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RESEARCH ESTABLISHMENT

LUCAS HEIGHTS RESEARCH LABORATORIES

RESULTS OF PIPE BEND ANALYSIS PART II: STRESS DISTRIBUTIONS FROM BENDING FLANGED PIPE ELBOWS

by

J.F. WHATHAM

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ABSTRACT

Graphs of outside surface stress distributions are presented and numerical values of stresses on inside and outside surfaces tabulated for a wide range of flange-ended pipe elbows subjected to pure in-plane bending; calculations are based on linear thin shell theory.

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PIPES; STRESSES; STRESS ANALYSIS; FLANGES

CONTENTS

1. INTRODUCTION

An analysis of flange-ended pipe elbows subjected to pure in-plane bending, supported by experiment, has been published [Whatham 1979] and the detailed analysis given [Whatham 1982].

The objective of this report is to present the surface stress distributions for a range of flanged elbows to assist pipework design engineers and to provide analytic solutions for checking numerical solution methods. Wall thicknesses vary from 1 to 10 per cent of the pipe radius with bend radii two, three and five times the pipe radius.

Stresses were calculated by the thin shell theory of Novozhilov [1970] with the assumptions that:

(i) the pipe wall is thin ($t/r < 0.3$),

(ii) normal stresses through the wall are negligible,

(iii) normals through the wall remain normal to it and unchanged in length, and

(iv) the flanges are infinitely stiff.

2. STRESS DERIVATION

The flanged pipe elbow configuration is shown in Figure 1. An element of the elbow middle surface, an imaginary surface mid-way between the inner and outer surfaces, is shown in Figure 2 and is supposed to have forces T_θ, T_η, $T_{\theta\eta}$, $T_{\eta\theta}$, N_θ, N_η and moments M_θ, M_η, $M_{\eta\theta}$, $M_{\theta\eta}$ per unit length acting on its edges. The solution was obtained by thin shell theory in terms of these forces and moments; the stresses presented in this report were then derived as follows:

$$\text{Hoop stress: } \sigma_{\theta\theta} = T_\theta/t + 12zM_\theta/t^3$$

$$\text{Axial stress: } \sigma_{\eta\eta} = T_\eta/t + 12zM_\eta/t^3 \qquad (1)$$

Shear stress: $\sigma_{\eta\theta} = S/t + z(12H/t^3 - S/rt)$ (1) cont'd

where

$$S = T_{\theta\eta} - M_{\eta\theta}/r_\eta = T_{\eta\theta} - M_{\theta\eta}/r,$$

and

$$H = M_{\theta\eta} = M_{\eta\theta} \quad .$$

These stresses were close to those derived from beam theory when considering a straight pipe subjected to bending or torsion; if a moment M is applied to a straight pipe, Novozhilov's theory gives [see Whatham 1981]

$$T_\eta = \frac{12M\cos\theta}{(12+\gamma)\pi r^2}$$

$$M_\eta = \frac{\gamma M\cos\theta}{(12+\gamma)\pi r} \qquad (2)$$

$$T_\theta = M_\theta = S = H = 0$$

where $\gamma = (t/r)^2$.

Substituting in Equations (1), the axial stress distribution approximates that from beam theory, which is

$$\sigma_{\eta\eta} = \frac{M(r+z)\cos\theta}{\pi r^3 t(1+\gamma/4)} \quad . \qquad (3)$$

If torque T is applied to a straight pipe, Novozhilov's theory gives

$$S = \frac{3T}{2(3+\gamma)\pi r^2}$$

$$H = \frac{\gamma T}{4(3+\gamma)\pi r} \qquad (4)$$

$$T_\eta = M_\eta = T_\theta = M_\theta = 0 \quad .$$

Substituting in Equations (1), the shear stress distribution approximates that from beam theory, given by

$$\sigma_{\eta\theta} = \frac{T(r+z)}{2\pi r^3 t(1+\gamma/4)} \quad . \qquad (5)$$

Equations (1) assume that the strains are linearly distributed through the pipe wall; this is not true for curved shells and the stresses $\sigma'_{\theta\theta}$, $\sigma'_{\eta\eta}$, $\sigma'_{\eta\theta}$ derived by the following equations are theoretically more accurate, even though the results do not agree with beam theory in the case of straight pipes:

$$\sigma'_{\theta\theta} = \sigma_{\theta\theta} - z(A+\nu B)/(1-\nu^2)$$

$$\sigma'_{\eta\eta} = \sigma_{\eta\eta} - z(B+\nu A)/(1-\nu^2) \qquad (6)$$

$$\sigma'_{\eta\theta} = \sigma_{\eta\theta} - \frac{z}{2r}\left[(r/(r+z)+r/(r_\eta+z))\sigma_{\eta\theta} - (r_\eta-r)\bar{\sigma}_{\eta\theta}/(r_\eta+z)\right]$$

where

$$A = (\sigma_{\theta\theta} - \nu\sigma_{\eta\eta})/(r+z) ,$$

$$B = (\sigma_{\eta\eta} - \nu\sigma_{\theta\theta})/(r_\eta+z) , \quad \text{and}$$

$$\bar{\sigma}_{\eta\theta} = \tfrac{1}{2}\sigma_{\eta\theta}\ (\text{inside}) + \tfrac{1}{2}\sigma_{\eta\theta}\ (\text{outside}).$$

3. ELBOW CONFIGURATION AND RESULTS

Because of symmetry, stresses had only to be calculated for one side of the bend in Figure 1 (θ = 0-180°) and from flange to mid-bend (ϕ = 0-45°). Stresses acting in the hoop and axial directions on the outside surface are plotted in Appendix A, together with the stresses on theoretically unterminated pipe bends, in which case they are independent of ϕ. The maxima and minima of the latter curves are given by the floating numbers.

The two graphs for each pipe bend are accompanied by tabulated stresses from which the graphs were constructed. In addition, since shear stresses and inside surface stresses are also given and a linear variation through the wall is assumed, the complete stress state in each pipe bend is provided.

A computer program package BENDPAC, written in FORTRAN IV and ASSEMBLER for an IBM3031 computer and designed to calculate the stresses in and the flexibility of flanged pipe elbows under in-plane or out-of-plane loading, is available from either the Australian Atomic Energy Commission or the National Energy Software Center, Argonne National Laboratory, USA.

4. REFERENCES

Novozhilov, V.V. [1970] - Thin Shell Theory. 2nd Augmented and Revised Edition, Wolters-Noordhoff, Gröningen, The Netherlands.

Whatham, J.F. [1979] - In-plane bending of flanged pipe elbows. Trans. Inst. Eng. Aust., CE 21(2)80.

Whatham, J.F. [1981] - Thin shell equations for circular pipe bends. J. Nucl. Eng. Des., 65(1)77.

Whatham, J.F. [1982] - Analysis of circular pipe bends with flanged ends. J. Nucl. Eng. Des., 71(1)192.

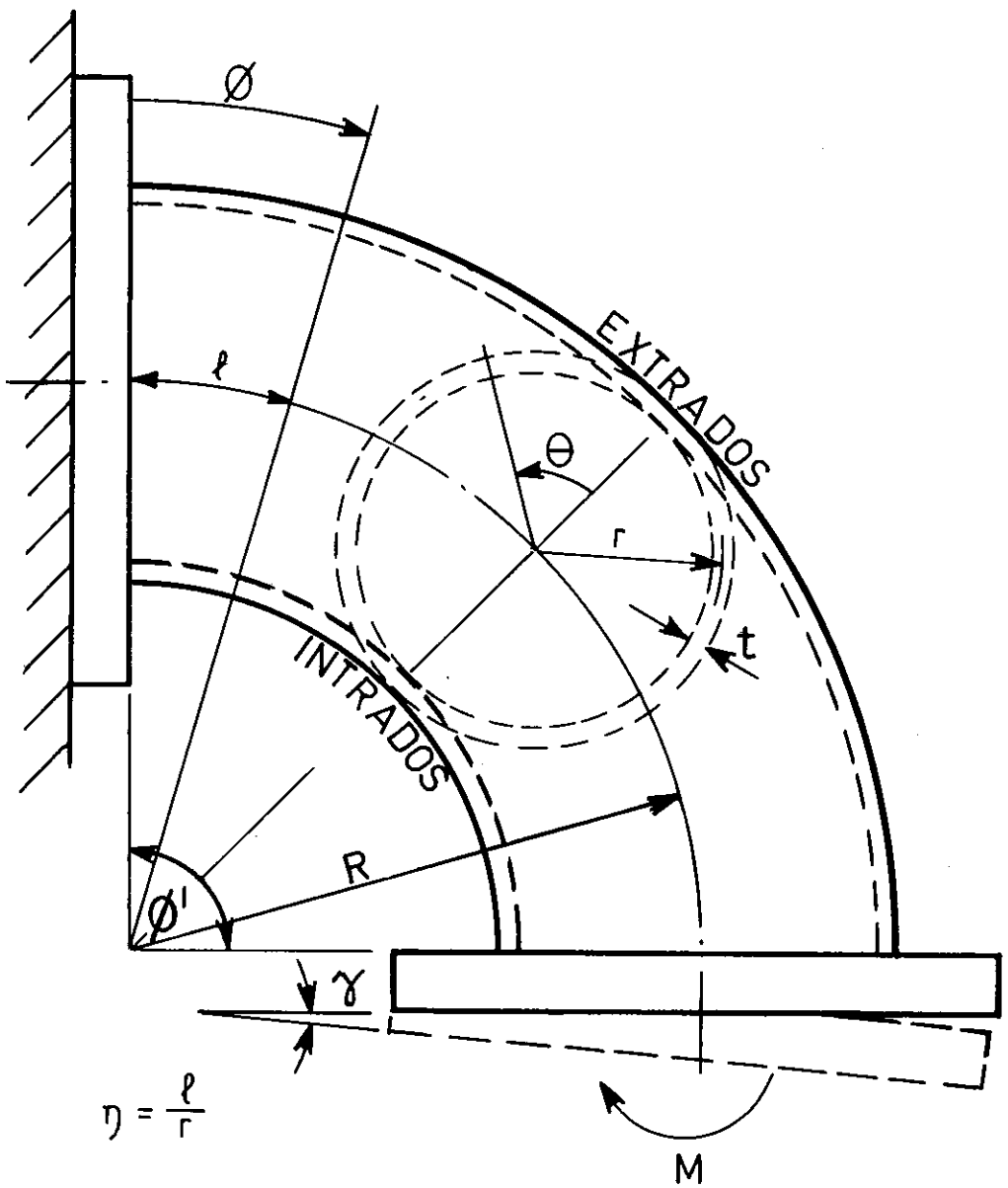

FIGURE 1. PIPE BEND CONFIGURATION

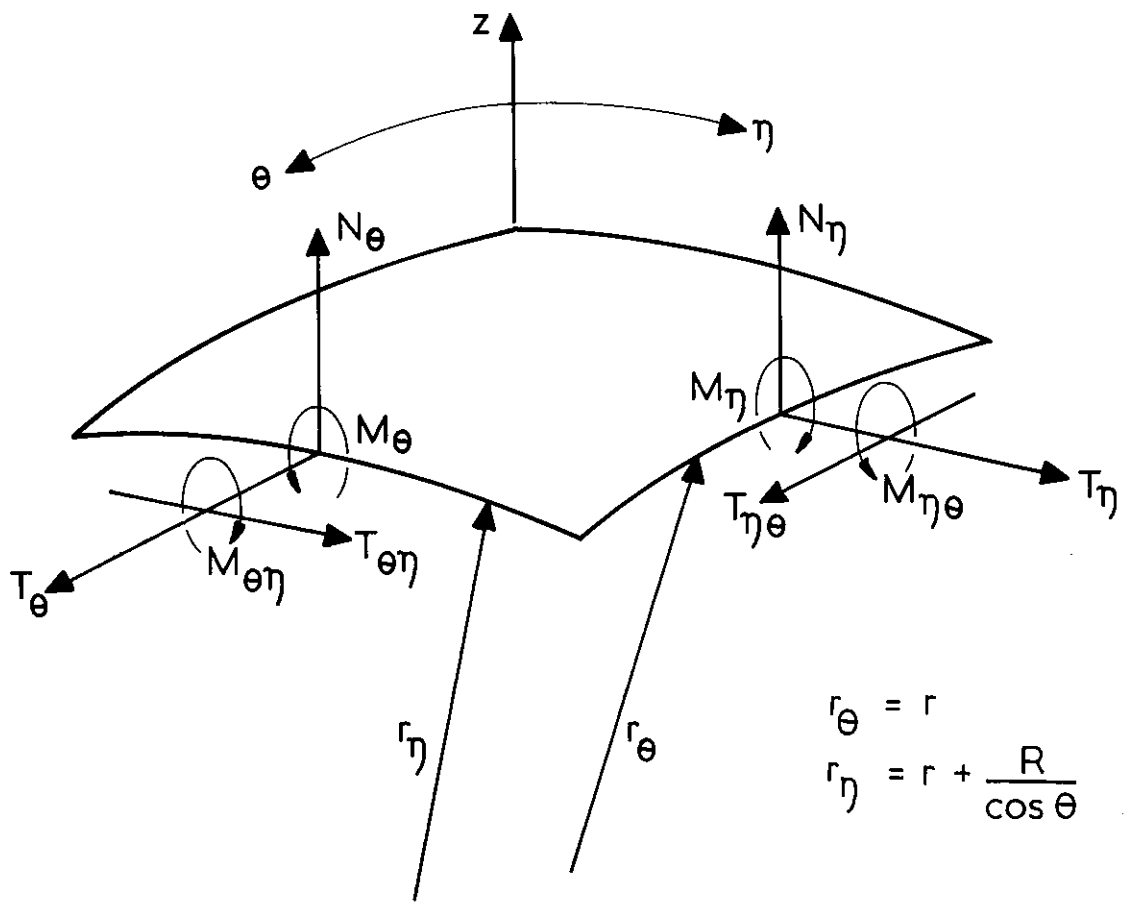

FIGURE 2. ELEMENT OF PIPE MIDDLE SURFACE

APPENDIX A
STRESSES IN FLANGED PIPE ELBOWS IN PURE BENDING

Parameters of pipe elbows considered:

$R/r = 2, 3, 5$

$t/r = 0.01, 0.02,, 0.05, 0.1$

$\nu = 0.3$

Stress factor = stress. $\pi r^2 t/M$

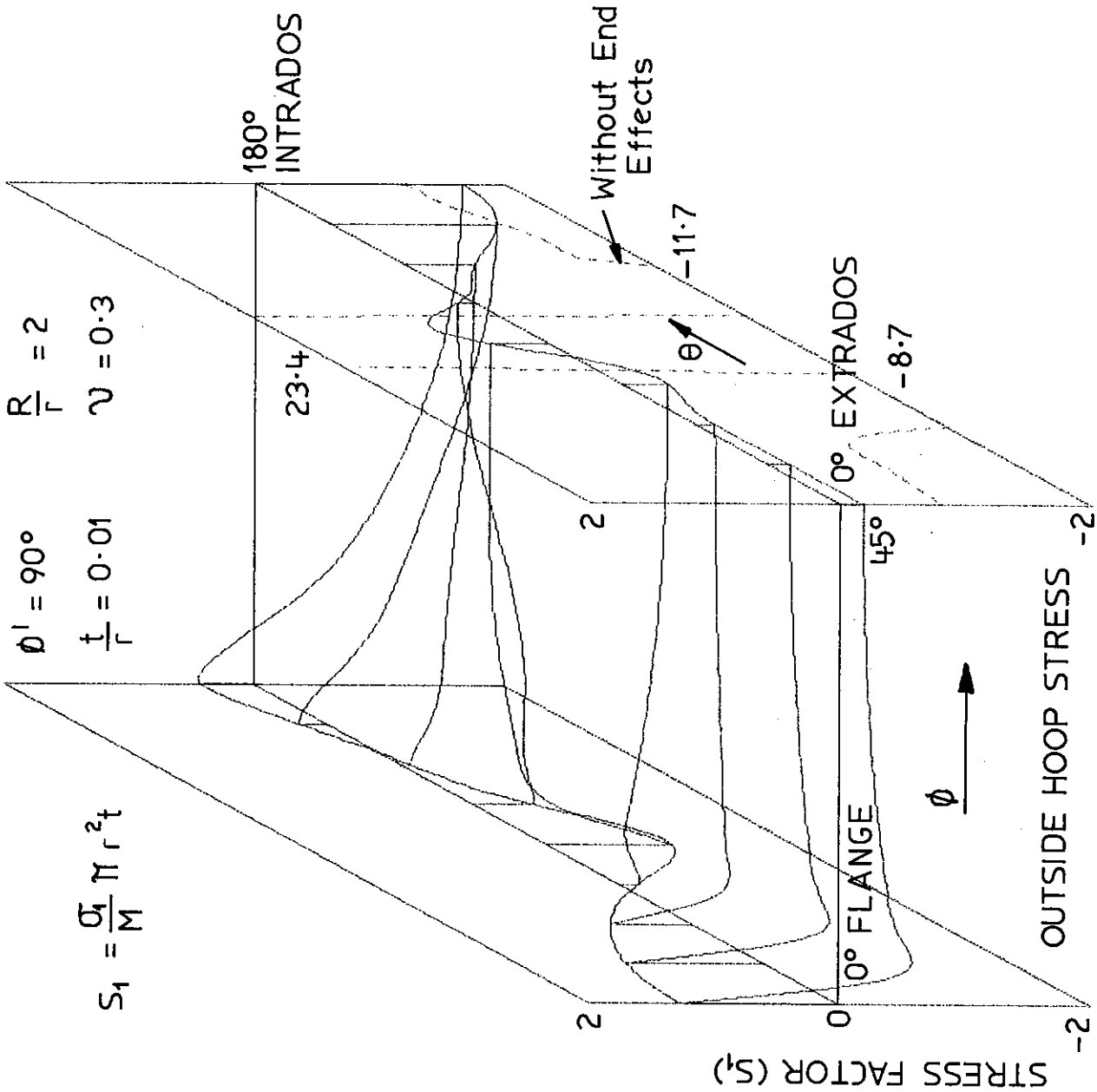
$S_1 = \frac{\sigma_1}{M} \pi r^2 t$
$\phi' = 90°$
$\frac{t}{r} = 0·01$
$\frac{R}{r} = 2$
$\nu = 0·3$
180° INTRADOS
23·4
Without End Effects
−11·7
θ
0° EXTRADOS
−8·7
2
45°
0° FLANGE
φ
OUTSIDE HOOP STRESS
STRESS FACTOR (S_1)
2
0
−2
−2

FIGURE A1

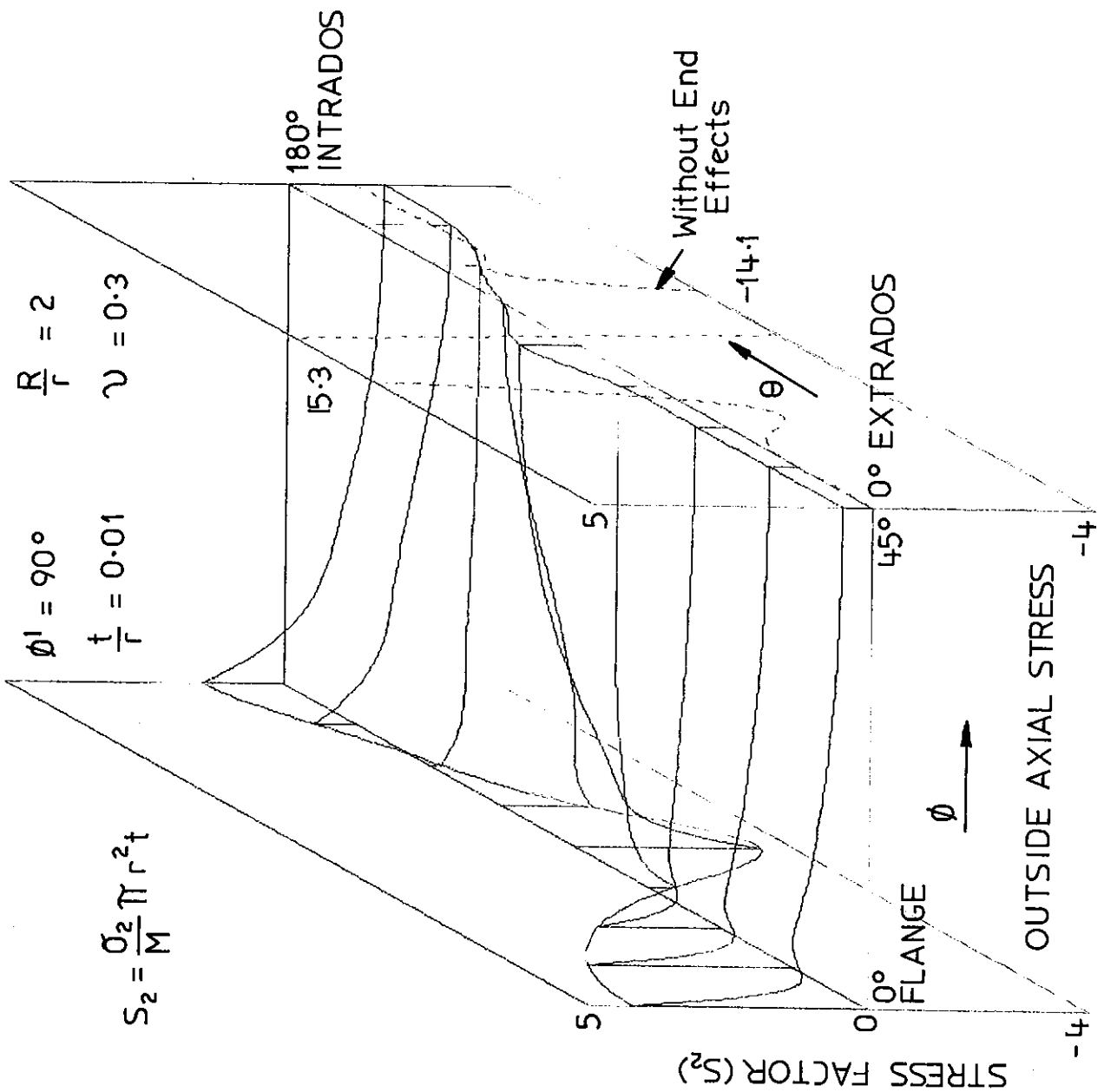
$S_2 = \frac{\sigma_2}{M} \pi r^2 t$
$\phi^1 = 90°$
$\frac{t}{r} = 0{\cdot}01$
$\frac{R}{r} = 2$
$\nu = 0{\cdot}3$
180° INTRADOS
15·3
5
-14·1
Without End Effects
θ
0° EXTRADOS
45°
0° FLANGE
φ
OUTSIDE AXIAL STRESS
STRESS FACTOR (S_2)
5
0
-4
-4

FIGURE A2

TABLE A1

R/r = 2.0 t/r = 0.01

OUTSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.4401	-0.0046	-0.5640	-0.9126	-1.1560	-1.3472	-1.4895	-1.5832	-1.6345	-1.6506	-1.1951
157.5	0.2323	-0.1147	-0.4422	-0.6319	-0.7932	-0.9558	-1.1080	-1.2326	-1.3147	-1.3433	-1.3633
135.0	-0.0644	-0.2789	-0.3487	-0.3801	-0.4260	-0.4777	-0.5228	-0.5560	-0.5756	-0.5821	-1.7647
112.5	-0.4848	-0.3973	-0.4078	-0.3785	-0.2904	-0.1722	-0.0488	0.0569	0.1275	0.1523	-11.1507
90.0	-1.0059	0.1210	0.2682	0.3552	0.4217	0.4574	0.4712	0.4725	0.4696	0.4680	23.3854
67.5	-0.1537	-0.0478	-0.1355	-0.2085	-0.2668	-0.3113	-0.3430	-0.3638	-0.3754	-0.3791	-7.7007
45.0	0.6531	-0.3024	-0.2475	-0.2318	-0.2140	-0.1979	-0.1845	-0.1747	-0.1686	-0.1666	-2.3000
22.5	1.1105	-0.4873	-0.3557	-0.3062	-0.2656	-0.2348	-0.2122	-0.1967	-0.1876	-0.1847	-0.8881
-0.0	1.2642	-0.5506	-0.3930	-0.3301	-0.2810	-0.2447	-0.2185	-0.2008	-0.1906	-0.1873	-0.8258

OUTSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	1.4670	-0.0844	-0.7126	-0.9939	-1.2267	-1.4280	-1.5739	-1.6637	-1.7096	-1.7234	-1.1878
157.5	0.7744	-0.2551	-0.5803	-0.7370	-0.9209	-1.1235	-1.3146	-1.4720	-1.5763	-1.6129	-1.2391
135.0	-0.2148	-0.6050	-0.6422	-0.6765	-0.7287	-0.7716	-0.7970	-0.8080	-0.8109	-0.8112	-0.9160
112.5	-1.6158	-1.2987	-1.2605	-1.0746	-0.8208	-0.5507	-0.3009	-0.1013	0.0269	0.0711	-11.7260
90.0	-3.3532	-0.7752	-0.3635	0.0925	0.4468	0.7066	0.8884	1.0064	1.0721	1.0931	8.0969
67.5	-0.5125	0.3298	0.4725	0.5733	0.6183	0.6317	0.6291	0.6209	0.6136	0.6108	5.2491
45.0	2.1772	0.9102	0.8894	0.8059	0.7323	0.6697	0.6204	0.5849	0.5637	0.5566	-0.9486
22.5	3.7017	1.2363	1.0895	0.9178	0.7880	0.6903	0.6191	0.5707	0.5426	0.5334	0.0548
-0.0	4.2141	1.3395	1.1421	0.9423	0.7952	0.6870	0.6096	0.5577	0.5278	0.5181	0.0234

OUTSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
157.5	-0.9344	-0.8970	-0.9033	-0.8819	-0.8202	-0.7206	-0.5839	-0.4126	-0.2138	-0.0000	0.0
135.0	-1.0313	-1.0287	-1.0153	-0.9460	-0.8314	-0.6861	-0.5225	-0.3501	-0.1751	0.0000	0.0
112.5	-0.7430	-0.6155	-0.4698	-0.3260	-0.2179	-0.1405	-0.0868	-0.0496	-0.0225	-0.0000	0.0
90.0	0.0026	0.1565	0.2564	0.2948	0.2964	0.2697	0.2210	0.1563	0.0808	-0.0000	0.0
67.5	0.8622	0.8551	0.7490	0.6335	0.5212	0.4117	0.3054	0.2019	0.1004	-0.0000	0.0
45.0	0.9228	0.8129	0.6358	0.4971	0.3829	0.2871	0.2047	0.1316	0.0644	0.0000	0.0
22.5	0.5447	0.4501	0.3364	0.2537	0.1900	0.1395	0.0979	0.0623	0.0303	0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0

TABLE A2

R/r = 2.0 t/r = 0.01

INSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	-0.4398	-0.0879	-0.3837	-0.6898	-0.9358	-1.1557	-1.3535	-1.5134	-1.6177	-1.6540	1.1946
157.5	-0.3155	-0.1560	-0.3974	-0.5984	-0.7431	-0.8598	-0.9518	-1.0161	-1.0530	-1.0649	1.3642
135.0	-0.2403	-0.2808	-0.3858	-0.4035	-0.3689	-0.3097	-0.2440	-0.1866	-0.1483	-0.1350	1.7920
112.5	-0.2728	-0.1970	-0.0461	0.0130	0.0262	0.0029	-0.0396	-0.0837	-0.1158	-0.1274	10.8953
90.0	0.1124	-0.2556	-0.2962	-0.4170	-0.4872	-0.5221	-0.5324	-0.5296	-0.5236	-0.5208	-26.9049
67.5	0.1118	-0.0468	0.0076	0.0459	0.0890	0.1268	0.1567	0.1777	0.1900	0.1941	7.4080
45.0	-0.0487	-0.2430	-0.2141	-0.1923	-0.1737	-0.1587	-0.1471	-0.1390	-0.1342	-0.1326	2.3477
22.5	-0.1631	-0.4199	-0.3278	-0.2743	-0.2329	-0.2021	-0.1798	-0.1647	-0.1560	-0.1532	0.8880
-0.0	-0.2058	-0.4830	-0.3648	-0.2997	-0.2506	-0.2149	-0.1894	-0.1724	-0.1627	-0.1595	0.8259

INSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	-1.4660	-0.4536	-0.3749	-0.6262	-0.8781	-1.0915	-1.2760	-1.4247	-1.5223	-1.5563	1.1828
157.5	-1.0517	-0.3957	-0.4508	-0.6710	-0.8500	-0.9836	-1.0847	-1.1559	-1.1975	-1.2111	1.2426
135.0	-0.8011	-0.5543	-0.6380	-0.6874	-0.6793	-0.6435	-0.5981	-0.5556	-0.5260	-0.5154	1.8986
112.5	-0.9095	-1.1521	-0.9558	-0.7667	-0.5816	-0.4119	-0.2711	-0.1665	-0.1023	-0.0807	-1.1067
90.0	0.3745	-1.1486	-0.5679	-0.2181	0.0623	0.2832	0.4482	0.5622	0.6290	0.6510	-7.0406
67.5	0.3725	0.1877	0.4499	0.5859	0.6666	0.7095	0.7293	0.7365	0.7382	0.7383	7.0971
45.0	-0.1623	1.0064	0.8741	0.8018	0.7314	0.6708	0.6225	0.5875	0.5664	0.5593	-0.4013
22.5	-0.5437	1.3746	1.0856	0.9202	0.7913	0.6940	0.6230	0.5748	0.5467	0.5375	-0.0238
-0.0	-0.6861	1.4784	1.1428	0.9468	0.7996	0.6913	0.6138	0.5617	0.5318	0.5220	-0.0323

INSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
157.5	-0.9251	-1.0298	-1.0355	-0.9641	-0.8490	-0.7058	-0.5432	-0.3679	-0.1855	0.0000	0.0
135.0	-1.0210	-1.0710	-1.0666	-1.0353	-0.9726	-0.8644	-0.7053	-0.4997	-0.2592	-0.0000	0.0
112.5	-0.7356	-0.8195	-0.6627	-0.5090	-0.3639	-0.2399	-0.1445	-0.0774	-0.0326	0.0000	0.0
90.0	0.0026	0.2218	0.3780	0.4520	0.4634	0.4246	0.3485	0.2461	0.1271	-0.0000	0.0
67.5	0.8536	0.9864	0.8331	0.6990	0.5675	0.4423	0.3241	0.2122	0.1049	0.0000	0.0
45.0	0.9136	0.8317	0.6460	0.5014	0.3839	0.2865	0.2035	0.1305	0.0638	-0.0000	0.0
22.5	0.5393	0.4547	0.3411	0.2559	0.1909	0.1396	0.0977	0.0620	0.0301	-0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0000	0.0

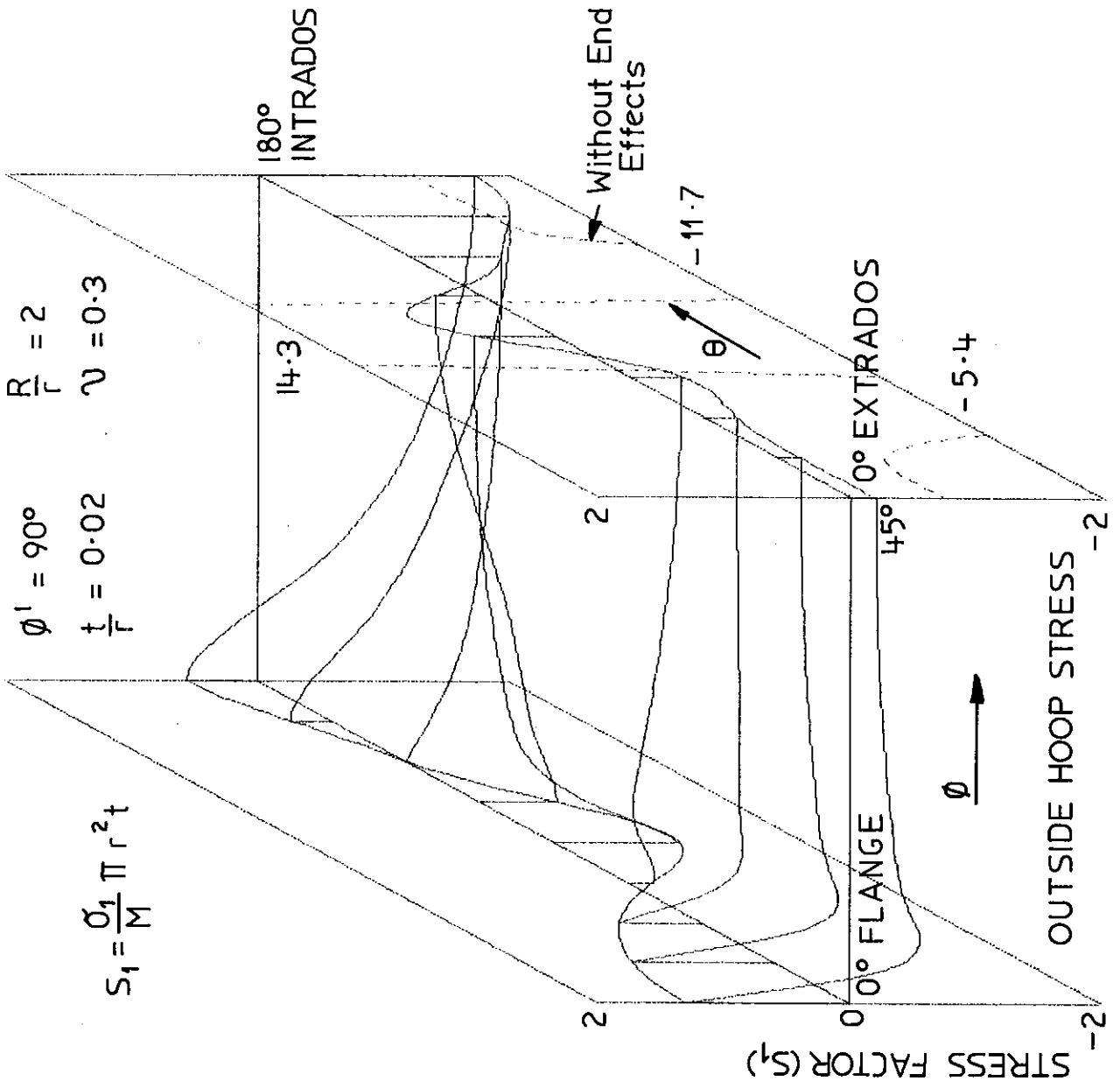
$S_1 = \frac{\sigma_1}{M} \pi r^2 t$
$\phi' = 90°$
$\frac{t}{r} = 0·02$
$\frac{R}{r} = 2$
$\nu = 0·3$
14·3
180° INTRADOS
Without End Effects
−11·7
θ
0° EXTRADOS
−5·4
2
45°
0° FLANGE
φ
OUTSIDE HOOP STRESS
STRESS FACTOR (S_1)
2
0
−2
−2

FIGURE A3

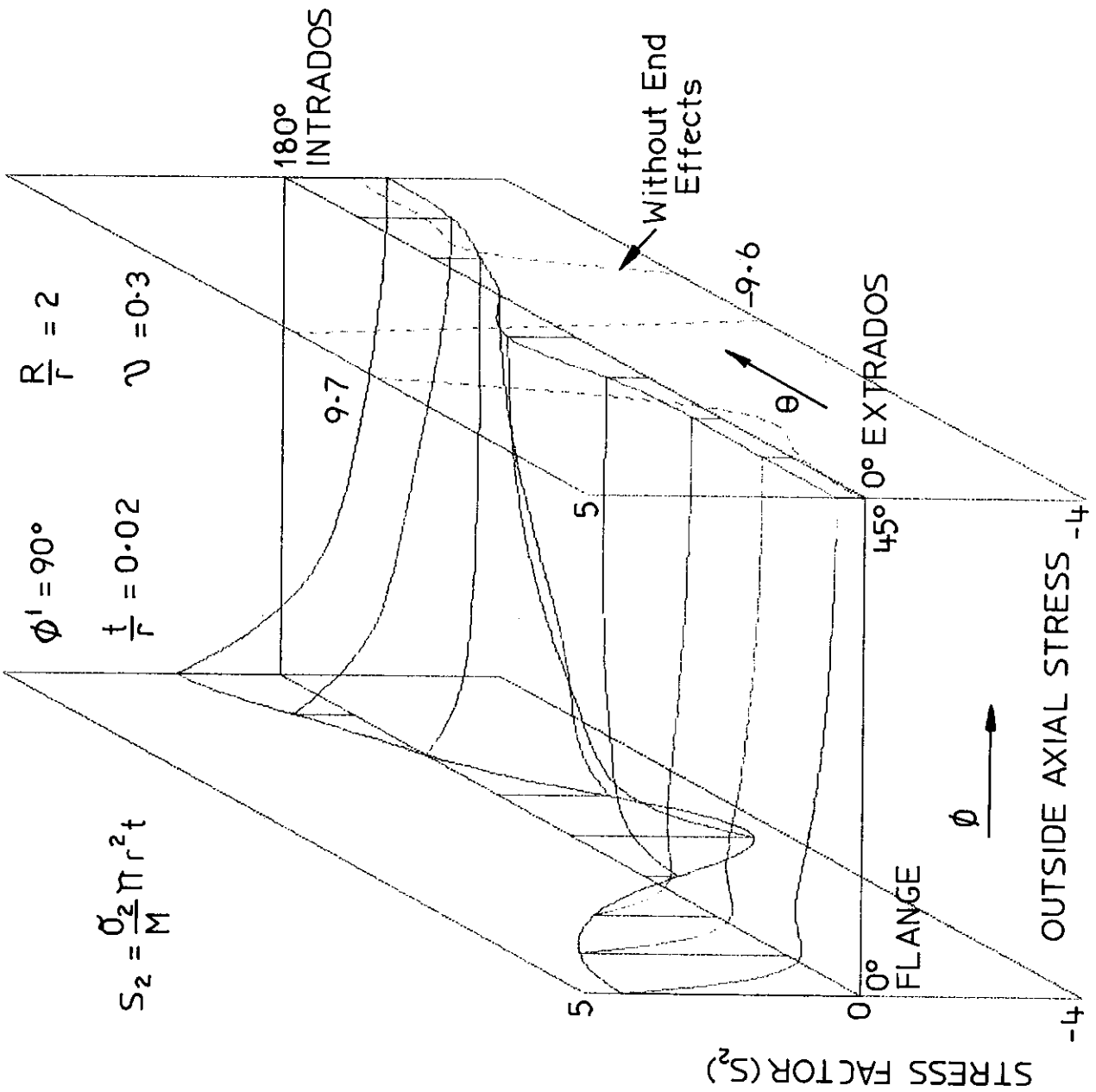
$S_2 = \frac{\sigma_2}{M} \pi r^2 t$
$\phi' = 90°$
$\frac{t}{r} = 0{\cdot}02$
$\frac{R}{r} = 2$
$\nu = 0{\cdot}3$
180° INTRADOS
9·7
Without End Effects
9·6
0° EXTRADOS
45°
0° FLANGE
θ
φ
5
0
-4
STRESS FACTOR (S_2)
OUTSIDE AXIAL STRESS

FIGURE A4

TABLE A3

R/r = 2.0 t/r = 0.02

OUTSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.5584	0.1832	-0.4076	-0.8544	-1.1509	-1.3572	-1.5097	-1.6191	-1.6858	-1.7082	-1.1844
157.5	0.3261	0.0451	-0.3464	-0.6312	-0.8368	-1.0102	-1.1643	-1.2899	-1.3723	-1.4010	-1.2206
135.0	-0.0061	-0.2537	-0.4382	-0.5405	-0.6076	-0.6599	-0.6999	-0.7270	-0.7421	-0.7468	-3.6569
112.5	-0.6073	-0.4634	-0.3431	-0.2572	-0.1351	0.0095	0.1493	0.2637	0.3384	0.3644	-4.2219
90.0	-0.9990	-0.0423	0.3198	0.4186	0.5011	0.5639	0.6030	0.6248	0.6351	0.6381	14.2537
67.5	-0.2027	-0.0580	-0.0772	-0.1663	-0.2394	-0.3015	-0.3520	-0.3888	-0.4112	-0.4187	-2.1347
45.0	0.6516	-0.2962	-0.2988	-0.2917	-0.2897	-0.2839	-0.2774	-0.2715	-0.2676	-0.2662	-3.8065
22.5	1.1325	-0.4843	-0.3733	-0.3101	-0.2698	-0.2372	-0.2130	-0.1963	-0.1866	-0.1834	-0.8669
-0.0	1.2901	-0.5588	-0.4101	-0.3373	-0.2902	-0.2537	-0.2275	-0.2097	-0.1994	-0.1961	-0.7469

OUTSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	1.8613	0.2408	-0.6518	-1.0709	-1.3097	-1.4970	-1.6563	-1.7785	-1.8543	-1.8798	-1.1721
157.5	1.0869	0.0019	-0.5460	-0.8058	-1.0021	-1.2062	-1.4068	-1.5739	-1.6831	-1.7209	-1.2056
135.0	-0.0204	-0.5692	-0.7707	-0.8483	-0.8909	-0.9165	-0.9262	-0.9240	-0.9180	-0.9151	-1.3663
112.5	-2.0243	-1.4406	-1.2815	-1.0881	-0.8199	-0.5454	-0.3027	-0.1136	0.0062	0.0472	-9.5356
90.0	-3.3300	-0.7410	-0.2257	0.1536	0.5057	0.7776	0.9741	1.1066	1.1830	1.2079	5.1399
67.5	-0.6757	0.3654	0.5728	0.6723	0.7358	0.7607	0.7641	0.7586	0.7524	0.7498	6.2809
45.0	2.1721	0.8065	0.8748	0.7769	0.6918	0.6206	0.5643	0.5239	0.4998	0.4917	-0.6659
22.5	3.7749	1.0233	1.0819	0.9000	0.7697	0.6728	0.6023	0.5544	0.5267	0.5176	-0.1654
-0.0	4.3005	1.0937	1.1406	0.9279	0.7818	0.6750	0.5985	0.5472	0.5176	0.5080	0.0684

OUTSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0000	0.0
157.5	-0.8489	-0.7826	-0.7848	-0.7853	-0.7502	-0.6700	-0.5467	-0.3869	-0.2005	-0.0000	0.0
135.0	-0.9862	-0.9575	-0.9251	-0.8426	-0.7183	-0.5738	-0.4246	-0.2785	-0.1376	-0.0000	0.0
112.5	-0.7009	-0.5050	-0.4095	-0.2911	-0.1964	-0.1295	-0.0827	-0.0488	-0.0227	0.0000	0.0
90.0	0.0190	0.1346	0.2054	0.2347	0.2288	0.2030	0.1635	0.1141	0.0586	-0.0000	0.0
67.5	0.7622	0.7302	0.6825	0.5786	0.4777	0.3801	0.2839	0.1888	0.0943	-0.0000	0.0
45.0	0.8594	0.7815	0.6325	0.4947	0.3835	0.2891	0.2070	0.1335	0.0654	0.0000	0.0
22.5	0.5121	0.4436	0.3332	0.2515	0.1889	0.1388	0.0975	0.0620	0.0302	0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0

TABLE A4

R/r = 2.0 t/r = 0.02

INSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	-0.5925	-0.1100	-0.2456	-0.5316	-0.8014	-1.0325	-1.2300	-1.3884	-1.4929	-1.5296	1.1829
157.5	-0.4107	-0.1529	-0.3223	-0.5464	-0.7072	-0.8020	-0.8526	-0.8769	-0.8868	-0.8893	1.2179
135.0	-0.2963	-0.2339	-0.2770	-0.2719	-0.2147	-0.1360	-0.0608	-0.0024	0.0338	0.0460	3.7993
112.5	-0.1951	-0.2436	-0.1048	-0.0921	-0.1440	-0.2203	-0.3031	-0.3760	-0.4254	-0.4428	3.4071
90.0	0.2087	-0.3952	-0.3789	-0.4998	-0.6066	-0.6721	-0.7085	-0.7263	-0.7334	-0.7351	-17.0399
67.5	0.1590	-0.1451	-0.0506	0.0038	0.0606	0.1197	0.1713	0.2106	0.2351	0.2434	1.5103
45.0	-0.0627	-0.1427	-0.1692	-0.1175	-0.0845	-0.0590	-0.0407	-0.0286	-0.0218	-0.0196	3.8834
22.5	-0.2013	-0.2760	-0.3280	-0.2583	-0.2203	-0.1918	-0.1714	-0.1578	-0.1499	-0.1474	0.8725
-0.0	-0.2496	-0.3284	-0.3649	-0.2802	-0.2331	-0.1980	-0.1731	-0.1565	-0.1470	-0.1439	0.7474

INSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	-1.9750	-0.8329	-0.4265	-0.4867	-0.6983	-0.9117	-1.0856	-1.2140	-1.2940	-1.3213	1.1888
157.5	-1.3691	-0.6447	-0.4683	-0.5820	-0.7442	-0.8648	-0.9373	-0.9768	-0.9960	-1.0018	1.1833
135.0	-0.9875	-0.6136	-0.5720	-0.5983	-0.5981	-0.5678	-0.5259	-0.4881	-0.4628	-0.4540	2.7142
112.5	-0.6503	-1.0882	-0.9786	-0.7953	-0.6502	-0.5289	-0.4302	-0.3583	-0.3150	-0.3005	-3.4875
90.0	0.6957	-0.9954	-0.6076	-0.2325	0.0179	0.2140	0.3649	0.4712	0.5343	0.5552	-4.3042
67.5	0.5301	0.1590	0.4176	0.6005	0.7036	0.7688	0.8080	0.8296	0.8402	0.8433	4.9620
45.0	-0.2089	1.0868	0.8601	0.7934	0.7259	0.6651	0.6157	0.5795	0.5574	0.5499	0.6610
22.5	-0.6710	1.5537	1.0554	0.9007	0.7729	0.6753	0.6043	0.5560	0.5280	0.5188	-0.2445
-0.0	-0.8321	1.6906	1.1138	0.9352	0.7902	0.6828	0.6060	0.5545	0.5248	0.5151	-0.0336

INSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
157.5	-0.8321	-0.9531	-0.9864	-0.9433	-0.8497	-0.7225	-0.5692	-0.3937	-0.2014	-0.0000	0.0
135.0	-0.9666	-1.0775	-1.1197	-1.0931	-1.0129	-0.8831	-0.7076	-0.4941	-0.2539	0.0000	0.0
112.5	-0.6870	-0.8710	-0.7108	-0.5312	-0.3795	-0.2558	-0.1606	-0.0910	-0.0405	-0.0000	0.0
90.0	0.0186	0.2197	0.3827	0.4501	0.4590	0.4213	0.3467	0.2455	0.1270	-0.0000	0.0
67.5	0.7471	1.0187	0.8667	0.7277	0.5967	0.4690	0.3458	0.2275	0.1128	0.0000	0.0
45.0	0.8424	0.8737	0.6557	0.5081	0.3880	0.2885	0.2043	0.1306	0.0637	0.0000	0.0
22.5	0.5020	0.4644	0.3373	0.2536	0.1885	0.1376	0.0961	0.0610	0.0296	0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0

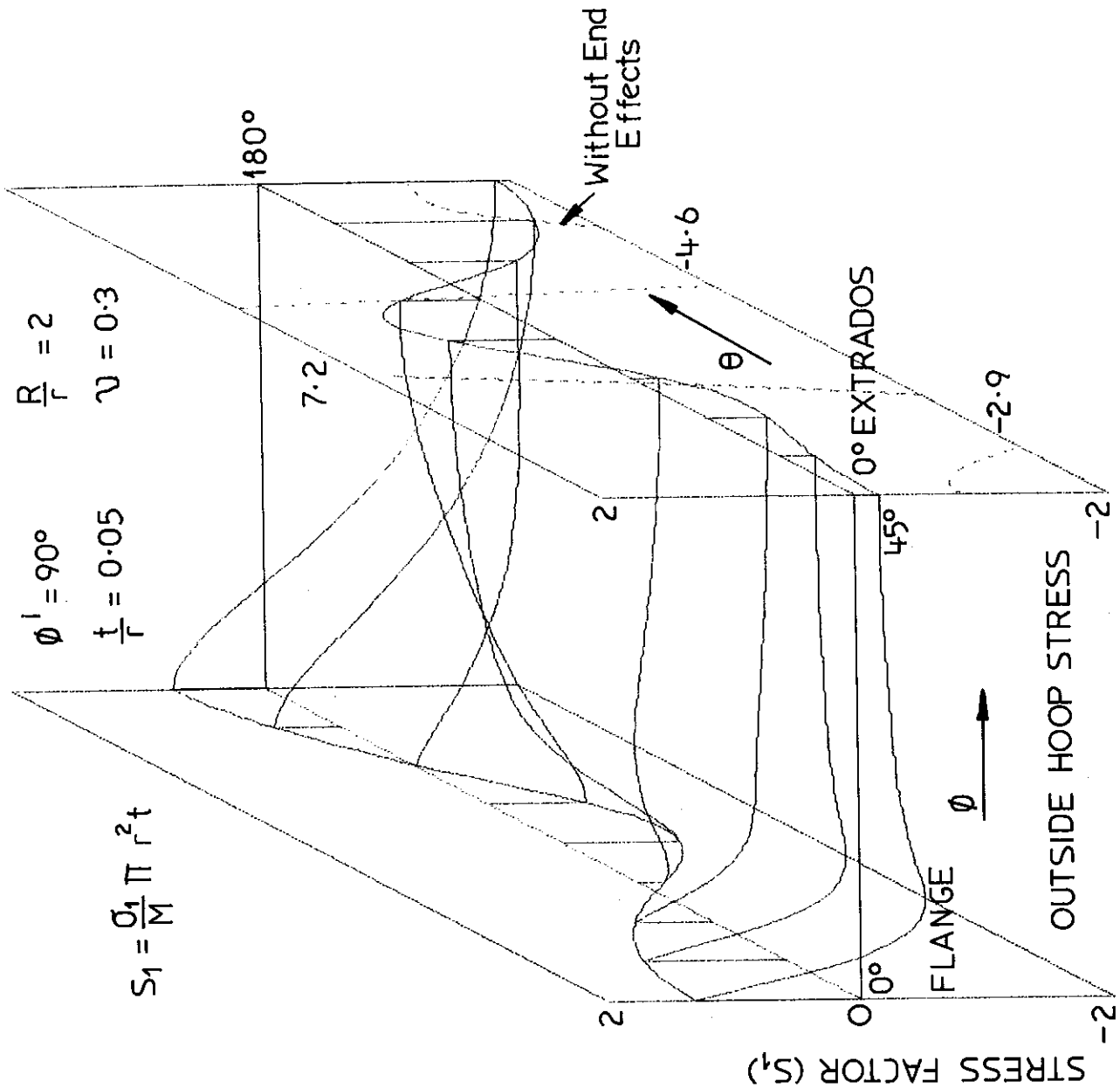
$S_1 = \frac{\sigma_1}{M} \pi r^2 t$
$\phi' = 90°$
$\frac{t}{r} = 0{\cdot}05$
$\frac{R}{r} = 2$
$\nu = 0{\cdot}3$
180°
7·2
Without End Effects
-4·6
θ
0° EXTRADOS
-2·9
2
45°
-2
0°
FLANGE
φ
OUTSIDE HOOP STRESS
STRESS FACTOR (S_1)
2
0
-2

FIGURE A5

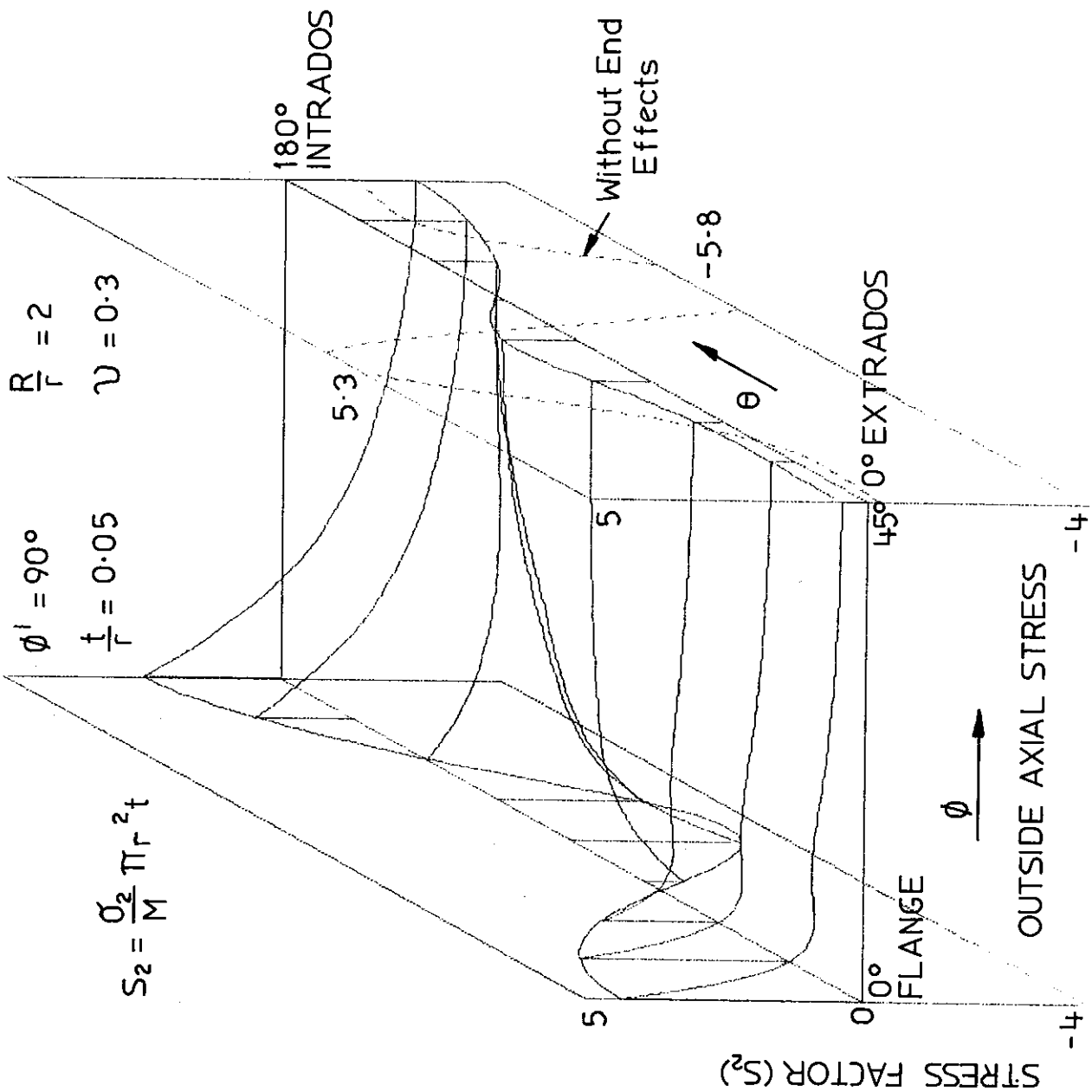
$S_2 = \frac{\sigma_2}{M} \pi r^2 t$
$\phi' = 90°$
$\frac{t}{r} = 0{\cdot}05$
$\frac{R}{r} = 2$
$\upsilon = 0{\cdot}3$
180° INTRADOS
5·3
Without End Effects
-5·8
θ
0° EXTRADOS
45°
5
0
-4
0° FLANGE
φ
OUTSIDE AXIAL STRESS
STRESS FACTOR (S_2)

FIGURE A6

TABLE A5

R/r = 2.0 t/r = 0.05

OUTSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.7378	0.4584	-0.0621	-0.5839	-1.0174	-1.3482	-1.5882	-1.7516	-1.8471	-1.8787	-1.0336
157.5	0.5264	0.2567	-0.1836	-0.6041	-0.9438	-1.1997	-1.3853	-1.5121	-1.5868	-1.6115	-1.5186
135.0	-0.0101	-0.2669	-0.5152	-0.6893	-0.7938	-0.8468	-0.8671	-0.8703	-0.8678	-0.8663	-4.5341
112.5	-0.7739	-0.5715	-0.2783	-0.0498	0.1327	0.2967	0.4427	0.5586	0.6327	0.6582	0.6523
90.0	-0.9245	-0.3249	0.2182	0.4750	0.6030	0.6911	0.7597	0.8090	0.8382	0.8478	7.2329
67.5	-0.2195	-0.1222	0.0016	-0.0039	-0.0603	-0.1183	-0.1658	-0.2016	-0.2242	-0.2319	1.1226
45.0	0.6108	-0.1420	-0.3498	-0.3729	-0.4035	-0.4363	-0.4609	-0.4776	-0.4875	-0.4909	-2.8812
22.5	1.1324	-0.2201	-0.4804	-0.3947	-0.3467	-0.3228	-0.3039	-0.2896	-0.2810	-0.2781	-1.7357
-0.0	1.3006	-0.2572	-0.5059	-0.3752	-0.3027	-0.2629	-0.2325	-0.2107	-0.1977	-0.1935	-0.8641

OUTSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	2.4592	0.9149	-0.2057	-0.9441	-1.4270	-1.7628	-2.0123	-2.1960	-2.3119	-2.3518	-1.1432
157.5	1.7547	0.5321	-0.3434	-0.9146	-1.2873	-1.5454	-1.7342	-1.8700	-1.9539	-1.9825	-0.9343
135.0	-0.0338	-0.6866	-1.0455	-1.2250	-1.2885	-1.2831	-1.2468	-1.2060	-1.1764	-1.1657	-3.5269
112.5	-2.5798	-1.6602	-1.1862	-0.9076	-0.6536	-0.3996	-0.1726	0.0019	0.1102	0.1468	-5.1786
90.0	-3.0817	-0.9180	-0.0625	0.3329	0.6248	0.8756	1.0755	1.2166	1.2995	1.3268	2.8162
67.5	-0.7316	0.2564	0.6989	0.8570	0.9300	0.9801	1.0126	1.0298	1.0372	1.0392	4.8176
45.0	2.0359	0.8034	0.8346	0.8189	0.7286	0.6476	0.5858	0.5407	0.5128	0.5034	1.0458
22.5	3.7746	0.9522	0.8792	0.8336	0.6967	0.5872	0.5117	0.4607	0.4309	0.4211	-0.3464
-0.0	4.3353	0.9801	0.9096	0.8662	0.7218	0.6103	0.5359	0.4867	0.4584	0.4491	-0.2856

OUTSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0000	0.0
157.5	-0.6993	-0.6107	-0.5692	-0.5402	-0.4991	-0.4350	-0.3477	-0.2419	-0.1239	-0.0000	0.0
135.0	-0.8511	-0.6683	-0.5798	-0.5070	-0.4245	-0.3347	-0.2449	-0.1593	-0.0782	-0.0000	0.0
112.5	-0.5645	-0.2980	-0.2491	-0.2082	-0.1601	-0.1167	-0.0812	-0.0515	-0.0251	-0.0000	0.0
90.0	0.0388	0.0970	0.1115	0.1191	0.1126	0.0951	0.0726	0.0486	0.0243	0.0000	0.0
67.5	0.5801	0.4674	0.4821	0.4296	0.3546	0.2793	0.2070	0.1370	0.0682	0.0000	0.0
45.0	0.6975	0.5855	0.5572	0.4533	0.3540	0.2699	0.1956	0.1274	0.0629	0.0000	0.0
22.5	0.4363	0.3758	0.3323	0.2539	0.1915	0.1426	0.1013	0.0651	0.0318	0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0

TABLE A6

R/r = 2.0 t/r = 0.05

INSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	-0.6240	-0.2882	-0.2097	-0.3460	-0.5430	-0.7238	-0.8611	-0.9522	-1.0028	-1.0189	1.0297
157.5	-0.6403	-0.2633	-0.2156	-0.2901	-0.3744	-0.4266	-0.4442	-0.4405	-0.4309	-0.4265	1.5491
135.0	-0.3827	-0.1863	-0.0726	-0.0023	0.0416	0.0711	0.0927	0.1081	0.1173	0.1204	4.6040
112.5	0.0161	-0.2599	-0.2780	-0.3336	-0.4583	-0.6085	-0.7473	-0.8554	-0.9233	-0.9464	-1.8869
90.0	0.3317	-0.4159	-0.5575	-0.6541	-0.7733	-0.8828	-0.9642	-1.0171	-1.0464	-1.0558	-9.2749
67.5	0.2129	-0.2348	-0.2665	-0.1976	-0.1345	-0.0798	-0.0289	0.0135	0.0414	0.0511	-1.9492
45.0	-0.0678	-0.0084	-0.1079	-0.0254	0.0647	0.1302	0.1798	0.2157	0.2373	0.2445	2.8487
22.5	-0.2586	0.0570	-0.2083	-0.1725	-0.1098	-0.0743	-0.0520	-0.0373	-0.0290	-0.0263	1.7640
-0.0	-0.3200	0.0588	-0.2731	-0.2486	-0.1912	-0.1620	-0.1451	-0.1341	-0.1280	-0.1260	0.8654

INSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	-2.7467	-1.5954	-0.8726	-0.5335	-0.4387	-0.4611	-0.5186	-0.5707	-0.6033	-0.6141	1.1249
157.5	-2.1343	-1.2340	-0.6950	-0.4606	-0.4046	-0.4249	-0.4627	-0.4932	-0.5106	-0.5160	1.6202
135.0	-1.2757	-0.7862	-0.5813	-0.5103	-0.4978	-0.5076	-0.5213	-0.5315	-0.5369	-0.5385	1.5266
112.5	0.0537	-0.6651	-0.8618	-0.8051	-0.7093	-0.6393	-0.5949	-0.5666	-0.5500	-0.5444	-3.1149
90.0	1.1057	-0.4049	-0.5541	-0.3108	-0.0758	0.0882	0.2005	0.2769	0.3224	0.3376	-2.2038
67.5	0.7096	0.2789	0.3213	0.5001	0.6479	0.7420	0.8015	0.8400	0.8620	0.8692	2.1155
45.0	-0.2259	1.0221	0.9148	0.8068	0.7697	0.7363	0.7035	0.6783	0.6628	0.6576	1.6092
22.5	-0.8619	1.5175	1.1557	0.8563	0.7291	0.6382	0.5665	0.5166	0.4875	0.4780	0.0641
-0.0	-1.0668	1.6852	1.2192	0.8686	0.7240	0.6229	0.5450	0.4920	0.4616	0.4517	-0.3164

INSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
157.5	-0.6652	-0.8039	-0.8983	-0.9270	-0.8880	-0.7885	-0.6383	-0.4486	-0.2313	-0.0000	0.0
135.0	-0.8096	-1.0919	-1.2108	-1.1903	-1.0796	-0.9133	-0.7113	-0.4860	-0.2464	-0.0000	0.0
112.5	-0.5370	-0.7834	-0.7073	-0.5414	-0.3860	-0.2625	-0.1688	-0.0986	-0.0450	0.0000	0.0
90.0	0.0369	0.2243	0.3710	0.4356	0.4361	0.3936	0.3208	0.2260	0.1166	0.0000	0.0
67.5	0.5518	0.9523	0.8937	0.7577	0.6252	0.4975	0.3719	0.2473	0.1235	-0.0000	0.0
45.0	0.6635	0.9191	0.7204	0.5454	0.4179	0.3136	0.2237	0.1438	0.0704	-0.0000	0.0
22.5	0.4150	0.5011	0.3532	0.2538	0.1879	0.1364	0.0947	0.0596	0.0288	-0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0000	0.0

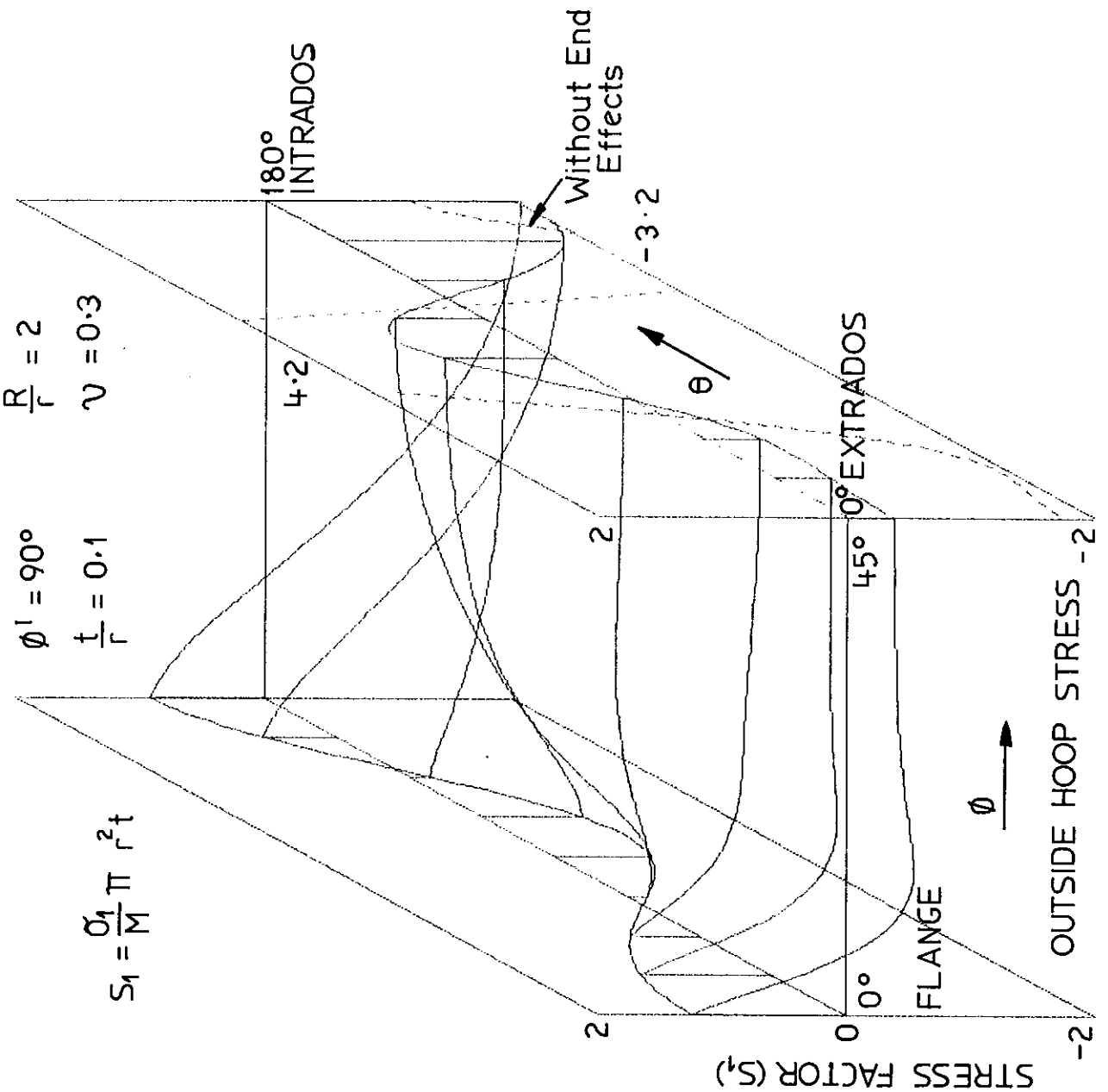
$S_1 = \frac{\sigma_1}{M} \pi r^2 t$
$\phi^1 = 90°$
$\frac{t}{r} = 0.1$
$\frac{R}{r} = 2$
$\nu = 0.3$
180° INTRADOS
4·2
Without End Effects
-3·2
θ
0° EXTRADOS
45°
0°
FLANGE
ϕ
2
0
-2
STRESS FACTOR (S_1)
OUTSIDE HOOP STRESS -2

FIGURE A7

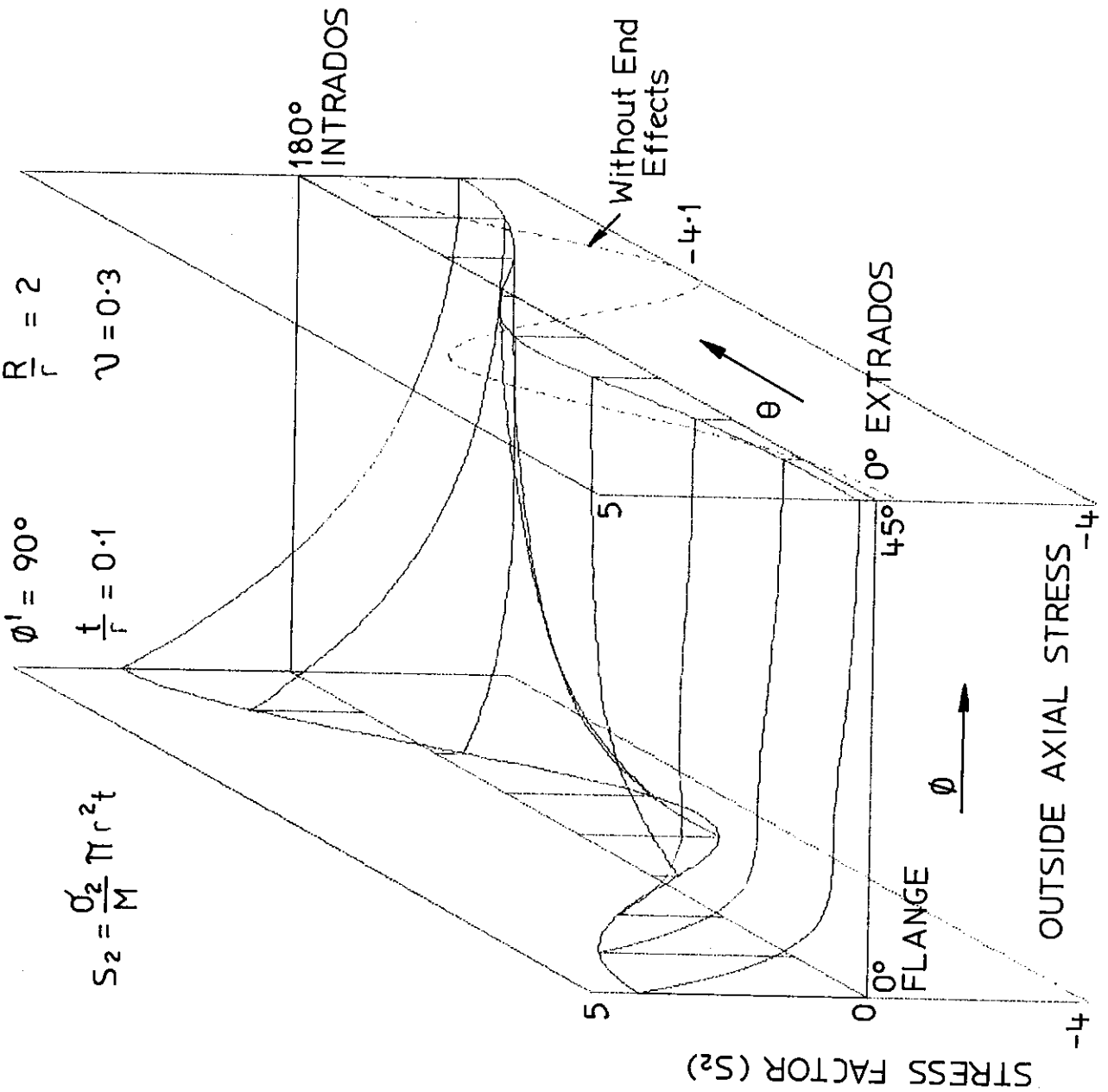
$S_2 = \frac{\sigma_2}{M} \pi r^2 t$
$\phi' = 90°$
$\frac{t}{r} = 0{\cdot}1$
$\frac{R}{r} = 2$
$\nu = 0{\cdot}3$
180° INTRADOS
Without End Effects
-4·1
0° EXTRADOS
θ
5
45°
0° FLANGE
φ
OUTSIDE AXIAL STRESS
-4
5
0
-4
STRESS FACTOR (S_2)

FIGURE A8

TABLE A7

R/r = 2.0 t/r = 0.10

OUTSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.9145	0.5996	0.1009	-0.4341	-0.9257	-1.3369	-1.6550	-1.8788	-2.0111	-2.0549	-1.1576
157.5	0.6048	0.3031	-0.1299	-0.5711	-0.9613	-1.2781	-1.5176	-1.6831	-1.7798	-1.8115	-2.3514
135.0	-0.1564	-0.3063	-0.4586	-0.5771	-0.6585	-0.7084	-0.7344	-0.7449	-0.7476	-0.7478	-2.8364
112.5	-0.8029	-0.6050	-0.2970	-0.0133	0.2150	0.3941	0.5332	0.6354	0.6987	0.7202	1.5342
90.0	-0.7671	-0.4228	0.0305	0.3609	0.5712	0.7051	0.7946	0.8547	0.8904	0.9023	4.2128
67.5	-0.1550	-0.1354	-0.0089	0.0756	0.1048	0.0991	0.0809	0.0635	0.0523	0.0485	1.5405
45.0	0.5621	0.0229	-0.2576	-0.3312	-0.3561	-0.3868	-0.4207	-0.4479	-0.4645	-0.4699	-1.3245
22.5	1.0636	0.0720	-0.4341	-0.5063	-0.4764	-0.4580	-0.4548	-0.4554	-0.4558	-0.4558	-1.9071
-0.0	1.2374	0.0796	-0.4864	-0.5344	-0.4692	-0.4238	-0.4010	-0.3880	-0.3802	-0.3774	-1.7442

OUTSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	3.0483	1.4492	0.1619	-0.8235	-1.5572	-2.0938	-2.4767	-2.7347	-2.8843	-2.9334	-0.8583
157.5	2.0161	0.7174	-0.2843	-1.0210	-1.5468	-1.9132	-2.1614	-2.3203	-2.4089	-2.4373	-1.5238
135.0	-0.5212	-0.9086	-1.1421	-1.2820	-1.3519	-1.3686	-1.3518	-1.3220	-1.2967	-1.2869	-3.7764
112.5	-2.6765	-1.7007	-1.0728	-0.6806	-0.4059	-0.1863	-0.0041	0.1365	0.2259	0.2565	-2.8026
90.0	-2.5569	-0.9830	-0.0976	0.4005	0.7107	0.9316	1.1000	1.2231	1.2989	1.3245	1.7780
67.5	-0.5168	0.1523	0.6202	0.8987	1.0407	1.1140	1.1595	1.1911	1.2106	1.2172	3.3249
45.0	1.8736	0.8709	0.7760	0.8388	0.8322	0.7805	0.7281	0.6910	0.6699	0.6630	1.6332
22.5	3.5454	1.1560	0.7148	0.6970	0.6395	0.5431	0.4582	0.4004	0.3681	0.3577	0.0575
-0.0	4.1246	1.2205	0.6770	0.6497	0.5871	0.4849	0.3966	0.3376	0.3050	0.2945	-0.4041

OUTSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0000	0.0
157.5	-0.5316	-0.3631	-0.2575	-0.1914	-0.1462	-0.1107	-0.0799	-0.0517	-0.0253	-0.0000	0.0
135.0	-0.6482	-0.3437	-0.2032	-0.1369	-0.0987	-0.0707	-0.0478	-0.0291	-0.0136	-0.0000	0.0
112.5	-0.3913	-0.1382	-0.0849	-0.0793	-0.0757	-0.0665	-0.0529	-0.0367	-0.0188	-0.0000	0.0
90.0	0.0560	0.0662	0.0563	0.0437	0.0302	0.0182	0.0093	0.0038	0.0011	0.0000	0.0
67.5	0.4184	0.2565	0.2646	0.2500	0.2092	0.1623	0.1175	0.0762	0.0374	0.0000	0.0
45.0	0.5065	0.3354	0.3603	0.3290	0.2670	0.2044	0.1479	0.0963	0.0475	0.0000	0.0
22.5	0.3270	0.2314	0.2469	0.2167	0.1705	0.1284	0.0922	0.0598	0.0294	0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0

TABLE A8

R/r = 2.0 t/r = 0.10

INSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	-1.0778	-0.5250	-0.2735	-0.1887	-0.1796	-0.1939	-0.2076	-0.2143	-0.2158	-0.2157	1.1554
157.5	-0.8360	-0.3949	-0.1640	-0.0462	0.0169	0.0563	0.0855	0.1081	0.1230	0.1283	2.4216
135.0	-0.3126	-0.1740	-0.0624	0.0055	0.0268	0.0127	-0.0196	-0.0541	-0.0792	-0.0883	2.6379
112.5	0.1935	-0.1733	-0.3452	-0.4854	-0.6444	-0.8160	-0.9769	-1.1057	-1.1881	-1.2163	-2.8123
90.0	0.3805	-0.2754	-0.5760	-0.7502	-0.8857	-1.0047	-1.1047	-1.1793	-1.2248	-1.2400	-5.8181
67.5	0.2170	-0.1854	-0.3755	-0.4108	-0.3821	-0.3435	-0.3116	-0.2881	-0.2734	-0.2683	-2.3647
45.0	-0.0671	0.0307	-0.0906	-0.0786	0.0108	0.1022	0.1716	0.2190	0.2470	0.2563	1.1579
22.5	-0.2823	0.1948	0.0236	-0.0221	0.0351	0.1010	0.1466	0.1743	0.1895	0.1944	1.9088
-0.0	-0.3582	0.2492	0.0367	-0.0466	-0.0127	0.0354	0.0660	0.0822	0.0903	0.0927	1.7450

INSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	-3.5926	-2.3175	-1.3588	-0.7011	-0.2821	-0.0317	0.1093	0.1838	0.2189	0.2291	1.4772
157.5	-2.7867	-1.7548	-1.0273	-0.5600	-0.2837	-0.1339	-0.0605	-0.0290	-0.0178	-0.0152	1.6537
135.0	-1.0421	-0.7586	-0.6175	-0.5465	-0.5152	-0.5103	-0.5216	-0.5388	-0.5531	-0.5586	0.2982
112.5	0.6448	-0.1404	-0.5280	-0.6533	-0.6609	-0.6373	-0.6174	-0.6078	-0.6052	-0.6049	-2.0488
90.0	1.2683	0.1416	-0.2426	-0.2612	-0.1585	-0.0465	0.0385	0.0929	0.1222	0.1313	-1.3134
67.5	0.7235	0.4427	0.3628	0.3997	0.4886	0.5784	0.6456	0.6878	0.7103	0.7173	0.8195
45.0	-0.2237	0.8238	0.9159	0.8070	0.7482	0.7343	0.7303	0.7250	0.7198	0.7178	1.2400
22.5	-0.9411	1.1373	1.2245	0.9287	0.7368	0.6422	0.5857	0.5457	0.5207	0.5121	0.5047
-0.0	-1.1940	1.2560	1.3159	0.9434	0.7050	0.5848	0.5124	0.4620	0.4311	0.4206	0.0954

INSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
157.5	-0.4809	-0.7042	-0.8552	-0.9186	-0.8975	-0.8037	-0.6521	-0.4580	-0.2359	-0.0000	0.0
135.0	-0.5865	-0.9568	-1.1265	-1.1376	-1.0427	-0.8834	-0.6862	-0.4672	-0.2363	-0.0000	0.0
112.5	-0.3541	-0.5615	-0.5592	-0.4659	-0.3536	-0.2523	-0.1695	-0.1033	-0.0487	0.0000	0.0
90.0	0.0507	0.2354	0.3477	0.3911	0.3843	0.3423	0.2756	0.1923	0.0986	0.0000	0.0
67.5	0.3785	0.7929	0.8255	0.7280	0.6063	0.4841	0.3628	0.2418	0.1209	0.0000	0.0
45.0	0.4583	0.8268	0.7476	0.5874	0.4517	0.3420	0.2472	0.1607	0.0792	0.0000	0.0
22.5	0.2959	0.4884	0.4022	0.2925	0.2136	0.1564	0.1103	0.0705	0.0343	0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0

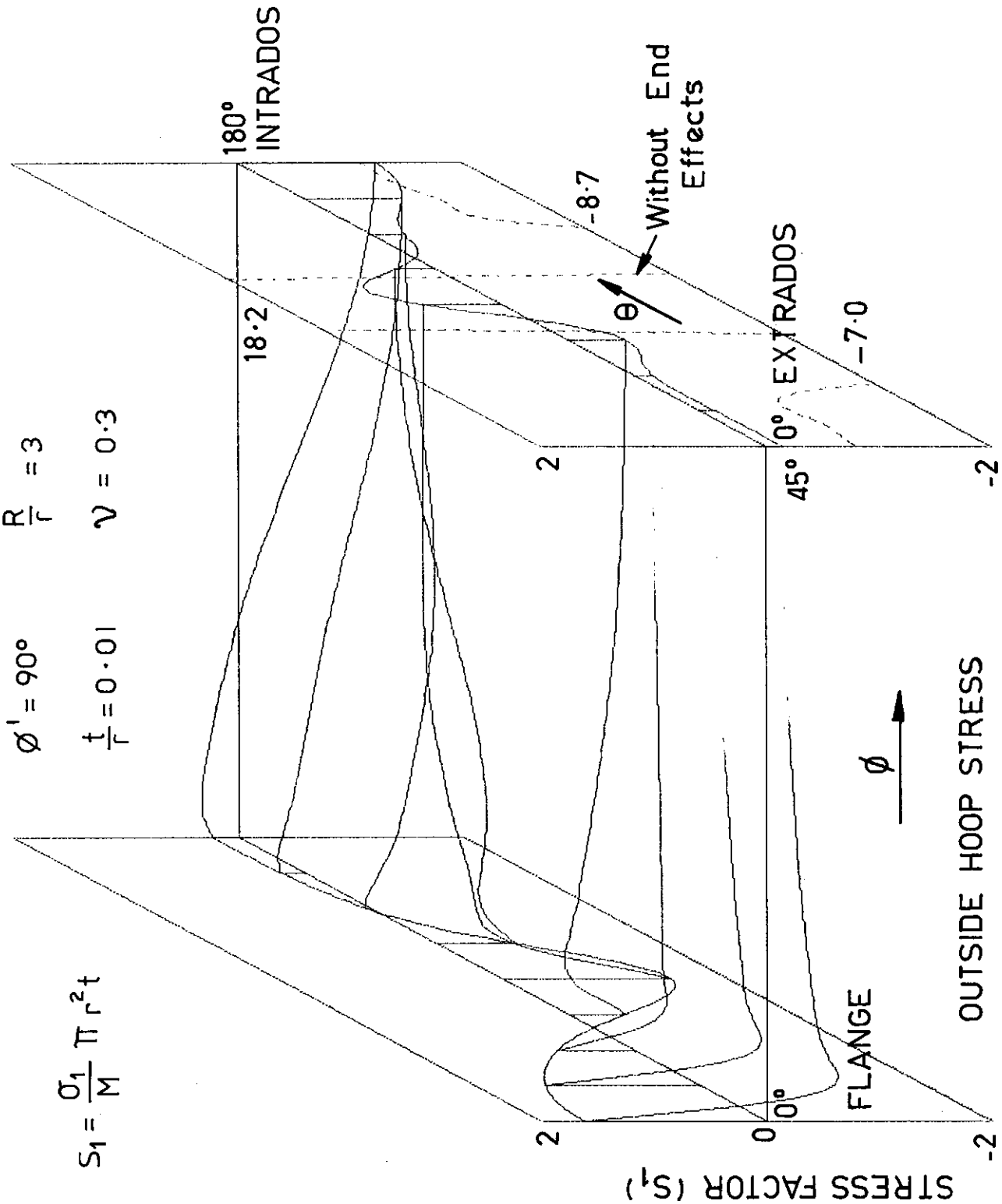
$S_1 = \frac{\sigma_1}{M} \pi r^2 t$
$\phi' = 90°$
$\frac{t}{r} = 0.01$
$\frac{R}{r} = 3$
$\nu = 0.3$
STRESS FACTOR (S_1)
2
0
-2
OUTSIDE HOOP STRESS
FLANGE
0°
ϕ
45°
EXTRADOS
0°
2
-2
θ
18·2
180°
INTRADOS
-8·7
Without End Effects
-7·0

FIGURE A9

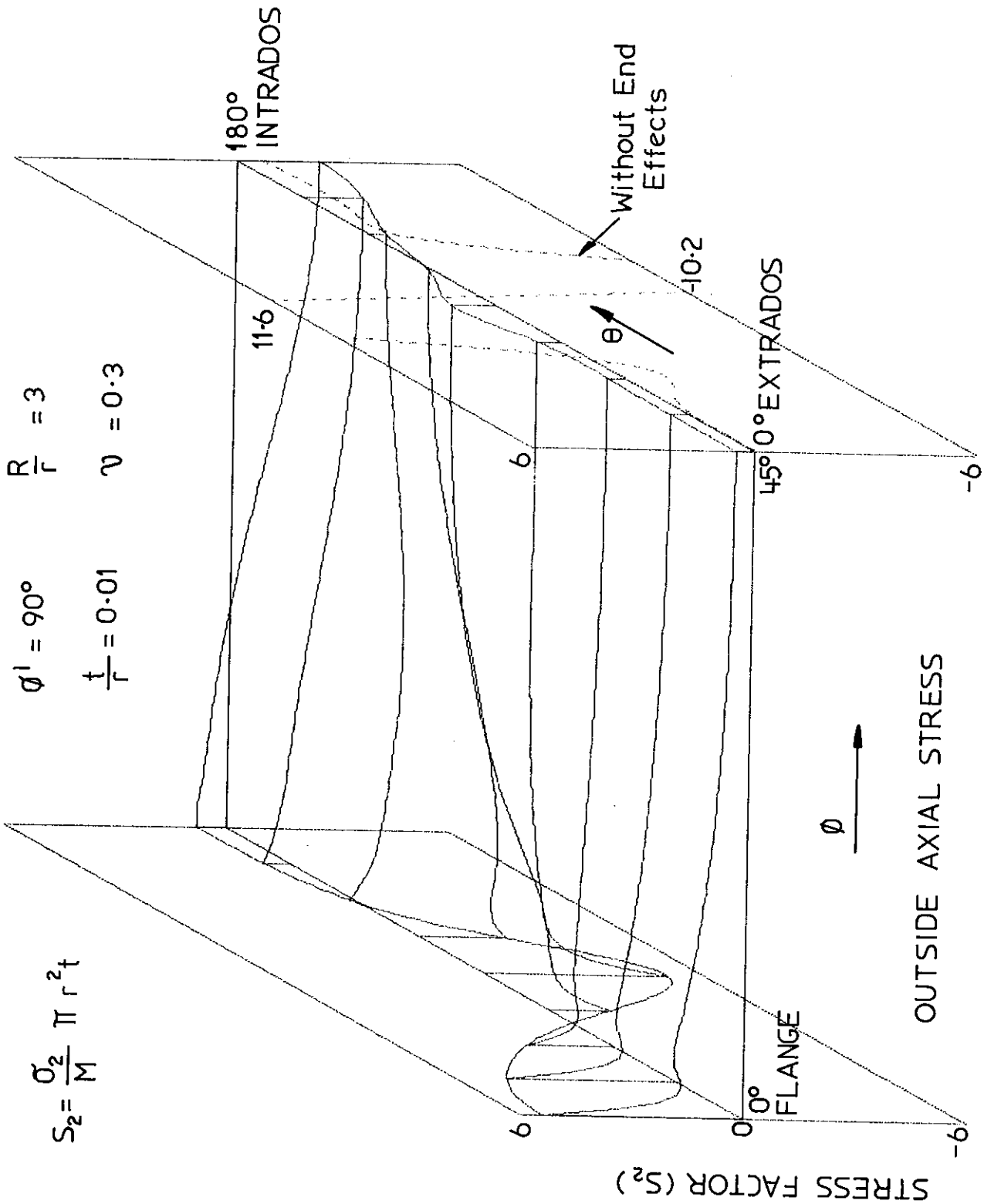
$S_2 = \frac{\sigma_2}{M} \pi r^2 t$
$\phi' = 90°$
$\frac{R}{r} = 3$
$\frac{t}{r} = 0.01$
$\nu = 0.3$
180° INTRADOS
11·6
Without End Effects
-10·2
θ
0° EXTRADOS
45°
6
-6
6
0
-6
0° FLANGE
φ
OUTSIDE AXIAL STRESS
STRESS FACTOR (S_2)

FIGURE A10

TABLE A9

R/r = 3.0 t/r = 0.01

OUTSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.2402	0.2952	0.1593	-0.0156	-0.2383	-0.4933	-0.7569	-0.9931	-1.1592	-1.2192	-1.0451
157.5	0.2252	0.1081	-0.0194	-0.1531	-0.3130	-0.4845	-0.6450	-0.7722	-0.8521	-0.8791	-1.1496
135.0	0.0488	-0.2333	-0.3826	-0.5045	-0.5703	-0.5632	-0.4993	-0.4132	-0.3430	-0.3162	-2.8711
112.5	-0.6931	-0.3931	-0.4342	-0.3396	-0.1815	-0.0074	0.1472	0.2634	0.3338	0.3572	-6.2355
90.0	-1.4875	0.2584	0.4167	0.5737	0.6659	0.7063	0.7130	0.7038	0.6926	0.6879	18.1680
67.5	-0.5023	0.0076	-0.1316	-0.2439	-0.3378	-0.4091	-0.4591	-0.4909	-0.5083	-0.5138	-4.4420
45.0	0.6880	-0.2477	-0.2362	-0.2271	-0.2143	-0.2009	-0.1890	-0.1799	-0.1743	-0.1724	-3.3085
22.5	1.3869	-0.4258	-0.3328	-0.2736	-0.2285	-0.1949	-0.1706	-0.1541	-0.1446	-0.1415	-0.8132
-0.0	1.6240	-0.4953	-0.3781	-0.3043	-0.2504	-0.2114	-0.1837	-0.1653	-0.1548	-0.1513	-0.8527

OUTSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.8005	0.5732	0.3202	-0.0131	-0.4290	-0.9003	-1.3829	-1.8106	-2.1082	-2.2151	-0.7180
157.5	0.7508	0.2065	-0.0461	-0.3480	-0.6769	-0.9978	-1.2733	-1.4774	-1.5996	-1.6399	-0.7955
135.0	0.1628	-0.6833	-0.9499	-1.1296	-1.1629	-1.0658	-0.8907	-0.7037	-0.5644	-0.5132	-0.6012
112.5	-2.3102	-2.0297	-1.9201	-1.5836	-1.1663	-0.7510	-0.3930	-0.1237	0.0419	0.0975	-9.7407
90.0	-4.9585	-1.4781	-0.6786	-0.0098	0.4720	0.8002	1.0101	1.1342	1.1979	1.2174	6.0826
67.5	-1.6743	0.0858	0.4097	0.5828	0.6549	0.6718	0.6630	0.6466	0.6332	0.6282	5.8509
45.0	2.2935	1.1084	0.9817	0.8554	0.7406	0.6446	0.5699	0.5169	0.4853	0.4749	-1.1844
22.5	4.6230	1.6769	1.3161	1.0585	0.8671	0.7268	0.6268	0.5600	0.5216	0.5090	-0.0773
-0.0	5.4134	1.8486	1.4038	1.1010	0.8838	0.7288	0.6205	0.5492	0.5086	0.4954	-0.0455

OUTSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
157.5	-0.3648	-0.4716	-0.5870	-0.6793	-0.7216	-0.6966	-0.5998	-0.4392	-0.2318	-0.0000	0.0
135.0	-0.7650	-0.8822	-0.9146	-0.8696	-0.7686	-0.6342	-0.4830	-0.3244	-0.1627	-0.0000	0.0
112.5	-0.9904	-0.8236	-0.5838	-0.3900	-0.2461	-0.1455	-0.0794	-0.0387	-0.0151	-0.0000	0.0
90.0	-0.3366	-0.0560	0.1088	0.1983	0.2356	0.2335	0.2013	0.1466	0.0770	0.0000	0.0
67.5	0.8056	0.8415	0.7224	0.6085	0.4970	0.3896	0.2869	0.1886	0.0934	-0.0000	0.0
45.0	1.0781	0.9279	0.7034	0.5336	0.4006	0.2940	0.2061	0.1309	0.0636	-0.0000	0.0
22.5	0.6782	0.5370	0.3868	0.2813	0.2044	0.1464	0.1008	0.0632	0.0305	-0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0000	0.0

TABLE A10

R/r = 3.0 t/r = 0.01

INSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.1603	0.2154	0.0827	-0.0573	-0.2121	-0.3722	-0.5185	-0.6320	-0.7019	-0.7251	1.0445
157.5	0.0195	0.0872	-0.0570	-0.1843	-0.2893	-0.3561	-0.3881	-0.3988	-0.4007	-0.4006	1.1489
135.0	-0.2575	-0.1530	-0.1764	-0.1128	-0.0359	0.0192	0.0409	0.0381	0.0272	0.0219	2.9345
112.5	-0.4118	-0.0939	-0.0215	-0.0273	-0.0903	-0.1722	-0.2464	-0.3004	-0.3317	-0.3418	5.8506
90.0	0.0226	-0.2320	-0.4742	-0.6432	-0.7401	-0.7798	-0.7835	-0.7711	-0.7576	-0.7521	-20.2240
67.5	0.1490	0.0195	0.0649	0.1443	0.2236	0.2907	0.3413	0.3754	0.3948	0.4010	4.0990
45.0	0.0035	-0.1926	-0.1418	-0.1086	-0.0819	-0.0615	-0.0467	-0.0367	-0.0308	-0.0289	3.3623
22.5	-0.1194	-0.3957	-0.2865	-0.2249	-0.1801	-0.1477	-0.1249	-0.1099	-0.1012	-0.0984	0.8137
-0.0	-0.1687	-0.4626	-0.3251	-0.2479	-0.1933	-0.1550	-0.1285	-0.1112	-0.1014	-0.0983	0.8530

INSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.5345	0.4124	0.1782	-0.1243	-0.4669	-0.8269	-1.1666	-1.4448	-1.6265	-1.6896	0.7349
157.5	0.0651	0.1583	-0.1158	-0.3939	-0.6545	-0.8760	-1.0466	-1.1650	-1.2342	-1.2569	0.7554
135.0	-0.8584	-0.6042	-0.8039	-0.8598	-0.8219	-0.7276	-0.6139	-0.5112	-0.4409	-0.4161	2.1455
112.5	-1.3725	-1.7695	-1.5578	-1.2927	-1.0007	-0.7225	-0.4837	-0.3016	-0.1879	-0.1493	-3.6899
90.0	0.0754	-1.6872	-0.9712	-0.4599	-0.0670	0.2217	0.4235	0.5545	0.6275	0.6509	-5.4593
67.5	0.4966	-0.0271	0.3845	0.6171	0.7442	0.8058	0.8297	0.8350	0.8337	0.8326	6.5881
45.0	0.0116	1.0769	0.9801	0.8677	0.7616	0.6705	0.5984	0.5467	0.5158	0.5055	0.1606
22.5	-0.3980	1.6428	1.3154	1.0598	0.8697	0.7300	0.6302	0.5633	0.5249	0.5123	-0.0414
-0.0	-0.5624	1.8132	1.4095	1.1078	0.8913	0.7365	0.6282	0.5567	0.5160	0.5028	0.0532

INSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
157.5	-0.3611	-0.4584	-0.6050	-0.7323	-0.8202	-0.8377	-0.7602	-0.5806	-0.3149	-0.0000	0.0
135.0	-0.7574	-0.8870	-0.9818	-1.0162	-0.9699	-0.8480	-0.6702	-0.4590	-0.2322	-0.0000	0.0
112.5	-0.9805	-1.0875	-0.8434	-0.5840	-0.3489	-0.1681	-0.0521	0.0036	0.0139	0.0000	0.0
90.0	-0.3332	-0.0087	0.2454	0.3807	0.4232	0.3994	0.3307	0.2337	0.1205	0.0000	0.0
67.5	0.7976	0.9927	0.8554	0.7122	0.5715	0.4396	0.3182	0.2062	0.1013	-0.0000	0.0
45.0	1.0673	0.9551	0.7192	0.5398	0.4019	0.2931	0.2045	0.1295	0.0628	0.0000	0.0
22.5	0.6715	0.5484	0.3937	0.2843	0.2053	0.1463	0.1003	0.0628	0.0302	0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0

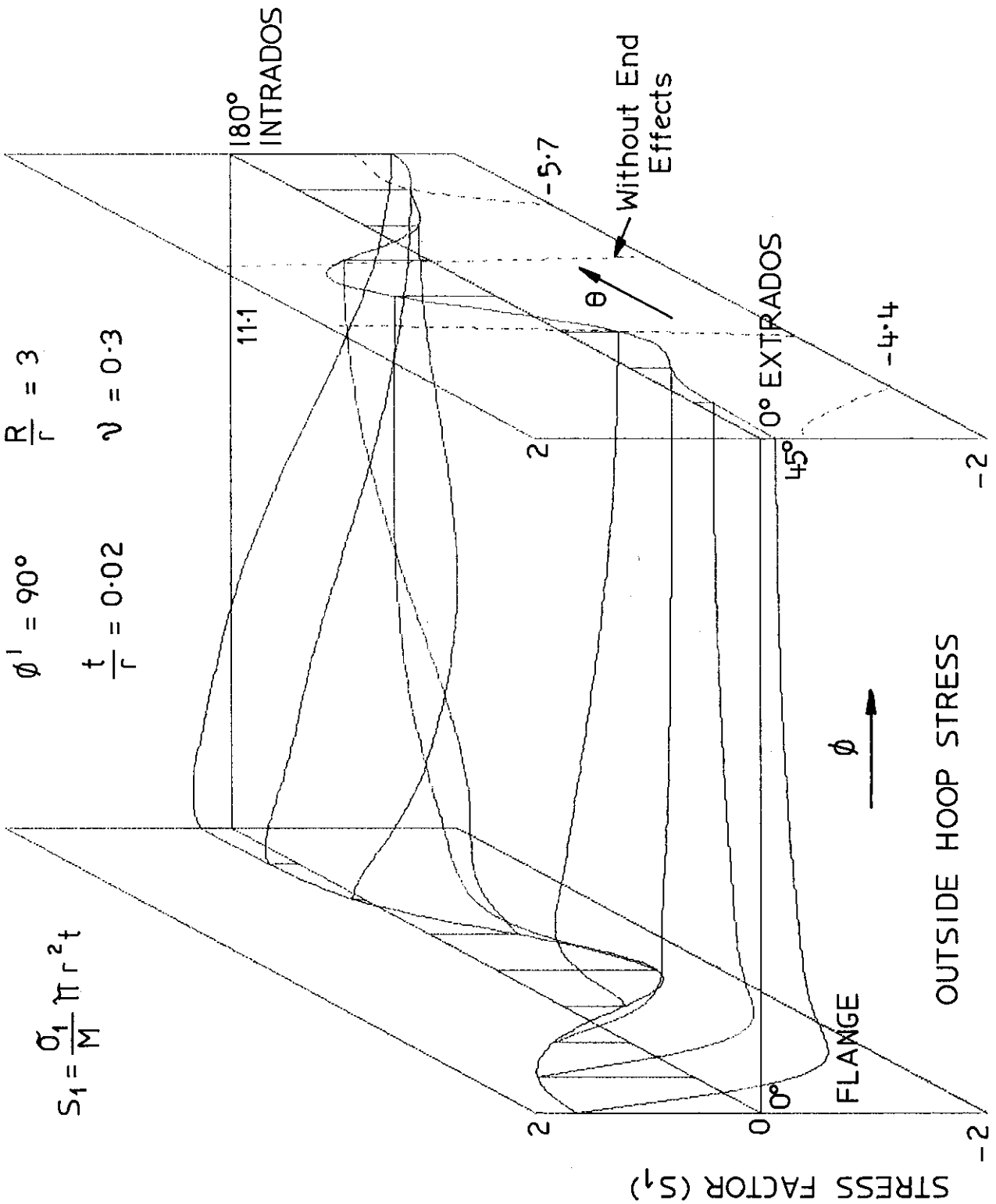
$S_1 = \frac{\sigma_1}{M} \pi r^2 t$
$\phi^1 = 90°$
$\frac{t}{r} = 0{\cdot}02$
$\frac{R}{r} = 3$
$\nu = 0{\cdot}3$
180° INTRADOS
11·1
-5·7
Without End Effects
θ
0° EXTRADOS
-4·4
45°
2
-2
0°
FLANGE
φ
OUTSIDE HOOP STRESS
STRESS FACTOR (S_1)
2
0
-2

FIGURE A11

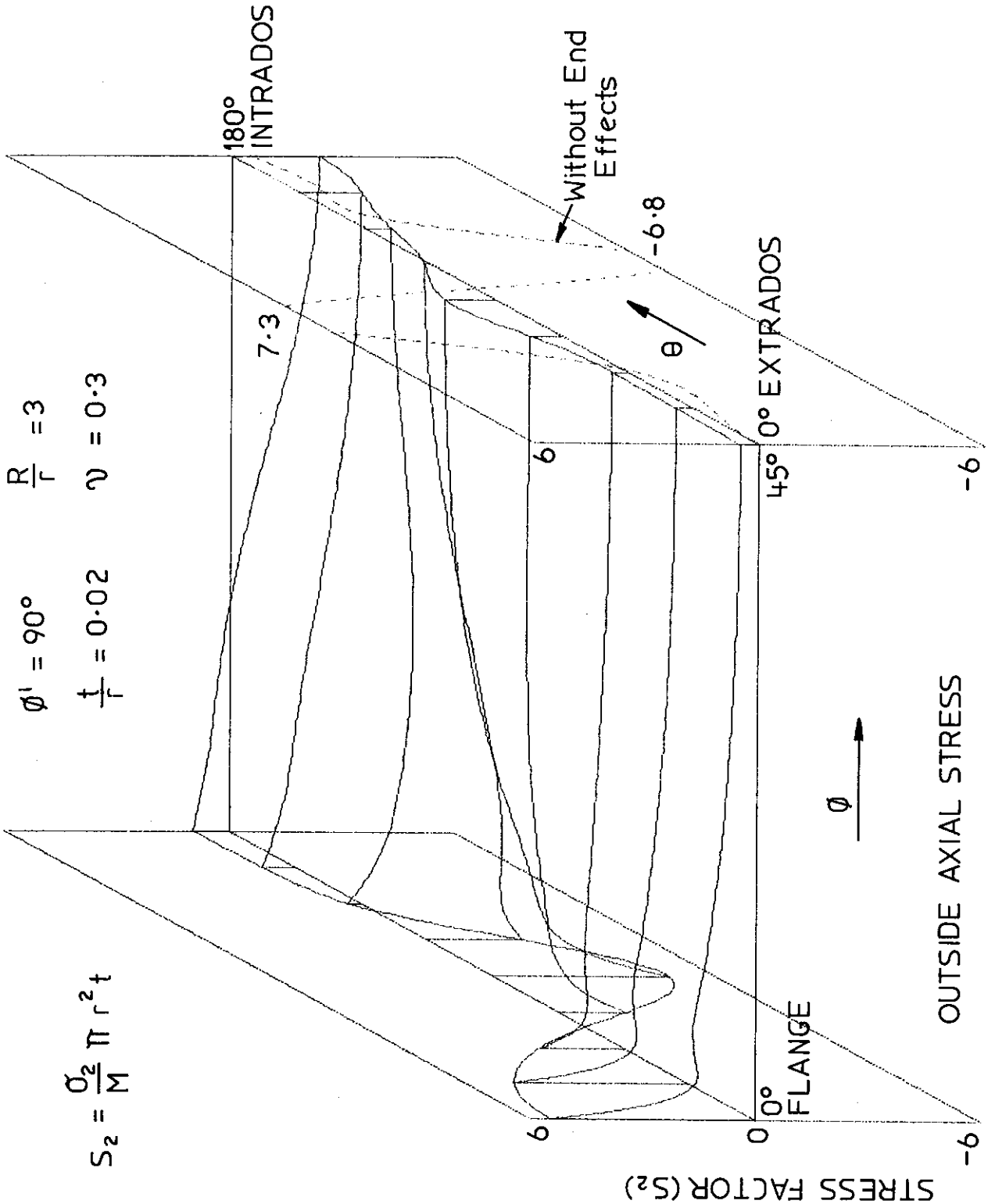
$S_2 = \frac{\sigma_2}{M} \pi r^2 t$
$\phi' = 90°$
$\frac{R}{r} = 3$
$\frac{t}{r} = 0.02$
$\nu = 0.3$
180° INTRADOS
7·3
Without End Effects
-6·8
θ
0° EXTRADOS
45°
-6
6
0°
FLANGE
0
-6
6
STRESS FACTOR (S_2)
OUTSIDE AXIAL STRESS
φ

FIGURE A12

TABLE A11

R/r = 3.0 t/r = 0.02

OUTSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.2815	0.3045	0.1664	0.0072	-0.2204	-0.5121	-0.8317	-1.1243	-1.3306	-1.4050	-1.0278
157.5	0.2715	0.1605	-0.0194	-0.1882	-0.3899	-0.5970	-0.7794	-0.9181	-1.0036	-1.0323	-1.0379
135.0	0.1010	-0.2917	-0.5838	-0.7426	-0.8107	-0.7876	-0.7004	-0.5921	-0.5062	-0.4738	-4.5286
112.5	-0.7719	-0.3687	-0.3264	-0.1702	0.0500	0.2775	0.4777	0.6294	0.7226	0.7540	-0.9748
90.0	-1.4250	0.2434	0.4925	0.6774	0.8074	0.8772	0.9043	0.9071	0.9016	0.8985	11.1326
67.5	-0.5559	0.0736	-0.0271	-0.1338	-0.2373	-0.3289	-0.4018	-0.4538	-0.4847	-0.4948	-0.1954
45.0	0.6595	-0.3005	-0.3160	-0.3530	-0.3755	-0.3876	-0.3925	-0.3936	-0.3932	-0.3929	-3.9562
22.5	1.3970	-0.4992	-0.3467	-0.2928	-0.2471	-0.2118	-0.1857	-0.1677	-0.1573	-0.1538	-1.1850
-0.0	1.6363	-0.5752	-0.3800	-0.3103	-0.2553	-0.2151	-0.1866	-0.1675	-0.1566	-0.1531	-0.6520

OUTSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.9382	0.5654	0.3125	0.0138	-0.4045	-0.9078	-1.4320	-1.8942	-2.2117	-2.3248	-0.7422
157.5	0.9050	0.2640	-0.0364	-0.3551	-0.7122	-1.0479	-1.3275	-1.5332	-1.6578	-1.6993	-0.5364
135.0	0.3367	-0.7797	-1.1517	-1.3309	-1.3622	-1.2640	-1.0925	-0.9117	-0.7775	-0.7283	-2.0859
112.5	-2.5730	-1.9898	-1.9037	-1.5436	-1.1231	-0.7107	-0.3532	-0.0811	0.0879	0.1452	-6.6954
90.0	-4.7499	-1.1990	-0.5792	0.0676	0.5478	0.8872	1.1142	1.2545	1.3294	1.3528	3.8467
67.5	-1.8530	0.2281	0.5236	0.7409	0.8418	0.8764	0.8766	0.8635	0.8507	0.8457	5.6537
45.0	2.1984	1.0345	0.9560	0.8146	0.6870	0.5797	0.4961	0.4370	0.4019	0.3903	-0.1997
22.5	4.6565	1.4991	1.2687	1.0037	0.8122	0.6723	0.5730	0.5069	0.4690	0.4567	-0.4321
-0.0	5.4542	1.6543	1.3693	1.0676	0.8562	0.7053	0.6000	0.5306	0.4911	0.4783	-0.0331

OUTSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
157.5	-0.3663	-0.4780	-0.5669	-0.6190	-0.6102	-0.5443	-0.4355	-0.3004	-0.1525	-0.0000	0.0
135.0	-0.7333	-0.8127	-0.7960	-0.7162	-0.6119	-0.4988	-0.3812	-0.2589	-0.1312	0.0000	0.0
112.5	-0.8915	-0.6733	-0.4973	-0.3455	-0.2418	-0.1693	-0.1158	-0.0729	-0.0353	-0.0000	0.0
90.0	-0.2859	-0.0619	0.0623	0.1248	0.1522	0.1534	0.1341	0.0989	0.0524	-0.0000	0.0
67.5	0.6707	0.7078	0.6211	0.5241	0.4333	0.3449	0.2579	0.1716	0.0857	0.0000	0.0
45.0	0.9733	0.8889	0.6784	0.5191	0.3931	0.2907	0.2050	0.1307	0.0636	0.0000	0.0
22.5	0.6251	0.5298	0.3801	0.2779	0.2025	0.1452	0.1000	0.0628	0.0303	0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0

TABLE A12

R/r = 3.0 t/r = 0.02

INSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.0752	0.1730	0.0138	-0.1471	-0.2820	-0.3702	-0.4008	-0.3881	-0.3615	-0.3490	1.0267
157.5	-0.0466	0.0600	-0.1029	-0.1892	-0.2178	-0.2143	-0.1982	-0.1829	-0.1740	-0.1712	1.0419
135.0	-0.3509	-0.0357	0.0419	0.1685	0.2584	0.2818	0.2506	0.1933	0.1424	0.1224	4.6201
112.5	-0.3472	-0.1331	-0.0839	-0.1928	-0.3461	-0.5082	-0.6484	-0.7513	-0.8126	-0.8327	0.3152
90.0	0.1387	-0.3854	-0.5638	-0.7934	-0.9316	-1.0008	-1.0222	-1.0182	-1.0076	-1.0027	-12.7638
67.5	0.2189	-0.1201	-0.0446	0.0251	0.1186	0.2091	0.2851	0.3410	0.3746	0.3859	-0.3298
45.0	-0.0034	-0.1366	-0.0400	0.0386	0.1008	0.1463	0.1776	0.1974	0.2082	0.2116	3.9969
22.5	-0.1690	-0.3441	-0.2492	-0.1883	-0.1460	-0.1167	-0.0968	-0.0838	-0.0765	-0.0742	1.1964
-0.0	-0.2263	-0.4194	-0.2980	-0.2246	-0.1734	-0.1378	-0.1133	-0.0974	-0.0884	-0.0854	0.6525

INSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.2508	0.2697	0.0605	-0.2396	-0.5352	-0.8020	-1.0175	-1.1699	-1.2586	-1.2874	0.7001
157.5	-0.1555	0.0555	-0.1557	-0.3947	-0.5855	-0.7396	-0.8602	-0.9476	-1.0010	-1.0191	0.9351
135.0	-1.1697	-0.6222	-0.7036	-0.7378	-0.7062	-0.6546	-0.6039	-0.5643	-0.5400	-0.5319	1.8401
112.5	-1.1572	-1.7250	-1.4628	-1.2635	-1.0506	-0.8481	-0.6730	-0.5375	-0.4517	-0.4223	-4.2242
90.0	0.4623	-1.6533	-0.9131	-0.4824	-0.1377	0.1291	0.3260	0.4607	0.5391	0.5648	-3.3500
67.5	0.7296	-0.1290	0.3761	0.6320	0.7920	0.8844	0.9334	0.9567	0.9661	0.9684	4.0745
45.0	-0.0114	1.0988	0.9692	0.8795	0.7856	0.7009	0.6315	0.5807	0.5497	0.5394	1.4053
22.5	-0.5632	1.7196	1.2599	1.0116	0.8216	0.6817	0.5817	0.5147	0.4761	0.4636	-0.1669
-0.0	-0.7544	1.9077	1.3628	1.0742	0.8624	0.7109	0.6050	0.5350	0.4952	0.4823	-0.0547

INSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
157.5	-0.3591	-0.4174	-0.5709	-0.7185	-0.8228	-0.8475	-0.7689	-0.5851	-0.3162	-0.0000	0.0
135.0	-0.7187	-0.9152	-1.0228	-1.0502	-0.9921	-0.8620	-0.6806	-0.4675	-0.2373	-0.0000	0.0
112.5	-0.8739	-1.1201	-0.8472	-0.5879	-0.3606	-0.1859	-0.0711	-0.0117	0.0055	-0.0000	0.0
90.0	-0.2803	-0.0130	0.2340	0.3688	0.4177	0.4011	0.3372	0.2411	0.1252	0.0000	0.0
67.5	0.6575	1.0132	0.8681	0.7351	0.5972	0.4634	0.3374	0.2195	0.1080	0.0000	0.0
45.0	0.9541	0.9935	0.7337	0.5513	0.4093	0.2972	0.2065	0.1302	0.0630	-0.0000	0.0
22.5	0.6127	0.5481	0.3873	0.2784	0.2002	0.1422	0.0973	0.0608	0.0293	-0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0000	0.0

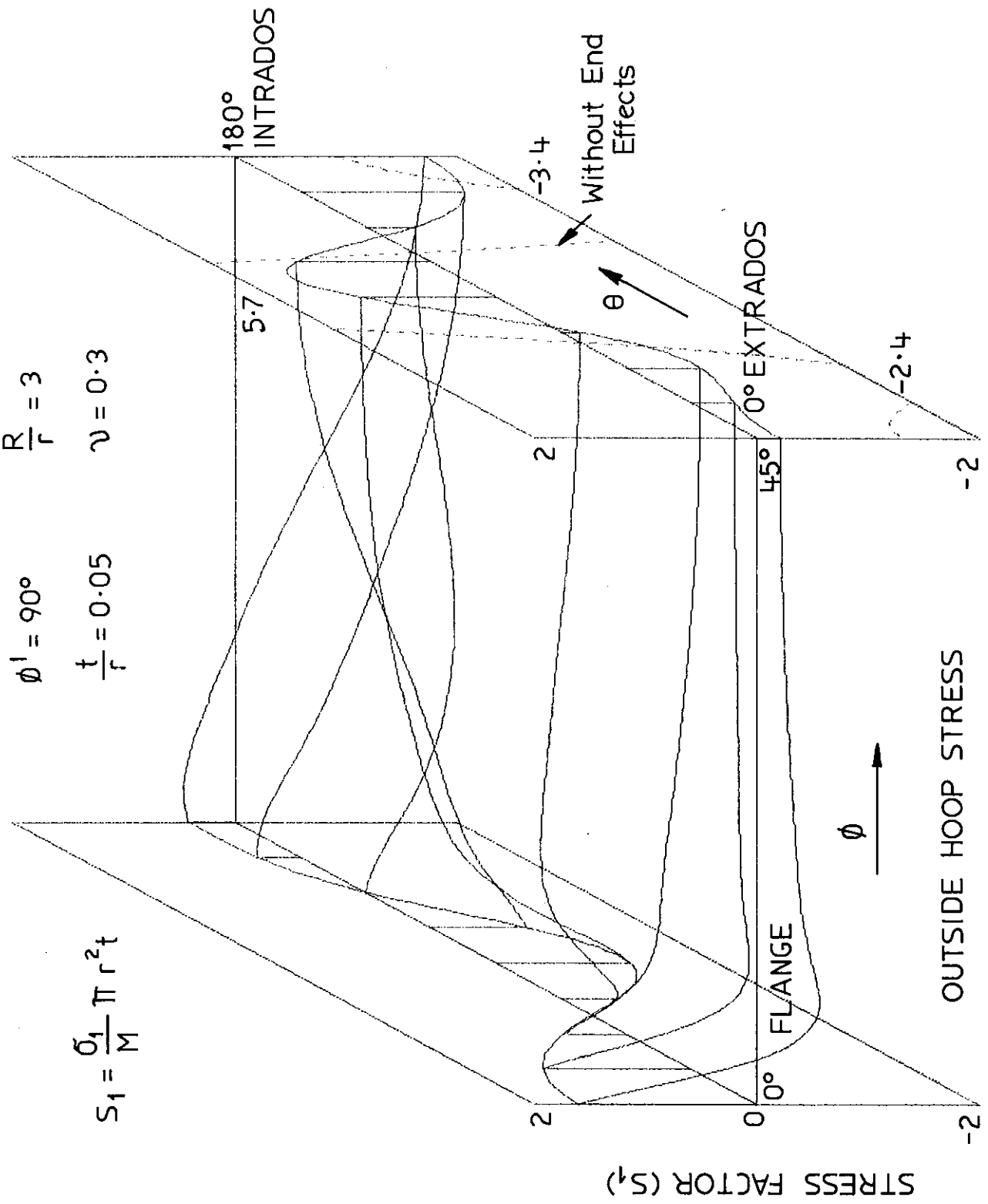
$S_1 = \frac{\sigma_1}{M} \pi r^2 t$
$\phi^1 = 90°$
$\frac{R}{r} = 3$
$\nu = 0.3$
$\frac{t}{r} = 0.05$
180° INTRADOS
5·7
-3·4
Without End Effects
θ
0° EXTRADOS
-2·4
2
45°
-2
0° FLANGE
φ
OUTSIDE HOOP STRESS
STRESS FACTOR (S_1)
2
0
-2

FIGURE A13

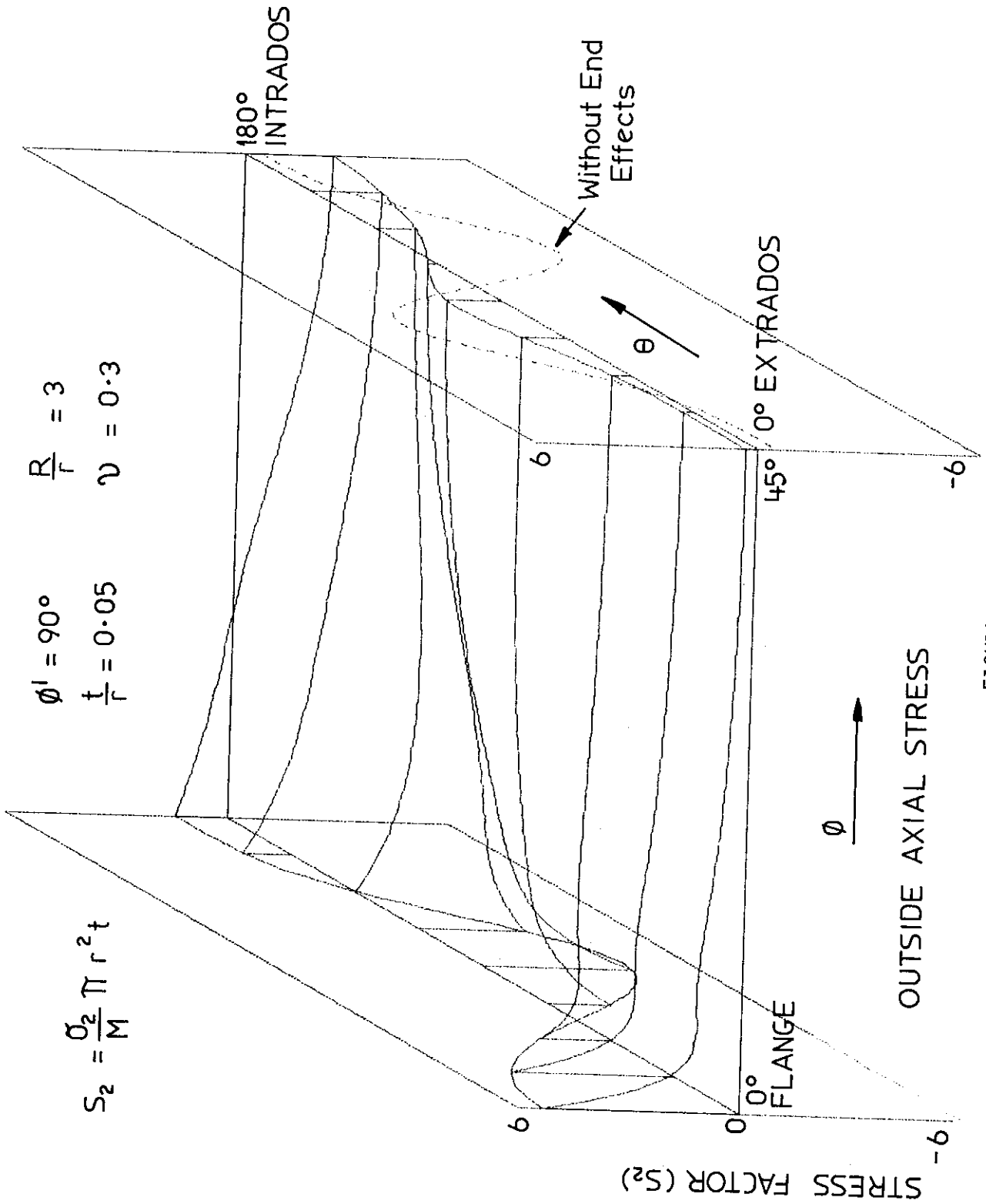
$S_2 = \frac{\sigma_2}{M} \pi r^2 t$
$\phi' = 90°$
$\frac{t}{r} = 0·05$
$\frac{R}{r} = 3$
$\nu = 0·3$
180° INTRADOS
Without End Effects
0° EXTRADOS
45°
0° FLANGE
θ
φ
6
0
-6
OUTSIDE AXIAL STRESS
STRESS FACTOR (S_2)

FIGURE A14

TABLE A13

R/r = 3.0 t/r = 0.05

OUTSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.4213	0.3960	0.1469	-0.1270	-0.4377	-0.7872	-1.1368	-1.4337	-1.6318	-1.7013	-0.9225
157.5	0.3920	0.1708	-0.1894	-0.4812	-0.7358	-0.9718	-1.1786	-1.3388	-1.4398	-1.4741	-2.0819
135.0	-0.0022	-0.3199	-0.6296	-0.7757	-0.7968	-0.7406	-0.6464	-0.5487	-0.4766	-0.4502	-3.2713
112.5	-0.8608	-0.3908	-0.1145	0.0938	0.3472	0.6150	0.8569	1.0472	1.1685	1.2102	1.6253
90.0	-1.2077	-0.0321	0.5159	0.7317	0.9017	1.0334	1.1221	1.1759	1.2041	1.2128	5.7116
67.5	-0.5132	0.0167	0.1829	0.1390	0.0749	0.0050	-0.0642	-0.1220	-0.1599	-0.1731	1.6497
45.0	0.5607	-0.2249	-0.3278	-0.4046	-0.4864	-0.5531	-0.6050	-0.6417	-0.6635	-0.6707	-2.1330
22.5	1.3331	-0.4179	-0.4815	-0.4354	-0.4256	-0.4141	-0.4030	-0.3940	-0.3881	-0.3860	-1.9614
-0.0	1.5953	-0.4796	-0.4858	-0.3804	-0.3304	-0.2882	-0.2550	-0.2313	-0.2171	-0.2124	-1.3110

OUTSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	1.4042	0.7695	0.3087	-0.0921	-0.5653	-1.0909	-1.5927	-2.0004	-2.2644	-2.3556	-0.4274
157.5	1.3067	0.3100	-0.2516	-0.6255	-0.9665	-1.2883	-1.5645	-1.7736	-1.9032	-1.9471	-0.8873
135.0	-0.0075	-0.9963	-1.4344	-1.5744	-1.5597	-1.4702	-1.3512	-1.2375	-1.1574	-1.1287	-3.2536
112.5	-2.8692	-1.8163	-1.5738	-1.2764	-0.8921	-0.5163	-0.1918	0.0581	0.2158	0.2697	-3.1741
90.0	-4.0258	-1.0041	-0.3074	0.1694	0.6047	0.9460	1.1957	1.3663	1.4658	1.4985	2.0959
67.5	-1.7105	0.2541	0.7060	0.9188	1.0692	1.1545	1.1949	1.2107	1.2151	1.2157	3.8530
45.0	1.8689	0.9293	1.0095	0.9038	0.7923	0.6931	0.6093	0.5464	0.5075	0.4944	1.3287
22.5	4.4435	1.1699	1.1247	0.8783	0.6725	0.5254	0.4196	0.3485	0.3075	0.2942	-0.2930
-0.0	5.3178	1.2318	1.1814	0.9064	0.6867	0.5373	0.4340	0.3665	0.3284	0.3161	-0.5289

OUTSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
157.5	-0.3721	-0.4560	-0.4525	-0.3974	-0.3088	-0.2126	-0.1290	-0.0675	-0.0274	-0.0000	0.0
135.0	-0.6622	-0.5596	-0.5071	-0.4156	-0.3189	-0.2346	-0.1640	-0.1039	-0.0503	0.0000	0.0
112.5	-0.6636	-0.3699	-0.3184	-0.2509	-0.2025	-0.1683	-0.1354	-0.0967	-0.0507	0.0000	0.0
90.0	-0.1830	-0.0316	0.0079	0.0215	0.0190	0.0126	0.0068	0.0029	0.0009	-0.0000	0.0
67.5	0.4512	0.4102	0.4069	0.3338	0.2683	0.2115	0.1582	0.1058	0.0531	-0.0000	0.0
45.0	0.7161	0.6280	0.5496	0.4219	0.3252	0.2468	0.1786	0.1164	0.0575	0.0000	0.0
22.5	0.4957	0.4387	0.3557	0.2622	0.1958	0.1440	0.1013	0.0646	0.0315	0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0

TABLE A14

R/r = 3.0 t/r = 0.05

INSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	-0.1197	0.0371	-0.1308	-0.2551	-0.2414	-0.1184	0.0590	0.2357	0.3637	0.4103	0.9202
157.5	-0.2648	0.0298	0.0177	0.0326	0.1150	0.2259	0.3326	0.4175	0.4717	0.4902	2.1187
135.0	-0.4228	0.0239	0.2372	0.3315	0.3433	0.2854	0.1823	0.0709	-0.0126	-0.0434	3.2124
112.5	-0.1405	-0.2420	-0.2122	-0.4024	-0.6649	-0.9285	-1.1641	-1.3495	-1.4676	-1.5081	-2.4216
90.0	0.2748	-0.5319	-0.6593	-0.9049	-1.1175	-1.2593	-1.3455	-1.3929	-1.4152	-1.4215	-6.9128
67.5	0.2849	-0.3501	-0.3164	-0.2886	-0.2380	-0.1610	-0.0796	-0.0105	0.0353	0.0514	-2.2472
45.0	0.0092	-0.0721	-0.0213	0.1291	0.2505	0.3525	0.4323	0.4887	0.5223	0.5334	2.0624
22.5	-0.2325	-0.0106	-0.1063	0.0131	0.0849	0.1323	0.1638	0.1831	0.1935	0.1967	1.9794
-0.0	-0.3173	-0.0270	-0.1961	-0.0990	-0.0517	-0.0255	-0.0100	-0.0015	0.0026	0.0038	1.3121

INSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	-0.3989	-0.1397	-0.1523	-0.3179	-0.4546	-0.5196	-0.5324	-0.5201	-0.5038	-0.4968	0.9518
157.5	-0.8828	-0.3024	-0.2180	-0.3231	-0.4221	-0.4800	-0.5104	-0.5265	-0.5344	-0.5368	1.2644
135.0	-1.4092	-0.7964	-0.6613	-0.6638	-0.6911	-0.7191	-0.7490	-0.7784	-0.8005	-0.8087	0.0782
112.5	-0.4683	-1.3454	-1.2243	-1.0516	-0.9476	-0.8693	-0.8076	-0.7643	-0.7389	-0.7306	-2.9195
90.0	0.9167	-1.1438	-0.8196	-0.4445	-0.2028	-0.0170	0.1287	0.2333	0.2964	0.3175	-1.7255
67.5	0.9498	-0.0766	0.2355	0.5206	0.6909	0.8081	0.8900	0.9435	0.9737	0.9835	1.5963
45.0	0.0305	1.0726	0.9316	0.9077	0.8745	0.8339	0.7971	0.7679	0.7492	0.7427	1.7294
22.5	-0.7750	1.7979	1.1890	0.9425	0.7757	0.6437	0.5470	0.4808	0.4422	0.4295	0.3870
-0.0	-1.0577	2.0336	1.2509	0.9397	0.7374	0.5839	0.4754	0.4033	0.3620	0.3486	-0.1552

INSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
157.5	-0.3540	-0.4562	-0.6315	-0.7680	-0.8302	-0.8048	-0.6928	-0.5067	-0.2672	-0.0000	0.0
135.0	-0.6299	-1.0005	-1.0918	-1.0654	-0.9782	-0.8424	-0.6669	-0.4615	-0.2358	-0.0000	0.0
112.5	-0.6312	-0.9712	-0.7687	-0.5407	-0.3590	-0.2221	-0.1260	-0.0639	-0.0258	-0.0000	0.0
90.0	-0.1741	0.0159	0.2170	0.3268	0.3691	0.3585	0.3056	0.2212	0.1159	0.0000	0.0
67.5	0.4292	0.9338	0.8332	0.7163	0.6018	0.4833	0.3627	0.2417	0.1208	0.0000	0.0
45.0	0.6812	1.0423	0.7664	0.5821	0.4422	0.3268	0.2298	0.1462	0.0710	0.0000	0.0
22.5	0.4715	0.6023	0.4017	0.2874	0.2066	0.1456	0.0986	0.0610	0.0291	0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0

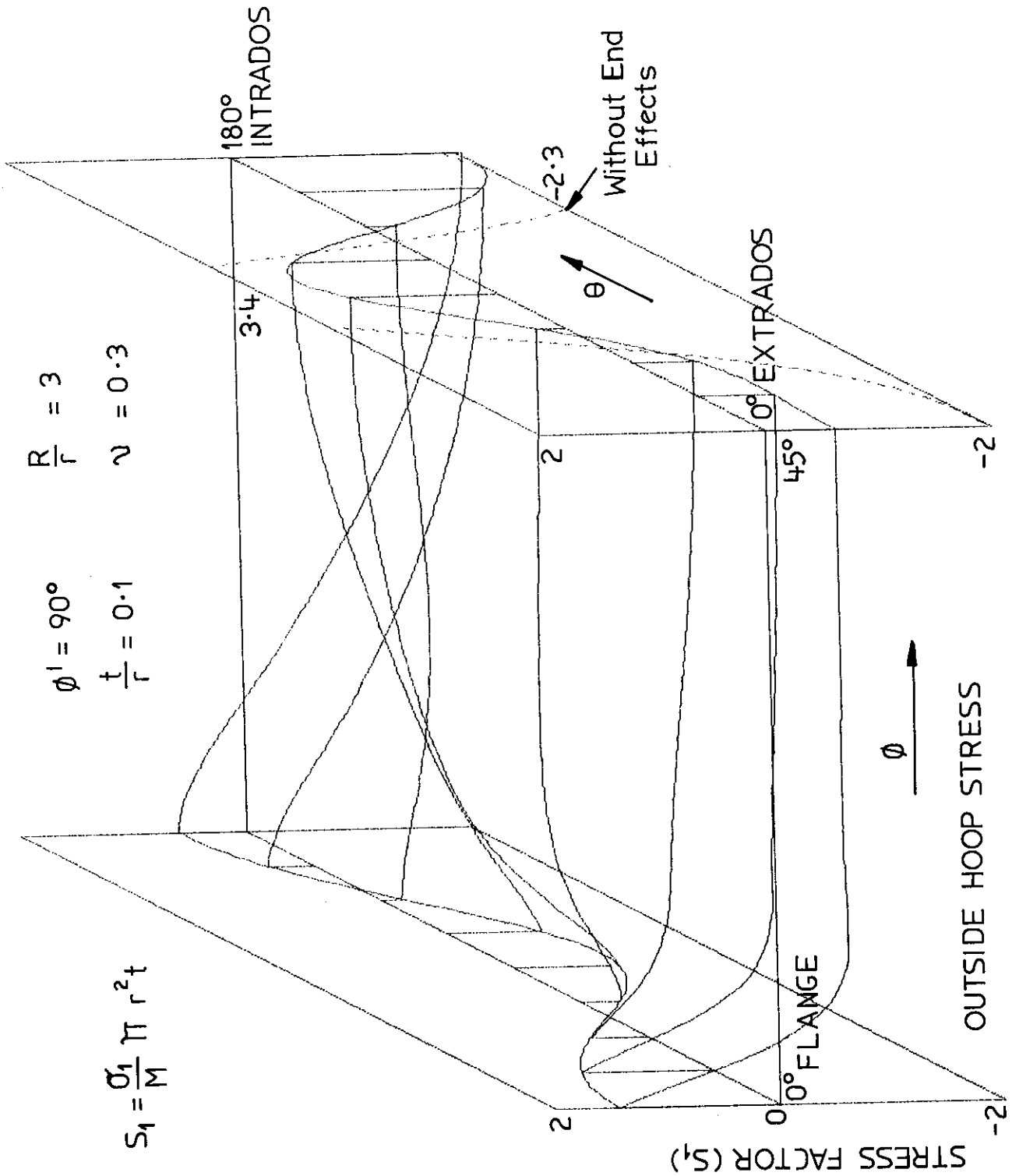
$S_1 = \frac{\sigma_1}{M} \pi r^2 t$
$\phi^1 = 90°$
$\frac{t}{r} = 0{\cdot}1$
$\frac{R}{r} = 3$
$\nu = 0{\cdot}3$
180° INTRADOS
3·4
2
0° EXTRADOS
45°
-2
-2·3
Without End Effects
θ
φ
0° FLANGE
STRESS FACTOR (S_1)
2
0
-2
OUTSIDE HOOP STRESS

FIGURE A15

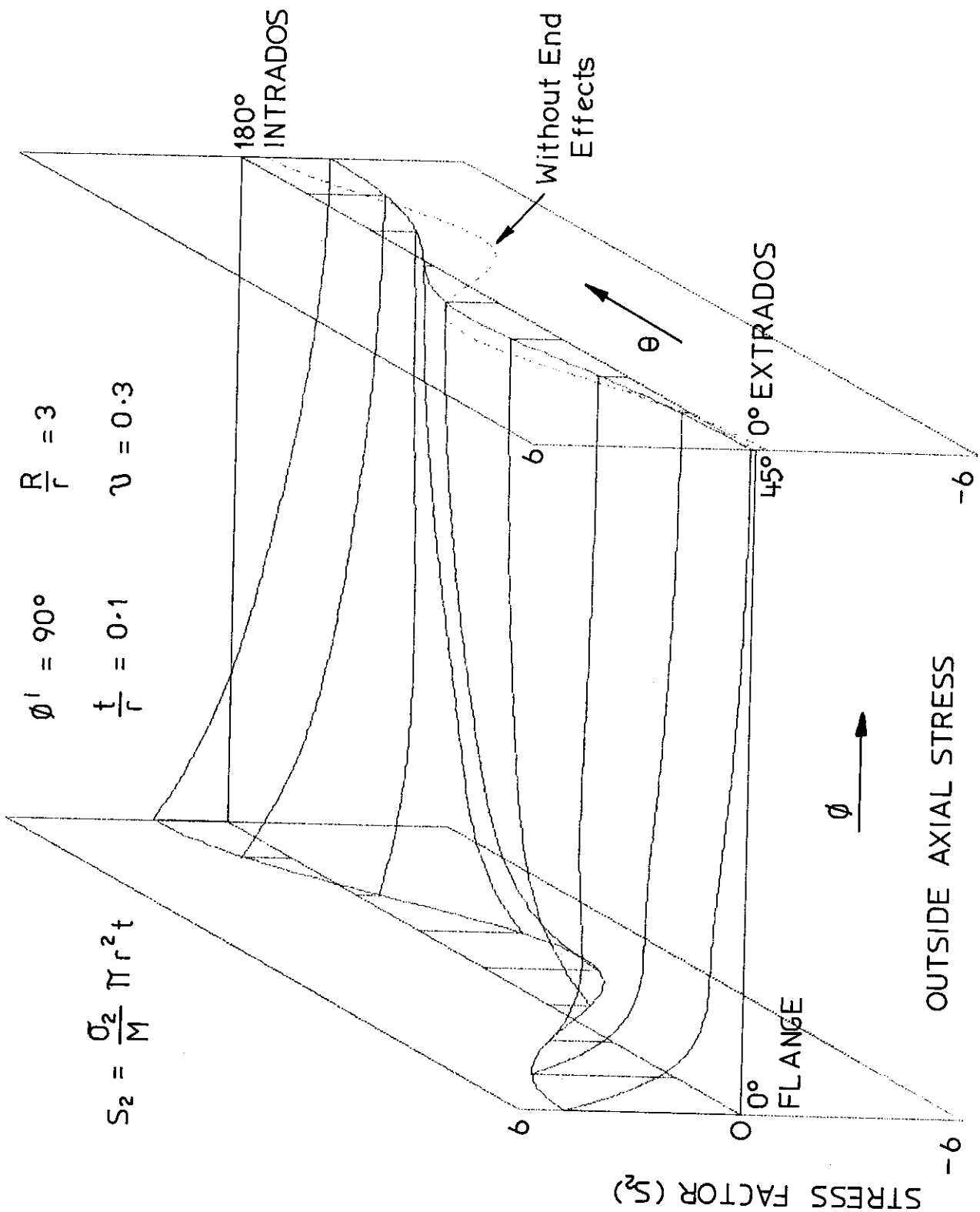
OUTSIDE AXIAL STRESS
STRESS FACTOR (S_2)
$S_2 = \frac{\sigma_2}{M} \pi r^2 t$
$\phi' = 90°$
$\frac{t}{r} = 0{\cdot}1$
$\frac{R}{r} = 3$
$\upsilon = 0{\cdot}3$
180° INTRADOS
0° EXTRADOS
0° FLANGE
45°
Without End Effects
θ
ϕ
6
0
-6

FIGURE A16

TABLE A15

R/r = 3.0 t/r = 0.10

OUTSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.6006	0.3506	-0.1146	-0.5683	-0.9697	-1.3221	-1.6222	-1.8554	-2.0041	-2.0553	-1.8824
157.5	0.4032	0.1217	-0.3042	-0.6749	-0.9703	-1.2064	-1.3939	-1.5330	-1.6194	-1.6488	-2.2597
135.0	-0.1921	-0.2962	-0.4222	-0.4885	-0.4912	-0.4490	-0.3876	-0.3291	-0.2886	-0.2742	-1.4023
112.5	-0.8402	-0.4195	-0.0211	0.2624	0.5061	0.7376	0.9443	1.1063	1.2089	1.2439	1.7555
90.0	-0.9351	-0.2259	0.3626	0.6728	0.8716	1.0298	1.1570	1.2496	1.3055	1.3241	3.3624
67.5	-0.3539	-0.0676	0.1995	0.2909	0.3041	0.2951	0.2808	0.2663	0.2555	0.2516	1.5784
45.0	0.4993	-0.0803	-0.2391	-0.2794	-0.3410	-0.4090	-0.4671	-0.5109	-0.5383	-0.5477	-0.8183
22.5	1.1748	-0.1567	-0.5470	-0.5657	-0.5870	-0.6200	-0.6467	-0.6652	-0.6762	-0.6798	-1.8438
-0.0	1.4232	-0.1923	-0.6395	-0.6244	-0.6128	-0.6191	-0.6238	-0.6255	-0.6260	-0.6261	-1.9848

OUTSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	2.0020	0.8269	-0.0149	-0.6163	-1.1046	-1.5315	-1.8945	-2.1731	-2.3480	-2.4075	-0.6837
157.5	1.3441	0.1912	-0.5416	-1.0114	-1.3499	-1.6204	-1.8399	-2.0053	-2.1084	-2.1435	-1.4797
135.0	-0.6404	-1.0911	-1.3363	-1.4403	-1.4423	-1.3953	-1.3389	-1.2928	-1.2639	-1.2541	-2.6914
112.5	-2.8006	-1.6324	-1.1505	-0.8594	-0.5738	-0.2954	-0.0577	0.1192	0.2273	0.2635	-1.5775
90.0	-3.1171	-0.9473	-0.1213	0.3003	0.6319	0.9165	1.1429	1.3046	1.4011	1.4332	1.3099
67.5	-1.1796	0.1340	0.7067	0.9618	1.1131	1.2265	1.3100	1.3652	1.3963	1.4064	2.5023
45.0	1.6645	0.8605	0.9572	0.9777	0.9167	0.8553	0.8071	0.7709	0.7481	0.7403	1.4945
22.5	3.9160	1.1604	0.9247	0.8105	0.6325	0.4847	0.3787	0.3062	0.2635	0.2493	0.1867
-0.0	4.7440	1.2289	0.8884	0.7392	0.5306	0.3628	0.2456	0.1673	0.1218	0.1068	-0.3029

OUTSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0
157.5	-0.3293	-0.2418	-0.1698	-0.0942	-0.0203	0.0359	0.0638	0.0622	0.0374	0.0000	0.0
135.0	-0.5240	-0.2630	-0.1847	-0.1223	-0.0607	-0.0133	0.0134	0.0207	0.0140	-0.0000	0.0
112.5	-0.4504	-0.1642	-0.1425	-0.1324	-0.1164	-0.0991	-0.0796	-0.0564	-0.0293	-0.0000	0.0
90.0	-0.1055	-0.0202	-0.0175	-0.0340	-0.0518	-0.0612	-0.0591	-0.0462	-0.0252	0.0000	0.0
67.5	0.2819	0.1721	0.1967	0.1563	0.1068	0.0690	0.0427	0.0243	0.0109	0.0000	0.0
45.0	0.4508	0.2932	0.3203	0.2577	0.1919	0.1411	0.1001	0.0645	0.0316	0.0000	0.0
22.5	0.3217	0.2239	0.2351	0.1852	0.1386	0.1032	0.0742	0.0482	0.0238	0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0

TABLE A16

R/ = 3.0 / = 0.10

INSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	-0.4692	-0.0968	-0.0011	0.0956	0.2777	0.5263	0.7892	1.0149	1.1655	1.2181	1.8776
157.5	-0.4707	-0.0524	0.1227	0.2507	0.3933	0.5496	0.6985	0.8191	0.8966	0.9232	2.2678
135.0	-0.3146	-0.0452	0.1191	0.1528	0.0956	-0.0048	-0.1145	-0.2101	-0.2748	-0.2976	1.1824
112.5	0.0591	-0.2458	-0.3433	-0.5445	-0.8252	-1.1158	-1.3719	-1.5696	-1.6942	-1.7367	-2.5210
90.0	0.3296	-0.4392	-0.6914	-0.9136	-1.1401	-1.3365	-1.4872	-1.5918	-1.6534	-1.6737	-4.3099
67.5	0.2732	-0.3340	-0.4926	-0.5177	-0.5182	-0.5055	-0.4816	-0.4556	-0.4363	-0.4293	-2.1465
45.0	0.0069	-0.0388	-0.1171	-0.0100	0.1168	0.2234	0.3111	0.3778	0.4194	0.4336	0.6534
22.5	-0.2454	0.1975	0.0741	0.1790	0.3052	0.3960	0.4606	0.5053	0.5317	0.5404	1.8291
-0.0	-0.3431	0.2777	0.1101	0.1925	0.3003	0.3704	0.4152	0.4439	0.4600	0.4651	1.9872

INSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	-1.5641	-0.7502	-0.3449	-0.2098	-0.1671	-0.1280	-0.0744	-0.0180	0.0240	0.0394	1.2586
157.5	-1.5688	-0.7603	-0.4129	-0.3178	-0.3087	-0.3091	-0.2988	-0.2816	-0.2667	-0.2609	0.8534
135.0	-1.0486	-0.7903	-0.6933	-0.6670	-0.6865	-0.7263	-0.7667	-0.7983	-0.8179	-0.8245	-0.5912
112.5	0.1970	-0.7637	-0.9227	-0.8499	-0.7892	-0.7699	-0.7713	-0.7782	-0.7840	-0.7862	-1.8210
90.0	1.0985	-0.4619	-0.5892	-0.3913	-0.2215	-0.1132	-0.0427	0.0042	0.0317	0.0408	-1.0452
67.5	0.9108	0.1845	0.1805	0.3475	0.4941	0.5933	0.6606	0.7066	0.7339	0.7431	0.5752
45.0	0.0230	0.9332	0.8598	0.8013	0.8034	0.8049	0.8007	0.7967	0.7944	0.7937	1.1429
22.5	-0.8179	1.4874	1.2170	0.9198	0.7834	0.6920	0.6207	0.5706	0.5413	0.5316	0.7644
-0.0	-1.1435	1.6860	1.3155	0.9231	0.7349	0.6094	0.5139	0.4475	0.4087	0.3960	0.4816

INSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
157.5	-0.2979	-0.5635	-0.7314	-0.7902	-0.7657	-0.6799	-0.5482	-0.3832	-0.1969	-0.0000	0.0
135.0	-0.4741	-0.9310	-1.0460	-0.9957	-0.8798	-0.7332	-0.5668	-0.3859	-0.1954	-0.0000	0.0
112.5	-0.4075	-0.6944	-0.6147	-0.4650	-0.3360	-0.2368	-0.1604	-0.0993	-0.0475	0.0000	0.0
90.0	-0.0954	0.0858	0.2122	0.2726	0.2859	0.2649	0.2188	0.1551	0.0802	0.0000	0.0
67.5	0.2551	0.7693	0.7465	0.6417	0.5396	0.4375	0.3321	0.2234	0.1123	0.0000	0.0
45.0	0.4078	0.9158	0.7551	0.5794	0.4514	0.3461	0.2521	0.1648	0.0815	0.0000	0.0
22.5	0.2911	0.5758	0.4328	0.3115	0.2321	0.1717	0.1215	0.0778	0.0380	0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0000	0.0

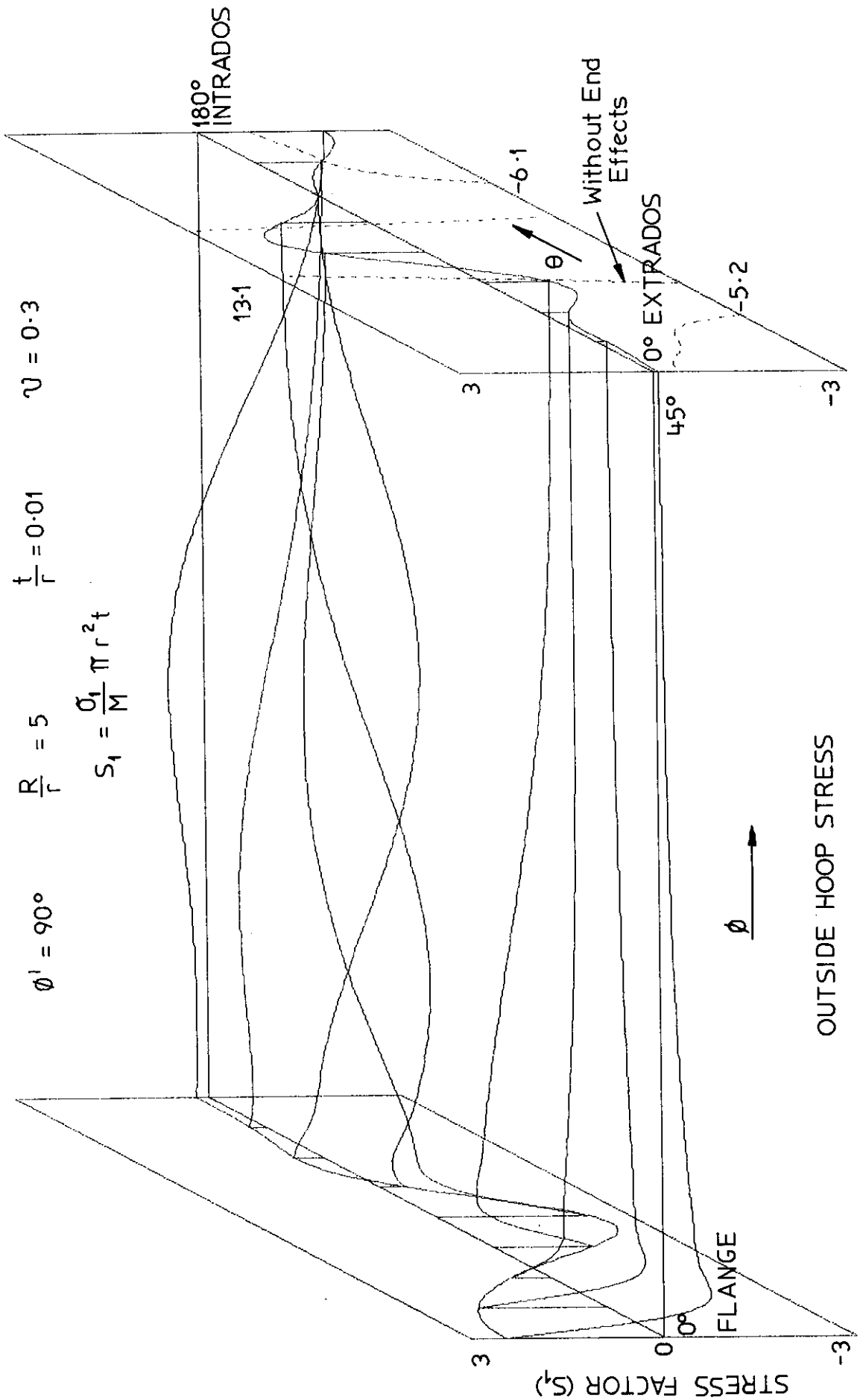
180° INTRADOS
-6·1
Without End Effects
θ
0° EXTRADOS
-5·2
13·1
3
-3
45°
$\phi' = 90°$
$\frac{R}{r} = 5$
$S_1 = \frac{\sigma_1}{M} \pi r^2 t$
$\frac{t}{r} = 0·01$
$\nu = 0·3$
ϕ
OUTSIDE HOOP STRESS
STRESS FACTOR (S_1)
3
0
-3
0° FLANGE

FIGURE A17

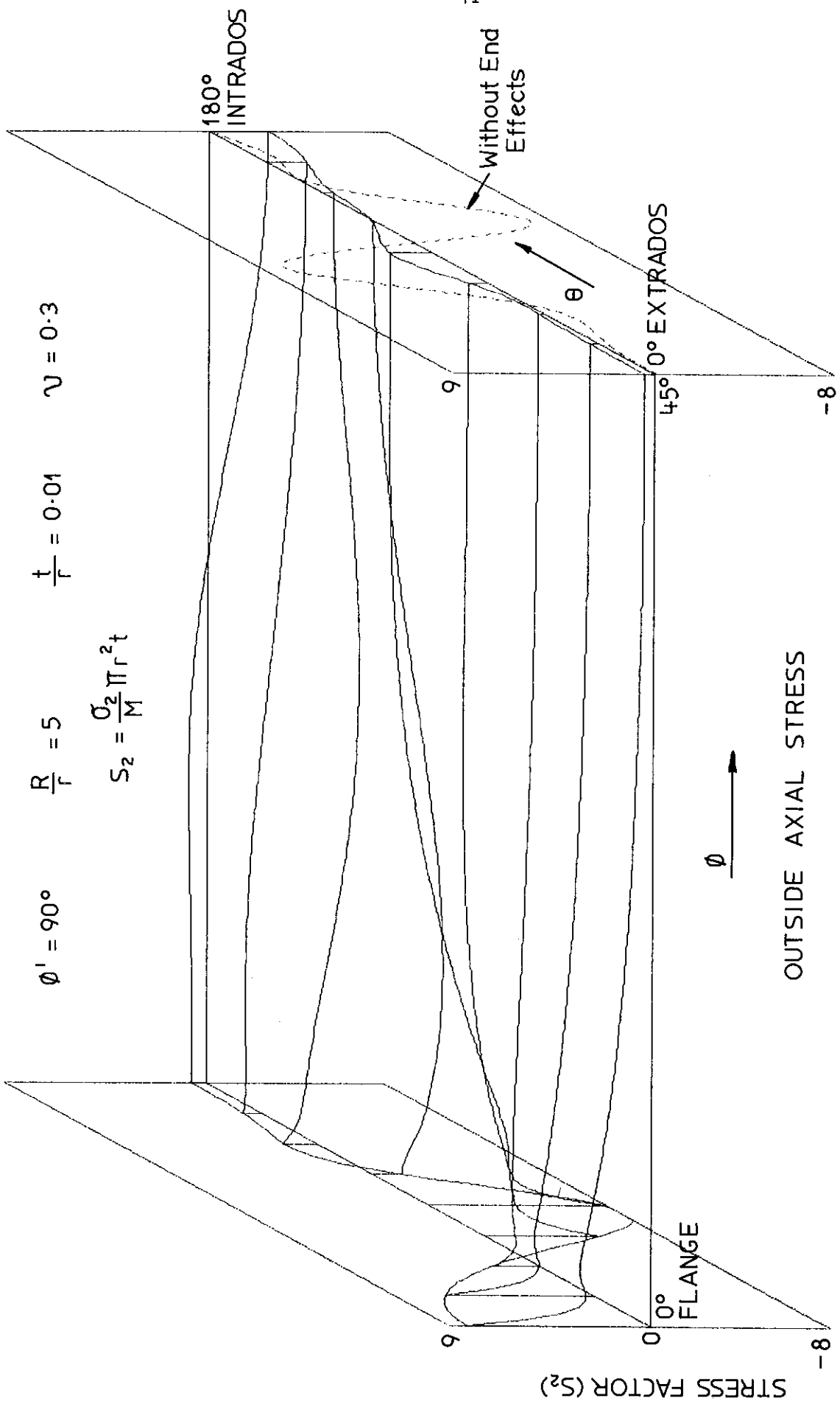
180° INTRADOS
Without End Effects
θ
0° EXTRADOS
45°
9
-8
$\phi' = 90°$
$\frac{R}{r} = 5$
$\frac{t}{r} = 0{\cdot}01$
$\upsilon = 0{\cdot}3$
$S_2 = \frac{\sigma_2}{M} \pi r^2 t$
OUTSIDE AXIAL STRESS
ϕ
STRESS FACTOR (S_2)
9
0
-8
0° FLANGE

FIGURE A18

TABLE A17

R/r = 5.0 t/r = 0.01

OUTSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.2042	0.1730	0.2833	0.4878	0.5767	0.3250	-0.2904	-1.0663	-1.7004	-1.9432	-0.9729
157.5	0.2564	0.2819	0.3722	0.2676	-0.0284	-0.3852	-0.6911	-0.9047	-1.0270	-1.0666	-0.9446
135.0	0.4575	-0.0591	-0.5814	-1.1675	-1.5216	-1.5107	-1.1722	-0.6735	-0.2425	-0.0735	-4.2777
112.5	-0.3880	-0.6615	-0.8267	-0.5660	-0.0568	0.4861	0.9151	1.1802	1.3058	1.3402	-1.7045
90.0	-2.3670	0.4995	1.1650	1.6726	1.9341	1.9762	1.8777	1.7283	1.6048	1.5577	13.0851
67.5	-1.5706	0.1384	-0.0659	-0.3314	-0.5840	-0.7815	-0.9103	-0.9785	-1.0063	-1.0129	-1.1074
45.0	0.6022	-0.2733	-0.3927	-0.4703	-0.5090	-0.5207	-0.5184	-0.5120	-0.5069	-0.5051	-4.1015
22.5	2.0026	-0.4058	-0.3158	-0.2461	-0.1957	-0.1608	-0.1377	-0.1233	-0.1156	-0.1131	-0.9662
-0.0	2.4725	-0.4978	-0.3790	-0.2950	-0.2374	-0.1980	-0.1714	-0.1544	-0.1449	-0.1418	-0.7686

OUTSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.6807	0.6593	0.7426	0.7819	0.5483	-0.0620	-0.9300	-1.8054	-2.4404	-2.6707	-0.5141
157.5	0.8545	0.8013	0.6938	0.3374	-0.1656	-0.6800	-1.1343	-1.4981	-1.7400	-1.8258	-0.3459
135.0	1.5251	0.1918	-0.7035	-1.4314	-1.7976	-1.7814	-1.4778	-1.0547	-0.7011	-0.5647	-1.4846
112.5	-1.2933	-2.7560	-3.0943	-2.8195	-2.2170	-1.5081	-0.8423	-0.3125	0.0260	0.1422	-6.8774
90.0	-7.8899	-2.9390	-1.3362	-0.0676	0.8382	1.4116	1.7190	1.8451	1.8761	1.8781	4.2467
67.5	-5.2355	-0.5929	0.3765	0.8357	1.0016	1.0140	0.9639	0.9048	0.8633	0.8488	5.6610
45.0	2.0073	1.2128	1.0304	0.8096	0.6069	0.4438	0.3241	0.2442	0.1988	0.1841	-0.8044
22.5	6.6753	2.3676	1.7021	1.2458	0.9292	0.7095	0.5595	0.4621	0.4072	0.3894	-0.3898
-0.0	8.2417	2.7265	1.8963	1.3557	0.9949	0.7518	0.5897	0.4864	0.4290	0.4106	-0.0788

OUTSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	-0.0000	-0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0000	-0.0000	-0.0000	0.0
157.5	0.0008	-0.0695	-0.2387	-0.3866	-0.4210	-0.3350	-0.1918	-0.0693	-0.0096	-0.0000	0.0
135.0	-0.1833	-0.4692	-0.5443	-0.4954	-0.4238	-0.3752	-0.3348	-0.2663	-0.1506	-0.0000	0.0
112.5	-0.9435	-0.8422	-0.5839	-0.4218	-0.3328	-0.2777	-0.2274	-0.1660	-0.0886	0.0000	0.0
90.0	-0.9798	-0.5152	-0.2466	-0.0881	0.0160	0.0835	0.1151	0.1079	0.0649	-0.0000	0.0
67.5	0.5267	0.6473	0.5694	0.4946	0.4185	0.3386	0.2549	0.1695	0.0843	-0.0000	0.0
45.0	1.3466	1.1145	0.7944	0.5693	0.4063	0.2849	0.1919	0.1181	0.0561	0.0000	0.0
22.5	0.9549	0.7058	0.4687	0.3165	0.2156	0.1463	0.0967	0.0589	0.0279	0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0

TABLE A18

R/r = 5.0 t/r = 0.01

INSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.1815	0.1691	0.0739	-0.2074	-0.5001	-0.5296	-0.1910	0.3717	0.8785	1.0798	0.9726
157.5	0.1966	0.0383	-0.1658	-0.2247	-0.0904	0.1178	0.2844	0.3749	0.4099	0.4178	0.9459
135.0	-0.0010	0.0564	0.3966	0.8816	1.2052	1.2083	0.9028	0.4362	0.0258	-0.1364	4.3291
112.5	-0.5546	0.3243	0.4830	0.2348	-0.2458	-0.7420	-1.1083	-1.3059	-1.3785	-1.3926	1.3597
90.0	-0.2463	-0.5497	-1.2847	-1.8270	-2.0942	-2.1244	-2.0081	-1.8430	-1.7095	-1.6591	-14.1285
67.5	0.1633	-0.0358	0.0655	0.2886	0.5283	0.7253	0.8568	0.9275	0.9564	0.9634	0.8029
45.0	0.0895	-0.0214	0.1277	0.2463	0.3244	0.3695	0.3931	0.4051	0.4110	0.4128	4.1374
22.5	-0.0291	-0.3255	-0.2190	-0.1491	-0.1018	-0.0686	-0.0449	-0.0289	-0.0196	-0.0165	0.9700
-0.0	-0.0812	-0.4013	-0.2526	-0.1573	-0.0951	-0.0537	-0.0263	-0.0090	0.0006	0.0037	0.7688

INSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.6051	0.6672	0.6023	0.3395	-0.0956	-0.5465	-0.8651	-1.0105	-1.0401	-1.0376	0.4826
157.5	0.6554	0.6270	0.3554	0.0435	-0.2218	-0.4428	-0.6492	-0.8403	-0.9819	-1.0346	0.6539
135.0	-0.0035	0.0601	-0.3700	-0.5662	-0.6075	-0.5945	-0.5933	-0.6225	-0.6625	-0.6809	1.7084
112.5	-1.8486	-2.1602	-2.3008	-2.1996	-1.9836	-1.6978	-1.3732	-1.0603	-0.8291	-0.7434	-4.7217
90.0	-0.8212	-3.0249	-2.0294	-1.1961	-0.5279	-0.0173	0.3444	0.5743	0.6969	0.7347	-3.9271
67.5	0.5444	-0.7208	0.2762	0.8590	1.1665	1.3002	1.3340	1.3218	1.3002	1.2907	5.2009
45.0	0.2982	1.2105	1.1302	0.9789	0.8165	0.6726	0.5596	0.4809	0.4352	0.4203	1.1871
22.5	-0.0969	2.3401	1.6968	1.2465	0.9317	0.7126	0.5630	0.4662	0.4117	0.3941	-0.1054
-0.0	-0.2705	2.7122	1.9042	1.3710	1.0136	0.7720	0.6105	0.5074	0.4500	0.4315	0.1070

INSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	-0.0000	-0.0000	-0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
157.5	0.0008	0.0472	-0.0130	-0.2201	-0.5133	-0.7631	-0.8527	-0.7303	-0.4194	-0.0000	0.0
135.0	-0.1815	-0.3076	-0.6313	-0.8638	-0.9385	-0.8758	-0.7218	-0.5116	-0.2654	0.0000	0.0
112.5	-0.9341	-1.3347	-1.1612	-0.8427	-0.4967	-0.1987	0.0053	0.0946	0.0789	-0.0000	0.0
90.0	-0.9700	-0.5957	-0.0868	0.2292	0.3861	0.4212	0.3714	0.2692	0.1399	-0.0000	0.0
67.5	0.5215	0.9693	0.8940	0.7536	0.5951	0.4422	0.3059	0.1895	0.0899	0.0000	0.0
45.0	1.3332	1.2014	0.8461	0.5967	0.4195	0.2912	0.1955	0.1206	0.0576	0.0000	0.0
22.5	0.9454	0.7276	0.4769	0.3197	0.2174	0.1478	0.0979	0.0598	0.0284	0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0000	0.0

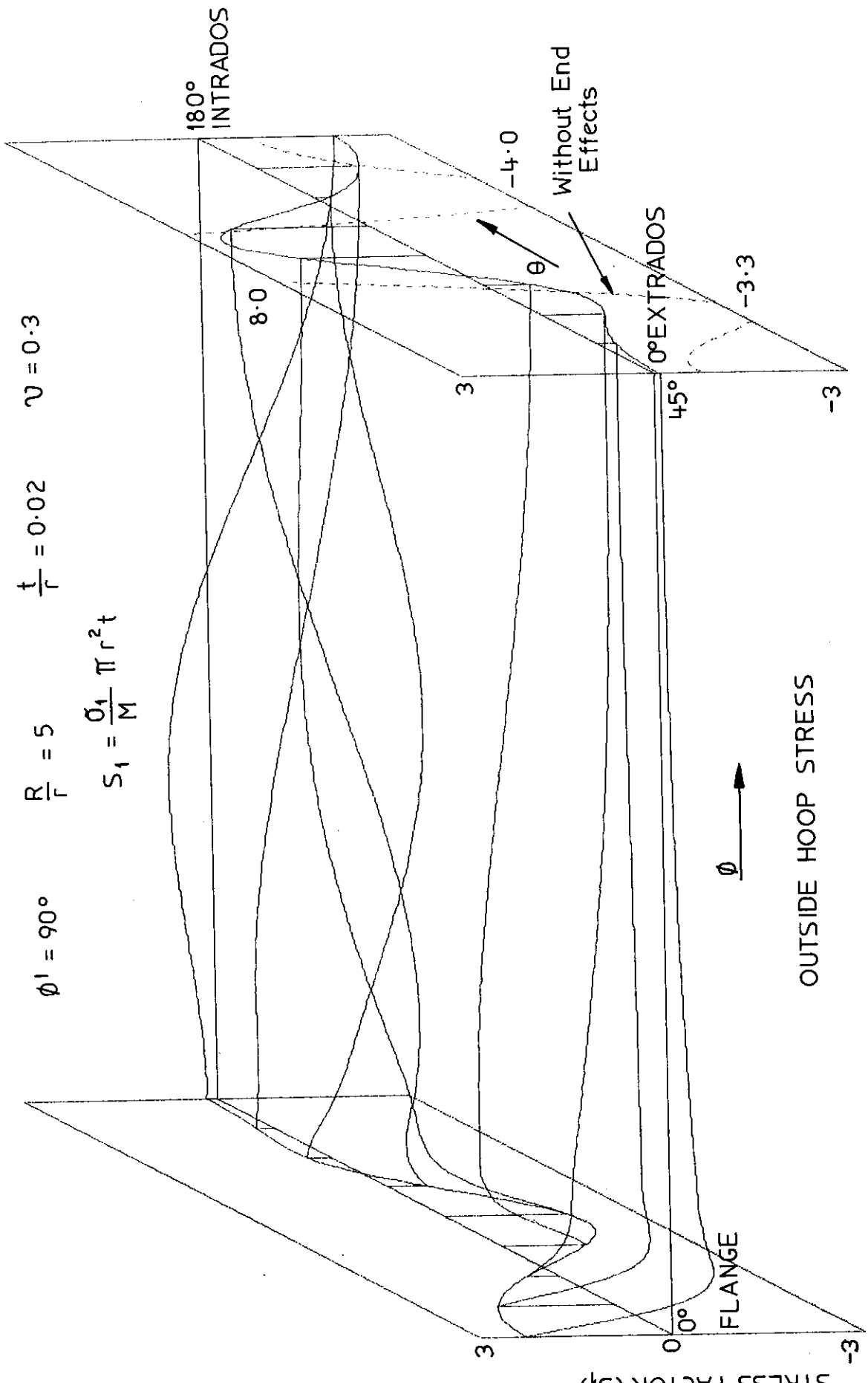
180°
INTRADOS
8·0
-4·0
Without End
Effects
0°EXTRADOS
-3·3
3
45°
-3
θ
φ
OUTSIDE HOOP STRESS
STRESS FACTOR (S1)
3
0
-3
0°
FLANGE
φ' = 90°
R/r = 5
t/r = 0·02
υ = 0·3
S1 = σ1/M π r²t

FIGURE A19

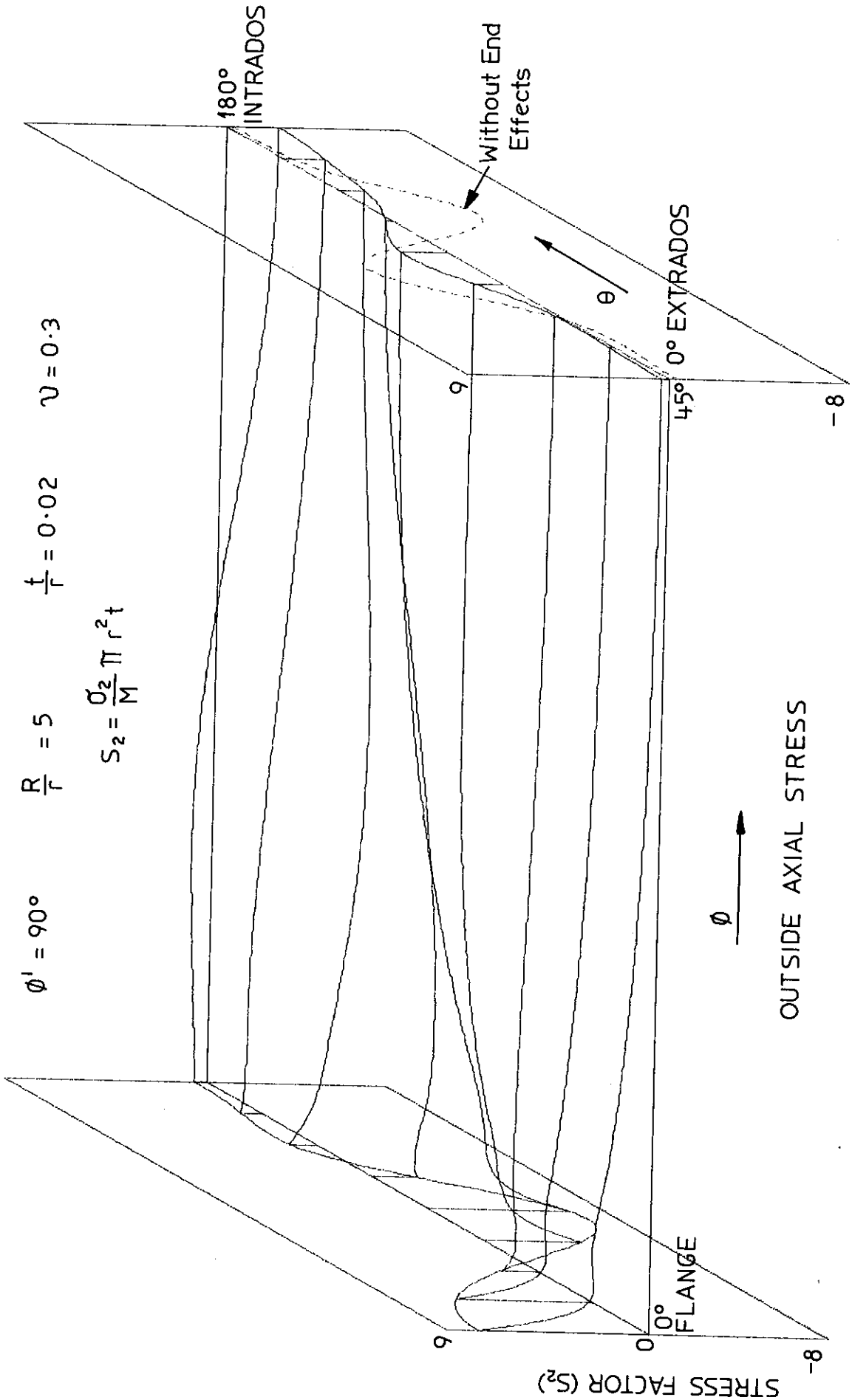
$\phi' = 90°$
$\frac{R}{r} = 5$
$\frac{t}{r} = 0{\cdot}02$
$\upsilon = 0{\cdot}3$
$S_2 = \frac{\sigma_2}{M} \pi r^2 t$
180° INTRADOS
Without End Effects
0° EXTRADOS
θ
9
45°
-8
OUTSIDE AXIAL STRESS
φ
9
0
0° FLANGE
-8
STRESS FACTOR (S_2)

FIGURE A20

TABLE A19

R/r = 5.0 t/r = 0.02

OUTSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.1694	0.3018	0.5432	0.6666	0.4881	-0.0178	-0.7216	-1.4222	-1.9291	-2.1130	-0.7488
157.5	0.2868	0.2469	0.1961	-0.0334	-0.3682	-0.7359	-1.0840	-1.3716	-1.5626	-1.6298	-1.6276
135.0	0.3703	-0.3595	-0.9190	-1.3781	-1.5583	-1.4357	-1.1004	-0.7017	-0.3901	-0.2733	-3.9828
112.5	-0.5983	-0.4810	-0.4966	-0.1935	0.2915	0.8387	1.3583	1.7836	2.0627	2.1601	1.1808
90.0	-1.9080	0.4626	1.0173	1.5346	1.8884	2.0645	2.0966	2.0464	1.9815	1.9534	8.0354
67.5	-1.3291	0.3210	0.2946	0.1735	-0.0169	-0.2304	-0.4306	-0.5912	-0.6946	-0.7302	1.3038
45.0	0.4774	-0.2755	-0.4837	-0.6724	-0.8180	-0.9162	-0.9726	-0.9989	-1.0078	-1.0095	-3.3249
22.5	1.8322	-0.4557	-0.4221	-0.3983	-0.3725	-0.3463	-0.3226	-0.3038	-0.2918	-0.2877	-1.7219
-0.0	2.2792	-0.4870	-0.3583	-0.2699	-0.2059	-0.1614	-0.1320	-0.1142	-0.1049	-0.1020	-0.7486

OUTSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.5645	0.7485	0.8797	0.7532	0.2945	-0.3977	-1.1462	-1.7872	-2.2098	-2.3564	-0.3233
157.5	0.9559	0.7245	0.4876	0.0866	-0.3713	-0.8306	-1.2550	-1.6052	-1.8383	-1.9204	-0.3891
135.0	1.2345	-0.4614	-1.2331	-1.7398	-1.9227	-1.8565	-1.6572	-1.4355	-1.2724	-1.2133	-2.7148
112.5	-1.9942	-2.5534	-2.6115	-2.3028	-1.7998	-1.2171	-0.6394	-0.1463	0.1872	0.3053	-4.0627
90.0	-6.3601	-2.2545	-1.0327	-0.0202	0.7567	1.3177	1.6971	1.9333	2.0598	2.0994	2.6695
67.5	-4.4304	-0.3042	0.6088	1.1149	1.3564	1.4320	1.4137	1.3567	1.3038	1.2828	4.5687
45.0	1.5914	1.1754	1.0552	0.8669	0.6668	0.4871	0.3429	0.2398	0.1787	0.1584	0.5610
22.5	6.1073	2.0938	1.4434	1.0021	0.6942	0.4817	0.3392	0.2491	0.1996	0.1838	-0.5878
-0.0	7.5975	2.4247	1.6450	1.1543	0.8299	0.6136	0.4707	0.3800	0.3297	0.3136	-0.3361

OUTSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	-0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	-0.0000	-0.0000	-0.0000	0.0000	0.0
157.5	-0.0048	-0.1780	-0.3208	-0.3394	-0.2380	-0.0859	0.0405	0.0947	0.0714	-0.0000	0.0
135.0	-0.2743	-0.4719	-0.4230	-0.3284	-0.2445	-0.1817	-0.1315	-0.0862	-0.0427	-0.0000	0.0
112.5	-0.8083	-0.6243	-0.3917	-0.2815	-0.2501	-0.2502	-0.2405	-0.1957	-0.1107	0.0000	0.0
90.0	-0.6701	-0.3302	-0.1772	-0.1090	-0.0721	-0.0472	-0.0288	-0.0157	-0.0067	0.0000	0.0
67.5	0.3684	0.4663	0.3762	0.3157	0.2701	0.2296	0.1856	0.1326	0.0695	-0.0000	0.0
45.0	1.0479	0.9162	0.6502	0.4761	0.3521	0.2577	0.1813	0.1157	0.0564	-0.0000	0.0
22.5	0.7908	0.6345	0.4259	0.2918	0.2009	0.1369	0.0901	0.0544	0.0256	0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0

TABLE A20

R/r = 5.0 t/r = 0.02

INSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.2027	0.0509	-0.2542	-0.5604	-0.6110	-0.3115	0.2440	0.8572	1.3225	1.4947	0.7481
157.5	0.1434	-0.0272	-0.1070	-0.0104	0.2030	0.4583	0.7063	0.9145	1.0547	1.1044	1.6420
135.0	-0.2213	0.2292	0.7044	1.1476	1.3360	1.2143	0.8609	0.4308	0.0902	-0.0382	3.9928
112.5	-0.4939	0.2240	0.2164	-0.0876	-0.5711	-1.1072	-1.6075	-2.0115	-2.2746	-2.3660	-1.6151
90.0	-0.0691	-0.4623	-1.1572	-1.7300	-2.1092	-2.2847	-2.2988	-2.2237	-2.1380	-2.1019	-8.8648
67.5	0.2550	-0.2411	-0.3496	-0.2647	-0.0795	0.1431	0.3566	0.5292	0.6406	0.6790	-1.6739
45.0	0.1068	0.0088	0.2533	0.4843	0.6700	0.8012	0.8823	0.9250	0.9431	0.9478	3.3199
22.5	-0.0950	-0.2201	-0.0430	0.0583	0.1197	0.1543	0.1722	0.1805	0.1837	0.1845	1.7356
-0.0	-0.1657	-0.3497	-0.1985	-0.1268	-0.0838	-0.0559	-0.0367	-0.0234	-0.0153	-0.0126	0.7491

INSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.6756	0.5823	0.3504	-0.0024	-0.3359	-0.5407	-0.5926	-0.5406	-0.4643	-0.4304	0.5388
157.5	0.4781	0.4538	0.1947	-0.0204	-0.1891	-0.3210	-0.4240	-0.4991	-0.5450	-0.5603	1.0297
135.0	-0.7376	-0.2922	-0.5377	-0.5950	-0.6072	-0.6555	-0.7627	-0.9003	-1.0149	-1.0593	0.3945
112.5	-1.6464	-1.9306	-1.9356	-1.8382	-1.7075	-1.5631	-1.4195	-1.2956	-1.2113	-1.1814	-3.9197
90.0	-0.2302	-2.2992	-1.5939	-1.0365	-0.5770	-0.1914	0.1278	0.3736	0.5310	0.5854	-2.4121
67.5	0.8499	-0.5756	0.2375	0.7550	1.0818	1.2783	1.3862	1.4377	1.4577	1.4625	2.8580
45.0	0.3560	1.1156	1.1583	1.1047	1.0106	0.9051	0.8065	0.7273	0.6762	0.6586	2.0064
22.5	-0.3168	2.0506	1.4990	1.0921	0.8000	0.5919	0.4478	0.3540	0.3013	0.2843	0.1400
-0.0	-0.5523	2.3593	1.6447	1.1558	0.8279	0.6074	0.4611	0.3687	0.3177	0.3015	-0.1621

INSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	-0.0000	-0.0000	-0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
157.5	-0.0047	0.0727	-0.1070	-0.3759	-0.6198	-0.7481	-0.7260	-0.5664	-0.3082	-0.0000	0.0
135.0	-0.2689	-0.4770	-0.7224	-0.8552	-0.8835	-0.8292	-0.7042	-0.5146	-0.2724	0.0000	0.0
112.5	-0.7923	-1.1843	-0.9729	-0.7002	-0.4371	-0.2260	-0.0849	-0.0122	0.0079	-0.0000	0.0
90.0	-0.6568	-0.4503	-0.0586	0.1930	0.3333	0.3849	0.3631	0.2806	0.1526	-0.0000	0.0
67.5	0.3611	0.8431	0.8106	0.7176	0.5984	0.4710	0.3450	0.2246	0.1104	0.0000	0.0
45.0	1.0272	1.1356	0.8247	0.5945	0.4226	0.2925	0.1931	0.1162	0.0543	0.0000	0.0
22.5	0.7752	0.6764	0.4442	0.2957	0.1986	0.1329	0.0866	0.0522	0.0246	0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0

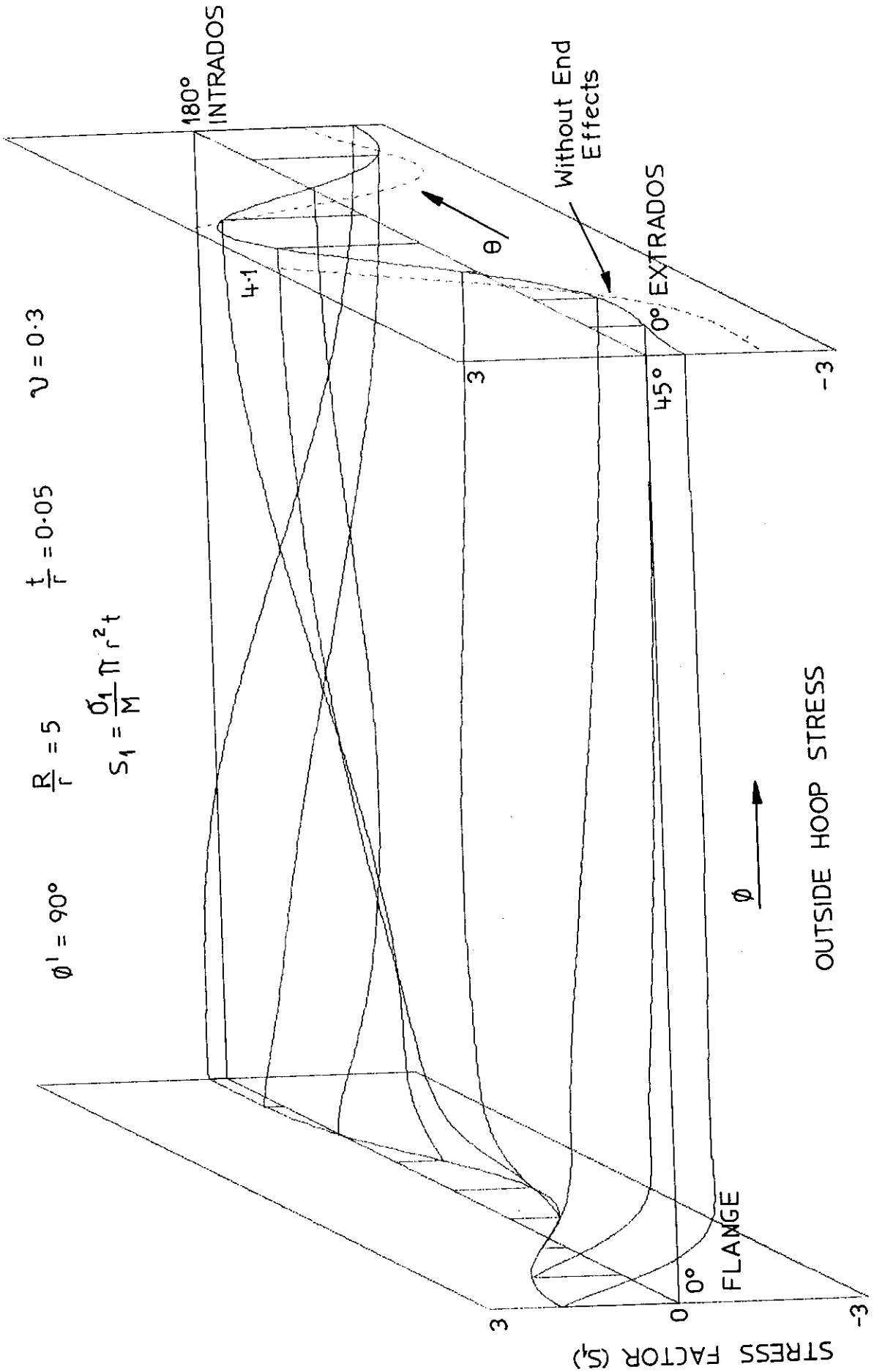
180° INTRADOS
Without End Effects
0° EXTRADOS
θ
4·1
3
45°
-3
$\phi' = 90°$
$\frac{R}{r} = 5$
$S_1 = \frac{\sigma_1}{M} \pi r^2 t$
$\frac{t}{r} = 0{\cdot}05$
$\nu = 0{\cdot}3$
ϕ
OUTSIDE HOOP STRESS
0° FLANGE
3
0
-3
STRESS FACTOR (S_1)

FIGURE A21

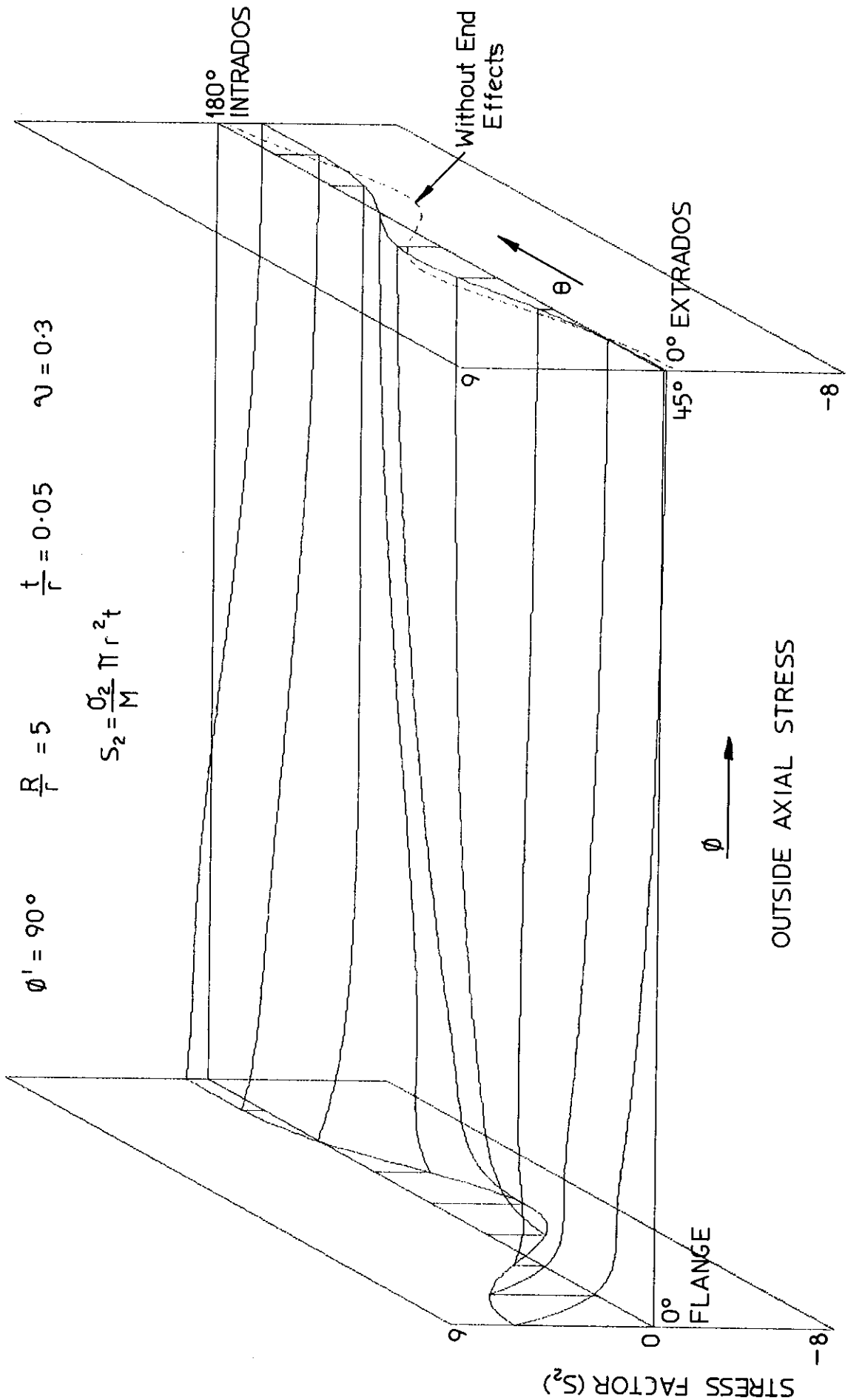
180° INTRADOS
Without End Effects
θ
0° EXTRADOS
45°
9
-8
φ
OUTSIDE AXIAL STRESS
STRESS FACTOR (S2)
9
0
-8
0° FLANGE
φ' = 90°
R/r = 5
t/r = 0·05
ν = 0·3
S2 = σ2/M π r²t

FIGURE A22

TABLE A21

R/r = 5.0 t/r = 0.05

OUTSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.2880	0.2786	0.2043	-0.0843	-0.5671	-1.1379	-1.6909	-2.1414	-2.4325	-2.5328	-1.7172
157.5	0.2966	0.0143	-0.2344	-0.5359	-0.8877	-1.2426	-1.5625	-1.8157	-1.9778	-2.0335	-2.2201
135.0	0.0198	-0.3840	-0.6985	-0.8038	-0.7565	-0.6114	-0.4324	-0.2716	-0.1632	-0.1252	-1.6195
112.5	-0.7404	-0.1956	-0.0775	0.2384	0.6657	1.1309	1.5696	1.9262	2.1580	2.2383	1.9449
90.0	-1.2622	0.3298	0.7313	1.1214	1.4635	1.7435	1.9627	2.1218	2.2190	2.2518	4.1482
67.5	-0.7969	0.3283	0.4828	0.5433	0.5299	0.4659	0.3799	0.2979	0.2401	0.2194	1.8438
45.0	0.3749	-0.1394	-0.2227	-0.3684	-0.5249	-0.6779	-0.8141	-0.9218	-0.9910	-1.0149	-1.1647
22.5	1.4392	-0.5199	-0.5556	-0.6516	-0.7290	-0.7885	-0.8314	-0.8600	-0.8763	-0.8816	-2.0043
-0.0	1.8460	-0.6375	-0.5981	-0.6332	-0.6495	-0.6523	-0.6459	-0.6360	-0.6277	-0.6244	-1.9001

OUTSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.9599	0.6962	0.4823	0.0308	-0.5165	-1.0384	-1.4672	-1.7743	-1.9554	-2.0149	-0.3935
157.5	0.9887	0.1900	-0.1653	-0.5659	-0.9661	-1.3276	-1.6289	-1.8542	-1.9930	-2.0399	-1.1395
135.0	0.0661	-1.0476	-1.4331	-1.5715	-1.5956	-1.5758	-1.5553	-1.5474	-1.5482	-1.5497	-2.4956
112.5	-2.4681	-1.8192	-1.7076	-1.3540	-0.9587	-0.5763	-0.2473	0.0020	0.1563	0.2084	-1.6735
90.0	-4.2075	-1.1833	-0.5368	0.1118	0.6404	1.0752	1.4241	1.6836	1.8447	1.8995	1.4342
67.5	-2.6562	0.1152	0.6740	1.0853	1.3459	1.5143	1.6242	1.6945	1.7344	1.7474	2.7620
45.0	1.2495	1.0672	1.1112	1.0515	0.9609	0.8613	0.7682	0.6933	0.6449	0.6282	1.4157
22.5	4.7972	1.5318	1.1643	0.7954	0.5251	0.3225	0.1735	0.0703	0.0093	-0.0109	-0.0882
-0.0	6.1534	1.6696	1.1702	0.7133	0.4036	0.1878	0.0397	-0.0570	-0.1118	-0.1295	-0.5706

OUTSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.0000	0.0000	0.0000	0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0
157.5	-0.1255	-0.2671	-0.2042	-0.0703	0.0666	0.1606	0.1929	0.1658	0.0945	0.0000	0.0
135.0	-0.3589	-0.3568	-0.2307	-0.0946	0.0109	0.0779	0.1041	0.0933	0.0542	-0.0000	0.0
112.5	-0.5244	-0.2996	-0.1902	-0.1406	-0.1295	-0.1242	-0.1097	-0.0821	-0.0439	-0.0000	0.0
90.0	-0.3049	-0.0943	-0.0738	-0.0953	-0.1245	-0.1411	-0.1358	-0.1068	-0.0587	-0.0000	0.0
67.5	0.2207	0.2680	0.1739	0.1003	0.0518	0.0207	0.0029	-0.0044	-0.0042	0.0000	0.0
45.0	0.5798	0.5197	0.3488	0.2433	0.1776	0.1320	0.0957	0.0632	0.0315	0.0000	0.0
22.5	0.4686	0.4059	0.2700	0.1903	0.1401	0.1048	0.0765	0.0507	0.0254	0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0

TABLE A22

R/r = 5.0 t/r = 0.05

INSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.0699	-0.1018	-0.2748	-0.1375	0.2512	0.7864	1.3432	1.8144	2.1252	2.2333	1.7163
157.5	-0.0945	0.0476	0.1194	0.3456	0.6409	0.9596	1.2604	1.5059	1.6660	1.7216	2.2301
135.0	-0.3422	0.2523	0.5301	0.6460	0.5807	0.3929	0.1616	-0.0470	-0.1882	-0.2378	1.5193
112.5	-0.2457	0.0113	-0.0903	-0.4308	-0.8912	-1.4012	-1.8882	-2.2877	-2.5490	-2.6398	-2.3859
90.0	0.1199	-0.4334	-0.8635	-1.3269	-1.7073	-2.0096	-2.2409	-2.4066	-2.5072	-2.5411	-4.7591
67.5	0.2824	-0.4204	-0.6058	-0.7065	-0.6971	-0.6214	-0.5169	-0.4167	-0.3459	-0.3205	-2.2132
45.0	0.1127	-0.1391	0.0121	0.1936	0.3895	0.5782	0.7445	0.8751	0.9587	0.9875	1.0762
22.5	-0.1408	-0.0226	0.2097	0.4045	0.5522	0.6613	0.7385	0.7896	0.8187	0.8281	2.0037
-0.0	-0.2491	-0.0261	0.1889	0.3463	0.4444	0.5019	0.5317	0.5445	0.5486	0.5494	1.9006

INSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.2330	0.2325	-0.0341	-0.1853	-0.2112	-0.1385	-0.0101	0.1244	0.2232	0.2592	1.0481
157.5	-0.3150	0.0236	-0.1611	-0.2691	-0.3110	-0.3098	-0.2826	-0.2474	-0.2194	-0.2089	0.6925
135.0	-1.1407	-0.6584	-0.6909	-0.7352	-0.7976	-0.8921	-1.0022	-1.1036	-1.1742	-1.1995	-0.8242
112.5	-0.8191	-1.4510	-1.2477	-1.1734	-1.1403	-1.1511	-1.1910	-1.2396	-1.2777	-1.2920	-2.3170
90.0	0.3997	-1.4134	-0.8906	-0.6154	-0.3996	-0.2296	-0.0985	-0.0042	0.0527	0.0718	-1.2547
67.5	0.9412	-0.3481	0.1794	0.4724	0.6916	0.8628	0.9972	1.0964	1.1580	1.1790	0.9868
45.0	0.3757	0.9260	0.9807	1.0137	1.0227	1.0224	1.0193	1.0163	1.0145	1.0139	1.5468
22.5	-0.4695	1.7561	1.2614	1.0058	0.8095	0.6614	0.5514	0.4747	0.4291	0.4139	0.7651
-0.0	-0.8304	2.0239	1.3059	0.9385	0.6694	0.4741	0.3334	0.2376	0.1814	0.1629	0.2952

INSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
157.5	-0.1194	-0.2037	-0.4035	-0.5435	-0.5870	-0.5450	-0.4436	-0.3083	-0.1570	-0.0000	0.0
135.0	-0.3414	-0.6773	-0.7577	-0.7786	-0.7375	-0.6466	-0.5172	-0.3597	-0.1842	-0.0000	0.0
112.5	-0.4988	-0.8374	-0.6312	-0.4674	-0.3433	-0.2530	-0.1831	-0.1215	-0.0612	-0.0000	0.0
90.0	-0.2900	-0.1911	0.0310	0.1613	0.2221	0.2307	0.2017	0.1471	0.0771	0.0000	0.0
67.5	0.2100	0.6624	0.6165	0.5646	0.4954	0.4150	0.3241	0.2230	0.1137	0.0000	0.0
45.0	0.5516	0.9525	0.7058	0.5466	0.4212	0.3192	0.2315	0.1514	0.0751	0.0000	0.0
22.5	0.4457	0.6231	0.4188	0.2976	0.2119	0.1492	0.1014	0.0630	0.0302	-0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0000	0.0

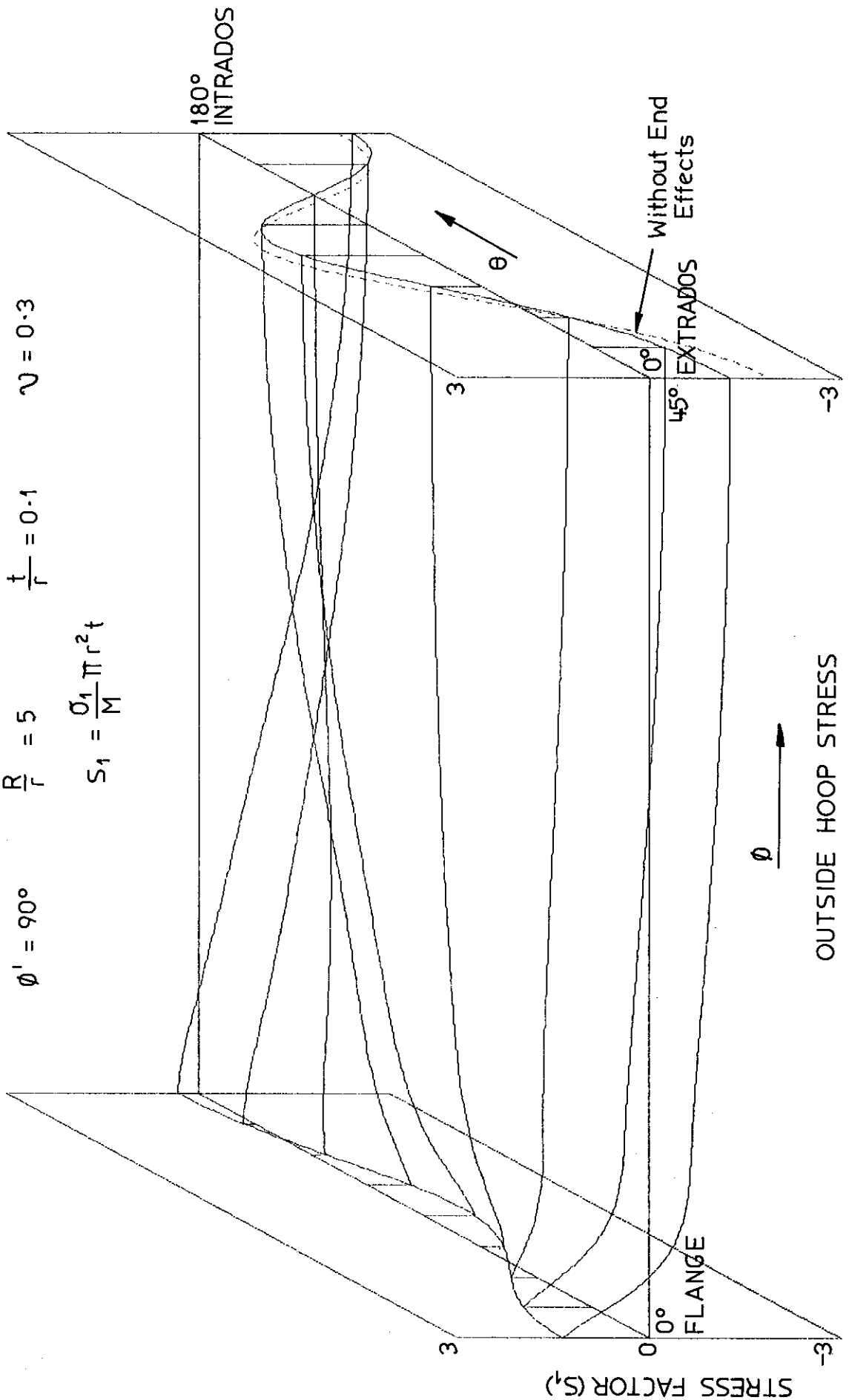
180°
INTRADOS
Without End
Effects
θ
0°
EXTRADOS
45°
3
-3
$\phi' = 90°$
$\frac{R}{r} = 5$
$\frac{t}{r} = 0.1$
$\nu = 0.3$
$S_1 = \frac{\sigma_1}{M} \pi r^2 t$
ϕ
OUTSIDE HOOP STRESS
STRESS FACTOR (S_1)
3
0
-3
0°
FLANGE

FIGURE A23

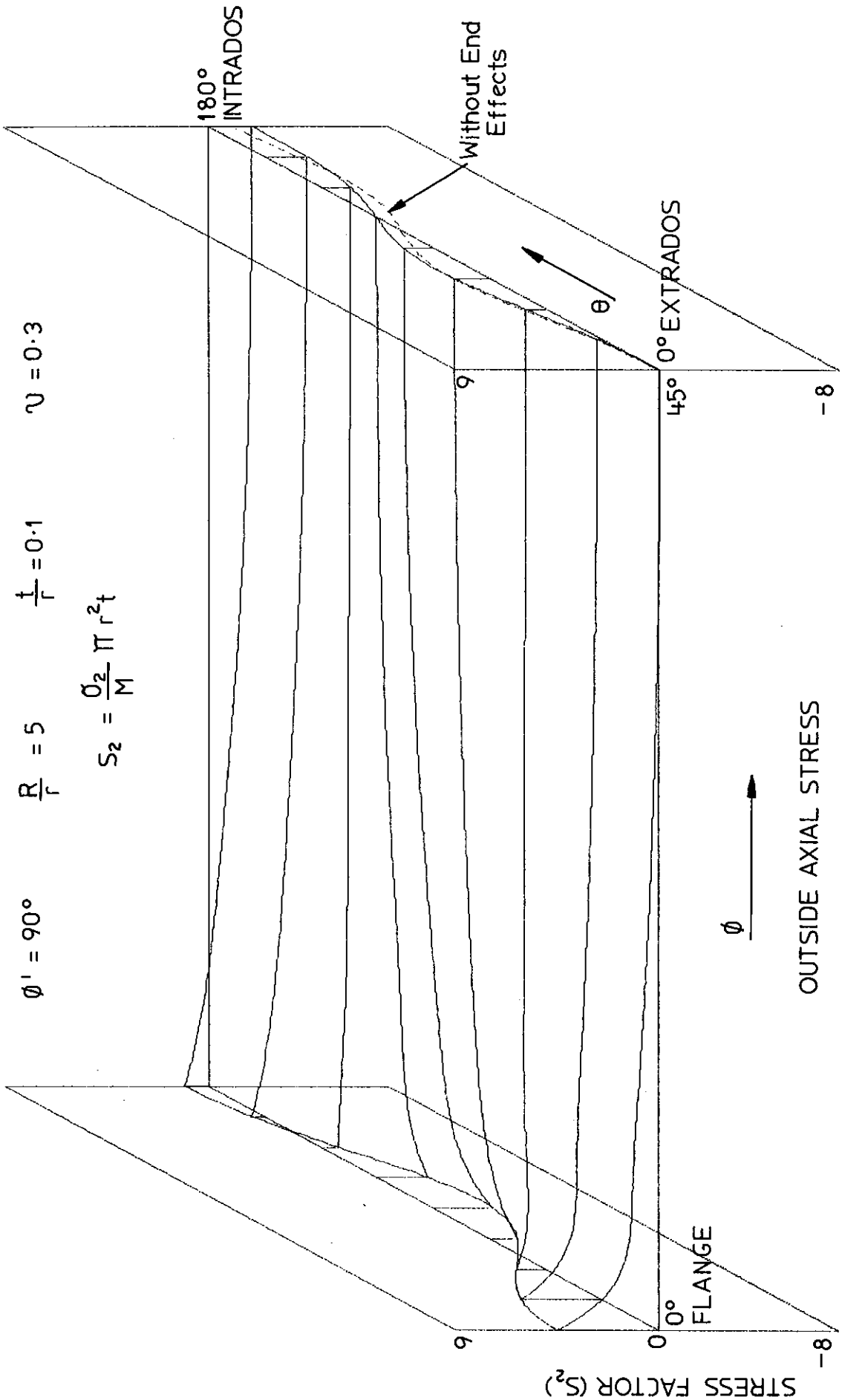
180° INTRADOS
Without End Effects
0° EXTRADOS
θ
9
45°
-8
φ' = 90°
R/r = 5
t/r = 0·1
υ = 0·3
S2 = σ2/M π r²t
φ
OUTSIDE AXIAL STRESS
STRESS FACTOR (S2)
9
0
-8
0° FLANGE

FIGURE A24

TABLE A23

R/r = 5.0 t/r = 0.10

OUTSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.3134	-0.0196	-0.4273	-0.8248	-1.2391	-1.6299	-1.9573	-2.1993	-2.3465	-2.3958	-2.1632
157.5	0.1780	-0.1195	-0.4593	-0.7478	-1.0221	-1.2717	-1.4786	-1.6316	-1.7251	-1.7565	-1.8049
135.0	-0.2174	-0.2230	-0.3006	-0.3011	-0.2493	-0.1837	-0.1238	-0.0788	-0.0515	-0.0425	-0.4198
112.5	-0.6744	-0.0845	0.2035	0.4758	0.7819	1.0730	1.3190	1.5032	1.6164	1.6545	1.5639
90.0	-0.7928	0.1460	0.5751	0.8737	1.1608	1.4159	1.6260	1.7829	1.8798	1.9126	2.3883
67.5	-0.3680	0.1523	0.3978	0.5117	0.5969	0.6617	0.7104	0.7457	0.7676	0.7750	1.3368
45.0	0.3937	-0.0944	-0.1153	-0.1753	-0.2541	-0.3309	-0.3978	-0.4490	-0.4809	-0.4917	-0.3864
22.5	1.0778	-0.3719	-0.5408	-0.6612	-0.7894	-0.9019	-0.9952	-1.0653	-1.1089	-1.1237	-1.5312
-0.0	1.3465	-0.4854	-0.6894	-0.8134	-0.9422	-1.0517	-1.1411	-1.2079	-1.2493	-1.2634	-1.8737

OUTSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	1.0448	0.0538	-0.4617	-0.8831	-1.2534	-1.5393	-1.7362	-1.8587	-1.9240	-1.9443	-1.1114
157.5	0.5934	-0.3136	-0.7518	-1.0660	-1.3331	-1.5465	-1.7031	-1.8081	-1.8680	-1.8874	-1.4255
135.0	-0.7247	-0.9895	-1.1554	-1.1923	-1.2053	-1.2284	-1.2604	-1.2931	-1.3172	-1.3261	-1.6442
112.5	-2.2479	-1.1703	-0.9330	-0.6664	-0.4216	-0.2375	-0.1110	-0.0319	0.0103	0.0235	-0.7144
90.0	-2.6428	-0.6022	-0.1077	0.2853	0.6185	0.8790	1.0747	1.2113	1.2918	1.3184	0.8777
67.5	-1.2265	0.2430	0.6612	0.9170	1.1203	1.2794	1.4030	1.4930	1.5482	1.5668	1.6493
45.0	1.3125	0.8608	0.9852	0.9664	0.9467	0.9326	0.9245	0.9214	0.9209	0.9210	1.2039
22.5	3.5926	1.1444	0.9991	0.7542	0.5658	0.4257	0.3224	0.2512	0.2095	0.1957	0.3788
-0.0	4.4883	1.2147	0.9680	0.6417	0.3957	0.2142	0.0801	-0.0130	-0.0681	-0.0864	0.0116

OUTSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.0000	0.0000	0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0
157.5	-0.1734	-0.1120	-0.0176	0.0892	0.1592	0.1834	0.1691	0.1270	0.0676	0.0000	0.0
135.0	-0.3110	-0.1379	-0.0366	0.0720	0.1397	0.1640	0.1530	0.1161	0.0622	0.0000	0.0
112.5	-0.3197	-0.1033	-0.0630	-0.0272	-0.0074	0.0031	0.0080	0.0084	0.0052	0.0000	0.0
90.0	-0.1436	-0.0239	-0.0417	-0.0753	-0.0960	-0.0998	-0.0882	-0.0649	-0.0342	-0.0000	0.0
67.5	0.1180	0.1004	0.0497	-0.0211	-0.0613	-0.0776	-0.0750	-0.0581	-0.0315	-0.0000	0.0
45.0	0.2754	0.1901	0.1274	0.0517	0.0098	-0.0124	-0.0209	-0.0196	-0.0115	-0.0000	0.0
22.5	0.2191	0.1525	0.1072	0.0582	0.0314	0.0155	0.0063	0.0017	0.0001	-0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0000	0.0

TABLE A24

R/r = 5.0 t/r = 0.10

INSIDE HOOP STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	-0.2648	-0.0037	0.1560	0.5028	0.9454	1.3858	1.7650	2.0504	2.2259	2.2850	2.1553
157.5	-0.2837	0.0503	0.2342	0.4849	0.7688	1.0390	1.2687	1.4421	1.5494	1.5857	1.7682
135.0	-0.2351	0.0518	0.1560	0.1209	0.0337	-0.0679	-0.1594	-0.2277	-0.2688	-0.2823	0.2374
112.5	-0.0274	-0.1679	-0.3145	-0.6508	-1.0259	-1.3816	-1.6843	-1.9119	-2.0521	-2.0994	-1.9741
90.0	0.1927	-0.4080	-0.6992	-1.0689	-1.4137	-1.7135	-1.9607	-2.1457	-2.2603	-2.2992	-2.8760
67.5	0.2278	-0.3798	-0.5573	-0.6960	-0.7944	-0.8624	-0.9122	-0.9482	-0.9706	-0.9783	-1.6729
45.0	0.0697	-0.1213	-0.1041	0.0025	0.1112	0.2158	0.3053	0.3727	0.4144	0.4285	0.2535
22.5	-0.1301	0.1314	0.2532	0.4768	0.6595	0.8129	0.9363	1.0271	1.0829	1.1017	1.5097
-0.0	-0.2167	0.2271	0.3707	0.6187	0.8091	0.9624	1.0827	1.1703	1.2238	1.2419	1.8790

INSIDE AXIAL STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	-0.8827	-0.3111	-0.3003	-0.3074	-0.2359	-0.1250	-0.0102	0.0863	0.1497	0.1718	0.5764
157.5	-0.9456	-0.4358	-0.4197	-0.4419	-0.4161	-0.3639	-0.3067	-0.2576	-0.2247	-0.2133	0.1343
135.0	-0.7836	-0.7355	-0.6966	-0.7229	-0.7652	-0.8082	-0.8484	-0.8809	-0.9017	-0.9088	-0.8310
112.5	-0.0915	-0.9354	-0.8161	-0.7733	-0.7974	-0.8454	-0.9012	-0.9513	-0.9854	-0.9975	-1.3302
90.0	0.6422	-0.6987	-0.4750	-0.3316	-0.2699	-0.2421	-0.2340	-0.2358	-0.2400	-0.2419	-0.7305
67.5	0.7592	0.0020	0.1858	0.3356	0.4279	0.4949	0.5435	0.5766	0.5958	0.6021	0.3451
45.0	0.2323	0.8422	0.7678	0.7920	0.8113	0.8297	0.8478	0.8628	0.8728	0.8763	0.9476
22.5	-0.4336	1.4657	1.0747	0.9408	0.8543	0.7936	0.7534	0.7283	0.7147	0.7103	0.9630
-0.0	-0.7222	1.6883	1.1574	0.9546	0.8210	0.7244	0.6574	0.6134	0.5884	0.5803	0.8759

INSIDE SHEAR STRESS FACTORS

THETA	PHI=0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	WITHOUT END EFFECTS
180.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0
157.5	-0.1569	-0.4066	-0.4690	-0.4538	-0.3955	-0.3147	-0.2286	-0.1466	-0.0711	-0.0000	0.0
135.0	-0.2814	-0.6659	-0.6555	-0.5850	-0.4944	-0.3929	-0.2894	-0.1891	-0.0931	-0.0000	0.0
112.5	-0.2892	-0.5285	-0.4124	-0.3168	-0.2492	-0.1950	-0.1460	-0.0980	-0.0493	-0.0000	0.0
90.0	-0.1299	-0.0008	0.0807	0.1140	0.1131	0.0943	0.0694	0.0443	0.0213	0.0000	0.0
67.5	0.1068	0.5345	0.4619	0.3986	0.3333	0.2652	0.1971	0.1302	0.0647	0.0000	0.0
45.0	0.2492	0.7136	0.5309	0.4206	0.3357	0.2619	0.1939	0.1285	0.0641	0.0000	0.0
22.5	0.1982	0.4782	0.3306	0.2507	0.1946	0.1496	0.1101	0.0729	0.0364	0.0000	0.0
-0.0	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	0.0