of BM .

HOGGING MOMENT LARGER THAN SAGGING MOMENT

DESIGN STRESS IN COMPRESSION LARGER THAN DESIGN STRESS IN TENSION

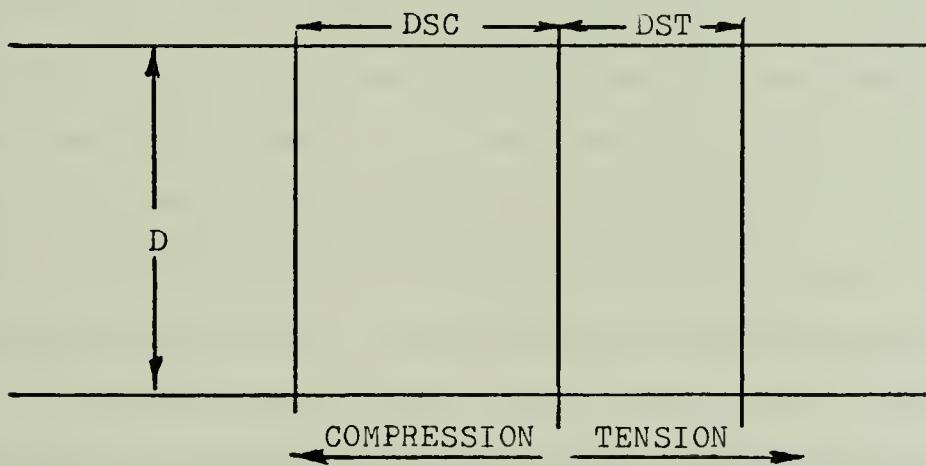
The situation we are analysing in this section

$$HM > SM$$

$$DSC > DST$$

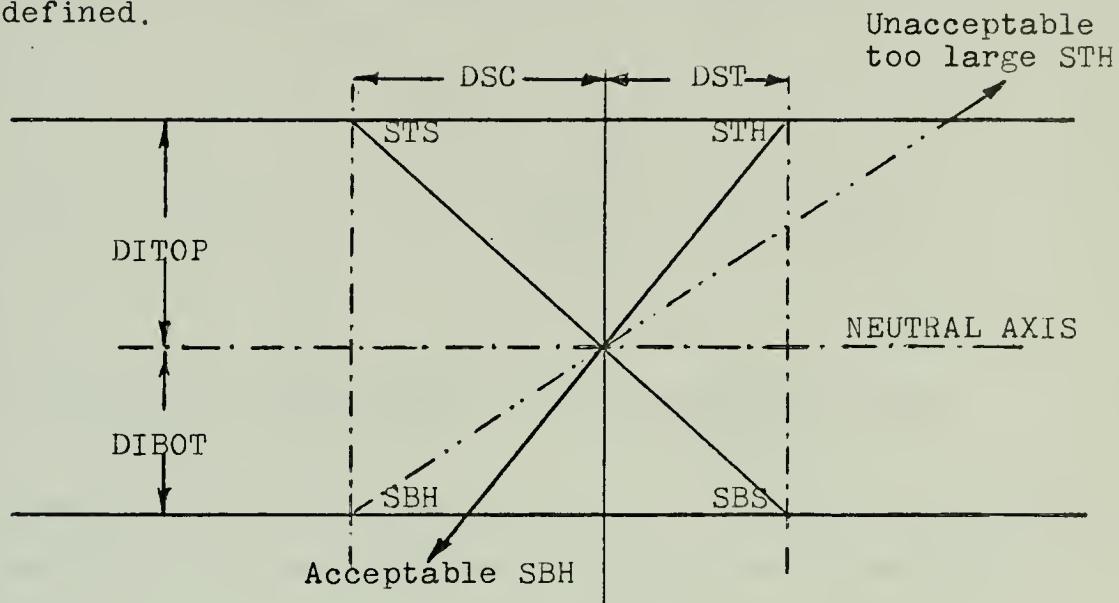
is perhaps more interesting than the previous ones because its study provided us with a much simpler method for determining the thicknesses and the neutral axis location; we call here the attention of the reader to fully understand the steps of this section because the following sections till the end of this work will use this same method of analysis applied to their own particular case.

Indicated in the next diagram are the ranges within which we may stress the material in order to satisfy the requirement of not exceeding DSC or DST.



Let's consider now that we will try to determine the best position for the neutral axis by first gaining some insight into

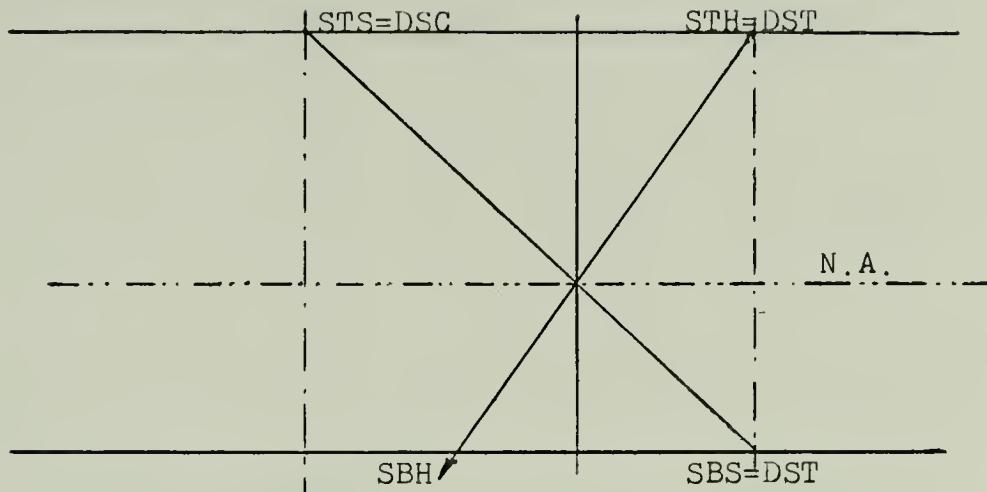
the geometry of the stress distributions and the stress limits already defined.



From the previous diagram we may easily understand that if we decide to stress the material to its maximum in tension and compression when under the effect of a sagging bending moment (SBS - STS) we end up with a neutral axis closer to the bottom due to the fact that $DST < DSC$ and we see that when considering the hogging moment the only possible alternative left is to limit the stress caused by this moment in tension on top $STH = DST$; in this case the compressive stress on the bottom SBH would automatically fall inside the acceptable range.

If for the hogging moment we choose to allow the stress in compression on the bottom to attain its maximum value $SBH = DSC$ we see from the diagram that we are forcing the STH to fall outside of the acceptable range. We are left in this situation with an acceptable solution so far and we must investigate it further.

At this stage we have



We may see from the diagram that we are asking for $SBS = STH = DST$ to have the same value and at the same time to have the neutral axis located closer to the bottom $DITOP > DIBOT$.

We note that the equations that give STH and SBS are

$$STH = HM * DITOP / I$$

and $SBS = SM * DIBOT / I$

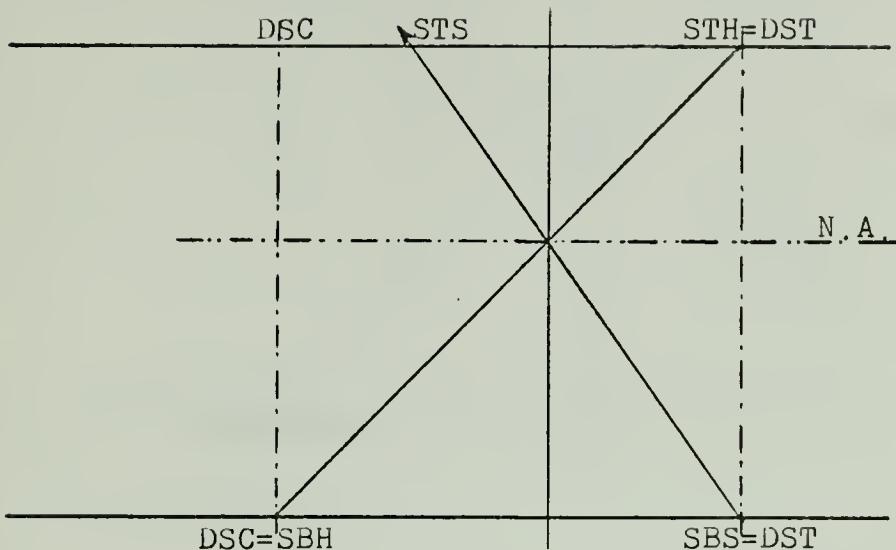
and since I is the same STH can never be of the same magnitude as SBS because

$$STH = HM * DITOP / I > SBS = SM * DIBOT / I$$

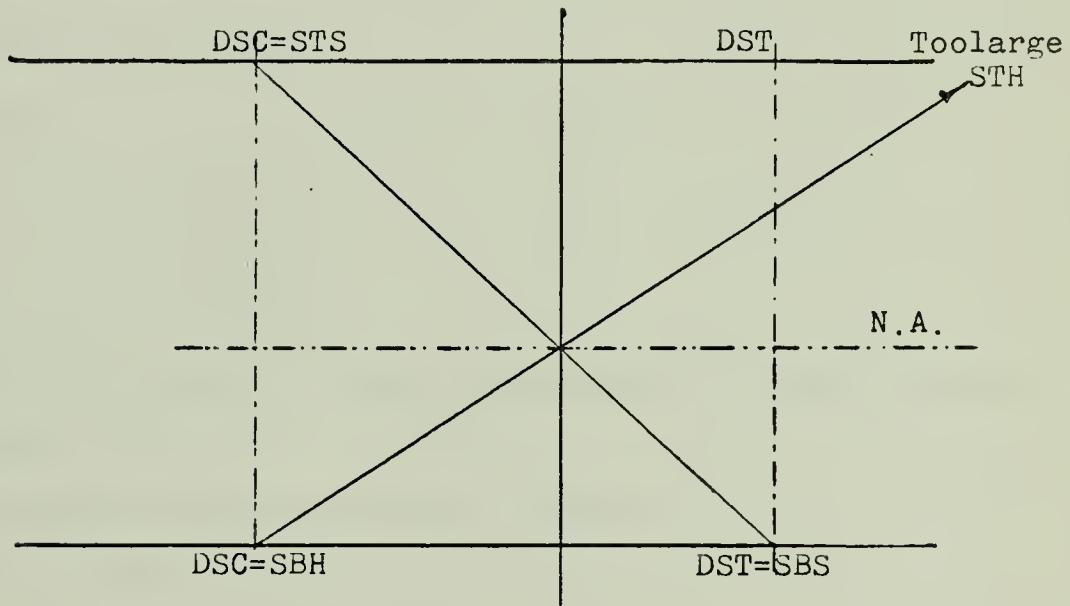
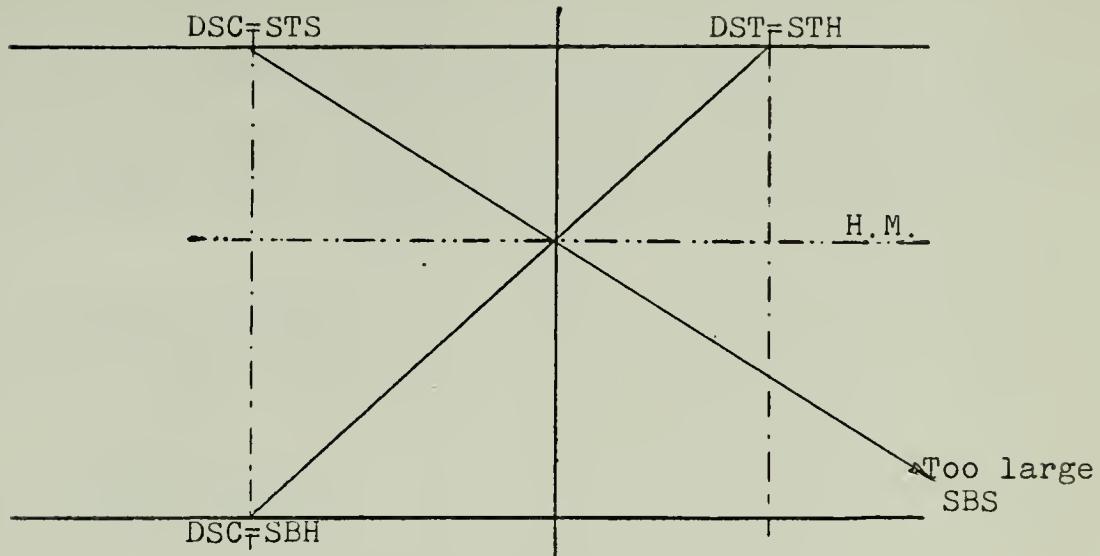
both because $DITOP$ is being set larger than $DIBOT$ and also because we are considering $HM > SM$ to begin with. Thus we are left with the alternative of making $DIBOT$ larger than $DITOP$ to make it possible to satisfy

$$STH = HM * DITOP / I = SBS = SM * DIBOT / I$$

The situation would then be



Besides this is only natural because what we are doing here is to make the material to be stressed to its allowable limit while resisting the larger of the two moments; hogging in this case. This situation will be worked out here as an example and it seems to be quite clear that similarly, cases where $SM > HM$ or $DST > DSC$ or other situation like $DST > DSC$ with $HM > SM$ or $DST < DSC$ with $SM > HM$ could be solved applying a similar reasoning. So, having $HM > SM$ and $DSC > DST$ we should consider the smaller design stress, in this case DST , and have the material stressed to this upper limit. Why?, because if the larger is considered, DSC in this case, there is no way we can have the material stressed to this higher limit in both hogging and sagging while considering the smaller we may attempt to do so. This can be better understood from the two next diagrams.



So, considering the lower design stress, in this case DST, we will stress the material to this maximum in both hogging and sagging thus giving

$$STH = HM * DITOP/I = DST$$

$$SBS = SM * DIBOT/I = DST$$

Note here that we already know that the neutral axis will

be closer to the top $DITOP < DIBOT$ which means that we must obtain a thickness for the plating at the top larger than at the bottom and so $TS=TOP$ which means that we will be using the following formulas

$$DITOP = \frac{D * (B * BOT + D * TOP)}{P}$$

$$DIBOT = \frac{D * TOP * (B + D)}{P}$$

$$I = \frac{4 * D^2 * TOP * ((3 * B^2 + 2 * B * D) * BOT + (D^2 + 2 * B * D) * TOP)}{P}$$

where $P = (2 * D + B) * TOP + B * BOT$

we have also

$$STH = DST = HM * DITOP / I$$

$$SBS = DST = SM * DIBOT / I$$

$$SBH = DSC = HM * DIBOT / I$$

From these three equations we may combine the two first to obtain

$$HM * DITOP = SM * DIBOT$$

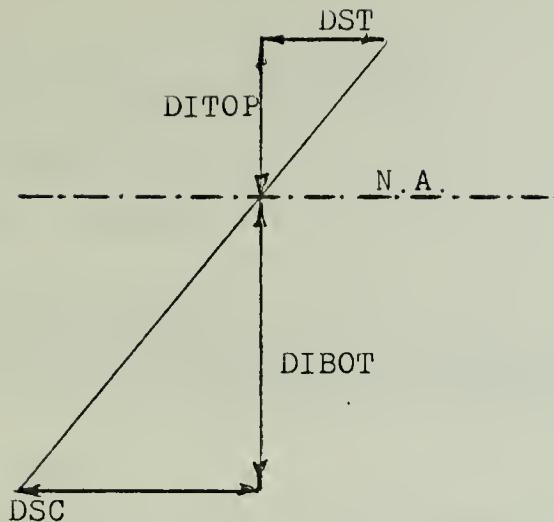
and combining the second and third we obtain

$$DST * HM = DSC * SM$$

After combining these two equations we obtain

$$DST * DIBOT = DSC * DITOP$$

This equation could have been obtained more easily just by looking at the diagram we are considering and notice the similar triangles



Note also that what we obtain from this equation is to determine the N.A. location by making DITOP and DIBOT proportional to DST And DSC.

Proceeding with this equation we obtain:

$$DST * (D * TOP * (B + D)) / P + DSC * (D * B * BOT + D^2 * TOP) / P$$

$$TOP * (DST * B + DST * D - DSC * D) = DSC * B * BOT$$

and making

$$AC = DST / DSC + D * (DST - DSC) / (DSC * B)$$

we obtain

$$BOT = AC * TOP$$

We need now an equation to stress the material to its design limit and this can be done by either using

$$STH = DST = HM * DITOP / I$$

$$\text{or } SBH = DSC = HM * DIBOT / I$$

From these two equations I prefer to use the second especially because it will simplify the calculations that follow as can be understood from the simpler expression that gives DIBOT as

compared with the one that gives DITOP.

We will then consider here

$$SBH = DSC = HM * DIBOT / I$$

which gives

$$DSC = \frac{HM * D * TOP * (B + D)}{4 * D^2 * TOP ((3 * B^2 + 2 * B * D) * BOT + (D^2 + 2 * B * D) * TOP)}$$

Simplifying we obtain

$$TOP = \frac{HM * (B + D)}{DSC * 4 * D * (D^2 + 2 * B * D)} - \frac{3 * B^2 + 2 * B * D}{D^2 + 2 * B * D} * BOT$$

or making

$$A = HM * (B + D) / (DSC * 4 * D * (D^2 + 2 * B * D))$$

$$AB = (3 * B^2 + 2 * B * D) / (D^2 + 2 * B * D)$$

we have

$$TOP = A - AB * BOT$$

replacing here

$$BOT = AC * TOP$$

we obtain

$$TOP = \frac{A}{1 + AB * AC}$$

Having already found TOP and BOT we may use Bryan's formula to determine S; since the thickness of plating is for this case smaller at the bottom we must consider this thickness and along with it DSC because this will be the larger compressive stress the bottom will be subjected to.

$$\text{From } DSC = \frac{E}{0.30396 * (1 - POI * POI)} * \frac{BOT^2}{S^2}$$

We obtain

$$S = \sqrt{\frac{1}{0.30396 * \frac{1 - POI * POI}{E} * DSC}} * BOT$$

or making

$$Z = \sqrt{\frac{1}{0.30396 * \frac{1 - POI * POI}{E} * DSC}}$$

we have

$$S = Z * BOT$$

A computer program was written and applied to two particular sets of dimensions and two different materials namely steel and aluminum. The results are presented next in the computer printouts.

STRENGTH OF SHIPS ON THE NEUTRAL AXIS LOCATION

PAGE

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274 C   *AL* IS THE LENGTH
274 C   AL=500.
275 C   R=AL/8.
276 C   *DRA* IS THE DRAFT
277 C   DRA=8/3.
278 C   D=AL/9.
279 C   *POI* IS THE POISSON'S RATIO OF THE MATERIAL
280 C   FOR STEEL
281 C   POI=0.3
282 C   *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
283 C   FOR STEEL
284 C   E=30.*10.*1000000.
285 C   *DST* IS THE DESIGN STRESS IN TENSION
286 C   DST=25000.
287 C   *DSC* IS THE DESIGN STRESS IN COMPRESSION
288 C   DSC=300000.
289 C   *HM* IS THE HOGGING BENDING MOMENT
290 C   HM=1.37143*B*DRA*AL*AL
291 C   *SM* IS THE SAGGING BENDING MOMENT
292 C   SM=B*DRA*AL*AL
293 C   W=0.30396*(1.2POI*POI)*DSC/E
294 C   U=SQRT(W)
295 C   Z=1./U
296 C   A=HM*(B+D)/(DSC*4.*B*(D+D+2.*B*D))
297 C   AB=(3.*B*B+2.*B*D)/(D+D+2.*B*D)
298 C   AC=DST/DSC+D*(DST-DSC)/(DSC*B)
299 C   *TOP* IS THE THICKNESS OF THE TOP PLATING
300 C   *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
301 C   TOP=A/(1.+AB*AC)
302 C   BOT=AC*TOP
303 C   WRITE(5,10)TOP
304 C   10 FORMAT('1',22Y,'TOP='E12.4)
305 C   WRITE(5,20)BOT
306 C   20 FORMAT('1',22Y,'BOT='E12.4)
307 C   *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
308 C   S=Z*BOT
309 C   WRITE(5,30)S
310 C   30 FORMAT('1',22Y,'S='E12.4)
311 C   P=2.*C*TOP+B*(TOP+BOT)
312 C   *DTOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
313 C   DTOP=D*(B*BOT+C*TOP)/P
314 C   WRITE(5,40)DTOP
315 C   40 FORMAT('1',18Y,'DTOP='E10.4)
316 C   *DIBOT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS
317 C   DIBOT=D*(B*TOP+C*TOP)/P
318 C   WRITE(5,50)DIBOT
319 C   50 FORMAT('1',18Y,'DIBOT='E10.4)
320 C   *GMI* IS THE MOMENT OF INERTIA OF THE X SECTION ABOUT N.A.
321 C   GMI=4.*C*C*((2.*B*B+2.*B*D)*TOP*BOT+(D*D+2.*B*B)*TOP*TOP)/P
322 C   *STH* IS THE STRESS ON TOP DUE TO HOGGING
323 C   *STS* IS THE STRESS ON TOP DUE TO SAGGING
324 C   *SRH* IS THE STRESS ON BOT DUE TO HOGGING

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STRENGTH OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE 2

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1A8   F    *SBS* IS THE STRESS ON BOT DUE TO SAGGING
1A8   C    *STCRIT* IS THE CRITICAL STRESS ON TOP
1A8   C    *SBCRIT* IS THE CRITICAL STRESS ON BOT
1A8   STH=HM*DTTOP/GMT
1A8   STS=SM*DTTOP/GMT
1A8   SRH=HM*DTBOT/GMT
1A8   SBS=SM*DTBOT/GMT
1A8   STCRIT=TOP*TOP*F/(0.36396*S*S*(1.-BOT*POI))
1A8   SBCRIT=BOT*BOT*F/(0.36396*S*S*(1.-BOT*POI))
1A8   WRITE(5,40)STS
1A8   40 FORMAT(1 1,20X,19THI1E12.3)
1A8   WRITE(5,70)STS
1A8   70 FORMAT(1 1,20X,1STS1E12.3)
1A8   WRITE(5,80)STCRIT
1A8   80 FORMAT(1 1,17Y,1STCRIT1E10.3)
1A8   WRITE(5,90)SRH
1A8   90 FORMAT(1 1,20Y,1SRH1E10.3)
1A8   WRITE(5,100)SBS
1A8   100 FORMAT(1 1,20Y,1SBS1E12.3)
1A8   WRITE(5,110)SBCRIT
1A8   110 FORMAT(1 1,17Y,1SBCRIT1E10.3)
1A8   END

```

| | | | | |
|---------|-----------------|-----------------|---------------|-----------------|
| [S] 011 | 0584 [V] AL | 058C [V] R | 05C4 [V1] DPA | 15CC [V1] D |
| [V] BOT | 05DC [V] F | 0400G[S] | 05FC[V1] DST | 15F4 [V1] DSC |
| [V] HM | 0624 [V] SM | 0602 [V] W | 0614 [V] U | 1630 [S1] SRT |
| [V] Z | 061C [V] A | 0640 [V] AR | 0644 [V] AC | 0648 [V] TDP |
| [V] BOT | 0100[L] 10 | 000P[S] | 0202[L] 20 | 0650 [V] S |
| [L] 39 | 0654 [V] P | 0650 [V] DITOP | 0200[L] 40 | 1650 [V1] DTBPT |
| [L] 52 | 0660 [V] GMT | 0660 [V] STH | 0670 [V] STS | 1674 [V1] S24 |
| [V] SBS | 067C [V] STCRIT | 0680 [V] SBCRIT | 0404 [L] 60 | 048A [L] 70 |
| [L] 82 | 0528 [L] 90 | 055F [L] 100 | 0504 [L] 110 | 0320 [S1] .V |

L

RAM TABLES:

| | | | | | |
|------------|----------|------------|-----------|----------|---------|
| 170 *MAIN* | 2DPA .V | 2RBA .COMP | 2RDC ALOG | 2D98 .I | 26F4 .F |
| 182 *ZERO | 2PEP \$6 | 2734 .A | 2RDF .MES | 2RFD .W | 29E4 EY |
| 1FA ATNT | 27E6 SRT | 2C22 .RARG | 2 7F .5 | 2C54 \$8 | 2C86 .F |
| 186 .0 | 2D5C .U | 3EB4 | | | |

HY-POINTS:

| | | | | | |
|-----------|-------------|----------|------------|----------|---------|
| 1F4 .R | 2734 .A | 27E6 SRT | 2RDC ALOG | 2RFL EXP | 2AFA AI |
| 15C .W | 2RBA .COMP | 2RFS \$6 | 2 22 .RARG | 2C54 \$8 | 2C7E .5 |
| 182 *ZFRD | 2C86 .FRONT | 2C88 .O | 2RDE .MES | 2F68 .U | 2D3E .V |
| 198 .T | | | | | |

ATION-BLOCKS:

C

FINED SUBROUTINES:

TOP= 3.3464
BOT= 3.2374
S= 14.2732
DTTOP= 25.2525
DTBOT= 31.3030
STH= 25035.000
STS= 18225.152
STCRIT= 63933.629
SRH= 30032.012
SBS= 21874.992
SRCRTT= 29999.961

| | | |
|----------------------|-------------------|-----|
| 08 HANDLING CHARGE | \$.25 / JAR | .25 |
| 18 LINES PRINTED PR1 | \$ 1.25 / K LINE | .1 |
| 80 CARDS READ | \$ 1.50 / K CARDS | .12 |
| 00 PLOTTER VECTORS | \$.25 / 1000 | .02 |
| 19 MODEL 72 SECONDS | \$25.00 / HOUR | .1 |
| 00 MODEL 82 SECONDS | \$12.50 / HOUR | .02 |
| TOTAL CHARGE | | .72 |

EIR 400 14731 LOGGED OUT 04/21/74 20:22. \$ 9.05 LEFT AFTER 54 LOGINS.

STRENGTH OF SHIPS ON THE NEUTRAL AXIS LOCATION

PAGE 1

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14 C *AL* IS THE LENGTH
14 C AL=50.0
15 C B=AL/2.0
16 C *DRA* IS THE DRAFT
17 C DRA=12.0
18 C D=AL/2.0
19 C *EGR* IS THE PLIISON'S RATIO OF THE MATERIAL
20 C FOR ALUMINUM
21 C PII=0.35
22 C *EY* IS THE YOUNG'S MODULUS OF THE MATERIAL
23 C FOR ALUMINUM
24 C E=1.0*1.0*5
25 C *UST* IS THE DESIGN STRESS IN TENSION
26 C UST=0.0
27 C *UOC* IS THE DESIGN STRESS IN COMPRESSION
28 C USC=0.0
29 C *MHT* IS THE HOGGING BENDING MOMENT
30 C MHT=1.0/1.3*(DRA*AL)
31 C *MSH* IS THE SAGGING BENDING MOMENT
32 C MSH=1.0*(DRA*AL)
33 C Z=0.2*(1.0-PII*PII)*USC/E
34 C U=Sum(1.0)
35 C Z=1.0
36 C A=MHT*(1.0+Z)*(DSC+4.0*(D+B+2.0*B*D))
37 C AB=(B+0.5+0.5*B*D)/(D*D+2.0*B*D)
38 C AC=USC*USC*(Z*DHT*DSC)/(DEC*E)
39 C *TCP* IS THE THICKNESS OF THE TOP PLATING
40 C *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
41 C TCP=AL*(1.0+Z*AC)
42 C BUT=AL-TCP
43 C WRITE(6,1) TCP
44 10 FORMAT(1X,2X,'TCP='F12.4)
45 C WRITE(6,2) -CT
46 20 FORMAT(1X,2X,'BOT='F12.4)
47 C *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
48 C S=Z*PCT
49 C WRITE(6,3) S
50 30 FORMAT(1X,22X,'S='F12.4)
51 C P=2.0*TCP+4.0*(TCP+PCT)
52 C *DITCP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
53 C DITCP=0.5*(Z*BCT+D*TCP)/P
54 C WRITE(6,4) DITCP
55 40 FORMAT(1X,18X,'DITCP='F10.4)
56 C *DIBOT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS
57 C DIBOT=0.5*(Z*TCP+D*TCP)/P
58 C WRITE(6,5) DIBOT
59 50 FORMAT(1X,18X,'DIBOT='F12.4)
60 C *GMI* IS THE MOMENT OF INERTIA OF THE X SECTION ABOUT N.A.
61 C GMI=4.0*D*(3.0*B*B+2.0*B*D)*TOP*BOT+(D*D+2.0*B*B*D)*TOP*TCP)/P
62 C *STH* IS THE STRESS ON TOP DUE TO HOGGING
63 C *STS* IS THE STRESS ON TOP DUE TO SAGGING
64 C *SEH* IS THE STRESS ON BOT DUE TO HOGGING

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STRENGTH OF SHEET PILES THE NEUTRAL AXIS LOCATION

PAGE 2

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371 C      *EPS= TS T-C STRESS IN FOT DUE TO SAGGING
372 C      *STC=CT IS THE CRITICAL STRESS ON TOP
373 C      *SPC=CT IS THE CRITICAL STRESS ON BOT
374 C      STC=0.4*IT + 1/6*I
375 C      STS=0.4*IT + 1/6*I
376 C      SPC=0.4*IT + 1/6*I
377 C      S=S=0.4*IT + 1/6*I
378 C      STC(I)=I + 0.4*(P01+P02) + 39.396*3*S*(1.0+P01+P02)
379 C      SPC(I)=I + 0.4*(P01+P02) + 39.396*3*S*(1.0+P01+P02)
380 C      WRITE(0,*) STC
381 C      60 FORMAT(1X,2X,ISTC=1F11.3)
382 C      WRITE(0,*) STS
383 C      70 FORMAT(1X,2X,ISTS=1F11.3)
384 C      WRITE(0,*) SPC(I)
385 C      80 FORMAT(1X,17X,ISTC IT=1F11.3)
386 C      WRITE(0,*) SPC(I)
387 C      90 FORMAT(1X,2X,ISTC(I)=1F11.3)
388 C      WRITE(0,*) STC(I)
389 C      100 FORMAT(1X,2X,ISTS(I)=1F11.3)
390 C      WRITE(0,*) STS(I)
391 C      110 FORMAT(1X,17X,ISPC(I)=1F11.3)
392 C      END
393 •U 2524[L] 1L      0E00[V] 8      25C4[L] 0FA      1500[V] 0
394 P01 2EDC0[L] F      0.0 [S] •R      2E84[V] 0S1      1SF1[V] DEC
395 •R 6.4E0[L] 50      0.614[V] W      2E1V[V] U      18.1[S] SORT
396 Z 2E150[L] 1      0.630[V] AF      2E4V[V] AC      1644[V] TCP
397 ACT 21000[L] 1*     0.0 [S] @I      0202[L] 20      1640[V] S
398 SV 26E50[L] F      2441[V] DJTOP    2E01[L] 40      2651[V] DIRECT
399 SV 1.6E00[L] 0.1    1.3441[V] STH     1.6E0[V] STS    2671[V] SBR
400 SBS 1.67E0[L] ST+IT 2.6721[V] SPGRIT   0484[L] 60      142A[L] 74
401 •P 2528[L] 1L      0.556[L] 1.0      2594[L] 110     0.24[S] •V
402 L

```

LABELS:

| | | | | | |
|--------|-----------|------------|-----------|---------|----------|
| •MAJ * | 2D5H •V | 2P46 •COMP | 2B08 ALCG | 2D94 •I | 26F0 •R |
| •ZER | 2BFC 16 | 2732 •A | 2CDA •MES | 2B58 •W | 29E0 EXP |
| •AINT | 27E2 RGET | 2C1E •RAFG | 2C7A •S | 2C50 48 | 2C32 •EF |
| •O | 2C6H •L | 3E9H | | | |

POINT CINTS:

| | | | | | |
|------|-------------|-----------|------------|----------|----------|
| •R | 2734 •A | 2752 SORT | 2B08 ALCG | 29E0 EXP | 2AE6 AII |
| •W | 2BHE •CC | 2BDC \$6 | 2C1E •RAFG | 2C50 \$8 | 2C7A •S |
| •ZER | 2C82 •ERC T | 2C84 •C | 2CDA •MES | 2D64 •U | 2D8A •V |
| •I | | | | | |

COMBLOCKS:

REFINED SIROUTINES:

TCR = .2464
 FCT = .8374
 S = .8270
 DITCR = .850258E
 DIFCT = .8343
 STCR = .8343
 STC = 1.025015
 STCHIT = .72000728
 SIT = 1.025015
 SIT = 1.025015
 SLCFT = 0.000000

| | | | | |
|----|----------------|------|--------|-----|
| 1. | WHEELING CRASH | .35 | / JTB | .35 |
| 1. | LINES PRINTER | 1.25 | / KLI | .15 |
| 1. | PPDS READ | 1.5 | / K CL | .12 |
| 1. | LOTT & VECTORS | .65 | / 1.0 | .65 |
| 1. | CDFL 70 SEC | .55 | / HOUR | .10 |
| 1. | CODEL 80 SEC | .55 | / HOUR | .06 |
| | TOTAL CPU-SF | \$ | | .72 |

BY 489 14731 LOGGED IN 47,1774 20:200 \$ 9.80 LEFT AFTER 33 LOGINS.

STRENGTH OF SHIPS-ON THE NEUTRAL AXIS LOCATION

```

104 C *AL* IS THE LENGTH
104 AL=1000.
105 C *DRA* IS THE DRAFT
105 DRA=B/3.3
106 C *EAL* IS THE EAL/14.
107 C *POI* IS THE POISSON'S RATIO OF THE MATERIAL
108 C FOR STEEL
109 C POI=0.3
110 C *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
111 C FOR STEEL
112 C E=30.*10.**6
113 C *DST* IS THE DESIGN STRESS IN TENSION
114 DST=25000.
115 C *DSC* IS THE DESIGN STRESS IN COMPRESSION
116 DSC=30000.
117 C *HM* IS THE HOGGING BENDING MOMENT
118 HM=1.37143*B*DRA*AL*AL
119 C *SM* IS THE SAGGING BENDING MOMENT
120 SM=R*DRA*AL*AL
121 W=0.30396*(1.-POI*POI)*DSC/E
122 U=SQRT(W)
123 Z=1./U
124 A=HM*(B+D)/(DSC*4.*D*(D+D+2.*B*D))
125 AB=(3.*R*B+2.*R*D)/(D+D+2.*B*D)
126 AC=DST/DSC+D*(DST-DSC)/(DSC*B)
127 C *TOP* IS THE THICKNESS OF THE TOP PLATING
128 C *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
129 TOP=A/(1.+AB*AC)
130 BOT=AC*TOP
131 WRITE(5,10)TOP
132 10 FORMAT(11,20X,'TOP'=F10.4)
133 WRITE(5,20)BOT
134 20 FORMAT(11,20X,'BOT'=F10.4)
135 C *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
136 S=Z*BOT
137 WRITE(5,30)S
138 30 FORMAT(11,22X,'S'=F10.4)
139 P=2.*D*TOP+B*(TOP+BOT)
140 C *DITOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
141 DITOP=D*(B*BOT+D*TOP)/P
142 WRITE(5,40)DITOP
143 40 FORMAT(11,18X,'DITOP'=F10.4)
144 C *DIROT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS
145 DIROT=D*(B*TOP+D*TOP)/P
146 WRITE(5,50)DIROT
147 50 FORMAT(11,18X,'DIROT'=F10.4)
148 C *GMI* IS THE MOMENT OF INERTIA OF THE X SECTION ABOUT N.A.
149 GMI=4.*P*D*((2.*R*B+2.*R*D)*TOP*BOT+(D*D+2.*B*D)*TOP*TOP)/P
150 C *STH* IS THE STRESS ON TOP DUE TO HOGGING
151 C *STS* IS THE STRESS ON TOP DUE TO SAGGING
152 C *SRH* IS THE STRESS ON BOT DUE TO HOGGING

```


STRENGTH OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE 2

```

13A8 C *SBS* IS THE STRESS ON BOT DUE TO SAGGING
13A8 C *STCRIT* IS THE CRITICAL STRESS ON TOP
13A8 C *SBCRIT* IS THE CRITICAL STRESS ON BOT
13A8 C STH=HM*DITOP/GMT
13A8 C STS=SM*DITOP/GMT
13A8 C SBH=HM*DIBOT/GMT
13A8 C SBS=SM*DIBOT/GMT
13A8 C STCRIT=TOP*TOD*F/(0.3e326*S*S*(1.-POI*POI))
13A8 C SBCRIT=BOT*BOT*F/(0.3e326*S*S*(1.-POI*POI))
13A8 C WRITE(5,50)STS
13A8 C FORMAT(1,1,20Y,1,STH,E10.3)
13A8 C WRITE(5,70)STS
13A8 C FORMAT(1,1,20Y,1,STS,E10.3)
13A8 C WRITE(5,80)STCRIT
13A8 C FORMAT(1,1,17Y,1,STCRIT,E10.3)
13A8 C WRITE(5,90)SBS
13A8 C FORMAT(1,1,20Y,1,SBH,E10.3)
13A8 C WRITE(5,100)SBS
13A8 C FORMAT(1,1,20Y,1,SBS,E10.3)
13A8 C WRITE(5,110)SBCRIT
13A8 C FORMAT(1,1,17Y,1,SBCRIT,E10.3)
13A8 C END

```

| | | | | | |
|------|-----|----------------|----------------|-------------|---------------|
| 1[S] | •II | 25B4[V] AL | 25B5[V] R | 25C4[V] DRA | 25CC[V] N |
| 1[V] | P0I | 25DC[V] F | 25D0[S] .R | 25FC[V] DST | 25F4[V] DSC |
| 1[V] | HM | 2604[V] SM | 2609[V] W | 2614[V] U | 2630[S] SCRT |
| 1[V] | Z | 261C[V] A | 2640[V] AB | 2648[V] AC | 264C[V] TOP |
| 1[V] | BOT | 210C[L] 10 | 2200[R] @I | 22C2[L] 20 | 2654[V] S |
| 1[L] | 37 | 2658[V] P | 265C[V] DITOP | 22C3[L] 40 | 2660[V] DTR01 |
| 1[L] | 57 | 2664[V] GMI | 2670[V] STH | 2674[V] STS | 2A78[V] SBS |
| 1[V] | SBS | 2680[V] STCRIT | 2684[V] SBCRIT | 24C4[L] 60 | 24BA[L] 70 |
| 1[L] | 87 | 2528[L] 90 | 255E[T] 100 | 25C4[L] 110 | 2207[S] .V |

L

PROGRAM LABELS:

| | | | | | |
|------------|-----------|------------|-----------|----------|---------|
| 270 *MAIN* | 2D8E •V | 2B8F •COMP | 29E9 ALG | 2D9C @I | 26F8 •Z |
| 2C86 •ZERO | 2BF4 \$F | 2738 •A | 2CE2 .MFS | 2B6C •W | 22E8 Fx |
| 2AEF ATNT | 27FA SCRT | 2C26 •RARG | 2C82 .5 | 2C5F \$8 | 2C8A •E |
| 2CRA •O | 2D60 •U | 2EBR | | | |

RY-POINTS:

| | | | | | |
|------------|-------------|-----------|------------|----------|---------|
| 2F8 •R | 2738 •A | 27EA SCRT | 2-E9 ALG | 29E8 EXP | 2AEF AT |
| 2B60 •W | 2B8F •COMP | 2BE4 \$6 | 2726 .RARG | 2C5F \$8 | 2C82 •5 |
| 2C86 •ZERO | 2C8A •ERCNT | 2C8C •O | 2CE2 .MES | 2D4C •U | 2D92 •V |
| 2D9C @I | | | | | |

NON-BLOCKS:

E

REFINED SUBROUTINES:

TOP= 3.0299
BOT= 2.3252
S= 139.8265
DITOP= 32.4675
DIBOT= 38.9610
STH= 25000.000
STS= 18226.152
STCRIT= 51278.250
SBH= 29999.996
SBS= 21874.994
SPCRIT= 29999.961

| | | | |
|-----------------------|---------|--------|-----|
| 108 HANDLING CHARGE | \$.25 | / Job | .25 |
| 118 LINES PRINTED PR1 | \$ 1.25 | / K LN | .15 |
| 80 CARDS READ | \$ 1.50 | / K CP | .12 |
| 20 PLOTTER VECTORS | \$.25 | / 1000 | .25 |
| 14 MODEL 70 SECONDS | \$25.00 | / HOU | .1 |
| 80 MODEL 80 SECONDS | \$12.50 | / HOU | .0 |
| TOTAL CHARGE * | | | .72 |

EIR 460 14731 LOGGED OUT 04/21/76 20:27. * 7.58 LEFT AFTER 36 LOGINS.

STRENGTH OF SHIPS ON THE 'NEUTRAL' AXIS LOCATION

```

204 C *AL* IS THE LENGTH
204 AL=1000.
200 R=AL/5.75
118 C *DRA* IS THE DRAFT
118 DRA=B/3.3
124 R=AL/14.
130 C *POI* IS THE POISSON'S RATIO OF THE MATERIAL
130 FOR ALUMINUM
130 POI=0.33
138 C *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
138 FOR ALUMINUM
138 E=10.*10.*10.*6
140 C *DST* IS THE DESIGN STRESS IN TENSION
140 DST=25000.
154 C *DSC* IS THE DESIGN STRESS IN COMPRESSION
154 DSC=30000.
150 C *HM* IS THE HOGGING BENDING MOMENT
150 HM=1.37143*B*DRA*AL*A
174 C *SM* IS THE SAGGING BENDING MOMENT
174 SM=B*DRA*AL*A
188 W=0.32396*(1.-POI*POI)*DSC/E
188 W=SQRT(W)
184 Z=1./W
190 A=HM*(B+D)/(DSC*4.*B*(D*D+2.*B*B))
190 AB=(3.*B*B+2.*B*B)/(D*D+2.*B*B)
158 AC=DST/DSC+D*(DST-DSC)/(DSC*B)
180 C *TOP* IS THE THICKNESS OF THE TOP PLATING
180 C *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
180 TOP=A/(1.+AB*AC)
184 BOT=AC*TOP
188 WRITE(5,10)TOP
190 10 FORMAT('1',2X,I10,E10.4)
196 WRITE(5,20)BOT
192 20 FORMAT('1',2X,I10,E10.4)
210 C *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
210 S=Z*BOT
228 WRITE(5,30)S
244 30 FORMAT('1',2X,I5,E10.4)
250 P=2.*B*TOP+B*(TOP+BOT)
280 C *DITOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
280 DITOP=B*(B*BOT+P*TOP)/P
284 WRITE(5,40)DITOP
300 40 FORMAT('1',18X,I10,E10.4)
300 C *DIBOT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS
300 DIBOT=B*(B*TOP+P*TOP)/P
302 WRITE(5,50)DIBOT
310 50 FORMAT('1',18X,I10,E10.4)
338 C *GMI* IS THE MOMENT OF INERTIA OF THE X SECTION ABOUT N.A.
338 GMI=4.*B*D*((5.*B*B+2.*B*D)*TOP*BOT+(D*D+2.*B*B)*TOP*TOP)/P
348 C *STH* IS THE STRESS ON TOP DUE TO HOGGING
348 C *STS* IS THE STRESS ON TOP DUE TO SAGGING
348 C *SBH* IS THE STRESS ON BOT DUE TO HOGGING

```


STRENGTH OF SHIPS-ON THE NEUTRAL AXIS LOCATION

```

548      C      *SAS* IS THE STRESS ON BOT DUE TO SAGGING
548      C      *STCRIT* IS THE CRITICAL STRESS ON TOP
548      C      *SBCRIT* IS THE CRITICAL STRESS ON BOT
548      C      STH=HM*DITOP/GMT
548      C      STS=SM*DITOP/GMT
548      C      SPH=HM*DIBOT/GMT
548      C      SBS=SM*DIBOT/GMT
548      C      STCRIT=TOP*TDP*F/(C.3e396*S*S*(1-FDI*POI))
548      C      SBCRIT=BOT*BOT*F/(C.3e396*S*S*(1-FDI*POI))
548      C      WRITE(5,60)STS
548      60      FORMAT(' ',27Y,1STH,E11.3)
548      C      WRITE(5,70)STC
548      70      FORMAT(' ',27Y,1STS,E11.3)
548      C      WRITE(5,80)STCRIT
548      80      FORMAT(' ',17Y,1STCRIT,E11.3)
548      C      WRITE(5,90)SPH
548      90      FORMAT(' ',27Y,1SPH,E11.3)
548      C      WRITE(5,100)SBS
548      100     FORMAT(' ',27Y,1SBS,E11.3)
548      C      WRITE(5,110)SBCRIT
548      110     FORMAT(' ',17Y,1SBCRIT,E11.3)
548      C      END
548      C      •II      0FB4[V] AL      05B6[V] B      05C4[V] DPA      05CC[V] D
548      C      PC1      0FDC[V] F      0000[S] •R      05C3[V] DST      05E9[V] DSC
548      C      HM      0600[V] SM      0604[V] W      0611[V] U      0621[S] SORT
548      C      Z      0618[V] A      0630[V] AR      0644[V] AC      0649[V] TDP
548      C      BOT      0100[L] 10      0000[S] @I      0202[L] 20      0451[V] S
548      C      30      0654[V] P      0658[V] DITOP      0201[L] 40      0650[V] DIBOT
548      C      50      0660[V] GMT      0660[V] STH      0673[V] STS      0674[V] SPH
548      C      SRS      067C[V] STCRIT      0680[V] SBCRIT      0494[L] 60      049A[L] 77
548      C      80      0528[L] 90      055F[1] 100      0504[L] 110      0200[S] .V
548      C      L

```

PROGRAM LABELS:

| | | | | | |
|-------------|-----------|------------|-----------|---------|---------|
| 2070 *MAIN* | 208A •V | 208A •COMP | 208C ALOG | 2098 •T | 20F4 •P |
| 2082 •ZER0 | 20E0 \$4 | 2734 •A | 20DE •MES | 20E0 •W | 20E4 FY |
| 20AFA ATINT | 27E6 SORT | 2022 •RARG | 207E •S | 2054 •R | 2086 •E |
| 2086 •O | 205C •U | 2F94 | | | |

TRY-POINTS:

| | | | | | |
|------------|-------------|-----------|------------|----------|----------|
| 20F4 •R | 2734 •A | 27E6 SORT | 20DC ALOG | 20F4 EXP | 20EA ATI |
| 20E0 •W | 208A •COMP | 20E0 \$6 | 2022 •RARG | 2054 •R | 207E •S |
| 2082 •ZER0 | 2086 •FRONT | 2098 •O | 20DE •MES | 2068 •T | 208E •V |
| 2098 •T | | | | | |

MON-BLOCKS:

E

DEFINED SUBROUTINES:

TOP= 3.0779
 BOT= 2.3252
 S= 81.5687
 DJTOP= 32.4475
 DJBOT= 38.9610
 STH= 25020.203
 STS= 19226.152
 STCRIT= 51270.383
 SRH= 29999.996
 SBS= 21874.984
 SBCRIT= 32000.035

| | | |
|----------------------|-----------------|-----|
| 08 HANDLING CHARGE | \$.25 / Job | .25 |
| 18 LINES PRINTED PR1 | \$ 1.25 / K LNS | .15 |
| 80 CARDS READ | \$ 1.50 / K CAR | .12 |
| 00 PLOTTER VECTORS | \$.25 / 1000 | .02 |
| 18 MODEL 70 SECONDS | \$25.00 / HOUR | .15 |
| 00 MODEL 80 SECONDS | \$12.50 / HOUR | .02 |
| TOTAL CHARGE | | .72 |

FIR 490 14731 LOGGED OUT 04/21/74 20:24. \$ 8.32 LEFT AFTER 35 LOGINS.

HOGGING MOMENT AND SAGGING MOMENT OF EQUAL MAGNITUDE
DESIGN STRESS IN TENSION AND DESIGN STRESS IN COMPRESSION OF
EQUAL VALUE; LATERAL LOAD ALSO CONSIDERED

The lateral load being here considered will be a "head" of salt water of eight feet on the top plating ($H_{TOP}=8$ ft) and a "head" of salt water equal to the draft on the bottom plating ($H_{BOT}=DRA$).

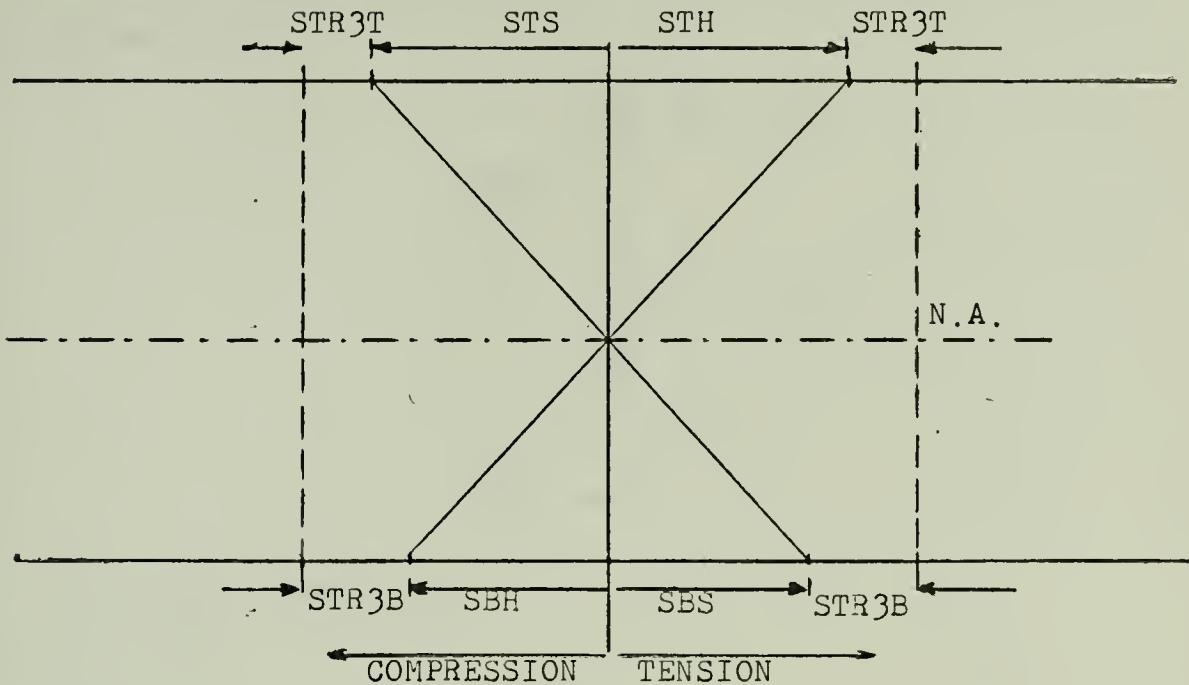
We will use here the simplified approach as suggested in the following note; this simplified approach is at least conservative.

Note: Bleich, from his experiments and theoretical studies on the effect of normal pressure in the buckling strength of thin panels, concluded that the buckling strength is increased when combined with a sufficiently large normal load, and that the increase is greater for the simply supported edges situation than with fixed edges. For heavier plating, where the deflection does not exceed half of the plating thickness, the increase in buckling strength resulting from normal load is negligible. It was therefore suggested, for simplicity, that the critical stress be computed for in plane loading only.

The tertiary stresses we are interested in considering here are those exerted at points B directed longitudinally; these will combine with the longitudinal bending stresses or primary stresses as described in a previous section.

Since now we have $DST=DSC$ and $HM=SM=BM$ we may think of

a diagram for the stress distributions as indicated next figure:



From this diagram we may understand that the neutral axis should be located closer to the bottom which means that the thickness at the bottom will be larger than at the top $BOT > TOP$. So, we may already write the following formulas where TS was replaced by BOT

$$DITOP = D * (B+D) * BOT / P$$

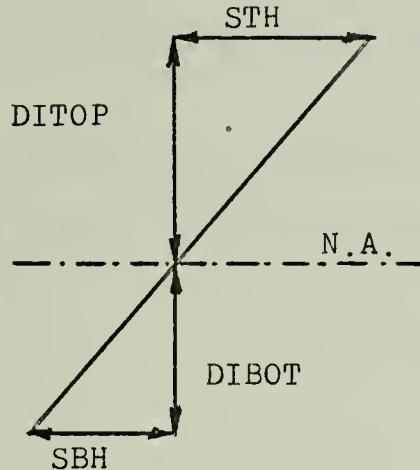
$$DIBOT = D * (B * TOP + D * BOT) / P$$

$$I = 4 * D * D * ((3 * B^2 + 2 * B * D) * TOP + (D^2 + 2 * B * D) * BOT) * BOT / P$$

where

$$P = 2 * D * BOT + B * (TOP + BOT)$$

We may now think of the following relationships to determine TOP and BOT.



$$STH \cdot DIBOT = SBH \cdot DITOP$$

or knowing that

$$STR3T = 0.152222 * HTOP * \left(\frac{S}{TOP}\right)^2$$

$$STR3B = 0.152222 * HBOT * \left(\frac{S}{BOT}\right)^2$$

and anticipating

$$S = Z \cdot TOP$$

where

$$Z = 1 / \left(\sqrt{0.30396 * \frac{1 - POI * POI}{E} * DST} \right)$$

we have

$$Z^2 = \left(\frac{S}{TOP}\right)^2$$

$$\text{If we now make } \left(\frac{S}{BOT}\right)^2 = Z^2$$

in order to simplify the equations, we see that when we do this, since

$$\left(\frac{S}{BOT}\right)^2 < \left(\frac{S}{TOP}\right)^2$$

we are increasing the value of STR3B and this means that since

$$DST = SBH + STR3B$$

we are decreasing "slightly" the value of SBH that could be allowed to reach a larger value; so , the substitution

$$\left(\frac{S}{BOT}\right)^2 = Z^2$$

is on the safe side and has the advantage of simplifying the equations considerably.

So we may write

$$STH = DST - STR3T$$

$$SBH = DST - STR3B$$

$$STR3T = 0.152222 * HTOP * Z^2$$

$$STR3B = 0.152222 * HBOT * Z^2$$

$$A = DST - STR3T$$

$$AB = DST - STR3B$$

so

$$A*DIBOT = AB*DITOP$$

and we obtain replacing DITOP and DIBOT by their equations, and simplifying

$$TOP = \frac{AB * (B + D) - A * D}{A * B} * BOT$$

or making

$$AC = (AB*(B+D)-A*D)/(A*B)$$

we finally obtain

$$TOP = AC*BOT$$

Now in order to stress the material to its design stress we may either consider STH, STS, SBH, SBS.

Due to ease of calculation we may either choose STS or STH; the expressions will be exactly the same. I will consider here

$$STH = BM*DITOP/I$$

and

$$STH = DST-STR3T = A$$

Substituting for DITOP and I we obtain

$$A = \frac{BM*D*(B+D)*BOT}{4*D^2*BOT*((3*B^2+2*B*D)*TOP+(D^2+2*B*D)*BOT)}$$

and after simplifying we arrive at

$$BOT = \frac{BM*(B+D)}{A*4*D*(D^2+2*B*D)} - \frac{3*B^2+2*B*D}{D^2+2*B*D} *TOP$$

Making

$$AD = BM*(B+D)/(A*4*D*(D^2+2*B*D))$$

$$AE = (3*B^2+2*B*D)/(D^2+2*B*D)$$

we obtain

$$BOT = AD-AE*TOP$$

substituting

$$\text{TOP} = \text{AC} * \text{BOT}$$

we obtain

$$\text{BOT} = \frac{\text{AD}}{1 + \text{AC} * \text{AE}}$$

Considering now the instability formula (BRYAN) we notice that since the top will have the thinner plating we will consider TOP stressed to the maximum allowed DST.

So we start with

$$Z = 1 / \left(\sqrt{0.30396 * \frac{1 - \text{POI} * \text{POI}}{\text{E}}} * \text{DST} \right)$$

$$S = Z * \text{TOP}$$

The total stresses will then be given by

$$\text{TSTH} = \text{BM} * \text{DITOP} / \text{I} + \text{STR3T}$$

$$\text{TSTS} = \text{BM} * \text{DITOP} / \text{I} + \text{STR3T}$$

$$\text{TSBH} = \text{BM} * \text{DIBOT} / \text{I} + 0.152222 * \text{HBOT} * S^2 / \text{BOT}^2$$

$$\text{TSBS} = \text{BM} * \text{DIBOT} / \text{I} + 0.152222 * \text{HBOT} * S^2 / \text{BOT}^2$$

The computer printouts for the same cases analysed in the previous section are presented next.

STRENGTH OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE 1

```

3004      C      *AL* IS THE LENGTH
3004      AL=500.
300C      B=AL/8.
3018      C      *DRA* IS THE DRAFT
3018      DRA=B/3.
3024      D=AL/9.
3030      C      *POI* IS THE POISSON'S RATIO OF THE MATERIAL
3030      FOR STEEL
3030      POI=0.3
3038      C      *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
3038      FOR STEEL
3038      E=30.*10.***6
304C      C      *DST* IS THE DESIGN STRESS
304C      DST=25000.
3054      C      *BM* IS THE BENDING MOMENT
3054      BM=1.37143*B*DRA*AL*AL
306C      W=0.30396*(1.-POI*POI)*DST/E
308C      U=SQRT(W)
3098      Z=1./U
31A4      *HTOP* IS THE HEAD OF WATER ON DECK
31A4      HTOP=8.
31AC      *HBOT* IS THE HEAD OF WATER ON BOTTOM
31AC      HBOT=DRA
31B4      STR3T=0.152222*HTOP*Z*Z
31C8      STR3B=0.152222*HBOT*Z*Z
31DC      A=DST-STR3T
31E8      AB=DST-STR3B
31F4      AC=(AB*(B+D)-A*D)/(A*R)
31C          AD=BM*(B+D)/(A*4.*D*(D*D+2.*B*D))
3178          AE=(3.*B*B+2.*B*D)/(D*D+2.*B*D)
31C4      C      *TOP* IS THE THICKNESS OF THE TOP PLATING
31C4      C      *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
31C4      BOT=AD/(1.+AC*AE)
31DC      TOP=AC*BOT
31E8      WRITE(5,10)TOP
3204      10 FORMAT('1',20X,'TOP='F10.4)
321E      WRITE(5,20)BOT
323A      20 FORMAT(' ',20X,'BOT='F10.4)
3254      C      *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
3254      S=Z*TOP
3260      WRITE(5,30)S
327C      30 FORMAT(' ',22X,'S='F10.4)
3294      P=2.*D*BOT+B*(TOP+BOT)
3288      C      *DITOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
3288      DITOP=D*(B*BOT+D*BOT)/P
32DC      WRITE(5,40)DITOP
32F8      40 FORMAT(' ',18X,'DITOP='F10.4)
3314      C      *DIBOT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS
3314      DIBOT=D*(B*TOP+D*BOT)/P
3338      WRITE(5,50)DIBOT
3354      50 FORMAT(' ',18X,'DIBOT='F10.4)
3370      C      *GMI* IS THE MOMENT OF INERTIA OF THE X SECTION ABOUT N.O.A.

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STRENGHT OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE 2

```

1270      GMI=4.*D*D*((3.*B*B+2.*B*D)*TOP*BOT+(D*D+2.*B*B)*BOT*BOT)/P
13E0      C      *TSTH* IS THE STRESS ON TOP DUE TO HOGGING
13E0      C      *TSTS* IS THE STRESS ON TOP DUE TO SAGGING
13E0      C      *TSBH* IS THE STRESS ON BOT DUE TO HOGGING
13E0      C      *TSBS* IS THE STRESS ON BOT DUE TO SAGGING
13E0      C      *STCRIT* IS THE CRITICAL STRESS ON TOP
13E0      C      *SBCRIT* IS THE CRITICAL STRESS ON BOT
13E0      C      TSTH=BM*DITOP/GMI+STR3T
3F4      TSTS=BM*DITOP/GMI+STR3T
408      STCRIT=TOP*TOP*E/(0.30396*S*S*(1.-POI*POI))
448      WRITE(5,60)TSTH
464      60 FORMAT(' ',19X,'TSTH=',F10.3)
47E      WRITE(5,70)TSTS
49A      70 FORMAT(' ',19X,'TSTS=',F10.3)
484      WRITE(5,80)STCRIT
4D0      80 FORMAT(' ',17X,'STCRIT='F10.3)
4EC      TSBH=BM*DIBOT/GMI+0.152222*HBOT*S*S/(BOT*BOT)
528      TSBS=BM*DIBOT/GMI+0.152222*HBOT*S*S/(BOT*BOT)
564      SBCRIT=BOT*BOT*E/(0.30396*S*S*(1.-POI*POI))
544      WRITE(5,90)TSBH
5C0      90 FORMAT(' ',19Y,'TSBH=',F10.3)
5D4      WRITE(5,100)TSBS
5F6      100 FORMAT(' ',19X,'TSBS=',F10.3)
610      WRITE(5,110)SBCRIT
62C      110 FORMAT(' ',17X,'SBCRIT='F10.3)
648      END

```

| | | | | | |
|------|------|---------------|---------------|----------------|----------------|
| *[S] | •U | 064C[V] AL | 0654[V] B | 065C[V] DRA | 0664[V] D |
| C[V] | POI | 0674[V] E | 0000[S] •R | 0684[V] DST | 068C[V] BM |
| 4[V] | W | 06A0[V] U | 0000[S] SQRT | 06A4[V] Z | 06A8[V] HTOP |
| C[V] | HBOT | 06B0[V] STR3T | 06B8[V] STR3B | 06BC[V] A | 06C0[V] AB |
| 4[V] | AC | 06D8[V] AD | 06EC[V] AE | 06F0[V] BOT | 06F4[V] TOP |
| 4[L] | 10 | 0000[S] @I | 023A[L] 20 | 06F8[V] S | 027C[L] 30 |
| C[V] | P | 0700[V] DITOP | 02F8[L] 40 | 0704[V] DIBOT | 0354[L] 52 |
| R[V] | GMI | 0714[V] TSTH | 0718[V] TSTS | 071C[V] STCRIT | 0464[L] 60 |
| 4[L] | 70 | 0400[L] 80 | 0720[V] TSBH | 0724[V] TSBS | 0728[V] SBCRIT |
| 0[L] | 90 | 05F6[L] 100 | 062C[L] 110 | 0000[S] •V | |

EQ L

F

PROGRAM LABELS:

| | | | | | |
|-------------|-----------|------------|-----------|-----------|---------|
| 2070 *MAIN* | 2EB2 •V | 2CE2 •COMP | 2984 ALOG | 2EC0 •I | 279C •F |
| 2DAA •ZERO | 2D08 \$6 | 27DC •A | 2E06 •MES | 2C84 •W | 2A8C E |
| 2C12 AINT | 288E SQRT | 2D4A •RARG | 2D46 .5 | 2A8C AEXP | 2DAE •F |
| 2D7C \$8 | 2DAE •O | 2E84 •U | 3FDC | | |

TRY-POINTS:

| | | | | | |
|-----------|------------|-------------|-----------|------------|---------|
| 279C •R | 27DC •A | 288E SQRT | 2984 ALOG | 2A8C AEXP | 2A8C E |
| 2C12 AINT | 2C84 •W | 2CE2 •COMP | 2D08 #6 | 2D4A •RARG | 2D7C \$ |
| 2D46 •5 | 2DAA •ZERO | 2DAE •ERCNT | 2E80 •O | 2E06 •MES | 2E90 •I |
| 2EB6 •V | 2EC0 •I | | | | |

TOP= 0.1671
BOT= 0.8383
S= 11.0049
DITOP= 35.3820
DIBOT= 20.1736
TSTH= 25000.012
TSTS= 25000.012
STCRIT= 25000.000
TSRH= 11728.668
TSBS= 11728.668
SBCRIT=706635.250

END

F VIO OPERATING SYSTEM VERSION 1 REVISION 012 03/04/74 GENERATED 04/27/74

| | | |
|-----------------------|-----------------|-----|
| JOB HANDLING CHARGE | \$.35 / JOB | .35 |
| 125 LINES PRINTED PR1 | \$ 1.25 / K LN | .16 |
| 84 CARDS READ | \$ 1.50 / K Cn | .13 |
| 00 PLOTTER VECTORS | \$.25 / 1000 | .00 |
| 15 MODEL 70 SECONDS | \$25.00 / HOUR | .16 |
| 00 MODEL 80 SECONDS | \$12.50 / HOUR | .00 |
| | TOTAL CHARGE \$ | .74 |

PEIR 490 14731 LOGGED OUT 04/29/74 18:35. \$ 33.19 LEFT AFTER 42 LOGINS.

Note here that because we have in this run $BOT \gg TOP$ the approximation made to simplify the formulas, namely

$$Z = \frac{S}{BOT}$$

becomes very inaccurate compared to what the actual value should be

$$Z = \frac{S}{TOP}$$

this is the cause for obtaining such low stresses at the bottom. We might refine the result for this case as is done for the "1000 ft steel case" also included in this section which presented still another difficulty. Since all steps to have the bottom stressed to DST are explained in detail for such case they will be omitted here.

STIFFNESS OF SHIPS ON THE NEUTRAL AXIS LOCATION

PAGE 1

```

0104 C *AL* IS THE LENGTH
2104 AL=500.
0105 C D=L/2.
2106 D=L/2.
0107 C G=L/2.
2108 G=L/2.
0109 C K1=15 THE POISSON'S RATIO OF THE MATERIAL
2109 K1=0.3.
0110 C E* IS THE YOUNG'S MODULUS OF THE MATERIAL
2110 E=100000.
0111 C P0T=1.3.
2111 P0T=1.3.
0112 C F=100000000.
2112 F=100000000.
0113 C S0T=1.5 THE DESIGN STRESS
2113 S0T=25000.
0114 C M0T=1.5 THE BENEFITING MOMENT
2114 M0T=1.37143*E*P0T*A*S0T
0115 C D=(1.37143*E*P0T*A*S0T)*SIZE
2115 D=50000.
0116 C Z=1.70
2116 Z=1.70.
0117 C HTOP* IS THE HEAD OF WATER ON DECK
2117 HTOP=0.
0118 C HBOT* IS THE HEAD OF WATER ON BOTTOM
2118 HBOT=0.
0119 C STB31=-152620+T10*Z*Z
2119 STB30=-152620+T0T*Z*Z
0120 C A=0.5*(STB31-STB30)
2120 A=0.5*(STB31-STB30)
0121 C AF=(A*(*C*T10+Z*Z))/10000
2121 AF=(A*(*C*T10+Z*Z))/10000
0122 C AD=-M*(*C*T10+Z*Z)/10000
2122 AD=(-M*(*C*T10+Z*Z))/10000
0123 C AT=(B**3+B**2+R**2)/(H*R+D*B*D)
2123 AT=(B**3+B**2+R**2)/(H*R+D*B*D)
0124 C *TOP* IS THE THICKNESS OF THE TOP PLATING
2124 TOP=0.
0125 C *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
2125 BOT=AD/(1.0+AC+AT)
0126 C TOP=AC*T10
2126 TOP=AC*T10
0127 C WRITE(5,12)TOP
2127 WRITE(5,12)TOP
0128 C 12 FORMAT('1',2X,TOP=F10.4)
2128 12 FORMAT('1',2X,TOP=F10.4)
0129 C WRITE(5,BOT)
2129 WRITE(5,BOT)
0130 C 20 FORMAT('1',2X,BOT=F10.4)
2130 20 FORMAT('1',2X,BOT=F10.4)
0131 C *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
2131 S=7*TOP
0132 C WRITE(5,S)
2132 WRITE(5,S)
0133 C 30 FORMAT('1',2X,IS=I1.0)
2133 30 FORMAT('1',2X,IS=I1.0)
0134 C R=2.*D*BOT+6.*TOP+BOT
2134 R=2.*D*BOT+6.*TOP+BOT
0135 C *DITOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
2135 DITOP=D*(3*BOT+2*TOP)/R
0136 C WRITE(5,DITOP)
2136 WRITE(5,DITOP)
0137 C 40 FORMAT('1',18X,DITOP=F10.4)
2137 40 FORMAT('1',18X,DITOP=F10.4)
0138 C *DIBOT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS
2138 DIBOT=D*(B*TOP+2*BOT)/R
0139 C WRITE(5,DIBOT)
2139 WRITE(5,DIBOT)
0140 C 50 FORMAT('1',18X,DIBOT=F10.4)
2140 50 FORMAT('1',18X,DIBOT=F10.4)
0141 C *GMI* IS THE MOMENT OF INERTIA OF THE X SECTION ABOUT N.A.
2141 GMI=0.

```


STRAIGHT OF SHIPS ON THE FIDUCIAL AXIS LOCATION

PAGE 2

```

170
171 C GMI=4.*D*( (S+3.*S+2.*S*D)*TOP*BOT+(D+D+2.*B*D)*BOT*BOT)/P
172 C *TSRH*ID THE STRESS ON TOP DUE TO LOGGING
173 C *TSRS*ID THE STRESS ON TOP DUE TO SAGGING
174 C *TSRH*T THE STRESS ON BOT DUE TO LOGGING
175 C *TSRS*T THE STRESS ON BOT DUE TO SAGGING
176 C *SICRIT IS THE CRITICAL STRESS ON TOP
177 C *SBCKRIT IS THE CRITICAL STRESS ON BOT
178 C TSTR=MM*MTOP/2.1+ST*ST
179 C TS10=MM*MTOP/2.1+ST*ST
180 C STCRIT=1.1*TOP/(1.3-3.2*6*S*(1.0+POI*POI))
181 C WRITE(5,100)TSTR
182 C FORMAT(1.1,12X,1TSTR,1F14.3)
183 C WRITE(5,100)TS10
184 C FORMAT(1.1,12X,1TS10,1F14.3)
185 C WRITE(5,100)STCRIT
186 C FORMAT(1.1,12X,1STCRIT,1F14.3)
187 C TS10=MM*MTOP/2.1+2.1*6*2.2*HBOT*S*S/(BOT*BOT)
188 C TS20=MM*MTOP/2.1+2.1*6*2.2*HBOT*S*S/(BOT*BOT)
189 C STCRIT=1.1*TOP/(1.3-3.2*6*S*S*(1.0+POI*POI))
190 C WRITE(5,100)TS10
191 C FOR IAT(1:1,19),19,N=1F14.3)
192 C WRITE(5,100)TS10
193 C FORMAT(1.1,12X,1TS10,1F14.3)
194 C WRITE(5,110)STCRIT
195 C FORMAT(1.1,12X,1STCRIT,1F14.3)
196 C END

[6] .1      44C[V]  aL      1454[V]  R      455C[V]  DRA      8664[V]  D
[7] PNT    ,674[V]  F      ,200[S]  .R     664*[V]  DST      8638[V]  RM
[8] .2      169C[V]  M      117[S]  GIFT     664*[V]  Z      1644[V]  HTOP
[9] M-IT   264C[V]  STS1    674[V]  STS2B    664*[V]  A      26BC[V]  AB
[10] A-    404[V]  AD      659[V]  AE     664[C[V]  BOT      26F2[V]  TOP
[11] I     2450[S]  I      234[L]  2V     664[V]  S      2220[L]  32
[12] F     24FC[V]  M1TOP    2F2[L]  4V     671*[V]  DJBOT    1354[L]  50
[13] G-T   1711[V]  TSrh    714[V]  TSrs    671*[V]  STCRIT   1464[L]  60
[14] L    040C[L]  B0      710[V]  TSrh    672*[V]  TSes     8724[V]  SBCKRIT
[15] 9     05F6[L]  190     620[L]  110     604*[S]  .V

```

GRAN LAGO

2070 *11-111 261E 1 20DF +COP 2080 1LOG 20BC AI 2798 •
 20A6 •2FF0 2004 5W 2708 •A 2642 •MES 208C •W 2A88 E
 208E A71T 205A S-T 214A •ARG 20A2 .5 2A88 AEAP 20AA •
 2078 \$* 211A • 2038 •H 20D8

BY-NC-ND

2798 • 27D2 • 218A 6CFT 298C ALLOG 2A82 AEKP 2A88 E-
2CJE A1NT 2C3V • 2CDE • CFCIP 2744 6 2D4E • RARG 2D78 \$-
2DA2 • 2DA6 • ZFRU 21AA • ERCHT 27AC ,0 2E02 • MES 2E8C •
2EP2 • V 2E0C 01

1924- 2683.

T0T= 4.9217
 M0T= .4215
 S= 12.7632
 LITOT= 29.6122
 LIFT= 25.9343
 TSTOT= 24.0402
 TST= 24.0402
 STOT= 25.1123
 TSP= 23.23441
 TSS= 23.23441
 SPCEITE= 43705.632

ND

VIO OPERATING SYSTEM VERSION 312 03/04/74 GENERATED 04/27/74

| | | | |
|----|--------------------|----------------|------|
| 0R | HANDLING CHARGE | • 0.25 / JDS | • 33 |
| 25 | LITERS PRINTED PRT | • 1.00 / K/L | • 13 |
| 84 | CARDS READ | • 1.00 / K/CN | • 13 |
| 00 | PLATES FACTORS | • 0.25 / JDS | • 33 |
| 15 | WHEELS RECORDING | • 25.00 / K/RS | • 1 |
| 30 | MONITOR RECORDING | • 12.50 / K/R | • 17 |
| | TOTAL CHARGE | • 74 | |

EFIR #6 14731 LOGGED OUT 04/29/74 18:05 • 5 26-17 LEFT AFTER 38 LOGINS.

This case gave a result close to the correct solution with the bottom stressed to almost DST.

Next is presented the "1000 ft steel case" where still another difficulty was encountered and a procedure to have the bottom stressed to DST is exemplified.

STRENGHT OF SHIPS~ON THE NEUTRAL AXIS LOCATION

PAGE 1

```

04   C   *AL* IS THE LENGTH
04   AL=1000.
0C   B=AL/5.75
18   C   *DRA* IS THE DRAFT
18   DRA=B/3.3
24   D=AL/14.
30   C   *POI* IS THE POISSON'S RATIO OF THE MATERIAL
30   FOR STEEL
30   POI=0.3
38   C   *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
38   FOR STEEL
38   E=30.*10.*6
4C   C   *DST* IS THE DESIGN STRESS
4C   DST=25000.
54   C   *EM* IS THE BENDING MOMENT
54   BM=1.37143*B*DRA*AL*AL
6C   W=0.34396*(1.-POI*POI)*DST/E
8C   U=SQRT(W)
98   Z=1./U
A4   *HTOP* IS THE HEAD OF WATER ON DECK
A4   HTOP=8.
AC   *HBOT* IS THE HEAD OF WATER ON BOTTOM
AC   HBOT=DRA
B4   STR3T=0.152222*HTOP*Z*Z
C8   STR3B=0.152222*HBOT*Z*Z
DC   A=DST-STR3T
E8   AB=DST-STR3B
F4   AC=(AB*(B+C)-A*D)/(A*B)
2C   AD=BM*(B+D)/(A*4.*D*(D*D+2.*B*D))
78   AE=(3.*B*B+2.*B*D)/(D*D+2.*B*D)
C4   C   *TOP* IS THE THICKNESS OF THE TOP PLATING
C4   *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
C4   BOT=AD/(1.+AC*AE)
DC   TOP=AC*BOT
E8   WRITE(5,10)TOP
34   10 FORMAT('1',20X,'TOP='F10.4)
1E   WRITE(5,20)BOT
3A   20 FORMAT(' ',22X,'BOT='F10.4)
54   C   *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
54   S=Z-TOP
50   WRITE(5,30)S
7C   30 FORMAT(' ',22X,'S='F10.4)
74   P=2.*D*BOT+B*(TOP+BOT)
88   C   *DITOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
88   DITOP=D*(B*BOT+D*BOT)/P
DC   WRITE(5,40)DITOP
88   40 FORMAT(' ',18X,'DITOP='F10.4)
14   C   *DIBOT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS
14   DIBOT=D*(B*TOP+D*BOT)/P
18   WRITE(5,50)DIBOT
24   50 FORMAT(' ',18X,'DIBOT='F10.4)
20   C   *GMI* IS THE MOMENT OF INERTIA OF THE X SECTION ABOUT N.A.

```


STRENGHT OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE 2

```

170      GMI=4.*D*D*((3.*A*B+2.*B*D)*TOP*BOT+(D*D+2.*B*D)*BOT*BOT)/P
1E0      C      *TSTH* IS THE STRESS ON TOP DUE TO HOGGING
1E0      C      *TSTS* IS T-E STRESS ON TOP DUE TO SAGGING
1E0      C      *TSBH* IS THE STRESS ON BOT DUE TO HOGGING
1E0      C      *TSBS* IS THE STRESS ON BOT DUE TO SAGGING
1E0      C      *STCRIT* IS THE CRITICAL STRESS ON TOP
1E0      C      *SBCRIT* IS THE CRITICAL STRESS ON BOT
1E0      TSTH=BM*DITOP/GMI+STR3T
F4       TSTS=BM*DITOP/GMI+STR3T
28       STCRIT=TOP*TOP*E/(2.30396*S*S*(1.-POI*POI))
48       WRITE(5,60)TSTH
64       60 FORMAT(' ',19X,'TSTH='F10.3)
7E       WRITE(5,70)TSTS
9A       .
70       FORMAT(' ',19X,'TSTS='F10.3)
54       WRITE(5,80)STCRIT
80       FORMAT(' ',17X,'STCRIT='F10.3)
EC       TSBH=BM*DIBOT/GMI+E.152222*HBOT*S*S/(BOT*BOT)
28       TSBS=BM*DIBOT/GMI+E.152222*HBOT*S*S/(BOT*BOT)
64       SBCRIT=BOT*BOT*E/(2.30396*S*S*(1.-POI*POI))
A4       WRITE(5,90)TSBH
CQ       90 FORMAT(' ',19X,'TSBH='F10.3)
DA       WRITE(5,100)TSBS
F6       100 FORMAT(' ',19X,'TSBS='F10.3)
10       WRITE(5,110)SBCRIT
2C       110 FORMAT(' ',17X,'SBCRIT='F10.3)
48       END
[S]   •U    064C[V] AL    0654[V] B     065C[V] DRA    0664[V] P
[V]   POI   0674[V] E     0690[S] •R    0684[V] DST    068C[V] BM
[V]   W    06A0[V] U     0700[S] SQRT   06A4[V] Z     06A8[V] HTOP
[V]   HBOT  06B4[V] STR3T  06BC[V] STR3B  06C0[V] A     06C4[V] AB
[V]   AC    06DC[V] AD    06F0[V] AE    06F8[V] BOT    06FC[V] TOR
[L]   10    0720[S] @I    073A[L] 20    0720[V] S     072C[L] 3A
[V]   P    0708[V] DITOP  07F8[L] 4A    070C[V] DIBOT  0354[L] 5V
[V]   GMI   071C[V] TSTH   0720[V] TSTS   0724[V] STCRIT 0464[L] 6W
[L]   70    04D0[L] 80    0728[V] TSBH   072C[V] TSBS   0730[V] SBCRIT
[L]   90    05F6[L] 100   062C[L] 110   0000[S] •V
[Q]   L

```

RAM LABELS:

| | | | | | |
|------------|-----------|------------|-----------|----------|----------|
| 170 •MAIN* | 2E3A •V | 2C6A •COMP | 298C ALOG | 2E48 @I | 27A4 •R |
| 132 •ZERO | 2C90 \$6 | 27E4 •A | 2D8E •MES | 2C0C •W | 2A94 EXP |
| 19A AINT | 2896 SQRT | 2CD2 •RARG | 2D2E •5 | 2D04 \$8 | 2D36 •E |
| 36 •O | 2E0C •U | 3F64 | | | |

Y-POINTS:

| | | | | | |
|----------|-------------|-----------|------------|----------|----------|
| A4 •R | 27E4 •A | 2896 SQRT | 298C ALOG | 2A94 EXP | 2B9A AIN |
| 2C •W | 2C6A •COMP | 2C90 \$6 | 2CD2 •RARG | 2D04 \$8 | 2D2E •5 |
| 32 •ZERO | 2D36 •ERCNT | 2D38 •0 | 2D8E •MES | 2E18 •U | 2E3E •V |
| 48 @I | | | | | |

TOP= 6.1748
BOT= -5.5523
S= 406.7124
DITOP= 142.7614
DIBOT= -70.6328
TSTH= 24999.992
TSTS= 24999.992
STCRIT= 24999.988
TSBH= 33241.840
TSBS= 33241.840
SBCRIT= 2 213.254

ND

VIO OPERATING SYSTEM VERSION 1 REVISION 012 03/04/74 GENERATED 04/30/74

| | | | |
|----------------------|---------|--------|-----|
| JB HANDLING CHARGE | \$.35 | / JNB | .35 |
| 25 LINES PRINTED FR2 | \$ 1.25 | / K LN | .16 |
| 34 CARDS READ | \$ 1.50 | / K CD | .13 |
| 10 PLOTTER VECTORS | \$.25 | / 1000 | .02 |
| 21 MODEL 70 SECONDS | \$25.00 | / HOUR | .15 |
| 10 MODEL 80 SECONDS | \$12.50 | / HOUR | .06 |
| TOTAL CHARGE \$ | | | .79 |

REIR 490 14731 LOGGED OUT 04/30/74 21:26. \$ 27.07 LEFT AFTER 50 LOGINS.

It does not come as a surprise that the program does not work for the "1000 ft steel case" since in this situation we obtain STR3B DST which cannot be accepted and also this program is not prepared to handle.

$$AL = 1000$$

$$B = AL/5.75 = 173.913$$

$$DRA = B/3.3 = 52.7$$

$$POI = 0.3$$

$$E = 30 \times 10^6$$

$$DST = 25000$$

$$BM = 1.37143 \times B \times DRA \times AL^2 = 12569.45 \times 10^6$$

$$W = 0.30396 \times (1 - POI^2) \times DST/E = 230.503 \times 10^{-6}$$

$$U = W = 15.182 \times 10^{-3}$$

$$Z = 1/U = 65.867$$

$$HBOT = DRA = 52.7$$

$$STR3B = 0.152222 \times HBOT \times Z^2 = 34803.57 \quad DST$$

Since we understand that the program should work for DST > STR3B we make the next run with DST = 35000 to prove that in such case a solution is obtained, and after proceed to obtain the actual solution for the case we were considering with DST = 25000.

STRENGTH OF SHIPS ON THE NEUTRAL AXIS LOCATION

```

04      C      *AL* IS THE LENGTH
04      C      AL=10000.
0C      C      B=AL/5.75
18      C      *DRA* IS THE DRAFT
18      C      DRA=B/3.3
24      C      D=AL/14.
30      C      *POI* IS THE POISSON'S RATIO OF THE MATERIAL
30      C      FOR STEEL
30      C      POI=0.3
38      C      *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
38      C      FOR STEEL
38      C      E=30.*10.*1000000.
40      C      *DST* IS THE DESIGN STRESS
40      C      DST=350000.
54      C      *BM* IS THE BEARING MOMENT
54      C      BM=1.37143*B*DRA*AL*AL
60      C      W=0.34396*(1.-POI*POI)*DST/E
80      C      U=SQRT(W)
98      C      Z=1./U
A4      C      *HTOP* IS THE HEAD OF WATER ON DECK
A4      C      HTOP=8.
AC      C      *HBOT* IS THE HEAD OF WATER ON BOTTOM
AC      C      HBOT=DRA
84      C      STR3T=0.152222*HTOP*Z*Z
C8      C      STR3B=0.152222*HBOT*Z*Z
DC      C      A=DST-STR3T
E8      C      AB=DST-STR3B
F4      C      AC=(AB*(B+D)-A*D)/(A*B)
F0      C      AD=BM*(B+D)/(A*4.*D*(D*D+2.*B*D))
78      C      AE=(3.*B*D+2.*B*D)/D*D+2.*B*D)
C4      C      *TOP* IS THE THICKNESS OF THE TOP PLATING
C4      C      *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
C4      C      BOT=AD/(1.+AC-AE)
DC      C      TOP=AC*BOT
C8      C      WRITE(5,1F)TOP
C4      10 FORMAT('1',22X,'TOP='F10.4)
E      C      WRITE(5,2W)BOT
IA      20 FORMAT('1',22X,'BOT='F10.4)
C      C      *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
C      C      S=Z*TOP
C      C      WRITE(5,30)S
C      30 FORMAT('1',22X,'S='F10.4)
C      C      P=2.*D*BOT+B*(TOP+BOT)
C      C      *DITOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
C      C      DITOP=D*(B*BOT+D*BOT)/P
C      C      WRITE(5,40)DITOP
C      40 FORMAT('1',18X,'DITOP='F10.4)
C      C      *DIBOT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS
C      C      DIBOT=D*(B*TOP+D*BOT)/P
C      C      WRITE(5,50)DIBOT
C      50 FORMAT('1',18X,'DIBOT='F10.4)
C      C      *GMI* IS THE MOMENT OF INERTIA OF THE X SECTION ABOUT N.A.

```


STRENGHT OF SHIPS-ON THE NEUTRAL AXIS LOCATION

```

70      GMI=4.*D*D*((3.*R*R+2.*B*B)*TOP*BOT+(D*D+2.*B*B)*BOT*BOT)/P
E0      C *TSTH* IS THE STRESS ON TOP DUE TO HOGGING
E0      C *TSTS* IS THE STRESS ON TOP DUE TO SAGGING
E0      C *TSRH* IS THE STRESS ON BOT DUE TO HOGGING
E0      C *TSBS* IS THE STRESS ON BOT DUE TO SAGGING
E0      C *STCRIT* IS THE CRITICAL STRESS ON TOP
E0      C *SBCRIT* IS THE CRITICAL STRESS ON BOT
E0      C TSTH=EM*DITOP/GMI+S-R3T
F4      TSTS=BH*DITOP/GMI+S-R3T
08      STCRIT=TOP*TOP+E/(P.30396*S*S*(1.-POI*POI))
48      WRITE(5,60)TSTH
64      60 FORMAT(' ',19X,'TSTH='F10.3)
7E      WRITE(5,70)TSTS
9A      70 FORMAT(' ',19X,'TSTS='F10.3)
34      WRITE(5,80)STCRIT
D0      80 FORMAT(' ',17X,'STCRIT='F10.3)
EC      TSBH=EM*DIP01/GMI+0.152222*HBOT*S*S/(BOT*BOT)
28      TSBS=EM*DIP01/GMI+0.152222*HBOT*S*S/(BOT*BOT)
54      SBCRIT=BOT*BOT+E/(P.32396*S*S*(1.-POI*POI))
44      WRITE(5,90)TSBH
100     90 FORMAT(' ',19X,'TSBH='F10.3)
1A      WRITE(5,100)TSBS
66      100 FORMAT(' ',19X,'TSBS='F10.3)
10      WRITE(5,110)SBCRIT
1C      110 FORMAT(' ',17X,'SBCRIT='F10.3)
98      END
L(S) •U 064C[V] AL    0654[V] B    065C[V] DRA    0664[V] D
E(V) POI 0674[V] E    0684[V] DST    068C[V] BM
S(V) W   06A0[V] U    06A4[V] Z    06A5[V] HTOP
8(V) HBOT 06B4[V] STR3T 06B8C[V] STR3B 06C0[V] A    06C4[V] AF
C(V) AC   06DC[V] AD    06F[V] AE    06F8[V] BOT    06FC[V] TOP
1(L) 10   0000[S] @I    0231[L] 20    0700[V] S    0270[L] 32
(V) P   0708[V] DITOP  02F9[L] 40    0720C[V] DIBOT  0354[L] 52
1(V) GMI  071C[V] TSTH  0720[V] TSTS  0724[V] STCRIT  0464[L] 62
1(L) 70   04D0[L] 80    0728[V] TSRH  072C[V] TSBS  0730[V] SBCRIT
0(L) 90   05F6[L] 100   062C[L] 110   0000[S] .V
3      L

```

RAM LABELS:

| | | | | | |
|-----------|-----------|------------|-----------|-----------|----------|
| 70 *MAIN* | 2E8A .V | 2CEA .COMP | 298C ALOG | 2EC8 @I | 27A4 .R |
| B2 •ZERO | 2D10 \$6 | 27E4 .A | 2E0E •MES | 2C8C •W | 2A94 EXP |
| 1A AINT | 2896 SQRT | 2D52 •RARG | 2DAE •5 | 2A94 AEXP | 2D26 •E |
| 184 \$8 | 2DB6 .C | 2E8C .U | 3FE4 | | |

HY-POINTS:

| | | | | | |
|---------|------------|-------------|-----------|------------|----------|
| 1A •R | 27E4 .A | 2896 SQRT | 298C ALOG | 2A94 AEXP | 2A94 EXP |
| 1A AINT | 2C8C .W | 2CFA •COMP | 2D10 \$6 | 2D52 •RARG | 2D84 \$8 |
| 1AE •5 | 2DB2 •ZERO | 2DB6 •ERCNT | 2DB8 .C | 2E0E •MES | 2E98 .U |
| 1BE •V | 2EC8 @I | | | | |

TCP= 0.4626
BCT= 9.7569
S= 25.7529
DITCP= 53.9186
DIBCT= 17.5099
TSTH= 34999.977
TSTS= 34999.977
STCRIT= 35000.016
TSPH= 1 196.547
TSES= 1 196.547
SBCRIT=***** (too high outside format range)

ND

AVIC OPERATING SYSTEM VERSION 1 REVISION 012 03/04/74 GENERATED 04/27/74

| | | |
|----------------------|-----------------|-----|
| 08 HANDLING CHARGE | \$.35 / JOB | .35 |
| 25 LINES PRINTED PRF | \$ 1.25 / K LN | .16 |
| 34 CARDS READ | \$ 1.50 / K CD | .13 |
| 30 PLOTTER VECTORS | \$.25 / 1000 | .00 |
| 15 MODEL 70 SECONDS | \$ 25.20 / HOUR | .10 |
| 20 MODEL 80 SECONDS | \$ 12.50 / HOUR | .00 |
| | TOTAL CHARGE \$ | .74 |

REIR 490 14731 LOGGED OUT 04/29/74 20:46. \$ 32.45 LEFT AFTER 43 LOGINS.

Now let's consider our situation with DST = 25000. Once the situation is such that due to the approximation made in

$$\frac{S}{BOT} = Z$$

we end up with a STR3B > DST we must consider a value Z1 lower than Z to bring STR3B down. This can be also understood since it is acceptable to make here

$$\frac{S}{TOP} = Z$$

but because we obtain with the program as is TOP << BOT, making the approximation

$$\frac{S}{BOT} = Z$$

makes Z attain a much larger value than it actually should.

We must then consider Z1 < Z = 65.8 and may start by trying

$$Z1 = 35$$

The computer printout in this case is as follows.

STRENGTH OF SHIPS ON THE NEUTRAL AXIS LOCATION

PAGE 1

```

84      C      *AL* IS THE LENGTH
84          AL=1000.
80      C      *HAL* IS THE DRAFT
80          HAL=13.3
84      C      *E* IS THE POISSON'S RATIO OF THE MATERIAL
80      C      FOR STEEL
80      C      E=0.3
80      C      *EY* IS THE YOUNG'S MODULUS OF THE MATERIAL
80      C      FOR STEEL
80          EY=210000000000.0
80      C      *SIG* IS THE ALLOWED STRESS
80          SIG=500000000.0
80      C      *M* IS THE BENDING MOMENT
80          M=1.37143*B*HAL*AL
80          M=2.26346*(1+AF)*SIG*D
80          D=SIG/EY
80          Z=1.71
80      C      *HTOP* IS THE HEAD OF WATER ON DECK
80          HTOP=8.
80      C      *HBOT* IS THE HEAD OF WATER ON BOTTOM
80          HBOT=0
84      C      STRGT=0.158222*HTOP*Z*Z
80          Z1=2F.
80          STRGP=0.158222*HBOT+Z1*Z1
80          AF=STRGT-STRGP
80          AF=SIG-STRGP
80          AC=(AF*(B+D)-A*F)/((A*P))
80          AF=(F-M*(B+D))/((A*4.*P*(D*B+2.*B*D)))
80          M=(D*2.*B+2.*B*D)/(P*D+2.*B*D)
80      C      *TCP* IS THE THICKNESS OF THE TOP PLATING
80      C      *EOT* IS THE THICKNESS OF THE BOTTOM PLATING
80          EOT=D/(1+AC*AF)
80          TCP=AC*EOT
80          WRITE(5,10)TCP
80      10 FORMAT(1I,20X,1TOP=F10.4)
80      WRITE(5,20)EOT
80      20 FORMAT(1I,20X,1BOT=F10.4)
80      C      *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
80          S=2*TCP
80          WRITE(5,30)S
80      30 FORMAT(1I,20X,1S=F10.4)
80          S=2.*E*EOT+F*TGP+EOT
80      C      *LTOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
80          LTOP=D*(P*BCT+D*BCT)/P
80          WRITE(5,40)LTOP
80      40 FORMAT(1I,18X,1LTOP=F10.4)
80      C      *LBOT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS
80          LBOT=D*(B*TGP+D*BCT)/P
80          WRITE(5,50)LBOT
80      50 FORMAT(1I,18X,1LBOT=F10.4)

```


STRENGTH OF SHIPS ON THE NEUTRAL AXIS LOCATI

PAGE 2

178 C \rightarrow S₁₁₁ IS THE MOMENT OF INERTIA OF THE X SECTION ABOUT Z+Z
 179 C \rightarrow T₁₁₁=4.00*10⁻¹((D+2.*R+D)*TOP*BOT+(D*D+2.*R*R)*BOT*BOT)/R
 180 C \rightarrow T₁₁₁ IS THE STRESS ON TOP DUE TO FOGGING
 181 C \rightarrow T₁₁₁ IS THE STRESS ON TOP DUE TO FOGGING
 182 C \rightarrow T₁₁₁ IS THE STRESS ON BOT DUE TO FOGGING
 183 C \rightarrow T₁₁₁ IS THE STRESS ON BOT DUE TO FOGGING
 184 C \rightarrow S₁₁₁ IS THE CRITICAL STRESS ON TOP
 185 C \rightarrow S₁₁₁ IS THE CRITICAL STRESS ON BOT
 186 C \rightarrow T₁₁₁=MODTUR/G*(1+S₁₁₁)
 187 C \rightarrow T₁₁₁=MODTUR/G*(1+S₁₁₁)
 188 C \rightarrow S₁₁₁=TOP*T₁₁₁*F/(1.24396*8*S*(1-F01*F01))
 189 C \rightarrow WHITE (5.62) TSHT
 190 C PLANET(1,1,18Y,11SHT=F10.3)
 191 C \rightarrow WHITE (5.70) TSHT
 192 C PLANET(1,1,18Y,11SHT=F10.3)
 193 C \rightarrow WHITE (5.70) STR3T
 194 C \rightarrow PLANET(1,1,17Y,11TOPIT=F10.3)
 195 C \rightarrow S₁₁₁=TOPIT*BOT/(1.152222*HGT*8*S*(BOT*BOT))
 196 C \rightarrow T₁₁₁=TOPIT*BOT/(1.152222*HGT*8*S*(BOT*BOT))
 197 C \rightarrow S₁₁₁=IT=F01*BOT*BOT/(1.24396*8*S*(1-F01*F01))
 198 C \rightarrow WHITE (5.62) TSHT
 199 C PLANET(1,1,18Y,11SHT=F11.3)
 200 C \rightarrow WHITE (5.100) TSHT
 201 C PLANET(1,1,18Y,11SHT=F10.3)
 202 C \rightarrow WHITE (5.111) TSHT
 203 C PLANET(1,1,17Y,11SHT=F11.3)
 204 C END

| | | | | | |
|-----|--------|---------------|---------------|--------------|----------------|
| [S] | * | 2E54[V] AL | .650[V] R | 6E4[V] DRA | 1660[V] P |
| [V] | PCT | 2E7CFV] E | .100[S] .R | 6E0C[V] DST | 2E94[V] RM |
| [V] | * | 2EAFMV] U | .90[S] SRFT | 6E0C[V] Z | 2AB7[V] HTOP |
| [V] | HGT | 2EACMV] STR3T | 604[V] Z1 | 6E0C[V] STFB | 2AD1[V] A |
| [V] | A | 2E08[V] AC | 5E0C[V] AD | 671*[V] AE | 2788[V] BOT |
| [V] | TDF | 2E0CELV] 1P | 800[S] SI | 2E42[L] 2P | 2711[V] S |
| [L] | 3 | 2714[V] P | 2718[V] DITOP | 2308[L] 4P | 2710[V] DIBOT |
| [L] | 5 | 2720[V] GMI | 2720[V] TSH | 2720[V] TSTS | 2734[V] STCRIT |
| [L] | 6 | 24A8ELV] 7P | 408[L] 86 | 2728[V] TSFH | 2730[V] TSFS |
| [V] | SACRIT | 2ECAELV] 9P | 5E0E[L] 10P | 2634[L] 11P | 2004[S] .V |

L

GRAM LABELS:

| | | | | | |
|-----------|-----------|------------|-----------|------------|---------|
| 2E0 *MAIN | 2ECA *V | 2EFA *COMP | 2E9C ALG | 2ED8 @I | 27B4 *? |
| 2E2 *ZERO | 2E24 \$C | 27F4 *A | 2E1E *MES | 2C9C *W | 2AA4 EX |
| 2E8A ATNT | 2E26 SRFT | 2.62 *RARG | 2E8E *S | 2AA4 AEEXP | 2D06 *E |
| 2E4 4P | 2ECC *C | 2E9C *U | 2EF4 | | |

KEY-POINTS:

| | | | | | |
|----------|------------|-------------|----------|------------|---------|
| 2E4 *P | 2EFA *A | 2E46 SOFT | 2E9C ALG | 2AA4 AEEXP | 2AA4 EX |
| 2E4 ATNT | 2EFC *P | 2EFA *COMP | 2E22 *S | 2D42 *RARG | 2D94 *? |
| 2E4 *S | 2ECC *ZERO | 2ECA *EFONT | 2E0E *Q | 2E1F *YES | 2EA8 *U |
| 2E4 *V | 2EFC *P | | | | |

TOPS= 3.4624
 EOT= 5.1711
 S#= 225.4150
 LITOP= 42.3758
 LIFF= 31.7423
 TSTUS= 24990.023
 TSTB= 24990.023
 STC91TB= 24990.022
 TSC4= 31022.945
 TSB3= 31022.945
 SACHIT= 54892.211

NO

V10 OPERATING SYSTEM VERSION 1 REVISION 112 3/04/74 GENERATED 4/27/74

| | | | | |
|----------------------|--------|-------|-------|-----|
| CB HANDLING CHARGE | 4 | •25 | / JHR | •20 |
| 25 LINES PRINTED PR1 | 7 | 1.25 | / L | •14 |
| 25 CARDS READ | 5 | 1.25 | / C | •13 |
| 22 PLOTTER VECTORS | 2 | •25 | / JHR | •00 |
| 21 MODEL 2 SEC'DS | 225.00 | / KHR | •15 | |
| 67 MODEL 3 SEC'DS | 512.00 | / KHR | •20 | |
| TOTAL CHARGE | | | | •70 |

FIR 490 14731 LOGGED OUT 34/29/74 2A:59.0 ± 0.00 LEFT AFTER 4th ENGINE.

This time we obtained a realistic but still unacceptable result; we notice that the bottom is being stressed to 31000 psi when it can only go up to 25000 psi; besides we assumed

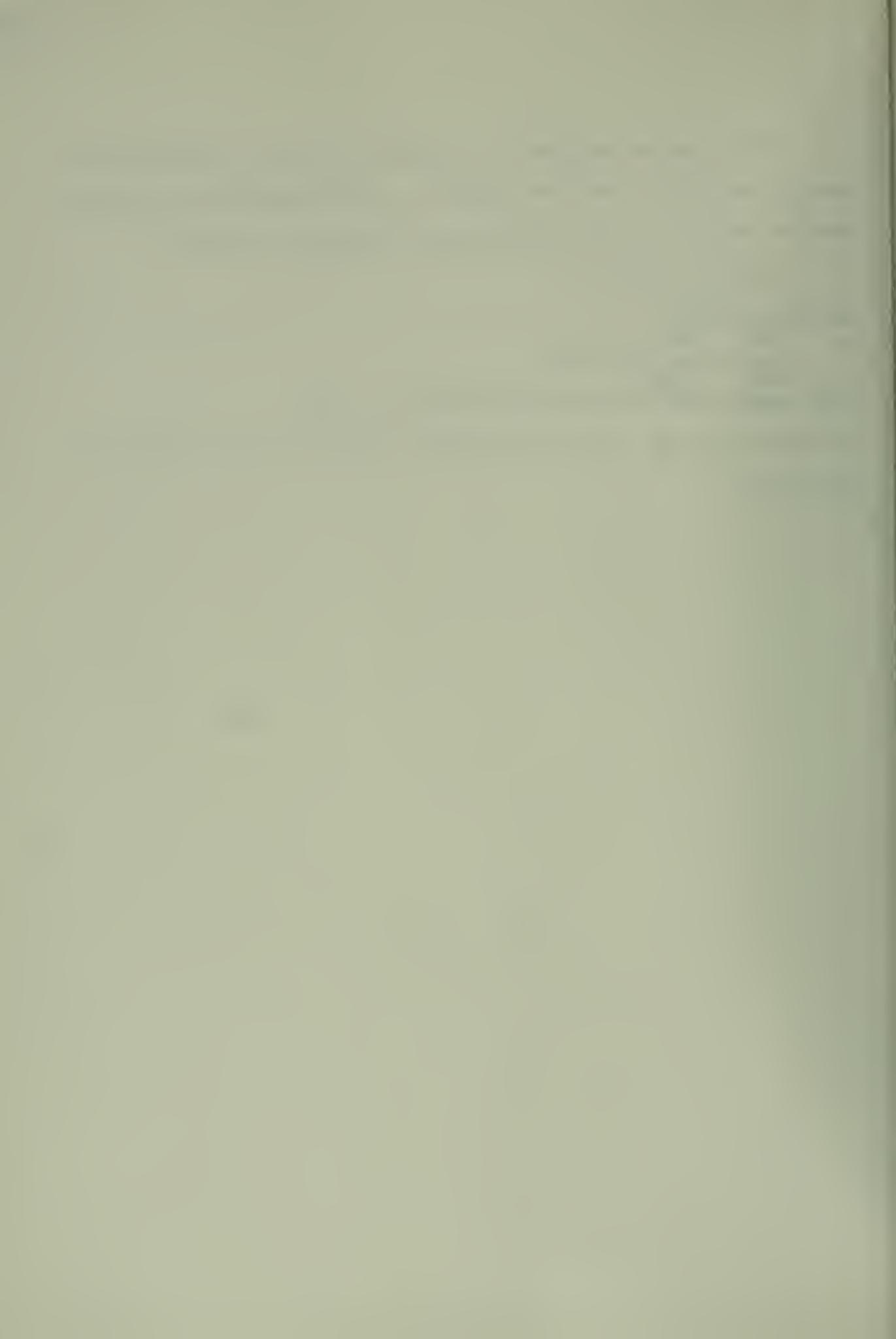
$$Z_1 = \frac{S}{BOT} = 35$$

and end up with

$$\frac{S}{BOT} = \frac{225.4}{5.07} = 44.46$$

This means that the Z_1 value should be higher.

We may now try $Z_1 = 40$; the computer results for this case are shown next.



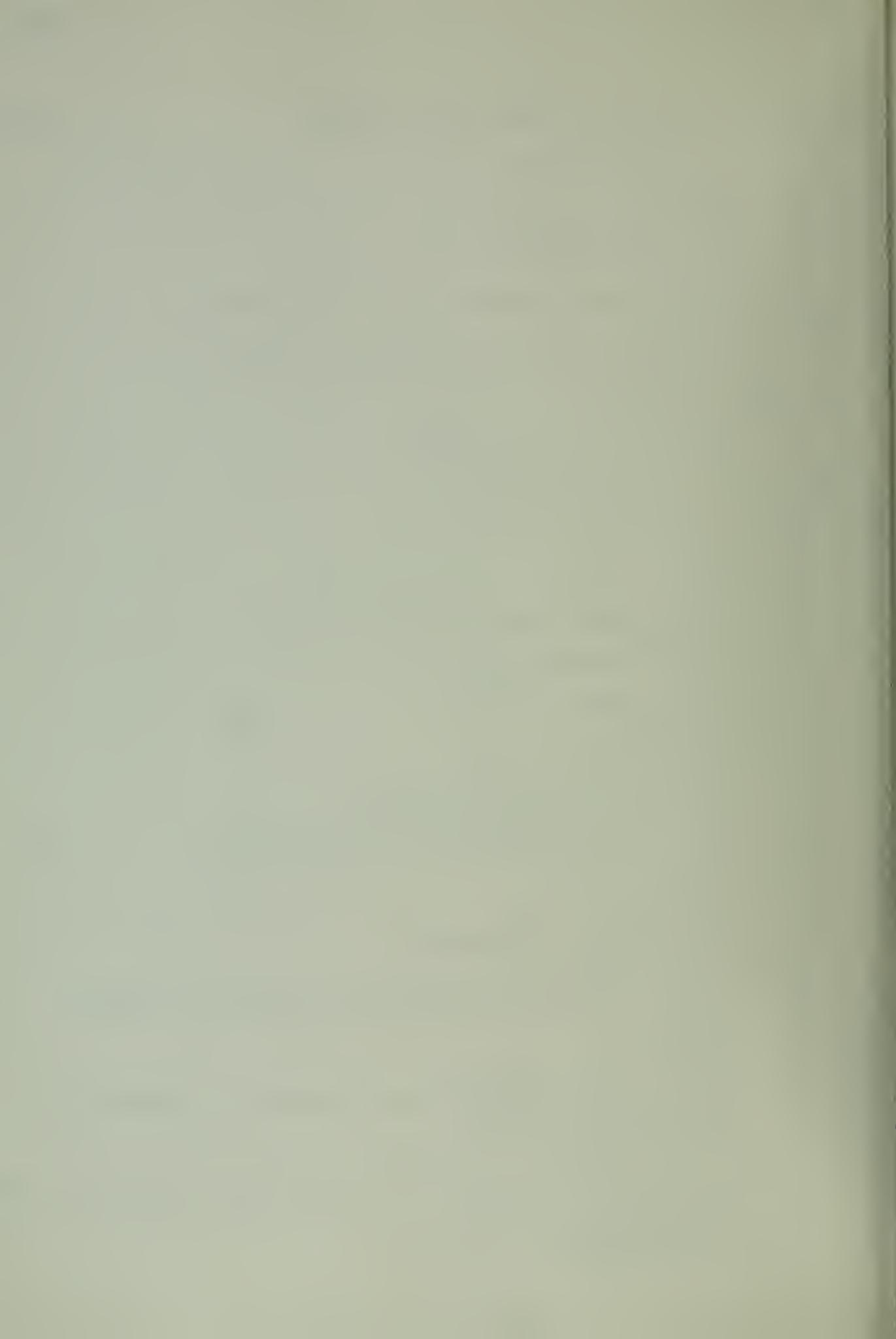
STRENGTH OF SHIPSON THE NEUTRAL AXIS LOCATION

PAGE 1

```

24      C      *AL* IS THE LENGTH
24          AL=100.0
20      C      *DRA* IS THE DRAFT
18          DRA=K/3.0
24          DRA/14.0
30      C      *POI* IS THE POISSON'S RATIO OF THE MATERIAL
22          FOR STEEL
32          POI=.25
32      C      *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
30          FOR STEEL
38          E=30.*E1***6
40      C      *GST* IS THE DESIGN STRESS
40          GST=250.0
54      C      *BMT* IS THE BENDING MOMENT
54          BMT=1.37143*B*DRA*AL*AL
60          =B0.34376*(1+GST*POI)*GST/E
80          GST=(N)
95          Z=1.70
14      C      *HTOP* IS THE HEAD OF WATER ON DECK
14          HTOP=R.
40      C      *HOT* IS THE HEAD OF WATER ON BOTTOM
40          HOT=DRA
64          STR3T=0.152222*HTOP*Z+Z
62          Z1=4.0
10          STR3B=0.152222*HOT*Z1+Z1
64          AF=GST-STR3T
64          AM=GST-STR3B
64          ACF=(AF*(R+D)-A*F)/(A*B)
134         AF=BM*((R+D)/(A+B+*D*(D+D+2.*B*D)))
180         AEF=(3.*B**B+2.*B*D)/(D*D+2.*B*D)
100      C      *TOP* IS THE THICKNESS OF THE TOP PLATING
100      C      *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
100          BOT=AD/(1+AC*AF)
154          TOP=AC*BOT
150          WRITE(5,10)TOP
210          1  FORMAT('1',2X,1TOP=1E12.4)
226          WRITE(5,20)BOT
242          2  FORMAT('1',22V,1BOT=1E12.4)
400          C      *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
400          S=Z+TOP
400          WRITE(5,30)S
284          3  FORMAT('1',22V,1S=1E12.4)
400          P=2.*D*BOT+B*(TCP+BOT)
400          *DITOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
400          DITOP=D*(E*BOT+C*BOT)/P
400          WRITE(5,40)DITOP
400          4  FORMAT('1',18V,1DITOP=1E10.4)
400          *DIBOT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS
400          DIBOT=D*(E*TCP+C*BOT)/P
400          WRITE(5,50)DIBOT
400          5  FORMAT('1',18V,1DIBOT=1E10.4)

```



STRENGTH OF SHIPS ON THE NEUTRAL AXIS LOCATION

PAGE 2

```

279 C *GMI* IS THE MOMENT OF INERTIA OF THE X SECTION ABOULT ' +A.
278 C GMI=4.*D*D*((D+R+B+2.*R*D)*TOP*BOT+(D*D+2.*B*D)*BOT*B*T)/P
288 C *TSTH* IS THE STRESS ON TOP DUE TO LOGGING
288 C *TSFH* IS THE STRESS ON TOP DUE TO FLOGGING
288 C *TSBF* IS THE STRESS ON BOT DUE TO LOGGING
288 C *TSBS* IS THE STRESS ON BOT DUE TO FLOGGING
288 C *TCRIT* IS THE CRITICAL STRESS ON TOP
288 C *TSRCRIT* IS THE CRITICAL STRESS ON BOT
288 C TETH=FRM*D10P/9.1*TSTH
288 C TSTS=9.1*TDF/G*1.1*TSTH
310 C STCRIT=TOP*BOT*E/(C.37396*E*S*(1.+F01*PC1))
310 C WRITF(S,40)TSTH
460 C F1FORMAT(' ',19X,11S1H=(F11.3))
466 C WF1TF(S,70)TSTS
462 C F2FORMAT(' ',19X,11S1H=(F11.3))
380 C WF1TF(S,80)STCRIT
388 C F3FORMAT(' ',19X,11TCRIT=(F11.3))
484 C TSE=FRM*D10P/9.1*22222*HROT*S*E/(BOT*RCT)
484 C TFS=FRM*D10P/9.1*22222*HROT*S*E/(BOT*RCT)
460 C STCRIT=D07*HOT*E/(C.37396*E*S*(1.+F01*PC1))
460 C WF1TF(S,80)TSTS
488 C F4FORMAT(' ',19X,11S1H=(F11.3))
488 C WF1TF(S,100)TSTS
488 C F5FORMAT(' ',19X,11S1H=(F11.3))
488 C WF1TF(S,110)STCRIT
484 C F6FORMAT(' ',19X,11S1H=(F11.3))
50 C E17
{S} .0. 6654[V] AL 6650[V] B 6674[V] DRA 6660[V] D
{V} F01 6670[V] E 6627[S] .R 6610[V] DST 6694[V] BM
{V} . 6684[V] I 6628[S] SGET 6610[V] Z 6680[V] HTOP
{V} R OT 6690[V] STFBT 6654[V] Z1 6610[V] STFB 66D1[V] A
{V} R 6698[V] AC 6650[V] AD 6710[V] AE 6738[V] BOT
{V} TOT 6620[L] 10 6622[S] OI 6242[L] 28 6710[V] S
{L} 3. 2714[0] P 6714[V] D10P 6302[L] 42 6710[V] DIGUT
{L} 3. 6720[V] GMI 6720[V] TSTH 6720[V] TSTS 6734[V] STCRIT
{L} 6. 6412[L] 72 6408[L] 80 6733[V] TSFH 6730[V] TSTS
{V} S-CRIT 6508[L] 92 6500[L] 104 6634[L] 110 6000[S] .V
{ED} L

```

PROGRAM LABELS:

| | | | | | |
|-------------|-----------|------------|------------|-----------|---------|
| 2670 •MAIN• | 2ECA •V | 2EFA •COMF | 299C ALLOG | 2ED8 @I | 2784 • |
| 2D02 •ZEPH• | 2D20 \$6 | 2EFA •A | 2E1E •MES | 2C9C •W | 2AA4 E |
| 2C2A ATNT | 2RA6 SKRT | 2D62 •RARG | 2D0E ,5 | 2AA4 AEXP | 2DC6 •E |
| 2D94 •R | 2D66 •C | 2E9C •U | 2EE4 | | |

TRY-POINTS:

| | | | | | |
|-----------|------------|-------------|------------|------------|---------|
| 27E4 •- | 27F4 •4 | 2EFA SQRT | 299C ALLOG | 2AA4 AEXP | 2AA4 E |
| 1C2A ATNT | 2C9C •" | 2CFA •CONP | 2D20 \$6 | 2D62 •RARG | 2D94 \$ |
| 2D8E •5 | 2DC2 •ZERO | 2D66 •ERCNT | 2DCE ,0 | 2E1E •MES | 2EA8 • |
| 1ECE •V | 2ED8 @I | | | | |

TOP= 3.2289
 BOT= 6.5153
 RE 199.404
 FITOP= 44.1743
 DIPOP= 21.2523
 TSTH= 24999.004
 TSTS= 24999.004
 STCRIT= 24999.004
 TSRH= 19514.004
 TSLR= 19514.004
 SPCRITE= 118337.001

NP

MINI OPERATING SYSTEM VERSION 1 REVISION V12 (3/04/74) GENERATED 4/27/74

| | | |
|-----------------------|-----------------|-----|
| JOB HANDLING CHARGE | \$ 1.25 / JOB | •35 |
| 126 LINES PRINTED PER | \$ 1.25 / K LN | •14 |
| 8K CADAS + EXP | \$ 1.50 / K CD | •13 |
| 20 PLOTTER VECTORS | \$ 1.25 / 1000 | •00 |
| 15 128X128 SCOMPS | \$ 25.00 / HOUR | •17 |
| 20 1024X1024 SCOMPS | \$ 12.50 / HOUR | •07 |
| TOTAL CHARGE | | •74 |

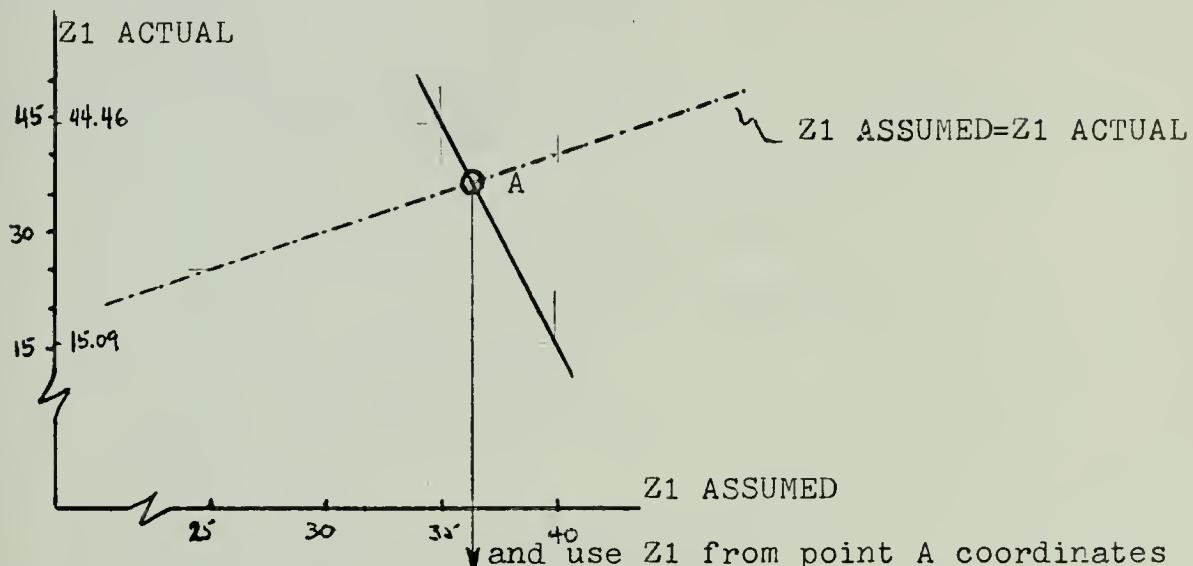
REF ID: A4731 LOGGED OUT 04/29/74 21:22 • \$ 28.62 LEFT AFTER 68 LOGINS.

In this case we assumed $Z_1 = 40$ and ended up with

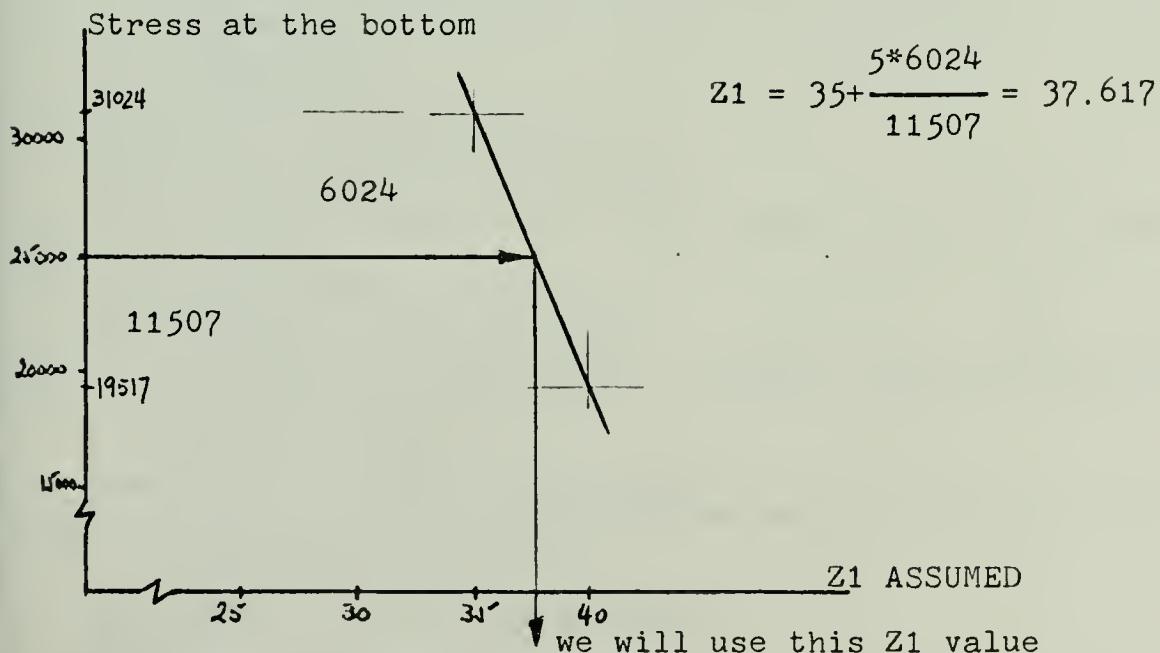
$$\frac{S}{BOT} = \frac{199.5}{6.59} = 15.09$$

and a stress at the bottom of only 19000 psi which is too small.

We may now try to use a better Z_1 value and can do the following:



or which is "the same":



The results obtained with this Z_1 value are the following:

STRENGHT OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE 1

```

184      C      *AL* IS THE LENGTH
184      AL=1000.
185      D=AL/5.75
186      C      *DRA* IS THE DRAFT
187      DRA=B/3.3
188      D=AL/14.
189      C      *POI* IS THE POISSON'S RATIO OF THE MATERIAL
190      FOR STEEL
191      POI=0.3
192      C      *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
193      FOR STEEL
194      E=30.*10.*+6
195      C      *DST* IS THE DESIGN STRESS
196      DST=25000.
197      C      *RM* IS THE BENDING MOMENT
198      RM=1.37143*B*DRA*AL
199      M=0.3*396*(1.-POI*POI)*DST/E
200      U=SQRT(M)
201      Z=1./U
202      C      *HTOP* IS THE HEAD OF WATER ON DECK
203      HTOP=?
204      C      *HBOT* IS THE HEAD OF WATER ON BOTTOM
205      HBOT=DRA
206      STR3T=2.*152222*HTOP*Z*Z
207      Z1=35.*5.*4*V24./115.7.
208      STR3B=2.*152222*HBOT*Z1*Z1
209      A=DST-STR3T
210      AB=DST-STR3B
211      AC=(AB*(B+D)-A*D)/(A*D)
212      AD=RM*(B+D)/(A*4.*D*(D*D+2.*B*D))
213      AE=(3.*B*B+2.*B*D)/(D*D+2.*B*D)
214      C      *TOP* IS THE THICKNESS OF THE TOP PLATING
215      C      *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
216      BOT=AD/(1.+AC*AE)
217      TOP=AC*BOT
218      WRITE(5,10)TOP
219      10 FORMAT(' ',20X,'TOP='F12.4)
220      WRITE(5,20)BOT
221      20 FORMAT(' ',20X,'BOT='F10.4)
222      C      *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
223      S=2.*TOP.
224      WRITE(5,30)S
225      30 FORMAT(' ',22X,'S='F10.4)
226      P=2.*D*BOT+B*(TOP+BOT)
227      C      *DITOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
228      DITOP=D*(B+BOT+D*BOT)/P
229      WRITE(5,40)DITOP
230      40 FORMAT(' ',18X,'DITOP='F10.4)
231      C      *DIBOT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS
232      DIBOT=D*(B-TOP+D*BOT)/P
233      WRITE(5,50)DIBOT
234      50 FORMAT(' ',18X,'DIBOT='F10.4)

```


STRENGHT OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE 2

```

384 C *GMI* IS THE MOMENT OF INERTIA OF THE X SECTION ABOUT N.A.
384 C GMI=4.*D*D*((3.*R*R+2.*B*D)*TOP*BOT+(D*D+2.*B*D)*BOT*BOT)/P
3F4 C *TSTH* IS THE STRESS ON TOP DUE TO HOGGING
3F4 C *TSTS* IS THE STRESS ON TOP DUE TO SAGGING
3F4 C *TSBH* IS THE STRESS ON BOT DUE TO HOGGING
3F4 C *TSBS* IS THE STRESS ON BOT DUE TO SAGGING
3F4 C *STCRIT* IS THE CRITICAL STRESS ON TOP
3F4 C *SBCRIT* IS THE CRITICAL STRESS ON BOT
3F4 C TSTH=BM*DI TOP/GMI+STR3T
408 C TSTS=BM*DI TOP/GMI+STR3T
41C C STCRIT=TOP*TOP*E/(A.32336*S*S*(1.-POI*POI))
45C C WRITE(5,60)TSTH
478 C 60 FORMAT(' ',19X,'TSTH='F10.3)
492 C WRITE(5,70)TSTS
5AE C 70 FORMAT(' ',19X,'TSTS='F10.3)
5C8 C WRITE(5,80)STCRIT
5E4 C 80 FORMAT(' ',17X,'STCRIT='F10.3)
500 C TSBH=BM*DI BOT/GMI+A.152222*HBOT*S*S/(BOT*BOT)
53C C TSBS=BM*DI BOT/GMI+A.152222*HBOT*S*S/(BOT*BOT)
578 C SBCRIT=BOT*BOT*E/(A.32336*S*S*(1.-POI*POI))
568 C WRITE(5,90)TSBH
5D4 C 90 FORMAT(' ',19X,'TSBH='F10.3)
5EE C WRITE(5,100)TSBS
50A C 100 FORMAT(' ',19X,'TSBS='F10.3)
524 C WRITE(5,110)SBCRIT
540 C 110 FORMAT(' ',17X,'SBCRIT='F10.3)
55C C END
[S] •U 0660[V] AL 0668[V] B 0670[V] DRA 2678[V] D
[V] POI 0688[V] E 0690[S] •R 0698[V] DST 26A1[V] BM
[V] W 06B4[V] U 0699[S] SQRT 06B8[V] Z 26B0[V] HTOP
[V] HBOT 06C8[V] STR3T 06D0[V] Z1 06E4[V] STR3B 26F8[V] A
[V] AB 06F0[V] AC 0704[V] AD 0718[V] AE 2720[V] BOT
[V] TOP 0218[L] 10 0722[S] @I 074E[L] 20 2728[V] S
[L] 30 072C[V] P 0732[V] DITOP 0300[L] 40 2734[V] DI BOT
[L] 50 0738[V] GMT 0744[V] TSTH 0748[V] TSTS 2740[V] STCRIT
[L] 60 074E[L] 70 074E[L] 80 0750[V] TSBH 2754[V] TSBS
[V] SBCRIT 05D4[L] 90 0601[L] 100 0640[L] 110 2000[S] •V
EQ L

```

PROGRAM LABELS:

| | | | | | |
|------------|-----------|------------|-----------|-----------|----------|
| 070 *MAIN* | 2EE2 •V | 2D12 •COMP | 29B4 ALDG | 2EF0 @I | 2700 •R |
| DDA •ZERO | 2D38 \$6 | 280C •A | 2E36 •MES | 2CB4 •W | 2AFC EXP |
| 542 AINT | 28BE SQRT | 2D7A •RARG | 2DD6 •5 | 2ABC AEXP | 2D7E •EF |
| DAC \$8 | 2DDE •C | 2EB4 •U | 402C | | |

TRY-POINTS:

| | | | | | |
|----------|------------|------------|-----------|------------|----------|
| 7CC •R | 280C •A | 28BF SQRT | 29B4 ALDG | 2ABC AEXP | 2AFC EXP |
| 542 AINT | 2CB4 •W | 2D12 •COMP | 2D38 \$6 | 2D7A •RARG | 2D7C #8 |
| DD6 •5 | 2DDA •ZERO | 2DDE •RCNT | 2DE0 •0 | 2E36 •MES | 2EC2 •U |
| EE6 •V | 2EF0 @I | | | | |

TOP= 3.2486
BOT= 5.7418
S= 213.9701
DITOP= 42.2107
DIBOT= 29.2179
TSTH= 25000.000
TSTS= 25000.000
STCRIT= 24999.992
TSBH= 24788.316
TSBS= 24788.316
SBCHIT= 78100.937

END

: VIO OPERATING SYSTEM VERSION 1 REVISION 012 03/04/74 GENERATED 04/27/74 1

| | | | |
|----------------------|---------|--------|-----|
| 10B HANDLING CHARGE | \$.35 | / JOB | .35 |
| 26 LINES PRINTED PR2 | \$ 1.25 | / K LN | .16 |
| 85 CARDS READ | \$ 1.50 | / K CD | .13 |
| 00 PLOTTER VECTORS | \$.25 | / 1000 | .00 |
| 15 MODEL 70 SECONDS | \$25.00 | / HOUR | .10 |
| 00 MODEL 80 SECONDS | \$12.50 | / HOUR | .02 |
| TOTAL CHARGE \$ | | | .74 |

EIR 490 14731 LOGGED OUT 04/29/74 21:30. \$ 27.86 LEFT AFTER 49 LOGINS.

The results show that we have obtained

$$Z_1 = \frac{S}{BOT} = \frac{213.9701}{5.7418} = 37.265$$

while it was assumed

$$Z_1 = 37.617$$

We could further correct the result until Z_1 assumed and Z_1 actual would coincide but it seems that there is no need to refine more the solution for the purpose here involved.

Note that this procedure should also be followed for the other cases in order to bring the stress at the bottom to its maximum allowed DST for such cases as well.

STIFFNESS OF SHIPSHIP IN THE NEUTRAL AXIS LOCATION

```

46      C      *L* IS THE LENGTH
47      L=12.0
48      =AUX=7
49      DRAK IS THE DRAFT
50      DRA=5.3*3
51      DEX=L/1.4
52      POI=0.3 IS THE POISSON'S RATIO OF THE MATERIAL
53      FOR ALUMINUM
54      P0T=11.23
55      EK IS THE YOUNG'S MODULUS OF THE MATERIAL
56      FOR ALUMINUM
57      E=12.412*10^6
58      DST=1.0 IS THE DESIGN STRESS
59      DST=250MPA
60      MM=TR IS THE BENDING MOMENT
61      MM=1.37143*BDRHAKAL*AL
62      =E=3.33333*(1.-POI*P0T)*DST/E
63      M=MM/(L)
64      Z=1.71
65      HTOP* IS THE HEAD OF WATER ON DECK
66      TOPR*
67      CHOPT IS THE HEAD OF WATER ON BOTTOM
68      OPTERA
69      STTRATE=1.150222*HTOP+Z*Z
70      STTRATE=1.150222*HRBT+Z*Z
71      ACTR=HTOP-Z
72      =HTOP=STTRATE
73      =ACTR=STTRATE
74      =C=(ACTR*(D+1.64*D)/(D*3))
75      =DEMM=(D*4D)/(D*4*D+(D*D+2.*B*D))
76      ACTR=(D*D+2.*B*D)/(D*D+2.*B*D)
77      C      *TOP* IS THE THICKNESS OF THE TOP PLATING
78      *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
79      BOTR=D/((1.+ACTR))
80      TOPBACK=BOT
81      =HTOP=(3.12)TOP
82      FORMAT(1.1,2/X,1TOP=E12.4)
83      =HTOP=(5.0)BOT
84      20 FORMAT(1.1,2/X,1BOT=E12.4)
85      C      *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
86      S=7*TOP
87      =HTOP=(5.37)S
88      32 FORMAT(1.1,22X,1S=E12.4)
89      =HTOP=BOT+(TOP+BOT)
90      C      *HTOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
91      DHTOP=D*(BOT+TOP)/2
92      =HTOP=(5.41)HTOP
93      40 FORMAT(1.1,18X,1DTOP=E12.4)
94      C      *DTOP* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS
95      DTOP=D*(HTOP+BOT)/2
96      =HTOP=(5.52)DTOP
97      52 FORMAT(1.1,18X,1DIRATE=E12.4)
98      C      *MIX* IS THE MOMENT OF INERTIA OF THE X SECTION ABOUT N.A.

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1370      SMTS2=XP*D1*((3+X*B+2*X*B*D)*TOP*BOT+(D*D+2*X*B*D)*BOT*BOT)/P
1372      C      *TOTS2 IS THE STRESS ON TOP DUE TO HOGGING
1373      C      *TOTS3 IS THE STRESS ON TOP DUE TO SAGGING
1374      C      *TOTS4 IS THE STRESS ON BOT DUE TO HOGGING
1375      C      *TOTS5 IS THE STRESS ON BOT DUE TO SAGGING
1376      C      *STCRIT2 IS THE CRITICAL STRESS ON TOP
1377      C      *STCRIT3 IS THE CRITICAL STRESS ON BOT
1378      C      TOTHEM=MD1+MD2/GMI+G1-RBT
1379      C      TOTSG=MD1+MD2/GMI+G2-RBT
1380      C      STCRIT2=TOP*HRE/(L+32396*S*S*(1.-POI*POI))
1381      C      RBT=(L+4M1)*TS2
1382      60      FORMAT(1.,1.9X,TOTHE14.3)
1383      C      RBT=(L+7M1)*TS3
1384      70      FORMAT(1.,1.9X,TOTS217.3)
1385      C      RBT=(L+8M1)*STCRIT
1386      80      FORMAT(1.,1.9X,STCRIT14V+3)
1387      C      TOTHEM=MD1+MD2/GMI+4.152222*HRBT*S*S/(BOT*BOT)
1388      C      TOTSG=MD1+MD2/GMI+4.152222*HRBT*S*S/(BOT*BOT)
1389      C      RBT=TOP*HRE/(L+32396*S*S*(1.-POI*POI))
1390      C      RBT=(L+8M1)*TS4
1391      90      FORMAT(1.,1.9X,TOTS314.3)
1392      C      RBT=(L+11M1)*TS5
1393      100     FORMAT(1.,1.19X,TOTS517.3)
1394      C      RBT=(L+12M1)*STCRIT
1395      110     FORMAT(1.,1.17X,STCRIT14V+3)
1396      C      END
1397      C      1398      0.0      1399      0.0      1400      0.0      1401      0.0
1402      POI      1374[V]  F      1375[V]  *R      1376[V]  DRA      0664[V]  D
1403      GMI      1375[V]  F      1376[V]  *R      1377[V]  DST      2628[V]  BM
1404      K      1376[V]  H      1377[V]  GRT      1378[V]  Z      2644[V]  HTOP
1405      HRBT      1377[V]  ST#BT      1378[V]  ST#BS      1379[V]  A      2602[V]  AB
1406      AC      1378[V]  AF      1379[V]  AE      1380[V]  BOT      2628[V]  TOP
1407      14      1379[V]  AF      1380[V]  AE      1381[V]  S      2270[EL]  32
1408      R      1374[V]  DIBOT      1375[V]  42      1376[V]  DIBOT      2354[EL]  52
1409      GMI      1375[V]  TS+H      1376[V]  TS2S      1377[V]  STCRIT      2444[EL]  62
1410      70      1376[V]  G0      1377[V]  GRT      1378[V]  TSBS      0720[V]  SBCRIT
1411      82      1376[V]  10      1377[V]  112      1378[V]  *V

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| | | | | | |
|-------------|-----------|------------|------------|-----------|---------|
| 1970 *MAINT | 205A .4V | 205A .COMP | 298A ALOG | 2EC4 SI | 27A0 .R |
| 198E -ZEPH | 207A 9A | 2757 .A | 2EA0A .MES | 2C88 .W | 2A90 EX |
| 2016 AINT | 242P SORT | 276F .PARB | 2DAA .S | 2A90 AEXP | 2D82 .E |
| 1988 68 | 2032 .D | 2E4B .H | 3EE0 | | |

TOP-POINTS?

| | | | | | |
|-----------|------------|-------------|-----------|------------|----------|
| 27A3 .R | 27F3 .A | 2892 SGRT | 2988 ALOG | 2A90 AEXP | 2A90 EX |
| 2016 AINT | 2C88 .W | 2C54 .COMP | 2D9C \$6 | 2D4E .RARG | 2D80 \$8 |
| 201A .S | 2D4F .ZERR | 2D12 .EPCNT | 2DB4 .O | 2E0A .MES | 2E94 .U |
| 2E8A .V | 2ECA .SI | | | | |

T01# 8-16
 T02# 6-21 2
 RE 92-0340
 T03# P# 45-5867
 T04# T# P# 42-
 T05# 25-100-18
 T06# 25-100-18
 STC# 1# P# 7-774
 T# 14945-727
 T# 848# 1 P# 5-727
 APP# 1# 1494-287

-10-

UNIVAC OPERATING SYSTEM VENSTON 1 REVISTON 312 03/04/74 GENERATED 04/27/74

| | | | |
|-----------------------|-----------------|--------|-----|
| 103 HANDLING CHARGE | \$.35 | / JHR | .35 |
| 205 LINES PRINTED PBP | \$ 3.25 | / K LN | .16 |
| 404 CARDS READ | \$ 1.50 | / K CD | .13 |
| 701 PLOTTER MACHINES | \$ 1.25 | / 12HR | .24 |
| 102 MODEL 72 ROUNDS | \$ 0.50 | / 45HR | .12 |
| 104 MODEL 87 ROUNDS | \$ 2.50 | / 40HR | .25 |
| | TOTAL CHARGE \$ | | .76 |

FTR 490 14734 LOGGED OUT 04/27/74 18:28+ S 34-67 LEFT AFTER 40 LOGINS.

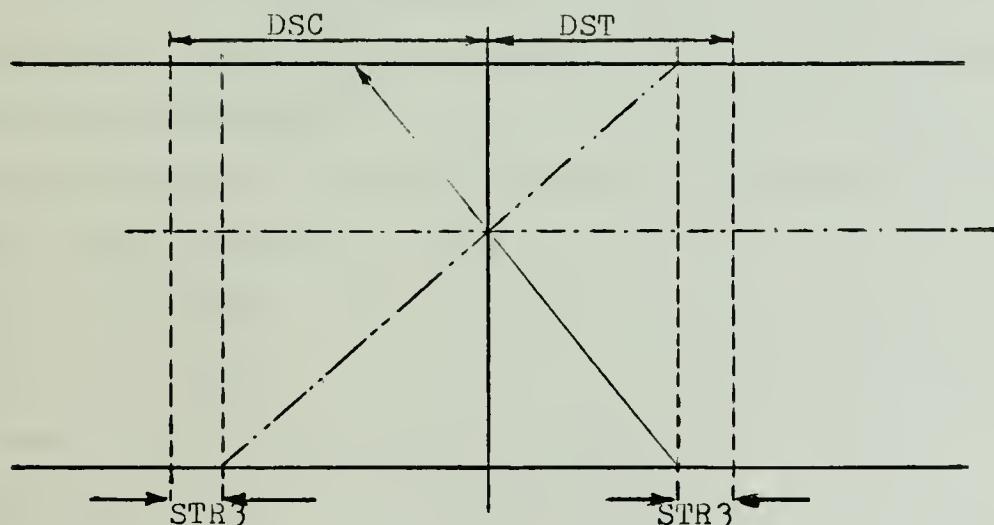
This 1000 ft aluminum case shows again a stress at the bottom much lower than DST. It should be corrected as done for "1000 ft steel" in the previous situation.

HOGGING MOMENT LARGER THAN SAGGING MOMENT

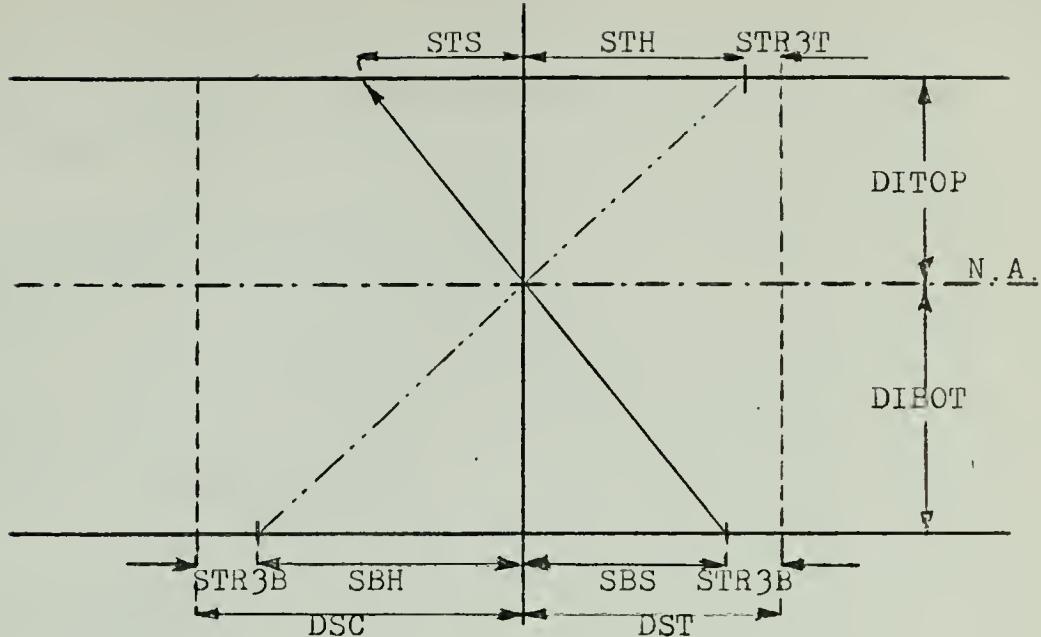
DESIGN STRESS IN COMPRESSION LARGER THAN DESIGN STRESS IN TENSION

LATERAL LOAD ALSO CONSIDERED

With the help of what was understood for the similar situation without the lateral load being included, we may here proceed at once to look at what the diagram of stress distributions might look like. Actually, the diagram that will be considered first is basically the same with only a small change due to the addition of the tertiary stresses; since these will probably be of the same magnitude on both top or bottom and assuming that their actual value does not differ considerably, what we may start looking into is a diagram as follows:



We would consider here the same basic distribution of longitudinal bending stresses thus obtaining



We will then expect to obtain $\text{TOP} > \text{BOT}$ and $\text{DITOP} < \text{DIBOT}$ and we may already consider the respective expressions for DITOP, DIBOT and I with TS replaced by TOP

From the diagram we may consider the following equations:

$$\text{STH} * \text{DIBOT} = \text{SBH} * \text{DITOP}$$

and notice here that if we want to stress the material to the allowable design stresses we have

$$\text{STH} = \text{DST} - \text{STR3T}$$

$$\text{SBH} = \text{DSC} - \text{STR3B}$$

we may combine these equations to obtain

$$(\text{DST} - \text{STR3T}) * \text{DIBOT} = (\text{DSC} - \text{STR3B}) * \text{DITOP}$$

STR3T and STR3B are given by

$$\text{STR3T} = 0.152222 * \text{HTOP} * \left(\frac{\text{S}}{\text{TOP}} \right)^2$$

$$\text{STR3B} = 0.152222 * \text{HBOT} * \left(\frac{\text{S}}{\text{BOT}} \right)^2$$

anticipating here that $S = Z \cdot BOT$ because BOT is the thinner plating we have

$$\left(\frac{S}{BOT}\right)^2 = Z^2$$

and thus may write

$$STR3B = 0.152222 * HBOT * Z^2$$

Since

$$\left(\frac{S}{TOP}\right)^2 < \left(\frac{S}{BOT}\right)^2$$

because $TOP > BOT$, if we make

$$\left(\frac{S}{TOP}\right)^2 = Z^2$$

to simplify the equations that will follow we will understand that in doing so we are only increasing the value of $STR3T$.

This as we see from

$$STH = DST - STR3T$$

will make us have STH with a slightly lower value than the one that is allowed, so we are on the safe side when we consider

$$\left(\frac{S}{TOP}\right)^2 = Z^2$$

Now if we end up too much on the safe side and we have a $TSTH$ too low we may bring it to a value closer to DST by considering a Z_1 value as done and exemplified in the previous section and done again in this section for the case 1000 ft steel where for this particular example it is $TSBH$ that needs correction as explained in detail.

We may then write

$$Z = \frac{1}{\sqrt{0.30396 * \frac{1 - POI * POI}{E} * DSC}}$$

$$STR3T = 0.152222 * HTOP * Z^2$$

$$STR3B = 0.152222 * HBOT * Z^2$$

and from

$$(DST - STR3T) * DIBOT = (DSC - STR3B) * DITOP$$

we have if we make

$$A = DST - STR3T$$

$$AB = DSC - STR3B$$

$$P = (2 * D + B) * TOP + B * BOT$$

$$A * \frac{D * TOP * (B + D)}{P} = AB * \frac{D * (B * BOT + D * TOP)}{P}$$

which gives after simplification

$$A * ((B + D) - AB * D) * TOP = AB * B * BOT$$

and making

$$AC = (A * (B + D) - AB * D) / (AB * B)$$

we have

$$BOT = AC * TOP$$

Following the suggestions of a previous section we will also use the equation that will make the bottom to be stressed the most in compression under the larger of the moments being considered (HM in this case).

We obtain

$$SBH = HM * DIBOT / I = AB$$

Replacing DIBOT and I by their expressions we obtain

$$AB = \frac{HM*D*TOP*(B+D)}{4*D^2*TOP*((3*B^2+2*B*D)*BOT+(D^2+2*B*D)*TOP)}$$

simplifying we end up with

$$TOP = \frac{HM*(B+D)}{AB*4*D*(D^2+2*B*D)} - \frac{3*B^2+2*B*D}{D^2+2*B*D} * BOT$$

now making

$$AD = HM*(B+D)/(AB*4*D*(D^2+2*B*D))$$

$$AE = (3*B^2+2*B*D)/(D^2+2*B*D)$$

we have

$$TOP = AD-AE*BOT$$

substituting here

$$BOT = AC*TOP$$

we obtain finally

$$TOP = \frac{AD}{1+AC*AE}$$

Considering here again the bottom as the location of the thinner plating (in this particular situation we are looking at), and knowing that it will be subject to a compressive stress of magnitude as large as DSC we may again write $S = Z*BOT$
We finally obtain the total stress on top and bottom in both tension and compression by adding the longitudinal bending stresses to the tertiary stresses.

$$TSTH = HM*DITOP/I + 0.152222*HTOP*S^2/TOP^2$$

$$TSTS = SM*DITOP/I + 0.152222*HTOP*S^2/TOP^2$$

$$TSBH = HM*DIBOT/I + STR3B$$

$$TSBS = SM*DIBOT/I + STR3B$$

NOTE: since usually the secondary stresses are assigned a constant value like 2000 psi or 3000 psi they can be accounted for when giving a value to the design stresses.

STRENGTH OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE 1

```

0004 C *AL* IS THE LENGTH
0004 AL=50.0
000C
0118 C *DRAY* IS THE DRAFT
0118 DRAY=8.0
0124 C U=AL/9.0
0130 C *POI* IS THE POISSON'S RATIO OF THE MATERIAL
0130 FOR ALU INUM
0130 POI=.33
0138 C *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
0138 FOR ALU INUM
0138 E=12.0*10^6
0140 C *AST* IS THE DESIGN STRESS IN TENSION
0140 AST=250.0
0154 C *DSC* IS THE DESIGN STRESS IN COMPRESSION
0154 DSC=350.0
015C C *HM* IS THE DESIGN BENDING MOMENT
015C HM=1.37143*E*POI*AL*U
0174 C *SM* IS THE DESIGN BENDING MOMENT
0174 SM=HM*DRAY*AL*U
0188 C *=E*3.1376*(1+POI)*POI*DSC/E
01A8 HSGAT( )
01B4 Z=1.70
01C0 C *HTOP* IS THE HEAD OF WATER ON DECK
01C0 HTOP=8.0
01C8 C *HOT* IS THE HEAD OF WATER ON BOTTOM
01C8 HOT=DRA
01D0 STRBT=0.152225*HTOP+Z+Z
01E4 STRBH=V-152225*-HOT+Z+Z
01F8 A=AST-STRBT
01F8 AB=DSC-STRBH
01F8 AC=(A*(V+D)-AB*U)/(AB*U)
01F8 AD=HM*(V+D)/(AB*4+2*POI*(D+2.0*B+D))
01F8 AL=(B*U*P+2.0*V*U)/(V*U+2.0*B*D)
1E0 C *TOP* IS THE THICKNESS OF THE TOP PLATING
1E0 C *HOT* IS THE THICKNESS OF THE BOTTOM PLATING
1E0 TOP=AD/(1+AC*AL)
1F8 BOT=AC*TOP
1F8 WRITE(5,17)TOP
17 FORMAT('1',2X,17TOP=1E12.4)
23A WRITE(5,2V)BOT
256 PC FORMAT('1',2X,17BOT=1E12.4)
270 G *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
270 S=Z-BOT
270 WRITE(5,3V)S
298 37 FORMAT('1',2X,17=S=1E12.4)
298 P=2.0*D*TOT+U*(TOT+2*U)
3D4 C *DITOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXES
3D4 DITOP=D*(B*BOT+D*TOT)/P
3F8 WRITE(5,4D)DITOP
314 47 FORMAT('1',18X,17=DITOP=1E12.4)
330 C *DIBOT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXES

```


STRENGTH OF SHIPS ON THE AUTOMATICS LOCATION

PAGE 5

```

0330      D1EFT=D*(P*T124+*TOP),F
0354      *WHITE(5,50)TS101
0370      6 FORMAT(1,13X,1,I10)
038C      C *TS101 IS THE WEIGHT OF THE X SECTION AND T=1.7.
038C      C S01=4.*X*(P*(1.7+1.3*0.5*H)+TOP*H01+(D*P+2.*R*P)*TOP+F*T124)
03FC      C *TS102 IS THE STRESS IN TOP DUE TO HOGGING
03FC      C *TS103 IS THE STRESS IN TOP DUE TO LAGGING
03FC      C *TS104 IS THE STRESS IN BOT DUE TO HOGGING
03FC      C *TS105 IS THE STRESS IN BOT DUE TO LAGGING
03FC      C *S101 IS THE CRITICAL STRESS IN TOP
03FC      C *S102 IS THE CRITICAL STRESS IN BOT
03FC      C TS101=S101*TOP/G101+1.12222*HTOP*S101/(TOP*TOP)
0438      TS102=S102*TOP/G102+1.12222*HTOP*S102/(TOP*TOP)
0474      S101=TOP*T101/(1.3*396*8*S101*(1.-POI*POI))
0484      *WHITE(5,50)TS102
0490      A FORMAT(1,13X,1,T3TH=(F11.3))
04EA      *WHITE(5,74)TS103
0526      7 FORMAT(1,13X,1,T3TH=(F11.3))
0529      *WHITE(5,92)TS104
0530      8 FORMAT(1,13X,1,T3TH=(F11.3))
0558      TS101=H01*D1EFT/2.0+RTH*SF
0560      TS102=S102*D1EFT/2.0+RTH*SF
0582      S101=CTH01*SF/(1.3*396*8*S101*(1.-POI*POI))
0590      *WHITE(5,90)TS105
05DC      9 FORMAT(1,13X,1,T3TH=(F11.3))
05F6      *WHITE(5,100)TS106
0612      10 FORMAT(1,13X,1,T3TH=(F11.3))
0620      *WHITE(5,110)TS107
0648      11 FORMAT(1,13X,1,T3TH=(F11.3))
0664      END

```

| | | | | | | | | | |
|--------|--------|----------|--------|----------|------|----------|-------|----------|-------|
| I [S] | •U | 1638 [V] | AL | 520 [V] | B | 8670 [V] | DR | 948 [V] | D |
| 39 [V] | POI | 1639 [V] | E | 1221 [L] | *R | 8690 [V] | DST | 16A4 [V] | D3C |
| 40 [V] | HU | 1634 [V] | SM | 539 [V] | N | 8694 [V] | U | 938 [S] | S1P1 |
| CS [V] | Z | 860 [V] | HTOP | 500 [L] | HBCT | 8694 [V] | STFBT | 8600 [V] | ST 34 |
| EP [V] | A | 1644 [V] | AB | 1670 [V] | AC | 8695 [V] | AD | 271 [V] | AF |
| 14 [V] | TOP | 1716 [V] | BCT | 220 [L] | 10 | 8701 [S] | @J | 1256 [L] | E |
| 15 [V] | S | 1720 [L] | BC | 1720 [V] | P | 8724 [V] | DITOP | 1314 [L] | 4 |
| 29 [V] | DIRT | 1371 [L] | SC | 1720 [V] | GMI | 8738 [V] | TSH | 1730 [V] | TSTS |
| 47 [V] | STCRIT | 1400 [L] | 63 | 1516 [L] | 70 | 8530 [L] | SC | 1744 [V] | TSRH |
| 49 [V] | TSBS | 1740 [V] | SBCHIT | 1500 [L] | 90 | 8612 [L] | 100 | 1648 [L] | 110 |
| M [S] | •V | | | | | | | | |
| XEQ | L | | | | | | | | |
|]F | | | | | | | | | |

PROGRAM LABELS:

| | | | | | |
|-------------|-----------|------------|-----------|---------|---------|
| 2070 *MAIN* | 2E56 •V | 2C84 •EOMP | 29A8 /LOG | 2E64 QT | 27C0 •A |
| 204E •ZERO | 2C1C 26 | 2332 •A | 21AA •MES | 2C28 •W | 2A3C EX |
| 2886 AINT | 28L2 S1PT | 2CE2 •EARG | 214A •5 | 2D2C 88 | 2D52 •S |
| 2052 •0 | 2E28 •U | 3E31 | | | |

TRY-POINTS:

| | | | | | |
|---------|---------|-----------|-----------|----------|---------|
| 27C0 •R | 26C0 •A | 2832 S1PT | 124A8 ALG | 2A81 EXP | 2B86 AI |
|---------|---------|-----------|-----------|----------|---------|

TOP= 1.34 8
BOT= 4.27 11
S= 10.27 11
DITOP= 26.3 30
DIE01= 29.2 310
TSH= 24489.7 34
TSTS= 18187.7 1
STCRIT= 45487.3 44
TSR= 29999.9 16
TSS= 22931.3 14
SPCRIT= 30400.99

/ END

ICE VIO OPERATING SYSTEM VERSION 1.1 REVISION 12 3/24/74 GENERATED 14/3/74

| | | |
|-----------------------|--------------------|-------|
| JOB HANDLING CHARGE | \$ 0.05 / UNIT | • 3% |
| 130 LINES PRINTED PR1 | \$ 1.05 / LINE | • 14% |
| 88 CARDS READ | \$ 1.65 / 100 | • 19% |
| 00 PLOTTER VECTORS | \$ 0.04 / 100 | • 1% |
| 15 MODEL 7 SECTIONS | \$ 25.00 / SECTION | • 11% |
| 00 MODEL 8 SECONDS | \$ 12.00 / SECOND | • 1% |
| TOTAL CHARGE | | • 74 |

REIRE 499 14731 LOGGED OUT AT 11/74 22:19. \$ 26.33 LEFT AFTER 0 LOGINS.

As we see the results obtained for the 500 ft aluminum case are acceptable and agree with all our considerations in the derivation of the formulas, namely $\text{TOP} > \text{BOT}$.

The following two runs, for 500 ft steel and 1000 ft aluminum show that the results are in disagreement with $\text{TOP} > \text{BOT}$ used in the formulas. We will see next why this happens and derive the proper set of formulas to be used for such cases.

STRENGHT OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE 1

```

2004 C   *AL* IS THE LENGTH
2004          AL=5000.
200C          B=AL/R.
2018 C   *DRA* IS THE DRAFT
2018          DRA=B/3.
2024          D=AL/S.
2030 C   *POI* IS THE POISSON'S RATIO OF THE MATERIAL
2030          FOR STEEL
2030          POI=.3
2038 C   *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
2038          FOR STEEL
2038          E=30.*10.**6
204C C   *DST* IS THE DESIGN STRESS IN TENSION
204C          DST=25000.
2054 C   *DSC* IS THE DESIGN STRESS IN COMPRESSION
2054          DSC=30000.
205C C   *HM* IS THE HOGGING BENDING MOMENT
205C          HM=1.37143*B*DRA*AL*AL
2074 C   *SM* IS THE SAGGING BENDING MOMENT
2074          SM=B*DRA*AL*AL
2088 V=0.37396*(1.-POI*POI)*DSC/E
20A8 U=SGRT(V)
20B4 Z=1./U
20C0 C   *HTOP* IS THE HEAD OF WATER ON DECK
20C0          HTOP=8.
20C8 *HBOT* IS THE HEAD OF WATER ON BOTTOM
20C8          HBOT=DRA
20D0 STR3T=0.152222*HTOP+Z*Z
20E4 STR3B=0.152222*HBOT+Z*Z
20F8 A=DST-STR3T
124 AB=DSC-STR3B
110 AC=(A*(B+D)-AB*D)/(AB*B)
148 AD=HM*(B+D)/(AB*4.*D*(D*D+2.*B*D))
194 AE=(3.*B*D+2.*B*D)/(D*D+2.*B*D)
1E0 C   *TOP* IS THE THICKNESS OF THE TOP PLATING
1E0 C   *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
1E2 TOP=AD/(1.+AC*AE)
1F8 BOT=AC*TOP
224 WRITE(5,10)TOP
220 10 FORMAT('1',22X,'TCP='F10.4)
23A WRITE(5,20)BOT
256 20 FORMAT(' ',22X,'BOT='F10.4)
270 C   *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
270          S=Z-BOT
27C WRITE(5,30)S
298 30 FORMAT(' ',22X,'S='F10.4)
2B0          P=2.*D*TOP+B*(TOP+R*T)
2D4 C   *DITOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
2D4          DITOP=D*(B-BOT+D*TOP)/P
2F8 WRITE(5,40)DITOP
314 40 FORMAT(' ',18X,'DITOP='F10.4)
330 C   *DIBOT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS

```


STRENGHT OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE 2

```

0330      DIFOT=D*(B+TOP+D*TOP)/P
0354      WRJTE(5,50)DIBOT
0370      50 FORMAT(' ',18X,'DIBOT='F10.4)
038C      C      *GMI* IS THE MOMENT OF INERTIA OF THE X SECTION ABOUT N.A.
038C      GMI=4.*D*D*((3.*B*B+2.*B*D)*TOP*BOT+(D*D+2.*B*D)*TOP*TOP)/P
03FC      C      *TSTH* IS THE STRESS ON TOP DUE TO HOGGING
03FC      C      *TSTS* IS THE STRESS ON TOP DUE TO SAGGING
03FC      C      *TSBH* IS THE STRESS ON BOT DUE TO HOGGING
03FC      C      *TSBS* IS THE STRESS ON BOT DUE TO SAGGING
03FC      C      *STCRIT* IS THE CRITICAL STRESS ON TOP
03FC      C      *SBCRIT* IS THE CRITICAL STRESS ON BOT
03FC      TSTH=HM*DITOP/GMI+0.152222*HTOP*S*S/(TOP*TOP)
0438      TSTS=SM*DITOP/GMI+0.152222*HTOP*S*S/(TOP*TOP)
0474      STCRIT=TOP*TOP*E/(0.30396*S*S*(1.-POI*POI))
0484      WRITE(5,60)TSTH
0490      60 FORMAT(' ',19X,'TSTH='F10.3)
04EA      WRITE(5,70)TSTS
0526      70 FORMAT(' ',19X,'TSTS='F10.3)
0520      WRITE(5,80)STCRIT
0530      80 FORMAT(' ',17X,'STCRIT='F10.3)
0558      TSBH=HM*DIBOT/GMI+STR3B
056C      TSES=SM*DIBOT/GMI+STR3B
0580      SBCRIT=EOT*BOT*E/(0.30396*S*S*(1.-POI*POI))
0590      WRITE(5,90)TSBH
0600      90 FORMAT(' ',19X,'TSBH='F10.3)
0612      WRITE(5,100)TSBS
0620      100 FORMAT(' ',19X,'TSBS='F10.3)
0648      WRITE(5,110)SBCRIT
0664      110 FORMAT(' ',17X,'SBCRIT='F10.3)
END
? [S]  •U      0668[V] AL      067 [V] B      0678[V] DRA      0681[V] D
? [V] POI      0690[V] E      0000[S] •R      06A0[V] DST      06A3[V] DSC
? [V] HM       26E8[V] SM      06B0[V] W      06C8[V] U      0044[S] SQRT
? [V] Z        06D0[V] HTOP     06D4[V] HRBT     06D8[V] STR3T    76E1[V] STR3B
? [V] A        06E8[V] AB      06E0[V] AC      0700[V] AD      0714[V] AE
? [V] TOP      0710[V] BOT     0220[L] 10      0000[S] @I      0256[L] 20
? [V] S        2298[L] 30      0724[V] P      0728[V] DITOP    0314[L] 40
? [V] DIBOT    0370[L] 50      0730[V] GMI     073C[V] TSTH    0744[V] TSTS
? [V] STCRIT   0400[L] 60      059E[L] 70      053C[L] 80      2748[V] TSBH
? [V] TSBS     2750[V] SBCRIT  05D0[L] 90      0612[L] 100     0648[L] 110
? [S]  •V
? EQ          L
? F

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PROGRAM LABELS:

| | | | | | |
|-------------|-----------|------------|-----------|----------|----------|
| 2270 *MAIN* | 2E5A •V | 2C8A •COMP | 29AC ALOG | 2E68 @I | 27C4 •R |
| 2D52 •ZERO | 2C80 \$6 | 2804 •A | 2DAE •MES | 2C2C •W | 2AB4 EXP |
| 288A AINT | 2E86 SQRT | 2CF2 •RARG | 2D4E •5 | 2D24 \$8 | 2D56 •E |
| 2D56 •O | 2E2C •U | 3F84 | | | |

TRY-POINTS:

| | | | | | |
|---------|---------|-----------|-----------|----------|---------|
| 27C4 •R | 2804 •A | 2886 SQRT | 29AC ALOG | 2AB4 EXP | 2B8A AI |
|---------|---------|-----------|-----------|----------|---------|

TOP= 0.3923
BOT= 0.4748
S= 28.5459
DITOP= 29.2419
DIBOT= 26.3137
TSTH= 27045.305
TSTS= 21466.824
STCRIT= 24483.910
TSRH= 31000.012
TSRS= 24980.129
SBCRIT= 29939.953

END

: VIO OPERATING SYSTEM VERSION 1 REVISION 012 03/04/74 GENERATED 04/30/74 1

| | | |
|----------------------|-----------------|-----|
| JOB HANDLING CHARGE | \$.35 / JOB | .35 |
| 30 LINES PRINTED PR2 | \$ 1.25 / K LN | .16 |
| 88 CARDS READ | \$ 1.50 / K CD | .13 |
| 20 PLOTTER VECTORS | \$.25 / 1 02 | .00 |
| 15 MODEL 70 SECONDS | \$25.00 / H-UR | .10 |
| 40 MODEL 80 SECONDS | \$12.50 / HOUR | .00 |
| | TOTAL CHARGE \$ | .74 |

EIR 490 14731 LOGGED OUT 25/21/74 22:23. \$ 25.59 LEFT AFTER 02 LOGINS.

STRENGHT OF SHTPS-ON THE NEUTRAL AXIS LOCATION

PAGE 1

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004      C      *AL* IS THE LENGTH
004          AL=10000.
00C          B=AL/5.75
018      C      *DRA* IS THE DRAFT
018          DRA=R/3.3
024          D=AL/14.
030      C      *POI* IS THE POISSON'S RATIO OF THE MATERIAL
030          FOR ALUMINUM
030          POI=0.33
038      C      *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
038          FOR ALUMINUM
038          E=10.*12.*E
04C      C      *DST* IS THE DESIGN STRESS IN TENSION
04C          DST=250E6.
054      C      *DSC* IS THE DESIGN STRESS IN COMPRESSION
054          DSC=300E6.
05C      C      *HM* IS THE HOGGING BENDING MOMENT
05C          HM=1.37143*B*DRA*AL*AL
074      C      *SM* IS THE SAGGING BENDING MOMENT
074          SM=B*DRA*AL*AL
088          W=0.32396*(1.-POI*POI)*DSC/E
0A8          U=SQRT(W)
0B4          Z=1./U
0C0          *HTOP* IS THE HEAD OF WATER ON DECK
0C0          HTOP=8.
0C8          *HBOT* IS THE HEAD OF WATER ON BOTTOM
0C8          HBOT=DRA
0D0          STPBT=0.152222*HTOP*Z*Z
0D4          STPBT=0.152222*HBOT*Z*Z
0F8          A=DST-STR3T
1I4          AB=DSC-STR3B
1.0          AC=(A*(B+D)-AB*D)/(AB*B)
1.8          AD=HMM*(B+D)/(AB*4.***(D*D+2.*B*D))
1.4          AE=(3.*B*B+2.*B*D)/(D*D+2.*B*D)
0      C      *TOP* IS THE THICKNESS OF THE TOP PLATING
0      C      *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
0      TOP=AD/(1.+AC*AE)
0      BOT=AC*TOP
0      WRITE(5,10)TOP
0      10 FORMAT('1',20X,'TOP='F10.4)
0      WRITE(5,20)BOT
0      20 FORMAT(' ',20X,'BOT='F10.4)
0      C      *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
0      S=Z*BOT
0      WRITE(5,30)S
0      30 FORMAT(' ',20X,'S='F10.4)
0      P=2.*D*TOP+B*(TOP+BOT)
0      C      *DITOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
0      DITOP=D*(B-BOT+D*TOP)/P
0      WRITE(5,40)DITOP
0      40 FORMAT(' ',10X,'DITOP='F10.4)
0      C      *DIBOT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS

```


STRENGT OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE 2

```

30      DIBOT=D*(B+TOP+D+TOP)/P
34      WRITE(5,50)DIBOT
370     50 FORMAT(' ',18X,'DIR-T='F10.4)
38C     C   *GMI* IS THE MOMENT OF INERTIA OF THE X SECTION ABOUT N.A.
38C     C   GMI=4.*D*D+(3.*B*B+2.*B*D)*TOP*BOT+(D*D+2.*B*D)*TOP*TOP)/P
3FC     C   *TSTH* IS THE STRESS ON TOP DUE TO HOGGING
,FC     C   *TSTS* IS THE STRESS ON TOP DUE TO SAGGING
3FC     C   *TSRH* IS THE STRESS ON BOT DUE TO HOGGING
3FC     C   *TSBS* IS THE STRESS ON BOT DUE TO SAGGING
4FC     C   *STCRIT* IS THE CRITICAL STRESS ON TOP
4FC     C   *SBCRIT* IS THE CRITICAL STRESS ON BOT
4C      TSTH=HM*DITOP/GMI+0.152222*HTOP*S*S/(TOP*TOP)
38      TSTS=SM*DITOP/GMI+0.152222*HTOP*S*S/(TOP*TOP)
74      STCRIT=TOP+TOP*E/(0.34396*S*S*(1.-POI*POI))
84      WRITE(5,60)TSTH
DA      60 FORMAT(' ',18X,'TSTH='F10.3)
EA      WRITE(5,70)TSTS
76      70 FORMAT(' ',18X,'TSTS='F10.3)
20      WRITE(5,80)STCRIT
30      80 FORMAT(' ',17X,'STCRIT='F10.3)
58      TSBH=HM*DIBOT/GMI+STR3B
60      TSBS=SM*DIBOT/GMI+S-R3B
80      SBCRIT=BOT-BOT*E/(0.34396*S*S*(1.-POI*POI))
20      WRITE(5,90)TSBH
DC      90 FORMAT(' ',18X,'TSBH='F10.3)
F6      WRITE(5,100)TSBS
12      100 FORMAT(' ',18X,'TSBS='F10.3)
20      WRITE(5,110)SBCRIT
18      110 FORMAT(' ',17X,'SBCRIT='F10.3)
04      END

```

| | | | | | | | | |
|------------|---------|--------|---------|------|---------|-------|---------|-------|
| [S] •U | 0668[V] | AL | 0670[V] | B | 0678[V] | DRA | 0681[V] | D |
| [V] POI | 0690[V] | E | 0700[S] | •R | 0690[V] | DST | 06A4[V] | DSC |
| [V] HM | 0684[V] | SM | 0688[V] | W | 06C4[V] | U | 0000[S] | SQRT |
| [V] Z | 0600[C] | HTOP | 06D4[V] | HBOT | 06D8[V] | STR3T | 06E2[V] | STR3B |
| [V] A | 06E8[V] | AB | 06EC[V] | AC | 0700[V] | AD | 0714[V] | AE |
| [V] TOP | 0720[V] | BOT | 0722[L] | 10 | 0000[S] | •I | 0256[L] | 20 |
| [V] S | 0298[L] | 30 | 0728[V] | P | 0720[V] | DITOP | 0314[L] | 40 |
| [V] DIBOT | 0370[L] | 50 | 0734[V] | GMI | 0740[V] | TSTH | 0744[V] | TSTS |
| [V] STCRIT | 0400[L] | 60 | 0750[L] | 70 | 0530[L] | 80 | 0740[V] | TSRH |
| [V] TSBS | 0754[V] | SBCRIT | 05DC[L] | 90 | 0612[L] | 100 | 0648[L] | 112 |
| SJ •V | | | | | | | | |

L

RAM LABELS:

| | | | | | |
|-----------|-----------|------------|-----------|----------|-----------|
| 70 •MAIN* | 2E5E •V | 2CPE •COMP | 29B0 ALOG | 2E6C •I | 27C8 •R |
| 56 •ZERO | 2CB4 \$6 | 2B0R •A | 2DB2 •MES | 2C30 •W | 2AB8 EXP |
| BE AINT | 2BBA SQRT | 2CF6 •RAFG | 2D52 •5 | 2D28 \$8 | 2D5A •ERC |
| 5A •O | 2E30 •U | 3F88 | | | |

Y-POINTS:

| | | | | | |
|-------|---------|-----------|-----------|----------|-----------|
| 28 •R | 2808 •A | 28BA SQRT | 29B0 ALOG | 2AB8 EXP | 2BEB AINT |
|-------|---------|-----------|-----------|----------|-----------|

TOP= 3.1023
BOT= 3.8359
S= 134.5649
DITOP= 38.4762
DIBOT= 32.9524
TSTH= 25792.578
TSTS= 19427.625
STCRIT= 19622.289
TSBH= 29999.980
TSBS= 24548.805
SBCRIT= 30000.031

END

VIO OPERATING SYSTEM VERSION 1 REVISION 012 03/04/74 GENERATED 04/30/74 1

| | | |
|----------------------|----------------|-----|
| JOB HANDLING CHARGE | \$.35 / JOB | .35 |
| 30 LINES PRINTED PR2 | \$ 1.25 / K LN | .15 |
| 88 CARDS READ | \$ 1.50 / K CD | .13 |
| 00 PLOTTER VECTORS | \$.25 / 100 | .02 |
| 22 MODEL 70 SECONDS | \$25.00 / HOUR | .15 |
| 00 MODEL 80 SECONDS | \$12.50 / HOUR | .02 |
| | TOTAL CHARGE * | .79 |

EIR 490 14731 LOGGED OUT 25/01/74 22:26. \$ 24.80 LEFT AFTER 03 LOGINS.

STEEL

$$\text{POI} = 0.3$$

$$E = 30 \times 10^6$$

$$AL = 500$$

$$B = AL/8 = 62.5$$

$$DRA = B/3 = 20.833$$

$$D = AL/9 = 55.556$$

$$HM = 1.37143 * B * DRA * AL^2 = 44642.187 \times 10^4$$

$$SM = B * DRA * AL^2 = 32551.562 \times 10^4$$

$$W = 0.30396 * (1 - \text{POI}^2) * DSC/E = 276.6 \times 10^{-6}$$

$$Z = 60.129$$

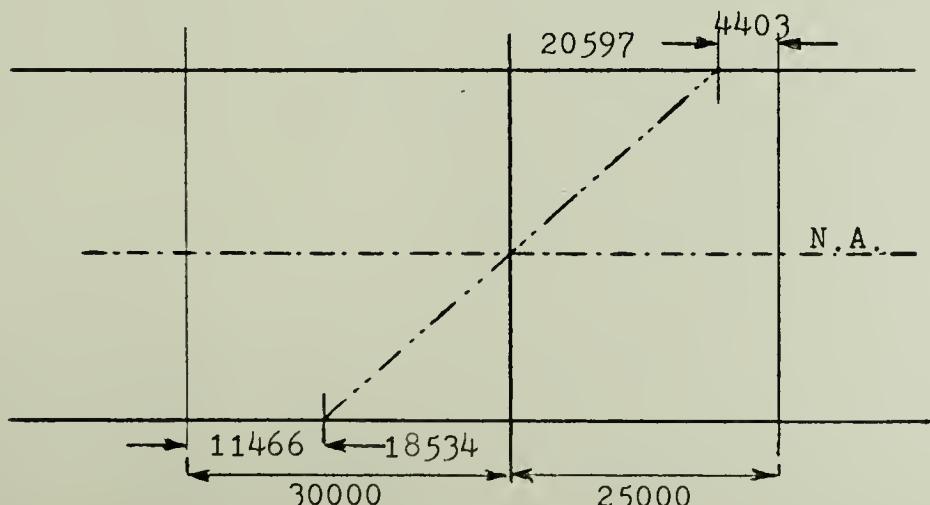
$$HTOP = 8$$

$$HBOT = 20.833$$

$$STR3T = 0.152222 * HTOP * Z^2 = 4402.865 \quad \text{note that this value should be corrected for the Z approximation and actually is slightly smaller}$$

$$STR3B = 0.152222 * HBOT * Z^2 = 11465.61$$

We see from the tertiary stresses obtained that we end up with the following diagram of stress distributions:



From the diagram we see that the neutral axis will end up closer to the bottom and so we must consider BOT > TOP in the formulas.

The same type of diagram will be obtained for 1000' aluminum case since the tertiary stresses obtained in such case are

$$\text{STR3T} = 1498.73$$

$$\text{STR3B} = 9873.078$$

For the 1000' steel case the same type of diagram will occur due to the tertiary stresses being

$$\text{STR3T} = 4402.86$$

$$\text{STR3B} = 29004.$$

Besides this situation requiring us also to consider the neutral axis closer to the bottom, still another problem arises since STR3B is larger than $\text{DST}=25000$. This case is solved by properly correcting the inaccuracy that was introduced by the Z approximation as exemplified next.

Now let's derive the formulas capable of handling the 500' steel case, the 1000' steel case and the 1000' aluminum case.

We must consider BOT > TOP and DITOP > DIBOT

$$\text{DITOP} = D * (B+D) * \text{BOT}/P$$

$$\text{DIBOT} = D * (B * \text{TOP} + D * \text{BOT})/P$$

$$I = 4 * D^2 * \text{BOT} * ((3 * B^2 + 2 * B * D) * \text{TOP} + (D^2 + 2 * B * D) * \text{BOT})/P$$

where

$$P = 2 * D * \text{BOT} + B * (\text{TOP} + \text{BOT})$$

Starting again with the equation

$$\text{STH} * \text{DIBOT} = \text{SBH} * \text{DITOP}$$

and making

$$A = \text{DST} - \text{STR3T}$$

$$AB = \text{DSC} - \text{STR3B}$$

we obtain

$$A * \text{DIBOT} = AB * \text{DITOP}$$

Knowing that now the top is the thinner plating we anticipate

$$S = Z * \text{TOP}$$

and may write

$$\text{STR3T} = 0.152222 * \text{HTOP} * Z^2$$

$$\text{STR3B} = 0.152222 * \text{HBOT} * Z^2$$

where the Z value in STR3B should be $\frac{S}{\text{BOT}}$ which has a smaller value than Z.

We then obtain:

$$A * D * (B * \text{TOP} + D * \text{BOT})/P = AB * D * (B + D) * \text{BOT}/P$$

Simplifying and making

$$AC = (AB*(B+D)-A*D)/(A*B)$$

we obtain

$$TOP = AC*BOT$$

Making now the top to be stressed the most in tension we have.

$$STH = HM*DITOP/I = A$$

Replacing DITOP and I by their equations we have

$$A = \frac{HM*D*(B+D)*BOT}{4*D^2*BOT*((3*B^2+2*B*D)*TOP+(D^2+2*B*D)*BOT)}$$

and obtain

$$BOT = \frac{HM*(B+D)}{A*4*D*(D^2+2*B*D)} - \frac{3*B^2+2*B*D}{D^2+2*B*D} *TOP$$

Making

$$AD = HM*(B+D)/(A*4*D*(D^2+2*B*D))$$

$$AE = (3*B^2+2*B*D)/(D^2+2*B*D)$$

the formulas become

$$BOT = AD-AE*TOP$$

and substituting

$$TOP = AC*BOT$$

we finally have

$$BOT = \frac{AD}{1+AC*AE}$$

The results obtained for the examples chosen are presented next:

STRENGTH IF SHIP FROM THE NEUTRAL AXIS LOCATION

PAGE 1

184 C *AL* IS THE LENGTH
 184 AL=52M.
 185 L=AL/R.
 186 C *DPA* IS THE DRAFT
 187 DPA=8/3.
 188 R=AL/Y.
 189 C *EII* IS THE ROTISSONNE'S RATIO OF THE MATERIAL
 190 FOR STEEL
 191 EII=2.9
 192 C *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
 193 FOR STEEL
 194 E=3V.**1.**6
 195 C *UST* IS THE DESIGN STRESS IN TENSION
 196 UST=250Mpa.
 197 C *USC* IS THE DESIGN STRESS IN COMPRESSION
 198 USC=310Mpa.
 199 C *RM* IS THE HOGGING BENDING MOMENT
 200 RM=1.37142*B*H*Y=AL*A
 201 C *B* IS THE BASIC BENDING MOMENT
 202 B=H*D*Y=A*L*A
 203 C Z=1.3225A*(1+AF)*FCT*PSC/E
 204 Q=SQRT(Z)
 205 Z=1.71
 206 C *HTOP* IS THE HEAD OF WATER ON DECK
 207 HTOP=8.
 208 C *HOT* IS THE HEAD OF WATER ON BOTTOM
 209 HOTT=1.2M
 210 C STR3T=-152222*HTOP*Z*Z
 211 C STR3B=-152222*-HTOP*Z*Z
 212 A=UST-STR3T
 213 AB=PSC-STR3B
 214 AC=(AB*(B+HTOP)-A*Z)/(A*Z)
 215 AD=HTOP*(1+HTOP)/(A*4.4*B*(1+HTOP+2*B*HTOP))
 216 AF=(3.4*B+2*B*HTOP)/(1+HTOP+2*B*HTOP)
 217 C *TOP* IS THE THICKNESS OF THE TOP PLATING
 218 C *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
 219 BOT=AD/(1+AC*AF)
 220 TOP=AC*HTOP
 221 C WRITE(S,10)TOP
 222 10 FORMAT('11,22X,1TOP='E10.4)
 223 C WRITE(S,22)BOT
 224 22 FORMAT('1,22X,1BOT='E10.4)
 225 C *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
 226 S=Z*TOP
 227 C WRITE(S,32)S
 228 32 FORMAT('1,22X,1S='E10.4)
 229 P=0.4*B*HTOP+B*(TOP+BOT)
 230 C *HTOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
 231 HTOP=(P+BOT+2*BOT)/P
 232 C WRITE(S,42)HTOP
 233 42 FORMAT('1,18X,1HTOP='E10.4)
 234 C *BOT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS

STRENGTH OF SHIPS ON THE EUTRAL AXIS LOCATION

PAGE 2

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IGRAM & ABET - 1

| | | | | | | |
|--------------|------------|-----------|------------|------------|----------|---------|
| GRAM LABLES: | 270 •MAIS• | 2ECA •V | 2D1A •COMP | 29AC ALG | 2EE8 @I | 27C4 •R |
| 002 •ZERO | 2C3 \$6 | 2X04 •A | 2E2E •MES | 2CAC •W | 2AB4 EXI | |
| 03A AINT | 29E6 SOFT | 2D72 •ARG | 2DCE •S | 2AB4 AFEXP | 2D06 •EI | |
| 044 \$8 | ECF6 •E | 2FAE •II | 4C04 | | | |

13Y-POINTS:

29AC ALG 20AB4 AEXP 24B4 EXP

TOP= 2.271
 B01= 4.4576
 S= 22.3 47
 D110R= 29.2413
 D1HOT= 26.3134
 TST= 24.9999.
 TSTS= 19421.016
 STCHITE= 29999.000
 TSKE= 26070.140
 TSSE= 211130.000
 BICKITE= 46627.742

END

C: VIO OPERATING SYSTEM VERSION 4.0 REVISION 012 03/04/74 GENERATED 5/02/74

| | | |
|------------------------|----------------|--------|
| OP HANDLING CHARGE | \$ 0.35 / JH | • 35 |
| 132 LINES PRINTED BY C | \$ 1.25 / KBL | • 125 |
| 88 CARDS READ | \$ 1.50 / CDS | • 150 |
| IV PLOTTER INCHES | \$ 0.25 / INCH | • 0.25 |
| 21 MODEL 7 SECONDS | \$ 25.00 / SEC | • 1 |
| 1000 LINE 8 SECONDS | \$ 12.50 / SEC | • 1 |
| TOTAL CHARGE | | • 79 |

EIR 49 147.31 LOGGED OUT 29/09/76 12:41 • 17.92 LEFT AFTER 12 LOGINS.

We could have obtained TSBH = 30000 by correcting the approximation used $Z = S/BOT$ as is done for the 1000' steel case that follows next.

In this case we already anticipate the use of a Z_1 value as done in the previous section and according to the output obtained we will then obtain the correct result.

STRENGTH OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE 1

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004 C *AL* IS THE LENGTH
004 D1=100.0
004 D2=AL/5.75
018 C *DRA* IS THE DRAFT
018 D3=DRA/3.3
024 C D=AL/14.
030 C *POI* IS THE POISSON'S RATIO OF THE MATERIAL
030 FOR STEEL
030 D4=POI=0.3
038 C *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
038 FOR STEEL
038 D5=E=30.516.**6
040 C *DST* IS THE DESIGN STRESS IN TENSION
040 DST=D5*1.7
054 C *DSC* IS THE DESIGN STRESS IN COMPRESSION
054 DSC=D5*1.7
056 C *M* IS THE HANGING BENDING MOMENT
056 M=1.371434*DRA*AL/AL
074 C *MT* IS THE SAGGING BENDING MOMENT
074 MT=-M
078 C M=M-(1.0+POI*POI)*DSC/E
078 M=M*(1.0)
082 C Z=3.0
082 D6=HTOP IS THE HEAD OF WATER ON DECK
082 HTOP=0.
088 C *HBT* IS THE HEAD OF WATER ON BOTTOM
088 HBT=0.
092 C GTRBT=-152222*HTOP*Z*Z
092 Z1=35.
096 C GTRBP=-152222*HBT+Z1*Z1
100 C A=GST-GTRBT
100 D7=DRC+GSTBP
104 C D8=(A+C*(D+D))/C*A*B
104 D9=B*(C*(D+D)/(A+C*(D+D+2.*B*D)))
104 D10=C*(B*D+D.*B*D)/(D*D+2.*B*D)
108 C *TOP* IS THE THICKNESS OF THE TOP PLATING
108 *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
112 C BOT=A*D/(1.+AC*AE)
116 C TOP=A*C*BT
116 D11=HTOP*(5/12)*TOP
120 I0 FORMAT('1',2X,'TOP'=F12.4)
124 D12=HTOP*(5/12)*BOT
128 C D13 IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
128 D14=Z*TCP
132 C WRITE(1,30),S
136 D15=FORMAT('1',2X,'S='F10.4)
140 D16=P*D13*TCP+(TOP+BOT)
144 C *DITOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
144 D17=D16*(HBTG+GSTT)/P
148 C WRITE(1,40),DITOP
152 I0 FORMAT('1',1X,'DITOP'=F12.4),

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STRENGTH OF CHIDRON THE NEUTRAL AXIS LOCATION

PAGE 2

6388 C ACCEPT= IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS
 6389 IBCOTD=(IHTOP*D+BOT)/P
 6390 WRITE(5,11)THC
 6391 50 FORMAT(1X,19X,10X,T10.4)
 6392 C GMI= IS THE MOMENT OF INERTIA OF THE X SECTION ABOUT N.A.
 6393 GI=I*(I+D)*(3.*R**2.+R**3)*TOP*BOT+(D**2.*R**3)*BOT*BOT)/P
 6394 C ITOTL= IS THE STRESS ON TOP DUE TO HOGGING
 6395 C ITSTR= IS THE STRESS ON TOP DUE TO SAGGING
 6396 C ITOTB= IS THE STRESS ON BOT DUE TO HOGGING
 6397 C ITOTB= IS THE STRESS ON BOT DUE TO SAGGING
 6398 C *STCRIT= IS THE CRITICAL STRESS ON TOP
 6399 C *SRCRIT= IS THE CRITICAL STRESS ON BOT
 6400 C TS=HMPD*T/P/GMI+STCRIT
 6401 C TSTR=HMPD*T/P/GMI+ITOTB
 6402 C STOT=ITOTB+TSTR
 6403 C TS=30396*S*G*(1.+POI*PNI))
 6404 WRITE(5,11)TS
 6405 60 FORMAT(1X,19X,1TST=1F10.3)
 6406 C TS=HMPD*T/GMI+1.152222*HROT*S*S/(BOT*BOT)
 6407 C TS=HMPD*T/GMI+1.152222*HROT*S*S/(BOT*BOT)
 6408 C SHCRIT=BOT*HOT*EX((1.+30396*S*S*(1.+POI*PNI)))
 6409 C WRITE(5,11)SHCRIT
 6410 50 FORMAT(1X,17X,1STC IT=1F10.3)
 6411 C TS=HMPD*T/GMI+1.152222*HROT*S*S/(BOT*BOT)
 6412 C TS=HMPD*T/GMI+1.152222*HROT*S*S/(BOT*BOT)
 6413 C SHCRIT=BOT*HOT*EX((1.+30396*S*S*(1.+POI*PNI)))
 6414 C WRITE(5,11)SHCRIT
 6415 10W FORMAT(1X,19X,1TSRH=1F10.3)
 6416 C WRITE(5,10)TSRH
 6417 10W FORMAT(1X,19X,1TSRS=1F10.3)
 6418 C WRITE(5,11)TSRS
 6419 11W FORMAT(1X,17X,1SHCRIT=1F10.3)
 6420 C END
 "([S] *U 0670[V] AL 0674[V] B 0680[V] DRA 0688[V] D
 0%[V] FOI 0698[V] E 0699[S] *R 06A8[V] DST 06B1[V] DSC
 08[V] HM 06C0[V] SM 06C4[V] W 06D0[V] U 0000[S] SGRT
 04[V] Z 06D5[V] HTOP 06E1[V] HBOT 06E4[V] STRBT 06E0[V] Z1
 04[V] STRBT 06FF[V] A 06FC[V] AB 0700[V] AC 0714[V] AD
 02[V] AF 0730[V] BOT 0734[V] TOP 0228[L] 10 0000[S] @1
 05[L] Z0 0738[V] S 02A0[L] 30 0730[V] P 0744[V] DITOP
 01[L] 40 0744[V] DIROT 0371[L] 50 0745[V] GMI 0754[V] TSTH
 02[V] TSTH 0750[V] SHCRIT 0481[L] 60 04BE[L] 70 04F4[L] 80
 02[V] TSBH 0764[V] TSBS 0765[V] SHCRIT 05E4[L] 90 061A[L] 120
 05[L] 110 0480[S] *V
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PROGRAM LABELS:

| | | | | | |
|-------------|-----------|------------|-----------|-----------|--------|
| 2870 •MAIN• | 2EF2 •V | 2D2P •COMP | 29C4 AL0G | 2F00 RI | 27DC • |
| 2DEA •ZFAC | 2D48 36 | 2F1C •A | 2E46 •YES | 2CC4 •W | 2ACC E |
| 2C52 AINT | 28CE SGRT | 2D2A •RARG | 2DE6 •5 | 2ACC AEXP | 2DEE • |
| 2DBC #8 | 2DEE •C | 2EC4 •U | 421C | | |

TRY-POINTS:

TOP= 3.5788
BOT= 3.6868
S= 215.1808
DITCP= 36.4863
DIRECT= 36.3423
TSTH= 21620.000
TSTS= 1.421.523
SECRT= 20999.984
TSRH= 47512.793
TSFS= 4.749.328
SECRT= 31824.254

END

CFC VII OPERATING SYSTEM - VERSION 1 REVISION 012 03/04/74 GENERATED 05/02/74

| | | |
|-----------------------|-----------------|-----|
| JOB : ANDLING CHARGE | \$.35 / JCB | .35 |
| 131 LINES PRINTED FFP | \$ 1.25 / K LN | .16 |
| 69 CARDS READ | \$ 1.52 / K CR | .13 |
| 40 PLOTTER VECTORS | \$.25 / 1000 | .00 |
| 15 CODEL 70 SECONDS | \$ 5.72 / HOUR | .12 |
| 40 CODEL 70 SECONDS | \$ 12.52 / HOUR | .02 |
| TOTAL CHARGE \$ | | .74 |

TYPEIR 492 14731 LOGGED OUT 29/03/75 02:48. \$ 16.44 LEFT AFTER 14 LOGINS

STRENGTH OF SHIPS ON THE NEUTRAL AXIS LOCATION

PAGE

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0704      C      *AL* IS THE LENGTH
0704          AL=1000.
070C          R=AL/5.75
0718      C      *DRA* IS THE DRAFT
0718          DRA=R/3.2
0724          D=AL/14.
0730      C      *POI* IS THE POISSON'S RATIO OF THE MATERIAL
0730          POI=0.3
0730          PUI=.3
0738      C      *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
0738          E=30*10**6
074C      C      *DST* IS THE DESIGN STRESS IN TENSION
074C          DST=25.0M
0754      C      *DSC* IS THE DESIGN STRESS IN COMPRESSION
0754          DSC=300.0
075C      C      *H* IS THE HOGGING BENDING MOMENT
075C          H=1.37148*E*(AL+AL)
0774      C      *S* IS THE RAISING BENDING MOMENT
0774          S=E*DRA*(AL+AL)
0788          W=7.33333*(1-PUI*POI)*DSC/E
07A8          U=S/DT(1)
07B4          Z=1.7U
07C0          ZHTOP* IS THE HEAD OF WATER ON DECK
07C0          HTOP=8.
07C8          *HOT* IS THE HEAD OF WATER ON BOTTOM
07C8          HOT=DRA
100          STBGT=-152222*HTOP+Z*Z
11E4          Z1=4.0
11EC          STBGT=-152222*HTOP+Z1*Z1
1120          A=DST-DTRGT
112C          AH=DSC-DTRGT
1118          AC=(AB*(C+D)-A*B)/(A*B)
1150          AD=HTOP*(C+D)/(A*B+D*(B+C+2*D))
119C          AE=(B+C+2*D)/((B+C+2*D)+B*D)
11E8      C      *TOP* IS THE THICKNESS OF THE TOP PLATING
11E8      C      *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
11E8          BOT=AD/(1+AC+AE)
200          TOP=AC*BOT
20C          WRITE(5,10)TOP
228          1 FORMAT('11.2X,1TOP=F10.4)
242          WRITE(5,22)BOT
25E          21 FORMAT('11.2X,1BOT=F10.4)
278      C      *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
278          S=Z*TOP
284          WRITE(5,23)S
2A0          30 FORMAT('11.2X,1S=F10.4)
288          R=2.0*D*BOT+B*(TOP+BOT)
2DC      C      *DITOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
2DC          DITOP=R*(E*BOT+D*BOT)/E
300          WRITE(5,42)DITOP
31C          40 FORMAT('11.18X,1DITOP=F10.4)

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STRENGTH OF SHIPS IN THE NEUTRAL AXIS LOCATION

PAGE 2

0338 C *DIBOT* IS THE DISTANCE OF THE BOT FROM THE NEUTRAL AXIS
 0338 DIBOT=F*(S*TGP+T*BOT)*P
 035C WRITB(S,B)INTOT
 0378 R FORMAT(F11,18Y,F10.4)
 0394 C *GMI* IS THE MOMENT OF THE TIA OF THE X SECTION ABOVE +A.
 0394 GMI=4.*B*H+((D.*X+342.*B*H)*TOP*BOT+(D*D+2.*B*C)*BOT*B*T)/P
 0404 C *TSFH* IS THE STRESS ON TOP DUE TO FOGGING
 0404 C *TSFS* IS THE STRESS IN TOP DUE TO SAGGING
 0404 C *TSRH* IS THE STRESS IN BOT DUE TO FOGGING
 0404 C *TSRS* IS THE STRESS IN BOT DUE TO SAGGING
 0404 C *SCHIT* IS THE CRITICAL STRESS ON TOP
 0404 C *SCRIT* IS THE CRITICAL STRESS ON BOT
 0404 TSTF=HM.D11P/8*TSFH
 0418 TSFE=SM.D11P/8*TSFH
 0420 TSCE=(T+TOP*TOP*F1.9*395*S*S*(1.+F01*P01))
 046C WRITB(S,B)TSH
 0488 R FORMAT(F11,18Y,F10.3)
 04A2 WRITB(S,B)TSFS
 04BE 7 FORMAT(F11,18Y,F10.3)
 04DE WRITB(S,B)TSRH
 04F4 8 FORMAT(F11,18Y,F10.3)
 0510 TSFH=T*TGP*G1+1.162222*HRBT*S*S/(ROT*BCT)
 054C . TSFS=SM.D11(T/G1+1.162222*HRBT*S*S)/(ROT*BCT)
 0588 SHCFIT=HM.TSFS/(1.3*345*S*S*(1.+F01*P01))
 05C8 WRITB(S,B)TSRS
 05E4 9 FORMAT(F11,18Y,F10.3)
 05FE WRITB(S,B)TOP
 061A 10 FORMAT(F11,18Y,F10.3)
 0634 WRITB(S,B)SCRIT
 0650 11 FORMAT(F11,18Y,F10.3)
 066C END

 0 [S] •U 662. [V] AL 672. [V] R 66 1[V] DRA 6722EV 1D
 9^ [V] P01 665E [V] E 673E [V] •R 661.5[V] DST 76B 1[V] 77C
 8^ [V] HM 66C1 [V] CM 674 [V] I 660.1[V] U 773 1[S] 782
 D4 [V] Z 660.8 [V] HTCH 660E [V] HRBT 664 [V] STR3T 74EC [V] Z1
 F4 [V] STR3R 66F8 [V] A 660E [V] AR 671.1[V] AC 7714 [V] A0
 2^ [V] AE 673. [V] BOT 674 [V] TOP 624.8 [L] 12 7741 [S] 81
 5E [L] 2^ 673E [V] S 670 [L] 30 673C [V] P 674. [V] CTTHP
 1C [L] 40 674 [V] D10T 672E [L] SF 674.8 [V] GMI 7754 [V] TSH
 6^ [V] TSFS 675C [V] SCHIT 6438 [L] 60 641E [L] 70 64F4 [L] 81
 6^ [V] TSRH 6764 [V] TSRS 673 [V] SCRIT 65F4 [L] 90 661A [L] 171
 6^ [L] 113 670E [S] •V

 XEQ L
 DF

PROGRAM LABELS:

| | | | | | |
|-------------|-----------|------------|-----------|-----------|---------|
| 2070 *MATH* | 2EFP •V | 2EPP •COMP | 24C4 ALOG | 2E0F OT | 27DC •E |
| 2DEA •ZERO | 2D48 SE | 2E1C •A | 2E46 MES | 2CC4 •V | 2ACC EY |
| 2C52 AINT | 2KCE SIPT | 2E8A •ARG | 27E6 .5 | 2ACC AEXP | 2GEE • |
| 2DBC \$R | 2DFF •C | 2EC4 •U | 4C1C | | |

ITRY-POINTS:

| | | | | | |
|---------|---------|-----------|-----------|-----------|---------|
| 27DC •R | 281C •A | 2ECE SART | 29C4 ALOG | 2ACC AEXP | 2ACC EY |
|---------|---------|-----------|-----------|-----------|---------|

TOP= 2.3 .6
 BOT= 4.4277
 S4= 203.6253
 DITCP= 32.9611
 DISPC= 32.4674
 TSTH= 240.1000
 TSTS= 16421.163
 STCHIT= 29390.252
 TSRE= 34131.155
 TERSE= 29439.152
 SHCHIT= 51270.154

/ END

JCF VIO OPERATING SYSTEM VERSION 1 PREVISION C12 03/14/74 GENERATED 5/ 2/74

| | | |
|-----------------------|------------------|------|
| JOB HANDLING CHARGE | • 05 / JH | • 35 |
| 131 LINES PRINTED PPI | • 1.25 / K | • 16 |
| 89 CARDS READ | • 1.50 / K CR | • 13 |
| 00 PLOTTER VECTORS | • 05 / 1K | • 10 |
| 20 MODEL 7 SECONDS | • 05 • 05 / 1000 | • 10 |
| 00 MODEL 3 SECONDS | • 12 • 05 / 1000 | • 12 |
| | TOTAL CHARGE | • 72 |

ERREIR 491 14/31 LOGGED OUT 23/ 9/75 2:5 • 5 15.66 LEFT AFTER 45 LOGINS

Now we see that with an assumed value $Z_1 = 35$ we obtain

$$S = 215.1808$$

$$BOT = 3.686 \quad \text{so } Z_1 \text{ actual} = 58.38$$

$$TSBH = 47512.793 \text{ (too high)}$$

$$TSBS \quad \text{also too high}$$

The Z_1 actual value obtained suggests that we should have assumed an higher Z_1 value and with an assumed value $Z_1 = 40$ we then obtain

$$S = 203.626$$

$$BOT = 4.428 \quad \text{so } Z_1 \text{ actual} = 45.98$$

$$TSBH = 34131.855 \text{ (too high)}$$

$$TSBS \quad \text{also too high}$$

This suggests an assumed Z_1 value higher than 40 but now we may interpolate with the two results already obtained and determine the Z_1 value that will bring $TSBH = DSC = 30000$ psi and done properly this new Z_1 assumed will end up being Z_1 actual.

From interpolation we obtain

$$Z_1 = 40 + \frac{(40-35)*(34131.855-30000)}{(47512.793-34131.855)} = 41.544$$

and now assume this value obtaining the following result:

STRENGTH OF SHIP ON THE NEUTRAL AXIS LOCATION

PAGE

01E4 C *AL= IS THE LENGTH
 024 AL=1.00
 07E0 R=AL/5.75
 0018 C *DEA= IS THE DRAFT
 0418 DRAE=H/3.0
 0124 DEAL/14.
 0130 C *PCIS IS THE POISSON'S RATIO OF THE MATERIAL
 0130 C FOR STEEL
 0730 PCIS=0.3
 0130 C *E IS THE YOUNG'S MODULUS OF THE MATERIAL
 0130 C FOR STEEL
 0130 E=30.0E+00
 0140 C *UST= IS THE CRITICAL STRESS IN TENSION
 0140 UST=2.0E+00
 0154 C *USC= IS THE CRITICAL STRESS IN COMPRESSION
 0154 USC=4.0E+00
 0150 C *M1= IS THE HEADING FENDING MOMENT
 0150 M1=1.32145E+00*A1*
 0174 C *M2= IS THE SIDEWING FENDING MOMENT
 0174 M2=-0.37E+00*A1
 0181 I=I+0.018*(1.0E-001)*FCY*USC/E
 01A8 U=ST/(1.0E-001)
 0124 Z=1.0E+00
 01CF *HTOP= IS THE HEAD OF WATER ON DECK
 01CF HTOP=0.
 01C9 *HBOT= IS THE HEAD OF WATER ON BOTTOM
 01C9 HBOT=0.0
 01DC STHGT=V+152222+TOP*Z+Z
 01E4 Z1=4.0E+0.4131.055713E-0.928
 01F8 STPG =V+152222+HOT*Z1+Z1
 01AC U=UST-STHGT
 0118 AR=USC*STRE
 0124 AC=(AR*(E+P)-A*P)/(A+E)
 0150 AP=H1*(1+0)/((1+4.0E+0.01H+2.0E+0))
 01AX AE=(3.0E+0+2.0E+0)/((1+1+2.0E+0))
 01F4 C *TCP= IS THE THICKNESS OF THE TOP PLATING
 01F4 *BCT= IS THE THICKNESS OF THE BOTTOM PLATING
 01FC P0T=AP/(1.0+AC*AE)
 0218 TCP=AC*HOT
 0218 *RITF(5.0V)TOP
 0234 1c FORMAT('11.22y,1TOP=F10.4)
 024E *RITF(5.0V)BOT
 026A 2a FORMAT('1.22y,1BOT=F10.4)
 0284 C *S= IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
 0284 S=Z+TOP
 0290 *RITF(5.0V)S
 02AC 3a FORMAT('1.22y,1SF=F10.4)
 0204 P=2.0D+HTOP+(TCP+BOT)
 02E8 C *HTOP= IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
 02E8 HTOP=(R+HOT+S*BCT)/P
 02VC *RITF(5.0V)HTOP
 0328 4a FORMAT('1.18y,1HTOP=F10.4)

STRENGTH OF SHIPS ON THE NEUTRAL AXIS LOCATION

PAGE 2

0344 C DIRECT IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS
 0344 DIRECT=(R*T05+*R*T1)*
 0268 WHITF(5,6)*T05
 0384 RE CLMNT(1,19Y,T1T05=F10.4)
 0340 C *G1* IS THE MOMENT OF INERTIA OF THE X SECTION ABOUT +A.
 0340 G1=4.*X**I*((D+1**E+2.*R*D)+TOP*BOT+(D*D+2.*BOT)*BOT*T1)/D
 0410 C *TSH* IS THE STRESS ON TOP DUE TO HOGGING
 0410 *TSB* IS THE STRESS ON TOP DUE TO SAGGING
 0410 C *TBS* IS THE STRESS ON BOT DUE TO HOGGING
 0410 C *TSR* IS THE STRESS ON BOT DUE TO SAGGING
 0410 C *SCT* IS THE CRITICAL STRESS ON TOP
 0410 C *SCT* IS THE CRITICAL STRESS ON BOT
 0410 TSTH=H*T05/G1*TSH
 0424 TSTS=H*T05/G1*TSB
 0438 SCTR=H*T05*(TOP+BOT+2.396*S*S*(1.+R*D*PO1))
 0478 WHITF(5,6)*TSH
 0494 6C FORMAT(1,19Y,T1T05=F10.3)
 04AE WHITF(5,6)*TSTS
 04CA 7C FORMAT(1,19Y,T1T05=F10.3)
 04E4 WHITF(5,6)*TSR
 04FC 8C FORMAT(1,17Y,T1T05=F10.3)
 0510 TSRE=F10.3,T1T05=F10.1*2222*H*BOT*S*S/(BOT*BCT)
 0558 TSRS=F10.3,T1T05=F10.1*2222*H*BOT*S*S/(BOT*BCT)
 0594 SCTR=H*BOT*S*S*(1.396*S*S*(1.+R*D*PO1))
 06D4 WHITF(5,6)*TSH
 06F6 9 C FORMAT(1,19Y,T1T05=F10.3)
 06E4 WHITF(5,6)*TSTS
 0626 10C FORMAT(1,19Y,T1T05=F10.3)
 0640 WHITF(5,6)*TSR
 045C 11C FORMAT(1,17Y,T1T05=F10.3)
 0179 END
 01[S] •U 067C[V] AL 1684[V] R 064C[V] DRA 0594[V] P
 01[V] PO1 0644[V] E 1600[2] .R 0644[V] DST 06PC[V] PSC
 04[V] HM 0600[V] RM 0600[V] W 065C[V] U 060C[5] SFT
 E [V] Z 06E4[V] STOP 16FC[V] HBC
 01[V] ST93B 0718[V] A 1714[V] AB 0718[V] STF3T 06F8[V] Z1
 4. [V] AF 0748[V] BC1 74C[V] TDF 0734[L] 1P 072C[V] AD
 6 [L] 2P 0750[V] S 2AC[1] 2P 07E4[V] P 070C[5] AI
 2P [L] 4P 0750[V] DIROT 384[1] 5P 0742[V] GMI 0758[V] DITOR
 7 [V] TSTS 0774[V] STCRIT 4494[1] 6P 04CA[L] 7P 0760[V] TSH
 7 [V] TSBH 077C[V] TSBS 1782[V] SBCRIT 0540[L] 9P 0540[L] 8P
 5C[L] 11D 0760[5] .V 0782[V] SBCRIT 0540[L] 9P 0626[L] 12P
 NEG L
 DF

ICGPAM LABELS:

| | | | | | |
|-------------|------------|------------|-----------|-----------|---------|
| 2H70 *MAIN* | 2F1A .N | 2D3A .CUMP | 29DC ALOG | 2F1F RI | 2F4 .P |
| 2E02 *ZERO | 21A .M | 2A34 .A | 2F5F .MES | 2C0C .W | 2A54 E |
| 2C6A AINT | 2F1A .CIFT | 2A32 .PANG | 2DFF .S | 2AF4 AEXP | 2E46 .E |
| 2D04 SR | 2F1F .L | 2E0C .H | 4234 | | |

TRY-POINTS:

| | |
|---------|-----------|
| TOPF | 3.03 .55 |
| BOTF | 4.7414 |
| SF | 193.620 |
| DITOPF | 40.0312 |
| DIFOTF | 31.3967 |
| TSTHF | 24959.013 |
| TSTSF | 19421.516 |
| STCKTF | 88900.962 |
| TSR4F | 3.194.643 |
| TSR3F | 25817.044 |
| SBCH1TF | 61950.123 |

END

CF VIO OPERATING SYSTEM VERSION 1.1 REVISION 012 5/24/74 GENERATED 5/23/74

| | | |
|-----------------------|------------------|---------|
| CR HANDLING CHARGE | \$ 0.25 / JCH | \$ 0.25 |
| 131 LINES PRINTED P/M | \$ 1.05 / K LIN | \$ 1.16 |
| 89 CARDS READ | \$ 1.52 / K CAR | \$ 1.30 |
| 64 PLOTTER VECTOR-S | \$ 0.05 / 100' S | \$ 0.05 |
| 22 MODEL 70 SECONDS | \$25.00 / 40 SE | \$ 1.5 |
| 12 MODEL 80 SECONDS | \$12.00 / 40 SE | \$ 0.72 |
| TOTAL CHARGE | | \$ 7.9 |

A-EIR 490 14731 LOGGED OUT 09/19/75 03:01 • B 14:07 LEFT AFTER 16 LINES.

We see that TSBH is just a little too high and the same happens with TSBS; here it might be the case that TSBS should have been the one under consideration for the choice of a Z_1 value. Nevertheless for the purpose of this work this example shows the procedure to be used along with the equation derived. The accuracy obtained can be total. Here we assumed $Z_1 = 41.544$ and ended up with Z_1 actual = 41.83 which is close enough for our purpose and TSBH and TSBS is very close to what it should be to use the material effectively.

STRENGTH OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE

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084 C *AL* IS THE LENGTH
0724 AL=1022.
0720 B=AL/5.75
0718 C *DRA* IS THE DRAFT
0718 DRA=B/3.3
0724 D=AL/14.
0730 C *POI* IS THE POISSON'S RATIO OF THE MATERIAL
0730 FOR ALUMINUM
0730 POI=0.33
0735 C *E* IS THE YOUNG'S MODULUS OF THE MATERIAL
0735 FOR ALUMINUM
0735 E=17.*1.***6
0740 C *CST* IS THE DESIGN STRESS IN TENSION
0740 DST=25.7.
0754 C *DSC* IS THE DESIGN STRESS IN COMPRESSION
0754 DSC=31.72.
0750 C *HMM* IS THE HOGGING BENDING MOMENT
0750 HMM=1.37143*B*DRA*AL*AL
0744 C *SMA* IS THE SAGGING BENDING MOMENT
0744 SMA=B*DRA*AL*AL
0748 H=0.34296*(1.-POI)*P_I*DSC/E
0748 U=GCR(T)
0748 Z=1./U
0750 C *HTOP* IS THE HEAD OF WATER ON DECK
0750 HTOP=R.
0758 C *HBOT* IS THE HEAD OF WATER ON BOTTOM
0758 HBOT=U*P
0760 STRBT=Z+15.2222*HTOP+Z*Z
0764 STRBB=Z+15.2222*HBOT+Z*Z
0768 A=DST-STRBT
0772 AB=DSC-STRBB
0776 AC=(AB*(B+D)-4*D)/(A*B)
0780 AD=HMM*(B+D)/(A*4.*D*(D*D+2.*B*D))
0784 AE=(B.*B*D+2.*B*D)/(D*D+2.*B*D)
0790 C *TOP* IS THE THICKNESS OF THE TOP PLATING
0790 C *BOT* IS THE THICKNESS OF THE BOTTOM PLATING
0790 BOT=AB/(1.+AC-AE)
0798 C TOP=AC-BOT
0804 WRITE(5,1)TOP
0810 10 FORMAT('1',20X,'TOP='F10.4)
0814 WRITE(5,20)BOT
0820 20 FORMAT(' ',20X,'BOT='F10.4)
0824 C *S* IS THE SPACING OF LONGITUDINAL STIFFENING MEMBERS
0824 S=Z-TOP
0830 WRITE(5,30)S
0834 30 FORMAT(' ',20X,'S='F10.4)
0840 P=2.*D*BOT+B*(TOP+BOT)
0844 C *DITOP* IS THE DISTANCE OF THE TOP FROM THE NEUTRAL AXIS
0844 DITOP=D*(B*BOT+D*BOT)/P
0848 WRITE(5,40)DITOP
0854 40 FORMAT(' ',18X,'DITOP='F10.4)
0860 C *DIBOT* IS THE DISTANCE OF THE BOTTOM FROM THE NEUTRAL AXIS

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STRENGTH OF SHIPS-ON THE NEUTRAL AXIS LOCATION

PAGE 2

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0330      DIBOT=D*(B+TOP+D*BOT)/P
0354      WRITE(5,F4)DIBOT
0370      50 FORMAT(1 1,18X,'DIBOT='F12.4)
0380      C   *GMI* IS THE MOMENT OF INERTIA OF THE X SECTION ABOUT N.A.
0380      GMI=4.*D*D*((3.*R*R+2.*R*D)*TOP*BOT+(D*D+2.*B*D)*BOT*BOT)/P
0390      C   *TSTH* IS THE STRESS ON TOP DUE TO HOGGING
0390      C   *TSTS* IS THE STRESS ON TOP DUE TO SAGGING
0390      C   *TSBH* IS THE STRESS ON BOT DUE TO HOGGING
0390      C   *TSBS* IS THE STRESS ON BOT DUE TO SAGGING
0390      C   *STCRIT* IS THE CRITICAL STRESS ON TOP
0390      C   *SBCRIT* IS THE CRITICAL STRESS ON BOT
0390      TSTH=HM*DITOP/GMI+S*RBT
0410      TSTS=SM*DIBOT/GMI+S*RBT
0420      STCRIT=TOP*TDFE/(1.30396*S*S*(1.-POI*POI))
0440      WRITE(5,49)TSTH
0480      60 FORMAT(1 1,18X,'TSTH='F10.3)
0490      WRITE(5,70)TSTS
0466      70 FORMAT(1 1,18X,'TSTS='F10.3)
0400      WRITE(5,80)STCRIT
04EC      80 FORMAT(1 1,17X,'STC.RIT='F10.3)
0508      TSBH=HM*DIBOT/GMI+2.152222*HBOT*S*S/(BOT*BOT)
0544      TSBS=SM*DIBOT/GMI+2.152222*HBOT*S*S/(BOT*BOT)
0580      SBCRIT=BOT*BCT*TDFE/(1.30396*S*S*(1.-POI*POI))
05C0      WRITE(5,90)TSBH
05DC      90 FORMAT(1 1,18X,'TSBH='F10.3)
05F6      WRITE(5,10)TSBS
0512      100 FORMAT(1 1,18X,'TSBS='F10.3)
0520      WRITE(5,11)SBCRIT
0548      110 FORMAT(1 1,17X,'SBCRIT='F10.3)
0564      END

```

| | | | | | |
|------|--------|----------------|--------------|---------------|---------------|
| 0[S] | *U | 0568[V] AL | 0671[V] B | 0678[V] DRA | 0680[V] D |
| 8[V] | POI | 0690[V] F | 0900[S] *R | 0690[V] DST | 06A4[V] DSC |
| C[V] | HM | 0694[V] SM | 0698[V] W | 06C4[V] U | 0000[S] SQRT |
| 8[V] | Z | 06CC[V] HTOP | 06D4[V] HBOT | 06D8[V] STRBT | 26E1[V] STR3B |
| 4[V] | A | 06E8[V] AB | 06EC[V] AC | 0700[V] AD | 0714[V] AE |
| C[V] | BOT | 0720[V] TG | 0721[L] 12 | 0000[S] @I | 025A[L] 20 |
| 4[V] | S | 0298[L] 32 | 0729[V] P | 0720[V] DITOP | 0314[L] 40 |
| 0[V] | DIBOT | 0372[L] 52 | 0734[V] GMI | 0740[V] TSTH | 0744[V] TSTS |
| 8[V] | STCRIT | 0487[L] 62 | 0494[L] 72 | 04EC[L] 80 | 0740[V] TSBH |
| 0[V] | TSBS | 0754[V] SBCRIT | 0500[L] 92 | 0612[L] 100 | 0648[L] 110 |
| 2[S] | *V | | | | |
| AEQ | L | | | | |

PROGRAM LABELS:

| | | | | | |
|-------------|-----------|------------|-----------|-----------|----------|
| 2070 *MAIN* | 2FDE *V | 2DDE *COMP | 29B0 ALOG | 2EEC @I | 27C8 *R |
| 2DD6 *ZERO | 2D34 \$6 | 2809 *A | 2E32 *MES | 2CB0 *W | 2AB8 EXP |
| 2C3E AINT | 28BA SQRT | 2D7A *ARG | 2DD2 *S | 2AB8 AEXP | 2DDA *ER |
| 2DAB \$8 | 2DDA *O | 2EB0 *U | 4028 | | |

TRY-POINTS:

| | | | | | |
|---------|---------|-----------|-----------|-----------|----------|
| 27C8 *P | 2808 *A | 28BA SQRT | 29B0 ALOG | 2AB8 AEXP | 2AB8 EXP |
|---------|---------|-----------|-----------|-----------|----------|

TOP= 2.9992
BOT= 3.7608
S= 105.2122
DITOP= 38.4761
DIBOT= 32.9524
TSTH= 24999.988
TSTS= 18635.431
STCRIT= 3.710.004
TSRH= 24476.747
TSHS= 2.954.855
SRCRIT= 47172.344

' END

CF VIC OPERATING SYSTEM VERSION 1 REVISION 012 03/24/74 GENERATED 05/02/74

| | | |
|-----------------------|-----------------|-----|
| JCB HANDLING CHARGE | \$.35 / JMB | .35 |
| 132 LINES PRINTED PRE | \$ 1.28 / K LN | .16 |
| 88 CARDS READ | \$ 1.50 / K CD | .13 |
| 40 PLOTTER VECTORS | \$.25 / 1 /Z | .04 |
| 15 ODEL 77 SECONDS | \$ 25.00 / HOUR | .12 |
| 70 ODEL 87 SECONDS | \$ 12.50 / HOUR | .04 |
| | TOTAL CHARGE \$ | .74 |

RREIR 492 14731 LOGGED OUT 29/09/75 02:45+ \$ 17.18 LEFT AFTER 13 LOGINS.

This last example shows that TSBH is low and the Z approximation used in the formulas here again should be corrected as already exemplified in order to bring it closer to the DSC value.

CONCLUSION

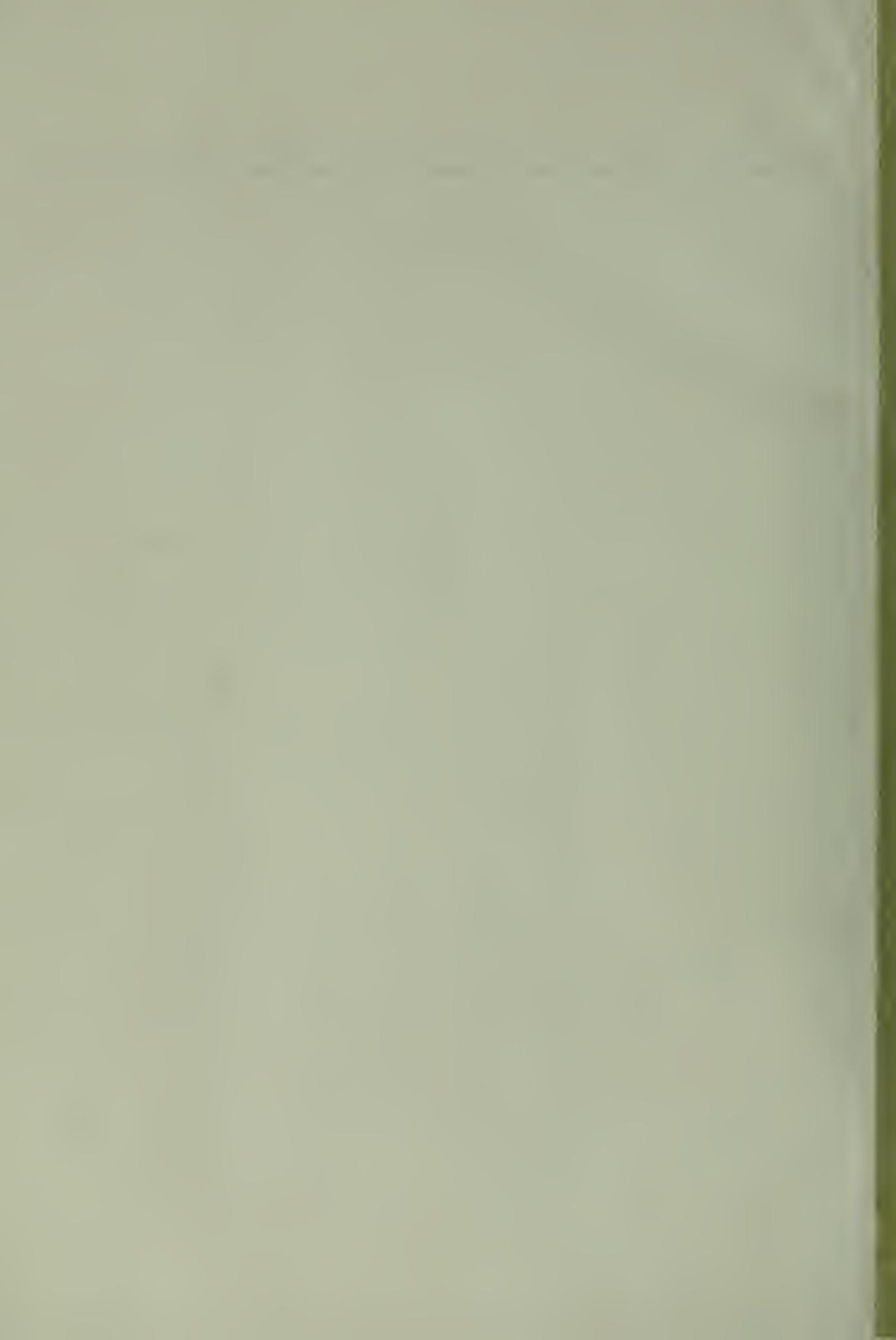
From this work the author is led to conclude that there is no simplified approach to the neutral axis location in the midship section, capable of handling properly all or only a majority of cases. It is advisable to look into each particular situation by first gaining some insight at what the diagrams of stress distributions may look like as exemplified in several sections. The two last sections exemplify well why this may be of some advantage and specially the last section which shows that while at first it was expected for the examples studied a neutral axis closer to the top, actually the results ended up requiring a neutral axis closer to the bottom and a new set of formulas had to be derived.

As a future development for this work it is here suggested that a more ship like cross section could be analysed as a step forward towards obtaining a method of determination of scantlings as direct as possible. This next step should consider the derivation of proper formulas for DITOP, DIBOT and I involving only the plate thicknesses as unknowns. It should be considered then, in order to simplify the problem., a standard type of frame and its scantlings should be constant throughout the midship section.

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