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**SOLA — A Numerical Solution Algorithm for
Transient Fluid Flows
— Addendum —**

by

C. W. Hirt
B. D. Nichols
N. C. Romero

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SOLA — A NUMERICAL SOLUTION ALGORITHM FOR
TRANSIENT FLUID FLOWS

— ADDENDUM —

by

C. W. Hirt
B. D. Nichols
N. C. Romero

Several improvements have been made in the SOLA-SURF code since its publication in the report LA-5852. Principally, the pressure iteration convergence is accelerated by a modification of the equation for δp when it is chosen under the constraints imposed by rigid interior boundaries. These changes, for the text and code listing, are given below, along with the correction of two errors.

1. Page 25, column 1, line 17:

$$\frac{\partial U_n}{\partial p} = \frac{\delta t}{\delta y} \left\{ 1 + \frac{2 \delta y^2}{\delta x^2} (1-\zeta) - \frac{(HB_{i+1} - HB_{i-1}) \delta y}{4 \delta x^2} \right. \\ \left. \left[\max(0, JB_{i-1} - JB_i) - \max(0, JB_{i+1} - JB_i) \right] \right\}$$

2. Page 28, column 2, last line:

$$\frac{\partial F}{\partial p} = \kappa + (1-\zeta) \left\{ 1 + 2h \delta y^2 / \delta x^2 + \frac{(H_{i+1} - H_{i-1}) \delta y}{4 \delta x^2} \right. \\ \left. \left[\max(0, JT_i - JT_{i-1}) - \max(0, JT_i - JT_{i+1}) \right] \right\}$$

3. Page 35, line 3:

The first array listed, XPUT, should have 26 words of storage, i.e.,
XPUT (25)

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4. Page 40, line 50:

$$\begin{aligned} \text{DFDP} = & \text{DELT} * \text{RDY} * (1.0 + 2.0 * \text{VBM} * \text{DELY}^{**2} * \text{RDX}^{**2} - 0.25 * \text{RDX}^{**2} \\ & * \text{DELY} * (\text{HB}(\text{I}+1) - \text{HB}(\text{I}-1)) * (\text{AMAXO} (0, \text{JB}(\text{I}-1) - \text{JB}(\text{I})) \\ & - \text{AMAXO} (0, \text{JB}(\text{I}+1) - \text{JB}(\text{I})))) \end{aligned}$$

5. Page 40, line 55:

$$\text{F} = -0.25 * \text{RDX} * (\text{H}(\text{I}+1) - \text{H}(\text{I}-1)) * (\text{U}(\text{I}, \text{J}) + \text{U}(\text{I}-1, \text{J})) + \text{V}(\text{I}, \text{J}-1)$$

6. Page 41, line 2:

$$\begin{aligned} \text{DFDP} = & - \text{DELT} * \text{RDY} * (1.0 + 2.0 * \text{VTM} * \text{DELY}^{**2} * \text{RDX}^{**2} \\ & + 0.25 * \text{RDX}^{**2} * \text{DELY} * (\text{H}(\text{I}+1) - \text{H}(\text{I}-1)) * (\text{AMAXO} (0, \text{JT}(\text{I}) - \text{JT}(\text{I}-1)) \\ & - \text{AMAXO} (0, \text{JT}(\text{I}) - \text{JT} (\text{I}+1)))) \end{aligned}$$

7. Page 42, line 5:

GO TO 2000

These changes have been made in the SOLA-SURF deck available from the Argonne Code Center. The address is

Argonne Code Center
Argonne National Laboratory
9700 South Cass Avenue
Argonne, IL 60439

A sample test problem for SOLA-SURF and an explanation of the sub-routines used in the SOLA and SOLA-SURF codes have been written to supplement the report. The sample test problem, which gives the input parameters and output data, should be helpful in testing new SOLA-SURF codes. The subroutines are primarily used for plotting information on microfilm. Although the codes are written in FORTRAN IV and should be compatible with all computers that have a FORTRAN IV capability, the subroutines used for plotting are not compatible with the software at other computing facilities. The entire plot section of the codes can be skipped by putting the instruction GO TO 5600 immediately after statement number 5100.

SOLA-SURF SAMPLE TEST PROBLEM

B. D. Nichols

A sample test problem has been run to help test new SOLA-SURF codes. In this problem, an undular bore is generated by assigning a positive initial velocity ($UI = 0.20$) to the fluid, which runs it into the rightmost rigid wall. The fluid height, $FLHT$, is initially set to 1.0 dimensionless units. ($FLHT$ is the only parameter specified in this problem that is not an input parameter, but it is already set to 1.0 in the deck available from the Argonne Code Center and in the report, LA-5852, listing.) To insure continuous flow necessary to maintain the bore, a continuative inflow boundary is set at the left wall by the input parameter $WL = 3.0$. All other walls are free-slip ($WR = WT = WB = 1.0$).

The spatial resolution is somewhat coarse with $\bar{I} = 20$ and $\bar{J} = 8$. The undisturbed fluid is resolved vertically by 5 cells with $\delta y = 0.2$; $\delta x = 0.6$, giving a mesh length of 12. A time step of 0.2 is used, which allows about five time steps for the fluid to convect through a cell. $ALPHA$ and $GAMMA$ are set to 0.3.

A complete list of input parameters, with a free surface configuration and velocity vector plot at cycle 1, is shown in Fig. 1. The free surface configuration and velocity vector plots, at cycles 25 and 50, are shown in Fig. 2. Tables I, II, and III list computed results at cycles 1, 25, and 50.

The calculated wave form and speed agree very well with theory. The calculated depth of the fluid behind the bore, i.e., at the rightmost wall, is

1.211. The bore speed in this case is defined as the speed at which the mid point on the bore front ($h = 1.105$) is moving into the incoming fluid. The calculated bore speed, relative to still water in front of the bore, is 1.121. Equations derived from mass and momentum conservation predict the fluid depth behind the bore to be 1.209 and the bore speed to be 1.156.

This problem was run on a CDC-7600 computer and required 15 seconds of central processor time to run to a problem time of 10 (50 cycles).

Figure 1 is a line graph showing the variation of the ratio of the maximum to the minimum value of the function $f(x)$ versus the parameter α . The y-axis represents the ratio and ranges from 0.0 to 1.8 with major ticks every 0.2. The x-axis represents α and ranges from 0.0 to 1.0 with major ticks every 0.2. The curve is a horizontal line at $y=1.0$ for α from 0.0 to approximately 0.9, then rises slightly to about 1.1 at $\alpha=1.0$.

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Fig. 2. Free surface configuration and velocity vector field of the undular bore at times 4.0 (left) and 10.0 (right).

TABLE 1

ITER= 27 TIME= 2.00000E+01 CYCLE= 1 FVOL= 1.20000E+01

1	2	U	V	P	M	SUR CELL	DOT CELL
1	1	2.00000E+01	0.	0.	1.00000E+00	7	2
1	2	2.00000E+01	1.42159E+15	0.	1.00000E+00	7	2
1	3	2.00000E+01	-5.68434E+15	0.	1.00000E+00	7	2
1	4	2.00000E+01	1.42159E+15	0.	1.00000E+00	7	2
1	5	2.00000E+01	-5.68434E+15	0.	1.00000E+00	7	2
1	6	2.00000E+01	-5.68434E+15	0.	1.00000E+00	7	2
1	7	2.00000E+01	-3.00000E+01	0.	1.00000E+00	7	2
1	8	2.00000E+01	0.	0.	1.00000E+00	7	2
2	1	2.00000E+01	0.	0.	1.00000E+00	7	2
2	2	2.00000E+01	-1.55658E+13	9.00000E+01	1.00000E+00	7	2
2	3	2.00000E+01	-5.05308E+13	7.00000E+01	1.00000E+00	7	2
2	4	2.00000E+01	-7.29437E+13	5.00000E+01	1.00000E+00	7	2
2	5	2.00000E+01	-3.51755E+14	3.00000E+01	1.00000E+00	7	2
2	6	2.00000E+01	2.72195E+12	1.00000E+01	1.00000E+00	7	2
2	7	2.00000E+01	1.45340E+13	-1.00000E+01	1.00000E+00	7	2
2	8	2.00000E+01	0.	0.	1.00000E+00	7	2
3	1	2.00000E+01	0.	0.	1.00000E+00	7	2
3	2	2.00000E+01	-8.34993E+12	9.00000E+01	1.00000E+00	7	2
3	3	2.00000E+01	-1.51073E+11	7.00000E+01	1.00000E+00	7	2
3	4	2.00000E+01	-1.04648E+11	5.00000E+01	1.00000E+00	7	2
3	5	2.00000E+01	9.06347E+12	3.00000E+01	1.00000E+00	7	2
3	6	2.00000E+01	5.19035E+11	1.00000E+01	1.00000E+00	7	2
3	7	2.00000E+01	2.47537E+11	-1.00000E+01	1.00000E+00	7	2
3	8	2.00000E+01	0.	0.	1.00000E+00	7	2
4	1	2.00000E+01	0.	0.	1.00000E+00	7	2
4	2	2.00000E+01	-1.51000E+10	9.00000E+01	1.00000E+00	7	2
4	3	2.00000E+01	-1.62691E+10	7.00000E+01	1.00000E+00	7	2
4	4	2.00000E+01	-6.14083E+11	5.00000E+01	1.00000E+00	7	2
4	5	2.00000E+01	1.95421E+10	3.00000E+01	1.00000E+00	7	2
4	6	2.00000E+01	5.89747E+10	1.00000E+01	1.00000E+00	7	2
4	7	2.00000E+01	3.99724E+10	-1.00000E+01	1.00000E+00	7	2
4	8	2.00000E+01	0.	0.	1.00000E+00	7	2
5	1	2.00000E+01	0.	0.	1.00000E+00	7	2
5	2	2.00000E+01	-1.50598E+09	9.00000E+01	1.00000E+00	7	2
5	3	2.00000E+01	-1.12704E+09	7.00000E+01	1.00000E+00	7	2
5	4	2.00000E+01	1.17931E+10	5.00000E+01	1.00000E+00	7	2
5	5	2.00000E+01	2.14822E+09	3.00000E+01	1.00000E+00	7	2
5	6	2.00000E+01	4.54812E+09	1.00000E+01	1.00000E+00	7	2
5	7	2.00000E+01	3.57364E+09	-1.00000E+01	1.00000E+00	7	2
5	8	2.00000E+01	0.	0.	1.00000E+00	7	2
6	1	2.00000E+01	0.	0.	1.00000E+00	7	2
6	2	2.00000E+01	-9.27099E+09	9.00000E+01	1.00000E+00	7	2
6	3	2.00000E+01	-4.27401E+09	7.00000E+01	1.00000E+00	7	2
6	4	2.00000E+01	4.46547E+09	5.00000E+01	1.00000E+00	7	2
6	5	2.00000E+01	1.56083E+08	3.00000E+01	1.00000E+00	7	2
6	6	2.00000E+01	2.60092E+08	1.00000E+01	1.00000E+00	7	2
6	7	2.00000E+01	2.20244E+08	-1.00000E+01	1.00000E+00	7	2
6	8	2.00000E+01	0.	0.	1.00000E+00	7	2
7	1	2.00000E+01	0.	0.	1.00000E+00	7	2
7	2	2.00000E+01	-3.77967E+08	9.00000E+01	1.00000E+00	7	2
7	3	2.00000E+01	-5.45520E+09	7.00000E+01	1.00000E+00	7	2
7	4	2.00000E+01	3.71928E+08	5.00000E+01	1.00000E+00	7	2
7	5	2.00000E+01	8.17456E+08	3.00000E+01	1.00000E+00	7	2
7	6	2.00000E+01	1.19197E+07	1.00000E+01	1.00000E+00	7	2
7	7	2.00000E+01	1.05326E+07	-1.00000E+01	1.00000E+00	7	2
7	8	2.00000E+01	0.	0.	1.00000E+00	7	2
8	1	1.99999E+01	0.	0.	1.00000E+00	7	2
8	2	1.99999E+01	-1.08714E+07	9.00000E+01	1.00000E+00	7	2
8	3	1.99999E+01	3.71334E+08	7.00000E+01	1.00000E+00	7	2
8	4	1.99999E+01	2.00000E+07	5.00000E+01	1.00000E+00	7	2

0	5	2.00000E-01	3.51407E-07	3.00001E-01	1.00000E+00	7	2
0	6	2.00000E-01	4.62062E-07	1.00000E-01	1.00000E+00	7	2
0	7	2.00000E-01	4.18927E-07	-1.00000E-01	1.00000E+00	7	2
0	8	2.00000E-01	0.	0.	1.00000E+00	7	2
0	1	1.99997E-01	0.	0.	1.00000E+00	7	2
0	2	1.99997E-01	-2.19763E-07	0.00003E-01	1.00000E+00	7	2
0	3	1.99997E-01	3.16188E-07	7.00003E-01	1.00000E+00	7	2
0	4	1.99998E-01	8.47576E-07	5.00003E-01	1.00000E+00	7	2
0	5	1.99998E-01	1.28827E-06	3.00002E-01	1.00000E+00	7	2
0	6	1.99999E-01	1.58136E-06	1.00001E-01	1.00000E+00	7	2
0	7	2.00001E-01	1.43991E-06	-1.00001E-01	1.00000E+00	7	2
0	8	2.00001E-01	0.	0.	1.00000E+00	7	2
10	1	1.99992E-01	0.	0.	1.00000E+00	7	2
10	2	1.99992E-01	-1.47319E-07	9.00001E-01	1.00000E+00	7	2
10	3	1.99992E-01	1.51565E-06	7.00001E-01	1.00000E+00	7	2
10	4	1.99993E-01	3.01639E-06	5.00001E-01	1.00000E+00	7	2
10	5	1.99996E-01	4.22217E-06	3.00000E-01	1.00000E+00	7	2
10	6	1.99998E-01	4.86685E-06	1.00002E-01	1.00000E+00	7	2
10	7	2.00002E-01	4.55384E-06	-1.00002E-01	1.00000E+00	7	2
10	8	2.00002E-01	0.	0.	1.00000E+00	7	2
11	1	1.99977E-01	0.	0.	1.00000E+00	7	2
11	2	1.99977E-01	9.98209E-07	9.00003E-01	1.00000E+00	7	2
11	3	1.99978E-01	5.32443E-06	7.00003E-01	1.00000E+00	7	2
11	4	1.99980E-01	9.68078E-06	5.00002E-01	1.00000E+00	7	2
11	5	1.99988E-01	1.25372E-05	3.00002E-01	1.00000E+00	7	2
11	6	1.99996E-01	1.41888E-05	1.00007E-01	1.00000E+00	7	2
11	7	2.00004E-01	1.33597E-05	-1.00007E-01	1.00000E+00	7	2
11	8	2.00004E-01	0.	0.	1.00000E+00	7	2
12	1	1.99937E-01	0.	0.	1.00000E+00	7	2
12	2	1.99937E-01	5.45289E-06	9.00000E-01	1.00000E+00	7	2
12	3	1.99942E-01	1.81143E-05	7.00001E-01	1.00000E+00	7	2
12	4	1.99953E-01	2.78616E-05	5.00003E-01	1.00000E+00	7	2
12	5	1.99970E-01	3.55681E-05	3.00005E-01	1.00000E+00	7	2
12	6	1.99989E-01	3.83697E-05	1.00009E-01	1.00000E+00	7	2
12	7	2.00011E-01	3.61355E-05	-1.00009E-01	1.00000E+00	7	2
12	8	2.00011E-01	0.	0.	1.00000E+00	7	2
13	1	1.99837E-01	0.	0.	1.00000E+00	7	2
13	2	1.99837E-01	2.20732E-05	9.00296E-01	1.00000E+00	7	2
13	3	1.99850E-01	5.09170E-05	7.00274E-01	1.00000E+00	7	2
13	4	1.99882E-01	7.84000E-05	5.00223E-01	1.00000E+00	7	2
13	5	1.99922E-01	9.35395E-05	3.00145E-01	1.00000E+00	7	2
13	6	1.99974E-01	1.02768E-04	1.00091E-01	1.00000E+00	7	2
13	7	2.00026E-01	9.77522E-05	-1.00091E-01	1.00000E+00	7	2
13	8	2.00026E-01	0.	0.	1.00000E+00	7	2
14	1	1.99582E-01	0.	0.	1.00000E+00	7	2
14	2	1.99582E-01	6.12027E-05	9.00786E-01	1.00000E+00	7	2
14	3	1.99626E-01	1.45819E-04	7.00724E-01	1.00000E+00	7	2
14	4	1.99698E-01	2.00006E-04	5.00579E-01	1.00000E+00	7	2
14	5	1.99809E-01	2.48724E-04	3.00378E-01	1.00000E+00	7	2
14	6	1.99932E-01	2.58344E-04	1.00129E-01	1.00000E+00	7	2
14	7	2.00068E-01	2.44158E-04	-1.00129E-01	1.00000E+00	7	2
14	8	2.00068E-01	0.	0.	1.00000E+00	7	2
15	1	1.98964E-01	0.	0.	1.00000E+00	7	2
15	2	1.98964E-01	1.92832E-04	9.00204E-01	1.00000E+00	7	2
15	3	1.99053E-01	3.62373E-04	7.001847E-01	1.00000E+00	7	2
15	4	1.99257E-01	5.34888E-04	5.001485E-01	1.00000E+00	7	2
15	5	1.99514E-01	6.15654E-04	3.00053E-01	1.00000E+00	7	2
15	6	1.99888E-01	6.69269E-04	1.00035E-01	1.00000E+00	7	2
15	7	2.00167E-01	6.38203E-04	-1.00035E-01	1.00000E+00	7	2
15	8	2.00167E-01	0.	0.	1.00000E+00	7	2
16	1	1.97396E-01	0.	0.	1.00000E+00	7	2
16	2	1.97396E-01	4.57672E-04	9.005117E-01	1.00000E+00	7	2
16	3	1.97671E-01	9.74891E-04	7.004889E-01	1.00000E+00	7	2
16	4	1.98132E-01	1.30637E-03	5.003713E-01	1.00000E+00	7	2

16	5	1.98814E-01	1.58798E-03	3.02408E-03	1.00033E+00	7	2
16	6	1.99381E-01	1.63957E-03	1.00827E-03	1.00033E+00	7	2
16	7	2.00481E-01	1.99399E-03	-1.00827E-03	1.00033E+00	7	2
16	8	2.00481E-01	0.	0.	1.00033E+00	7	2
17	1	1.99380E-01	0.	0.	1.00033E+00	7	2
17	2	1.99380E-01	1.28126E-03	9.12998E-01	1.00033E+00	7	2
17	3	1.99176E-01	2.39796E-03	7.11677E-01	1.00033E+00	7	2
17	4	1.99397E-01	3.39313E-03	5.09319E-01	1.00033E+00	7	2
17	5	1.97019E-01	3.88746E-03	3.53864E-01	1.00033E+00	7	2
17	6	1.96986E-01	4.15333E-03	1.02077E-01	1.00033E+00	7	2
17	7	2.01014E-01	3.99517E-03	-1.02017E-01	1.00033E+00	7	2
17	8	2.01014E-01	0.	0.	1.00033E+00	7	2
18	1	1.84087E-01	0.	0.	1.00209E+00	7	2
18	2	1.84087E-01	3.04589E-03	9.32193E-01	1.00209E+00	7	2
18	3	1.85636E-01	6.02147E-03	7.29149E-01	1.00209E+00	7	2
18	4	1.88517E-01	8.22044E-03	5.25128E-01	1.00209E+00	7	2
18	5	1.92674E-01	9.78795E-03	3.14907E-01	1.00209E+00	7	2
18	6	1.97429E-01	1.02394E-02	1.05127E-01	1.00209E+00	7	2
18	7	2.02971E-01	9.72069E-03	-1.05127E-01	1.00209E+00	7	2
18	8	2.02971E-01	0.	0.	1.00209E+00	7	2
19	1	1.61059E-01	0.	0.	1.00513E+00	7	2
19	2	1.61059E-01	7.69315E-03	9.79934E-01	1.00513E+00	7	2
19	3	1.64446E-01	1.46433E-02	7.72241E-01	1.00513E+00	7	2
19	4	1.71243E-01	2.05029E-02	5.57998E-01	1.00513E+00	7	2
19	5	1.81174E-01	2.42638E-02	3.37099E-01	1.00513E+00	7	2
19	6	1.93442E-01	2.58630E-02	1.12831E-01	1.00513E+00	7	2
19	7	2.06558E-01	2.43339E-02	-1.12831E-01	1.00513E+00	7	2
19	8	2.06558E-01	0.	0.	1.00513E+00	7	2
20	1	1.07203E-01	0.	0.	1.01300E+00	7	2
20	2	1.07203E-01	1.78530E-02	1.08676E+00	1.01300E+00	7	2
20	3	1.13144E-01	3.50339E-02	8.78903E-01	1.01300E+00	7	2
20	4	1.29932E-01	9.00806E-02	6.43869E-01	1.01300E+00	7	2
20	5	1.47699E-01	6.12784E-02	3.93784E-01	1.01300E+00	7	2
20	6	1.82147E-01	6.90104E-02	1.32509E-01	1.01300E+00	7	2
20	7	2.29186E-01	5.74673E-02	-1.32509E-01	1.01300E+00	7	2
20	8	2.29186E-01	0.	0.	1.01300E+00	7	2
21	1	0.	0.	0.	1.04507E+00	7	2
21	2	0.	3.96772E-02	1.40213E+00	1.04507E+00	7	2
21	3	0.	7.33977E-02	1.18647E+00	1.04507E+00	7	2
21	4	0.	1.19386E-01	8.93073E-01	1.04507E+00	7	2
21	5	0.	1.64623E-01	5.77687E-01	1.04507E+00	7	2
21	6	0.	2.29351E-01	2.13064E-01	1.04507E+00	7	2
21	7	0.	3.01747E-01	-2.13064E-01	1.04507E+00	7	2
21	8	0.	0.	0.	1.04507E+00	7	2
22	1	0.	0.	0.	1.08000E+00	7	2
22	2	0.	3.96772E-02	0.	1.08000E+00	7	2
22	3	0.	7.33977E-02	0.	1.08000E+00	7	2
22	4	0.	1.19386E-01	0.	1.08000E+00	7	2
22	5	0.	1.64623E-01	0.	1.08000E+00	7	2
22	6	0.	2.29351E-01	0.	1.08000E+00	7	2
22	7	0.	3.01722E-01	0.	1.08000E+00	7	2
22	8	0.	0.	0.	1.08000E+00	7	2

TABLE II

ITER= 16		TIME= 5.00000E+00	CYCLE= 25		FVOL= 1.330415E+01			
I	J	U	V	P	M	SUR CELL	DOT CELL	
1	1	1.99872E-01	0.	0.	1.00000E+00	7	2	
1	2	1.99872E-01	1.15005E-06	0.	1.00000E+00	7	2	
1	3	1.99878E-01	3.03370E-06	0.	1.00000E+00	7	2	
1	4	1.99891E-01	4.64934E-06	0.	1.00000E+00	7	2	
1	5	1.99911E-01	6.25739E-06	0.	1.00000E+00	7	2	
1	6	1.99935E-01	7.47980E-06	0.	1.00000E+00	7	2	
1	7	1.99964E-01	-3.13580E-01	0.	1.00000E+00	7	2	
1	8	1.99972E-01	0.	0.	1.00000E+00	7	2	
2	1	1.99865E-01	0.	0.	1.00000E+00	7	2	
2	2	1.99865E-01	1.53943E-06	9.00011E-01	1.00000E+00	7	2	
2	3	1.99872E-01	3.64788E-06	7.00011E-01	1.00000E+00	7	2	
2	4	1.99886E-01	5.47250E-06	5.00009E-01	1.00000E+00	7	2	
2	5	1.99906E-01	7.20808E-06	3.00007E-01	1.00000E+00	7	2	
2	6	1.99931E-01	8.53388E-06	1.00005E-01	1.00000E+00	7	2	
2	7	1.99962E-01	9.42829E-06	-9.99986E-02	1.00000E+00	7	2	
2	8	1.99962E-01	0.	0.	1.00000E+00	7	2	
3	1	1.99802E-01	0.	0.	1.00006E+00	7	2	
3	2	1.99802E-01	1.97074E-05	9.00111E-01	1.00006E+00	7	2	
3	3	1.99811E-01	3.99595E-05	7.00105E-01	1.00006E+00	7	2	
3	4	1.99830E-01	5.84843E-05	5.00095E-01	1.00006E+00	7	2	
3	5	1.99858E-01	7.46159E-05	3.00079E-01	1.00006E+00	7	2	
3	6	1.99893E-01	8.76550E-05	1.00058E-01	1.00006E+00	7	2	
3	7	1.99934E-01	9.69716E-05	-9.99656E-02	1.00006E+00	7	2	
3	8	1.99934E-01	0.	0.	1.00006E+00	7	2	
4	1	1.99651E-01	0.	0.	1.00015E+00	7	2	
4	2	1.99651E-01	4.83578E-05	9.00261E-01	1.00015E+00	7	2	
4	3	1.99666E-01	9.64780E-05	7.00249E-01	1.00015E+00	7	2	
4	4	1.99698E-01	1.41011E-04	5.00225E-01	1.00015E+00	7	2	
4	5	1.99746E-01	1.78411E-04	3.00190E-01	1.00015E+00	7	2	
4	6	1.99806E-01	2.08053E-04	1.00149E-01	1.00015E+00	7	2	
4	7	1.99877E-01	2.26933E-04	-9.99076E-02	1.00015E+00	7	2	
4	8	1.99877E-01	0.	0.	1.00015E+00	7	2	
5	1	1.99346E-01	0.	0.	1.00032E+00	7	2	
5	2	1.99346E-01	9.77822E-05	9.00526E-01	1.00032E+00	7	2	
5	3	1.99374E-01	1.93931E-04	7.00505E-01	1.00032E+00	7	2	
5	4	1.99432E-01	2.83981E-04	5.00456E-01	1.00032E+00	7	2	
5	5	1.99519E-01	3.59232E-04	3.00388E-01	1.00032E+00	7	2	
5	6	1.99628E-01	4.19992E-04	1.00301E-01	1.00032E+00	7	2	
5	7	1.99758E-01	4.59564E-04	-9.98018E-02	1.00032E+00	7	2	
5	8	1.99758E-01	0.	0.	1.00032E+00	7	2	
6	1	1.98766E-01	0.	0.	1.00064E+00	7	2	
6	2	1.98766E-01	1.87287E-04	9.01010E-01	1.00064E+00	7	2	
6	3	1.98817E-01	3.70578E-04	7.00967E-01	1.00064E+00	7	2	
6	4	1.98921E-01	5.43574E-04	5.00882E-01	1.00064E+00	7	2	
6	5	1.99080E-01	6.88764E-04	3.00755E-01	1.00064E+00	7	2	
6	6	1.99279E-01	8.07940E-04	1.00593E-01	1.00064E+00	7	2	
6	7	1.99518E-01	8.87969E-04	-9.95983E-02	1.00064E+00	7	2	
6	8	1.99518E-01	0.	0.	1.00064E+00	7	2	
7	1	1.97686E-01	0.	0.	1.00123E+00	7	2	
7	2	1.97686E-01	3.49856E-04	9.01900E-01	1.00123E+00	7	2	
7	3	1.97777E-01	6.91724E-04	7.01822E-01	1.00123E+00	7	2	
7	4	1.97965E-01	1.01804E-03	5.01667E-01	1.00123E+00	7	2	
7	5	1.98250E-01	1.29076E-03	3.01438E-01	1.00123E+00	7	2	
7	6	1.98609E-01	1.51923E-03	1.01145E-01	1.00123E+00	7	2	
7	7	1.99042E-01	1.67791E-03	-9.92030E-02	1.00123E+00	7	2	
7	8	1.99042E-01	0.	0.	1.00123E+00	7	2	
8	1	1.95713E-01	0.	0.	1.00235E+00	7	2	
8	2	1.95713E-01	6.41063E-04	9.03514E-01	1.00235E+00	7	2	
8	3	1.95872E-01	1.26794E-03	7.03377E-01	1.00235E+00	7	2	
8	4	1.96202E-01	1.86461E-03	5.03104E-01	1.00235E+00	7	2	

8	5	7.96704E-01	2.57663E-03	3.02700E-01	1.00235E+00	7	2
8	6	1.97339E-01	2.80809E-03	1.02181E-01	1.00235E+00	7	2
8	7	1.98110E-01	3.11869E-03	-9.84391E-02	1.00235E+00	7	2
8	8	1.98110E-01	0.	0.	1.00235E+00	7	2
9	1	1.92180E-01	0.	0.	1.00442E+00	7	2
9	2	1.92180E-01	1.15084E-03	9.06398E-01	1.00442E+00	7	2
9	3	1.92449E-01	2.28040E-03	7.06164E-01	1.00442E+00	7	2
9	4	1.93013E-01	3.35660E-03	5.05694E-01	1.00442E+00	7	2
9	5	1.93870E-01	4.29796E-03	3.05000E-01	1.00442E+00	7	2
9	6	1.94966E-01	5.10010E-03	1.04101E-01	1.00442E+00	7	2
9	7	1.96306E-01	5.70166E-03	-9.69777E-02	1.00442E+00	7	2
9	8	1.96306E-01	0.	0.	1.00442E+00	7	2
10	1	1.86004E-01	0.	0.	1.00820E+00	7	2
10	2	1.86004E-01	2.01471E-03	9.11440E-01	1.00820E+00	7	2
10	3	1.86438E-01	4.00856E-03	7.11053E-01	1.00820E+00	7	2
10	4	1.87364E-01	5.90480E-03	5.10272E-01	1.00820E+00	7	2
10	5	1.88768E-01	7.60782E-03	3.09118E-01	1.00820E+00	7	2
10	6	1.90589E-01	9.07614E-03	1.07609E-01	1.00820E+00	7	2
10	7	1.92846E-01	1.02293E-02	-9.42149E-02	1.00820E+00	7	2
10	8	1.92846E-01	0.	0.	1.00820E+00	7	2
11	1	1.75534E-01	0.	0.	1.01497E+00	7	2
11	2	1.75534E-01	3.41624E-03	9.20009E-01	1.01497E+00	7	2
11	3	1.76193E-01	6.83696E-03	7.19402E-01	1.01497E+00	7	2
11	4	1.77621E-01	1.00890E-02	5.18167E-01	1.01497E+00	7	2
11	5	1.79790E-01	1.30971E-02	3.16331E-01	1.01497E+00	7	2
11	6	1.82650E-01	1.57473E-02	1.13907E-01	1.01497E+00	7	2
11	7	1.86287E-01	1.79337E-02	-8.90634E-02	1.01497E+00	7	2
11	8	1.86287E-01	0.	0.	1.01497E+00	7	2
12	1	1.58527E-01	0.	0.	1.02679E+00	7	2
12	2	1.58527E-01	5.56424E-03	9.34041E-01	1.02679E+00	7	2
12	3	1.59428E-01	1.11728E-02	7.33149E-01	1.02679E+00	7	2
12	4	1.61427E-01	1.65740E-02	5.31337E-01	1.02679E+00	7	2
12	5	1.64468E-01	2.17003E-02	3.28606E-01	1.02679E+00	7	2
12	6	1.68578E-01	2.64000E-02	1.24956E-01	1.02679E+00	7	2
12	7	1.74032E-01	3.04850E-02	-7.96106E-02	1.02679E+00	7	2
12	8	1.74032E-01	0.	0.	1.02679E+00	7	2
13	1	1.32527E-01	0.	0.	1.04682E+00	7	2
13	2	1.32527E-01	8.54113E-03	9.55834E-01	1.04682E+00	7	2
13	3	1.33541E-01	1.71881E-02	7.54669E-01	1.04682E+00	7	2
13	4	1.35884E-01	2.57129E-02	5.52298E-01	1.04682E+00	7	2
13	5	1.39507E-01	3.40486E-02	3.48662E-01	1.04682E+00	7	2
13	6	1.44546E-01	4.20755E-02	1.45898E-01	1.04682E+00	7	2
13	7	1.51772E-01	6.94956E-02	-6.26841E-02	1.04682E+00	7	2
13	8	1.51772E-01	0.	0.	1.04682E+00	7	2
14	1	9.61646E-02	0.	0.	1.07933E+00	7	2
14	2	9.61646E-02	1.19888E-02	9.87202E-01	1.07933E+00	7	2
14	3	9.68954E-02	2.42189E-02	7.85982E-01	1.07933E+00	7	2
14	4	9.87628E-02	3.66092E-02	5.83449E-01	1.07933E+00	7	2
14	5	1.01768E-01	4.92029E-02	3.79474E-01	1.07933E+00	7	2
14	6	1.06118E-01	6.20285E-02	1.73867E-01	1.07933E+00	7	2
14	7	1.13569E-01	7.47626E-02	-3.36602E-02	1.07933E+00	7	2
14	8	1.13569E-01	0.	0.	1.07933E+00	7	2
15	1	3.17485E-02	0.	0.	1.12875E+00	7	2
15	2	3.17485E-02	1.46759E-02	1.02762E+00	1.12875E+00	7	2
15	3	3.14788E-02	2.98278E-02	8.26849E-01	1.12875E+00	7	2
15	4	3.13632E-02	4.56414E-02	6.25194E-01	1.12875E+00	7	2
15	5	3.13471E-02	6.24502E-02	4.22445E-01	1.12875E+00	7	2
15	6	3.15937E-02	8.06387E-02	2.18282E-01	1.12875E+00	7	2
15	7	3.48691E-02	1.00209E-01	1.22238E-02	1.12875E+00	7	2
15	8	3.48691E-02	0.	0.	1.12875E+00	7	2
16	1	8.15642E-03	0.	0.	1.19553E+00	7	2
16	2	8.15642E-03	1.44195E-02	1.07170E+00	1.19553E+00	7	2
16	3	6.27429E-03	2.94930E-02	8.72112E-01	1.19553E+00	7	2
16	4	2.76856E-03	4.57066E-02	6.72811E-01	1.19553E+00	7	2

16	5	-2.34179E-03	6.36939E-02	4.73687E-01	1.19553E+00	7	2
16	6	-1.03194E-02	8.43438E-02	2.74471E-01	1.19553E+00	7	2
16	7	-1.78181E-02	1.08575E-01	7.47371E-02	1.19553E+00	7	2
16	8	-1.78181E-02	0.	0.	1.19553E+00	7	2
17	1	-1.99158E-02	0.	0.	1.26371E+00	8	2
17	2	-1.99158E-02	9.25868E-03	1.10861E+00	1.26371E+00	8	2
17	3	-2.29720E-02	1.90303E-02	9.10392E-01	1.26371E+00	8	2
17	4	-2.90242E-02	2.96358E-02	7.14129E-01	1.26371E+00	8	2
17	5	-3.86121E-02	4.16703E-02	5.19796E-01	1.26371E+00	8	2
17	6	-5.32499E-02	5.59861E-02	3.27636E-01	1.26371E+00	8	2
17	7	-7.20587E-02	7.40753E-02	1.37714E-01	1.26371E+00	8	2
17	8	-8.48708E-02	9.64262E-02	-4.96952E-02	1.26371E+00	8	2
17	9	-8.48708E-02	0.	0.	1.26371E+00	8	2
18	1	-2.18433E-02	0.	0.	1.28463E+00	8	2
18	2	-2.18433E-02	5.76397E-04	1.12652E+00	1.28463E+00	8	2
18	3	-2.39936E-02	9.33879E-04	9.28812E-01	1.28463E+00	8	2
18	4	-2.83104E-02	6.97768E-04	7.33594E-01	1.28463E+00	8	2
18	5	-3.52669E-02	-4.08810E-04	5.41198E-01	1.28463E+00	8	2
18	6	-4.66750E-02	-2.59758E-03	3.52492E-01	1.28463E+00	8	2
18	7	-6.16687E-02	-6.05082E-03	1.67359E-01	1.28463E+00	8	2
18	8	-6.45909E-02	-1.28108E-02	-1.18624E-02	1.28463E+00	8	2
18	9	-6.45909E-02	0.	0.	1.28463E+00	8	2
19	1	-5.40643E-03	0.	0.	1.22724E+00	8	2
19	2	-5.40643E-03	-5.50587E-03	1.12329E+00	1.22724E+00	8	2
19	3	-4.66233E-03	-1.19502E-02	9.24196E-01	1.22724E+00	8	2
19	4	-2.76808E-03	-2.04590E-02	7.26143E-01	1.22724E+00	8	2
19	5	8.46608E-04	-3.24952E-02	5.29158E-01	1.22724E+00	8	2
19	6	6.22297E-03	-5.01255E-02	3.33370E-01	1.22724E+00	8	2
19	7	1.93403E-02	-7.71248E-02	1.38924E-01	1.22724E+00	8	2
19	8	1.93403E-02	-1.05102E-01	-5.35737E-02	1.22724E+00	8	2
19	9	1.93403E-02	0.	0.	1.22724E+00	8	2
20	1	3.61598E-03	0.	0.	1.17371E+00	7	2
20	2	3.61598E-03	-2.97356E-03	1.11100E+00	1.17371E+00	7	2
20	3	4.91706E-03	-6.23779E-03	9.09958E-01	1.17371E+00	7	2
20	4	7.99015E-03	-9.77062E-03	7.07690E-01	1.17371E+00	7	2
20	5	1.30771E-02	-1.38702E-02	5.03400E-01	1.17371E+00	7	2
20	6	1.96371E-02	-1.84002E-02	2.95920E-01	1.17371E+00	7	2
20	7	3.25888E-02	-2.28164E-02	8.29335E-02	1.17371E+00	7	2
20	8	3.25888E-02	-9.43171E-02	-8.98021E-02	1.17371E+00	7	2
21	1	0.	0.	0.	1.21035E+00	8	2
21	2	0.	1.08139E-03	1.10735E+00	1.21035E+00	8	2
21	3	0.	2.95773E-03	9.07056E-01	1.21035E+00	8	2
21	4	0.	5.38656E-03	7.06104E-01	1.21035E+00	8	2
21	5	0.	9.97398E-03	5.03328E-01	1.21035E+00	8	2
21	6	0.	1.63674E-02	3.04329E-01	1.21035E+00	8	2
21	7	0.	2.74447E-02	1.04142E-01	1.21035E+00	8	2
21	8	0.	3.83077E-02	-9.44040E-02	1.21035E+00	8	2
21	9	0.	0.	0.	1.21035E+00	8	2
22	1	0.	0.	0.	1.00000E+00	8	2
22	2	0.	1.08139E-03	0.	1.00000E+00	8	2
22	3	0.	2.95773E-03	0.	1.00000E+00	8	2
22	4	0.	5.38656E-03	0.	1.00000E+00	8	2
22	5	0.	9.97398E-03	0.	1.00000E+00	8	2
22	6	0.	1.63674E-02	0.	1.00000E+00	8	2
22	7	0.	2.74447E-02	0.	1.00000E+00	8	2
22	8	0.	3.79689E-02	0.	1.00000E+00	8	2
22	9	0.	0.	0.	1.00000E+00	8	2

TABLE III

FVOL = 1.00000E+01

CYCLE = 50

TIME = 1.00000E+01

ITEM	J	U	A	P	M	SUM CELL	NOT CELL
1	1	1.75299E-01	0.	0.	1.00000E+00		
1	1	1.75299E-01	1.40600E-04	0.	1.00000E+00		
1	3	1.67024E-01	3.14636E-04	0.	1.00000E+00		
1	4	1.77912E-01	4.75926E-04	0.	1.00000E+00		
1	5	1.79746E-01	6.54137E-04	0.	1.00000E+00		
1	6	1.82719E-01	7.77604E-04	0.	1.00000E+00		
1	7	1.86466E-01	-3.12331E-01	0.	1.00000E+00		
2	1	1.74772E-01	0.	0.	1.00000E+00		
2	2	1.74772E-01	1.75376E-04	9.00770E-01	1.00000E+00		
2	3	1.75502E-01	3.49499E-04	7.00707E-01	1.00000E+00		
2	4	1.77007E-01	5.17505E-04	5.00505E-01	1.00000E+00		
2	5	1.79265E-01	6.7767E-04	3.00407E-01	1.00000E+00		
2	6	1.82274E-01	8.26215E-04	1.00179E-01	1.00000E+00		
2	7	1.86071E-01	9.50694E-04	-1.00111E-01	1.00000E+00		
3	1	1.80433E-01	0.	0.	1.00000E+00		
3	2	1.74772E-01	0.	0.	1.00000E+00		
3	3	1.60666E-01	0.	0.	1.00000E+00		
3	4	1.60666E-01	1.96784E-03	9.12619E-01	1.00000E+00		
3	5	1.60666E-01	1.96784E-03	9.12619E-01	1.00000E+00		
3	6	1.60666E-01	0.	0.	1.00000E+00		
3	7	1.79963E-01	0.	0.	1.00000E+00		
4	1	1.56314E-01	0.	0.	1.00000E+00		
4	2	1.56314E-01	4.18429E-03	9.27942E-01	1.00000E+00		
4	3	1.57373E-01	6.53790E-03	7.27276E-01	1.00000E+00		
4	4	1.56905E-01	1.24150E-02	5.25909E-01	1.00000E+00		
4	5	1.61556E-01	1.63527E-02	3.24071E-01	1.00000E+00		
4	6	1.65092E-01	2.00990E-02	1.21522E-01	1.00000E+00		
4	7	1.6974E-01	2.55274E-02	-9.16612E-02	1.00000E+00		
5	1	1.69677E-01	0.	0.	1.00000E+00		
5	2	1.35450E-01	0.	0.	1.00000E+00		
5	3	1.35450E-01	6.82106E-03	9.48415E-01	1.00000E+00		
5	4	1.36616E-01	1.56129E-02	7.47401E-01	1.00000E+00		
5	5	1.38732E-01	2.03272E-02	5.4961E-01	1.00000E+00		
5	6	1.41823E-01	2.69047E-02	3.42930E-01	1.00000E+00		
5	7	1.45860E-01	3.32753E-02	1.39292E-01	1.00000E+00		
6	1	1.51726E-01	5.92590E-02	-6.54145E-02	1.00000E+00		
6	2	1.51726E-01	0.	0.	1.00000E+00		
6	3	1.06445E-01	0.	0.	1.00000E+00		
6	4	1.06445E-01	9.80036E-03	9.76115E-01	1.00000E+00		
6	5	1.06445E-01	1.96306E-02	7.75022E-01	1.00000E+00		
6	6	1.06356E-01	2.99010E-02	5.72260E-01	1.00000E+00		
6	7	1.06356E-01	3.94765E-02	3.69469E-01	1.00000E+00		
6	8	1.16166E-01	4.93362E-02	1.65063E-01	1.00000E+00		
6	9	1.22463E-01	5.90925E-02	-4.07743E-02	1.00000E+00		
7	1	1.22463E-01	0.	0.	1.00000E+00		
7	2	6.87127E-02	0.	0.	1.00000E+00		
7	3	6.87127E-02	1.25833E-02	1.01169E+00	1.00000E+00		
7	4	6.90725E-02	2.53093E-02	8.10703E-01	1.00000E+00		
7	5	7.00710E-02	3.83401E-02	6.06749E-01	1.00000E+00		
7	6	7.17424E-02	5.17920E-02	4.05766E-01	1.00000E+00		
7	7	7.41136E-02	6.58174E-02	2.01399E-01	1.00000E+00		
7	8	7.89531E-02	8.03201E-02	-4.42469E-03	1.00000E+00		
7	9	7.89531E-02	0.	0.	1.00000E+00		
8	1	2.65904E-02	0.	0.	1.00000E+00		
8	2	2.65904E-02	1.40014E-02	1.05310E+00	1.00000E+00		
8	3	2.65904E-02	2.65904E-02	8.52700E-01	1.00000E+00		
8	4	2.65904E-02	4.35131E-02	6.51817E-01	1.00000E+00		
8	5	2.65904E-02	0.	0.	1.00000E+00		
8	6	2.65904E-02	0.	0.	1.00000E+00		
8	7	2.65904E-02	0.	0.	1.00000E+00		
8	8	2.65904E-02	0.	0.	1.00000E+00		
8	9	2.65904E-02	0.	0.	1.00000E+00		
9	1	1.61299E+00	0.	0.	1.00000E+00		
9	2	1.61299E+00	0.	0.	1.00000E+00		
9	3	1.61299E+00	0.	0.	1.00000E+00		
9	4	1.61299E+00	0.	0.	1.00000E+00		
9	5	1.61299E+00	0.	0.	1.00000E+00		
9	6	1.61299E+00	0.	0.	1.00000E+00		
9	7	1.61299E+00	0.	0.	1.00000E+00		
9	8	1.61299E+00	0.	0.	1.00000E+00		
9	9	1.61299E+00	0.	0.	1.00000E+00		

8	5	2.40688E-02	5.92363E-02	4.50405E-01	1.16129E+00	7	2
8	6	2.23893E-02	7.64617E-02	2.48192E-01	1.16129E+00	7	2
8	7	2.24941E-02	9.52021E-02	4.40953E-02	1.16129E+00	7	2
8	8	2.24941E-02	0.	0.	1.16129E+00	7	2
9	1	-1.16216E-02	0.	0.	1.22206E+00	8	2
9	2	-1.16216E-02	1.28567E-02	1.09469E+00	1.22206E+00	8	2
9	3	-1.33695E-02	2.57735E-02	8.95157E-01	1.22206E+00	8	2
9	4	-1.65696E-02	3.99233E-02	6.96417E-01	1.22206E+00	8	2
9	5	-2.14596E-02	5.40613E-02	4.97966E-01	1.22206E+00	8	2
9	6	-2.84848E-02	7.20568E-02	3.00152E-01	1.22206E+00	8	2
9	7	-3.61268E-02	9.13672E-02	1.02328E-01	1.22206E+00	8	2
9	8	-3.93412E-02	1.11972E-01	-9.53076E-02	1.22206E+00	8	2
9	9	-3.93412E-02	0.	0.	1.22206E+00	8	2
10	1	-3.56634E-02	0.	0.	1.27527E+00	8	2
10	2	-3.56634E-02	8.04777E-03	1.12741E+00	1.27527E+00	8	2
10	3	-3.82070E-02	1.62621E-02	9.28961E-01	1.27527E+00	8	2
10	4	-4.30994E-02	2.51565E-02	7.32252E-01	1.27527E+00	8	2
10	5	-5.06151E-02	3.48362E-02	5.37222E-01	1.27527E+00	8	2
10	6	-6.16264E-02	4.59173E-02	3.44067E-01	1.27527E+00	8	2
10	7	-7.53724E-02	5.89775E-02	1.52824E-01	1.27527E+00	8	2
10	8	-8.64344E-02	7.46753E-02	-3.62622E-02	1.27527E+00	8	2
10	9	-8.64344E-02	0.	0.	1.27527E+00	8	2
11	1	-3.83362E-02	0.	0.	1.29406E+00	8	2
11	2	-3.83362E-02	8.95459E-04	1.14363E+00	1.29406E+00	8	2
11	3	-4.07187E-02	1.72582E-03	9.45695E-01	1.29406E+00	8	2
11	4	-4.52671E-02	2.45467E-03	7.49954E-01	1.29406E+00	8	2
11	5	-5.23147E-02	3.01724E-03	5.56563E-01	1.29406E+00	8	2
11	6	-6.28081E-02	3.41327E-03	3.65807E-01	1.29406E+00	8	2
11	7	-7.62552E-02	3.70663E-03	1.78028E-01	1.29406E+00	8	2
11	8	-8.61876E-02	3.62436E-03	-6.16429E-03	1.29406E+00	8	2
11	9	-8.61876E-02	0.	0.	1.29406E+00	8	2
12	1	-2.12564E-02	0.	0.	1.26506E+00	8	2
12	2	-2.12564E-02	-3.69301E-03	1.14065E+00	1.26506E+00	8	2
12	3	-2.23306E-02	-1.18232E-02	9.42201E-01	1.26506E+00	8	2
12	4	-2.42069E-02	-1.88428E-02	7.45386E-01	1.26506E+00	8	2
12	5	-2.70961E-02	-2.72490E-02	5.50351E-01	1.26506E+00	8	2
12	6	-3.17061E-02	-3.76162E-02	3.57321E-01	1.26506E+00	8	2
12	7	-3.65789E-02	-5.08649E-02	1.66599E-01	1.26506E+00	8	2
12	8	-3.62814E-02	-6.75003E-02	-2.13091E-02	1.26506E+00	8	2
12	9	-3.62814E-02	0.	0.	1.26506E+00	8	2
13	1	3.83204E-03	0.	0.	1.20988E+00	8	2
13	2	3.83204E-03	-6.36292E-03	1.12319E+00	1.20988E+00	8	2
13	3	4.61364E-03	-1.73443E-02	9.23309E-01	1.20988E+00	8	2
13	4	6.63569E-03	-2.76252E-02	7.23618E-01	1.20988E+00	8	2
13	5	9.87994E-03	-3.99504E-02	5.24057E-01	1.20988E+00	8	2
13	6	1.45777E-02	-5.53116E-02	3.24574E-01	1.20988E+00	8	2
13	7	2.22113E-02	-7.48849E-02	1.25113E-01	1.20988E+00	8	2
13	8	2.22113E-02	-9.43823E-02	-7.45176E-02	1.20988E+00	8	2
13	9	2.22113E-02	0.	0.	1.20988E+00	8	2
14	1	2.00595E-02	0.	0.	1.16503E+00	7	2
14	2	2.00595E-02	-5.40918E-03	1.10310E+00	1.16503E+00	7	2
14	3	2.20132E-02	-1.12090E-02	9.01781E-01	1.16503E+00	7	2
14	4	2.65527E-02	-1.78478E-02	6.98392E-01	1.16503E+00	7	2
14	5	3.39538E-02	-2.58724E-02	4.94425E-01	1.16503E+00	7	2
14	6	4.49127E-02	-3.60516E-02	2.87565E-01	1.16503E+00	7	2
14	7	6.07894E-02	-4.89111E-02	7.76146E-02	1.16503E+00	7	2
14	8	6.07894E-02	-9.37672E-02	-8.65548E-02	1.16503E+00	7	2
14	9	1.68826E-02	0.	0.	1.16503E+00	7	2
14	10	1.68826E-02	1.07785E-03	1.09421E+00	1.16503E+00	7	2
14	11	1.79670E-02	2.42655E-03	8.92515E-01	1.16503E+00	7	2
14	12	2.07283E-02	4.36784E-03	6.88937E-01	1.16503E+00	7	2
14	13	2.57277E-02	7.26152E-03	4.83051E-01	1.16503E+00	7	2
14	14	3.19702E-02	1.15763E-02	2.74146E-01	1.16503E+00	7	2
14	15	4.19508E-02	1.78560E-02	8.17892E-02	1.16503E+00	7	2

15	8	4.19508E-02	-8.98968E-02	-1.00540E-01	1.16764E+00	7	2
16	1	1.71044E-03	0.	0.	1.20113E+00	8	2
16	2	1.71044E-03	5.03854E-03	1.10037E+00	1.20113E+00	8	2
16	3	7.63377E-04	1.07731E-02	8.99876E-01	1.20113E+00	8	2
16	4	-1.00350E-03	1.80177E-02	6.98835E-01	1.20113E+00	8	2
16	5	-4.04887E-03	2.77919E-02	4.97159E-01	1.20113E+00	8	2
16	6	-9.16462E-03	4.15035E-02	2.94635E-01	1.20113E+00	8	2
16	7	-1.64675E-02	6.09762E-02	9.09551E-02	1.20113E+00	8	2
16	8	-1.64675E-02	8.04490E-02	-9.85905E-02	1.20113E+00	8	2
16	9	-1.64675E-02	0.	0.	1.20113E+00	8	2
17	1	-6.28203E-03	0.	0.	1.24416E+00	8	2
17	2	-6.28203E-03	2.66419E-03	1.11075E+00	1.24416E+00	8	2
17	3	-7.86107E-03	5.53698E-03	9.11627E-01	1.24416E+00	8	2
17	4	-1.09847E-02	8.86537E-03	7.13540E-01	1.24416E+00	8	2
17	5	-1.63189E-02	1.29530E-02	5.16840E-01	1.24416E+00	8	2
17	6	-2.50872E-02	1.82626E-02	3.22085E-01	1.24416E+00	8	2
17	7	-3.86378E-02	2.56526E-02	1.30110E-01	1.24416E+00	8	2
17	8	-4.45737E-02	3.50214E-02	-5.77235E-02	1.24416E+00	8	2
17	9	-4.45737E-02	0.	0.	1.24416E+00	8	2
18	1	-1.40861E-03	0.	0.	1.22421E+00	8	2
18	2	-1.40861E-03	-1.62445E-03	1.11300E+00	1.22421E+00	8	2
18	3	-1.35863E-03	-3.79189E-03	9.13481E-01	1.22421E+00	8	2
18	4	-9.05954E-04	-7.15148E-03	7.15143E-01	1.22421E+00	8	2
18	5	1.81426E-04	-1.26516E-02	5.17570E-01	1.22421E+00	8	2
18	6	2.09033E-03	-2.17108E-02	3.21307E-01	1.22421E+00	8	2
18	7	6.78759E-03	-3.68525E-02	1.26847E-01	1.22421E+00	8	2
18	8	6.78759E-03	-5.39730E-02	-6.48896E-02	1.22421E+00	8	2
18	9	6.78759E-03	0.	0.	1.22421E+00	8	2
19	1	1.94029E-03	0.	0.	1.19021E+00	7	2
19	2	1.94029E-03	-1.11620E-03	1.10906E+00	1.19021E+00	7	2
19	3	2.42728E-03	-2.37826E-03	9.08673E-01	1.19021E+00	7	2
19	4	3.73793E-03	-3.92617E-03	7.07649E-01	1.19021E+00	7	2
19	5	6.08283E-03	-5.89335E-03	5.05695E-01	1.19021E+00	7	2
19	6	9.31650E-03	-8.30206E-03	3.02033E-01	1.19021E+00	7	2
19	7	1.50739E-02	-1.10642E-02	9.55552E-02	1.19021E+00	7	2
19	8	1.50739E-02	-3.99085E-02	-9.98895E-02	1.19021E+00	7	2
20	1	-1.16461E-05	0.	0.	1.21393E+00	8	2
20	2	-1.16461E-05	6.50531E-04	1.10805E+00	1.21393E+00	8	2
20	3	-2.82912E-04	1.55421E-03	9.08770E-01	1.21393E+00	8	2
20	4	-8.26431E-04	3.07510E-03	7.08766E-01	1.21393E+00	8	2
20	5	-1.93814E-03	5.74929E-03	5.08560E-01	1.21393E+00	8	2
20	6	-5.38281E-03	1.06488E-02	3.08723E-01	1.21393E+00	8	2
20	7	-8.74843E-03	1.85892E-02	1.09146E-01	1.21393E+00	8	2
20	8	-1.09883E-02	2.72766E-02	-8.90656E-02	1.21393E+00	8	2
20	9	-1.09883E-02	0.	0.	1.21393E+00	8	2
21	1	0.	0.	0.	1.20861E+00	8	2
21	2	0.	-4.01544E-06	1.10937E+00	1.20861E+00	8	2
21	3	0.	-8.80035E-05	9.09374E-01	1.20861E+00	8	2
21	4	0.	-3.73771E-04	7.09930E-01	1.20861E+00	8	2
21	5	0.	-1.01958E-03	5.08700E-01	1.20861E+00	8	2
21	6	0.	-2.81407E-03	3.10090E-01	1.20861E+00	8	2
21	7	0.	-3.72934E-03	1.10473E-01	1.20861E+00	8	2
21	8	0.	-9.39210E-03	-8.89343E-02	1.20861E+00	8	2
21	9	0.	0.	0.	1.20861E+00	8	2
22	1	0.	0.	0.	1.00000E+00	8	2
22	2	0.	-8.01544E-06	0.	1.00000E+00	8	2
22	3	0.	-9.80003E-05	0.	1.00000E+00	8	2
22	4	0.	-3.73771E-04	0.	1.00000E+00	8	2
22	5	0.	-1.01958E-03	0.	1.00000E+00	8	2
22	6	0.	-2.81407E-03	0.	1.00000E+00	8	2
22	7	0.	-3.72934E-03	0.	1.00000E+00	8	2
22	8	0.	-9.39214E-03	0.	1.00000E+00	8	2
22	9	0.	0.	0.	1.00000E+00	8	2

SUBROUTINES USED IN THE SOLA CODES

The SOLA and SOLA-SURF codes call several subroutines to display information on microfilm. The following brief explanation of these subroutines is taken from material prepared by the LASL Computer Science Division.

SC-4020 GENERAL DESCRIPTION

The SC-4020 is a microfilm recording CRT device which either plots or prints on a 1024 x 1024 grid on the face of the CRT. The (0, 0) and (1023, 1023) coordinate positions are at the top left and lower right corners of the grid respectively. Vectors and/or axes may be drawn in any direction up to the full width of the plotting frame. Two frame sizes are available, normal and expanded, with adjacent frames butted under expanded conditions. Two light intensities provide for normal or light exposures. Normal spacing in "typing," or printing, mode is based on 128 characters/line and 64 lines/page. One can print up to 96 lines/page without overlap. Color output is available by using the special color routines provided.

SUBROUTINES

1) ADVance Film

Calling Sequence: CALL ADV(NF)

Where NF is an integer from 1 to 21. If NF is not in this range the call is ignored. Otherwise, NF frames are advanced.

2) Define Line Number

Calling Sequence: CALL LINCNT(NL)

Where NL is modulo 64. The next line directed to the film file is printed on the NLth line.

3) Draw a Vector

Calling Sequence: CALL DRV(IX1,IY1,IX2,IY2)

A straight line vector will be drawn from (IX1,IY1) to (IX2,IY2). Example: CALL DRV(512,512,1023,0) will cause a straight line to be drawn from the center (512,512) to the upper right-hand corner (1023,0).

4) Draw a FRAME

Calling Sequence: CALL FRAME(IXL,IXR,IYT,IYB)

The L, R, T, and B refer to the Left, Right, Top, and Bottom coordinates of the frame. A frame will be drawn around the area defined by these coordinates. IXL and IXR can be interchanged in the calling sequence, as can IYT and IYB.

Example: CALL FRAME(0,1023,0,1023)

A frame will be drawn around the entire plotting area.

5) CONVERT to 4020 coordinate

Calling Sequence: CALL CONVRT(Z,IZ,Z1,Z2,IZ1,IZ2)

The floating point number Z is converted to a 4020 coordinate based on Z1 and Z2 as the floating point numbers associated with the boundaries IZ1 and IZ2 respectively. The result is then stored at IZ for the programmers use. The conversion is performed by the formula:

$$IZ = IZ1 + \frac{Z - Z1}{Z2 - Z1} (IZ2 - IZ1) .$$

IZ is tested to insure that it lies within the boundaries specified by IZ1 and IZ2. If it lies outside these limits, it is then set equal to the appropriate limit. The quantity (Z2 - Z1) is tested for zero value and if zero IZ is set equal to the larger of IZ1 or IZ2 and an abort is performed. A comment is printed out on-line, and that part of the calculation is deleted, control by-passing this subroutine and returning to the parent routine.

Example: CALL CONVRT(1.,IX,0.,2.,100,900)

Upon return location IX will contain the integer 500.

6) Scale graph boundaries

Calling Sequences: CALL SLLIN(NY,K)

CALL SBLIN(NX,K)

These routines print numerical scales on the specified boundary. The L and B following the S in the entry name refers to the Left and Bottom boundaries respectively. The LIN defines Linear scale for the grid. NX or NY is the number of linear intervals to scale and K is the format code which is an integer ($0 \leq K \leq 6$ or $10 \leq K \leq 16$) where the units digit

specifies the number of digits to be printed to the right of the decimal point. Fixed point format (F-type) is specified by a tens digit of 0 and floating point (E-type) by a tens digit of one. One digit is always printed to the left of the decimal point. The numbers for the scale are obtained from the values assigned to the graph boundaries by the programmer. For linear scaling N equally spaced intervals are marked off by pip marks (plus signs) on the specified boundary.

7) Plot N points

Calling Sequence: CALL PLØT(N,X,MX,Y,MY,ICHAR,ICØN)

For the linear plotting of N points on a graph area previously defined using the routines listed earlier in this section. X and Y are the origins of tables of abscissas and ordinates stored at MX and MY intervals respectively. ICHAR defines the character desired from the 64 available and ICØN, if non-zero, calls for consecutive points to be connected by vectors.

8) Standardized Plot

Calling Sequence: CALL SPLØT(IØP,N,X,Y,ICHAR,ICØN)

Four types of grid, Linear-Linear, Linear-Log, Log-Linear, and Log-Log, are specified by setting IØP equal to 1, 2, 3, or 4 respectively. N points are plotted using values from the tables X and Y (abscissas and ordinates respectively) whose spacing between successive values is assumed to be one. ICHAR defines the character to be plotted. If ICØN is non-zero consecutive points will be connected by vectors.

The graph is drawn such that all points lie within, or on, the graph boundaries. For log grids an integral number of cycles are drawn, up to 25. LOG_{10} must be provided for the logarithmic variable. If an attempt is made to draw more than 25 cycles an error message will be printed. Linear scaling is done with fixed point numbers where possible. Space available to the programmer for labeling, etc., includes that area above Y = 42, below Y = 945, left of X = 32, and right of X = 980 in 4020 coordinates.

DEFINITION OF ARGUMENTS

ICHAR	Integer code for the character to be plotted.
ICØN	Option to connect consecutive points with a straight line vector.
IØP	Type of graph option. $1 \leq IØP \leq 4$.
IX	4020 Horizontal raster position, includes all arguments starting with IX.
IY	4020 Vertical raster position, includes all arguments starting with IY.
IZ	Either IX or IY as required by usage.
K	Format code for scaling numbers printed along graph boundary.
MX	Memory spacing of consecutive abscissas in table.
MY	Memory spacing of consecutive ordinates in table.
N	Number of points to be plotted.
NF	Number of frames to advance.
NL	Line number on which data is written on film.
NX	Number of equally spaced intervals in X direction.
NY	Number of equally spaced intervals in Y direction.
X	Origin of table in abscissas.
Y	Origin of table in ordinates.
Z	Floating point number associated with 4020 coordinate IZ.

Three additional subroutines are used. GETQ, DAT1, and CLØCK1 are used to provide the information necessary to list the computer run number, date, and time on each page of printed data.