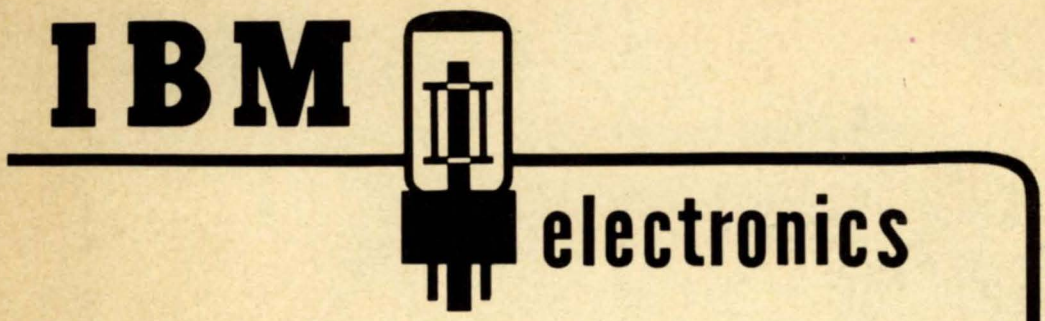
Fred Greenberger



applied science department

technical newsletter no. 1

IBM

APPLIED SCIENCE DEPARTMENT

Technical Newsletter No. 1

June 1950

CONTENTS

INTRODUCTION

Technical Newsletter Number 1 is the first of a series to be published by the Applied Science Department of the International Business Machines Corporation. The purpose of these Newsletters is to allow rapid interchange of information between computers concerning computational methods on IBM punched-card equipment.

Technical Newsletter Number 1 describes general purpose control panel diagrams which have been used successfully. Three of these diagrams are for the IBM Card-Programmed Electronic Calculator. The fourth diagram is for the IBM Type 604 Electronic Calculator.

1.

604 Electronic Calculator Control Panels for Multiply, Divide, and Square Root on the Card-Programmed Electronic Calculator.

D. W. Pendery
International Business Machines Corporation

IBM

ELECTRONIC CALCULATING PUNCH - TYPE 604 - PLANNING CHART

ALL VALUES ASSUMED
LESS THAN 1.0

$a_{1-10} \times b_{1-10} = c_{1-10}$

APPLICATION CARD PROG. CALCULATOR PROBLEM MULTIPLICATION – 10 DECIMALS

NOTES:

X OR D CODE

CARD NAME OR FUNCTION

ELECTRO NO.

	OPERATION - NOTES	PROGRAM SUPPRESS	PROGRAM NUMBER	FACTOR STORAGE ASSIGNMENT 6-4 (8-5) 8-6 — 1	2	3	4	MULT. QUOT.	COUNTER	GENERAL STORAGE ASSIGNMENT 6-4 (8-5) 8-6 — 1	2	3	4
R	READ		R	XXX	a_{3-10} XXXXX	a_{1-2} XX	b_{1-2} XX				b_{3-10} XXXXX		
1	ROFS3, RI +		1			RO			XX				
2	ROFS1-2, RI+, RI 3rd		2						a_{1-10} XXXXXXXXXX				
3	ROCTR, RIMQ		3					a_{1-5} XXXXX	RO				
4	RRCTR, RIGS3-4, RO 6th		4						RR				a_{6-10} XXXXX
5	ROGS1-2, MULT +		5						$a_{1-5} \times b_{3-10}$ XXXXXXXXXXXXX		RO		
6	RRCTR, RIFS1-2, RO 6th		6	XXX	XXXXX				RR				
7	ROGS3-4, RIMQ		7					a_{6-10} XXXXX					RO
8	ROFS4, MULT +		8				RO		$a_{6-10} \times b_{1-2}$ XXXXXXX				
9	RRCTR, RIGS3-4, RO 3rd		9						RR				XXXXX
10	ROGS1-2, MULT +		10						$a_{6-10} \times b_{3-10}$ XXXXXXXXXXXXX		RO		
11	ROFS1-2, RI +		11	RO					XXXXXXXXXXXXX				
12	ROGS3-4, RI +		12						XXXXXXXXXXXXX				RO
13	$\frac{1}{2}$ ADJ, RI 3rd		13						$\leftarrow c_{1-10} \rightarrow$ XXXXXXXXXX5				
14			14										
15			15										
16			16										
17			17										
18			18										
19			19										
20			20										
P	PUNCH		P										

IBM

ALL VALUES ASSUMED LESS THAN 1.0

$$\frac{a_{1-10}}{b_{1-10}} = c_{1-10}$$

ELECTRONIC CALCULATING PUNCH-TYPE 604-PLANNING CHART

APPLICATION CARD PROG. CALCULATOR PROBLEM DIVISION — 10 DECIMALS

	OPERATION - NOTES	PROGRAM SUPPRESS	PROGRAM NUMBER	FACTOR STORAGE ASSIGNMENT 6-4 (6-5) 1	FACTOR STORAGE ASSIGNMENT 6-4 (6-5) 2	FACTOR STORAGE ASSIGNMENT 6-6 3	FACTOR STORAGE ASSIGNMENT 6-6 4	MULT. QUOT.	COUNTER	GENERAL STORAGE ASSIGNMENT 6-4 (6-5) 1	GENERAL STORAGE ASSIGNMENT 6-4 (6-5) 2	GENERAL STORAGE ASSIGNMENT 6-6 3	GENERAL STORAGE ASSIGNMENT 6-6 4
R	READ		R		a_{3-10} XXXXXX	a_{1-2} XX	b_{1-2} XX				b_{3-10} XXXXXX		
1	ROFS1-2, RI+, RI 3rd		1	RO					00XXXXXX				
2	ROFS3, RI +		2			RO			00XXXXXXXX				
3	RRCTR, RIFS1-2		3	XXX	XXXXX				RR				
4	ROGS1-2, RI+, RI 3rd		4						00XXXXXX	RO			
5	ROFS4, RI +		5				RO		00XXXXXXXX				
6	RRCTR, RIGS1-2		6						RR	XXX	XXXXX		
7	RIFS3, RIFS4		7			00	00						
8	ROFS1-2, RI+, RI 6th		8	RO					XXXXXXXX				
9	ROFS3, RI+, RI 4th		9			RO			XXXXXXXXXX				
10	ROGS1-2, DIVIDE,		10					c_{6-10}? XXXXX	INC. REM. 00000XXXXXXXX	RO			
11	RRCTR, RIGS3-4.		11						RR			XXX	XXXXX
12	ROGS3-4, RI+, RI 6th		12						XXXXXXXX			RO	
13	ROFS4, RIGS3-4, RI 4th		13										XX
14	ROGS3-4, MULT. —		14						CORR. REM. XXXXXXXXXX			RO	
15	ROMQ, RIGS3-4		15					RO					c_{6-10}? XXXXX
16	ROGS1-2, DIVIDE		16					c_{1-5} ? XXXXX	XXXXXXXX	RO			
17	RRCTR		17						RR				
18	ROGS3-4, RI+, RI 6th		18						c_{6-10}? XXXXX				RO
19	ROMQ, RI+		19					RO	c_{1-10} ? XXXXXXXXXX				
20			20										
P	PUNCH		P										

THESE STEPS SUPPRESSED EXCEPT FOR $b_{9-10} = 0$

NOTES: | X OR D CODE | CARD NAME OR FUNCTION | ELECTRO NO.

Paper 1., con't.

IBM

ELECTRONIC CALCULATING PUNCH - TYPE 604 - PLANNING CHART

ALL VALUES ASSUMMED LESS THAN 1.0

$X_n = .XXXXXXXX \quad N = .XXXXXXXX$

$$X_{n+1} = \frac{1}{2}\left(X_n + \frac{N}{X_n}\right)$$

APPLICATION CARD PROG. CALCULATOR PROBLEM SQUARE ROOT — 8 DECIMALS

	OPERATION - NOTES	PROGRAM SUPPRESS	PROGRAM NUMBER	FACTOR STORAGE ASSIGNMENT 6-4 (8-6) 1	2	(8-6) 3	4	MULT. QUOT.	COUNTER	GENERAL STORAGE ASSIGNMENT 6-4 (8-6) 1	2	(8-6) 3	4
R	READ		R		N								
1	ROFS1-2, RIFS3-4, (GROUP SUPPRESS)		1	R O			$X_0 = N$						
2	EMIT 5, RIMQ (GROUP SUPPRESS)		2					5					
3	ROFS1-2, MULT + (GROUP SUPPRESS)		3						$\frac{1}{2}$ N				
4	$\frac{1}{2}$ ADJ (GROUP SUPPRESS)		4						5				
5	RRCTR, RIFS1-2, RO 2nd (GROUP SUPPRESS)		5		$\frac{1}{2}$N		X_n		RR				
6	ROFS1-2, RI+, RI 6th		6	R O									
7	ROFS3-4, DIVIDE		7			R O		$(\frac{1}{2}N/X_n)_{6-10}$	REMAINDER				
8	RRCTR, RIGS 3-4		8						RR				REMAINDER
9	ROGS3-4, RI+, RI 6th		9										R O
10	ROMQ, RIGS1-2, RI 4th		10					R O					$(\frac{1}{2}N/X_n)_{6-10}$
11	ROFS3-4, DIVIDE		11			R O		$(\frac{1}{2}N/X_n)_{1-5}$	REMAINDER				
12	RRCTR		12						RR				
13	ROMQ, RI+, RI 2nd		13					R O					
14	ROGS1-2, RI+, RI 4th		14						$\frac{1}{2}$ N/X_n		R O		
15	$\frac{1}{2}$ ADJ, RI 3rd		15						5				
16	EMIT 5, RIMQ, RI 3rd		16					5					
17	ROFS3-4, MULT +		17			R O			$X_{n+1} = \frac{1}{2}(X_n + N/X_n)$				
18	ROFS3-4, RIGS 1-2		18			R O					X_n		
19	RRCTR, RIFS3-4, RO 4th		19				X_{n+1}		RR				
20	ROFS3-4, RI+, GROUP SUPPRESS D.O.		20			R O			X_{n+1}				
P	PUNCH		P										

SQUARE ROOT SET-UP

NORMAL 8-DIGIT DIVISION — CAN BE USED FOR BOTH SQUARE ROOT AND DIVISION OPERATIONS

SQUARE ROOT COMPLETION

NOTES: | X OR D CODE | CARD NAME OR FUNCTION | ELECTRO NO.

Paper 1., con't.

IBM

ELECTRONIC CALCULATING PUNCH - TYPE 604 - PLANNING CHART

APPLICATION _____ PROBLEM _____

NOTES:

X OR D CODE

CARD NAME OR FUNCTION

ELECTRO NO.

SQUARE ROOT TEST

MULTIPLICATION — 8 DECIMALS $a_{1-8} \times b_{1-8} = c_{1-8}$

	OPERATION - NOTES	PROGRAM SUPPRESS	PROGRAM NUMBER	FACTOR STORAGE ASSIGNMENT 6-4 8-6 (1)	FACTOR STORAGE ASSIGNMENT 8-6 (2)	FACTOR STORAGE ASSIGNMENT 8-6 (3)	FACTOR STORAGE ASSIGNMENT (4)	MULT. QUOT.	COUNTER	GENERAL STORAGE ASSIGNMENT 6-4 8-6 (1)	GENERAL STORAGE ASSIGNMENT 8-6 (2)	GENERAL STORAGE ASSIGNMENT 8-6 (3)	GENERAL STORAGE ASSIGNMENT (4)
R	READ		R										
21	ROGS1-2, RI-, BAL TEST		1						$(X_{n+1}-X_n)$ XXXXXXXX	RO			
22	RRCTR, RIGS3-4		2						RR			$(X_{n+1}-X_n)$ XXX	XXXXX
23	ROGS3-4, RI-, BAL TEST, (SUP ON-)	−	3						$-(X_{n+1}-X_n)$ XXXXXXXX			RO	
24	RRCTR, PROG. RPT, GRP. SUP. P.U. (SUP ON +)	+	4						RR				
25	ROFS3-4, RI+, RI4th (SUP ON −)	−	5			RO			$\sqrt{N}$ XXXXXXXX				
6			6										
R	READ		7	a_{1-8} XXX	XXXXX	XXX	b_{1-8} XXXXX						
1	ROFS1-2, RIMQ		8	RO				XXXXX					
2	ROFS3-4, MULT +		9			RO			XXXXXXXXXXXXX				
3	RRCTR, RIGS1-2, RO6th		10						RR	XXX	XXXXX		
4	ROFS1-2, RI+		11	RO					XXXXXXXX				
5	RRCTR, RIMQ, RO6th		12					XXX	RR				
6	ROFS3-4, MULT +		13			RO			XXXXXXXXXXXX				
7	ROGS1-2, RI+		14						XXXXXXXXXXXX				
8	$\frac{1}{2}$ ADJ, RI3rd		15						$\leftarrow c_{1-8} \rightarrow$ XXXXXXXX5				
16			16										
17			17										
18			18										
19			19										
20			20										
P	PUNCH		P										

Paper 1., con't.

2.

The "DUZ" General-Purpose Control Panel for the IBM type 604 Electronic Calculator

William Bell
Telecomputing Corporation

The "DUZ" General-Purpose Control Panel is designed for calculation of

1. Eight-digit by eight-digit multiplication.
2. Eight-digit by eight-digit division.
3. Addition of eight-digit numbers.
4. Subtraction of eight-digit numbers.
5. Summation of successive eight-digit numbers.
6. Differencing of successive eight-digit numbers.
7. Multiplication of eight-digits numbers by a five-digit constant.

through Card-Programming.

RI ON
X 80

APPLICATION	PROGRAM SUPPRESS	PROGRAM NUMBER	∝ FACTOR RI ON ∝ "X" X34, OR 39, OR 44, OR 49 6-4 (8-6) 1	∝ FACTOR RI ON ∝ "X" X34, OR 39, OR 44, OR 49 6-4 (8-6) 2	β FACTOR RI ON β "X" X35, OR 40, OR 50, OR 55 (8-6) 3	β FACTOR RI ON β "X" X35, OR 40, OR 50, OR 55 X23 4	RI ON C.C. CONST. MULTI. FIELD MULT. QUOT.	COUNTER	GENERAL STORAGE ASSIGNMENT 6-4 (8-6) 1	GENERAL STORAGE ASSIGNMENT 6-4 (8-6) 2	GENERAL STORAGE ASSIGNMENT (8-6) 3	GENERAL STORAGE ASSIGNMENT (8-6) 4
		R	XXX	XXXXX±	XXX	XXXXX±	XXXXX					
	N I	1			RO	RO	RI XXXX±					
	N I	2			RO	RO		+ XXX·XXXX				
	N I	3						RO & RE, RO 6th				RI XXX±
	N I	4	RO	RO			MULTI	XXXXXXXXXXXX				
	N I	5					RI XXX±					RO
CODE 1 ∝/β	N I	6						RO ONLY, RO 6th			RI XXX	RI XXX
	N I	7						RI (−), RI 6th			RO	RO
	N I	8						RO & RE, RO 4th	RI OO	RI OOXX		
	N I	9	RO	RO			MULTI	XXXXX·XXXX				
	N I	10						RI (+) XXX·XXXX			RO	RO
	N I	11						RO ONLY, RO 4th			RI XXX	RI XXX·XX
	N I	12						RI (−), RI 4th OOOOOOOOXXX			RO	RO
	N I	13					RI OOXX±	RO & RE				
	N I	14						RI (+), RI 6th XXXXX·XX			RO	RO
	N I	15					RO	RI (+), RI 3rd OOXX				
	N I	16						RI (+) XX XXXXX·XXXXX	RO	RO		
CODE 3 ∝/β	N 3	17	RO	RO				RI (+) XXX·XXXX				
	N 3	18			RO	RO	DIVIDE XXXX·					
	N 3	19						RO & RE	RI	RI		
	N 3	20						RI (+), RI 6th XXXX	RO	RO		
	N 3	P										

Paper 2., con't.

APPLICATION _____ PROBLEM _____

	PROGRAM SUPPRESS	PROGRAM NUMBER	FACTOR STORAGE ASSIGNMENT 1	2	3	4	MULT. QUOT.	COUNTER	GENERAL STORAGE ASSIGNMENT 1	2	3	4
		R										
	N 3	21					RO				RI XXX	RI XXOOO
	N 3	22			RO	RO	DIVIDE XXXX					
	N 3	23						RO & RE	RI	RI		
	N 3	24						RI (+), RI 3rd XXXXX	RO	RO		
α/β	N 3	25					RO		RI OOO.	RI XXXXX		
	N 3	26			RO	RO	DIVIDE XX					
	N 3	27						RO & RE				
	N 3	28					RO	RI (+) XX				
	N 3	29						RI (+), RI 3rd XXXXX	RO	RO		
	N 3	30						RI (+), RI 5th XXXXXXXXXXX			RO	RO
CODE 4 $\Sigma + \alpha$	N 4	31	RO	RO				(+) RI 3rd XXXXXXX				
CODE 5 $\Sigma + \alpha$	N 5	32	RO	RO				(−) RI 3rd XXXXXXX				
CODE 6		33	RO	RO				+ RI 3rd XXXXXXX				
CODE 6 $N+1\ \alpha\ \Sigma_N$		34						+ RI 3rd XXXXXXX			RO	RO
		35	RO	RO							RI XXX	RI XXXXX
CODE 7		36	RO	RO				+ RI 3rd XXXXXXX				
CODE 7 $N+1\ \alpha\ \Delta_N$		37						(−) RI 3rd XXXXXXX			RO	RO
		38	RO	RO							RI XXX	RI XXXXX
CODE 8 $K\alpha$		39	RO	RO			MULTI	XXXXXXXXXXXX				
		40										
		P										

A General-Purpose 604 Board for the Card-Programmed Electronic Calculator

Donald B. MacMillan and Richard H. Stark

This Control Panel is designed after the pattern suggested in the preliminary manual on the calculator. It performs the elementary arithmetic operations, and extracts square roots. It does all of these operations to 10-digit accuracy, using 10-digit factors.

The board also has provisions for transferring factors and results among the 604 storage units. It provides a 10-digit storage unit in the 604, in which a number may be retained through several card cycles, providing neither division nor square root is done. It provides for the summary punching of two 10-digit numbers from the 604. It provides one operation in addition to the elementary ones; this is multiplication followed by addition or subtraction:

$AB \pm D.$

Four 10-digit electronic storage units are set up: A, B, C, and D. C is in the counter, and D is all general storage, so that summary punching may be done from both of these. The counter is reset on the first program; it is suggested that channel C common on the tabulator be wired to counter RO, so that a result may be both stored and summary punched.

Operation 1 is addition.	$A + B = C$
Operation 2 is subtraction.	$A - B = C$
Operation 3 is multiplication.	$A \cdot B = C$

Operation 4 is division.	$A \div B = C$ This operation is subject to the restriction $A < B$.
Operation 5 is square root.	$\sqrt{A} = C$ The number 99999 99999 must be entered on channel B, to serve as a first guess at $\sqrt{A}$. The root will be taken as though a period appeared to the left of the ten digits of A.

Operation 6 is transfer of C to A at the end of the calculation.

Operation 7 interchanges the numbers in B and D before calculation starts.

Normally, C is read into D after each calculation, so that the result of the calculation appears in both C and D. Operation 8 prevents this, so that whatever was in D at the beginning of the calculation is preserved, providing it has not been destroyed by the calculation.

If the machine is not instructed to do any of operations 1 through 5, A will be transferred to C.

There are two combinations possible among the first five operations. They are 1 and 3, and 2 and 3. The calculations performed with these double instructions are, respectively, AB + D, and AB − D. If operation 7 is added to one of these combinations, the resulting calculation is AD + B or AD − B. This finds particular use in the evaluation of polynomials.

Storage A is undisturbed by calculation, except division. Storage B is destroyed by multiplication, division, and square root. It is partially destroyed by addition and subtraction; this partial destruction makes it useless for multiplication, but does not affect its usefulness for other calculactions or summary punching. Storage D is destroyed by division and square root. It is undisturbed

by addition and subtraction. It is partially destroyed by multiplication; this partial destruction is like that described for B, above.

One of the requirements under which this control panel was designed is peculiar to non-net balance operation. Referring to the programming of this control panel,notice that only two of the three positions of GS 3 entry are to be wired to channel exit hubs (on the accounting machine control panel). The other hub will be unwired. With this wiring, if a positive figure or a negative true figure is read into GS 3, the unwired position will go to zero, but if a complement figure is read into GS 3, the unwired position will receive a nine (while the two wired positions convert the complement to true figures). The unwanted nine may be eliminated by wiring on the accounting machine control panel, at the cost of tying up selectors (channel minus may be wired to the vacant positions, but must be selected out whenever a true negative figure is on the channel); we have designed this board to handle the problem in the 604.

STORAGE ASSIGNMENT:

A: First eight digits, FS 1 & 2, last two digits, GS 3 (pos. 3-2).

B: First eight digits, FS 3 & 4, last five digits, MQ.

C: Counter (pos. 13-4).

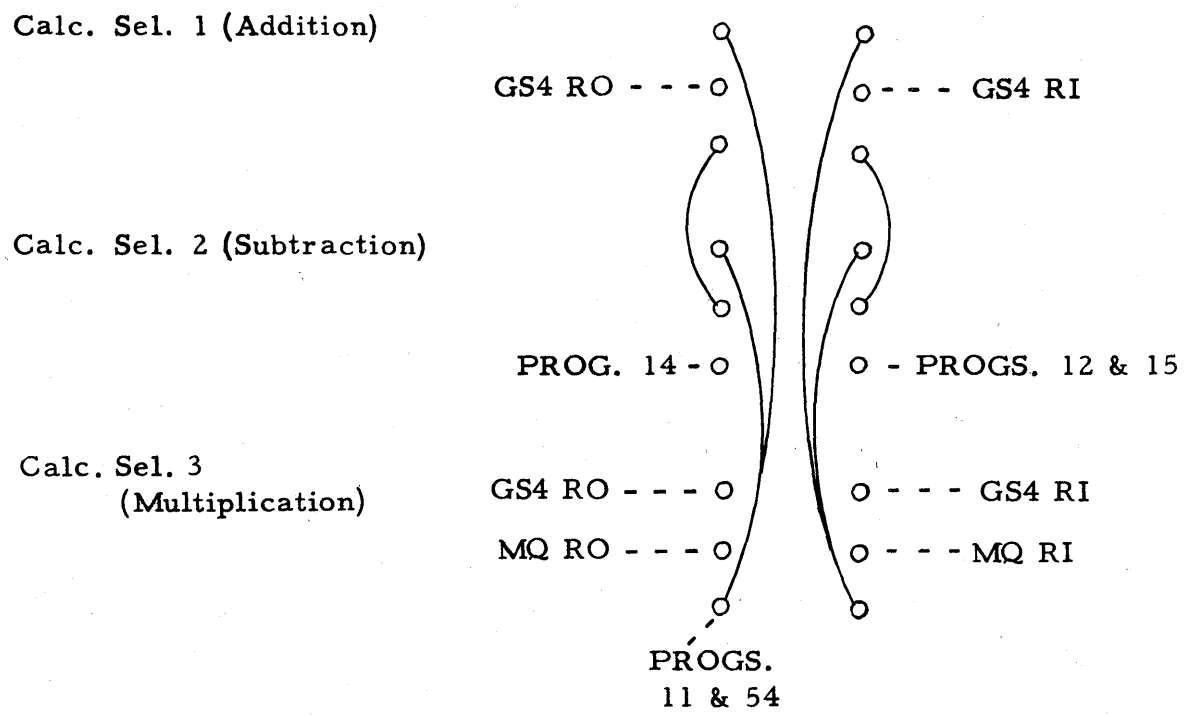
D: First eight digits, GS 1 & 2, last five digits, GS 4.

OPERATION					PROG. NO.	READ OUT	READ IN	SHIFT	SUPPRESSION	COMMENTS
ADD	SUBT.	MULT.	DIV.	SQ. RT.						
X	X	X	X	X	1	R. & R			None	
ACTIVE ONLY ON OPERATION NUMBER SEVEN					2	MQ	Ctr.		7	
					3	GS 4	MQ		7	
					4	R & R	GS 4		7	
					5	FS 3 & 4	Ctr.		7	
					6	GS 1 & 2	FS 3 & 4		7	
					7	R & R	GS 1 & 2		7	
		X			8	FS 3 & 4	Ctr.		3	
		X			9	R & R	FS 3 & 4	Out of 4	3	
X	X	X	X	X	10	GS 3	Ctr.	Into 3	0	
X	X	X	X	X	11	GS 4 ON X MQ OTHER	GS 3	Into 2	0	
X	X	X	X	X	12	R & R	MQ ON ± EXC. X GS 4 OTHER	Out of 4	0	See note on Read-In Order.
X	X	X	X	X	13	GS 3	Ctr.	Into 3	0	
X	X	X	X	X	14	MQ ON ± EXC. X GS 4 OTHER	GS 3	Into 2	0	See note on Read-Out Order.
X	X	X	X	X	15	R & R	MQ ON ± EXC. X GS 4 OTHER	Out of 4	0	See note on Read-In Order.
X	X		X	X	16	FS 1 & 2	Ctr.	Into 6	1	} When none of operations 1-5 is ordered, these
X	X		X	X	17	GS 3	Ctr.	Into 3	1	} two programs are active to cause A→C transfer.
			X	X	18	FS 3 & 4	÷		2	
		X			19	FS 1 & 2	x		3	
			X	X	20	R & R	GS 1 & 2		2	
			X	X	21	GS 1 & 2	Ctr.	INTO 4 ÷ INTO 6 $\sqrt{\ }$	2	
			X	X	22	MQ	GS 1 & 2	Into 4	2	
			X	X	23	FS 3 & 4	÷		2	
		X			24	FS 3 & 4	MQ		3	
			X	X	25	R & R	FS 1 & 2 (DIV. ONLY)		2	No Read-In on Square Root.

OPERATION					PROG. NO.	READ OUT	READ IN	SHIFT	SUPPRESSION	COMMENTS
ADD	SUBT.	MULT.	DIV.	SQ. RT.						
				X	26	FS 3 & 4	Ctr.	Into 3	5	
			X	X	27	GS 1 & 2	Ctr. −	INTO 3 (√ ONLY)	2	No shift on ÷
			X	X	28	MQ	Ctr. −		2	
				X	29	MQ	GS 4		5	
				X	30	Emit 5	MQ	Into 3	5	
				X	31	MQ	Ctr. −	BT	5	
			X	X	32	R & R	GS 1&2 (DIV. ONLY)		2	No Read-In on √
				X	33	GS 4	x		5	
			X		34	GS 4	MQ		4	
				X	35	Emit 5	MQ	Into 5	5	
			X	X	36	GS 1&2	x		2	
			X		37	FS 1&2	Ctr.	Into 3	4	
			X	X	38	FS 3&4	÷ ON ÷ x ON √		2	
		X			39	R & R	FS 3&4	Out of 6	3	
			X		40	R & R	FS 1&2		4	
			X		41	FS 1&2	Ctr.	Into 2	4	
			X		42	MQ	FS 1&2		4	
			X		43	FS 3&4	÷		4	
		X			44	GS 3	x		3	
			X		45	R & R			4	
			X		46	GS 1&2	Ctr. −	Into 6	4	
			X		47	MQ	Ctr.	Into 3	4	
			X		48	FS 1&2	Ctr.	Into 4	4	
		X			49	FS 3&4	Ctr.	Into 4	3	
		X			50	R & R	FS 3&4	Out of 5	3	
		X			51	FS 1&2	x		3	
		X			52	FS 3&4	Ctr.	Into 2	3	
X	X			X	53	GS 1&2 ON X FS 3&4 OTHER	CTR. + ON + ONLY CTR. − ON − ONLY	PROG. REPT. ON √ INTO 6 OTHER	SUPP. ON NEG. BAL.	} No Read-In unless either + or − is ordered.
X	X				54	GS 4 ON X MQ OTHER	CTR. + ON + ONLY CTR. − ON − ONLY	Into 4	None	
		X	X	X	55	Half Add		Into 3	0	
				X	56	RO	FS 3&4 ON √ BT FOR SAL. P.U. OTHER	Out of 6	None	
					57	RO	GS 1&2	Out of 6	8	
					58	RO	GS 4	Out of 4	8	
					59	RO	FS 1&2	Out of 6	6	
					60	RO	GS 3	Out of 3	6	

NOTE TO PROGRAMS 12, 14, and 15:

On these three programs the MQ order should be given when addition or subtraction is being done, unless multiplication is also being done; the GS 4 order should be given whenever multiplication is being done, without exception; and the GS 4 order should be given when division or square root is being done. A suggested wiring for this is:



KEY TO SUPPRESSION:

Suppression Type O: These programs should be active when any of operations 1-5 is taking place, and otherwise suppressed.

Suppression Type 1: These programs should be suppressed only when multiplication is taking place, and otherwise active.

Suppression Type 2: These programs should be active when division or square root is taking place, and otherwise suppressed.

Suppression Type 3: These programs should be active only on multiplication.

Suppression Type 4: These programs should be active only on division.

Suppression Type 5: These programs should be active only on square root.

Suppression Type 6: These programs should be active only on C → A transfer. They should always be suppressed on positive balance.

Suppression Type 7: These programs should be active only on D ↔ B interchange.

Suppression Type 8: These programs should be suppressed only on D preservation.

The suppression must be wired so as to use only three positions on calculate selectors Nos. 4 (division) and 5(square root) together.

R & R and RO, when they appear in the Read-Out column, mean counter Read-Out and Reset, and Counter Read-Out, respectively. The symbols x and ÷, where they stand alone in the Read-In column, refer to the Function Control hubs on the 604 control panel, and mean multiply + and Divide, respectively.

When the symbols +, -, x, ÷, $\sqrt{\ }$ appear with orders in the programming, they indicate how the orders must be selected so the programs may be used for several purposes. For example, in the Read-Out section of program 11, we have "GS4 on x, MQ other." The program hub would be wired through a position of selector number 3 (multiplication), so that when the selector is transferred, the connection goes to GS4 Read-Out, and when it is normal, the connection goes to MQ Read-Out.

We will be glad to answer questions about the wiring or programming of this control panel, or about the wiring of an accounting machine control panel to go with it.

604 Electronic Calculator Diagrams for the calculation of Sin X, Cos X, e^{x}, e^{-x^2}, Sinh X, and Cosh X on the Card-Programmed Electronic Calculator

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The 604 wiring diagram outlined, when used in conjunction with the combination, will compute Sin x, Cos x, e^{x}, e^{-x^2}, Sin h x, and Cos h x very rapidly. It was primarily wired for sine and cosine and computes the other functions with a small amount of additional selection. One card is required with no additional instruction cards. The time required is approximately two and one half cycles, depending on the size of x. Nine hundred sines and nine hundred cosines have been computed $\left[0 \leq x \leq 90^{\circ} \text{ in intervals of } .1^{\circ} \right]$ in a total time of 30 minutes. The functions were computed to seven decimal places with the following results:

For Cos x

exact to seven decimal places	296	angles
one digit too small	20	"
one digit too large	315	"
two digits too large	190	"
three digits too large	72	"
four digits too large	7	"
Total	900	

For Sin x

exact to seven decimal places	439	angles
one digit too large	42	"
one digit too small	363	"
two digits too small	55	"
three digits too small	1	"
Total	900	

This was more accuracy than we require at the moment so no attempt has been made to improve the results. You will notice considerable bias, especially in the cosine x, which could undoubtedly be improved. The accuracy of the remaining functions was not investigated, but it seems reasonable to expect corresponding accuracies if an adequate number of terms are computed. The actual speed natually depends on the punching required; by punching seven angles at a time, the overall speed can be considerably increased.

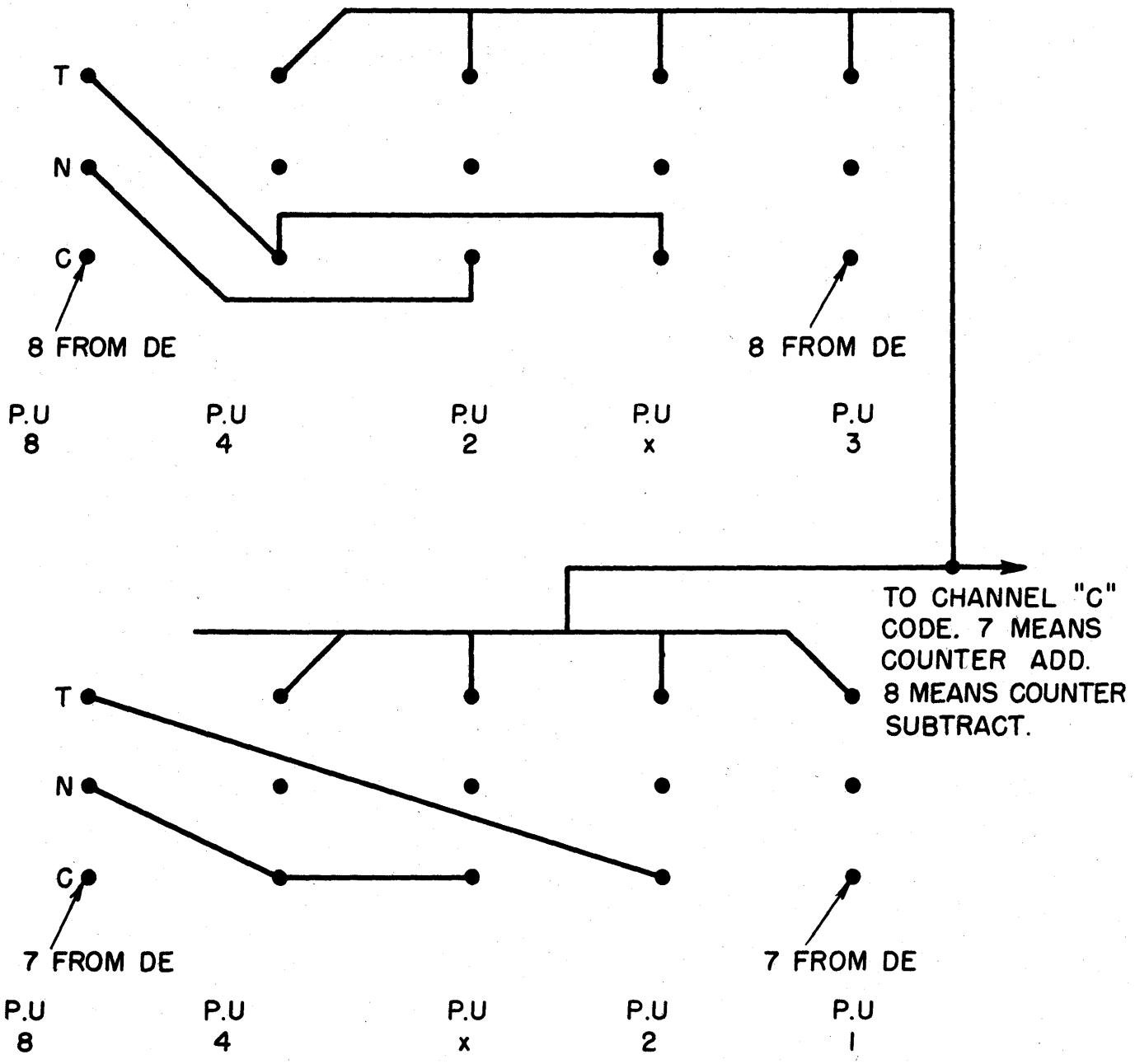
Use the 604 control panel as follows:

Function to be computed	Selectors to be picked up
Sin x	8
Cos x	7
e^{x}	1, 4, 5, 6, 7
e^{-x^2}	4, 5, 7
Sin h x	6, 8
Cos h x	6, 7

We require the sine and cosine in any quadrant and also for negative angles smaller than 90^{o}. The following selector system has been very useful.

Step (1) The angles expressed in min and sec are run through a 604 and converted to radians in the first quadrant. This is done by identifying the quadrant that the angle is in with a one, two, three or four and using this identification as a means of selection.

Step (2) The cards are put through the combination computing the sine or cosine and supplying the proper sign by emitting the "C" channel code that tells the accounting machine counters to add or subtract by the following selection. An eight in the operations channel computes the sine while a seven will compute the cosine. A seven or an eight along with the quadrant identification is sufficient to select the proper sign.



8 P.U INDICATES THE SINE
1 P.U INDICATES THE FIRST QUADRANT
2 P.U INDICATES THE SECOND QUADRANT
3 P.U INDICATES THE THIRD QUADRANT
4 P.U INDICATES THE FOURTH QUADRANT
x P.U INDICATES A NEGATIVE ANGLE SMALLER THAN 90°

Paper 4., con't.

Read in θ → FS 1 and 2 and GS 1 and 2

θ is in radians with seven decimals.

x^2 occupies GS 1 and 2

$\frac{x^{n-2}}{(n-2)!}$ occupies FS 1 and 2

$\sum$ of the series is in FS 3 and 4

n is in GS 3 and 4

---

(1) GS 1 and 2 → ctr.

(2) ctr. → MQ

(3) ctr. → GS 1 and 2 Reset - out of 6th

(4) FS 1 and 2 RO - Multiply

(5) GS 1 and 2 → MQ

(6) ctr. → GS 1 and 2 Reset - out of 6th

(7) GS 1 and 2 → ctr.

(8) FS 1 and 2 RO - Multiply

(9) 1/2 adj. → 2nd

(10) ctr. → GS 1 and 2 out of 3rd - Reset

Wired normal through Calculator Selector #1

If #1 is picked up, programs 1-10 are suppressed. also if GSPU is active prog. 1 - 14 are suppressed

---

(11) Digit emit 1 → MQ into 5th

(12) MQ → FS 1 and 2 into 4th

Start Cosine if cal. selector #7 is picked up.

---

(13) 1 → GS 3 and 4 (emitted)

Start Sine if cal. sel. #8 is picked up.

---

(14) FS 1 and 2 → FS 3 and 4

Program active if either cal. sel. #7 or cal. sel. #8 is picked up.

---

(15) FS 1 and 2 → ctr.

(16) ctr. → MQ

(17) ctr. → FS 1 and 2 - Reset - out of 6th

(18) GS 1 and 2 RO - Multiply

(19) FS 1 and 2 → MQ

(20) ctr. → FS 1 and 2 - Reset - out of 6th

(21) FS 1 and 2 → ctr.

(22) GS 1 and 2 RO - Multiply

(23) 1/2 adj → 2nd

(24) ctr. → FS 1 and 2 - Reset - out of 3rd

(25) GS 3 and 4 → ctr.

(26) emit 1 → ctr.

(27) ctr. → MQ

---

(28) emit 1 → ctr. If cal. sel. #4 is picked up, suppress this step.

---

(29) ctr. → GS 3 and 4 - Reset

---

(30) GS 3 and 4 RO - Multiply If cal. #5 is picked up,

(31) ctr. → MQ - Reset suppress 30 and 31.

---

(32) GS 3 and 4 → ctr.

---

(33) GS 3 and 4 → MQ This program is suppressed unless cal. #5 is picked up.

---

(34) MQ → ctr. into 6th

(35) ctr. → GS 3 and 4

(36) FS 1 and 2 → ctr. into 3rd

(37) MQ → FS 1 and 2 into 6th

(38) FS 1 and 2 RO - Divide

(39) GS 3 and 4 → FS 1 and 2

(40) ctr. → GS 3 and 4 - Reset

(41) GS 3 and 4 → ctr. into 6th

(42) MQ → GS 3 and 4

(43) FS 1 and 2 RO - Divide

(44) ctr. Read out and Reset

(45) MQ → ctr.

(46) GS 3 and 4 → ctr. into 6th

(47) 1/2 adj. → 2nd

(48) FS 1and 2 → MQ

(49) MQ → GS 3 and 4

(50) ctr. → FS 1 and 2 out of 3rd - Reset

(51) GS 3 and 4 → ctr. negative

(52) 1 → ctr. into 2nd

(53) 1 → ctr. into 1st B. T. for step. Sup.

(54) Ctr. Reset - Group Sup. Drop out.

---

(55) 1 → MQ — If cal. #6 picks up programs 55-56 - 57 will be suppressed.

(56) FS 1 and 2 RO - Multiply negatively

(57) ctr. → FS 1 and 2 (Doesn't reset)

---

(58) FS 3 and 4 → ctr.

---

(59) FS 1 and 2 → ctr. — This program will be active only if cal. sel. #6 is picked up.

---

(60) ctr. → FS 3 and 4 Reset - Prog. Repeat and GSPU *

* Step No. 60 suppressed on a negative balance.

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