X-RAY POLE FIGURE ANALYSIS

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Published September 1978

Final Report
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X-RAY POLE FIGURE ANALYSIS

BDX-613-1829 (Rev.), UNCLASSIFIED Final Report, Published
September 1978

Prepared by D. M. Jarboe and D. E. Lacey

The capability to produce X-ray pole figures at Bendix Kansas City has been developed. Operating procedures were established and appropriate software was created to allow data acquisition by a minicomputer. Existing FORTRAN IV software was modified to allow data reduction and CRT plotting.

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A prime contractor with the United
States Department of Energy under
Contract Number EY-76-C-04-0613

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SUMMARY

Crystal orientation in a polycrystalline material determines the characteristics of the material. When a material is deformed, a specific crystallographic orientation of the grains with respect to the deformation direction becomes predominant.

A technique used to determine crystal orientation or texture is the construction of a pole figure. A pole figure is a contour map, in stereographic projection, of the concentration of poles of selected crystallographic planes as a function of spatial orientation. The data used to produce pole figures are obtained by X-ray diffraction techniques. The techniques are complicated and can be simplified using computerized data acquisition, reduction, and CRT display techniques.

Pole figures of cold-rolled cartridge brass (70Cu-30Zn) taken from published literature were found to closely compare with results achieved at Bendix Kansas City.

DISCUSSION

SCOPE AND PURPOSE

The objective of this project, X-Ray Pole Figure Analysis, was to develop operating procedures and the capability to produce X-ray pole figures at Bendix Kansas City using computerized data acquisition, reduction, and CRT display techniques. Software programming was to be developed for a minicomputer to control and read the X-ray timer/scaler unit and convert the scaler readings to serial ASCII for input into a computer system with plotting capabilities. In addition, pole figure plotting software, obtained from Sandia Laboratories, Albuquerque, was to be compatible with the Bendix system.

To check the software, pole figures of cold-rolled cartridge brass (70Cu-30Zn) were to be obtained. This material was selected since it has been analyzed numerous times for texturing and the resulting pole figures have been documented in the literature.¹⁻³

ACTIVITY

Determination of Texture

A characteristic of single crystals is that their physical and mechanical properties are markedly orientation dependent (anisotropic). Metals and alloys in common use are generally polycrystalline in that they are comprised of many small crystals or grains. The anisotropy observed in single crystals is not generally present in a polycrystalline material because the grains are, for the most part, randomly oriented within the bulk structure.

When a polycrystalline material is plastically deformed, it appears to uniformly change shape with no orientation dependency. This is not the case, however, for the individual grains. Within each grain, dislocation glide is occurring along the closely packed directions and on the closely packed planes. The result is that a specific crystallographic orientation of the grains with respect to the deformation direction becomes predominant, and the bulk material itself becomes anisotropic. When this occurs, the material is said to have a preferred orientation or deformation texture.

The word "preferred" is used because the grain orientations, though not identical, are very similar. The same phenomenon occurs when the cold worked material is annealed. In this case, the material exhibits a recrystallization texture. The extent of the texturing, whether deformation or recrystallization, is dependent upon the amount and type of cold work the material was subjected to.

Preferred orientation in a polycrystalline material can be either beneficial or detrimental, depending on the requirements imposed. Magnetic materials, for example, are often processed to produce a strong preferred orientation in order to enhance the magnetic properties in one direction, as are tape wound magnetic cores. An unknown preferred orientation in a material designed for structural applications can present problems, however, due to variations in mechanical properties along different directions.

In view of the impact preferred orientation can have on the behavior of a material, it becomes important in many instances to determine if a texture exists and to define it. One technique employed in texture determination is the construction of a pole figure. A pole figure is a contour map, in stereographic projection, of the concentration of poles of selected crystallographic planes as a function of spatial orientation (the pole of a crystallographic plane is its normal). The data used to produce a pole figure are obtained by X-ray diffraction techniques. Figure 1 illustrates the geometry associated with the construction of a pole figure. Once the crystallographic plane for which the pole figure is to be produced has been selected, the incident angle of the monochromatic X-ray beam θ (theta) is calculated from Bragg's law. The sample is then selectively rotated around two mutually perpendicular axes, represented by the lines BN and ABC in Figure 1, while measurements are made of the diffracted X-ray intensities at various points of the polar projection. The sample itself is oscillated at a low frequency and amplitude in its own plane in order to achieve an integrated X-ray count over a larger surface area of the sample. By convention, rotation about the axis normal to the sample surface is termed α (alpha) and rotation about the axis which is parallel to the sample surface is termed ϕ (phi).

Experimental Equipment and Operating Procedure

The texture diffractometer used at Bendix (Figure 2) is contained within a safety box and is equipped so that both alpha and phi rotations can be mechanically coupled and simultaneously driven by a synchronous motor (the inset in Figure 2 is a close-up of a sample under test showing the effect of alpha and phi rotations). As a result, pole figure data are generated continuously in a spiral path. With this equipment, each 360 degrees of alpha rotation produces a corresponding phi angular displacement of 5 degrees.

Figure 1. Geometric Analysis of Pole Figure

Two speed settings are available for alpha rotation: 45 degrees/minute (360 degrees in 8 minutes) and 22.5 degrees/minute (360 degrees in 16 minutes). The slower speed was selected for this study to minimize data smearing. At this speed, the counting interval selected (20 seconds) yields 48 data points for each 360 degrees of synchronously driven alpha rotation.

The following operating procedure was used to collect the data for this project: Starting at an initial sample tilt (phi) of 65 degrees, 14 spirals were produced by decrementing phi by 5 degrees for each 360 degrees of alpha rotation to a final sample tilt of 0 degrees. This resulted in a total of 672 data points (48 per alpha rotation times 14 phi intervals). Three data collection modes were employed:

Automatic: Alpha and phi rotations are mechanically coupled and driven continuously by a synchronous motor.

Figure 2. Texture Diffractometer

Semiautomatic: Phi is manually decremented while alpha is driven by the synchronous motor. This provides data in concentric circles rather than spirals, thus reducing data smear in terms of the displacement.

Manual: Both alpha and phi are manually stepped. After decrementing phi by 5 degrees, an alpha rotation of 7.5 degrees was performed ($1/48$ of a revolution). After the 20 second count, alpha was again rotated 7.5 degrees and

another 20 second count taken. This is repeated until one alpha revolution is completed. The cycle is repeated for successive phi intervals.

Computer Techniques

Data Collection

A block diagram of the X-ray detection and control system is shown (Figure 3). Computer software was developed in the PAL III language which permitted the computer to control and read the timer/scaler unit and to convert the scaler readings to serial ASCII. The raw data were put on punched paper tape with hardcopy using an interfaced TTY terminal. A listing of the PAL III data collection program is given in Appendix A.

Data Reduction and Plotting

In order to transform the X-ray intensities and inferred positional data to sets of polar coordinates, an existing FORTRAN IV program, POLE II, was obtained from Sandia Laboratories, Albuquerque. This program was modified to accommodate subroutines for CRT plotting of pole figures on a graphics terminal. Figure 4 shows one of the pole figures obtained during this project as it was computer drawn on the terminal. Additional modifications were made to the program to reduce the field length from 60,000 (octal) to 38,000 (octal). A FORTRAN IV listing of this program and a sample data set are given in Appendix B.

Pole Figures

Cold rolled cartridge brass was selected as the material to be used to prove in the technique. Figure 5 shows a (111) pole figure (X-ray diffraction from the 111 planes) of heavily-rolled cartridge brass, taken from the literature. This is approximately a (110)[112] texture--having (110) planes parallel to the rolling plane and [112] directions parallel to the rolling direction. The term approximately is used because a pole figure is a contour map and is, therefore, statistical in nature. Assigning of a specific texture, such as (110)[112], is a useful technique, but it is only an idealized approximation.

Figures 6, 7, and 8 show the (111) pole figures obtained using the Bendix system's automatic, semi-automatic, and manual data collection modes, respectively. All three are similar to the (111) pole figure shown in Figure 4. This is significant because the brass used in this study was only 5 percent cold rolled as compared to 95 percent cold-rolled material described in the literature. All three of the Bendix (111) pole figures indicate an approximate

Figure 3. X-Ray Detection and Control System Diagram

(110)[112] texture. The ideal locations of the (111) poles for a (110)[112] texture are marked on the pole figures by small triangles.

By comparing Figures 6, 7, and 8 it is seen that, in going from the automatic to the manual mode, the contour lines are not as smooth. This is because of the decrease in data smearing caused by continuous alpha and phi motions during the counting intervals.

A (220) pole figure of the same sample is shown (Figure 9). It also indicates an approximate (110)[112] texture. The (110) and (220) planes are equivalent in crystallography, but diffraction of X-rays in a face-centered cubic lattice is not mathematically possible from the (110) planes.¹

Figure 4. Pole Figure From Graphics Terminal

Figures 10 and 11 are (111) pole figures of the brass sample after two successive annealing heat treatments. The ability of the Bendix pole figure to show the change in the material is quite evident. Comparison of these two pole figures indicates that a recrystallization texture may be developing with additional annealing. It is obvious from these pole figures that the use of an assigned texture definition is only an approximation.

ACCOMPLISHMENTS

Experimental operating procedures were established and the capability to produce pole figures at Bendix Kansas City has been developed. The Bendix system makes use of computer techniques for

Figure 5. (111) Pole
Figure of Cold-
Rolled Cartridge
Brass¹

control, data acquisition, data reduction, and CRT display of the pole figure. The ability of the system to provide useful pole figures was shown using cold-rolled cartridge brass.

Since the development of this capability at Bendix, the demand for pole figure analysis has increased. During the interim in which this report was being prepared, pole figures have been produced for the characterization of PVD aluminum on Kapton (Du Pont Corporation), metallized gold films on HMCs, and ultra-thin magnetic core alloys.

FUTURE WORK

Presently, the production of one pole figure requires approximately 10 man-hours of labor. In addition, the control panel with the minicomputer and timer/scaler is used for the X-ray diffraction and fluorescence equipment. It has been recommended that the present system be improved by interfacing with a larger computer system to allow complete computer control, including alpha and phi rotations, of the texture diffractometer, substantially reducing the man-hours for each pole figure. In addition, the dependency on the present control panel would be eliminated, increasing availability. A third advantage would be the reduction of data collection time by allowing the selection of optimum counting intervals and number of data points.

1 1 1 PLANE - COLD ROLLED CARTRIDGE BRASS - (CONTINUOUS SPIRAL)

T.D.

1	1000
2	2500
3	5000
4	6250
5	7500
6	8750
7	10000
8	11250

Figure 6. (111) Pole Figure of Cold-Rolled Cartridge Brass Showing Data Taken in the Automatic Mode

Figure 7. (111) Pole Figure of Cold-Rolled Cartridge Brass
Showing Data Taken in the Semiautomatic Mode

1 1 1 POLE-COLD ROLLED CART. BRASS, (DISCRETE STEPS-BOTH MOTIONS)
T.D.

1 1500
2 3000
3 5000
4 6000
5 7000
6 8000
7 9000
8 10000

Figure 8. (111) Pole Figure of Cold-Rolled Cartridge Brass
Showing Data Taken in the Manual Mode

2 2 0 PLANE-COLD ROLLED CART. BRASS, (SEMI-AUTO. MODE)

T.D.

1	500
2	1000
3	1500
4	2000
5	2500
6	3000

Figure 9. (220) Pole Figure of Cold-Rolled Cartridge Brass

111 POLE-ANNEALED COLD ROLLED CART. BRASS-SEMI-AUTO. MODE
T.D.

1 2500
2 5000
3 7500
4 10000
5 12500
6 15000
7 20000
8 40000

Figure 10. (111) Pole Figure of Cold-Rolled Cartridge Brass
After Annealing at 650°C for 3 Hours

Figure 11. (111) Pole Figure of Annealed Cartridge Brass
After a Second Anneal of 1000°C for 8 Hours

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²C. S. Barrett, *Structure of Metals*. New York: McGraw-Hill, 1943, pp 395-399.

³H. Hu and others, "Rolling Textures in Face-Centered Cubic Metals," *Transactions, A.I.M.E.*, Volume 194, Number 76, 1952.

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Appendix A

LISTING OF THE DATA COLLECTION PROGRAM
IN THE PAL III LANGUAGE

** UNCLASSIFIED **

/POLE FIGURE DATA COLLECTION PROGRAMS

/ WRITTEN BY D. E. LACEY

/

/SOURCE LANGUAGE: PAL III

/

/

0020 6267 TYPE1, 6267 /ADDR OF SUBR TO ENABLE TTY KEYBOARD
0021 7777 M1, -1 /MINUS ONE

0026 7772 M6, -6 /MINUS SIX

0030 7770 M10, -10 /MINUS EIGHT

0032 0600 PRINT, 600 /ADDR OF SUBR TO PRINT ONE CHARACTER

0034 0606 MSGP, 606 /ADDR OF SUBR TO PRINT PACKED ASCII MESSAGE
0035 0671 CRLF, 671 /ADDR OF SUBR TO PRINT A CR AND LF

0772 4040 4040 /ADDR OF PRINTED MESSAGE, 9 SPACES.
0773 4040 4040
0774 4040 4040
0775 4040 4040
0776 4000 4000

5373 4040 4040 /ADDR OF PRINTED MESSAGE, 5 SPACES, -5.
5374 4040 4040
5375 4055 4055
5376 6500 6500

4200 7300 *4200 /ADDR OF POLE FIGURE DATA COLLECTION PROG.
4201 5744 CLA CLL
4202 1350 JMP I A02600 /BR TO ROUTINE TO COUNT BACKGROUND
4203 3351 TAD CYCLES
4204 4420 DCA CYCLCT /INITIALIZE CYCLE COUNT
4205 7300 JMS I TYPE1 /BR TO SUBR, ENABLE KEYBOARD, RUBOUT ENITS
CLA CLL

ISSUE

SHEET 2

** UNCLASSIFIED **

** U N C L A S S I F I E D **

1	4206	1345	TAD SPLCT	
2	4207	3346	DCA TOTCT	/INITIALIZE TOTAL COUNTER
3	4210	4314	JMS START	/BR TO SUBR, START
4	4211	6382	6382	/SKIP IF COUNT COMPLETE
5	4212	5211	JMP.-1	/RETURN TO WAIT LOOP IF COUNT INCOMPLETE
6	4213	4220	JMS STORE	/BR TO SUBR, STORE
7	4214	4253	JMS CTPUN	/BR TO SUBR, CTPUN-COUNT & PUNCH PAPER TAPE
8	4215	2351	ISZ CYCLCT	/DECREMENT CYCLE COUNTER
9	4216	5204	JMP.-12	/RETURN TO BEGINNING OF LOOP
10	4217	5747	JMP I 482 623	/BR TO BACKGROUND COUNTING ROUTINE
11	4220	0000	STORE, 0	/ADDR OF SUBR, STORE
12	4221	1343	TAD P2	/FETCH SCALER SELECT PARAMETER
13	4222	6317	6317	/SELECT SCALER OUTPUT
14	4223	7300	CLA CLL	
15	4224	1341	TAD BUFF	
16	4225	3342	DCA PNTR	/INITIALIZE BUFFER POINTER ADDR
17	4226	1026	TAD M6	
18	4227	3247	DCA ICOUNT	/INITIALIZE DIGIT COUNTER
19	4230	1250	TAD N6317	
20	4231	3251	DCA NCOUNT	/INITIALIZE OUTPUT INSTR GENERATOR
21	4232	1251	TAD NCOUNT	
22	4233	1021	TAD M1	
23	4234	3251	DCA NCOUNT	/DECREMENT OUTPUT INSTR GENERATOR
24	4235	1251	TAD NCOUNT	
25	4236	3237	DCA. + 1	/DEPOSIT AND EXECUTE OUTPUT INSTRUCTIONS
26	4237	0000	0000	/OUTPUT INSTRUCTION REGISTER
27	4240	1252	TAD P260	/CONVERT BCD DIGIT TO ASCII
28	4241	3242	DCA I PNTR	
29	4242	2342	ISZ PNTR	/DECREMENT BUFFER POINTER ADDR
30	4243	2247	ISZ ICOUNT	/DECREMENT DIGIT COUNTER
31	4244	5232	JMP.-12	/BR TO BEGINNING OF LOOP
32	4245	7000	NOP	
33	4246	5620	JMP I STORE	/RETURN FROM SUBR, STORE
34	4247	0000	ICOUNT, 0	/DIGIT COUNTER
35	4250	6317	N6317, 6317	/VALUE USED TO INITIALIZE INSTR GENERATOR
36	4251	0000	NCOUNT, 0	/OUTPUT INSTR GENERATOR
37	4252	0260	P260, 260	/ADD TO BCD DIGIT TO CONVERT TO ASCII
38	4253	0000	CTPUN, 0	/ADDR OF SUBR, CTPUN-COUNT & PUNCH PAPER TAPE
39	4254	7300	CLA CLL	
40	4255	1030	OVER, TAD M10	/ADDR OF LABEL, OVER
41	4256	3311	DCA TCOUNT	/INITIALIZE COLUMN COUNTER
42	4257	2346	AGAIN, ISZ TOTCT	/LABEL, AGAIN-DECREMENT TOTAL COUNTER
43	4260	7410	SKP	
44	4261	5307	JMP STOP	/BR TO LABEL, STOP
45	4262	4314	JMS START	/BR TO SUBR, START
46	4263	1026	TAD M6	
47	4264	3312	DCA SIXCT	/INITIALIZE DIGIT COUNTER
48	4265	1341	TAD BUFF	
49	4266	3342	DCA PNTR	/INITIALIZE BUFFER POINTER ADDR
50	4267	1742	TAD I PNTR	
51	4270	4432	JMS I PRINT	/PRINT DIGIT LOCATED AT CURRENT BUFFER ADDR
52	4271	2342	ISZ PNTR	/DECREMENT POINTER ADDR
53	4272	2312	ISZ SIXCT	/DECREMENT DIGIT COUNTER
54				
55				
56			ISSUE	
57			SHEET 3	
58				
59			** U N C L A S S I F I E D **	
60				

** U N C L A S S I F I E D **

1	4273	5267	JMP, -4	/BR TO BEGINNING OF BUFFER READOUT LOOP
2	4274	1313	TAD P240	
3	4275	4432	JMS I PRINT	/PRINT A BLANK SPACE
4	4276	1313	TAD P240	
5	4277	4432	JMS I PRINT	/PRINT A BLANK SPACE
6	4300	6302	6302	/SKIP IF COUNT COMPLETE
7	4301	5300	JMP, -1	/RETURN TO WAIT LOOP IF COUNT INCOMPLETE
8	4302	4220	JMS STORE	/BR TO SUBR, STORE
9	4303	2247	ISZ ICOUNT	/DECREMENT COLUMN COUNTER
10	4304	5257	JMP AGAIN	/BR TO LABEL, AGAIN
11	4305	4435	JMS I CRLF	/BR TO SUBR, CRLF
12	4306	5255	JMP OVER	/BR TO LABEL, OVER
13	4307	7000	STOP, NOP	/LABEL, STOP
14	4310	5653	JMP I CTPUN	/RETURN FROM SUBR, CTPUN
15	4311	0000	TCOUNT, 0	/COLUMN COUNTER
16	4312	0000	SIXGT, 0	/DIGIT BUFFER COUNTER
17	4313	0240	P240, 240	/ASCII BLANK
18	4314	0000	START, 0	/ADDR OF SUBR, START
19	4315	7300	CLA CLL	
20	4316	6306	6306	/CLEAR INTERFACE STORAGE REGISTER
21	4317	1331	TAD SELECT	
22	4320	6304	6304	/SELECT TIMER-SCALER OPTION
23	4321	7300	CLA CLL	
24	4322	1332	TAD PRESET	
25	4323	6305	6305	/PRESET TIMER-SCALER PARAMETER
26	4324	6303	6303	/RESET TIMER-SCALER
27	4325	4333	JMS TO	/BR TO TIME-DELAY SUBR.
28	4326	6301	6301	/START TIMER-SCALER
29	4327	4333	JMS TO	/BR TO TIME-DELAY SUBR
30	4330	5714	JMP I START	/RETURN FROM SUBR, START
31	4331	0001	SELECT, 1	/TIMER-SCALER PARAMETER
32	4332	0102	PRESET, 102	/TIMER-SCALER PARAMETER
33	4333	0000	TO, 0	/ADDR OF TIME-DELAY SUBR
34	4334	7300	CLA CLL	
35	4335	7001	IAC	
36	4336	7420	SNL	
37	4337	5335	JMP, -2	
38	4340	5733	JMP I TO	/RETURN FROM SUBR, TO
39	4341	4352	BUFF, 4352	/BEGINNING ADDR OF DIGIT OUTPUT BUFFER
40	4342	0000	PNTR, 0	/BUFFER ADDRESS POINTER
41	4343	0002	P2, 2	/SCALER SELECT PARAMETER
42	4344	2600	AD2600, 2600	/POINTER ADDR OF ROUTINE TO COUNT BKG
43	4345	7717	SPLCT, 7717	/VALUE USED TO INITIALIZE TOTAL COUNTER
44	4346	0000	TOTCT, 0	/TOTAL COUNTER REGISTER
45	4347	2623	AD2623, 2623	/POINTER ADDR.
46	4350	7762	CYCLES, 7762	/VALUE USED TO INITIALIZE CYCLE COUNTER
47	4351	0000	CYCLCT, 0	/CYCLE COUNTER REGISTER
48	END		\$	

ISSUE

SHEET

** U N C L A S S I F I E D **

** U N C L A S S I F I E D **

1					
2					
3				*20	
4	0020	6267	TYPE1,	6267	/ADDR OF SUBR TO ENABLE TTY KEYBOARD
5	0021	7777	M1,	-1	/MINUS ONE
6					
7					
8				*26	
9	0026	7772	M6,	-6	/MINUS SIX
10					
11					
12				*30	
13	0030	7770	M10,	-10	/MINUS EIGHT
14					
15					
16				*32	
17	0032	0600	PRINT,	600	/ADDR OF SUBR TO PRINT ONE CHARACTER
18					
19					
20				*34	
21	0034	0606	MSGP,	606	/ADDR OF SUBR TO PRINT PACKED ASCII MESSAGE
22	0035	0671	CR LF,	671	/ADDR OF SUBR TO PRINT A CR AND LF
23					
24					
25				*772	/ADDR OF PRINTED MESSAGE, 9 SPACES.
26	0772	4040		4040	
27	0773	4040		4040	
28	0774	4040		4040	
29	0775	4040		4040	
30	0776	4000		4000	
31					
32					
33				*5373	/ADDR OF PRINTED MESSAGE, 5 SPACES,-5.
34	5373	4040		4040	
35	5374	4040		4040	
36	5375	4055		4055	
37	5376	6500		6500	
38					
39					
40				*2600	/ADDR OF ROUTINE TO COUNT BACKGROUND DATA.
41	2600	7300		CLA CLL	
42	2601	1215		TAD N7402	/FETCH HALT INSTR INTO AC.
43	2602	3616		DCA I CHNGE	/DEPOSIT HALT INSTR IN LOC., CHNGE.
44	2603	1213		TAD BKGCT	
45	2604	3614		DCA I CTSET	/INITIALIZE BACKGROUND COUNTER.
46	2605	4420		JMS I TYPE1	/BR TO SUBR - ENABLE TTY KEYBOARD.
47	2606	4217		JMS CTPUN	/BR TO SUBR - COUNT AND PUNCH DATA ON PAPER TA
48	2607	1213		TAD BKGCT	
49	2610	3614		DCA I CTSET	/INITIALIZE BACKGROUND COUNTER.
50	2611	4217		JMS CTPUN	/BR TO SUBR - COUNT AND PUNCH BACKGROUND DATA
51	2612	5724		JMP I A04202	/RETURN TO MAIN PROG AT LOC 4202
52	2613	7761	BKGCT,	-17	/BACKGROUND COUNT
53	2614	2666	CTSET,	CT2	/BACKGROUND COUNTER
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ISSUE
SHEET 2

** U N C L A S S I F I E D **

** U N C L A S S I F I E D **

1	2615	7482	N7482,	7482	/HALT INSTR.
2	2616	2711	CHNGE,	CHANGE	/ADDR OF CHANGE
3	2617	0000	CTPUN,	0	/ADDR OF SUBR TO COUNT AND PUNCH BACKGROUND DA
4	2620	7300		CLA CLL	
5	2621	1030	OVER,	TAD M10	
6	2622	3264		DCA TCOUNT	/INITIALIZE COLUMN COUNT
7	2623	2266	AGAIN,	ISZ CT2	/DECREMENT BACKGROUND COUNTER
8	2624	7410		SKP	
9	2625	5262		JMP STOP	/BRANCH TO END
10	2626	7300		CLA CLL	
11	2627	6306		6306	/CLEAR INTERFACE STORAGE REGISTER
12	2630	1267		TAD SELECT	/FETCH TIMER-SCALER SELECT PARAMETER
13	2631	6304		6304	/SELECT TIMER-SCALER OPTION
14	2632	7300		CLA CLL	
15	2633	1270		TAD PRESET	/FETCH PRESET PARAMETER
16	2634	6305		6305	/PRESET TIMER-SCALER PARAMETER
17	2635	7300		CLA CLL	
18	2636	6303		6303	/RESET TIMER-SCALER
19	2637	7300		CLA CLL	
20	2640	7001	TD1,	IAC	/ADDR OF TIME-DELAY LOOP
21	2641	7420		SNL	
22	2642	5240		JMP TD1	
23	2643	6301		6301	/START TIMER-SCALER
24	2644	7300		CLA CLL	
25	2645	7001	TD2,	IAC	/ADDR OF 2ND TIME-DELAY LOOP
26	2646	7420		SNL	
27	2647	5245		JMP TD2	
28	2650	6382	GNTNOV,	6382	/SKIP IF COUNT COMPLETE
29	2651	5250		JMP GNTNOV	/RETURN TO WAIT LOOP IF COUNT INCOMPLETE
30	2652	7300		CLA CLL	
31	2653	1265		TAD P2	/FETCH SCALER SELECT PARAMETER
32	2654	6317		6317	/SELECT SCALER
33	2655	4271		JMS TYPE	/BR TO SUBR TO ENABLE TTY KEYBOARD
34	2656	2264		ISZ TCOUNT	/DECREMENT COLUMN COUNTER
35	2657	5223		JMP AGAIN	/BR TO ADDR, AGAIN.
36	2660	4435		JMS I CRLF	/BR TO SUBR CRLF
37	2661	5221		JMP OVER	/BR TO ADDR, OVER.
38	2662	4435	STOP,	JMS I CRLF	/ADDR, STOP - BR TO SUBR, CRLF
39	2663	5617		JMP I CTPUN	/RETURN FROM SUBR, CTPUN.
40	2664	0000	TCOUNT,	0	/COLUMN COUNTER
41	2665	0002	P2,	2	/SCALER SELECT PARAMETER
42	2666	0000	CT2,	0	/TOTAL COUNTER
43	2667	0001	SELECT,	1	/TIMER SELECT PARAMETER
44	2670	0102	PRESET,	102	/TIMER PRESET PARAMETER
45	2671	0000	TYPE,	0	/ADDR OF SUBR, TYPE.
46	2672	7300		CLA CLL	
47	2673	1026		TAD N6	
48	2674	3320		DCA ICOUNT	/SET DIGIT COUNTER
49	2675	1321		TAD N6317	
50	2676	3317		DCA NCOUNT	/SET OUTPUT INSTR GENERATOR
51	2677	1317		TAD NCOUNT	
52	2700	1021		TAD M1	/DECREMENT OUTPUT INSTR.
53	2701	3317		DCA NCOUNT	/RESET OUTPUT INSTRUCTION
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ISSUE
SHEET 3

** U N C L A S S I F I E D **

** UNCLASSIFIED **

1	2702	1317	TAD NCOUNT	/FETCH OUTPUT INSTR.
2	2703	3304	OCA.+1	/DEPOSIT AND EXECUTE INSTRUCTION
3	2704	0000	0000	/LOCATION OF OUTPUT INSTRUCTIONS
4	2705	1322	TAD P260	/CONVERT BCD DIGIT TO ASCII
5	2706	4432	JMS I PRINT	/BR TO SUBR TO PRINT DIGIT
6	2707	2320	ISZ ICOUNT	/DECREMENT DIGIT COUNTER
7	2710	5277	JMP -11	/REPEAT LOOP TO FETCH NEXT BCD DIGIT
8	2711	0000	CHANGE, 0000	/ADDR, CHANGE
9	2712	1323	TAD P240	
10	2713	4432	JMS I PRINT	/PRINT BLANK
11	2714	1323	TAD P240	
12	2715	4432	JMS I PRINT	
13	2716	5671	JMP I TYPE	/RETURN FROM SUBR. TYPE
14	2717	0000	NCOUNT, 0	
15	2720	0000	ICOUNT, 0	
16	2721	6317	N6317, 6317	/VALUE USED TO INITIALIZE INSTR GENERATOR
17	2722	0260	P260, 260	/ADD TO BCD DIGIT TO CONVERT TO ASCII
18	2723	0240	P240, 240	/ASCII BLANK
19	2724	4202	AD4202, 4202	/RETURN ADDRESS TO MAIN PROGRAM
20		END	\$	

ISSUE
SHEET 4

** UNCLASSIFIED **

Appendix B

LISTING OF THE DATA REDUCTION AND PLOTTING
PROGRAM IN FORTRAN IV LANGUAGE WITH SAMPLE
DATA SET

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C

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	OVERLAY(POLE,0,0)	000100
	PROGRAM POLEBKC(INPUT=2008,OUTPUT=2008,TAPE5=INPUT,TAPE6)	000200
C		000300
1C	POLEBKC	000400
2C	AUTOMATIC GENERATION OF POLE FIGURES	000500
3C	REVISED /1/73	000600
4C	REVISED 7/1/75	000700
5C	REVISED 3/1/76 BY D. L. WANTOCH BKC TEKTRONIX SUBS	000800
6C	VARIOUS REVISIONS 1976 & 1977 BY D. E. LACEY BKC	000900
7	INTEGER RO	001000
8	COMMON /COM1/IK(20),IGUT(1801),TTL(10)	001100
9	COMMON /BACK/ BACK(10) /SCAN/ASTART,ADEC,PSTART,BDEC,PSTOP	001200
10	COMMON/ COM2/R(50,30),Z(50,30),U(50,30),UI50(8)	001300
11	DIMENSION WORD(7)	001400
12	DATA WORD/10H NUMBER OF,10H LINE SEGM,10HENTS DRAWN,10H =	001500
13	110H ,10H ,10H /	001600
14	CALL INITT(960)	001700
15	CALL TERM(3,1024)	001800
16C	RO IS THE RADIUS OF THE CIRCLE . THE AREA FOR PLOTTING	001900
17C	IS 1024 BY 1024 UNITS IN SIZE.	002000
18C	IK(3)....NPTS,NUMBER OF DATA POINTS IN A COMPLETE SCAN.	002100
19C	IK(5)....IMAX, NUMBER OF POINTS ON SPIRAL	002200
20C	IK(6)....JMAX, NUMBER OF SPIRALS IN THE COMPLETE POLE FIGURE	002300
21C	IK(7)....N4,NUMBER OF CONTOUR TO BE DRAWN	002400
22C	IK(19)....ADJUSTS INTENSITY IF .EQ. 1	002500
23C	IK(20)....TOTAL NUMBER OF SEGMENTS USED TO DRAW CONTOURS	002600
24	IK(19)=0	002700
25	RO=475	002800
26	CALL SETUP(RO)	002900
27	100 IK(20)=0	003000
28	CALL READER	003100
29	CALL UFILL	003200
30	IF(IK(19).EQ.1)CALL FIXER	003300
31	CALL RANGE(U(1,1),IK(5),IK(6),IK(3),UI50,IK(7),UI50,NNEW)	003400
32	IK(7)=NNEW	003500
33	CALL SKETCH	003600
34	CALL MAX	003700
35	CALL CIRCLE(RO)	003800
36C		003900
37C	PRINT THE TOTAL NUMBER OF LINE SEGMENTS DRAWN.	004000
38C		004100
39	FIX=-500.0	004200
40	FIY=-500.0	004300
41	CALL MOVEA(FIX,FIY)	004400
42	CALL AOUTST(32,WORD)	004500
43	FIX=-164.	004600
44	CALL MOVEA(FIX,FIY)	004700
45	ENCODE(6,1000,WORD(7)) IK(20)	004800
46	1000 FORMAT(I6)	004900
47	CALL AOUTST(6,WORD(7))	005000
48	CALL HDCOPY	005100
49	GO TO 100	005200
50	END	005300
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C		005400
	SUBROUTINE SETUP(RO)	005500
C		005600
1	C SETUP-SET UP SCAN COORDINATES REV..8/1/73	005700
2	COMMON /COM2/ R(50,30),Z(50,30),U(50,30),VISO(6)	005800
3	COMMON /COM1/IK(20),IGUT(1001),TTL(10)	005900
4	COMMON /BACK/ BACK(10) /SCAN/ASTART,ADEC,PSTART,BDEC,PSTOP	006000
5	INTEGER RO	006100
6	PSTART= VALUE OF PHI FOR FIRST SPIRAL(IN DEGREES)	006200
7	PSTOP= VALUE OF PHI FOR LAST SPIRAL	006300
8	ASTART= VALUE OF ALPHA FOR FIRST SPIRAL AND FIRST POINT	006400
9	PRATE= RATE OF CHANGE OF PHI IN DEGREES/MIN	006500
10	ARATE= RATE OF CHANGE OF ALPHA	006600
11	RINTVL= LENGTH OF DATA OUTPUT INTERVALS IN UNITS OF SECONDS	006700
12	READ 1,PSTART,PTOP,ASTART,PRATE,ARATE,RINTVL	006800
13	1 FCRMAT(6F10.3)	006900
14	PI=3.1415926	007000
15	RAO=57.2957795	007100
16	ASTART=ASTART/RAO	007200
17	PSTART=PSTART/RAO	007300
18	PTOP=PTOP/RAO	007400
19	ADEC=(ARATE/60.)*RINTVL/RAO	007500
20	BDEC=(PRATE/60.)*RINTVL/RAO	007600
21	IMAX=2.*PI/ADEC+1.001	007700
22	JMAX=(PSTART-PTOP)/(FLOAT(IMAX-1)*BDEC)+.001	007800
23	IK(5)=IMAX	007900
24	IK(6)=JMAX	008000
25	IK(3)=(IMAX-1)*JMAX+1	008100
26	FRO=FLOAT(RO)	008200
27	DO 100 J=1,JMAX	008300
28	DO 100 I=1,IMAX	008400
29	TIME=I-1+(IMAX-1)*(J-1)	008500
30	PHI=PSTART-BDEC*TIME	008600
31	ALPHA=ASTART-ADEC*TIME	008700
32	Z2=PHI/2.	008800
33	PTAN=FRO*SIN(Z2)/COS(Z2)	008900
34	R(I,J)=PTAN*SIN(ALPHA)	009000
35	Z(I,J)=-PTAN*COS(ALPHA)	009100
36	100 CONTINUE	009200
37	RETURN	009300
38	END	009400
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C		009500
	SUBROUTINE READER	009600
C		009700
1 C	READER	009800
2 C	DATA READ INCLUDES...TTL, THE TITLE OF THE PLOT	009900
3 C	...IGUT, THE RAW INTENSITY	010000
4 C	...N4, NUMBER OF CONTOURS	010100
5 C	...UIISO, INTENSITY FOR EACH CONTOUR	010200
6 C	IF NO MORE DATA IS FOUND, AN EXIT IS MADE.	010300
7 C	BACKGROUND CORRECTION CAN BE MADE.	010400
8	REAL NOBAC	010500
9	COMMON /COM1/IK(20),IGUT(1801),TTL(10)	010600
10	COMMON/ COM2/R(50,30),Z(50,30),U(50,30),UIISO(8)	010700
11	DATA BLANK/10H	010800
12	DATA BACK/10HBACKGROUND/	010900
13	DATA NOEAC/10HNOBACKGROU/	011000
14	NPTS=IK(3)	011100
15 C	NPTS=TOTAL NUMBER OF POINTS ON THE SPIRAL SCAN.	011200
16	READ(5,2) (TTL(I), I=1,8)	011300
17	READ 95, DIV	011400
18	95 FORMAT(F5.0)	011500
19	READ 7747, JKL	011600
20	READ 95, ANGLE	011700
21	READ 95, STEP	011800
22	7747 FORMAT(I2)	011900
23	IF (TTL(1).EQ.BLANK) 99,98	012000
24	98 CONTINUE	012100
25	2 FORMAT(8A10)	012200
26	IF (TTL(1).NE.BACK) GO TO 10	012300
27	ISWH=1	012400
28	CALL BKGRND(DIV,JKL,ANGLE,STEP)	012500
29	GO TO 20	012600
30	10 IF (TTL(1).NE.NOBAC) GO TO 30	012700
31	ISWH=0	012800
32	20 READ 2, (TTL(I), I=1,8)	012900
33	30 READ 1, (IGUT(I), I=1,NPTS)	013000
34	1 FORMAT(8(I6,2X))	013100
35	DO 97 I=1,NPTS	013200
36	97 IGUT(I)=(FLOAT(IGUT(I)))/DIV+.5	013300
37 C		013400
38 C	SET UP THE MICROFILM ROUTINES AND PRINT TITLE ON PLOT.	013500
39 C		013600
40	CALL NEWPAG	013700
41	CALL DWINDO(-671.,671.,-511.,512.)	013800
42	CALL CHRISZ(4)	013900
43	FIX=-500.0	014000
44	FIY=500.	014100
45	CALL MOVEA(FIX,FIY)	014200
46	CALL AOUTST(80,TTL)	014300
47	PRINT 40, (TTL(I), I=1,8)	014400
48	40 FORMAT(1H ,*PLOT IS *,8A10)	014500
49 C		014600
50 C	SKIP TO END OF DATA AS INDICATED BY A NEGATIVE NUMBER.	014700
51 C	READ THE NUMBER OF CONTOURS AND INTENSITY FOR EACH CONTOUR.	014800
52 C		014900
53	6 READ 11,IFLAG	015000
54	IF(IFLAG.GE.0)GO TO 6	015100
55	11 FORMAT(I7)	015200
56	READ 12,N4	015300
57	12 FORMAT(I10)	015400
58	IF (N4.LT.0)GO TO 99	015500
59	IK(7)=N4	015600
60	READ 13, (UIISO(L), L=1,N4)	015700

13	FORMAT(8F8.0)	015800
C		015900
C	PRINT LEGEND, CONTOUR NUMBER AND INTENSITY ON PLOT.	016000
C		016100
	FIX=368.0	016200
	FFIX=FIX+16.0	016300
1	FISPACE=20.0	016400
2	DO 5 N=1,N4	016500
3	FIY=FIY-FISPACE	016600
4	ICONT=UIISO(N)	016700
5	CALL MOVEA(FIX,FIY)	016800
6	ENCODE(2,1000,FN) N	016900
7	1000 FORMAT(I2)	017000
8	CALL AOUTST(2,FN)	017100
9	CALL MOVEA(FFIX,FIY)	017200
10	ENCODE(6,1100,FICONT) ICONT	017300
11	1100 FORMAT(I6)	017400
12	CALL AOUTST(6,FICONT)	017500
13	5 CONTINUE	017600
14	PRINT 14,N4,UIISO	017700
15	14 FORMAT(* DATA READ. *,I2,*CONTOURS WILL BE DRAWN AT *,8F6.0)	017800
16	IK(19)=ISWH	017900
17	RETURN	018000
18	C	018100
19	C FINISH EXECUTION IF NO MORE DATA IS ENCOUNTERED.	018200
20	C	018300
21	99 CALL FINITT(0.50)	018400
22	CALL EXIT	018500
23	END	018600
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C		018700
	SUBROUTINE BKGRND(DIV,JKL,ANGLE,STEP)	018800
C		018900
1	C ROUTINE AVERAGES TWO BACKGROUND READINGS FOR	019000
2	PHI AT DISCRETE POINTS STARTING AT "ANGLE" DEGREES	019100
3	C WITH DELTA PHI = "STEP" DEGREES.	019200
4	C THEN FITS A CURVE (LSQ) AND STORES THE	019300
5	C COEFFICIENTS IN ARRAY BACK FOR USE IN FIXER	019400
6	C	019500
7	COMMON /COM1/IK(20),IGUT(1401),GCALC(100),TCALC(100),GUT(100),	019600
8	1PHI(100),TTL(10)	019700
9	COMMON /BACK/BACK(10)	019800
10	DIMENSION IBK(28,2)	019900
11	PHID=ANGLE	020000
12	DO 200 I=1,JKL	020100
13	PHI(I)=PHID/57.2957795	020200
14	200 PHID=PHID-STEP	020300
15	DO 7707 J=1,1	020400
16	7707 READ 10, (IBK(I,J), I=1,JKL)	020500
17	DO 7708 J=2,2	020600
18	7708 READ 10, (IBK(I,J), I=1,JKL)	020700
19	10 FORMAT(8(I6,2X))	020800
20	DO 96 J=1,2	020900
21	DO 97 I=1,JKL	021000
22	97 IBK(I,J)=(FLOAT(IBK(I,J)))/DIV+.5	021100
23	96 CONTINUE	021200
24	DO 100 I=1,JKL	021300
25	100 GUT(I)=(IBK(I,1)+IBK(I,2))/2.0	021400
26	CALL LSQ(8,0,PHI,GUT,JKL,BACK,NOC,STDEF)	021500
27	RETURN	021600
28	END	021700
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C	SUBROUTINE LSQ(LOWDEG,IFLAG,X,Y,MAXPTS,U,NOCOEFS,STDEROR)	021800
C		021900
C		022000
1 C	WHERE X = X COORDINATE	022100
2 C	Y = Y COORDINATE	022200
3 C	MAXPTS = MAXIMUM NUMBER OF POINTS	022300
4 C	U = COEFFICIENT ARRAY OF LENGTH (LOWDEG+1)	022400
5 C	LOWDEG = ORDER OF FIT	022500
6 C	IFLAG = DETERMINES OUTPUT	022600
7 C	IF IFLAG = 1 PRINT OUT COEFFICIENTS	022700
8 C	IF IFLAG = 2 ENTIRE SUMMARY PRINTOUT	022800
9 C	IF IFLAG = 3 FIT NEXT HIGHER DEGREE ALSO	022900
10 C	IF IFLAG = 4 NO PRINTOUT	023000
11 C		023100
12 C	DATA, USING AN ORTHOGONAL POLYNOMIAL METHOD. LIMITS ARE 11TH	023200
13 C	THIS PROGRAM FITS LEAST SQUARES POLYNOMIALS TO BIVARIATE	023300
14 C	DEGREE FIT AND A MAX OF 500 DATA POINTS. PROGRAM ALLOWS USER	023400
15 C	TO SPECIFY THE LOWEST DEGREE POLYNOMIAL TO BE FIT, AND THEN	023500
16 C	FITS THE POLYNOMIALS IN ORDER OF ASCENDING DEGREE. AT EACH	023600
17 C	STAGE THE INDEX OF DETERMINATION IS PRINTED, AND THE USER HAS	023700
18 C	THE CHOICE OF GOING TO THE NEXT HIGHER DEGREE FIT, SEEING EITHER	023800
19 C	OF TWO SUMMARIES OF FIT AT THAT STAGE, OR OF STOPPING THE PROGRAM.	023900
20 C		024000
21	COMMON/UNITS/INPT,IOPT,ISCRGH	024100
22	DIMENSION A(30),B(30),S(30),G(30)	024200
23	DIMENSION C(30),P(30),Q(30)	024300
24	DIMENSION U(11),X(50),Y(50)	024400
25 C		024500
26	IERR = 0	024600
27	NOCOEFS = LOWDEG + 1	024700
28	IF(NOCOEFS.GE.12) GO TO 20	024800
29	GO TO 27	024900
30 20	PRINT 25	025000
31 25	FORMAT(*1TENTH DEGREE (ARBITRARY) IS THE LIMIT. THIS CALIBRATION	025100
32	IS TERMINATED.*)	025200
33	IERR = 1	025300
34	RETURN	025400
35 27	IF (MAXPTS.LT.NOCOEFS) GO TO 28	025500
36	GO TO 30	025600
37 28	PRINT 29,LOWDEG	025700
38	IERR = 1	025800
39 29	FORMAT(*1TOO FEW POINTS FOR FITTING DEGREE*,I2)	025900
40	RETURN	026000
41 30	IF (MAXPTS.GT.500) GO TO 40	026100
42	GO TO 50	026200
43 40	PRINT 45	026300
44	IERR = 1	026400
45 45	FORMAT(*1PROGRAM SIZE IS 500 DATA POINTS*)	026500
46	RETURN	026600
47 50	T7 = T8 = W7 = 0.0	026700
48	K = 12	026800
49	DO 70 I = 1,MAXPTS	026900
50	W7 = W7 + X(I)	027000
51	T7 = T7 + Y(I)	027100
52	T8 = T8 + Y(I)**2	027200
53 70	CONTINUE	027300
54	T9 = (MAXPTS*T8 - T7**2)/(MAXPTS**2-MAXPTS)	027400
55	VALXM = W7 / MAXPTS	027500
56	VALYM = T7 / MAXPTS	027600
57	STDY = SQRT(T9)	027700
58	IF (IFLAG.EQ.0) GO TO 75	027800
59	PRINT 71,MAXPTS,VALXM,VALYM,STDY	027900
60 71	FORMAT(1H1,/,4X,'LEAST SQUARES POLYNOMIALS'//10X	028000

	1,*NUMBER OF POINTS =*,I3,/,10X*MEAN VALUE OF X =*,E16.6 /10X,*MEAN	020100
	2VALUE OF Y =*,E16.6,/ 10X,*STD ERROR OF Y =*,E16.6)	020200
75	DO 80 I = 1,MAXPTS	020300
	P(I) = 0.0	020400
	Q(I) = 1.0	020500
80	CONTINUE	020600
1	DO 90 I=1.11	020700
2	A(I) = 0.0	020800
3	B(I) = 0.0	020900
4	S(I) = 0.0	029000
5	CONTINUE	029100
6	E1 = 0.0	029200
7	F1 = 0.0	029300
8	W1 = MAXPTS	029400
9	N4 = 12	029500
10	I = 1	029600
11	K1 = 2	029700
12	IF (NOCOEFS.EQ.0) GO TO 110	029800
13	K1 = 12	029900
14	W = 0.0	030000
15	DO 120 L = 1,MAXPTS	030100
16	W = W + Y(L) * Q(L)	030200
17	CONTINUE	030300
18	S(I) = W/W1	030400
19	IF (I-N4.GE.0) GO TO 200	030500
20	IF (I-MAXPTS.GE.0) GO TO 200	030600
21	E1 = 0	030700
22	DO 130 L = 1,MAXPTS	030800
23	E1 = E1 + X(L)*Q(L)*Q(L)	030900
24	CONTINUE	031000
25	E1 = E1/W1	031100
26	A(I+1) = E1	031200
27	W = 0.0	031300
28	DO 140 L=1,MAXPTS	031400
29	V = (X(L)-E1) * Q(L) - F1 * P(L)	031500
30	P(L) = Q(L)	031600
31	Q(L) = V	031700
32	W = W + V*V	031800
33	CONTINUE	031900
34	F1 = W / W1	032000
35	B(I+2) = F1	032100
36	W1 = W	032200
37	I = I+1	032300
38	GO TO 110	032400
39	DO 210 L = 2.11	032500
40	G(L) = 0.0	032600
41	CONTINUE	032700
42	G(1) = 1.0	032800
43	DO 250 J = 1,NOCOEFS	032900
44	S1 = 0	033000
45	DO 240 L = 1,NOCOEFS	033100
46	IF (L.EQ.1) GO TO 230	033200
47	IF (L.EQ.2) GO TO 220	033300
48	G(L) = G(L) - A(L) * G(L-1) - B(L)*G(L-2)	033400
49	GO TO 230	033500
50	G(L) = G(L) - A(L)*G(L-1) - B(L)*G(L-2)	033600
51	S1 = S1 + S(L) * G(L)	033700
52	CONTINUE	033800
53	U(J) = S1	033900
54	L = NOCOEFS	034000
55	DO 245 I2 = 2,NOCOEFS	034100
56	G(L) = G(L-1)	034200
57	L = L-1	034300
58	CONTINUE	034400
59	G(1) = 0.0	034500
60	CONTINUE	034600

	T = 0.0	034700
	DO 280 L = 1,MAXPTS	034800
	C(L) = 0.0	034900
	J = NOCOEFS	035000
	DO 270 I2 = 1,NOCCEFS	035100
	C(L) = C(L) * X(L) + U(J)	035200
1	J = J - 1	035300
2	270 CONTINUE	035400
3	T3 = Y(L) - C(L)	035500
4	T = T + T3**2	035600
5	280 CONTINUE	035700
6	IF (MAXPTS.NE.NOCOEFS) GO TO 300	035800
7	T5 = 0.0	035900
8	GO TO 320	036000
9	300 T5 = T/(MAXPTS - NOCOEFS)	036100
10	320 Q7 = 1-T / (T9*(MAXPTS-1))	036200
11	IQ7 = Q7	036300
12	IF (IFLAG.EQ.0) RETURN	036400
13	PRINT 330,LOWDEG,IQ7	036500
14	330 FORMAT (1H0,10X,*POLYFIT OF DEGREE*2X,I2,10X,*INDEX OF DETERM =	036600
15	1,I3)	036700
16	350 PRINT 355	036800
17	355 FORMAT(1H0,10X,*TERM COEFFICIENT*//)	036900
18	DO 365J = 1,NOCOEFS	037000
19	360 FORMAT(1H ,10X,I2,5X,E16.6)	037100
20	I2 =J-1	037200
21	PRINT 360,I2,U(J)	037300
22	365 CONTINUE	037400
23	PRINT 370	037500
24	370 FORMAT(1H0,7X,8HX-ACTUAL,7X,8HY-ACTUAL,8X,6HY-CALC,10X,4HCIEFF,9X,	037600
25	\$8HPCT-DIFF//)	037700
26	DO 400 L =1,MAXPTS	037800
27	Q8 = Y(L) - C(L)	037900
28	IF (C(L).EQ.0.0)GO TO 390	038000
29	PCTQ8 = 100.0 * Q8/ C(L)	038100
30	PRINT 380, X(L),Y(L),C(L),Q8, PCTQ8	038200
31	380 FORMAT(1H ,2X,4E15.6,6X,F7.3)	038300
32	GO TO 400	038400
33	390 PRINT 395, X(L),Y(L),C(L), Q8	038500
34	395 FORMAT(1H ,2X,4E15.6,5X,8HINFINITE)	038600
35	400 CONTINUE	038700
36	STDEROR = SQRT(T5)	038800
37	PRINT 410, STDEROR	038900
38	410 FORMAT (1H0,10X,*STD ERROR OF ESTIMATE = *,E16.6)	039000
39	END	039100
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	C		039200
		SUBROUTINE UFILL	039300
	C		039400
1	C	UFILL FILLS U WITH INTENSITY	039500
2		COMMON /COM1/IK(20),IGUT(1801),TTL(10)	039600
3		COMMON/ COM2/R(50,30),Z(50,30),U(50,30),VISO(8)	039700
4		IMAX=IK(5)	039800
5		JMAX=IK(6)	039900
6		K=1	040000
7		DO 100 J=1,JMAX	040100
8		DO 50 I=1,IMAX	040200
9		U(I,J)=IGUT(K)	040300
10		50 K=K+1	040400
11		100 K=K-1	040500
12		RETURN	040600
13		END	040700
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C	SUBROUTINE FIXER	040800
C		040900
C		041000
1 C	FIXER CORRECTS INTENSITY FOR BACKGROUND ETC	041100
2	COMMON /COM1/IK(20),IGUT(1001),TTL(10)	041200
3	COMMON /BACK/BACK(10) /SCAN/ASTART,ARATE,FSTART,BDEC,PSTOP	041300
4	COMMON /COM2/R(50,30),Z(50,30),U(50,30),UISO(8)	041400
5 C	INSERT ANY CONSTANTS NEEDED FOR CORRECTIONS HERE	041500
6 C	NORMALIZE ABSORPTION CORRECTION TO CENTER OF POLE FIG	041600
7 C	PHI=0. BY DIVIDING CORRECTION BY RCENT.R AT PHI=0.	041700
8	IMAX=IK(5)	041800
9	JMAX=IK(6)	041900
10	PRINT 101,(BACK(I),I=1,9)	042000
11	101 FORMAT(*OPOLYFIT COEF.=*,9E12.4)	042100
12	PRINT 102	042200
13	102 FORMAT(*ORAW INTENSITY*)	042300
14	PRINT 10,(((U(I,J),I=1,IMAX,5),J=1,JMAX))	042400
15	10 FORMAT(1H,12F5.0)	042500
16	DO 3 J=1,JMAX	042600
17	DO 1 I=1,IMAX	042700
18	PHI=PSTART-BDEC*FLOAT(I-1+(IMAX-1)*(J-1))	042800
19 C	COMPUTE BACKGROUND FROM POLYNOMIAL FIT	042900
20	BKG=BACK(1)	043000
21	PNTN=1.	043100
22	DO 2 N=1,8	043200
23	PNTN=PNTN*PHI	043300
24	2 BKG=BKG+BACK(N+1)*PNTN	043400
25	U(I,J)=U(I,J)-BKG	043500
26 C	MAKE ADDITIONAL INTENSITY CORRECTIONS HERE	043600
27	1 CONTINUE	043700
28	3 CONTINUE	043800
29	PRINT 100	043900
30	100 FORMAT(*OADJUSTED INTENSITY*)	044000
31	PRINT 10,(((U(I,J),I=1,IMAX,5),J=1,JMAX))	044100
32	RETURN	044200
33	END	044300
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C		044400
	SUBROUTINE RANGE(U,IM,JM,NPTS,COLD,NOLD,CNEW,NNEW)	044500
C		044600
1 C	RANGE RETURNS CNEW IN THE RANGE OF U	044700
2	DIMENSION U(121,1),COLD(NOLD),CNEW(NOLD)	044800
3	UMAX=U(1)	044900
4	UMIN=U(1)	045000
5	DO 99 J=1,JM	045100
6	DO 100 I=1,IM	045200
7	IF(U(I,J).GT.UMAX)UMAX=U(I,J)	045300
8	100 IF(U(I,J).LT.UMIN)UMIN=U(I,J)	045400
9	99 CONTINUE	045500
10	NNEW=0	045600
11	DO 200 N=1,NOLD	045700
12	IF (COLD(N).GT.UMAX) GO TO 200	045800
13	IF (COLD(N).LT.UMIN) GO TO 200	045900
14	NNEW=NNEW+1	046000
15	CNEW(NNEW)=COLD(N)	046100
16	200 CONTINUE	046200
17	RETURN	046300
18	END	046400
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C		046500
C	SUBROUTINE SKETCH	046600
C		046700
1 C	SKETCHII	046800
2 C	ROUTINE FOR CONTOUR PLOTTING OF A REGULAR MATRIX OF DATA.	046900
3 C	THE DATA MUST BE ARRANGED SO THAT ADJACENT ROWS AND COLUMNS	047000
4 C	REPRESENT ADJACENT R,Z COORDINATES. THIS IS THE CASE FOR DATA	047100
5 C	TAKEN ON THE POLE FIGURE GONIOMETER. THE ROWS ARE DATA TAKEN	047200
6 C	ON A PARTICULAR SPIRAL, WHILE THE COLUMNS REPRESENT DATA TAKEN AT THE	047300
7 C	SAME AZIMUTH. THE ROUTINE ORGANIZES DATA INTO SUBSETS OF FOUR	047400
8 C	POINTS WHICH FORM A BOX U,R,Z(1 THRU 4).	047500
9 C	A FIFTH POINT (5) IS INTERPOLATED IN THE CENTER OF THE BOX.	047600
10 C	NEXT THE BOX IS SUBDIVIDED INTO FOUR TRIANGLES, WITH THE FIFTH	047700
11 C	POINT SHARED BY ALL FOUR TRIANGLES. THE ROUTINE TRIANG DOES THE	047800
12 C	CONTOUR LOCATION AND PLOTTING. ON THE LAST SPIRAL, A SPECIAL	047900
13 C	PROCEDURE IS NECESSARY.	048000
14	DIMENSION U(5),R(5),Z(5),CNEW(8)	048100
15	COMMON /COM1/IK(20),IGUT(1001),TTL(10)	048200
16	COMMON /COM2/B(50,30),D(50,30),A(50,30),C(8)	048300
17	COMMON /SCAN/ASTART,ADEC,PSTART,BDEC,PSTOP	048400
18	M=1	048500
19	MU=1	048600
20	MUTOT=0	048700
21	N4=IK(7)	048800
22	IMAX=IK(5)-1	048900
23	IMAX2=2*IK(5)	049000
24	JMAX=IK(6)-1	049100
25 C	LOOP FOR EACH SPIRAL EXCEPT THE LAST	049200
26	DO 26 J=1,JMAX	049300
27	J9=J	049400
28	CALL RANGE(A(I,J9),IK(5),2,IMAX2,C,N4,CNEW,NNEW)	049500
29	IF (NNEW.LE.0) GO TO 26	049600
30 C	LOOP FOR EACH POINT ON SPIRAL	049700
31	DO 27 I3=1,IMAX	049800
32	I=I3	049900
33 C		050000
34 C	SET UP BOX	050100
35 C		050200
36	U(2)=A(I,J)	050300
37	R(2)=B(I,J)	050400
38	Z(2)=D(I,J)	050500
39	U(3)=A(I+1,J)	050600
40	R(3)=B(I+1,J)	050700
41	Z(3)=D(I+1,J)	050800
42	U(4)=A(I+1,J+1)	050900
43	R(4)=B(I+1,J+1)	051000
44	Z(4)=D(I+1,J+1)	051100
45	U(1)=A(I,J+1)	051200
46	R(1)=B(I,J+1)	051300
47	Z(1)=D(I,J+1)	051400
48	U(5)=0.25*(U(1)+U(2)+U(3)+U(4))	051500
49	R(5)=0.25*(R(1)+R(2)+R(3)+R(4))	051600
50	Z(5)=0.25*(Z(1)+Z(2)+Z(3)+Z(4))	051700
51 C	LOOK AT EACH CONTOUR (THERE ARE NNEW)	051800
52	DO 27 K1=1,NNEW	051900
53	K=K1	052000
54 C	LOOK AT EACH TRIANGLE (THERE ARE FOUR)	052100
55	DO 27 M5=1,4	052200
56	I1=M5	052300
57	I2=M5+1	052400
58	IEND=M5-1	052500
59	IF (I2.LE.4) GO TO 27	052600
60	I2=I2-4	052700

27	CALL TRIANG(U,R,Z,CNEW,I1,I2,K,IEND,LEGCOM,I,J9,MUTOT,MU)	052800
26	CONTINUE	052900
	IF(PSTOP.GT.0.001) GO TO 200	053000
C	ABANDON BOX PROCEDURE,USE TRIANGLES WITH THE CENTER OF	053100
C	THE POLE FIGURE AS THE COMMON VERTEX (5).	053200
	CALL RANGE(A(1,JMAX+1),IK(5),1,IMAX+1,C,N4,CNEW,NNEW)	053300
1	IF(NNEW.LE.0) GO TO 200	053400
2	U(5)=A(IMAX+1,JMAX+1)	053500
3	R(5)=0.	053600
4	Z(5)=0.	053700
5	I1=2	053800
6	I2=3	053900
7	J=JMAX+1	054000
8	DO 126 K1=1,NNEW	054100
9	K=K1	054200
10	DO 126 I=1,IMAX	054300
11	I9=I	054400
12	IEND=I-1	054500
13	U(2)=A(I,J)	054600
14	R(2)=B(I,J)	054700
15	Z(2)=D(I,J)	054800
16	U(3)=A(I+1,J)	054900
17	R(3)=B(I+1,J)	055000
18	Z(3)=D(I+1,J)	055100
19	CALL TRIANG(U,R,Z,CNEW,I1,I2,K,IEND,LEGCOM,I9,J,MUTOT,MU)	055200
20	126 CONTINUE	055300
21	C PLOT ALL REMAINING POINTS IN TRIANGLE BY CALLING WITH IEND=-1.	055400
22	200 IEND=-1	055500
23	CALL TRIANG(U,R,Z,C,I1,I2,K,IEND,LEGCOM,I9,J,MUTOT,MU)	055600
24	IK(20)=IK(20)+MUTCT	055700
25	RETURN	055800
26	END	055900
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C	SUBROUTINE TRIANG(U,R,Z,C,I1,I2,K,IEND,LECCOM,I,J,MUTOT,MU)	056000
G		056100
1C	NEWTRI	056200
2C		056300
3C	ROUTINE WHICH DETERMINES AND PLOTS THE POSITION OF CONTOURS.	056400
4C	INCLUDES LOGIC TO ELIMINATE REDUNDANT CALCULATIONS. FOR EXAMPLE,	056500
5C	EACH EDGE OF EVERY TRIANGLE IS SHARED WITH ANOTHER TRIANGLE.	056600
6C	BY USING CONTINUITY, THE NUMBER OF CALCULATION IS CUT IN HALF.	056700
7C	PLOTTING IS DONE WITH THE AID OF THE FUNCTIONS BRACE AND GUESS,	056800
8C	WHICH RESPECTIVELY DETERMINE IF A CONTOUR PASSES THRU A LEG AND	056900
9C	ITS INTERSECTION WITH THE LEG. PLOTTING IS DONE BY CALLING DVR1.	057000
10	INTEGER EDGE,XEDGE,YEDGE,X,Y,XL,YL	057100
11	DIMENSION R(5),Z(5),U(5),C(8)	057200
12	COMMON /COM1/IK(20),EDGE(10),XEDGE(10),YEDGE(10),X(105,2),Y(105,2)	057300
13	1,XL,YL,IDUM(1349),ITL(10)	057400
14	L=1	057500
15	IF(IEND)1000,100,10	057600
16C		057700
17C	DOES THE COMMON LEG HAVE A CONTOUR.	057800
18	10 IF(LECCOM.EQ.0) GO TO 20	057900
19	X(MU,L)=XL	058000
20	Y(MU,L)=YL	058100
21	L=2	058200
22	GO TO 20	058300
23C		058400
24C	DOES THE I1-5 LEG HAVE A CONTOUR	058500
25	100 IF (BRACE(U(I1),U(5),C(K)).LE.0.) GO TO 20	058600
26	X(MU,L)=GUESS(C(K),U(I1),U(5),R(I1),R(5))	058700
27	Y(MU,L)=GUESS(C(K),U(I1),U(5),Z(I1),Z(5))	058800
28	L=2	058900
29C		059000
30C	CHECK I1-I2 LEG	059100
31	20 GO TO (121,124,123,124),I1	059200
32	121 IF(I.EQ.1) GO TO 123	059300
33	IF(EDGE(K).LE.0) GO TO 500	059400
34	X(MU,L)=XEDGE(K)	059500
35	Y(MU,L)=YEDGE(K)	059600
36	GO TO 600	059700
37	123 IF(BRACE(U(I1),U(I2),C(K)).LE.0.) GO TO 223	059800
38C		059900
39C	I1-I2 LEG HAS A CONTOUR	060000
40C	SAVE FOR EDGE OF NEXT BOX.	060100
41	X(MU,L)=GUESS(C(K),U(I1),U(I2),R(I1),R(I2))	060200
42	Y(MU,L)=GUESS(C(K),U(I1),U(I2),Z(I1),Z(I2))	060300
43	EDGE(K)=1	060400
44	XEDGE(K)=X(MU,L)	060500
45	YEDGE(K)=Y(MU,L)	060600
46	GO TO 600	060700
47	223 EDGE(K)=0	060800
48	GO TO 500	060900
49	124 IF(BRACE(U(I1),U(I2),C(K)).GT.0.) GO TO 590	061000
50C		061100
51C	THE I1-I2 LINE HAS NO CONTOUR	061200
52	500 IF(L.EQ.2) GO TO 23	061300
53	LECCOM=0	061400
54	RETURN	061500
55C		061600
56C	THE I1-I2 LINE HAS A CONTOUR.	061700
57	590 X(MU,L)=GUESS(C(K),U(I1),U(I2),R(I1),R(I2))	061800
58	Y(MU,L)= GUESS(C(K),U(I1),U(I2),Z(I1),Z(I2))	061900
59	600 IF(L.EQ.2) GO TO 601	062000
60	L=2	062100
		062200

	GO TO 23	062300
1	601 LEGCOM =0	062400
	GO TO 24	062500
C		062600
1	THE I2-5 LEG HAS A CONTOUR. SAVE FOR NEXT TRIANGLE.	062700
23	X(MU,L)=GUESS(C(K),U(I2),U(5),R(I2),R(5))	062800
1	Y(MU,L)=GUESS(C(K),U(I2),U(5),Z(I2),Z(5))	062900
2	LEGCOM=1	063000
3	XL=X(MU,L)	063100
4	YL=Y(MU,L)	063200
5	24 MU=MU+1	063300
6		063400
7	WHEN 100 CONTOUR SEGMENTS ARE ACCUMULATED, THE PLOTTING ROUTINE	063500
8	OWN1 IS CALLED.	063600
9	IF(MU.LT.100)RETURN	063700
10	MU=MU-1	063800
11	DO 25 KK=1,MU	063900
12	FX=X(KK,1)	064000
13	FY=Y(KK,1)	064100
14	GX=X(KK,2)	064200
15	GY=Y(KK,2)	064300
16	CALL MOVEA(FX,FY)	064400
17	CALL DRAWA(GX,GY)	064500
18	25 CONTINUE	064600
19	MUTOT=MUTOT+MU	064700
20	MU=1	064800
21	26 RETURN	064900
22	1000 IF(MU.EQ. 1) GO TO 46	065000
23	DO 45 KK=1,MU	065100
24	PX=X(KK,1)	065200
25	PY=Y(KK,1)	065300
26	QX=X(KK,2)	065400
27	QY=Y(KK,2)	065500
28	CALL MOVEA(PX,PY)	065600
29	CALL DRAWA(QX,QY)	065700
30	45 CONTINUE	065800
31	46 PRINT 2,MUTOT	065900
32	2 FORMAT(26HOTAL NO. OF LINES DRAWN=,I4)	066000
33	RETURN	066100
34	END	066200
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	C		066300
		SUBROUTINE MAX	066400
1	C	MAXII LABELS MAXIMA AND CONTOURS WITHOUT OVERLAP	066500
2		COMMON /COM1/IK(20),MX(600),MY(600),MU(601),TTL(10)	066600
3		DIMENSION CONT(8),ITHETA(4)	066700
4		COMMON/ COM2/X(50,30),Y(50,30),U(50,30),UISO(8)	066800
5		13 IMAX=IK(5)-1	066900
6		JMAX=IK(6)-1	067000
7		UMAX=.95*UISO(1)	067100
8		MINXS=(8*9)**2	067200
9		MINYS=(8*4)**2	067300
10		NMAX=0	067400
11		JDIF=144	067500
12			067600
13	C	SEARCH FOR MAXIMUM9 IGNORE DATA LESS THAN 95 PERCENT OF LOWEST	067700
14		CONTOUR	067800
15		2 DO 20 J=2,JMAX	067900
16		DO 20 II=2,IMAX	068000
17		JJ=J-2*(J/2)	068100
18		IF(J.LE.0) GO TO 42	068200
19		I=IMAX-II+1	068300
20		GO TO 43	068400
21		42 I=II	068500
22		43 IF(U(I,J).LE.UMAX) GO TO 20	068600
23		IF(U(I,J)-U(I-1,J).LT.0.) GO TO 20	068700
24		IF(U(I,J)-U(I+1,J).LT.0.) GO TO 20	068800
25		IF(U(I,J)-U(I,J-1).LT.0.) GO TO 20	068900
26		IF(U(I,J)-U(I,J+1).LT.0.) GO TO 20	069000
27			069100
28	C	HERE A MAXIMUM HAS BEEN LOCATED. NEXT SECTION CHECKS FOR	069200
29		ANOTHER MAXIMUM IN THE NEIGHBORHOOD, DEFINED BY THE MINIMUM	069300
30		SPACING PARAMETERS ...MINX AND MINYS.	069400
31			069500
32		24 IU=U(I,J)	069600
33		IX=X(I,J)-40.	069700
34		IY=Y(I,J)	069800
35		IF(NMAX.LE.0) GO TO 100	069900
36		NN=1	070000
37		40 LX2=(MX(NN)-IX)**2	070100
38		LY2=(MY(NN)-IY)**2	070200
39		IF(LX2.GT.MINXS) GO TO 50	070300
40		IF(LY2.GT.MINYS) GO TO 50	070400
41			070500
42	C	A NEIGHBOR HAS BEEN FOUND. IGNORE IU IF LESS THAN NEIGHBOR.	070600
43		IF(IU.LE.MU(NN)) GO TO 20	070700
44			070800
45	C	ELIMINATE LESSER MAXIMUM AND UPDATE LISTS.,MU,MX,MY	070900
46			071000
47		NEW=NMAX	071100
48		IF(NN.EQ.NMAX) GO TO 101	071200
49		NMAX=NMAX-1	071300
50		DO 111 N1=NN,NMAX	071400
51		MU(N1)=MU(N1+1)	071500
52		MX(N1)=MX(N1+1)	071600
53		MY(N1)=MY(N1+1)	071700
54		111 CONTINUE	071800
55			071900
56	C	RESUME CHECK FOR NEIGHBORS.	072000
57			072100
58		GO TO 40	072200
59		50 NN=NN+1	072300
60		IF(NN.LE.NMAX) GO TO 40	072400
			072500

100	NMAX=NMAX+1	072600
	NEW=NMAX	072700
101	MU(NEW)=IU	072800
	MX(NEW)=IX	072900
	MY(NEW)=IY	073000
20	CONTINUE	073100
10	ALL ISOLATED MAXIMA HAVE BEEN LOCATED. PLOT THE 12 HIGHEST.	073200
20		073300
30		073400
4	IF (NMAX.LE.12) GO TO 11	073500
50	CALL SORT(MU(1),MU(2),NMAX,MX(1),MY(1))	073600
60	CALL SORTFX(-1)	073700
7	NMAX=12	073800
8	CONTINUE	073900
9	ITT=NMAX+1	074000
10	DO 10 N=1,NMAX	074100
11	BBBB=MX(N)	074200
12	CCCC=MY(N)	074300
13	CALL MOVEA(BBBBB,CCCC)	074400
14	ENCODE(6,1000,FMU) MU(N)	074500
15	1000 FORMAT(I6)	074600
16	CALL AOUTST(6,FMU)	074700
17	10 CONTINUE	074800
180		074900
190	PLOTTING OF MAXIMA COMPLETED.	075000
200		075100
21	DATA ITHETA/0.45,90.120/	075200
22	NTHETA=4	075300
230		075400
240	LABEL CONTOUR LINES ALONG RADII SELECTED BY ITHETA	075500
250		075600
26	NA=IK(7)	075700
27	DO 44 I=1,NTHETA	075800
28	IA=(ITHETA(I)*(IK(5)-1))/180+1	075900
29	JMAX=JMAX-1	076000
30	DO 44 J=1,JMAX	076100
31	DO 44 N=1,N4	076200
32	IF(GRACE(U(IA,J),U(IA,J+1),UISO(N)).LE.8.0) GO TO 44	076300
33	JX=GUESS(U(IA,J),U(IA,J+1),X(IA,J),X(IA,J+1))	076400
34	JY=GUESS(U(IA,J),U(IA,J+1),Y(IA,J),Y(IA,J+1))	076500
35	JX=JX-8	076600
360		076700
370	CHECK THAT LABEL DOES NOT OVERLAP MAXIMA OR LAST LABEL.	076800
380		076900
39	ITEST=1	077000
40	77 CONTINUE	077100
41	JDIST=(JX-JXL)**2+(JY-JYL)**2	077200
42	IF (JDIST.LE.JDIF) GO TO 44	077300
43	JXL=MX(ITEST)	077400
44	JYL=MY(ITEST)	077500
45	ITEST=ITEST+1	077600
46	IF(ITEST.LE.ITT)GO TO 77	077700
47	JXL=JX	077800
48	JYL=JY	077900
49	XJX=JX	078000
50	YJY=JY	078100
51	CALL MOVEA(XJX,YJY)	078200
52	ENCODE(2,1100,CONT(N)) N	078300
53	1100 FORMAT(I2)	078400
54	CALL AOUTST(2,CONT(N))	078500
55	44 CONTINUE	078600
56	RETURN	078700
57	END	078800
58		
59		
60		

C	SUBROUTINE CIRCLE (R)	078900
		079000
		079100
10	CIRCLE	079200
20	SUBROUTINE TO DRAW CIRCLE FOR POLE FIGURE AND LABEL	079300
30	ROLLING AND TRANSVERSE DIRECTIONS (RD AND TD).	079400
4	INTEGER R,R2,BX,BY,DEL	079500
5	COMMON/COM1/IK(20),BX(901),BY(901),TTL(10)	079600
6	R2=R**2	079700
7	DEL=4	079800
8	IZ=(R)/DEL)+1	079900
9	BX(1)=-R	080000
10	BY(1)=0	080100
11		080200
12	DRAW TICK MARKS ALONG ROLLING AND TRANSVERSE DIRECTIONS	080300
13		080400
14	TICK=12.0	080500
15	AR=R	080600
16	SR=AR-TICK	080700
17	FJ=0.0	080800
18	CALL MOVEA(FJ,AR)	080900
19	CALL DRAWA(FJ,SR)	081000
20	CALL MOVEA(FJ,-AR)	081100
21	CALL DRAWA(FJ,-SR)	081200
22	CALL MOVEA(AR,FJ)	081300
23	CALL DRAWA(SR,FJ)	081400
24	CALL MOVEA(-AR,FJ)	081500
25	CALL DRAWA(-SR,FJ)	081600
26		081700
27	DRAW OUTER CIRCLE ONE QUADRANT AT A TIME TO KEEP POINTS 0500.	081800
28	IZZ=IZ-1	081900
29	22 DO 21 I=2,IZ	082000
30	BX(I)=BX(I-1)+DEL	082100
31	21 BY(I)=SQRT(FLOAT(R2-(BX(I)**2)))	082200
32	DO 11 I=1,IZZ	082300
33	FBX=BX(I)	082400
34	FBY=BY(I)	082500
35	FBXX=BX(I+1)	082600
36	FBYY=BY(I+1)	082700
37	CALL MOVEA(FBX,FBY)	082800
38	CALL DRAWA(FBXX,FEYY)	082900
39	11 CONTINUE	083000
40	DO 23 I=2,IZ	083100
41	23 BY(I)=-BY(I)	083200
42	DO 13 I=1,IZZ	083300
43	FBX=BX(I)	083400
44	FBY=BY(I)	083500
45	FBXX=BX(I+1)	083600
46	FBYY=BY(I+1)	083700
47	CALL MOVEA(FBX,FBY)	083800
48	CALL DRAWA(FBXX,FEYY)	083900
49	13 CONTINUE	084000
50	DO 24 I=1,IZ	084100
51	24 BX(I)=-BX(I)	084200
52	DO 14 I=1,IZZ	084300
53	FBX=BX(I)	084400
54	FBY=BY(I)	084500
55	FBXX=BX(I+1)	084600
56	FBYY=BY(I+1)	084700
57	CALL MOVEA(FBX,FBY)	084800
58	CALL DRAWA(FBXX,FEYY)	084900
59	14 CONTINUE	085000
60	DO 25 I=1,IZ	085100

25	BY(I)=-BY(I)	085200
	DO 15 I=1, IZZ	085300
	FBX =BX(I)	085400
	FBY =BY(I)	085500
	FBXX=BX(I+1)	085600
	FBYY=BY(I+1)	085700
1	CALL MOVEA(FBX,FBY)	085800
2	CALL DRAWA(FBXX,FBYY)	085900
3	15 CONTINUE	086000
4	RD=6HR.0.	086100
5	TD=6HT.0.	086200
6	FK=-16.0	086300
7	FL=480.0	086400
8	FJ=-6.0	086500
9	CALL MOVEA(FK,FL)	086600
10	CALL AOUTST(6,TD)	086700
11	CALL MOVEA(FL,FJ)	086800
12	CALL AOUTST(6,RD)	086900
13	RETURN	087000
14	END	087100
15		
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	C		087200
		FUNCTION BRACE(S,T,V)	087300
	C		087400
1	C	BRACE	087500
2	C	FUNCTION WHICH DETERMINES IF A CONTOUR PASSES BETWEEN TWO	087600
3	C	POINTS. RETURN IS 1 IF IT DOES AND 0 IF NOT.	087700
4		IF(S-V)2,2,1	087800
5		2 IF(V-T)3,4,4	087900
6		1 IF(V-T)4,3,3	088000
7		3 BRACE=1.	088100
8		RETURN	088200
9		4 BRACE=0.	088300
10		RETURN	088400
11		END	088500
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	C.	FUNCTION GUESS(AA,BB,CC,DD,EE)	088600
			088700
			088800
1	C	GUESS	088900
2	C	INTERPOLATING FUNCTION FOR LOCATING CONTOUR.	089000
3		GUESS=DD+(EE-DD)*(AA-BB)/(CC-BB)	089100
4		RETURN	089200
5		END	089300
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4	003925	003830	003712	003464	003505	003500	003635
5	003323	003354	003329	003260	003189	003397	003282
6	003173	003170	003254	003220	003200	003029	003154
7	003364	003657	003776	003581			
8	004877	005087	004192	003903	003579	003475	003607
9	003802	003598	003763	003316	003261	003251	003325
10	003282	003301	003172	003086	003077	003136	003025
11	003531	004547	004457	003828			
12	1 1 1 PLANE - PVO ALUMINUM, SPL. NO. D-229, MARCH 1977						
13	005127	005096	005033	004799	004520	004357	004136
14	004038	004133	004115	004179	004170	004175	004241
15	004396	004465	004391	004544	004590	004917	005233
16	010716	010748	009924	009169	008500	007659	006874
17	005919	005686	005631	005554	005305	005488	005659
18	006180	006794	007173	007679	008130	009030	010024
19	021519	021320	019585	018613	016805	014628	013112
20	011161	010397	010159	009796	009217	009523	010135
21	012341	013747	015402	015960	017866	019090	020949
22	023602	023676	022922	023097	022796	021891	020442
23	017765	016325	016333	015575	015423	015560	016599
24	019075	020975	022088	022492	023064	023405	023291
25	020767	020884	021608	022416	024139	024176	024728
26	025222	024813	024520	023719	022933	022759	022533
27	024862	024658	024802	022708	022979	021671	020925
28	015675	016336	017205	018685	020800	023117	025468
29	030635	032157	033043	033059	032438	032227	030181
30	029144	026638	024387	021697	019983	017909	016913
31	007752	007927	008022	009183	009978	011249	013234
32	017628	019306	020405	021460	022664	022300	021247
33	017934	015407	013280	011768	009999	008933	008347
34	004395	004373	004408	004505	004752	004951	005262
35	006702	007044	007232	007340	007992	008161	007877
36	006496	005870	005608	005161	004917	004701	004591
37	003831	003902	003642	003875	004008	003912	003899
38	004190	004184	004251	004256	004422	004512	004392
39	004305	004043	004008	003925	004132	004025	003821
40	003758	003724	003760	003764	003822	003766	003746
41	003797	003788	003816	003779	003984	003797	003856
42	003777	003777	003844	003878	003734	003882	003973
43	003633	003588	003565	003668	003695	003666	003738
44	003737	003758	003699	003739	003629	003779	003756
45	003702	003770	003687	003733	003781	003700	003819
46	003720	003684	003703	003659	003765	003641	003611
47	003711	003636	003604	003695	003681	003571	003629
48	003606	003606	003575	003683	003849	003647	003673
49	003772	003601	003520	003602	003558	003630	003593
50	003476	003524	003551	003480	003533	003593	003554
51	003568	003572	003596	003636	003685	003535	003522
52	003578	003585	003689	003686	003579	003579	003607
53	003584	003583	003608	003566	003493	003475	003466
54	003571	003627	003544	003545	003553	003695	003708
55	003644	003629	003542	003567	003527	003472	003554
56	003575	003620	003535	003548	003561	003500	003599
57	003584	003573	003574	003626	003727	003623	003645
58	003649	003567	003708	003574	003612	003586	003600
59	003543	003582	003656	003695	003476	003595	003666
60	003481	004055	003596	003544	003666	003712	003562

	003518	003603	003587	003480	003526	003497	003654	003643
	003605	003694	003562	003562	003585	003446	003297	003552
	003538	003574	003578	003726	003641	003558	003691	003734
	003547	003556	003431	003613	003569	003560	003517	003646
	003650	003659	003591	003567	003571	003493	003568	003583
	003747	003574	003635	003491	003658	003453	003580	003494
1	003481	003415	003514	003533	003529	003557	003529	003505
2	003583	003529	003519	003539	003508	003665	003455	003605
3	003544	003557	003535	003553	003488	003463	003487	003511
4	003414	003442	003487	003451	003469	003501	003466	003477
5	003432	003485	003549	003453	003493	003425	003497	003380
6	003507	003484	003492	003523	003461	003490	003423	003425
7	003369	003514	003422	003379	003391	003410	003275	003453
8	003488	003493	003456	003536	003318	003505	003397	003445
9	003486	003306	003440	003474	003583	003497	003438	003375
10	003522	003554	003479	003419	003439	003406	003473	003262
11	003461	003428	003432	003393	003428	003478	003389	003564
12	003460	003435	003487	003524	003466	003538	003533	003562
13	004863	004754	004557	004124	003830	003752	003541	003484
14	003552	003362	003512	003445	003483	003519	003450	003452
15	003596	003655	003659	003700	003931	004096	004314	004815
16	016801	015897	013847	011750	009812	007420	006431	005868
17	005061	004885	004661	004606	004224	004563	004665	004876
18	005474	005641	006646	007927	009245	011659	013616	015695
19	104391	100659	085647	067997	053541	040454	032443	025853
20	021483	019538	018525	017894	017196	018263	018881	022399
21	026846	035366	043735	052789	061000	076694	093423	101730
22	366591	354655	313074	269471	215308	171972	148521	128210
23	110552	097313	092727	092499	095938	095908	109849	132597
24	159950	189639	220001	260017	290509	331574	362268	373996
25	399391	366801	336938	299846	270390	238265	212964	196107
26	183028	170880	171334	177931	185816	207830	229534	246382
27	282872	298873	333171	363459	385669	410788	408452	409080
28	202262	192041	175591	167641	164719	170465	168966	172972
29	174228	166665	181625	190839	196043	201716	210685	216983
30	231432	230803	228496	223020	217902	223143	217074	212340
31	-5							
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X-RAY POLE FIGURE ANALYSIS, D. M. Jarboe and
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The capability to produce X-ray pole figures at Bendix Kansas City has been developed. Operating procedures were established and appropriate software was created to allow data acquisition by a minicomputer. Existing FORTRAN IV software was modified to allow data reduction and CRT plotting.

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