

IDENTIFICATION: SOLUTION OF SIMULTANEOUS EQUATIONS AND
MATRIX INVERSION.

PURPOSE: To solve a set of M simultaneous equations and/or
invert a matrix of order M.

RESTRICTIONS: The program must be used in conjunction with CINCH
I. The maximum size problem is controlled by the
following expression:

$$C \geq 2M^2 + 2M + 360$$

where C = Amount of CINCH interpretive memory
available.

M = Number of equations.

Example: C = 1536 (16 line machine with CINCH I)
M $\leq$ 23

The maximum number of equations that can be handled
is forty (40).

Data Format: A maximum of 10 significant digits with
an exponent $\leq$ 38.

STORAGE: The program occupies CINCH locations 0004 - 0170.
The pivot vector 0200 - 0278. The identification of
pivot elements 0280 - 0359. The matrix starts in
location 0360, the first 2 M locations being the re-
quirements vector.

TIMING: The time required to obtain a solution is dependent on
the number of equations and the density of the matrix.
Computing time may be estimated using the following
formula:

$$T = 0.4 DM^3$$

where T = Compute time in seconds

D = Density of matrix $\frac{\text{\#non-zero elem.}}{\text{total \# elem.}}$

M = Number of equations

ACCURACY:

During computation 36 bits of mantissa and 6 bits of exponent are carried.

Output is rounded to 10 decimal digits mantissa and then truncated to 9 digits to eliminate round up accumulation.

USE:

1. Preparation of Data Tape:

Data must be entered using paper tape via the flexowriter. The format to be used is shown in the attached example. In general, the format is the same as described in the CINCH Manual on Page 4 - 5. The matrix is entered by columns with the requirements vector first. If the problem is a matrix inversion the requirements vector should be all zeroes. (All zero elements must be entered).

2. Loading CINCH I:

Prior to entering the program and data, CINCH I must be loaded into the computer. Instructions for loading CINCH are shown on Page B-1 of the CINCH Manual.

3. Loading Program:

The program is loaded via the flexowriter by typing R. When the flexowriter light comes on it indicates the program has been properly loaded. If the tape stops and the light does not come on it indicates a reading error and the program must be loaded again.

After the light comes on type R. The starting location of the program (0030) will be read and control transferred to the start of the program.

4. Loading Data:

After Step 3 is completed remove the program tape from the flexowriter and insert the data tape.

type: D+M(C/R)
E

where: M is the number of equations in the problem.
(C/R) indicates carriage return.

The data tape will be read and the solution typed out in the format shown in the example.

Additional problems may be run by repeating Step 4. The program need not be re-entered.

5. Re-Inversion for Check Purposes:

If it is desired the computations may be checked by re-inverting the generated matrix since the inverse occupies exactly the same position in memory as the original matrix. To re-invert the matrix depress the enable and breakpoint switches and then type I. Raise the enable and breakpoint switches and type:

\$0032(C/R)
G

The inverse will be inverted to the original matrix and typed out.

METHOD:

The program performs the matrix inversion and solution of simultaneous equations by a modified

Gaussian-Jordan reduction technique. Poorly behaved matrices can be handled since the updating pivot element is determined by obtaining the largest absolute unused value along the diagonal.

**ERROR
INDICATION:**

The word BAD followed by a vector consisting of the pivot elements used will be typed when a matrix cannot be inverted due to round off difficulties. Following this the word GOOD and the current status of the matrix printed in the normal format.

**SAMPLE PROBLEM FOR SOLUTION OF SIMULTANEOUS
EQUATIONS AND MATRIX INVERSION (A. W. MARZIANI)**

EQUATIONS

$$\begin{aligned} 10 &= 1X + 1Y + 1Z \\ 12 &= 1X + 2Y - 3Z \\ 40 &= 2X + 4Y + 1Z \end{aligned}$$

DATA TAPE

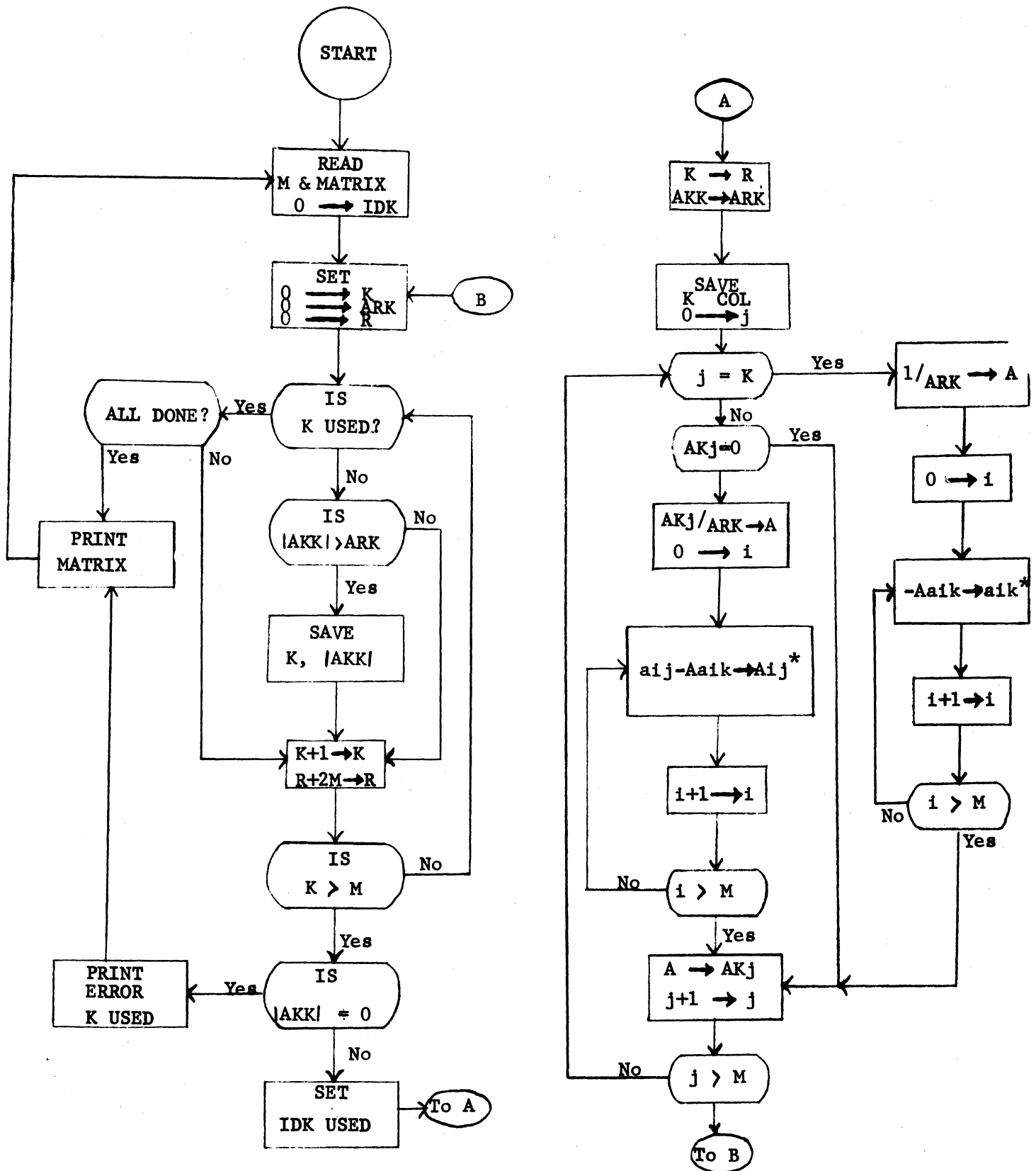
D+10	}	Requirements Vector
12		
40		
1	}	Column 1
1		
2		
1	}	Column 2
2		
4		
1	}	Column 3
-3		
1		
E		

SOLUTION

RRD+3	}	Instructions To Be Typed
E		
GOOD		

-.342857143+01	X	}	Solution
.111428571+02	Y		
.228571428+01	Z		
.200000000+01	Column 1	}	Inverse
-.100000000+01			
.000000000-37			
.428571429+00	Column 2		
-.142857143+00			
-.285714286+00			
-.714285714+00	Column 3		
.571428572+00			
.142857143+00			

SOLUTION of SIMULTANEOUS EQUATIONS
and
MATRIX INVERSION



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PROGRAM NAME SOLUTION of SIMULTANEOUS EQUATIONS PAGE 1 OF 6

PROGRAM NO. _____ SPECIAL I.D. _____

BY _____ DATE 7-6-62

L C O D E	LOCATION	C O D E	INSTRUCTION				SYM. OP CODE	NOTES
			T	O P	I R	ADDRESS		
	1							
	2							
	3							
	000 4							B Temp. Store
	5							
	6							
	7							
	8							M No. Equations
	9							
	001 0							R Pivot Row
	1							
	2							K Pivot Column
	3							
	4							ARK Pivot Element
	5							
	6							2M
	7							
	8							2M +2M
	9							
	002 0							2M+2
	1							
	2							A ari/ark
	3							
	4							+1 Constants
	5							
	6							+2
	7							
	8							+0
	9							
	003 0			16		0008	RTK	M --- 0008

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L C O D E	LOCATION	C O D E	INSTRUCTION				SYM. OP CODE	NOTES
			T	O P	I R	ADDRESS		
	0031			17		0360	RPT	Matrix → 0360
	2			10		0008	CAD	M → ACC
	3			14		0026	MUP	X2
	4			60		0016	STA	2M → 0016
	5			12		0026	ADD	+2
	6			60		0020	STA	2M+2 → 0020
	7			14		0008	MUP	X2
	8			60		0018	STA	2M+2M → 0018
	9			35		0009	SFL	Set Output to 9 Digits
	0040			02	A	0028	SIB	0 → A _B
	1			03	A	0026	SIM	2 → A _M
	2			04	A	0016	SIL	2M → A _L
	3			10		0028	CAD	0 → ACC
	4			60	A	0280	STA	0 → ID
	5			06	A	0044	MIT	Inc. & Test
	6			10		0028	CAD	0 → ACC
	7			60		0012	STA	0 → K
	8			60		0014	STA	0 → ARK
	9			02	A	0028	SIB	0 → AB
	0050			03	A	0026	SIM	2 → A _M
	1			04	A	0016	SIL	2M → A _L
	2			02	B	0026	SIB	2 → B _B
	3			03	B	0026	SIM	2 → B _M
	4			04	B	0016	SIL	2M → B _L
	5			02	C	0016	SIB	2M → C _B
	6			03	C	0020	SIM	2M+2 → C _M
	7			04	C	0018	SIL	2M ² +2M → C _L
	8			10	A	0280	CAD	ID → ACC
	9			44		0073	TNZ	≠0 Means K Used Go to End Check
	0060			11	C	0360	CAA	AKK → ACC

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L C O D E	LOCATION	C O D E	INSTRUCTION				SYM. OP CODE	NOTES
			T	O P	I R	ADDRESS		
	006 1			30		0014	CAM	AKK - ARK
	2			31		0065	TCL	< Go to Next Elem.
	3			60		0014	STA	> AKK → ARK
	4			05	A	0012	STB	K _A → K
	5			06	A	0066	MIT	Inc. A
	6			06	C	0058	MIT	Inc. & Test C Terminal Check
	7			10		0014	CAD	AKK → ACC
	8			43		0088	TAZ	If Zero to Error Exit BAD
	9			02	A	0012	SIB	K → A _B
	007 0			10		0014	CAD	AKK → ACC
	1			60	A	0280	STA	AKK → IDK Set SIG for K Used
	2			40		0095	TRU	Go Update MATRIX
	3			06	B	0065	MIT	Inc.&Test B End Inv? Yes 0074 No. 0065
	4			46		0164	TAC	Print Good
	5			02	A	0026	SIB	2 → A _B
	6			03	A	0026	SIM	2 → A _M
	7			04	A	0018	SIL	2M → A _L
	8			02	B	0028	SIB	0 → B _B
	9			03	B	0026	SIM	2 → B _M
	008 0			04	B	0016	SIL	2M → B _L
	1			46		0168	TAC	2 C/R
	2			06	B	0085	MIT	End Col?
	3			02	B	0026	SIB	Yes 2 → B _R
	4			46		0168	TAC	2 C/R
	5			27	A	0358	TNC	Type Elem. C/R
	6			06	A	0082	MIT	More ans?
	7			40		0030	TRU	No All Done Go Read Next M
	8			46		0166	TAC	Print BAD
	9			02	A	0026	SIB	2 → A _B
	009 0			03	A	0026	SIM	2 → A _M

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L C O D E	LOCATION	C O D E	INSTRUCTION				SYM. OP CODE	NOTES
			T	O P	I R	ADDRESS		
	009 1			04	A	0016	SIL	$2M \rightarrow A_L$
	2			27	A	0278	TNC	Type Pivot Elements
	3			06	A	0092	MIT	Inc. & Test
	4			40		0074	TRU	Go Print Matrix
	5			10		0012	CAD	$K \rightarrow ACC$
	6			60		0010	STA	$K \rightarrow R$
	7			14		0008	MUP	M
	8			12		0016	ADD	2M
	9			02	A	0000	SIB	$2KM+2M \rightarrow A_B$
	010 0			03	A	0026	SIM	$2 \rightarrow A_M$
	1			04	A	0016	SIL	$2M \rightarrow A_L$
	2			02	B	0026	SIB	$2 \rightarrow B_B$
	3			03	B	0026	SIM	$2 \rightarrow B_M$
	4			04	B	0016	SIL	$2M \rightarrow B_L$
	5			10	A	0360	CAD	$AIK \rightarrow ACC$
	6			60	B	0198	STA	$AIK \rightarrow K \text{ Area}$
	7			06	A	0108	MIT	Inc. A
	8			06	B	0105	MIT	Inc. & Test B
	9			02	A	0010	SIB	$R \rightarrow A_B$
	011 0			10	A	0200	CAD	$ARK \rightarrow ACC$
	1			60		0014	STA	$ARK \rightarrow ARK$
	2			02	A	0028	SIB	$0 \rightarrow A_B$
	3			03	A	0026	SIM	$2 \rightarrow A_M$
	4			04	A	0018	SIL	$2M^2 + 2M \rightarrow A_L$
	5			02	B	0028	SIB	$0 \rightarrow B_B$
	6			03	B	0026	SIM	$2 \rightarrow B_M$
	7			04	B	0016	SIL	$2M \rightarrow B_L$
	8			02	C	0010	SIB	$R \rightarrow C_B$
	9			03	C	0016	SIM	$2M \rightarrow C_M$
	012 0			04	C	0018	SIL	$2M^2 + 2M \rightarrow C_L$

To Pick up Pivot Col.

To Store Pivot Col.

Pickup & Store AI_j

Check R Col. and End

Pickup Pivot Row

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L C O D E	LOCATION	C O D E	INSTRUCTION				SYM. OP CODE	NOTES
			T	O P	I R	ADDRESS		
	0121			02	D	0026	SIB	2 → D _B
	2			03	D	0026	SIM	2 → D _M
	3			04	D	0016	SIL	2M → D _L
	4			10	C	0360	CAD	ARJ → ACC
	5			43		0144	TAZ	= 0 → 144 Skip Col.
	6			15		0014	DIV	ARJ/ARK
	7			60		0022	STA	→ A
	8			20	D	0198	CSU	- AIK
	9			43		0133	TAZ	= 0 → 133 Skip Elem.
	0130			14		0022	MUP	A (-AIK)
	1			12	A	0360	ADD	AIJ - A AIK
	2			60	A	0360	STA	→ AIJ*
	3			06	A	0134	MIT	Inc. A
	4			06	D	0128	MIT	Inc. & Test D
	5			10		0022	CAD	A → ACC
	6			60	C	0360	STA	A → ARj*
	7			05	B	0004	STA	K _B → B
	8			06	C	0139	MIT	Inc. C
	9			10		0012	CAD	K → ACC
	0140			30		0004	CAM	K - K _B
	1			33		0149	TCE	= Pivot Col. Next → 0149
	2			06	B	0121	MIT	no. Inc. & Test Col. Count B
	3			40		0046	TRU	End update Go Get New K
	4			05	A	0004	STB	A → B
	5			10		0016	CAD	2M → ACC
	6			12		0004	ADD	+B
	7			02	A	0000	SIB	Inc. A by 2M
	8			40		0137	TRU	Go to Next Column
	9			02	D	0026	SIB	2 → D _B
	0150			03	D	0026	SIM	2 → D _M

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L C O D E	LOCATION	C O D E	INSTRUCTION				SYM. OP CODE	NOTES
			T	O P	I R	ADDRESS		
	015 1			04	D	0016	STL	2M For Pivot Col.
	2			10		0024	CAD	1 → ACC
	3			15	C	0360	DIV	1/ARK
	4			60		0022	STA	→ A
	5			20	A	0360	CSU	- ATK
	6			14		0022	MUP	- A ATK
	7			60	A	0360	STA	→ ATK*
	8			06	A	0159	MIT	Inc. A
	9			06	D	0155	MIT	Inc. & Test D
	016 0			10		0022	CAD	A
	1			60	C	0360	STA	→ ARK*
	2			06	C	0163	MIT	Inc. C
	3			40		0142	TRU	Go Finish Update
	4							C/R Go } GOOD
	5							O D ; }
	6							C/R B A } BAD
	7							D C/R ; }
	8							C/R C/R ;
	9							
	0							
	1							
	2							
	3							
	4							
	5							
	6							
	7							
	8							
	9							
	0							