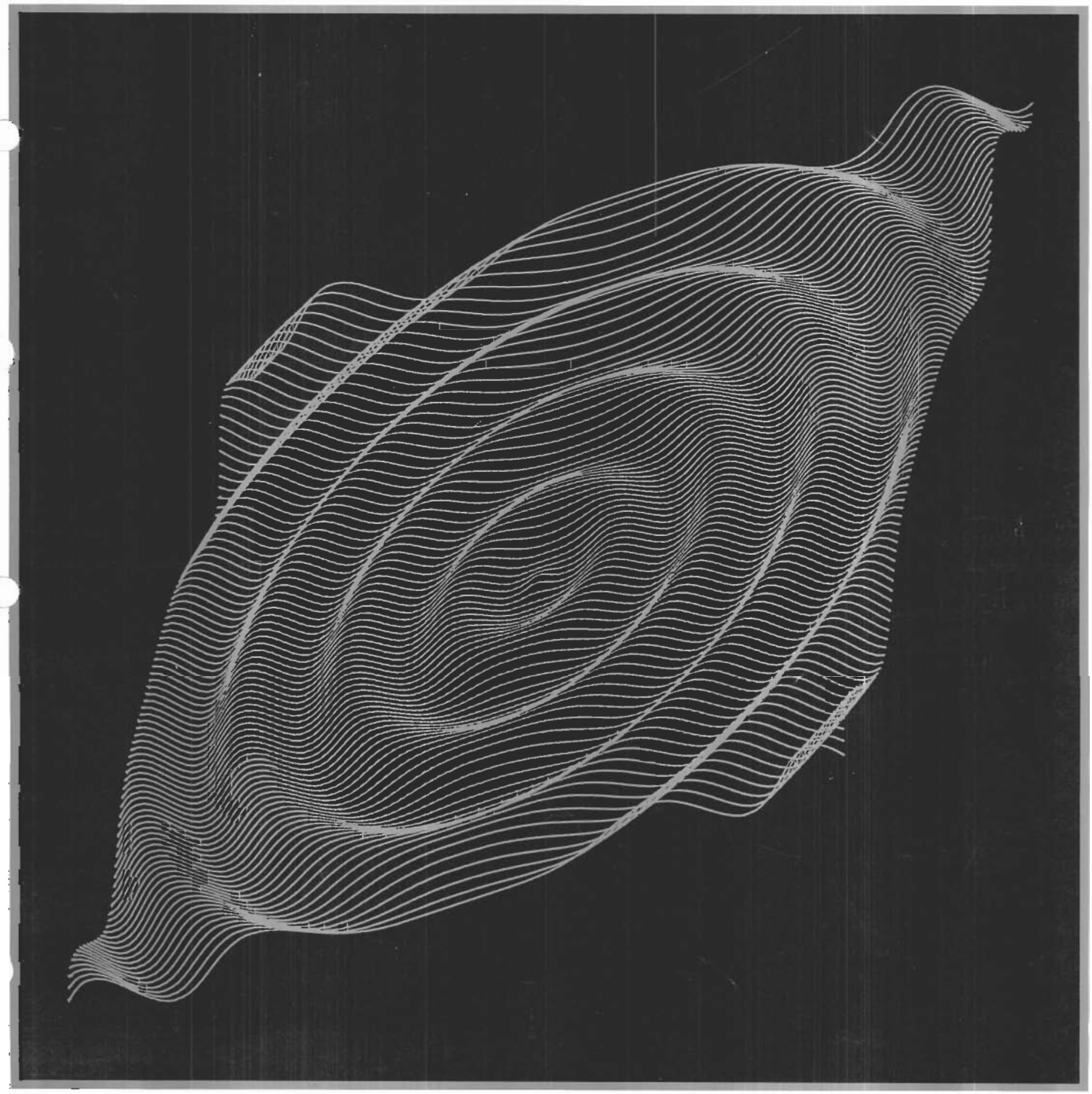
HEWLETT-PACKARD

KEYBOARD

VOL.3 NO.1



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TO HEWLETT-PACKARD SYSTEM 9100 USERS

In the *HP Keyboard,* we are trying to give you the types of information that will keep you up to date on the latest applications, programs and news concerning the HP System 9100.

This issue includes information on three peripherals, the Model 9160A Marked Card Reader, the new Model 9106A Typewriter Coupler, and the new Model 9125B Calculator Plotter, as well as an invitation to send in or share your mathematics programs.

The *Keyboard* is your magazine. Let us know what you want to see in it.

FASTER CALCULATOR PLOTTER

Now you can plot curves and other System 9100 graphic output up to two times as fast as you could before.

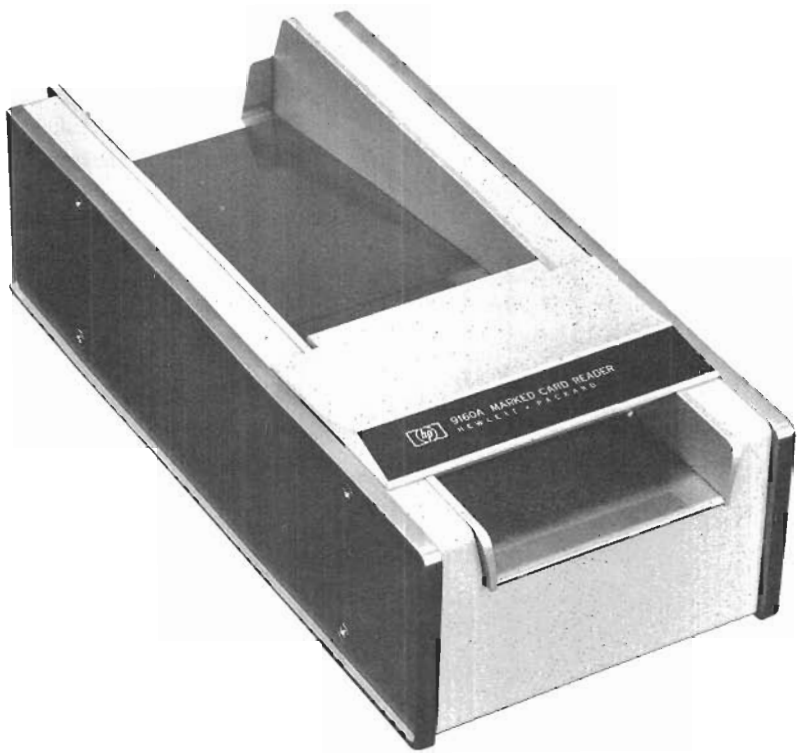
The new 9125B Calculator Plotter which is now being delivered plots between two points in as fast as 0.4 second compared to 0.9 second for the 9125A. The resolution and accuracy are the same for either model. This means that for the same plotting time you can program smaller line increments for a smoother curve, or for the same line increments, considerable time is saved in the case of complex plots.

Price and delivery information is available from your local HP salesman.

TABLE OF CONTENTS

COVER

The cover features WAVES, the first prize winning entry in the U.S. branch of the *Keyboard's* calculator art contest, submitted by Paul Milnarich of El Paso, Texas. See page 20 for details on this and other entries. The deadline for receiving entries from outside the U.S. was extended to February 15 and winners of that branch of the contest will be published in the next *Keyboard.*



9160A Speeds Data Input

The high speed computational ability of the 9100 series calculators points up the fact that most of us are not particularly adept at keying in data. The time required to key in program steps and data points can become a substantial fraction of the total calculator usage. One of the members of the growing family of calculator peripherals was designed by Hewlett-Packard specifically to solve this problem. The model 9160A Marked Card Reader allows easy off-line preparation of data and program instructions for the calculator.

The Marked Card Reader operates on a very simple principle. It reads the relative value of the light reflected off the card. The presence of a soft lead pencil mark alters the character of the reflected light. This difference is detected by photo transistors and sent to the calculator as input information. This information is in the form of octal key codes. Thus, just as depressing a key on the keyboard electrically generates an octal signal for the calculator, coding pencil marks on the marked card generates similar octal key codes.

Inserting the card into the 9160A starts a motor which draws the card past the reader's optical assembly and deposits it in the card hopper. Cards are manually inserted one at a time. Marks are best made with a blunt, soft lead pencil. A single horizontal line through the box is all that is required. Errors may be corrected by completely erasing the incorrect mark. Alternatively, a skip channel is provided on each card. Marking the skip channel causes the 9160A Marked Card Reader to completely ignore that line.

With the calculator set in program mode, operation of the card reader loads programs from the marked card into the calculator. Each card contains two complete registers of instructions and cards may be cascaded to completely fill the calculator's memory. Program steps are coded in the octal key code by adding the column weights to total the digits of the key code.

The card reader will also operate with the calculator in the run mode to load data directly into the three display registers. The data-formatted marked card is typically used for this application. Digits coded on the data card are entered directly into the calculator's X-register just as are digits keyed from the keyboard. By coding octal 27, the UP instruction, data can be moved into the calculator's Y and Z registers. Thus, it is possible to fill all three display registers in the calculator with data using a single marked card. The final code on the data card will normally be a CONTINUE instruction, octal 47. This will cause the calculator to begin automatic operation and accept and process the data which has just been entered by the marked card.

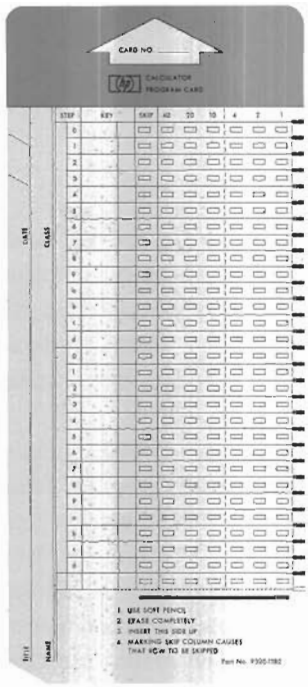
One special precaution is required when using the 9160A Marked Card Reader to enter data. After executing a stop for data entry the next two instructions stored in the calculator's memory should be PAUSE. Inserting a card in the 9160A blanks the display on the 9100. The printer and plotter take their information from the calculator's display registers. The card must be out of the card reader, for example, to enable executing a print command. The pause instructions allow enough time for the 9160A to eject the mark sense card before continuing with the balance of your program.

The marked card reader allows many people to simultaneously code programs for the equipment without tying up its keyboard. This is particularly useful in classroom situations. Students can be assigned programming problems which they can prepare at home away from the calculator without any special equipment. Programs prepared in this manner are immediately read into the calculator using the 9160A. This greatly increases machine utilization and allows every student an opportunity to program.

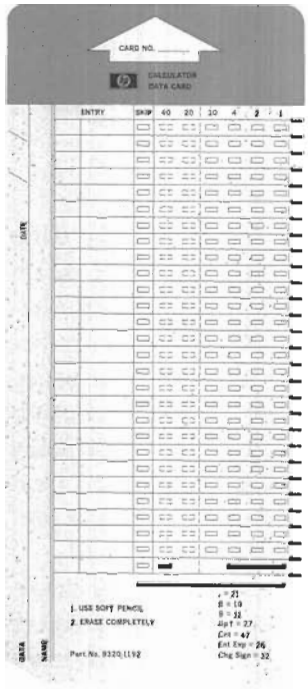
Data preparation can also be particularly time consuming. This is especially true where a number of statistical analyses are to be run on the same set of data. Preparing data on marked cards allows the data to be repetitively fed into the calculator rapidly without any possibility of errors in keyboard entry. You are assured that the data is exactly the same for each analysis, and it has only to be prepared once.

The marked card also allows data preparation in locations remote from the calculator itself. Surveyors, for example, find marked cards particularly useful in recording field data. At the end of the day's field work, the surveyor gives his notebook to a secretary, who in turn records the field data on marked cards. She uses the cards to run a compass rule adjustment of a traverse, calculating error of closure, precision ratio, and area. The cards are then retained for future reference as a part of the permanent surveying record.

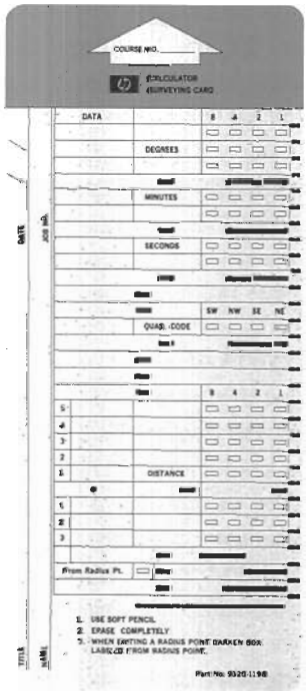
The model 9160A Marked Card Reader speeds data input in many other applications. Your local HP salesman will gladly show you how it can help with your own particular problems.



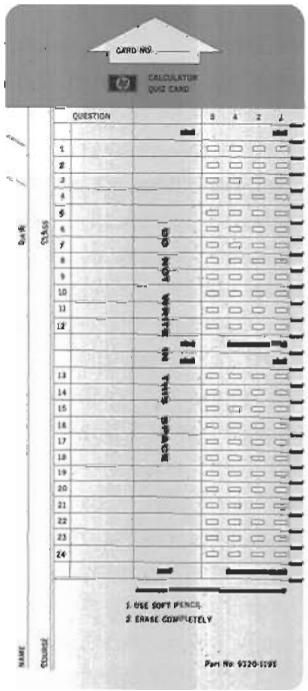
PROGRAM CARD



DATA CARD



SURVEYING CARD



QUIZ CARD

MATRIX INVERSION, N ≤ 14

EXTENDED MEMORY
Program II
Revised 15 Dec. 1970

This program will determine the inverse, A^{-1}, of a square matrix, A. The matrix can be shown in the following form:

$$A = \begin{pmatrix} A_{11}A_{12}A_{13} & \cdots & A_{1N} \\ A_{21}A_{22}A_{23} & \cdots & A_{2N} \\ A_{31}A_{32}A_{33} & \cdots & A_{3N} \\ \cdots & \cdots & \cdots \\ A_{N1}A_{N2}A_{N3} & \cdots & A_{NN} \end{pmatrix} \text{ for } 2 \leq N \leq 14$$

The program uses a modified Gauss-Jordan elimination technique. New elements are overlayed as they are computed in order to save storage space. In addition, a pivot search is utilized to maximize accuracy and allow the inclusion of "zero" elements in the initial matrix.

The user inputs the value of "N" and the matrix elements, row by row, either manually or using marked cards and the HP Model 9160A Marked Card Reader. The elements are stored in the 9101A from register 247 through 247 - (N x N). After the matrix has been loaded, the user may change any of the elements that were incorrectly specified by using the Corrector Option.

In the event that the matrix is singular, the calculator will execute a programmed error routine. This routine calls for division by zero, placing a 9.999 999 999 x 10^{99} in the Y-register and lighting the error light. The program will also stop execution.

Maximum execution time (for N = 14) is approximately 3-2/3 minutes. Upon completion of the program, the calculator will print out the inverse matrix, row by row. The inverse matrix is now stored in the 9101A over the original matrix.

With the Checking Option, the user may invert the inverse matrix (A^{-1}) to reobtain the original matrix. Comparing the reinverted matrix values with the original ones gives an indication of the inversion accuracy for a particular problem. Errors are partly due to inverting and partly to reinverting.

Editor's Note:

The original 14 x 14 Matrix Inversion program published in the 9101A Library and in *Keyboard* Vol. 2 No. 2 has some discrepancies which result in incorrect answers in some cases. The program published here has been revised to eliminate the discrepancies. In addition it allows easy reinversion to check operational accuracy, and allows optional data entry via marked cards.

Reference: V.N. Faddeeva. *Computational Methods of Linear Algebra,* Dover Publications, Inc., New York. 1959. pp. 85-89.

✓ ✓ ✓ ✓

✓ ✓ 4 x

PROGRAM LOADING

1.	File protect switch: OFF			
2.	PRESS: END			
3.	PRESS: CLEAR, FMT, SET FLAG	0	0	0
4.	ENTER PROGRAM P_0			
5.	PRESS: O, FMT, FMT	4	0	0
6.	ENTER PROGRAM P_1			
7.	PRESS: 1, FMT, FMT	13	0	0
8.	ENTER PROGRAM P_2			
9.	PRESS: 2, FMT, FMT	23	0	0
10.	ENTER PROGRAM P_3			
11.	PRESS: 3, FMT, FMT	29	0	0
12.	ENTER PROGRAM P_4			
13.	PRESS: 4, FMT, FMT	37	0	0

PROGRAM EXECUTION

1.	PRESS: 0, FMT, GO TO	4		
2.	PRESS: CONTINUE	14	(Maximum N)	
3.	ENTER DATA: N ($2 \leq N \leq 14$)	N		
4.	PRESS: CONTINUE	0	j(col.)	i(row)
5.	ENTER DATA: A_{ij} (by rows)	A_{ij}	j	i
6.	PRESS: CONTINUE			
	Return to step 5 to enter the next element of the matrix.			
	After all elements have been entered:	0	0	0

7. Check the printout to be sure the correct values have been entered.
8. If incorrect values have been entered, proceed to the Corrector Option.
9. If all the elements are correct, PRESS: CONTINUE.

   The calculator will begin execution.
10. OUTPUT: (by rows) $1 \leq i \leq N$, $1 \leq j \leq N$ A_{ij}^{-1}

    The original matrix is no longer in storage. To rerun the program for a new matrix return to execution step 1, or to check the inverse enter the Checking Option and PRESS: CONTINUE.

✓ ✓ ✓ ✓

✓ ✓ 4 x

CHECKING OPTION

1. ENTER CHECKING OPTION PROGRAM.
2. PRESS: CONTINUE
3: (by rows) $A = (A^{-1})^{-1}$ A_{ij}

CORRECTOR OPTION

1. PRESS: END, ENTER CORRECTOR OPTION PROGRAM
2. PRESS: CONTINUE 0 0 0
3. ENTER CORRECT DATA: i, j, A_{ij} A_{ij} j(col.) i(row)
4. PRESS: CONTINUE

   The calculator will store the correct A_{ij} value in the 9101A. To replace additional elements, return to step 3 above.

   After all corrections are made:
5. PRESS: 1, FMT, GO TO
6. PRESS: CONTINUE

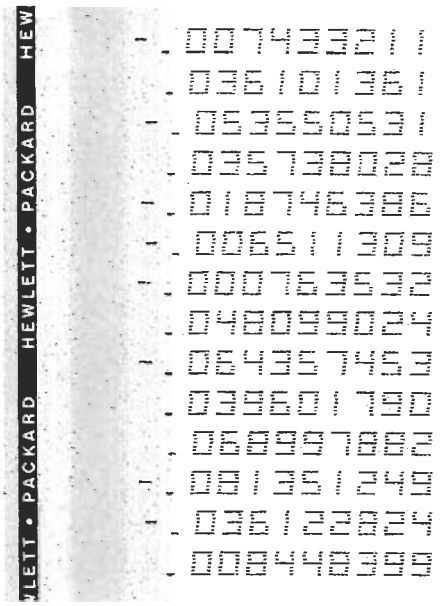
   The calculator will begin execution.

EXAMPLES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	2.6	3	7	-8	-4	6	-3	5	1	2	17	-1	.5	4
2	2.2	4	.34	8.7	6.6	1.7	.54	1.2	-3.4	.61	5.8	.9	-.40	.55
3	.7	.44	-.7	7.7	.97	-9.8	.24	.75	.67	.48	3.3	-.2	3.9	-.92
4	5.3	-5.1	5.9	1.3	.63	2.3	.81	.98	.42	-.33	.65	7.4	1.1	.94
5	7.4	2.1	-7.9	.91	.56	7.1	-.19	-2.3	.44	.99	3.7	.44	.52	.41
6	5.0	.26	5.6	.47	4.2	.93	-6.6	2.1	5.1	.42	4.4	-.58	.21	9.1
7	3.4	4.7	-.6	.75	8.3	.47	1.2	.5	.46	6.2	2.5	.84	-.63	7.3
8	7.5	2.1	3.5	-4.3	.74	-.9	5.6	.69	.25	1.2	8.6	.6	5.5	8.5
9	-5.9	9.1	7.2	.2	.58	9.1	.95	8.6	2.3	.87	.99	.67	1.2	6.4
10	4.3	-9.4	.37	.75	-.66	7.6	.79	8.1	-.83	.5	.94	.24	3.1	.78
11	1.9	8.5	.16	.54	6.5	-.17	.7	3.1	6.5	.42	.88	.18	0.7	-.59
12	.73	-.5	.2	-1.2	6.1	.91	.86	.1	.83	-.4	7.7	3.8	.74	-.18
13	.5	-8.3	1.2	-.6	3.4	3.8	9.2	2.9	.79	.79	-8.7	.39	.94	.53
14	-.3	6.9	.98	5.5	.48	7.9	1.3	8.1	1.1	.22	4.1	.66	-7.8	2

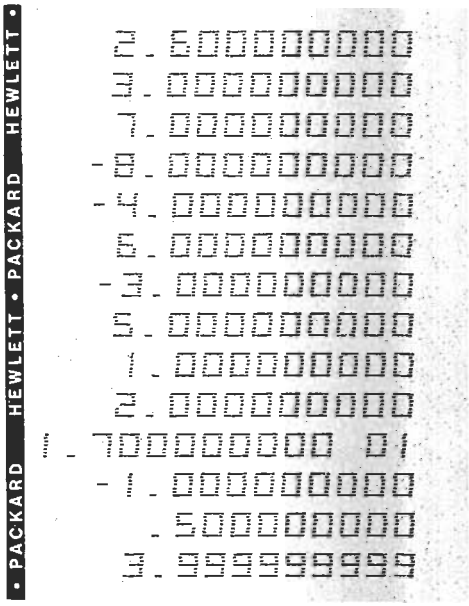
EXAMPLES

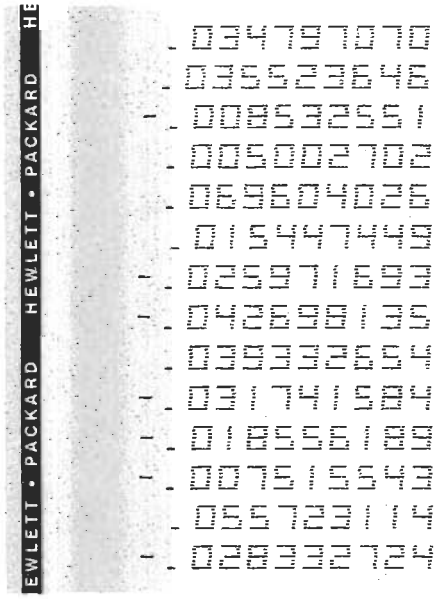
Sample Inverted Matrix Rows:



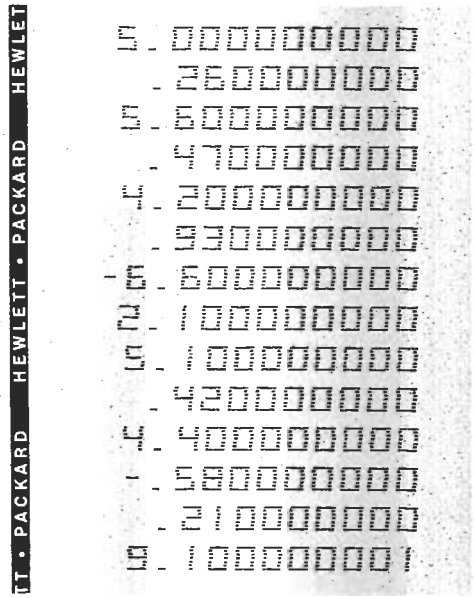
1st Row

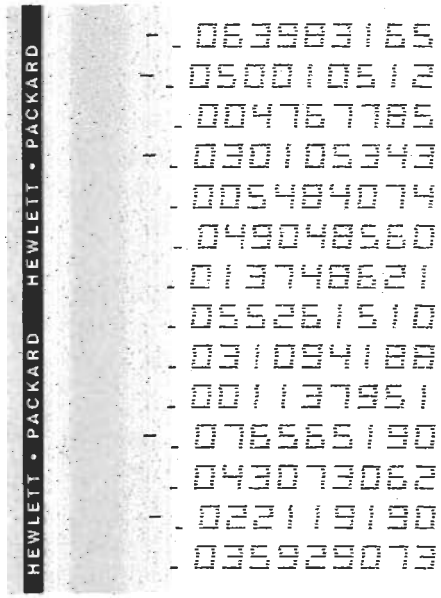
Sample Reinverted Matrix Rows:



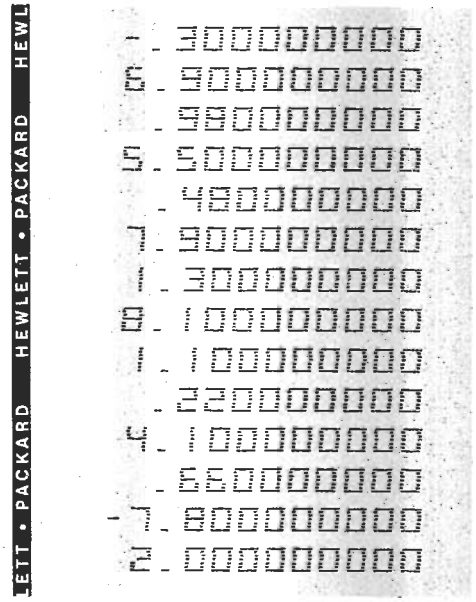


6th Row





14th Row



HILBERT MATRIX

The Hilbert matrix of order n

$$H_n = \begin{bmatrix} 1 & \frac{1}{2} & \frac{1}{3} & \cdots & \frac{1}{n} \\ \frac{1}{2} & \frac{1}{3} & \frac{1}{4} & \cdots & \frac{1}{n+1} \\ \frac{1}{3} & \frac{1}{4} & \frac{1}{5} & \cdots & \frac{1}{n+2} \\ \frac{1}{n} & \frac{1}{n+1} & & \cdots & \frac{1}{2n-1} \end{bmatrix}$$

is frequently used in testing algorithms for matrix inversion, because a very small change in the coefficients produces a very large change in the solution. The example below shows the results of inverting and reinverting a Hilbert matrix of order 5.

Original Matrix

```
 5.

 1.
  .5
  .333333
  .25
  .2

  .5
  .333333
  .25
  .2
  .166667

  .333333
  .25
  .2
  .166667
  .142857

  .25
  .2
  .166667
  .142857
  .125

  .2
  .166667
  .142857
  .125
  .111111
```

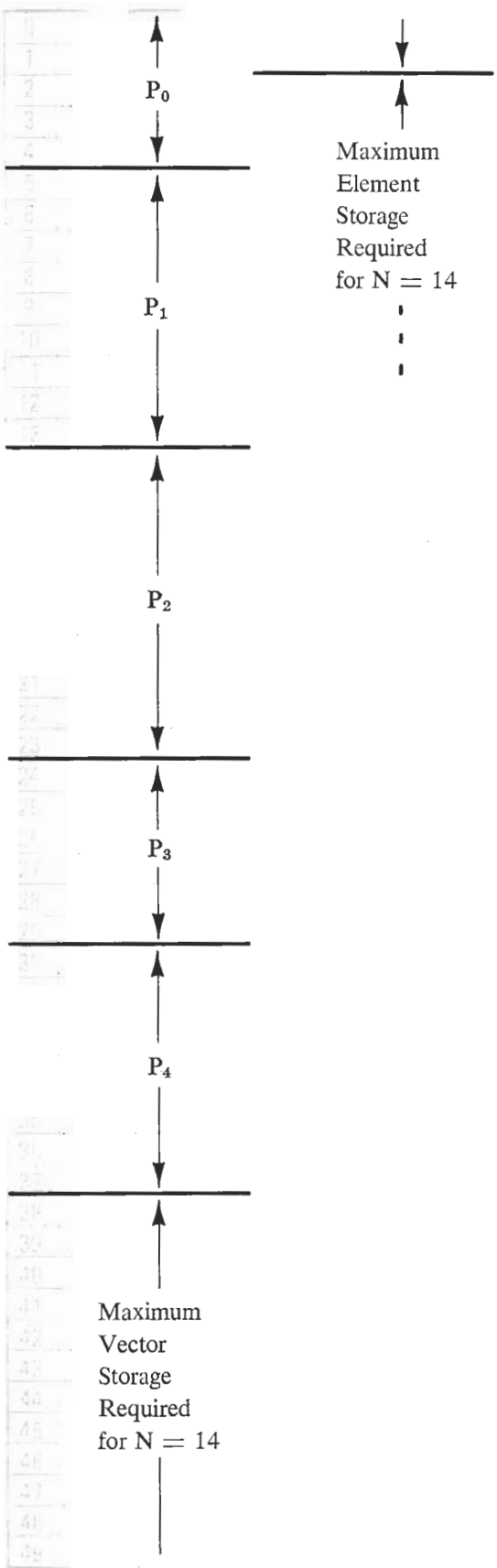
Inverted

```
 5.

 2.693141120 01
-3.360183559 02
 1.205113438 03
-1.634034255 03
 7.444113142 02

-3.360183574 02
 5.471181610 03
-2.178895579 04
 3.123723651 04
-1.472951786 04

 1.205113448 03
-2.178895585 04
 9.181065019 04
-1.363439137 05
 6.585911726 04

-1.634034313 03
 3.123723666 04
-1.363439140 05
 2.074588446 05
-1.020068465 05

 7.444113244 02
-1.472951796 04
 6.585911748 04
-1.020068466 05
 5.084521055 04
```

Reinverted

```
 5.

 1.000000
  .500000
  .333333
  .250000
  .200000

  .500000
  .333333
  .250000
  .200000
  .166667

  .333333
  .250000
  .200000
  .166667
  .142857

  .250000
  .200000
  .166667
  .142857
  .125000

  .200000
  .166667
  .142857
  .125000
  .111111
```

Reference: D. Morsund and C. Duris, *Elementary Theory and Application of Numerical Analysis,* McGraw-Hill Book Company, New York, 1967, pp 61-63 and 159-162.


P0
P1
P2
P3
P4
Maximum
Element
Storage
Required
for N = 14
Maximum
Vector
Storage
Required
for N = 14

Program P_0

00	CLR	20
01	1	01
02	4	04
03	STP	41
04	PSE	57
05	INT	64
06	PNT	45
07	PNT	45
08	XTO	23
09	d	17
0a	1	01
0b	+	33
0c	AC+	60
0d	RCL	61
10	UP	27
11	d	17
12	X=Y	50
13	CNT	47
14	SFL	54
15	CLX	37
16	STP	41
17	PSE	57
18	IFG	43
19	SFL	54
1a	PNT	45
1b	PNT	45
1c	RDN	31
1d	1	01
20	-	34
21	d	17
22	X	36
23	f	15
24	+	33
25	2	02
26	4	04
27	8	10
28	XEY	30
29	-	34
2a	DN	25
2b	FMT	42
2c	YTO	40
2d	IFG	43
30	3	03
31	8	10
32	CLX	37
33	UP	27
34	1	01
35	GTO	44
36	0	00
37	c	16
38	RCL	61
39	X=Y	50
3a	4	04
3b	2	02
3c	AC-	63
3d	GTO	44
40	0	00
41	a	13
42	CLR	20
43	XTO	23
44	a	13
45	STP	41
46	PSE	57
47	1	01
48	FMT	42
49	GTO	44
4a	END	46

Program P_1

00	a	13
01	UP	27
02	1	01
03	+	33
04	d	17
05	X<Y	52
06	8	10
07	8	10
08	YTO	40
09	a	13
0a	CLR	20
0b	XTO	23
0c	c	16
0d	XTO	23
10	b	14
11	UP	27
12	1	01
13	+	33
14	CLX	37
15	XTO	23
16	f	15
17	d	17
18	X<Y	52
19	6	06
1a	b	14
1b	YTO	40
1c	b	14
1d	a	13
20	UP	27
21	1	01
22	X=Y	50
23	4	04
24	7	07
25	-	34
26	UP	27
27	f	15
28	+	33
29	DN	25
2a	X>Y	53
2b	4	04
2c	7	07
2d	XTO	23
30	f	15
31	d	17
32	UP	27
33	X	36
34	f	15
35	+	33
36	2	02
37	4	04
38	8	10
39	XEY	30
3a	-	34
3b	b	14
3c	XEY	30
3d	FMT	42
40	π	56
41	X=Y	50
42	1	01
43	0	00
44	GTO	44
45	1	01
46	d	17
47	b	14
48	UP	27
49	d	17
4a	X	36
4b	-	34
4c	a	13
4d	+	33

50	2	02
51	4	04
52	8	10
53	XEY	30
54	-	34
55	DN	25
56	FMT	42
57	π	56
58	UP	27
59	|Y|	55
5a	c	16
5b	X>Y	53
5c	1	01
5d	0	00
60	X=Y	50
61	1	01
62	0	00
63	YTO	40
64	c	16
65	b	14
66	XTO	23
67	e	12
68	GTO	44
69	1	01
6a	0	00
6b	RCL	61
6c	X=Y	50
6d	DIV	35
70	STP	41
71	XTO	23
72	c	16
73	d	17
74	UP	27
75	X	36
76	a	13
77	+	33
78	2	02
79	4	04
7a	8	10
7b	XEY	30
7c	-	34
7d	DN	25
80	FMT	42
81	YTO	40
82	2	02
83	FMT	42
84	GTO	44
85	GTO	44
86	0	00
87	0	00
88	PNT	45
89	PNT	45
8a	3	03
8b	FMT	42
8c	GTO	44
8d	END	46

Program P_2

00	f	15
01	UP	27
02	1	01
03	+	33
04	d	17
05	X<Y	52
06	2	02
07	c	16
08	YTO	40
09	f	15
0a	a	13
0b	X=Y	50
0c	0	00
0d	2	02
10	RCL	61
11	d	17
12	X	36
13	-	34
14	2	02
15	4	04
16	8	10
17	XEY	30
18	-	34
19	YTO	40
1a	b	14
1b	a	13
1c	-	34
1d	YE	24
20	b	14
21	f	15
22	-	34
23	b	14
24	FMT	42
25	π	56
26	XEY	30
27	FMT	42
28	DIV	35
29	GTO	44
2a	0	00
2b	0	00
2c	1	01
2d	UP	27
30	b	14
31	FMT	42
32	π	56
33	DIV	35
34	b	14
35	FMT	42
36	YTO	40
37	YTO	40
38	b	14
39	c	16
3a	XEY	30
3b	1	01
3c	+	33
3d	d	17
40	X<Y	52
41	9	11
42	c	16
43	YTO	40
44	c	16
45	e	12
46	X=Y	50
47	3	03
48	b	14
49	CLX	37
4a	XEY	30
4b	1	01
4c	+	33
4d	d	17
50	X<Y	52
51	9	11
52	4	04
53	YTO	40
54	f	15
55	a	13
56	X=Y	50
57	4	04
58	b	14
59	RCL	61
5a	d	17
5b	X	36
5c	-	34
5d	f	15
60	+	33
61	2	02
62	4	04
63	8	10
64	XEY	30
65	-	34
66	c	16
67	RDN	31
68	FMT	42
69	π	56
6a	RDN	31
6b	d	17
6c	X	36
6d	-	34
70	2	02
71	4	04
72	8	10
73	XEY	30
74	-	34
75	a	13
76	-	34
77	DN	25
78	UP	27
79	FMT	42
7a	π	56
7b	RUP	22
7c	X	36
7d	YE	24
80	f	15
81	a	13
82	XEY	30
83	-	34
84	RDN	31
85	+	33
86	RDN	31
87	YE	24
88	f	15
89	FMT	42
8a	-	34
8b	RUP	22
8c	-	34
8d	UP	27
90	f	15
91	GTO	44
92	4	04
93	a	13
94	b	14
95	CHS	32
96	RUP	22
97	FMT	42
98	X	36
99	GTO	44
9a	3	03
9b	9	11
9c	FMT	42
9d	END	46

Program P_3

00	CLR	20
01	RCL	61
02	1	01
03	+	33
04	d	17
05	X<Y	52
06	5	05
07	c	16
08	YTO	40
09	e	12
0a	CLX	37
0b	XTO	23
0c	f	15
0d	UP	27
10	1	01
11	+	33
12	d	17
13	X<Y	52
14	0	00
15	1	01
16	X=Y	50
17	SFL	54
18	CNT	47
19	YTO	40
1a	f	15
1b	CLX	37
1c	RDN	31
1d	DN	25
20	1	01
21	+	33
22	d	17
23	UP	27
24	X	36
25	2	02
26	4	04
27	8	10
28	XEY	30
29	-	34
2a	YTO	40
2b	c	16
2c	DN	25
2d	XEY	30
30	-	34
31	f	15
32	XEY	30
33	FMT	42
34	π	56
35	X=Y	50
36	3	03
37	b	14
38	GTO	44
39	1	01
3a	d	17
3b	c	16
3c	XEY	30
3d	e	12
40	-	34
41	DN	25
42	FMT	42
43	π	56
44	UP	27
45	1	01
46	-	34
47	d	17
48	X	36
49	DN	25
4a	+	33
4b	2	02
4c	4	04
4d	8	10
50	XEY	30
51	-	34
52	DN	25
53	FMT	42
54	π	56
55	IFG	43
56	CNT	47
57	PNT	45
58	PNT	45
59	GTO	44
5a	0	00
5b	c	16
5c	CLR	20
5d	END	46

EXTENDED MEMORY Program II

Program P_4

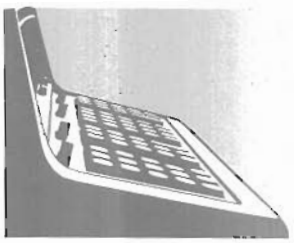
00	CLR	20	50	-	34	00	RCL	61
01	RCL	61	51	UP	27	01	1	01
02	1	01	52	DN	25	02	+	33
03	+	33	53	b	14	03	d	17
04	d	17	54	-	34	04	X<Y	52
05	X<Y	52	55	YTO	40	05	8	10
06	7	07	56	a	13	06	a	13
07	3	03	57	RCL	61	07	YTO	40
08	YTO	40	58	a	13	08	e	12
09	e	12	59	RDN	31	09	YTO	40
0a	1	01	5a	-	34	0a	b	14
0b	-	34	5b	YTO	40	0b	c	16
0c	UP	27	5c	a	13	0c	XEY	30
0d	DN	25	5d	DN	25	0d	-	34
10	1	01	60	FMT	42	10	DN	25
11	+	33	61	π	56	11	FMT	42
12	UP	27	62	XEY	30	12	π	56
13	DN	25	63	FMT	42	13	UP	27
14	c	16	64	π	56	14	CLX	37
15	XEY	30	65	YE	24	15	X>Y	53
16	-	34	66	a	13	16	7	07
17	YTO	40	67	XEY	30	17	c	16
18	b	14	68	FMT	42	18	RDN	31
19	e	12	69	YTO	40	19	DN	25
1a	XEY	30	6a	a	13	1a	1	01
1b	FMT	42	6b	RUP	22	1b	+	33
1c	π	56	6c	FMT	42	1c	UP	27
1d	X=Y	50	6d	YTO	40	1d	DN	25
20	2	02	70	GTO	44	20	c	16
21	5	05	71	3	03	21	XEY	30
22	GTO	44	72	a	13	22	-	34
23	0	00	73	CLR	20	23	YTO	40
24	d	17	74	XTO	23	24	a	13
25	c	16	75	a	13	25	b	14
26	XEY	30	76	1	01	26	XEY	30
27	-	34	77	FMT	42	27	FMT	42
28	DN	25	78	GTO	44	28	π	56
29	FMT	42	79	END	46	29	X=Y	50
2a	π	56				2a	3	03
2b	UP	27				2b	1	01
2c	b	14				2c	GTO	44
2d	FMT	42				2d	1	01
30	YTO	40				30	9	11
31	DN	25				31	CHS	32
32	e	12				32	XEY	30
33	X=Y	50				33	a	13
34	0	00				34	FMT	42
35	1	01				35	YTO	40
36	YTO	40				36	DN	25
37	b	14				37	e	12
38	CLX	37				38	X=Y	50
39	XTO	23				39	7	07
3a	f	15				3a	c	16
3b	UP	27				3b	YTO	40
3c	1	01				3c	b	14
3d	+	33				3d	CLX	37
40	d	17				40	XTO	23
41	X<Y	52				41	f	15
42	0	00				42	UP	27
43	1	01				43	1	01
44	YTO	40				44	+	33
45	f	15				45	d	17
46	1	01				46	X<Y	52
47	-	34				47	1	01
48	d	17				48	4	04
49	X	36				49	YTO	40
4a	2	02				4a	f	15
4b	4	04				4b	2	02
4c	8	10				4c	4	04
4d	XEY	30				4d	8	10

Checking Option

00	RCL	61	50	XEY	30	00	CLR	20
01	1	01	51	-	34	01	STP	41
02	+	33	52	b	14	02	PSE	57
03	d	17	53	UP	27	03	PSE	57
04	X<Y	52	54	1	01	04	PNT	45
05	8	10	55	-	34	05	PNT	45
06	a	13	56	d	17	06	AC+	60
07	YTO	40	57	X	36	07	DN	25
08	e	12	58	DN	25	08	1	01
09	YTO	40	59	-	34	09	-	34
0a	b	14	5a	YTO	40	0a	d	17
0b	c	16	5b	a	13	0b	X	36
0c	XEY	30	5c	RCL	61	0c	e	12
0d	-	34	5d	1	01	0d	+	33
10	DN	25	60	-	34	10	2	02
11	FMT	42	61	d	17	11	4	04
12	π	56	62	X	36	12	8	10
13	UP	27	63	a	13	13	XEY	30
14	CLX	37	64	RDN	31	14	-	34
15	X>Y	53	65	-	34	15	f	15
16	7	07	66	YTO	40	16	XEY	30
17	c	16	67	a	13	17	FMT	42
18	RDN	31	68	DN	25	18	YTO	40
19	DN	25	69	FMT	42	19	GTO	44
1a	1	01	6a	π	56	1a	0	00
1b	+	33	6b	XEY	30	1b	0	00
1c	UP	27	6c	FMT	42	1c	END	46
1d	DN	25	6d	π	56			
20	c	16	70	YE	24			
21	XEY	30	71	a	13			
22	-	34	72	XEY	30			
23	YTO	40	73	FMT	42			
24	a	13	74	YTO	40			
25	b	14	75	a	13			
26	XEY	30	76	RUP	22			
27	FMT	42	77	FMT	42			
28	π	56	78	YTO	40			
29	X=Y	50	79	GTO	44			
2a	3	03	7a	4	04			
2b	1	01	7b	1	01			
2c	GTO	44	7c	c	16			
2d	1	01	7d	UP	27			
30	9	11	80	e	12			
31	CHS	32	81	-	34			
32	XEY	30	82	1	01			
33	a	13	83	CHS	32			
34	FMT	42	84	XEY	30			
35	YTO	40	85	FMT	42			
36	DN	25	86	X	36			
37	e	12	87	GTO	44			
38	X=Y	50	88	0	00			
39	7	07	89	0	00			
3a	c	16	8a	4	04			
3b	YTO	40	8b	FMT	42			
3c	b	14	8c	GTO	44			
3d	CLX	37	8d	END	46			
40	XTO	23						
41	f	15						
42	UP	27						
43	1	01						
44	+	33						
45	d	17						
46	X<Y	52						
47	1	01						
48	4	04						
49	YTO	40						
4a	f	15						
4b	2	02						
4c	4	04						
4d	8	10						

Corrector Option

00	CLR	20	50	XEY	30	00	CLR	20
01	STP	41	51	-	34	01	STP	41
02	PSE	57	52	b	14	02	PSE	57
03	PSE	57	53	UP	27	03	PSE	57
04	PNT	45	54	1	01	04	PNT	45
05	PNT	45	55	-	34	05	PNT	45
06	AC+	60	56	d	17	06	AC+	60
07	DN	25	57	X	36	07	DN	25
08	1	01	58	DN	25	08	1	01
09	-	34	59	-	34	09	-	34
0a	d	17	5a	YTO	40	0a	d	17
0b	X	36	5b	a	13	0b	X	36
0c	e	12	5c	RCL	61	0c	e	12
0d	+	33	5d	1	01	0d	+	33
10	2	02	60	-	34	10	2	02
11	4	04	61	d	17	11	4	04
12	8	10	62	X	36	12	8	10
13	XEY	30	63	a	13	13	XEY	30
14	-	34	64	RDN	31	14	-	34
15	f	15	65	-	34	15	f	15
16	XEY	30	66	YTO	40	16	XEY	30
17	FMT	42	67	a	13	17	FMT	42
18	YTO	40	68	DN	25	18	YTO	40
19	GTO	44	69	FMT	42	19	GTO	44
1a	0	00	6a	π	56	1a	0	00
1b	0	00	6b	XEY	30	1b	0	00
1c	END	46	6c	FMT	42	1c	END	46
			6d	π	56			
70	YE	24						
71	a	13						
72	XEY	30						
73	FMT	42						
74	YTO	40						
75	a	13						
76	RUP	22						
77	FMT	42						
78	YTO	40						
79	GTO	44						
7a	4	04						
7b	1	01						
7c	c	16						
7d	UP	27						
80	e	12						
81	-	34						
82	1	01						
83	CHS	32						
84	XEY	30						
85	FMT	42						
86	X	36						
87	GTO	44						
88	0	00						
89	0	00						
8a	4	04						
8b	FMT	42						
8c	GTO	44						
8d	END	46						



AVERAGE PROPERTIES OF FLUID MIXTURES

by Walter Karger

PART NO. 09100-75609 9100B ONLY

This set of programs allows the averaging of several constants (properties such as MW, T_c, p_c, C_p) for a fixed or variable composition, where the fraction of each component (x_i) is derived in turn from either its weight (w_i) or its volume (v_i). The relationships that are used are:

For Program IA:

$$MW_{av} = \frac{\Sigma w_i}{\Sigma(\frac{w}{MW})_i} \quad \text{and} \quad x_i = \frac{(\frac{w}{MW})_i}{\Sigma(\frac{w}{MW})_i}$$

For Program IB:

$$MW_{av} = \frac{\Sigma(MW \cdot v)_i}{\Sigma v_i} \quad \text{and} \quad x_i = \frac{v_i}{\Sigma v_i}$$

Both programs store x_i for up to 16 components.

For Program II:

$p_c = \Sigma(x_i \cdot p_c, i)$; $T_c = \Sigma(x_i \cdot T_c, i)$, etc.

This program, cascaded from Program I, averages any two properties at a time, for a given composition of up to 16 components. Additional properties can be averaged, two at a time, by rerunning the program, with the same stored composition.

For Program III:

Using the same relations as Program II, it averages two properties for a variable composition of up to 16 components. Additional compositions can be considered by rerunning the program.

As an example, the programs allow calculating pseudocritical temperature T_c, pseudocritical pressure p_c and molal specific heats MC_p at two different temperatures for a mixture of gases. One application is in thermodynamics of gas compression or gas expansion. Pseudocritical properties are used to obtain the compressibility Z of a gas mixture, and average specific heats to calculate c_p/c_v in accordance with the relation $c_p/c_v = \frac{MC_p}{MC_p - R}$ with $R = 1.987$ in the usual English units.

The programs are written for use with the model 9100B computing Calculator and the 9120A Printer.

Program I, after entry of the molecular weight (MW) of each component, stores in memory the mole fraction x (or mole percent: 100) of each component i, up to a maximum of 16. If the average properties of these components are required for this particular percentage composition only, proceed directly to Program II. If, as happens in multistage compression problems, the mole fractions of the gases change from stage to stage while the kinds of gases and their properties remain the same, first recall, and print out manually, the mole fractions stored after completing Program I. Then proceed to Program III. Program III stores two properties of each gas and calculates their molal average. If more than two physical properties are to be averaged the program can be rerun.

NOTE: Property 1 (which may be T_c or p_c) in this program will always be rounded down to an integer, and Property 2 must not be larger than 10,000. Should Property 1 contain a significant fraction (as in the case of MC_p), it must be multiplied before data entry by 10, 100, 1000 etc. so that no significant figures are lost.

Units are as follows, with Σ designating sum, subscripts i designating component i, av denoting average, and 50 or 300, for example, referring to 50°F or 300°F:

- w = weight, or weight flow, in any consistent units (lb, lb/min, lb/hr, kg/hr, etc.)
- m = moles (or lb-moles/min, kg-moles/hr, etc.)
- p_c = critical pressure in psia, atm absolute or kg/cm² abs.
- T_c = critical temperature in degrees absolute
- MC_p = specific heat of one mole, at constant pressure, with a subscript designating the temperature (in BTU/mol-°F or Cal/mol-°C)
- v = volume in CFM, moles, mole percent, SCFH, etc.

Program IA

00	CLR	20	50	YE	24	a0	GTO	44	20	UP	27	00	CLR	20	50	INT	64
01	XTO	23	51	7	07	a1	9	11	21	GTO	44	01	XTO	23	51	-	34
02	d	17	52	YE	24	a2	0	00	22	.0	00	02	d	17	52	RUP	22
03	UP	27	53	8	10	a3	YE	24	23	2	02	03	UP	27	53	X	36
04	1	01	54	DIV	35	a4	-	34	24	RCL	61	04	1	01	54	YTO	40
05	+	33	55	YE	24	a5	f	15	25	XEY	30	05	+	33	55	-	34
06	YTO	40	56	8	10	a6	YE	24	26	UP	27	06	YTO	40	56	c	16
07	d	17	57	YE	24	a7	-	34	27	CLX	37	07	d	17	57	RDN	31
08	CLX	37	58	9	11	a8	e	12	28	PNT	45	08	CLX	37	58	DN	25
09	STP	41	59	DIV	35	a9	YE	24	29	GTO	44	09	STP	41	59	X	36
0a	IFG	43	5a	YE	24	aa	-	34	2a	0	00	0a	IFG	43	5a	EEX	26
0b	9	11	5b	9	11	ab	d	17	2b	0	00	0b	2	02	5b	4	04
0c	0	00	5c	YE	24	ac	YE	24	2c	1	01	0c	4	04	5c	X	36
0d	UP	27	5d	0	00	ad	c	16	2d	+	33	0d	PNT	45	5d	XFR	67
10	DN	25	60	DIV	35	b0	YE	24	30	1	01	10	PNT	45	60	-	34
11	DIV	35	61	YE	24	b1	b	14	31	8	10	11	UP	27	61	c	16
12	XEY	30	62	0	00	b2	YE	24	32	X=Y	50	12	EEX	26	62	XEY	30
13	CNT	47	63	YE	24	b3	a	13	33	2	02	13	4	04	63	AC+	60
14	PNT	45	64	a	13	b4	YE	24	34	4	04	14	DIV	35	64	PNT	45
15	PNT	45	65	DIV	35	b5	0	00	35	DN	25	15	DN	25	65	PNT	45
16	RUP	22	66	YE	24	b6	YE	24	36	GTO	44	16	XEY	30	66	CLX	37
17	AC+	60	67	a	13	b7	9	11	37	SUB	77	17	INT	64	67	UP	27
18	GTO	44	68	YE	24	b8	YE	24	38	4	04	18	+	33	68	GTO	44
19	SUB	77	69	b	14	b9	8	10	39	0	00	19	GTO	44	69	3	03
1a	a	13	6a	DIV	35	ba	YE	24	3a	DN	25	1a	SUB	77	6a	8	10
1b	3	03	6b	YE	24	bb	7	07	3b	GTO	44	1b	8	10	6b	1	01
1c	CLX	37	6c	b	14	bc	YE	24	3c	2	02	1c	6	06	6c	+	33
1d	UP	27	6d	YE	24	bd	6	06	3d	c	16	1d	CLX	37	6d	1	01
20	GTO	44	70	c	16	c0	YE	24	40	RDN	31	20	UP	27	70	8	10
21	0	00	71	DIV	35	c1	5	05	41	YE	24	21	GTO	44	71	X=Y	50
22	2	02	72	YE	24	c2	YE	24	42	-	34	22	0	00	72	7	07
23	RCL	61	73	c	16	c3	4	04	43	f	15	23	2	02	73	d	17
24	XEY	30	74	YE	24	c4	YE	24	44	YE	24	24	1	01	74	DN	25
25	UP	27	75	-	34	c5	3	03	45	-	34	25	+	33	75	GTO	44
26	DN	25	76	d	17	c6	YE	24	46	e	12	26	1	01	76	SUB	77
27	DIV	35	77	DIV	35	c7	2	02	47	YE	24	27	8	10	77	8	10
28	PNT	45	78	YE	24	c8	YE	24	48	-	34	28	X=Y	50	78	6	06
29	YE	24	79	-	34	c9	1	01	49	d	17	29	3	03	79	UP	27
2a	1	01	7a	d	17	ca	RTN	77	4a	YE	24	2a	6	06	7a	GTO	44
2b	DIV	35	7b	YE	24				4b	c	16	2b	DN	25	7b	6	06
2c	YE	24	7c	-	34				4c	YE	24	2c	GTO	44	7c	b	14
2d	1	01	7d	e	12				4d	b	14	2d	SUB	77	7d	RCL	61

Program II

30	YE	24	80	DIV	35	00	CLR	20	50	YE	24	30	8	10	80	UP	27
31	2	02	81	YE	24	01	XTO	23	51	a	13	31	6	06	81	CLX	37
32	DIV	35	82	-	34	02	d	17	52	YE	24	32	UP	27	82	PNT	45
33	YE	24	83	e	12	03	UP	27	53	0	00	33	GTO	44	83	GTO	44
34	2	02	84	YE	24	04	1	01	54	YE	24	34	2	02	84	0	00
35	YE	24	85	-	34	05	+	33	55	9	11	35	4	04	85	0	00
36	3	03	86	f	15	06	YTO	40	56	YE	24	36	CLR	20	86	YE	24
37	DIV	35	87	DIV	35	07	d	17	57	8	10	37	XTO	23	87	-	34
38	YE	24	88	YE	24	08	CLX	37	58	YE	24	38	d	17	88	f	15
39	3	03	89	-	34	09	STP	41	59	7	07	39	UP	27	89	YE	24
3a	YE	24	8a	f	15	0a	IFG	43	5a	YE	24	3a	1	01	8a	-	34
3b	4	04	8b	GTO	44	0b	2	02	5b	6	06	3b	+	33	8b	e	12
3c	DIV	35	8c	0	00	0c	c	16	5c	YE	24	3c	YTO	40	8c	YE	24
3d	YE	24	8d	0	00	0d	PNT	45	5d	5	05	3d	d	17	8d	-	34
40	4	04	90	1	01	10	GTO	44	60	YE	24	40	CLX	37	90	d	17
41	YE	24	91	+	33	11	SUB	77	61	4	04	41	STP	41	91	YE	24
42	5	05	92	1	01	12	4	04	62	YE	24	42	IFG	43	92	c	16
43	DIV	35	93	8	10	13	0	00	63	3	03	43	6	06	93	YE	24
44	YE	24	94	X=Y	50	14	XEY	30	64	YE	24	44	b	14	94	b	14
45	5	05	95	2	02	15	X	36	65	2	02	45	GTO	44	95	YE	24
46	YE	24	96	3	03	16	RUP	22	66	YE	24	46	SUB	77	96	a	13
47	6	06	97	DN	25	17	XEY	30	67	1	01	47	8	10	97	YE	24
48	DIV	35	98	GTO	44	18	X	36	68	YTO	40	48	6	06	98	0	00
49	YE	24	99	SUB	77	19	RDN	31	69	-	34	49	YTO	40	99	YE	24
4a	6	06	9a	a	13	1a	PNT	45	6a	f	15	4a	-	34	9a	9	11
4b	YE	24	9b	3	03	1b	PNT	45	6b	RTN	77	4b	f	15	9b	YE	24
4c	7	07	9c	UP	27	1c	AC+	60				4c	XEY	30	9c	8	10
4d	DIV	35	9d	CNT	47	1d	CLX	37				4d	UP	27	9d	YE	24

Program III

a0	7	07						
a1	YE	24						
a2	6	06						
a3	YE	24						
a4	5	05						
a5	YE	24						
a6	4	04						
a7	YE	24						
a8	3	03						
a9	YE	24						
aa	2	02						
ab	YE	24						
ac	1	01						
ad	RTN	77						
b0	END	46						

✓ ✓

✓ 5 x y z

PROGRAM IA

1. PRESS: GO TO ( ) ( ), -, 0, 0
2. ENTER PROGRAM
3. PRESS: GO TO ( ) ( ), -, 0, 0
4. PRESS: CONTINUE — i
5. ENTER DATA: w_i, MW_i — MW_i w_i
6. PRESS: CONTINUE — m_i MW_i w_i

Return to step No. 5 to enter data for each component. After all data has been entered,

7. PRESS: SET FLAG
8. PRESS: CONTINUE — Σm MW_{av} Σw

The mole fraction of each of the components is now stored in the calculator. Proceed to program II or program III.

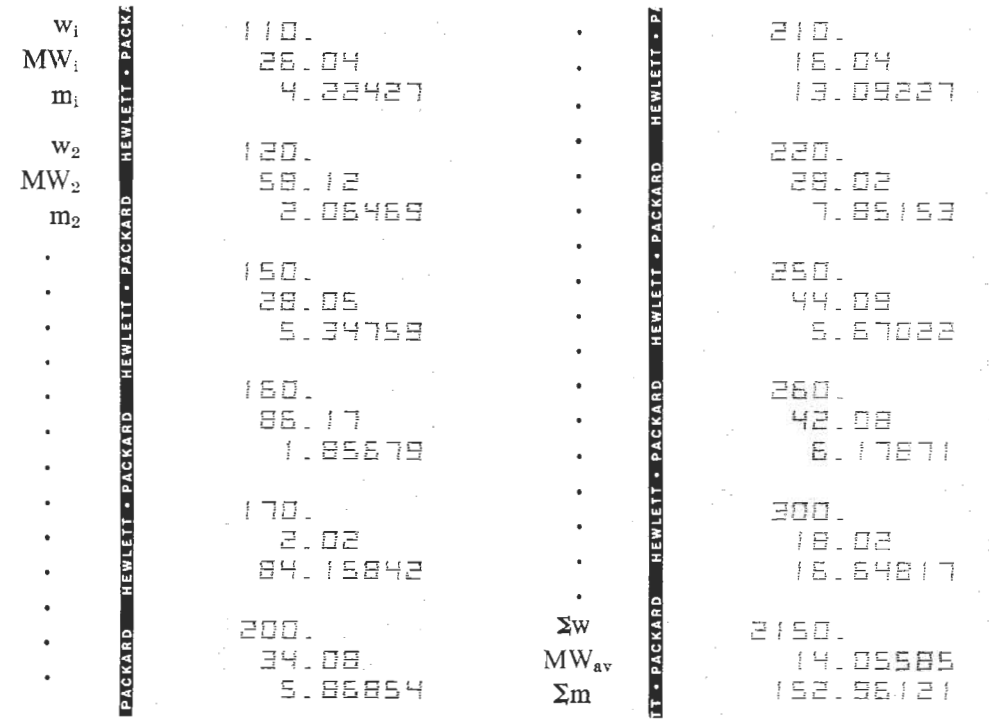
PROGRAM IB

To run this program using volumes (v_i and Σv) instead of weights (w_i and Σw) change the following steps:

—1, 1 (X)

—1, 3 R ↓

EXAMPLES PROGRAM IA



✓ ✓

✓ 5 x y z

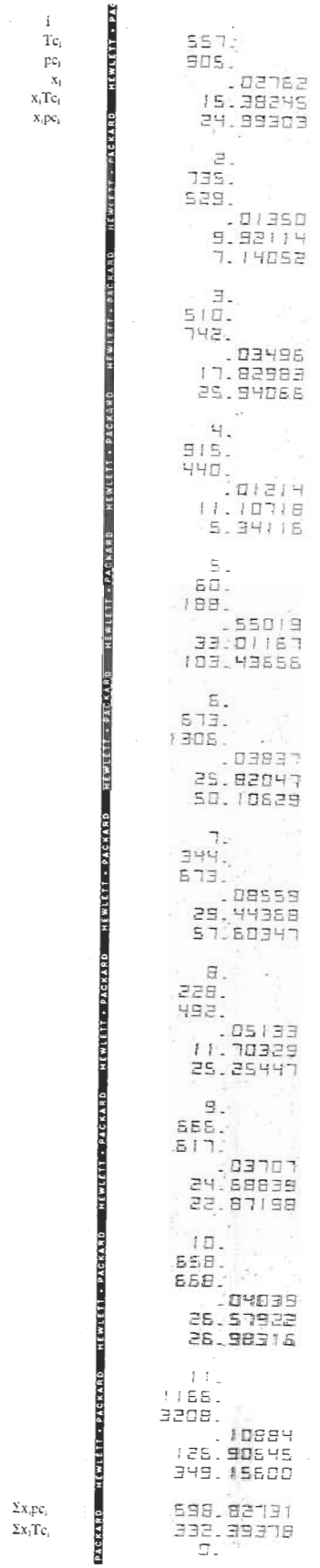
PROGRAM II

1. PRESS: GO TO ( ) ( ), -, 0, 0			
2. ENTER PROGRAM			
3. PRESS: GO TO ( ) ( ), -, 0, 0			
4. PRESS: CONTINUE		i	
5. ENTER DATA: Tc_i, pc_i	pc_i	Tc_i	i
6. PRESS: CONTINUE	x_i	Tc_i	pc_i
Return to step No. 5 to enter data for each component. After all data has been entered,			
7. PRESS: SET FLAG			
8. PRESS: CONTINUE	0	$\Sigma x_i Tc_i$	$\Sigma x_i pc_i$
To rerun the program for additional properties of the same stored mole fractions, return to step No. 5.			

PROGRAM III

1. PRESS: GO TO ( ) ( ), -, 0, 0			
2. ENTER PROGRAM			
3. PRESS: GO TO ( ) ( ), -, 0, 0			
4. PRESS: CONTINUE		i	
5. ENTER DATA: PHYSICAL PROPERTIES TO BE AVERAGED P_{1i}, P_{2i}	P_{2i}	P_{1i}	i
6. PRESS: CONTINUE			
Return to step No. 5 to enter data for each component. After all data has been entered,			
7. PRESS: SET FLAG			
8. PRESS: CONTINUE		i	
9. ENTER DATA: mole fraction x_i	x_i	i	
10. PRESS: CONTINUE	$x_i P_{2i}$	$x_i P_{1i}$	x_i
Return to step No. 9 to enter data for each component. After all data has been entered,			
11. PRESS: SET FLAG			
12. PRESS: CONTINUE		$\Sigma x_i P_{2i}$	$\Sigma x_i P_{1i}$
To rerun this program return to step No. 5.			

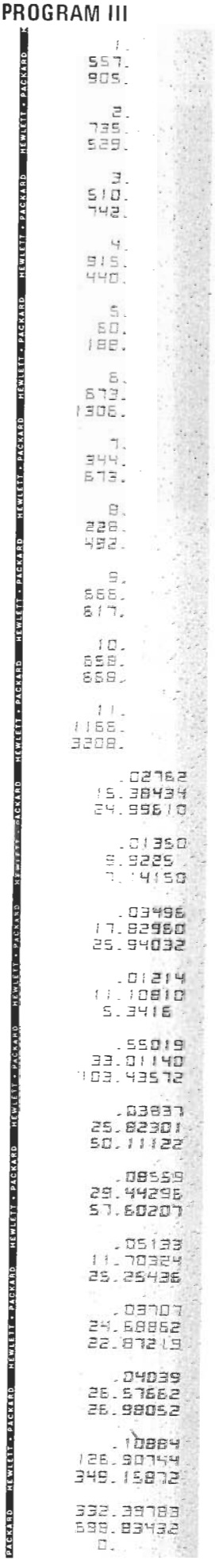
PROGRAM II



i	1.
Tc_i	557.
pc_i	905.
x_i	.02782
x_iTc_i	15.38245
x_ipc_i	24.99303
	2.
	735.
	529.
	.01350
	9.92114
	7.14052
	3.
	510.
	742.
	.03496
	17.82983
	25.94068
	4.
	915.
	440.
	.01214
	11.10718
	5.34116
	5.
	60.
	188.
	.55019
	33.01167
	103.43656
	6.
	673.
	1308.
	.03837
	25.82047
	50.10629
	7.
	344.
	673.
	.08559
	29.44368
	57.60347
	8.
	228.
	492.
	.05133
	11.70329
	25.25447
	9.
	668.
	617.
	.03707
	24.68839
	22.87198
	10.
	658.
	668.
	.04039
	26.57922
	26.98316
	11.
	1166.
	3208.
	.10884
	126.90645
	349.15600
Σx_ipc_i	698.82731
Σx_iTc_i	332.39378
	0.

EXAMPLES

PROGRAM III

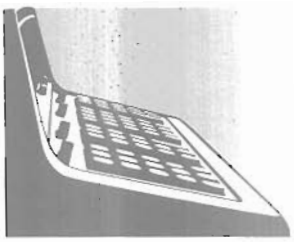


i	1.
$P1i$	557.
$P2i$	905.
	2.
	735.
	529.
	3.
	510.
	742.
	4.
	915.
	440.
	5.
	60.
	188.
	6.
	673.
	1308.
	7.
	344.
	673.
	8.
	228.
	492.
	9.
	668.
	617.
	10.
	658.
	668.
	11.
	1166.
	3208.
x_i	.02782
x_iP1i	15.38434
x_iP2i	24.99610
	.01350
	9.9225
	7.14150
	.03496
	17.82960
	25.94032
	.01214
	11.10810
	5.3416
	.55019
	33.01140
	103.43572
	.03837
	25.82301
	50.11122
	.08559
	29.44298
	57.60207
	.05133
	11.70324
	25.25436
	.03707
	24.68862
	22.87219
	.04039
	26.57662
	26.98052
	.10884
	126.90744
	349.15872
Σx_iP1i	332.39783
Σx_iP2i	698.83432
	0.

Walter Karger is the Regional Engineering Manager for Europe, Mideast and Africa of Elliott Overseas Corp., a subsidiary of Carrier Corp. He was born in Berlin, Germany, and lived in Quito, Ecuador until 1948 where he studied Civil Engineering at the Central University of Ecuador. After coming to the United States, Mr. Karger graduated from New York University with a BME degree in 1954, and obtained an M.S. degree at Purdue University the following year. He then joined the international division of Carrier Corporation, specializing in the application of centrifugal refrigeration and gas compressors. Since the merger of Elliott Co. into Carrier, he also handles mechanical drive steam turbines and other industrial equipment. He transferred from the New York to the London office in June, 1969.

9100B PROGRAMMING CONVENIENCE

Jean-Louis Gassee, calculator sales supervisor in the HP Orsay, France office, suggests that it is easier to press END, CONTINUE than GO TO ( ) ( ), —, 0, 0, CONTINUE. Storing data in the + registers on the 9100B requires less memory space for storage and recall commands, so it is better to enter the program on the minus page and reserve the + page for data. To do this and retain the operating convenience of pressing END, CONTINUE, you can use just the first register on the + page for initial program steps ending in GO TO ( ) ( ), —, 0, 0. An END statement as the last program step on the negative page, along with a CONTINUE by the user, brings the program back to the start, ready to solve a new problem.



CARBON DIOXIDE CONTENT OF HUMAN BLOOD

by Richard W. Blide, M.D.

PATHOLOGY
PROGRAM VII
Revised 11 Jan 1971

The determination of carbon dioxide content of human blood is frequently used in the diagnosis and treatment of disease. This measurement, along with the carbon dioxide tension or pH, will indicate whether acidosis or alkalosis is present, whether it is metabolic or respiratory in origin and whether it is acute (uncompensated) or chronic (compensated).

This program calculates the carbon dioxide content $[CO_2]$ of human blood from the carbon dioxide tension (Pco_2), pH, oxygen saturation (So_2), hematocrit (Hct) and temperature (T). $[CO_2]$ of whole blood (wb), plasma (pl), and red blood cells (ce) are obtained and displayed in mM/l.

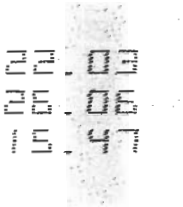
$$P = 7.4 - pH$$
$$PK = 6.26536 + .0948\ P - T\ (.00472 + .0014P)$$
$$T = 37 - T$$
$$SOL = .0307 + T(.00057 + .00002T)$$
$$[CO_2]\ pl = SOL \times Pco_2\ (1. + 10^{(pH - PK)})$$
$$DOX = .590 + .2913\ P - .0844\ P^2$$
$$DR = .664 + .2275\ P - .0938\ P^2$$
$$D = DR - DR \times So_2 + DOX \times So_2$$
$$[CO_2]\ ce = D \times [CO_2]pl$$
$$[CO_2]\ wb = Hct\ [CO_2]\ ce + [CO_2]\ pl - Hct\ [CO_2]\ pl$$

EXAMPLE:

$pH = 7.40$, $T = 38°$ Centigrade
$Pco_2 = 40$ mm Hg
$So_2 = .95$, $Hct = .38$

SOLUTION:

$[CO_2]$ wb = 22.03 mM/l
$[CO_2]$ pl = 26.06 mM/l
$[CO_2]$ ce = 15.47 mM/l



Richard W. Blide took his undergraduate training at the University of Rochester, his Medical training at Albany Medical College, and Specialty training in Medicine at the University of Maryland. He was Assistant Professor of Medicine and Head of the Pulmonary Laboratory at the University of Maryland until 1969. He is presently associate medical director and head of the Samuel Rosen Pulmonary Function Laboratory at the Will Rogers Hospital, Saranac Lake, New York.

Reference: Kelman, R.G. Digital Computer Procedure for the Conversion of Pco_2 into Blood CO_2 Content. Respiration Physiology 3:111-115, 1967.

✓ ✓

✓ ✓ 3 x y z

1. PRESS: END		
2. ENTER PROGRAM		
3. PRESS: CONTINUE	0	0
4. ENTER pH Value	pH	
5. PRESS ↑	pH	pH
6. ENTER T° Centigrade Value	T°	pH
7. PRESS: CONTINUE		
8. ENTER Pco_2 Value, mm Hg	Pco_2	
9. PRESS: CONTINUE		
10. ENTER Hct Value as fraction	Hct	
11. PRESS: $x \rightleftarrows y$		Hct
12. ENTER SO_2 Value as fraction	SO_2	Hct
13. PRESS: CONTINUE	$[CO_2]$ ce	$[CO_2]$ p1 $[CO_2]$ wb

To enter new data, return to Step 3.

00	CLR	20	20	2	02	40	DN	25	60	X	36	80	2	02	a0	X	36	c0	DN	25
01	STP	41	21	6	06	41	2	02	61	1	01	81	9	11	a1	d	17	c1	+	33
02	AC+	60	22	5	05	42	EEX	26	62	XEY	30	82	1	01	a2	+	33	c2	e	12
03	7	07	23	3	03	43	5	05	63	EXP	74	83	3	03	a3	UP	27	c3	+	33
04	.	21	24	6	06	44	CHS	32	64	+	33	84	X	36	a4	STP	41	c4	UP	27
05	4	04	25	+	33	45	X	36	65	DN	25	85	DN	25	a5	YTO	40	c5	f	15
06	XEY	30	26	d	17	46	5	05	66	X	36	86	+	33	a6	d	17	c6	PNT	45
07	-	34	27	UP	27	47	7	07	67	YTO	40	87	YE	24	a7	RDN	31	c7	END	46
08	YTO	40	28	.	21	48	EEX	26	68	e	12	88	f	15	a8	DN	25			
09	d	17	29	0	00	49	4	04	69	d	17	89	.	21	a9	X	36			
0a	.	21	2a	9	11	4a	CHS	32	6a	UP	27	8a	0	00	aa	XEY	30			
0b	0	00	2b	4	04	4b	+	33	6b	X	36	8b	9	11	ab	CHS	32			
0c	0	00	2c	8	10	4c	DN	25	6c	YTO	40	8c	3	03	ac	+	33			
0d	1	01	2d	2	02	4d	X	36	6d	f	15	8d	8	10	ad	f	15			
10	4	04	30	X	36	50	.	21	70	.	21	90	CHS	32	b0	RUP	22			
11	X	36	31	DN	25	51	0	00	71	0	00	91	X	36	b1	X	36			
12	.	21	32	+	33	52	3	03	72	8	10	92	.	21	b2	DN	25			
13	0	00	33	e	12	53	0	00	73	4	04	93	6	06	b3	+	33			
14	0	00	34	XEY	30	54	7	07	74	4	04	94	6	06	b4	e	12			
15	4	04	35	-	34	55	+	33	75	CHS	32	95	4	04	b5	X	36			
16	7	07	36	YTO	40	56	STP	41	76	X	36	96	+	33	b6	YTO	40			
17	2	02	37	e	12	57	X	36	77	.	21	97	YE	24	b7	f	15			
18	+	33	38	3	03	58	UP	27	78	5	05	98	d	17	b8	d	17			
19	f	15	39	7	07	59	1	01	79	9	11	99	.	21	b9	X	36			
1a	CHS	32	3a	XEY	30	5a	0	00	7a	+	33	9a	2	02	ba	UP	27			
1b	X	36	3b	f	15	5b	LN	65	7b	d	17	9b	2	02	bb	e	12			
1c	6	06	3c	-	34	5c	XEY	30	7c	UP	27	9c	7	07	bc	CHS	32			
1d	.	21	3d	UP	27	5d	e	12	7d	.	21	9d	5	05	bd	X	36			

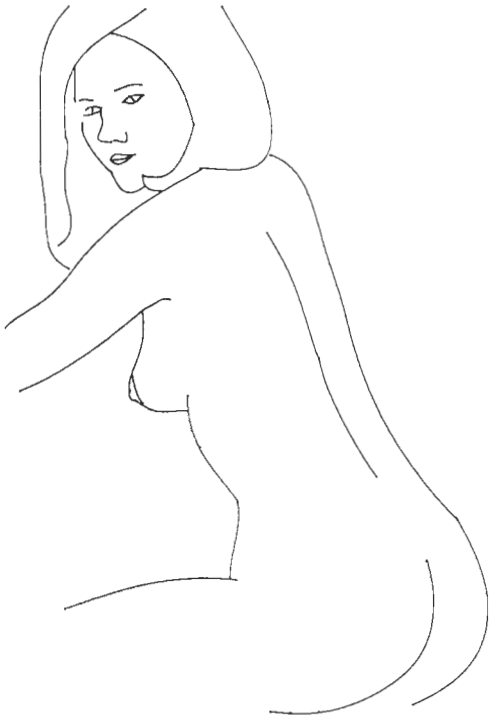
NEW DEVICE COUPLES TYPEWRITER WITH HP SYSTEM 9100

Complete and automatically typewritten records of computed data are joining the array of outputs available to users of the Hewlett-Packard 9100 Calculator System. With the new 9106A Typewriter Coupler just announced, the Calculator will print out computations through an IBM typewriter at a speed of 15 key strokes per second. The data can be typed either on preprinted forms or in tables.

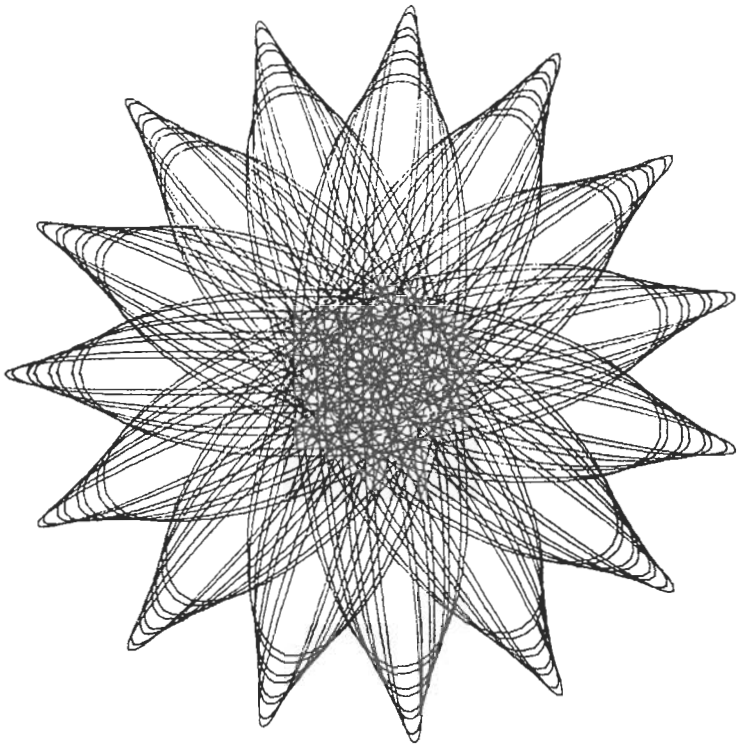
Formatting is accomplished by selecting the registers or combination of registers to be printed; either TAB or RETURN mode; and then initializing the PRINT command either manually or by programmed request. After printing, the typewriter automatically moves to the next desired position. Four additional control commands are provided for additional formatting flexibility.

Deliveries of the HP 9106A Typewriter Coupler begin in March 1971. Ask your local HP Sales office for a specific price and delivery quotation.

CALCULATOR ART CONTEST



THIRD PRIZE
PLAYMATE
John A. Ashbee
Route 3, Box 3045
Auburn, California 95603



HONORABLE MENTION
UNTITLED
Lt. Ronald P. Krahe
3115B South Gen. McMullen Dr.
San Antonio, Texas 78226

The last issue of *Keyboard* announced the calculator art contest for pleasing designs drawn using the HP 9125A Calculator Plotter. The winning entries in the continental U.S.A. portion of the contest are published in this issue.

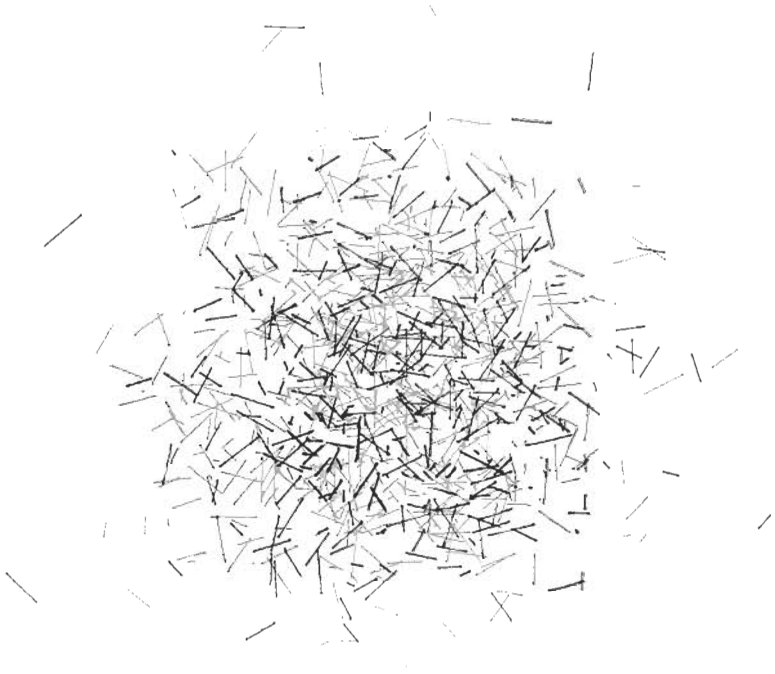
The first prize entry, WAVES, by Paul Milnarich, is featured on the front cover. The second prize entry, entitled EFFIGY, by Dr. G. Winston Barber, appears on the back cover, and the following pages show the third prize winner, honorable mention, and as many runners-up as space permits.

For entries outside of the U.S.A. the deadline was extended to February 15 due to mailing time considerations. Entries from all other countries will be shown in the next *Keyboard*.

In each branch of the contest, the first prize winner will receive a choice of three calculator program packets in the fields of Statistics, Surveying, Chemical Processing, Clinical Pathology, Cardiology, or Electric Utilities. The second prize winner will receive a choice of two program packets, and the third prize winner, one.

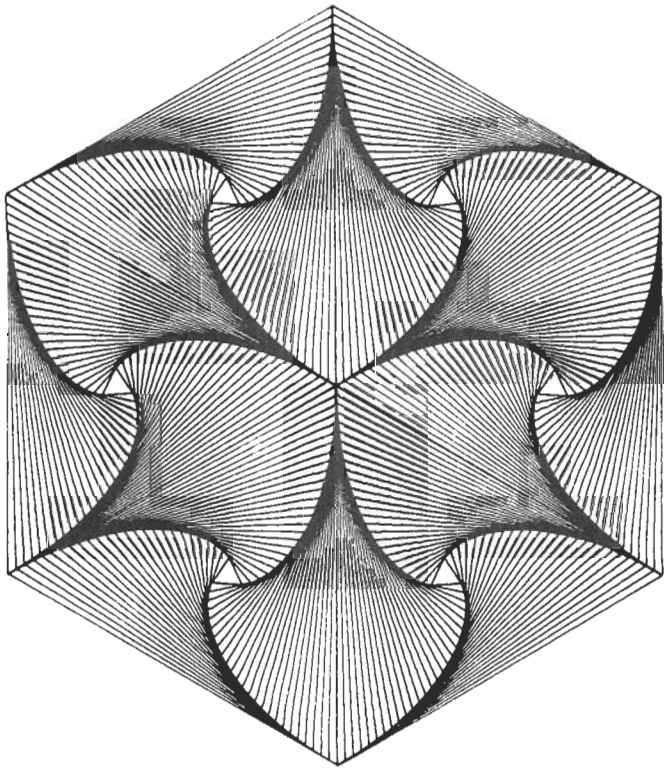
Although it is not possible to publish all of the runner-up entries, our thanks go to all contestants for their interest and entries.

James Disney, an artist and mountain climber of Loveland, Colorado, judged the U.S. branch of the contest. Mr. Disney has climbed and painted most of Colorado's highest peaks, and recently showed his works in oil at a one man exhibition at Larimer Square in Denver, Colorado.



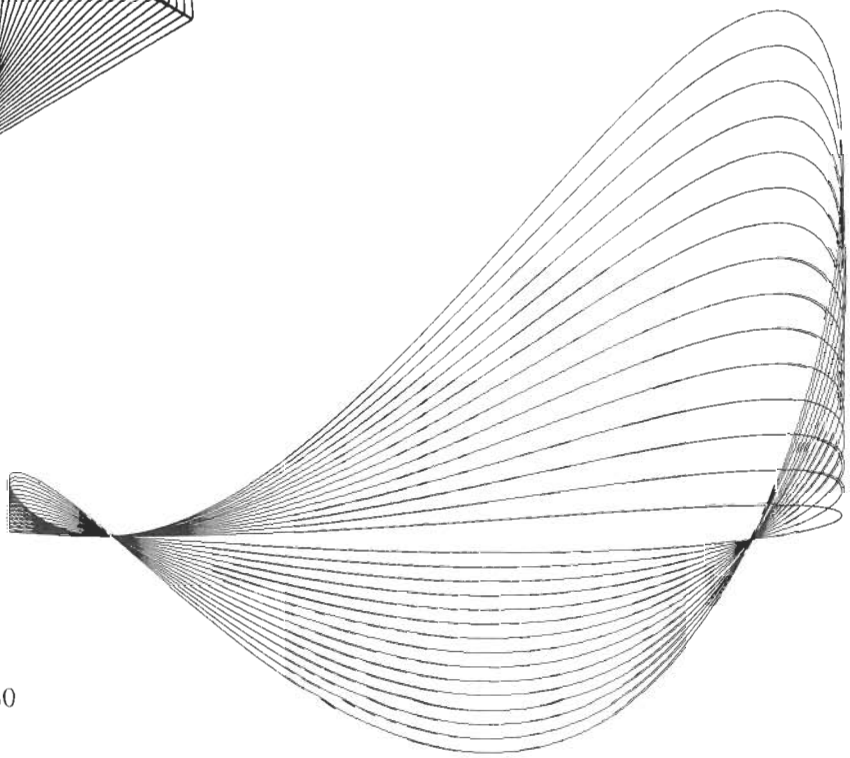
RANDOM PLOT

W. E. Shepherd
P.O. Box 127
San Diego, California 92112



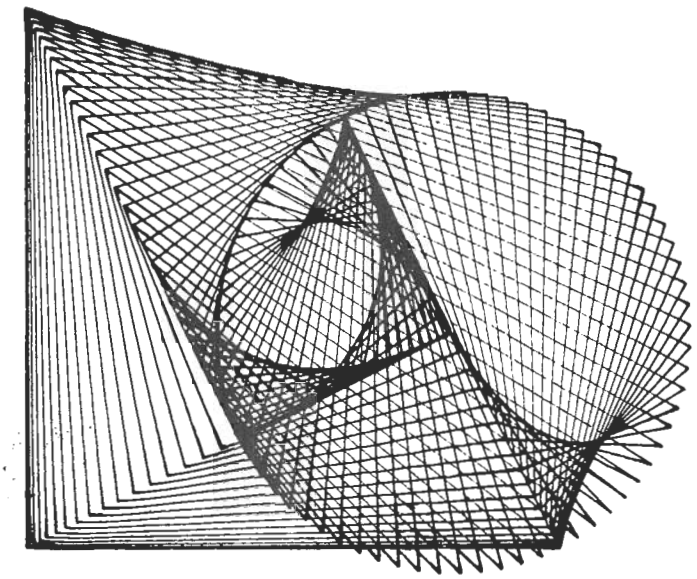
UNTITLED

N. M. Baker
10511 Shauna Dr.
Greenville, Texas 75401



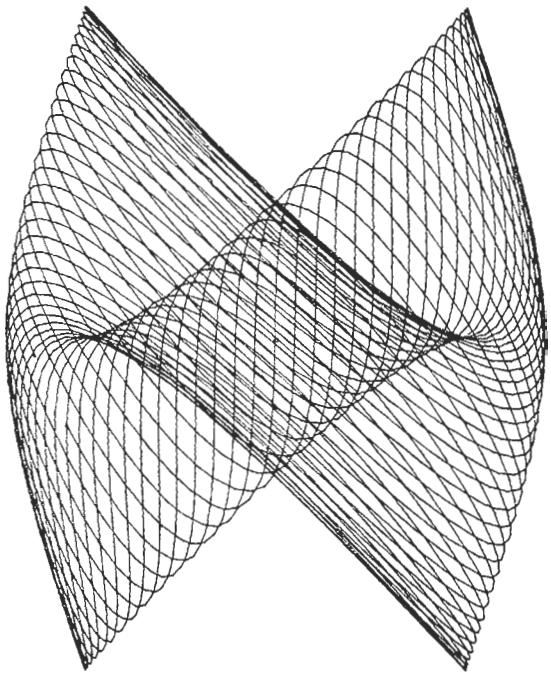
INFINITY

Peter Zimmerman
Staples High School
Westport, Connecticut 06880



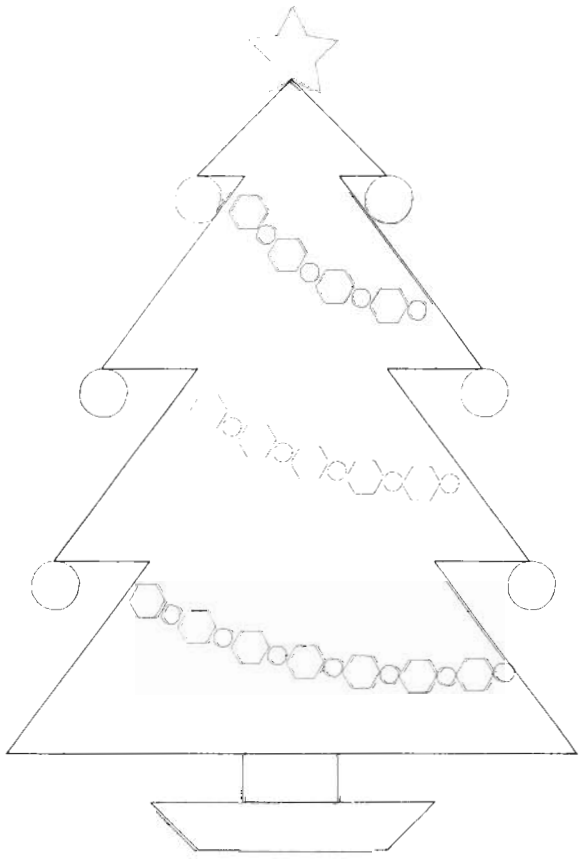
UNTITLED

Robert K. W. McCoy, Jr.
2400 Reynolda Rd.
Winston-Salem, North Carolina 27106



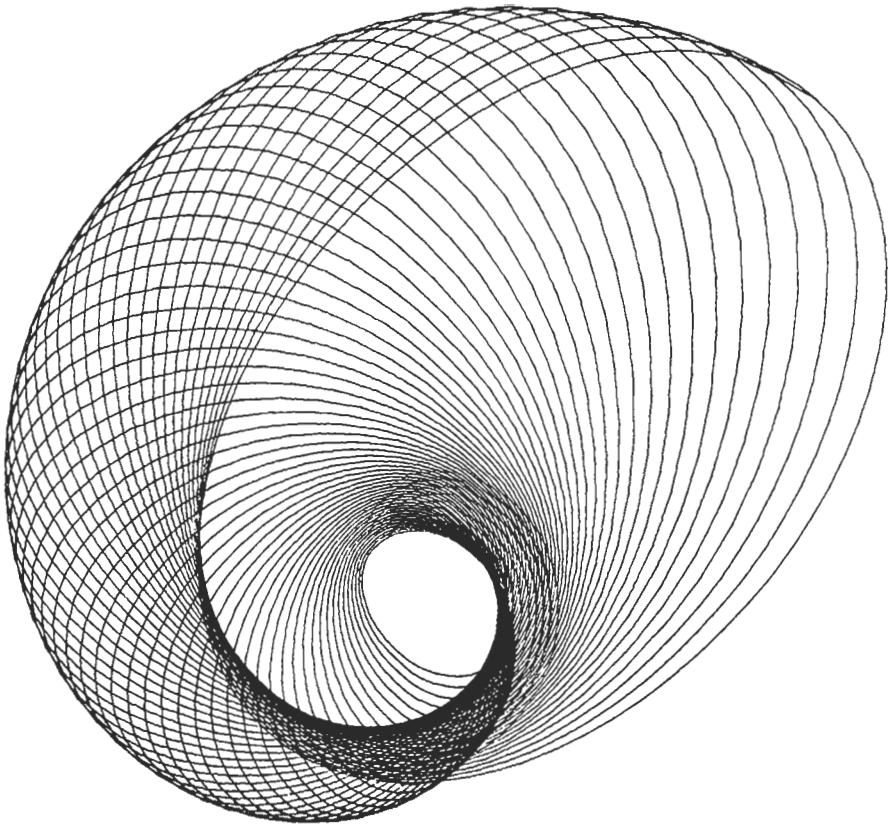
3-D OSCILLATION

Fred B. Otto
Department of Electrical Engineering
University of Maine
Orono, Maine 04473



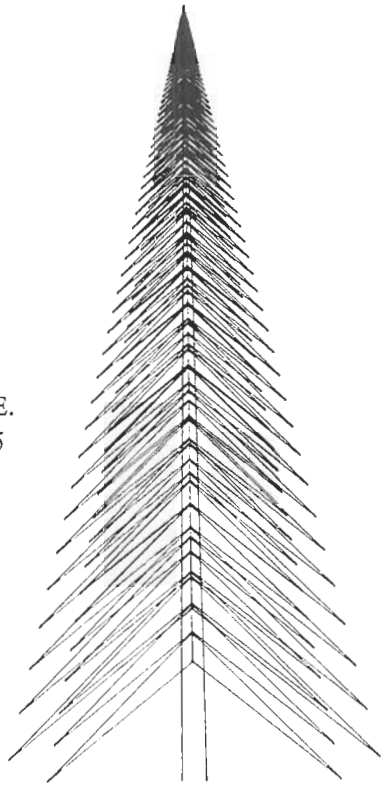
CHRISTMAS TREE

Prof. Wesley O. Doggett
Physics Department
North Carolina State University
Raleigh, North Carolina 27607



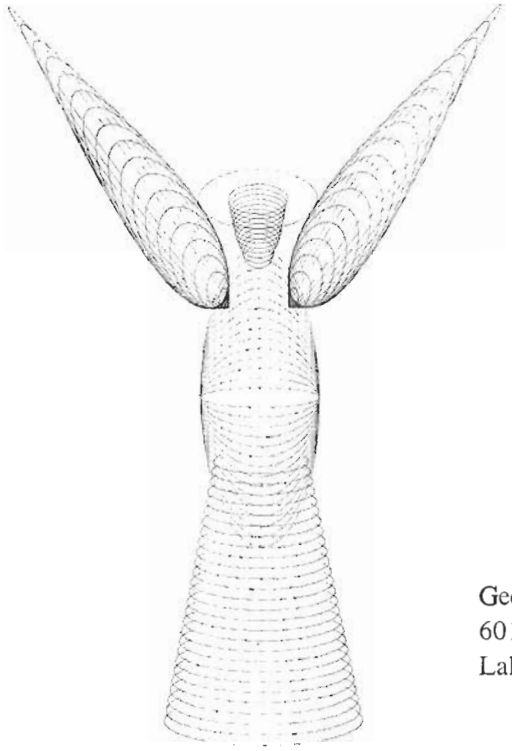
SEASHELL

George C. Tilley
Mathematics Department
Staples High School
Westport, Connecticut 06880



CHRISTMAS TREE

Ward W. Carson
4507 University Way N.E.
Seattle, Washington 98105



ANGEL

George F. Schrader
6018 E. Edgefield
Lakewood, California 90713

If you did not recognize the message of the word GHOT appearing in the Calculator Art Contest announcement in the last *Keyboard*, you may appreciate a translation. The word is

FISH: GH as in enou*GH*;
O as in w*O*men; and
T as in no*T*ion.

CAN YOU TOP THIS?

Howard Rathbun of the HP sales office in Oslo is being credited with the most northern calculator sale. A mining customer of his at Sulitjelma, Norway bought a 9100B. Sulitjelma is located above the Artic Circle at 67.1° North latitude. We would like to hear from anyone who can "top" that one!

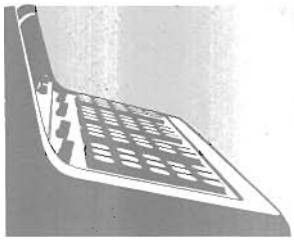
IT'S THE LITTLE THINGS THAT COUNT

Compatibility with peripherals is one advantage of the HP 9100 Calculator which you may be taking for granted. Have you noticed that the Calculator Printer, Calculator Plotter, and Marked Card Reader simply plug in and are ready to operate?

Many customers tell us the Model 9160A Marked Card Reader saves chunks of time and eliminates mistakes when the same data must be reentered correctly, or when quiz results from 30 students must be determined, or when the surveying crew returns to the office and gives the secretary field surveying data on marked cards. Other customers like the marked cards for program entry as well.

The finest graphs and plots of all types are made by the 9100 system. Users like yourself turn out smooth curves with **solid** lines, incremented to any desired precision. You can be confident that the plots you get are accurate.

"It's the little things that count."



TEST SCORING PROGRAM

PART NO. 09100-75823

The test scoring program frees teachers from the boring and laborious job of grading tests by automatically scoring multiple choice tests. Each test may consist of up to twenty-four questions with four possible answers. The program has been created for use with the 9100 Calculator, 9120A Printer, and the 9160A Card Reader. Students answer the multiple choice questions by selecting the appropriate box on the Calculator Quiz Card, part number 9320-1191. The instructor marks the correct answers on another quiz card to serve as a "master answer card." To run the program, the teacher first enters the master answer card on the 9160A and then enters each student's answer card. After each student card has been entered, the printer prints the number of each question the student missed (Z-register), the student's answer (Y-register), and the correct answer (X-register). After all incorrect answers have been displayed, it prints out the percent score for that student. This entire process takes only a few seconds. When every student in the class has been graded, the program displays the class average.

Liberating teachers from the chore of grading tests allows them to spend more time working with students who will benefit from this extra help. The test scoring program has many other applications. Teachers often want to give quizzes frequently instead of only a few large examinations, but time is often insufficient to correct them. Using the HP System, a teacher is free to quiz students as often as he wishes without spending hours grading papers. Another interesting application for the test scoring program is for use in correcting homework. Ideally, all homework should be corrected as soon as possible after completion. Normally however, a teacher is too busy to correct homework assignments. Thus the test scoring program also helps students by showing them instantly where they have made mistakes in their assignments. The test scoring program provides a method for using an innovative approach to testing, by which students may correct their own tests. Teachers have discovered that when students correct their own work, it becomes more a learning experience than an evaluation process. The HP calculator provides a rapid system for students to see which answers are wrong and which are correct.

There are many areas outside the educational market where test scoring programs may be used. For example, many quality control tests often require that a product must pass a certain percentage of the tests. Quality control inspectors simply mark in the appropriate boxes on the quiz card and the percentage result is calculated in seconds. The quality control department then has printed records of which inspections were failed and what values were recorded.

NOTES FOR USAGE

Each card can be used to score tests up to twenty-four questions. If less than twenty-four questions are to be used, change steps 1-4 and 1-5 to the number of questions actually used. Multiple choice questions may have at least four possible answers. The choices are marked in columns 1, 2, 4, 8. However, additional choices may be included by combining columns, for example by marking column one and two, or by not marking any of the columns (equivalent to entering zero).

The program need not be used with the 9120A Printer. If the printer is not available, change steps 3-8, 3-9, and 5-a, 5-b, from PRINT, PRINT (command 45) to STOP, CONTINUE.

When using the printer, you may not wish to display all the registers. To save time you may print out only the Z-register which shows the number of each incorrect student answer.

✓ ✓ ✓

✓ 1 x y z

1.	PRESS: END			
2.	ENTER PROGRAM			
3.	PRESS: END			
4.	ENTER DATA: Insert master answer card in HP 9160A Card Reader.	0	0	0
5.	ENTER DATA: Insert student answer card. Printer will print the number of each question missed (IA), followed by student's score in percent.			
	Number of incorrect answer			N
	Student's answer		SA	
	Correct answer	CA		
	When all questions have been scored:			
	DISPLAY Student's score	0	0	SS
6.	Continue entering student cards until the entire class has been graded. After the last quiz has been graded,			
7.	PRESS: CLEAR	0	0	0
8.	ENTER DATA: Number of students	NS		
9.	PRESS: CONTINUE			
	Class Average			CA
	Number of students	NS	NS	

00	XTO	23	20	SFL	54	40	9	11	60	RUP	22
01	b	14	21	UP	27	41	1	01	61	YE	24
02	YTO	40	22	1	01	42	+	33	62	8	10
03	a	13	23	0	00	43	YE	24	63	+	33
04	CLR	20	24	X	36	44	9	11	64	YE	24
05	XTO	23	25	DN	25	45	GTO	44	65	8	10
06	8	10	26	UP	27	46	0	00	66	UP	27
07	GTO	44	27	INT	64	47	b	14	67	a	13
08	6	06	28	-	34	48	XTO	23	68	XTO	23
09	7	07	29	YE	24	49	d	17	69	d	17
0a	AC+	60	2a	d	17	4a	f	15	6a	CLX	37
0b	YE	24	2b	XEY	30	4b	XTO	23	6b	SFL	54
0c	c	16	2c	IFG	43	4c	e	12	6c	XTO	23
0d	1	01	2d	2	02	4d	GTO	44	6d	9	11
10	2	02	30	1	01	50	1	01	70	XTO	23
11	X=Y	50	31	XTO	23	51	9	11	71	c	16
12	4	04	32	e	12	52	YE	24	72	UP	27
13	7	07	33	c	16	53	9	11	73	STP	41
14	2	02	34	RDN	31	54	DIV	35	74	PSE	57
15	4	04	35	X=Y	50	55	EEX	26	75	IFG	43
16	X=Y	50	36	3	03	56	2	02	76	0	00
17	5	05	37	d	17	57	X	36	77	a	13
18	2	02	38	PNT	45	58	CLX	37	78	YE	24
19	1	01	39	PNT	45	59	UP	27	79	8	10
1a	+	33	3a	GTO	44	5a	PNT	45	7a	DIV	35
1b	YTO	40	3b	0	00	5b	PNT	45	7b	UP	27
1c	c	16	3c	b	14	5c	RCL	61	7c	PNT	45
1d	e	12	3d	YE	24	5d	AC-	63	7d	END	46

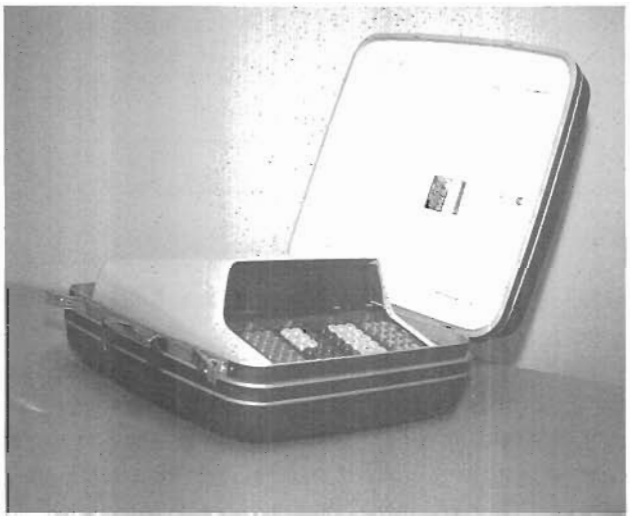
NEW ALGEBRA TEACHING RESOURCES AVAILABLE

A 260-page guide to using the hp Classroom Calculating System in teaching algebra is now available. Lesson plans, student assignments, and worked-out examples for typical first year topics are included. You can order this from your local HP Sales Office under HP part number 09100-90029.

CALCULATOR SHIPPING CASE AVAILABLE

If some of the duties of your 9100 Calculator include shipping it to different locations, you may want to consider the Model 11160A Calculator Shipping Case. The 9100 carrying case (Model 11154A) is not strong enough to withstand the stress and strain of shipment and provide adequate protection for your calculator. The Model 11160A has a rugged, durable case with dimensions of 14.5 in. x 23 in. x 29 in. (368 mm x 584 mm x 737 mm) and is equipped with casters for easy handling.

Check with the local HP sales office for price and availability.



MODEL 11154A CARRYING CASE

MODEL 11160A SHIPPING CASE

ERRATA

The correct part number of the Simplex Method Linear Programming program is 09100-75825 instead of 09100-74825 as it appeared in *Keyboard* Vol. 2, No. 2.

MATHEMATICS PROGRAMS NEEDED

From now until April 15, 1971, Hewlett-Packard will accept for evaluation and publication any unpublished system 9100 programs you have written for **pure mathematics applications.** For each program published, you will receive, in addition to an appropriate byline, a box of ten magnetic cards or one software packet of your choice from the following:

Stat-Pac Vol. I
Surveying Vol. I
Chemical Processing Vol. I or Vol. II
Clinical Pathology
Cardiology
Electric Utilities

Programs submitted, in addition to not being published previously in an HP program library, should meet the following criteria:

1. Program identification, including:
   a. Explanation of what the program does and what its applications are.
   b. Equations used.
   c. Explanatory diagrams or drawings if needed.
2. Text reference for further information, with page numbers.
3. Complete user instructions.
4. Numeric example to check and illustrate program operation.
   a. Applicable output such as sample plot or printer tape.
5. Program steps and step codes.
6. Recorded magnetic card.
7. Typewritten copy on 8½" x 11" paper, good enough to make legible machine copies.
8. A statement that Hewlett-Packard is permitted to publish the program in *Keyboard* and in any type of program library.
9. Desired wording for byline and acknowledgment.
10. A statement as to whether you will support your program by answering questions from other HP Calculator users.

PROGRAM SHARING PLAN

A program you are now writing may already exist in another 9100 owner's file. Oftentimes several people in different places write the same calculator program almost simultaneously.

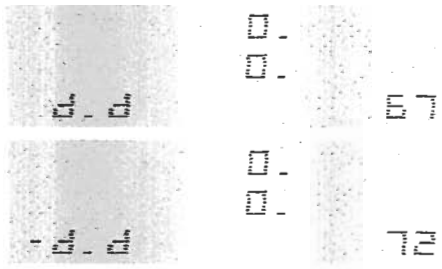
Perhaps you have programs which do not meet all of the conditions listed in the article above, or which you do not wish to have widely distributed. However, you may be willing to share these programs with other HP calculator users individually in return for some of theirs. If so, send us the title and description of each program you would like to share.

If there is enough interest in program sharing, we will issue and mail to persons contributing their program descriptions a list of unpublished mathematics and other programs which are available by contacting their authors. The inclusion of one or more of your program descriptions will entitle you to receive the list as soon as it is compiled.

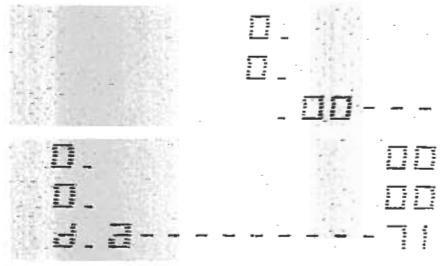
PROGRAMMING TIPS

ENTER vs RECORD

User preoccupation can cause some embarrassment when the operator is not sure whether he pressed the RECORD button when he intended to press ENTER, or vice versa. The best insurance against erasing a program on a magnetic card by mistakenly pressing RECORD is to clip off the recorded card along the outer edge of the arrowhead. If you happen to press RECORD when either a programmed or a blank uncut magnetic card is in the cardreader, the X register display on the 9100B will show the contents of the plus or minus dd step, depending on the starting memory page. Typical displays will appear like this:



On the 9100A the display will be similar to those shown below, depending on fixed point or floating point switch setting:



In both the 9100A and 9100B, the RECORD operation leaves the Y and Z register contents unchanged.

Pressing ENTER instead of an intended RECORD is an easier situation to correct. If you press ENTER with a blank magnetic card in the cardreader, the program in the calculator memory will usually not be destroyed, although the first step may be changed to a code 77 or other code. After correcting the first step, if the next few steps are correct, operating the program with a proven example will verify its correctness faster than visually checking each step.

LABELING RECORDED MAGNETIC CARDS

Typewritten titles on recorded magnetic cards look neat, but a typewritten period can make the card reader read some codes improperly if the period makes an indentation - this raises the magnetic coating surface in a small spot and prevents good contact between the surrounding area and the card reader. It is better to either avoid using periods on the typewriter or label the card using a pen or rubber stamp.

CLEARING ALL REGISTERS IN THE 9100A/B

Occasionally you may wish to have all of the 9100A or 9100B registers clear before entering and testing a program. Although X→( ) or Y→( ) will replace the contents of the addressed register with new data, you may wish to recall the contents of a register in testing a program and be sure its contents were placed there by the new program and not a previous one.

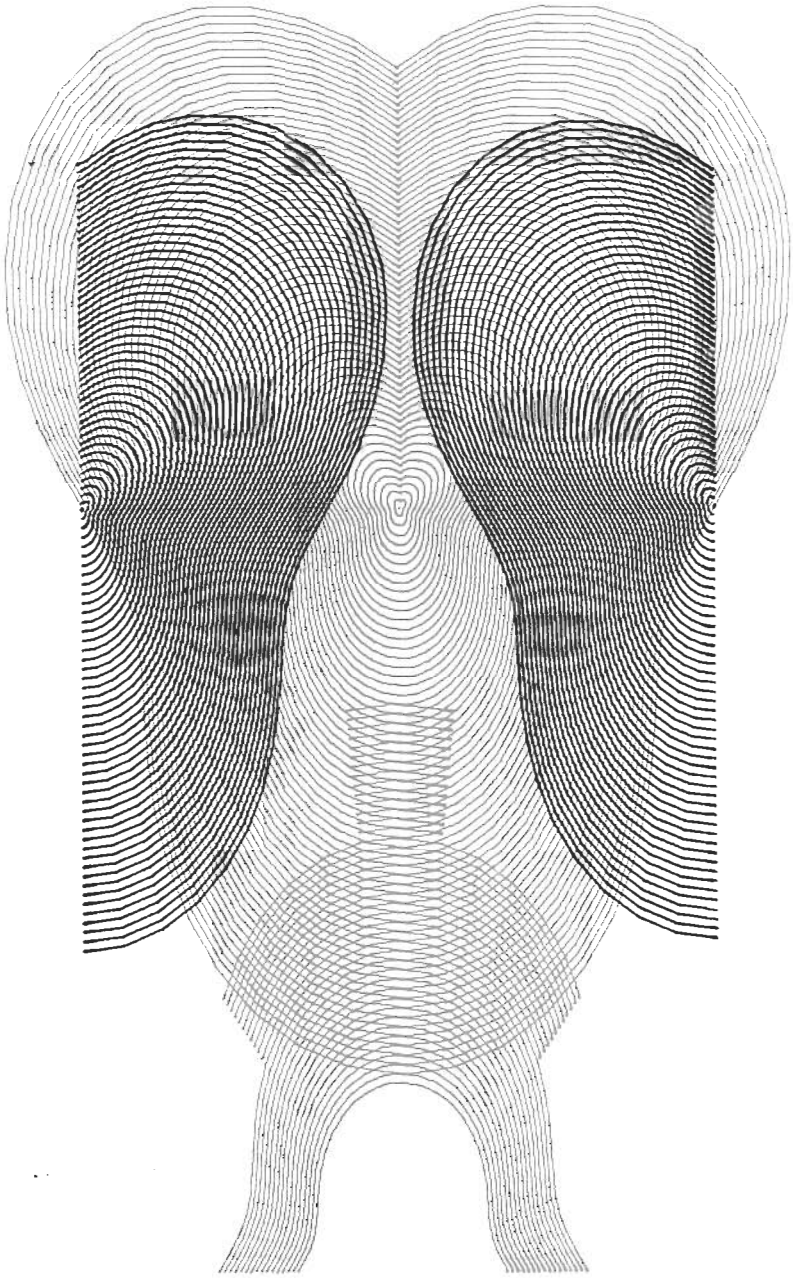
This short program will enter zeroes in each memory location in the 9100A or 9100B, and it takes only a few seconds to enter from a magnetic card and execute. After its execution, each memory location in the 9100B will contain a zero. Each location in the 9100A will contain either code 00 or code 40, which is a blanked zero.

USER INSTRUCTIONS

PRESS: END
ENTER: PROGRAM
PRESS: CONTINUE
Allow a second or so, then
PRESS: STOP

PROGRAM STEPS

Step	Key	Code	Step	Key	Code	Step	Key	Code
00	CLR	20	20	-	34	40	b	14
01	EEX	26	21	8	10	41	XTO	23
02	LN	65	22	XTO	23	42	a	13
03	XTO	23	23	-	34	43	XTO	23
04	-	34	24	9	11	44	0	00
05	0	00	25	XTO	23	45	XTO	23
06	XTO	23	26	-	34	46	1	01
07	-	34	27	a	13	47	XTO	23
08	1	01	28	XTO	23	48	2	02
09	XTO	23	29	-	34	49	XTO	23
0a	-	34	2a	b	14	4a	3	03
0b	2	02	2b	XTO	23	4b	XTO	23
0c	XTO	23	2c	-	34	4c	9	11
0d	-	34	2d	c	16	4d	XTO	23
10	3	03	30	XTO	23	50	8	10
11	XTO	23	31	-	34	51	XTO	23
12	-	34	32	d	17	52	7	07
13	4	04	33	XTO	23	53	XTO	23
14	XTO	23	34	-	34	54	6	06
15	-	34	35	e	12	55	XTO	23
16	5	05	36	XTO	23	56	4	04
17	XTO	23	37	-	34	57	XTO	23
18	-	34	38	f	15	58	5	05
19	6	06	39	XTO	23	59	END	46
1a	XTO	23	3a	d	17			
1b	-	34	3b	XTO	23			
1c	7	07	3c	c	16			
1d	XTO	23	3d	XTO	23			



SECOND PRIZE

EFFIGY

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KEYBOARD

Volume 3 Number 1

APPLICATIONS INFORMATION FOR HEWLETT-PACKARD CALCULATORS

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