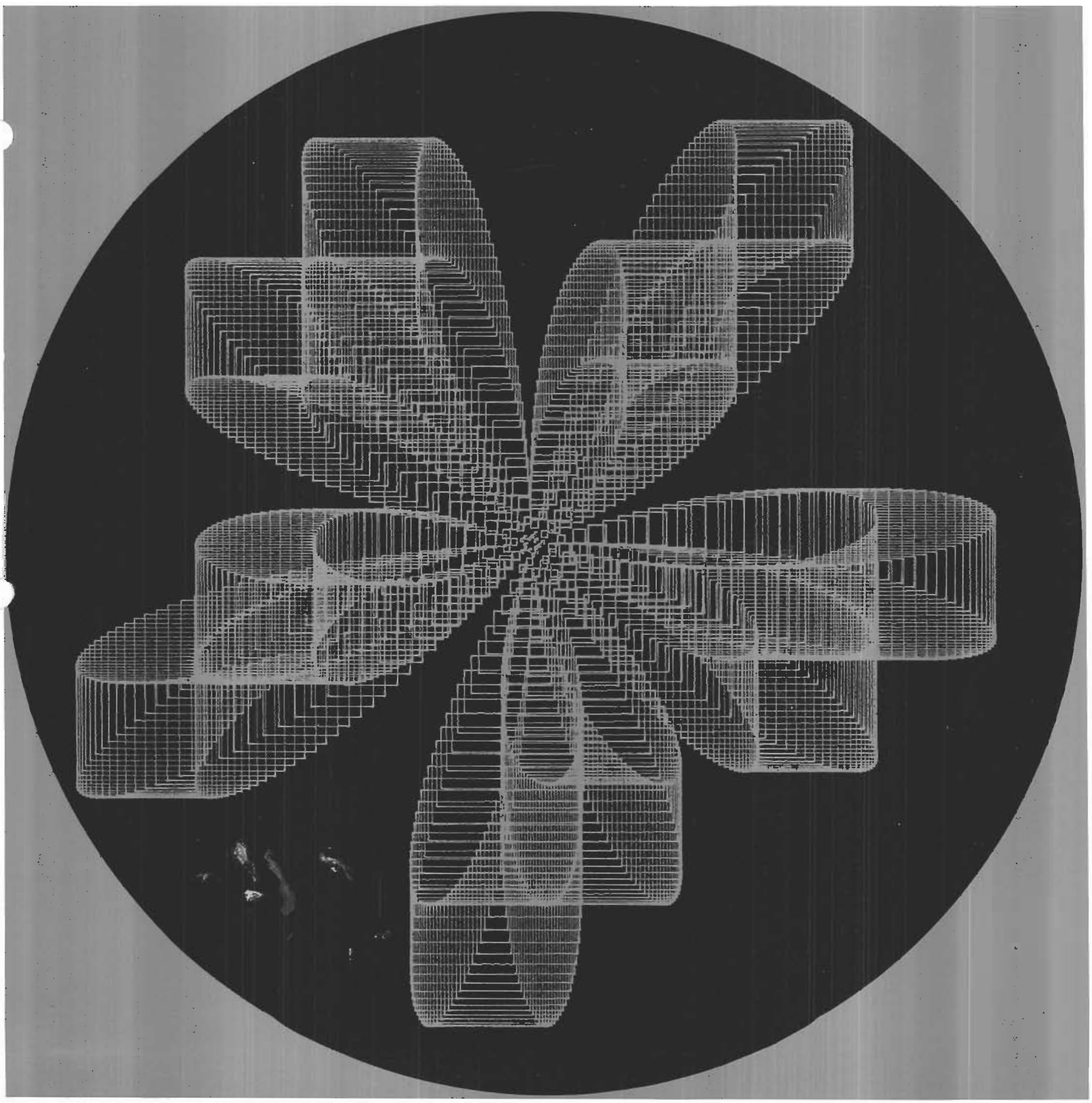
HEWLETT-PACKARD

KEYBOARD

VOL. 3 NO. 2



TO HP SYSTEM 9100 USERS

As a continuing service to users of the HP System 9100, the *HP KEYBOARD* is published periodically to bring you new programs, useful programming techniques, and information on the growing number of peripherals that can be used with the 9100 Calculator.

Included in this issue are articles describing two new System 9100 members - a punched paper tape reader and a typewriter coupler to provide formatted output.

Just as a reminder, you are invited to send in any programs or programming techniques that you feel would be useful to other calculator owners. This will increase the effectiveness of *KEYBOARD* as a medium for sharing programming information among calculator users.

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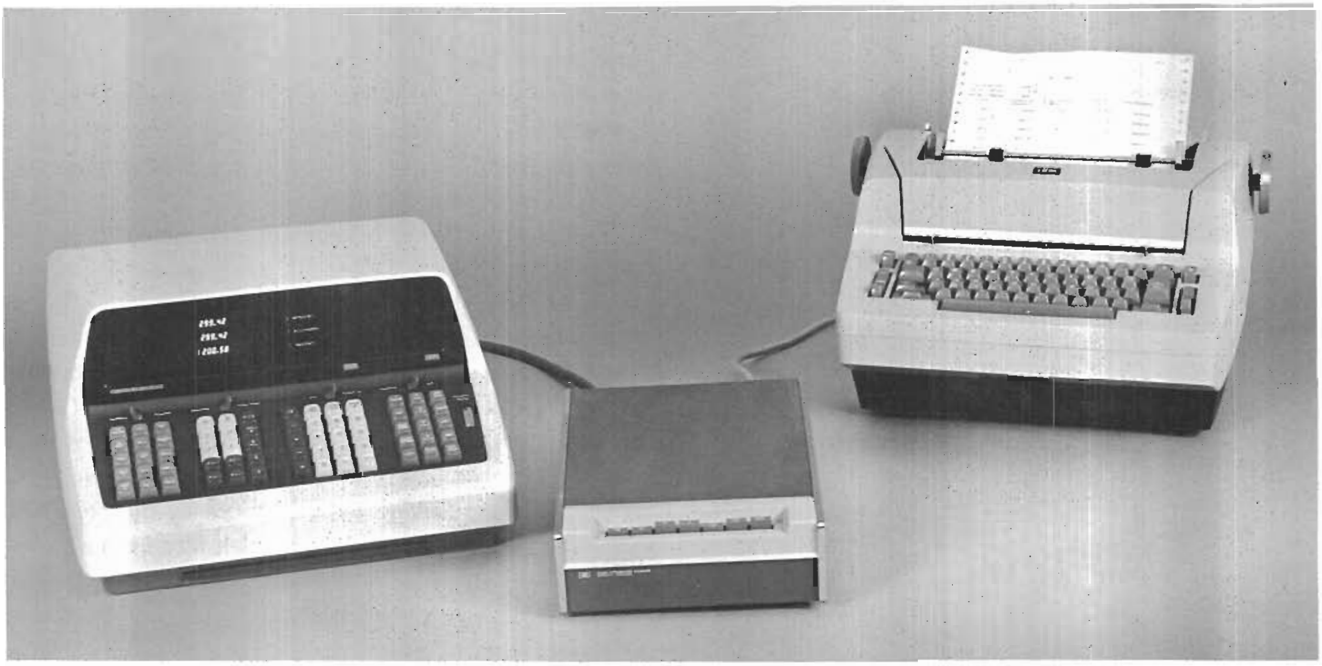
COVER

The plotter art display on the front cover is the first prize winner for the outside - U.S.A. branch of the *HP KEYBOARD* Calculator Art Contest. John B. Miller of Oslo, Norway, entitled this *PSYCHEDIL No. 5*.

See the article on page 10 for more information on entries in this branch of the contest. The second prize winning entry appears on the back cover.

Now, Formatted Output From The 9100



Output writer system with HP 9100, HP 9106A and IBM 73.

We have recently increased the capabilities of the HP 9100 system with the addition of a new peripheral--an output writer interface. Many 9100 system owners have requested a means of obtaining formatted output. Anyone who has large quantities of data that lends itself to tabulating will recognize the advantages of being able to choose his own format. Surveying and statistics are two fields which fit this category. The 9106A output writer interface will provide the numeric formatting capability that many 9100 users desire.

The requirements of an output writer for the 9100 system are quite high. It must be able to provide reliable, high quality performance for long periods of time without wearing. It must also be of the same high quality as the 9120A column printer. To meet these standards we chose the IBM model 73 series output writer. This series is designed by IBM to serve as a computer output terminal. It has been specially equipped with heavy duty parts to provide the type of continuous service required by a computer terminal, and by the 9100 system. It is also a capable secretarial typewriter when not in use with the 9100. The 73 series comes as the 733 with a 13 inch carriage or the 735 with a 15 inch carriage. Both accept z-fold paper, and can be had with a pin feed option. No modifications are required to the unit as supplied by IBM, and IBM will service it under their service contracts.

The 9106A-IBM 73 combination can be used as a direct replacement for the 9120A column printer. The 9106A is operated by the "print" command and will print selectively the x, y, and z registers, depending upon which combinations of the x, y, and z buttons are depressed. However, the user has his choice of any one of three different formats without changing his program. Assuming that x, y, and z are depressed, the user has a choice of depressing either the "tab", "return", or depressing neither of the two (See Figure 1). If the "return" button is depressed the 9106A will act as a column printer just as the 9120A does. If the "tab" button is pressed, the 9106A will print the contents of x, then tab automatically, print the contents of y, tab automatically, and print the contents of z and tab automatically. By setting the tabs properly the user can tab up to 5 columns on the 733 or 8 on the 735.

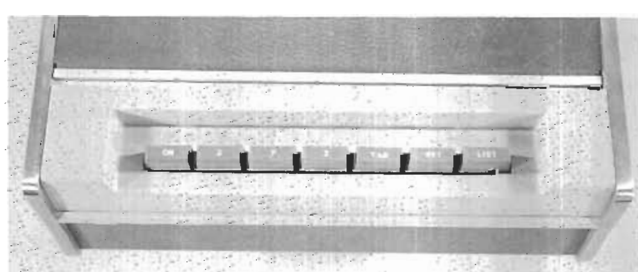


Figure 1. 9106A Typewriter Coupler

Figure 2 shows the 9106A output of a program written for the 9120A. In this figure, the left-hand column contains the number of each data entry. In most 9120A programs this is printed in the z register. The 9106A allows the user to choose the print sequence to be either x, y, z or z, y, x. The choice is made by positioning a switch at the back of the unit. The third choice is to have both the "tab" and "return" keys in the undepressed position. We call this the "Neither" mode. In this mode the 9106A will have the output writer print its field of characters for x, y, and z, and stop. This mode is particularly useful when the user intends to tailor his program to the capabilities of the 9106A.

LINEAR REGRESSION PRINTOUT

Data point	y	x
1.	56.	35.
2.	56.	41.
3.	36.	45.
4.	25.	26.
5.	46.	31.
6.	95.	61.
7.	45.	35.
8.	78.	55.
9.	71.	53.
10.	12.	10.
11.	67.	42.

y=mx + b

correlation coef.	slope	intercept
.9055	-5.8189	1.4966

Figure 2. Typewriter output of a column printer program.

The 9100 can control the location of the printing ball on the IBM 73 through use of format commands. When used as part of a program these commands allow the user to specify any place on a line that is convenient as the next place for the output writer to print. For example, the user may selectively print or not print columns. Most important of all, he can fill out preprinted forms.

The 9100 uses three commands to control the ball of the IBM 73. They are FMT x<y, which moves the ball one space to the right, FMT x>y, which moves the ball one space to the left, and FMT x=y, which is a tab command. The two spacing commands are usually used in subroutines coupled with a counter. This method allows the IBM 73 to print any place on a line, and to select that space by a number generated by the program. An example of a preprinted form that has been filled out by the 9106-IBM 73 is shown in Figure 3. Very complex forms can be filled out easily with the 9106A.

The 9106A comes complete with an instruction manual and several programs which demonstrate the capabilities of the machine. If formatted output interests you, please fill in and mail the enclosed reply card.

O

TO: MR. D. O'NAVEN
1234 N. E. STREET
MILWAUKEE, WISCONSIN

INVOICE 1

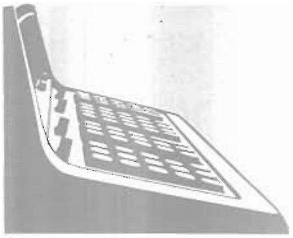
HEWLETT hp PACKARD

PAYMENT: N 30 D

SHIPPED BY: TRUCK

DESCRIPTION	PRICE	QUANTITY	DISCOUNT	NET VALUE
CABLE 5%	25.25	300.	378.75	7196.25
CABLE 6.54%	15.30	25.	25.02	357.48
FILTER 2.5%	26.50	75.	49.69	1937.81
			TOTAL NET VALUE	9491.55
DATE INVOICE	% TAX	TAX	EXPENSES	TOTAL TO PAY
1304.71	2.65	251.53	25.65	9768.72

Figure 3. Completed invoice with one tax.



AMORTIZED LOAN

PART NO.
09100-77504

Given a loan principal, annual interest rate, the annual payment and the starting year, this program computes and prints out:

1. the running year,
2. the payment towards interest,
3. the total annual payment,
4. the payment towards principal, and
5. the loan balance.

The program finalizes the computation after the loan balance equals zero and prints out:

6. the total amount paid towards interest,
7. the total payment, and
8. the total amount paid towards principal.

Editor's Note:
The Amortized Loan program is only one illustration of the formatted output obtainable with the new HP 9106A Typewriter Coupler used with the IBM 73 Typewriter in a 9100 system. Countless other applications exist for formatted output in the business and technical fields.

EXAMPLE

Loan principal	10000.
Annual interest %	7.
Annual payment	1500.

Year	Payment to interest:	Total annual payment:	Payment to principal:	Loan balance
1970.	700.00	1500.	800.00	9200.00
1971.	644.00	1500.	856.00	8344.00
1972.	584.08	1500.	915.92	7428.08
1973.	519.97	1500.	980.03	6448.05
1974.	451.36	1500.	1048.64	5399.41
1975.	377.96	1500.	1122.04	4277.37
1976.	299.42	1500.	1200.58	3076.78
1977.	215.37	1500.	1284.63	1792.16
1978.	125.45	1500.	1374.55	417.61
1979.	29.23	446.84	417.61	0.00
	3946.84	13946.84	10000.00	

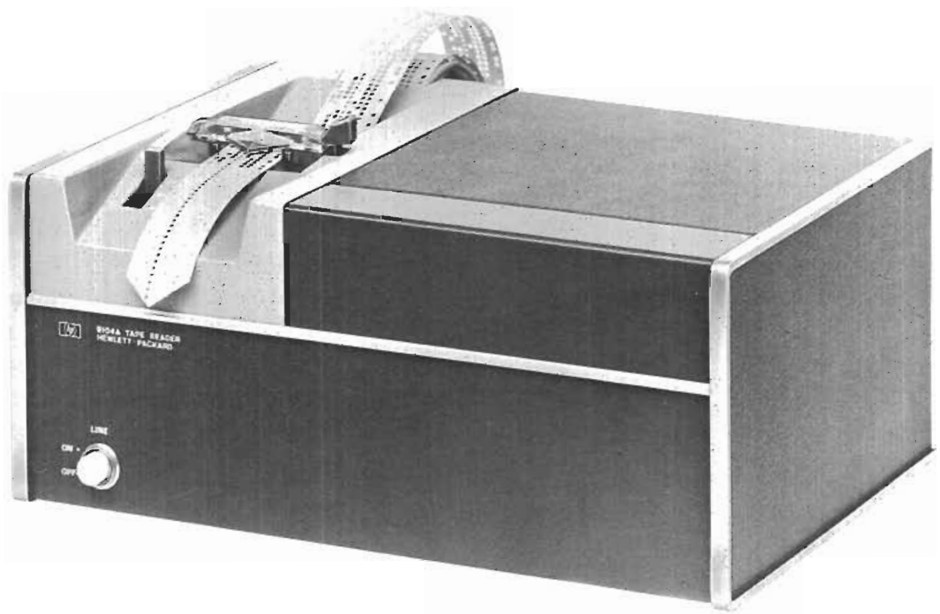
EQUIP ✓ ✓ 9120 ☐ ☐ 9104 ☑ 9106

✓ DEGREES ☐ ✓ FIXED DECIMAL 2 ☐ ☐ ☐ ON 9120

1. Set IBM 73 tabulator at position 16, 32, 48, 64, 80. If a preprinted form is used, align left page side at position 5 and head to writing line for: Principal loan.
2. Set line spacing to position 2 (medium)
3. Press on 9106A panel: ON, X, TAB.
4. PRESS: END
5. ENTER: PROGRAM, SIDE A
6. PRESS: CONTINUE
7. ENTER:
   - Loan principal P
   - Annual interest rate i
   - Annual payment p
8. PRESS: CONTINUE
9. ENTER: Starting year Y_1
10. PRESS: CONTINUE
11. To run another case, go to step 6.

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

9104A Tape Reader Adds a New Input Dimension



The new HP Model 9104A Tape Reader enters data into the system 9100 from ASCII coded punched paper tape (CCITT2 for Option 01). It is quiet, fast, and simple to operate and is compatible with existing system 9100 peripherals.

A Calculator command (FMT, CONTINUE) initiates the data reading so that the tape reader is under full control of the calculator. The reading is terminated by an "End of Entry" character on the tape. This character can be any ASCII character (or CCITT2 for Option 01), and is easily selected via a convenient patchboard located behind an access door in the front of the unit. The data reading is entered into the calculator's x register.

The data reading can also be terminated by an "End of Entry-Set Flag" character. This will set the flag after the data entry. "End of Entry-Set Flag" can also be any ASCII character selected by the user.

The 9104A can also be programmed to ignore certain specified areas of the tape. A "Begin Deletion" character on the tape tells the 9104A to continue reading tape, but to ignore all data on the tape until an "End Deletion" character is encountered. Both "Begin Deletion" and "End Deletion" can be any ASCII character.

Characters other than 0 through 9, minus sign, decimal point and those characters selected by the user or programmer are ignored by the reader, so that the reader enters only the desired characters into the calculator.

The tape reader operates under a variety of temperature and power input conditions. Temperatures of zero to 45° C are acceptable, as well as input power of either 115 or 230 Vac, +10% to -15%, and from 48 to 440 Hz line frequency.

If you would like more information on the Model 9104A Tape Reader, you can get it by checking the reply postcard or by calling your local HP sales office.

PROGRAMS AND PROGRAM LIBRARIES AVAILABLE

As a user of the HP 9100 Calculator System, you will be interested to know the number and variety of calculator program packets now available. Here is a list.

Part Number	Description
09100-70800	Stat-Pac Vol. 1
09100-70900	Analysis of Variance Pac
09100-70950	Quality Assurance Pac
09100-71200	Microwave Design Pac
09100-71374	Electric Utilities Pac
09100-74100	Surveying Pac Vol. 1
09100-74200	Structures Pac
09100-75203	Animal Ecology Pac
09100-75300	Cardiology Pac
09100-75350	Clinical Pathology Pac
09100-75598	Chemical Process Pac Vol. 1
09100-75599	Chemical Process Pac Vol. 2
09100-76999	Plotter Program Packet
09100-78000	Vermessung 1 (German Surveying)
09100-78200	British Surveying 1
09100-78400	Italian Surveying
09100-77000	Bautechnische 1 (German Structures 1)
09100-77100	Calcoli Di Strutture Civili (Italian Structures)
09100-78100	Stadsmätning (Swedish Surveying)
09100-78200	British Surveying Vol. 1
09100-79500	British Gear Design

Contact your HP calculator salesman for prices and availability of these packets. Many programs, not included in a package, which solve problems in a wide variety of applications are now available for purchase individually. Your calculator salesman will gladly help you locate any existing program you need.

IT'S THE LITTLE THINGS THAT COUNT

Many HP 9100 users have sent us bouquets for a small feature you may be taking for granted -- the ability to protect your programs recorded on magnetic cards. You can clip the corner from your program card along the outer arrowhead, making it impossible to wipe out a valuable program by pressing RECORD instead of ENTER. You can't do this with some makes of calculators. If your secretary mistakenly presses RECORD with a protected card in the HP 9100 card slot, nothing happens -- the program remains on the card. Her job is protected, and your temper is spared.

Or suppose you have a lengthy program, keyed into the calculator. You haven't made magnetic cards for it. The electric power suddenly fails. Have you lost a program because it is not yet in recorded card form? No -- the core memories are immune to power failure. When the electricity comes back on, you can proceed as if nothing happened.

Even the world's most dependable calculator is built of many components. Sooner or later, something will fail and you will experience some down time. How long does it take to get back "on the air"? As an HP 9100 user, you are fortunate, because the 9100 contains circuit board assemblies, most of which are quickly replaceable by plugging in another assembly while the original board is being repaired. The response to your call is fast. Down time is short, and your 9100 is soon doing your calculations as usual.

Remember, it's the little things that count!

ERRATA

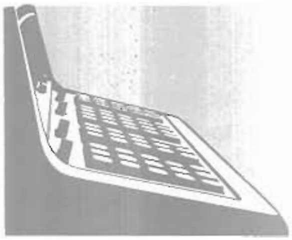
The following corrections apply to Walter Karger's Average Properties of Fluid Mixtures program (Part No. 09100-75609) in *KEYBOARD* Vol. 3 No. 1.

1. User Instructions, program IB, page 13:

STEP	PUBLISHED	CORRECT
1,1	X	X
1,2	no change	R ↑
1,3	R ↓	no change

2. On page 11, the NOTE refers to program III only.

3. On page 14, replace the last line of User Instructions for program III with the following: To rerun this program for *other mole fractions* with the same two stored properties, PRESS: GO TO, -, 3, 6 and proceed with step No. 8.



FACTORS OF N ($N<10^{13}$)

by Joseph S. Madachy, Monsanto Research Corp.
Mound Laboratory*, Miamisburg, Ohio

**PART NO.
09100-70060**

This program is an improvement over an earlier HP program (Factors of n, Part No. 09100-70013). That program may give erroneous factors when n is a 12-digit integer. The present program performs a check calculation to avoid erroneous results, and also prints out N - including the 11th and 12th digits, if keyed in - and the factors of N. A prime N is indicated by printing it a second time.

This program has two additional features explained in the notes following the USER INSTRUCTIONS:

- Factoring can be interrupted and resumed again at a later time, starting with the largest factor that had been tested. There is no need to start from the beginning. This is important when a large N is being factored and the 9100A Calculator must be preempted for other uses.

- Factoring of a series of integers can be done by changes in two or three program steps.

Even though this program does more examination of the factors to avoid erroneous results, there is no significant difference in speed between the earlier HP program and this one.

N, including the 11th and 12th digits (if keyed in), will be printed out. For an 11-digit N, the 11th digit will be printed immediately below the first 10 digits of N and be preceded by a minus sign. The 11th and 12th digits of a 12-digit N will appear on one or two extra lines immediately after the first 10 digits of N, and also be preceded by minus signs.

If the 11th and 12th digits are of the form . . . 00, the printout of these digits will be

-0.
-0.

If of the form . . . 0d, the printout of these digits will be

-0.
-d.

If of the forms . . . d0 or . . . cd, the printout will be

-d0.
-cd.

Factoring will start immediately after N is completely printed. Factors with 10 digits or less have no minus signs. If a factor has 11 or 12 digits, the printout will be as explained above for 11- or 12-digit N's. The program puts

EQUIPMENT ✓ ✓ ✓ 9120

DEGREES ✓ ED DEC 0 x ON 9

1. ENTER PROGRAM: Starting address is 0-0.
2. PRESS: END, CONTINUE — 0 0 0
3. ENTER N→x. (If N has 11 or 12 digits, these should be keyed in even though the display will switch over to floating point.)
4. PRESS: CONTINUE.

* Mound Laboratory is operated by Monsanto Research Corporation for the U. S. Atomic Energy Commission under Contract No. AT-33-1-GEN-53.

an extra space after the last factor is printed and returns to 0-0 for the entry of a new N.

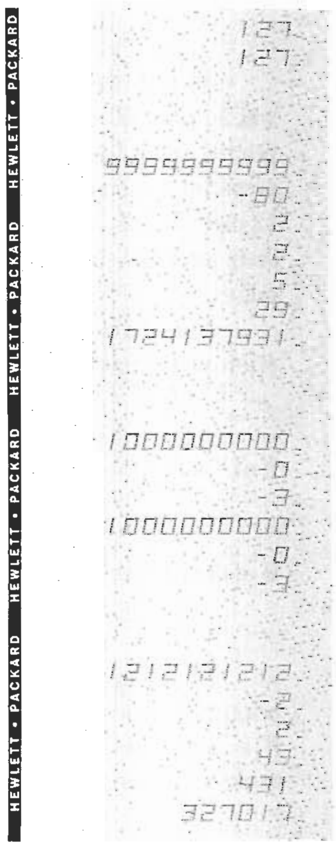
EXAMPLES:

Factor 127:
Printout will be
(127 is prime)

Factor 999999999980:
Printout:

Factor 100000000003:
Printout:
(100000000003 is prime)

Factor 12121212122:
Printout



NOTES:

If consecutive integers are to be factored, change program steps 89 and 8a from 0,0 to 9,a. Consecutive integers will be factored until manually stopped. If only odd integers are to be factored, change also step 9d from 1 to 2, and start with an odd N.

A valuable feature of this program is the ability to resume a long factorization after an interruption.

Suppose N = 100,000,000,003 is being factored (actually this number is prime and will take approximately 75 minutes on the 9100 Calculator). After some minutes, the calculator must be preempted for more important work. First PRESS: STOP. Now PRESS: RCL.

The x register will display the current factor being tested. The y register will display N, or the largest unfactored portion. Suppose the above N factorization was interrupted. The display, after the RCL key was pressed, might be:

1.000000000	11	y
	315011	x

(The 11th and/or 12th digits in y will have to be recovered if they are not known. This might happen if the y register displays an 11- or 12-digit unfactored portion of N.) Record the numbers in the x and y register.

When factoring is resumed later, divide x (315011 above) by 6 and determine what the remainder is. It will be either 1, 3, or 5. If the remainder is 3, subtract 2 from the x value; if the remainder is 5, subtract 4 from the x value. For 315011, the remainder after dividing by 6 is 5; subtracting 4 leaves 31507. Factoring is resumed as follows:

1. ENTER PROGRAM: Starting address is 0-0.
2. PRESS: END, CONTINUE
3. SET FLAG
4. ENTER N (or whatever was recorded from the y register) into registers d and e, and put it also into the y register.
5. ENTER 31507 (or whatever number resulted after division by 6 and subsequent subtraction of 2 or 4) into register f, and put it into the x register.
6. GO TO (0)(9)
7. CONTINUE

Factoring will resume where it had left off previously.

A rough estimate of the time required for the 9100A to run through the factorization of N, assuming it may turn out to be prime, is:

$$\frac{\sqrt{N}}{4200} = \text{Approximate time in minutes.}$$

Of course, if N is not prime, the factorization will be completed in less time.

Step	Key	Code	Step	Key	Code	Step	Key	Code	Step	Key	Code	Step	Key	Code	Step	Key	Code	Step	Key	Code
00	CLR	20	20	3	03	40	GTO	44	60	DIV	35	80	UP	27	a0	+	33			
01	STP	41	21	8	10	41	0	00	61	DN	25	81	INT	64	a1	DN	25			
02	GTO	44	22	c	16	42	9	11	62	UP	27	82	-	34	a2	GTO	44			
03	4	04	23	RDN	31	43	e	12	63	INT	64	83	GTO	44	a3	4	04			
04	9	11	24	CLX	37	44	UP	27	64	PNT	45	84	9	11	a4	9	11			
05	UP	27	25	RDN	31	45	SFL	54	65	-	34	85	5	05	a5	END	46			
06	1	01	26	6	06	46	GTO	44	66	.	21	86	PNT	45						
07	AC+	60	27	X>Y	53	47	4	04	67	1	01	87	PNT	45						
08	2	02	28	SFL	54	48	c	16	68	X>Y	53	88	GTO	44						
09	DIV	35	29	CNT	47	49	XTO	23	69	8	10	89	0	00						
0a	X>Y	53	2a	DN	25	4a	d	17	6a	b	14	8a	0	00						
0b	4	04	2b	2	02	4b	UP	27	6b	EEX	26	8b	EEX	26						
0c	3	03	2c	AC+	60	4c	EEX	26	6c	2	02	8c	1	01						
0d	XEY	30	2d	IFG	43	4d	1	01	6d	X	36	8d	X	36						
10	UP	27	30	3	03	50	0	00	70	DN	25	90	XEY	30						
11	INT	64	31	4	04	51	XEY	30	71	CHS	32	91	UP	27						
12	X=Y	50	32	AC+	60	52	X<Y	52	72	IFG	43	92	INT	64						
13	1	01	33	SFL	54	53	7	07	73	8	10	93	-	34						
14	8	10	34	RCL	61	54	2	02	74	6	06	94	CHS	32						
15	X<Y	52	35	GTO	44	55	XEY	30	75	PNT	45	95	PNT	45						
16	2	02	36	0	00	56	EEX	26	76	d	17	96	DN	25						
17	4	04	37	9	11	57	1	01	77	GTO	44	97	GTO	44						
18	RUP	22	38	RUP	22	58	1	01	78	0	00	98	6	06						
19	X	36	39	DIV	35	59	X>Y	53	79	5	05	99	d	17						
1a	XTO	23	3a	XEY	30	5a	7	07	7a	EEX	26	9a	CLR	20						
1b	c	16	3b	YTO	40	5b	a	13	7b	1	01	9b	d	17						
1c	e	12	3c	e	12	5c	EEX	26	7c	DIV	35	9c	UP	27						
1d	X=Y	50	3d	PNT	45	5d	2	02	7d	XEY	30	9d	1	01						

Joseph S. Madachy is a mathematician with Monsanto Research Corporation in Miamisburg, Ohio (near Dayton) and also the Editor of the *Journal of Recreational Mathematics*, published by Greenwood Periodicals, Inc., Westport, Conn.

He was raised in Cleveland, Ohio and received his B.S. and M.S. degrees in chemistry from Western Reserve University in 1955 and 1959.

His work at Monsanto involves mathematical and statistical studies of production and research data generated by the company.

Mr. Madachy has authored or co-authored two books on recreational mathematics: "Mathematical Diversions" with J.A.H. Hunter, and "Mathematics on Vacation". Before working for Monsanto he was the founder, editor, and publisher of *Recreational Mathematics Magazine*.

OUTSIDE THE U.S.A

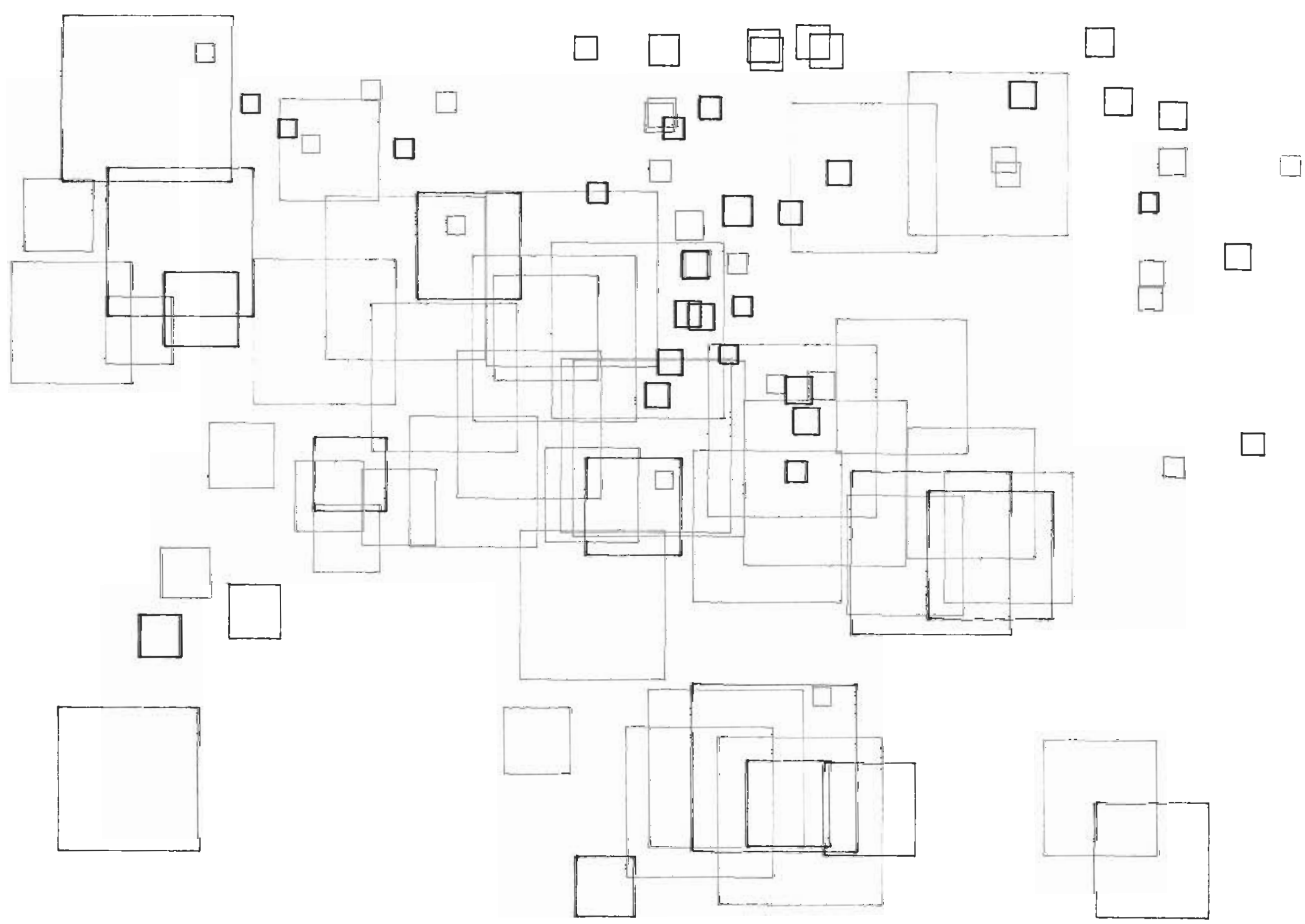
The branch of the *HP KEYBOARD* Calculator Art Contest open to contestants outside the continental U.S.A. elicited entries from Oslo, Norway and Sydney, Australia - about 9,900 miles apart.

The prize winning entries are shown in this issue; the first prize going to John B. Miller. His entry, *PSYCHEDIL No. 5,* is reproduced on the front cover. Mr. Miller is Head of Laboratories at Norsk Teknisk Byggekontroll AS, Jan Friis, Oslo, Norway. His program plots a multi-petaled rose such that for every increment a square is drawn with one corner at the coordinates of that increment. His program allows controlling the width of the petals as the number of petals is changed. Mr. Miller also submitted a different rose plot, as well as the random square plot shown on this page.

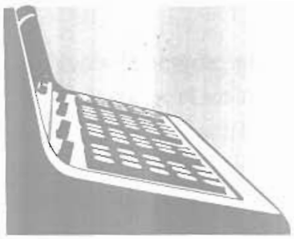
The second prize was awarded to Christopher J. Bell, Falkiner Nuclear Department, University of Sydney, Australia, whose circuit drawing program plot appears on the back cover. This program draws standard circuit symbols such as logic gates, transistors, resistors, etc., on an inch grid. Connecting leads are then added manually. Besides the symbol capability, the program plots characters generated on a 10 x 10 grid, as well as providing a circle drawing routine.

The first prize is a choice of three calculator program packets in the fields of Statistics, Surveying, Chemical Processing (Vol. 1 or Vol. 2), Clinical Pathology, Cardiology, or Electric Utilities. The second prize is a choice of two program packets.

Subsequent to publication of the U.S.A. Art Contest winners in the last issue of *KEYBOARD*, the first prize entry, *WAVES*, by Paul Milnarich, was selected for inclusion in a textbook on computer art being compiled by the New York Times. The participation of all contestants is appreciated.



VARIATION ON RANDOM SQUARES by John B. Miller



CALCULATOR NETWORK ANALYSIS (CNAP)

PART NO. 09100-71504

Several general purpose electronic network analysis programs have been written for large batch processing and time-share computer systems. These programs have gained tremendous popularity among engineers and students (1) by providing capability to predict circuit performance before committing designs to the more costly hardware phase, (2) by giving a quick way to optimize designs where a trial and error approach is most practical, and (3) by giving the user a method of obtaining greater insight into circuit theory.

There are, however, some disadvantages associated with these larger computer systems. Batch processing systems often have long delays before results can be obtained. This strongly limits the ability to do trial and error designs. Even when the user can interface more closely with the computer as with time-share, the input format is often complicated, making it difficult for the occasional user to remember how to use the program. Even then, the programs cannot usually be modified by the user for special applications, nor is it always possible to obtain plotted results.

A survey disclosed that many people use the large programs to analyze relatively simple circuits. In fact, most of the users surveyed only wanted gain (and sometimes phase) versus frequency outputs with the ability to select plotting or printout, or both. The natural question arose: why not write a program for a desktop calculator capable of performing these tasks right at the engineer's desk and free the large and more costly computer to do the larger problems?

Now, for the engineer who analyzes networks of up to 8 nodes and 22 components, this analysis may be carried out conveniently at his desk by using CNAP, a general purpose Calculator Network Analysis Program developed for the HP 9100 Programmable Calculator and the 9101 Extended Memory. With a 9125 Plotter added to the system, magnitude or phase versus frequency plots may be generated.

Besides the convenience of working at the desk, there is the advantage of easy program modification for special applications. For example, by merely changing 12 steps in the program, the input impedance may be printed and/or plotted versus frequency.

Using the Program

Using the Calculator Network Analysis Program (CNAP) is straightforward. The circuit to be analyzed is drawn and each node is assigned a number. Four types of components are allowed: resistors, capacitors, inductors, and voltage-controlled current sources. The precision and wide dynamic range of the calculator make it possible to transform other active elements into the required form. For example, a voltage-controlled voltage source with zero ohms internal impedance cannot be realized, but one with 0.0001 ohms can be; the difference is negligible for almost all problems.

Each component is specified by entering its value and the numbers of the nodes it is connected between. Each controlled source is specified by entering the trans-conductance, the controlling node, and the controlled node. The user then specifies the frequency range and the number of points to be computed. Either a linear or a logarithmic frequency scale is specified by a single key-board command.

A plot of the circuit gain or phase may be specified. The user enters the size of the paper and the maximum and minimum values along the Y axis. All scaling is then done automatically by the program.

When the output for the given circuit and frequency range has been completed, these options are available:

(1) Select a new frequency range.
(2) Change the value of a component.
(3) Start over with the specification of a new network.

A particularly valuable feature is the capability for user modification of the program for special applications. In the following example, the program has been modified to compute the real part and the imaginary part of a network's complex input impedance.

Example: Emitter Follower Input Impedance

If a node is driven from a 1 amp current source, the voltage at that node is equal to the impedance seen looking into the node. The program can be modified to calculate the real and imaginary values of output voltage, rather than the polar form of magnitude and phase. For example, the input impedance of the emitter follower circuit shown below, used in some oscillator circuits, exhibits a negative real part at certain frequencies.

This characteristic is examined and the results plotted in Figure 2.

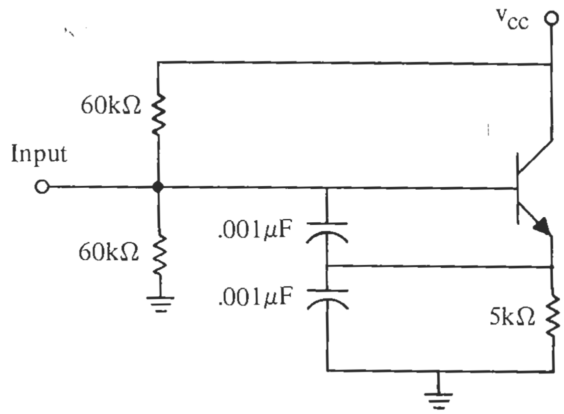


Figure 1. Emitter Follower Circuit

This is one of many time-saving programs which are now listed in the new Calculator Products Program Catalog, and purchasable through your local HP sales office. Your calculator salesman will gladly give you more information on how to obtain a copy of the program, complete with prerecorded magnetic cards.

PASSIVE RLC NETWORK ANALYSIS PROGRAM

The next issue of *KEYBOARD* will include a general RLC network analysis program developed by C.E. Weller and W.H. Glass of AVCO Electronics Division. Some of its features include analysis of ladder-like networks of up to 15 series and shunt branches with a total of 45 circuit elements. Program outputs include plots of amplitude and phase of the transfer function, and reflection coefficient or vswr vs. frequency on a linear or log scale. Reflection coefficient plots are made on a standard Smith chart, either expanded or normal scale.

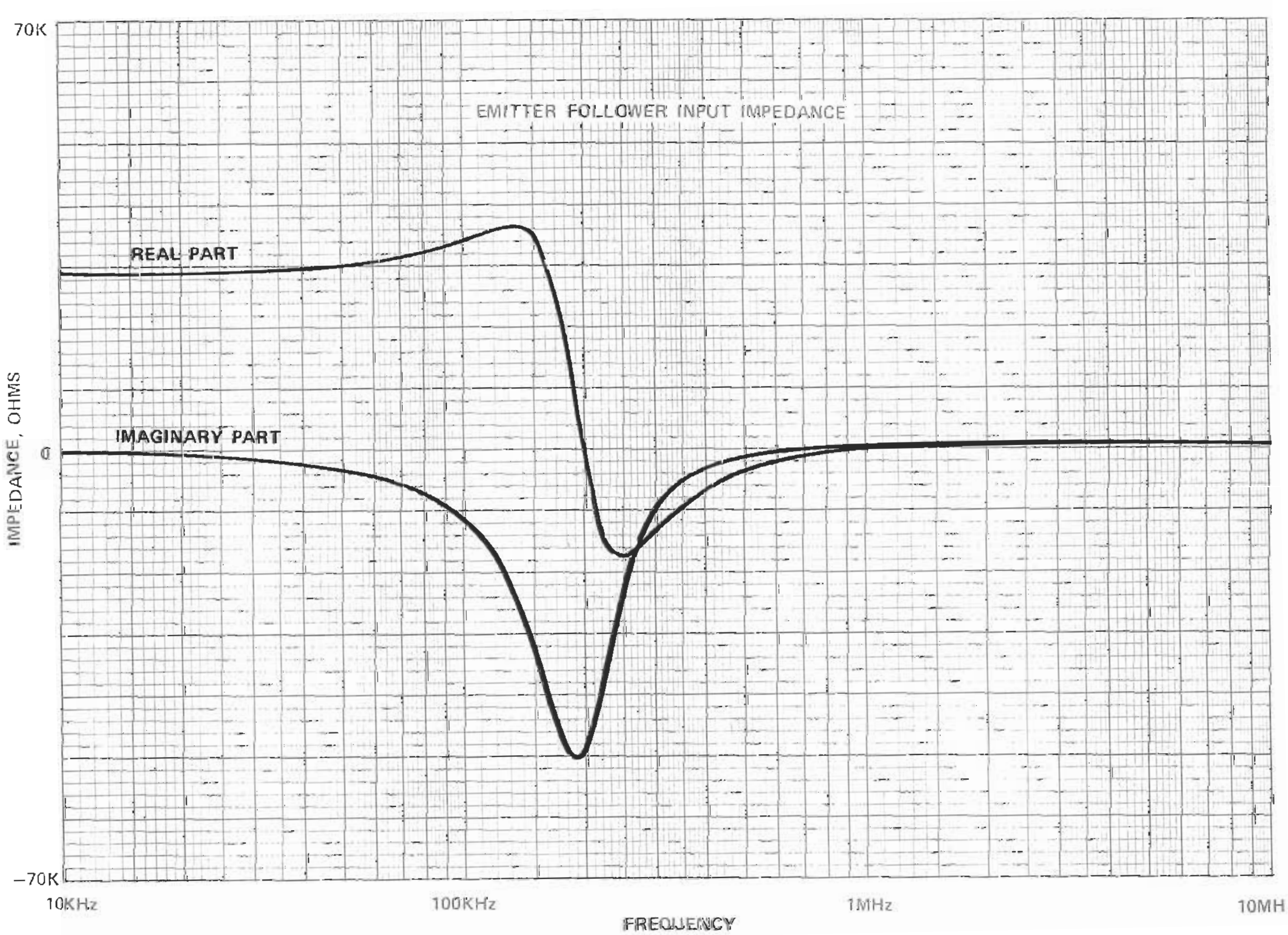


Figure 2. Emitter follower input impedance.

Simplifying The Analysis of Medical Data With a Programmable Calculator

Time saved and complex computational capabilities of new desk-top HP instrument evidenced in wide variety of medical applications

Grateful acknowledgement is made to *WALTER J. GAMBLE, M.D.,* who provided the majority of information presented in this article. Dr. Gamble, Senior Associate in the Department of Cardiology, The Children's Hospital Medical Center, Boston, Mass., has developed a number of innovative medical programs for the 9100 Calculator and made them available through the Medical Applications group of Hewlett-Packard in Loveland, Colorado, to any 9100 user in medicine and the life sciences.

The problem often facing today's researcher in medicine and the life sciences is not so much one of *acquiring* sufficient and accurate data, as it is one of quickly *reducing* it to meaningful and manageable proportions. To have more time for productive evaluation of results means spending less time *getting* the results – typically, through the use of computer-like devices. At the same time, practicality for many large and small laboratory applications requires a method lower in cost, easier to use and more accessible on short notice than allowed by a time-shared computer. In short, computer calculating speed and power in a form easily usable by anyone in a laboratory, is what is needed. This is the essential contribution of the HP 9100 programmable, electronic Calculator, exemplified here in a medical context in the following review of hospital and medical school applications.

STATISTICAL ANALYSIS OF CARDIOVASCULAR MEASUREMENTS

One of the major uses of the Calculator in the Cardiology Department at The Children's Hospital Medical Center (Boston) is statistical analysis of grouped data such as determining the Mean, Standard Deviation, Standard Error of Mean, as well as Linear Correlation determinations. Analyses such as these are used in reviewing the progress of a series of pediatric patients over a span of time, correlating intracardiac pressures, for example, with the ECG or vector, with growth, with outcome after surgical correction. The statistical methods permit precise determinations to be made, with greater assurance that they will be as error-free as possible. A further example of grouped data study is vectorcardiographic analysis, using measurements made from photographs at selected time intervals, to give right and left maximums, mean spatial vector plus individual spatial voltages, and frontal and horizontal angles.

The Mean and Standard Deviation calculations on data from normal subjects provide a scale against which a patient's value may be compared for normality or abnormality. In another example in research investigation, the weight of hearts from rats which have undergone exposure to varying concentrations of oxygen were compared to those of animals maintained on air. The Mean and Standard Error of the Mean of the two groups permits applications of a "T" test to determine the level of significance of the difference between the experimental and control groups.

Calculation of Linear Correlation is also done by the Department, using, as in the previous examples, a program developed by Dr. Gamble. This test is used to determine whether relationships exist between a measured independent and a controlled variable, such as between the pressure developed by an isolated, blood-perfused rat heart and the oxygen it consumes, and in another case, between VCG voltages and pressures measured in patients at catheterization. In all of the foregoing programs, Dr. Gamble has included specific and easily-followed key stroke instructions to allow the operator to correct any mistakes that may have been made in entering data. Thus if a piece of erroneous data is entered by mistake, it may be removed without having to restart the whole series of data. Further, Dr. Gamble has programmed these statistical analyses so that intermediate values are printed out to permit the combining of series of data (so that the individual points need not be reentered).

SIMPLIFIED CONSTRUCTION OF HISTOGRAMS

Another use of the Calculator within the Cardiology Department allows a microscopist to count grains within a cell and operate the Calculator without taking his eyes off the microscope. Using programs designed by Dr. Gamble for this purpose, the operator presses the "+" key for each grain or count visualized, and on completion of the cell, presses the "continue" key and then goes on to the next cell. (Through a special program sequence, the capacity of the Calculator's registers are, in effect, quadrupled. This means that 36 data storage sites are available, each able to store 999 counts - or well beyond the max. number of counts likely to be needed.) On completion of the slide count, a second program to construct a histogram is entered into the machine by magnetic card; the Calculator then starts a print-out of the number of cells found with each specific count beginning with 35 counts/cell and progressing down to 0 counts/cell.

VERIFICATION OF CARDIAC CATHETERIZATION MEASUREMENTS

When reviewing patients for research purposes, several programs enable the Department's investigators to rapidly check previously hand-calculated clinical data. (It has been felt that if the Calculator were located near the Cath Lab, it would probably be used to make the initial calculations as well.) Clinical data inputs to the Calculator include blood oxygen capacity, body surface area, oxygen consumption, pulmonary and systemic venous and arterial saturations, pulmonary and systemic arterial and venous mean pressures, and heart rate at time of output determination. Calculator print-out, which for ready comparison exactly parallels the Hospital's standard report forms, contains the following data: BSA; VO_2 (patient oxygen consumption); VO_2/M^2; pulmonary, systemic and effective pulmonary measurements of the following: A-V Oxygen Differences, Flows/Patient, and Flows/M^2; Shunts, Resistances, Heart Rate, Stroke Volumes and Stroke Indexes. Indicative of the time-saving nature of these cath calculations, Dr. Gamble feels that "any secretary can be taught how to run it in about five minutes. It takes me about two minutes to set up and program the Calculator, and less than one minute to run a patient's data."

In a similar manner, valve area calculations are made in stenotic valve studies from (1) data derived manually from simultaneous or sequential tracings of pressure gradient across the stenotic valve, and (2) data pertaining to cardiac output and heart rate. Entered data consists of body surface area, individual gradient measurements from traces, cardiac output and heart rate. Calculator printout delivers mean and peak gradient, time and percent of time valve is open, valve flow and flow/M^2, valve area and valve index.

Two other interesting calculating applications in this Cardiology Department suggest a usefulness limited only by the user's imagination. With one program card, the operator enters the month, day and year of, for example, a specific patient treatment, insertion of a pacemaker, patient's birthdate, etc., then repeats the steps for a second (end point) date of interest. The Calculator then tells the operator the exact number of elapsed days between the two dates, and the approximate elapsed time in days, months and years. The program supplies the exact time in days for any period since 1753 and to many centuries into the future (the 1753 "limitation" necessitated by a correction in the calendar made that year), taking into account the different month lengths, leap years, etc.

The second of these applications is more financial than medical: using a program card to have the Calculator do the necessary arithmetic, the operator enters the expenditures and obligations to date of a funded project and the project period in months. The print-out then tells him whether under- or overspending is occurring and where he stands in relation to the over-all project budget.

In common with many scientific groups, the Cardiology Division at Children's Hospital has several groups using one HP Calculator for a variety of data analysis problems. "Usually, a technician or secretary is shown how to use the specific desired program", Dr. Gamble reports. "She (or he) then will run the data with data print-out so that the correctness of the data entered may be ascertained. This is true of virtually all programs that I have written thus far." Commenting on the practicality of one Calculator serving a number of people, he adds ". . . the Calculator does lend itself very well to shared use between various groups. The only deterrent is the geographical separation of the investigators' bases of operation. Because of the speed of operation there have been virtually no scheduling difficulties."

Dr. Gamble is a Senior Associate in Cardiology at the Children's Hospital Medical Center, and is assistant Professor of Pediatrics at Harvard Medical School. A graduate of the University of Pennsylvania Medical School, he trained at the Children's Hospital of Philadelphia before coming to Boston to a fellowship in pediatric Cardiology.

TEACHERS CORNER

THE HP 9100 SYSTEM GOES TO SCHOOL

For the past six months, Hewlett-Packard and Loveland High School (Loveland, Colorado) have been working together to study the effectiveness of programmable calculators in secondary schools. HP loaned Loveland High School a 9100 Education System for the project and sent Howie Weissman (Education Support) to provide in-service training and to observe results. According to Weissman, the project has been an immense success.

The goals for the project were to become more aware of the needs and applications for programmable calculators and computers in schools. We wanted to learn firsthand how the 9100 system could be used and how it affects learning. We also wanted to test the effectiveness of the materials already written and learn what additional software was needed.

Last summer Hewlett-Packard contacted Loveland High School with the idea of creating an experimental mathematics class using the 9100 System. The class was to serve as a laboratory to test the "ways and means" of using computers and calculators in schools. The class would provide a clearing house to test some of the new computer-oriented techniques developed by teachers around the country and to provide the Hewlett-Packard staff with an in-depth understanding of the value of the calculator in schools.

The Mathematics Department was very enthusiastic about the project and agreed to create the experimental class if they could also use the system through their mathematics curriculum. An intermediate algebra class was selected as the experimental class. This decision was based on several factors. First, it was a team class with ninety students and three teachers, providing a wide background of both student and teacher experience. The students had a broad range of interest and ability levels, giving the opportunity to judge how computers affect gifted, average, and slow students. The teaching team also provided the unique chance to discover how teachers with a wide range of mathematical interests and educational philosophies would use the system. Second, we chose intermediate algebra, as opposed to advanced mathematics, because we wanted to determine how early a computer could be introduced. Third, the size of the class let us evaluate how many students could effectively use the system. This also allowed testing the large screen classroom display and x-y plotter for classroom demonstrations.

Hewlett-Packard provided the school with a 9100B Calculator, 9120A Printer, 9125B Plotter, Card Reader and two Classroom Displays. Two displays were used because the shape of the room (L-shaped) prevented clear visibility by students along the sides of the room. The system was completed by the high school shop class which built two portable carts for the equipment. The day the system was delivered, the project was immediately started by a group of curious students who wanted to know how to use it.

The first major task in the project was to instruct the teachers and the students how to program. All the teachers (but none of the students) had some background with computers. According to Weissman, "We quickly found that teaching programming in a lecture doesn't work. Students have to interact with the computer. They must sit at the keyboard and enter their programs themselves if they are going to discover how much fun computers can be". It wasn't long before smiling student faces began to appear. We chose an unusual approach to introduce programming. The students were asked to write programs to generate sets of numbers. Sets were chosen because we could easily develop topics about looping, subroutines, and testing. In addition, intermediate algebra usually starts with a review of set notation. In about one week, the students had acquired a good background in programming.

During the year we have isolated three major areas of usage for the computer that we wanted to emphasize. Student problem solving was the top priority. Many studies have indicated that computer problem solving increases motivation and strengthens reasoning and problem solving skills. In the beginning of the project programs were assigned whenever possible (about once a week or twice a week), but complaints started coming in that the students were spending more time writing programs and less time doing assignments for other subjects. At this point we became very conscious about the "time effectiveness". Problem solving had definite positive benefits both in motivation and reasoning skills, but in most cases it also demanded more time. The teaching team soon reached the decision that programming should be assigned only when it is the most effective method to reinforce a topic. We now assign about two or three programs a month. It is interesting to note that the computer's use has not dropped much; students are now bringing in unassigned programs which interest them. The results have been excellent. Jack Wilson, teaching captain, has commented that he has seen a noticeable improvement in the way students solve problems, "They are more meticulous". Walter Speece, another teacher in the team, happily adds that "There have been more students asking me questions about math in the first quarter this year than I had all last year".

The second major area of usage was classroom demonstrations. Whenever a topic was introduced that required extensive computation, we used the 9100 Calculator with the classroom displays. For example, points of a function were generated in micro-seconds with a very simple program which the students wrote. The students are often amazed to discover how fast the calculator can compute results. We have found that classroom demonstrations are most effective when we use the students' own programs. It makes them feel personally involved.

The third area of usage was to actually develop a topic in class through flowcharting and programming. In many cases the team felt they could better develop the mathematical relationships using computer-oriented techniques instead of traditional methods. Factoring is a good example. We used flowcharts extensively and reinforced this approach by assigning programming.

Test scoring has been another area of interest. Whenever a multiple choice test is suitable, we used the mark-sense test scoring cards and the mark-sense reader. This is an exciting timesaver for teachers. On a recent quarter test papers for the entire class (90 students) were scored in about twenty minutes.

Applications in other classes are just as interesting. In Mr. Speece's trigonometry and advanced algebra course, the students discovered several identities in their text which were not identities. They found that the identities often

failed outside the first quadrant even though they appeared to be verified by a deductive proof. They discovered these errors by writing programs to check the identities through a range of angles between 0 and 360 degrees: after careful investigation the students discovered their proofs were wrong. Mr. Riegel, Department Chairman, has been using the plotter to graph polar functions in his analytic geometry class. They have been able to do more plots than they thought possible before.

How do the students feel about computers and programming? You can almost see the personal satisfaction on their smiling faces when their programs run. "It can make your day", says Weissman. He once spotted a student feverishly debugging her program in class. He told her that he thought programming was boring and tedious. She argued with him saying, "No, it's fun, it's fun when you get the program to work". Mr. Wilson likes to tell the story about a student who came in to check his program. When it didn't work, Mr. Wilson said he'd help. The student said no, he'd rather do it himself. Wilson said it was the first time that student ever did something extra for a mathematics course.

How do the teachers at Loveland High School feel about computer-oriented instruction? According to Mr. Riegel, "The computer definitely has a place in mathematics instruction". Next year Loveland is planning to create its own computer course and use computers throughout its entire mathematics curriculum.

Hewlett-Packard has learned a lot about using calculators in secondary schools. As a result we will be better able to plan education materials and in-service training. This project has made a substantial contribution to our understanding of teachers' needs.

PROGRAMMING TIPS

PROGRAMMING THE MINUS e AND f REGISTERS

In programs for the 9100B, you may have occasion to load the entire plus page of the calculator memory with data and find you are a register or two short for your program on the minus page. Mr. John Ashcroft of New South Wales, Australia, suggests a good way to use the minus e and f registers for extra program capability.

Initially, you can store the parts of the program for the minus e and f registers in the plus c and b registers, for example. The following initializing routine will then place these program contents as desired, and leave the plus registers available for data storage.

STEP	KEY	CODE
00	CLR	20
01	c	16
02	XTO	23
03	-	34
04	e	12
05	b	14
06	XTO	23
07	-	34
08	f	15
09	0	00
0a	GTO	44
0b	-	34
0c	0	00
0d	0	00

Step 09 is a spare. The contents of the minus e and f registers can be either subroutines or part of the program, since after step -ed, the program branches to -a0 automatically, and after -fd, it branches to -c0. For a regular program sequence, then, the last steps in the minus 9 register should be GO TO, e,0; and for the minus b register, GO TO, f,0. The net gain in program steps available is thus 28 less the six branching steps, or 22.

If the plus 0 register is to hold program steps for the start of the main program, these may be programmed into the plus a register for magnetic card entry. A linking routine including instructions a, x TO, 0, GO TO, +, 0,0 must be stored initially in some other register, and its starting address placed in locations 0b through 0d.

HOW EQUAL IS EQUAL?

When you design a program using an equality test, remember that although your display may be in fixed point notation, your 9100 always compares 12 digits and the two-digit exponent. Even though the display is in floating point, your calculator is also comparing the two guard digits, as well as those you can see.

As an example, the following contents of the x and y registers are *not* equal:

$$9\,999\,999\,999\,(95) \times 10^2$$
$$9\,999\,999\,999\,(96) \times 10^2$$

Although both the numbers are considered by the calculator to be equal to the next higher power of 10 since the last guard digit is 5 or greater, the numbers are still not equal since 5 is not equal to 6.

If you want to compare numbers and branch when a lesser number of digits than 12 is desired to be compared, it is easy to use INT x to limit the comparison to the desired number of digits.

The HP 9100 does exactly what it is told to do, within its broad range of capability. If you are doubtful that it is obeying orders, running the diagnostic program will verify proper operation and may help disclose a bug in your programming logic.

IF FLAG -- SET FLAG

Our thanks go to Mr. G. B. Walford, a timber engineering scientist with the Forest Research Institute, New Zealand Forest Service, Rotorua, N. Z. for this tip.

The Spring 1969 *KEYBOARD* had a programming tip for alternate plus and minus accumulation in a program such as a sin x series which is looped. Mr. Walford accomplishes the same result with two less steps:

IF FLAG
ACC-
IF FLAG
ACC+
SET FLAG

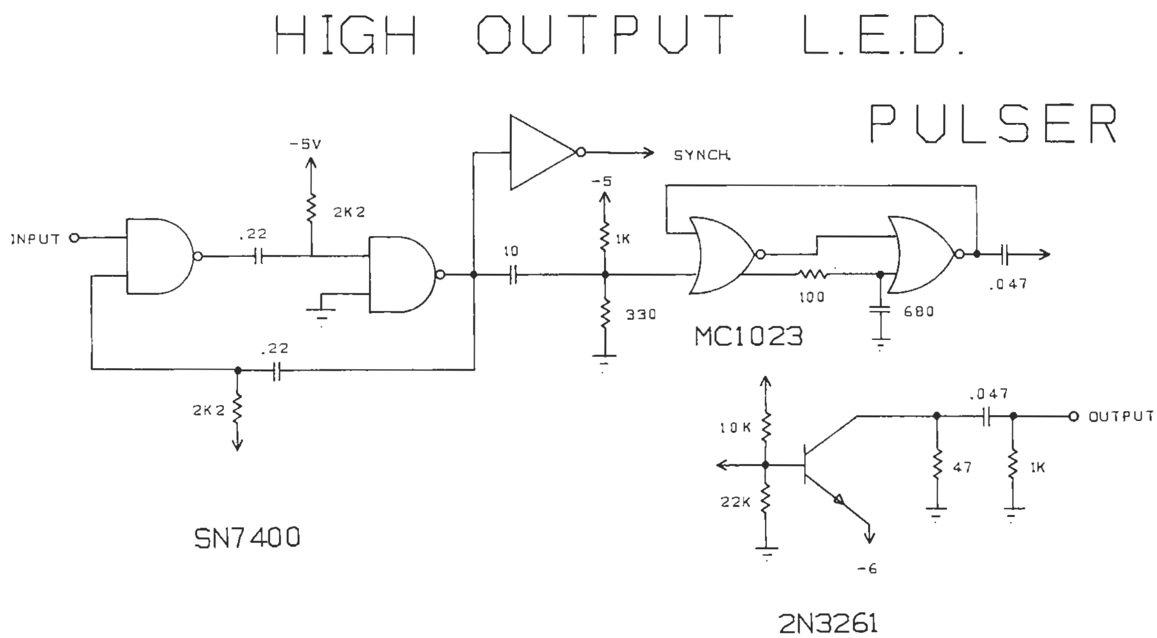
The resulting economy of two program steps will often be valuable. This tip is valid for either the HP 9100A or 9100B.

ARC TAN n

Claude Cardot, who contributed the Universal Four Operations Program (*KEYBOARD* VOL. 2 NO. 2), has sent us this programming tip for getting into the y register the arctan of a number n already in the y register:

Step	Key	Code	x	y
+00	1	01	1	n
01	TO POLAR	62	1/cos n	arc tan n

The alternate method would be the sequence, DOWN, ARC, TAN, UP -- four steps compared to two for Mr. Cardot's technique.



SECOND PRIZE: CIRCUIT PLOT, Christopher J. Bell, Falkiner Nuclear Department, University of Sydney, Sydney, Australia

KEYBOARD

Volume 3 Number 2

APPLICATIONS INFORMATION FOR HEWLETT-PACKARD CALCULATORS

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