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THE INSTITUTE OF NATIONAL PLANNING

Memo. No. 810

Hydraulic Aspects of the problem of the Movement of Tankers in the SUEZ CANAL

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20 Nov., 1967.

CAIRO
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The research center of the Suez Canal - Authority (R.C-S.S.C.A)- represented by Prof. Dr.M. Hassan, under secretary of state,& Mr. Eng. Mohamed El Ghamry, outlined the Hydraulic aspects of the problem of the movement of tankers in the Suez Canal, and requested that the planning and mathematical analysis centre of the Institute of National Planning (P.M.A.C.-I.N.P.) represented by Mr. Mohamed El Kafrawy - would carry out statistical analysis on numerous data collected by (R.C.-S.C.A.) on nearly 2000 tankers passed during the years 1966 & 1967. A similar work had been done before by the (P.M.A.C. - I.N.P.) for the (R.C.-S.C.A) and published by the Institute of National Planning on

Memo. No. 58 (Report No. 1), 28 June 1961 ,
Memo. No. 70 (Report No. 2), 25 Oct. 1961 ,
& Memo. No.121 (Report No. 3), 31 Dec. 1961 .

The work done manually by considering a sample of no more than 20 ships in that time, while this work was carried out by the use of electronic computer in the I.N.P. which gave us the advantage of considering the whole data given of the two thousand ships.

The working group which did the job was consisting of:

Prof. Dr. Salib Rofael, Supervisor

Mr. Mohamed El Kafrawy, Statistical and Mathematical Analysis.

Mr. A. Hamza
Mr. Yehia Abd El Rahman
Mr. A. Abd El Aziz.
Mr. S. El Adawy.
) Programming, testing and running the programs.

Description of the problem:

A Passing ship in a canal causes a certain number of phenomena, affecting its squat, and forward speed. When the ship moves forward, it displaces ahead of itself the amount of water what would otherwise occupy the space it is taking up. This water flows along the tankers side and finally fills the corresponding volume remaining free astern. This is known as the return current. According to Bernoulli's theorem, a depression in water level occurs. So ships squat due to this depression in water level and other factors.

These phenomena, i.e., return currents, depression in water level may cause damage to the facings and side slopes of the Canal. Also tankers may bottom owing to un-expected squat. It is the numerical relation between the squat, forward speed and dimensions of the Canal and tankers, that we are after.

The problem, however, may be looked upon from another point of view, namely to determine-guided by experimental data-the following operational variables:

a) The maximum permissible draught and forward speed according to the accepted squat.

b) The main dimensions the Canal cross section should have in order to ensure a safe passage of tankers of a given tonnage and a given speed.

To achieve these results the relation between squat and factors involved should be derived first.

Symbols :

y = depression of water level

z = squat

u = return current

h = mean depth

g = acceleration of gravity.

$y_1 = y/h$

$y_2 = \frac{\ell}{E} \cdot \frac{y}{h} = y_1'$

$y_3 = z/h$

$y_4 = \frac{\ell}{E} \cdot \frac{z}{h} = y_3'$

$y_5 = u_1 / \sqrt{gh}$

$y_6 = \frac{\ell}{E} \cdot \frac{u_1}{\sqrt{gh}} = y_5'$

$y_7 = u_2 / \sqrt{gh}$

$y_8 = \frac{\ell}{E} \cdot \frac{u_2}{\sqrt{gh}} = y_7'$

$$y_9 = u_3 / \sqrt{gh}$$

$$y_{10} = \frac{\ell}{\bar{E}} \cdot \frac{u_3}{\sqrt{gh}} = y'_9$$

$$x_1 = P/T$$

$$x_2 = L/B$$

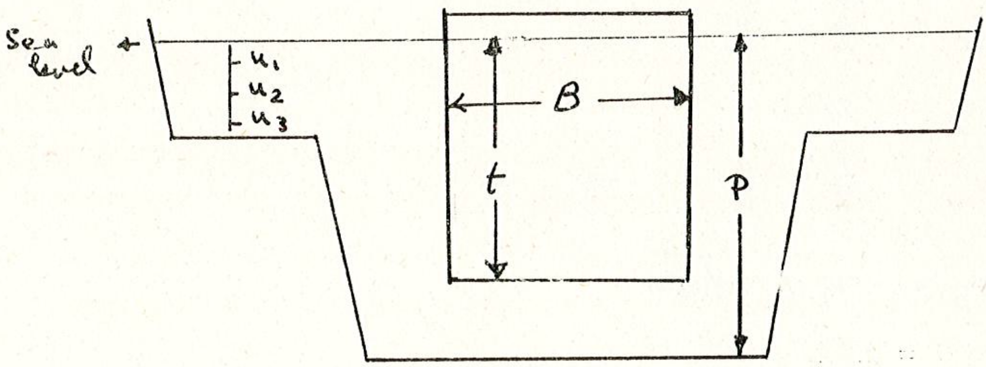
$$x_3 = V/V_\ell$$

u_1 is measured at depth 0.60 m. from sea level

u_2 is " " " 1.00 m. " " "

u_3 is " " " 1.30 m. " " "

$$y'_{2n+1} = \frac{\ell}{\bar{E}} \cdot y_{2n+1} = y_{2n} \quad ; n=0,1,2,3,4.$$



L x P = Canal Area

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$y_5 = u_1 / \sqrt{gh}$

$y_6 = \frac{\ell}{E} \cdot \frac{u_1}{\sqrt{gh}} = y_5'$

$y_7 = u_2 / \sqrt{gh}$

$y_8 = \frac{\ell}{E} \cdot \frac{u_2}{\sqrt{gh}} = y_7'$

then

$$\mathcal{E}(\xi_i) = \alpha_0 + \alpha_1 \xi_{1i} + \alpha_2 \xi_{2i} + \alpha_3 \xi_{3i}$$

and

$$A = \begin{bmatrix} 1 & \xi_{11} & \xi_{21} & \xi_{31} \\ 1 & \xi_{12} & \xi_{22} & \xi_{32} \\ 1 & \xi_{13} & \xi_{23} & \xi_{33} \end{bmatrix}$$

from relation (3)

$$C = A'A = \begin{bmatrix} n & \Sigma\xi_1 & \Sigma\xi_2 & \Sigma\xi_3 \\ \Sigma\xi_1 & \Sigma\xi_1^2 & \Sigma\xi_1\xi_2 & \Sigma\xi_1\xi_3 \\ \Sigma\xi_2 & \Sigma\xi_2\xi_1 & \Sigma\xi_2^2 & \Sigma\xi_2\xi_3 \\ \Sigma\xi_3 & \Sigma\xi_3\xi_1 & \Sigma\xi_3\xi_2 & \Sigma\xi_3^2 \end{bmatrix}$$

from relation (4)

So, we have to compute C^{-1}, then $A'y$ to get $C^{-1} A'y$ and finally $\theta^{*'} C \theta^*$

Computations

By the help of the preliminary trials, we figured out that the relation.

$$y_i = \phi_i \; (x_1 , x_2 , x_3) \quad ; i = 1 \longrightarrow 10.$$

should be in the form

$$y_i = A_i \; x_1^{\alpha_i} \; x_2^{\beta_i} \; x_3^{\gamma_i} \quad ; i = 1 \longrightarrow 10.$$

$$\text{or } \log y_i = a_{oi} + \sum_{j=1}^{3} a_{ji} \log x_j \; ; i = 1 \longrightarrow 10.$$

where the constants a_{oi} , a_{1i} , a_{2i} & a_{3i} are determined by solving simultane-ously the normal equations.

$$\sum y_i = a_{oi} \; n_i + a_{1i} \sum x_1 + a_{2i} \sum x_2 + a_{3i} \sum x_3$$

$$\sum x_1 y_i = a_{oi} \sum x_1 + a_{1i} \sum x_1^2 + a_{2i} \sum x_1 x_2 + a_{3i} \sum x_1 x_3$$

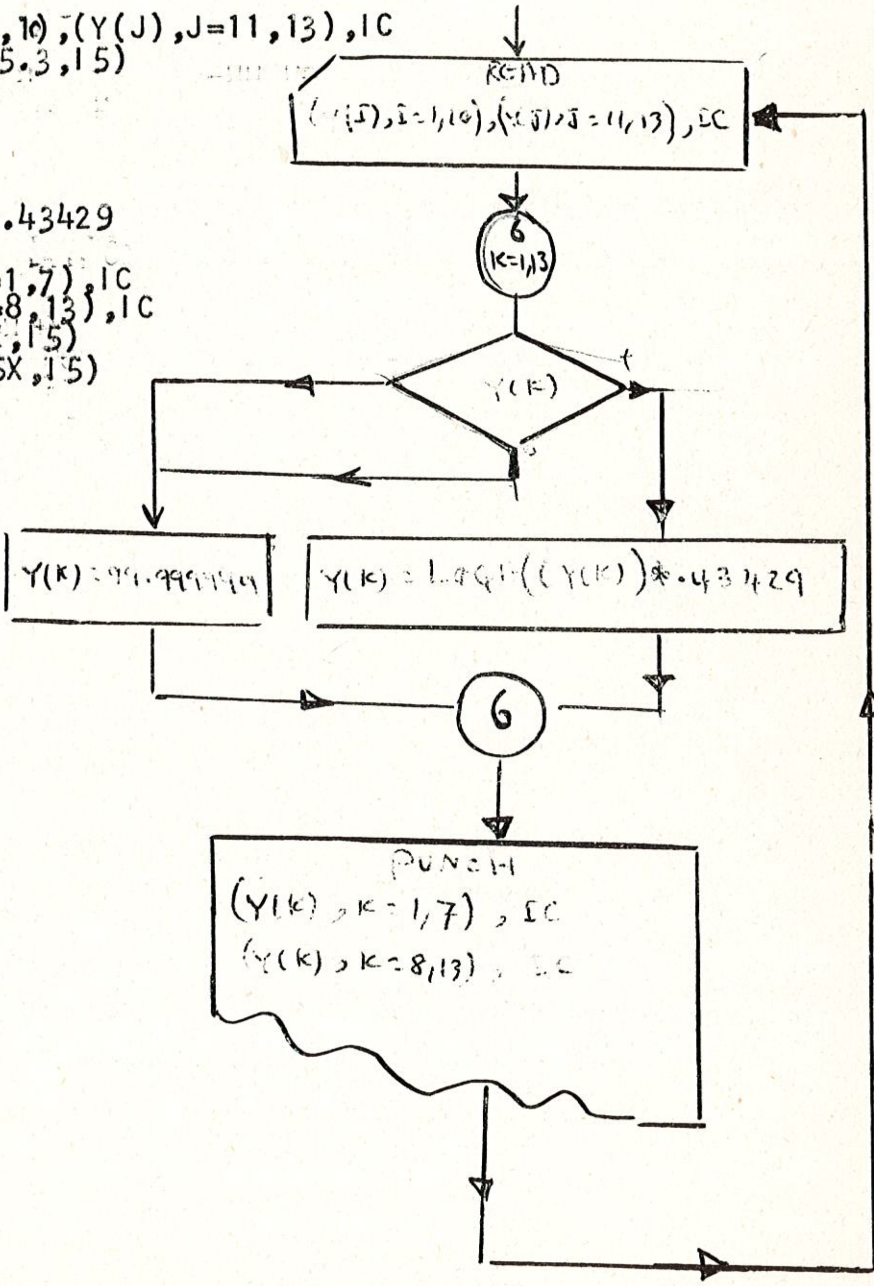
$$\sum x_2 y_i = a_{oi} \sum x_2 + a_{1i} \sum x_2 x_1 + a_{2i} \sum x_2^2 + a_{3i} \sum x_2 x_3$$

$$\sum x_3 y_i = a_{oi} \sum x_3 + a_{1i} \sum x_1 x_3 + a_{2i} \sum x_2 x_3 + a_{3i} \sum x_3^2$$

Four equations and four unknowrs (a_{oi}, a_{1i}, a_{2i} & a_{3i}) for each i; $i=1 \longrightarrow 10$.

So, the first step in our computations was to get logs of the all given data. The following program computes the required logs.

```
      DIMENSION Y(13)
  100 READ 1,(Y(I),I=1,10),(Y(J),J=11,13),IC
    1 FORMAT(10F6.4,3F5.3,I5)
      DO 6 K=1,13
      IF(Y(K))5,5,2
    5 Y(K)=99.999999
      GO TO 6
    2 Y(K)=LOGF(Y(K))*.43429
    6 CONTINUE
      PUNCH 3,(Y(K),K=1,7),IC
      PUNCH 4,(Y(K),K=8,13),IC
    3 FORMAT(7F10.6,5X,I5)
    4 FORMAT(6F10.6,15X,I5)
      GO TO 100
      END
```



Then using y instead of log y and x instead of log x in the previous system of equations. Because of lacking of some of the data, i.e. some x's or some y's, so if one of the x's is missing we ommit the whole ship, on the other hand, if one of the y's is missing, we ommit this ship for this y only and use it for the other nine y's. This is the answer of the question, why the n's are different?

The following program computes:

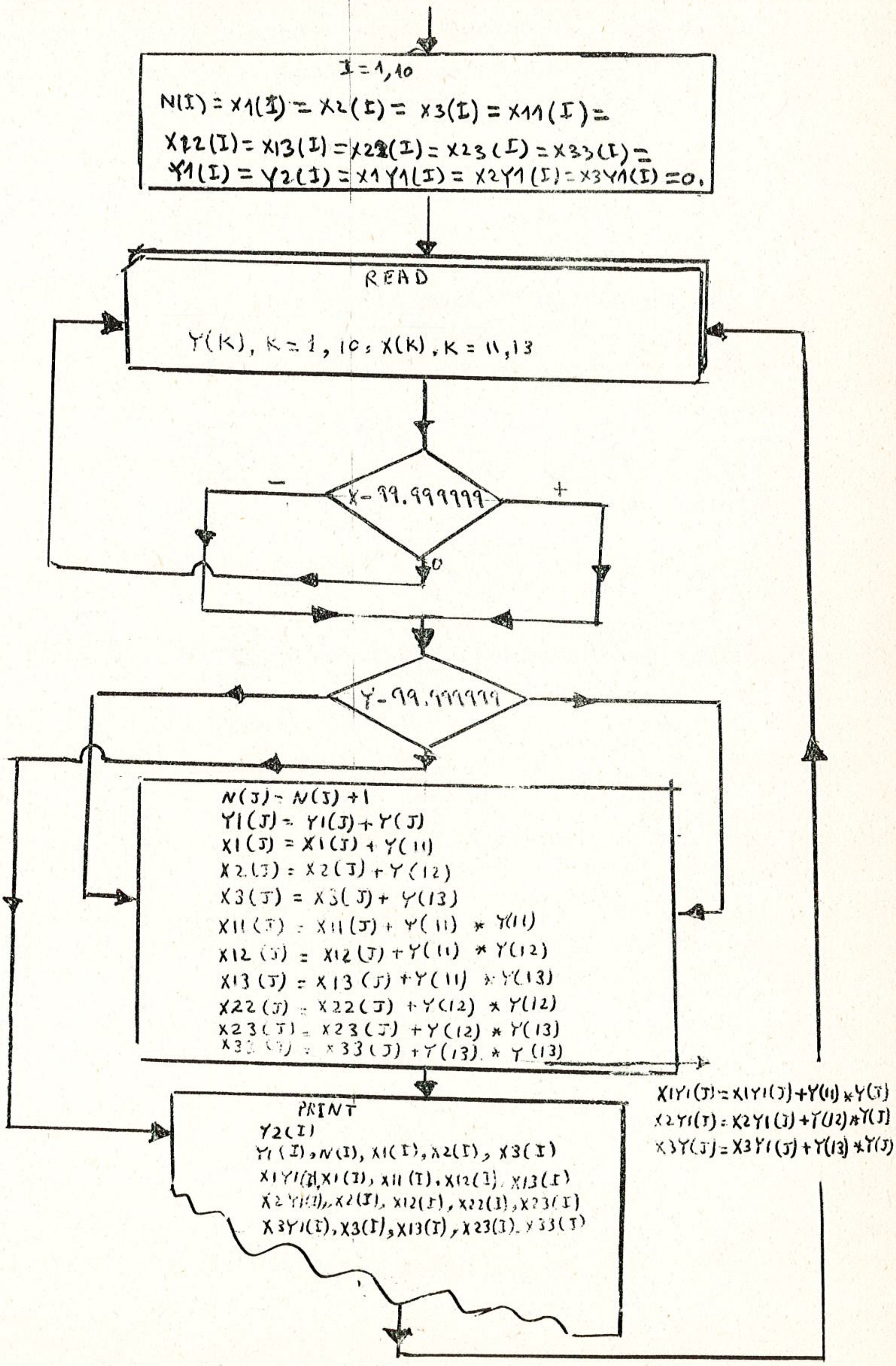
$$\sum y \ , \quad n \ , \quad \sum x_1 \ , \quad \sum x_2 \ , \quad \sum x_3$$

$$\sum x_1 y \ , \quad \sum x_1 \ , \quad \sum x_1^2 \ , \quad \sum x_1 x_2 \ , \quad \sum x_1 x_3$$

$$\sum x_2 y \ , \quad \sum x_2 \ , \quad \sum x_1 x_2 \ , \quad \sum x_2^2 \ , \quad \sum x_2 x_3$$

$$\sum x_3 y \ , \quad \sum x_3 \ , \quad \sum x_1 x_3 \ , \quad \sum x_2 x_3 \ , \quad \sum x_3^2$$

and by the order written above (repeated 10 times for each y).


I = 1,10
N(I) = X1(I) = X2(I) = X3(I) = X11(I) =
X12(I) = X13(I) = X22(I) = X23(I) = X33(I) =
Y1(I) = Y2(I) = X1Y1(I) = X2Y1(I) = X3Y1(I) = 0.
READ
Y(K), K = 1, 10 ; X(K), K = 11,13
X-99.999999
-
+
0
Y-99.999999
N(J) = N(J) + 1
Y1(J) = Y1(J) + Y(J)
X1(J) = X1(J) + Y(11)
X2(J) = X2(J) + Y(12)
X3(J) = X3(J) + Y(13)
X11(J) = X11(J) + Y(11) * Y(11)
X12(J) = X12(J) + Y(11) * Y(12)
X13(J) = X13(J) + Y(11) * Y(13)
X22(J) = X22(J) + Y(12) * Y(12)
X23(J) = X23(J) + Y(12) * Y(13)
X33(J) = X33(J) + Y(13) * Y(13)
X1Y1(J) = X1Y1(J) + Y(11) * Y(J)
X2Y1(J) = X2Y1(J) + Y(12) * Y(J)
X3Y(J) = X3Y1(J) + Y(13) * Y(J)
PRINT
Y2(I)
Y1(I), N(I), X1(I), X2(I), X3(I)
X1Y1(I), X1(I), X11(I), X12(I), X13(I)
X2Y1(I), X2(I), X12(I), X22(I), X23(I)
X3Y1(I), X3(I), X13(I), X23(I), X33(I)

```
*12 10
      DIMENSION Y(13),N(10),X1(10),X2(10),X3(10),X12(10),X13(10),X23(10)
     1,X33(10),Y1(10),X1Y1(10),X2Y1(10),X3Y1(10),X22(10),X11(1),Y2(10)
      DO9 I=1,10
      N(I)=0
      X1(I)=0.
      X2(I)=0.
      X3(I)=0.
      X11(I)=0.0
      X12(I)=0.
      X13(I)=0.
      X22(I)=.
      X23(I)=0.
      X33(I)=.
      Y1(I)=.
      Y2(I)=0.
      X1Y1(I)=0.
      X2Y1(I)=0.
    9 X3Y1(I)=.
    1 READ2,(Y(K),K=1,7),IC1
      READ3,(Y(K),K=8,13),IC2
    2 FORMAT(7F10.6,5X,I5)
    3 FORMAT(6F10.6,15X,I5)
      IF(IC1-IC2)4,6,4
    4 PRINT5,IC1,IC2
    5 FORMAT(8HERROR...,I6,2X,I6)
      PAUSE
      GOTO 1
    6 DO7 J=11,13
      IF(Y(J)-99.999999)7,1,7
    7 CONTINUE
    8 DO11 J=1,10
      IF(Y(J)-99.999999)10,11,10
   10 N(J)=N(J)+1
      Y1(J)=Y1(J)+Y(J)
      Y2(J)=Y2(J)+Y(J)*Y(J)
      X1(J)=X1(J)+Y(11)
      X2(J)=X2(J)+Y(12)
      X3(J)=X3(J)+Y(13)
      X11(J)=X11(J)+Y(11)*Y(11)
      X12(J)=X12(J)+Y(11)*Y(12)
      X13(J)=X13(J)+Y(11)*Y(13)
      X22(J)=X22(J)+Y(12)*Y(12)
      X23(J)=X23(J)+Y(12)*Y(13)
      X33(J)=X33(J)+Y(13)*Y(13)
      X1Y1(J)=X1Y1(J)+Y(11)*Y(J)
      X2Y1(J)=X2Y1(J)+Y(12)*Y(J)
      X3Y1(J)=X3Y1(J)+Y(13)*Y(J)
   11 CONTINUE
      IF(SENSE SWITCH 1)12,1
   12 DO13 I=1,10
```

```
      PUNCH14,Y2(J)
      PUNCH14,Y1(I),N(I),X1(I),X2(I),X3(I)
      PUNCH14,X1Y1(I),X1(I),X11(I),X12(I),X13(I)
      PUNCH14,X2Y1(I),X2(I),X12(I),X22(I),X23(I)
   13 PUNCH14,X3Y1(I),X3(I),X13(I),X23(I),X33(I)
   14 FORMAT(5F16.8)
      GOTO 1
      END
```

The results of the previous program are:

Case 1:

1906.91956700	1222.00000000	231.80752700	728.45180800	215.56416700
369.45847685	231.80752700	46.26789223	141.46970569	42.96746638
1151.73411832	728.45180800	141.46970569	441.29817308	132.57558260
352.02223321	215.56416700	42.96746638	132.57558260	45.02980371

Case 2:

-1821.56890800	1199.00000000	227.38572800	714.63029500	-211.52002500
-355.18654077	277.38572800	45.37601480	138.73892761	-42.12211615
-1103.93290405	714.63029500	138.73892761	432.82098386	-130.02230099
333.97848486	-211.52002500	-42.12211615	-130.02230099	44.09190888

Case 3:

-409.29995200	286.00000000	53.01043200	168.86744800	-47.13865600
-77.58290784	53.01043200	10.32841649	32.07591814	-9.23417536
-245.64458583	168.86744800	32.07591814	101.53023505	-28.87912083
70.83985546	-47.13865600	-9.23417536	-28.87912083	9.32807867

Case 4:

-387.16617600	279.00000000	51.59368000	164.61488200	-46.02217500
-73.87379620	51.59368000	10.02021456	31.18196073	-8.98269365
-233.16766977	164.61488200	31.18196073	98.86182859	-28.16252636
67.93345870	-46.02217500	-8.98269365	-28.16252636	9.11555355

Case 5:

-1356.09555700	960.00000000	181.08940500	571.33342000	-167.40836800
-262.94463009	181.08940500	35.79654508	110.20798241	-33.20915902
-820.35081384	571.33342000	110.20798241	345.35301607	-102.87930398
248.89537591	-167.40836800	-33.20915902	-102.87930398	35.03303093

Case 6:

-1306.71229900	950.00000000	179.23425400	565.46431900	-166.12812400
-255.01299779	179.23425400	35.43252703	109.08585007	- 32.94320948
-793.62629352	565.46431900	109.08585007	341.81844859	-102.07978731
242.64031455	-166.12812400	- 32.94320948	-102.07978731	34.77635285

Case 7:

-1457.38489400	1166.00000000	219.64424700	693.01406700	-203.51415900
-282.12368067	219.64424700	43.38749467	133.47507923	-40.20497013
-880.36958200	693.01406700	133.47507923	418.41269708	-124.68518068
267.13823257	-203.51415900	- 40.20497013	-124.68518068	42.08511507

Case 8:

-1376.88799500	1142.00000000	215.05513300	678.63625800	-199.37310800
-268.59385025	215.05513300	42.46762292	130.65122448	- 39.34340557
-835.40865756	678.63625800	130.65122448	409.62604262	-122.07798897
255.15994503	-199.37310800	- 39.34340557	-122.07798897	41.13782888

Case 9:

-1084.85313400	828.00000000	157.17299000	494.87129700	-147.09548000
-206.55920889	157.17299000	31.29935718	96.18397749	- 29.32493820
-642.95229658	494.87129700	96.18397749	300.71953896	- 90.78115331
198.31348860	-147.09548000	- 29.32493820	- 90.78115331	31.43417094

Case 10:

-990.12184900	804.00000000	152.55600300	480.25696600	-142.87601000
-195.52053547	152.55600300	30.36745451	93.30096884	-28.44140338
-606.43820578	480.25696600	93.30096884	291.68233713	-88.09381242
188.24535826	-142.87601000	-28.44140338	-88.09381242	30.45867810

Now, putting our problem in the form

$$\begin{bmatrix} \Sigma y_1 \\ \Sigma x_1 y_1 \\ \Sigma x_2 y_1 \\ \Sigma x_3 y_1 \end{bmatrix} = \begin{bmatrix} n & \Sigma x_1 & \Sigma x_2 & \Sigma x_3 \\ \Sigma x_1 & \Sigma x_1^2 & \Sigma x_1 x_2 & \Sigma x_1 x_3 \\ \Sigma x_2 & \Sigma x_1 x_2 & \Sigma x_2^2 & \Sigma x_2 x_3 \\ \Sigma x_3 & \Sigma x_1 x_3 & \Sigma x_2 x_3 & \Sigma x_3^2 \end{bmatrix} \begin{bmatrix} a_o \\ a_1 \\ a_2 \\ a_3 \end{bmatrix}$$

or, in matrix form:

$$B = C \quad A$$

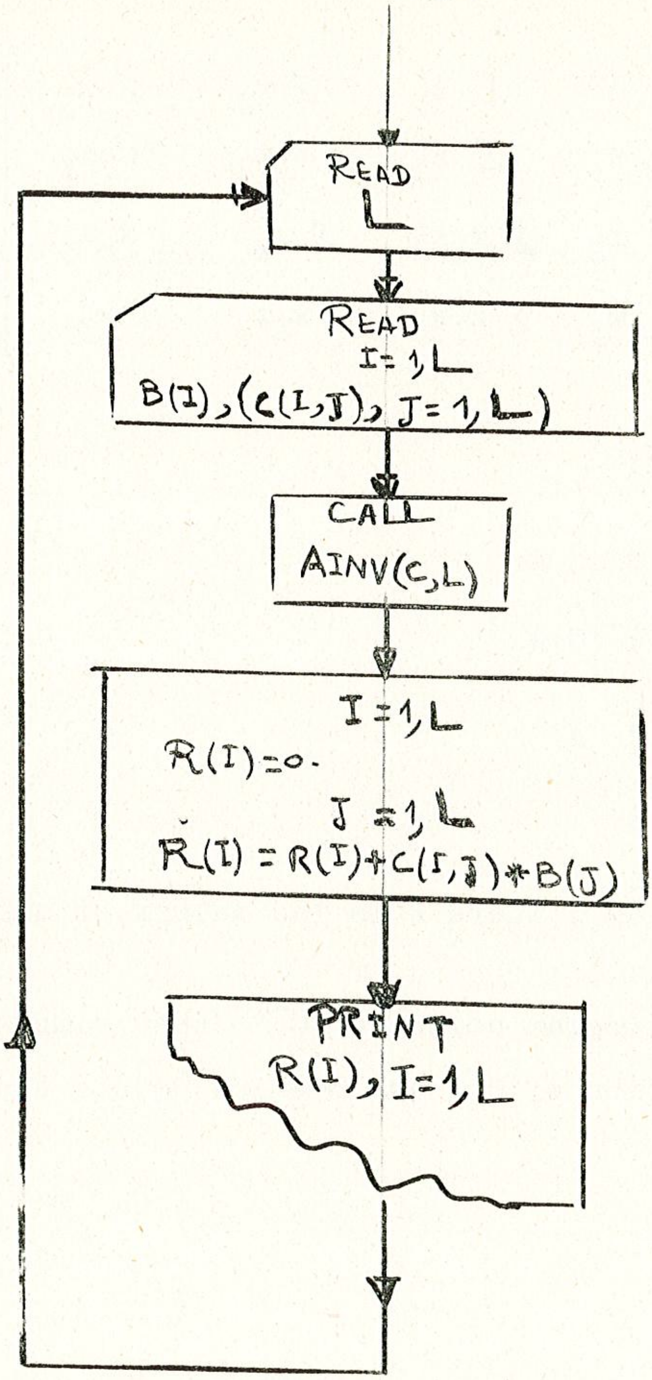
$$C^{-1}B = C^{-1}C \; A$$

$$= I \quad A$$

$$= A$$

or $A = C^{-1}B$; where A is the matrix of unknowns.

The following program computes C^{-1} then computes the matrices multiplication of C^{-1} and B which equals the matrix A.


READ
L
READ
I= 1, L
B(I), (C(I,J), J= 1, L)
CALL
AINV(C,L)
I = 1, L
R(I) = 0.
J = 1, L
R(I) = R(I)+C(I,J)*B(J)
PRINT
R(I), I=1, L

```
*1610
      DIMENSION C(25,25),B(25),R(25)
    1 READ2,L
    2 FORMAT(I2)
      DO3 I=1,L
    3 READ4,B(I),(C(I,J),J=1,L)
    4 FORMAT(5F16.8)
      CALLAINV(C,L)
      DO6 I=1,L
      R(I)=.
      DO6 J=1,L
    6 R(I)=R(I)+C(I,J)*B(J)
      IF(SENSE SWITCH 1)200,300
  20 PRINT7,(R(I),I=1,L)
    7 FORMAT(4F16.8)
  30 PUNCH7,(R(I),I=1,L)
      GOTO 1
      END
*1610
C     M.X.INVERSION
      SUBROUTINE AINV(C,L)
      DIMENSION C(25,25)
      DO1 IK=1,L
      XDIV=1./C(IK,IK)
      C(IK,IK)=1.
      DO2 J=1,L
    2 C(IK,J)=C(IK,J)*XDIV
      DO1 M=1,L
      IF(M-IK)3,1,3
    3 XDIV=C(M,IK)
      C(M,IK)=0.
      DO4 J=1,L
    4 C(M,J)=C(M,J)-C(IK,J)*XDIV
    1 CONTINUE
      RETURN
      END
```

	a_0	a_1	a_2	a_3
Case 1:				
	-.59714197	-.62835944	-.97910269	1.470413
Case 2:				
	-.30964314	-1.28694797	-1.16374206	1.54135686
Case 3:				
	-.33217009	.19230077	-1.59896736	1.15573326
Case 4:				
	-.10220271	-1.23626920	-1.41344511	1.35138854
Case 5:				
	-.27250786	-1.744434332	-1.05439871	1.05247237
Case 6:				
	.04047816	-2.07248367	-1.39581313	1.11013090
Case 7:				
	-.23762322	-1.48162829	- .94357491	.98752045
Case 8:				
	-.06854776	-2.01014899	-1.18757150	1.08814877
Case 9:				
	-.03039317	-1.24293286	-1.3964628	.97534525
Case 10:				
	.32351436	-1.77060960	-1.73797638	1.01791066.

The method described above has been carried out on a form of the regression relation to show, if the form derived fits the experimental data satisfactorily.

Let $Q = \Sigma Y_1^2 - \frac{1}{n} (\Sigma y_1)^2$ = corrected sum of squares.

= C.S.O.S

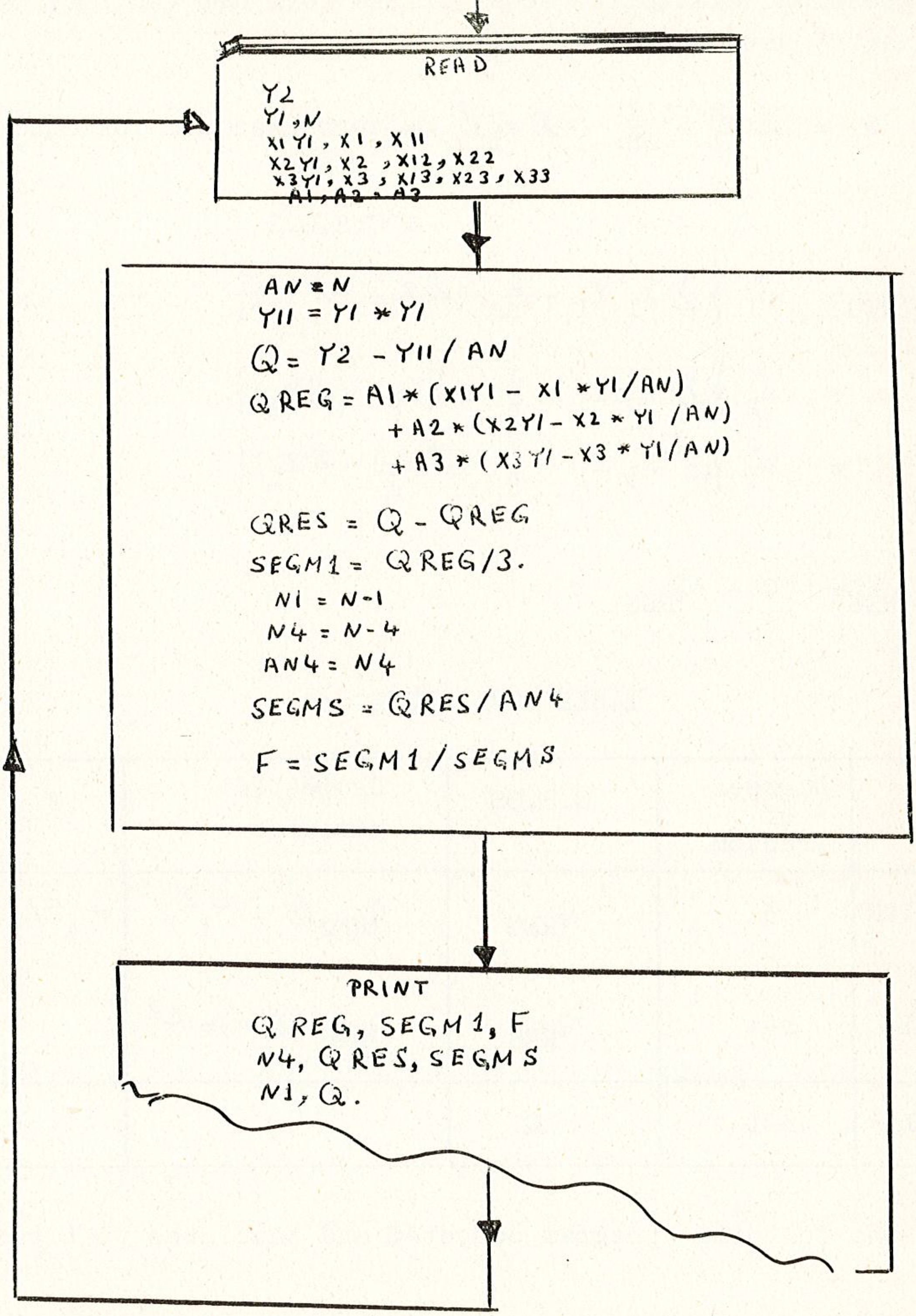
$$Q_{REG} = a_1^* \left\{ \Sigma X_1 Y_1 - \frac{1}{n} (\Sigma X_1)(\Sigma Y_1) \right\}$$
$$+ a_2^* \left\{ \Sigma X_2 Y_1 - \frac{1}{n} (\Sigma X_2)(\Sigma Y_1) \right\}$$
$$+ a_3^* \left\{ \Sigma X_3 Y_1 - \frac{1}{n} (\Sigma X_3)(\Sigma Y_1) \right\}$$

$$Q_{RES} = Q - Q_{REG}$$

TABLE OF ANOVA

Source	Degrees of freedom	C.S.OS	Estimated variance	F
REGRESSION	3	Q_{REG}	$Q_{REG}/3 = \sigma_1^2$	σ_1^2/σ^{*2}
RESIDUAL	n-4	Q_{RES}	$Q_{RES}/(N-4) = \sigma^{*2}$	
TOTAL	n-1	Q		

The following program computes and tabulates that table


READ
Y2
Y1, N
X1Y1, X1, X11
X2Y1, X2, X12, X22
X3Y1, X3, X13, X23, X33
A1, A2, A3
AN = N
Y11 = Y1 * Y1
Q = Y2 - Y11 / AN
QREG = A1 * (X1Y1 - X1 * Y1/AN)
+ A2 * (X2Y1 - X2 * Y1 /AN)
+ A3 * (X3Y1 - X3 * Y1/AN)
QRES = Q - QREG
SEGM1 = QREG/3.
N1 = N-1
N4 = N-4
AN4 = N4
SEGMS = QRES/AN4
F = SEGM1/SEGMS
PRINT
Q REG, SEGM 1, F
N4, Q RES, SEGMS
N1, Q.

```
*1610
C       ANALYSIS OF VARIANCE
    1 READ10,Y2
      READ10,Y1,N
      READ10,X1Y1,X1,X11
      READ10,X2Y1,X2,X12,X22
      READ1,X3Y1,X3,X13,X23,X33
   10 FORMAT(5F16.8)
      READ20,A1,A2,A3
   20 FORMAT(16X,3F16.8)
      AN=N
      Y11=Y1*Y1
      Q=Y2-Y11/AN
      QREG=A1*(X1Y1-X1*Y1/AN)+A2*(X2Y1-X2*Y1/AN)+A3*(X3Y1-X3*Y1/AN)
      QRES=Q-QREG
      SEGM1=QREG/3.
      N1=N-1
      N4=N-4
      AN4=N4
      SEGMS=QRES/AN4
      F=SEGM1/SEGMS
      IF(SENSE SWITCH 1)30,90
    3 PRINT4
   40 FORMAT(24X,30HTABLE OF ANALYSIS OF VARIANCE//76H--------------------
     1--------------------------------------------------------/8HSOUR(
     1E   ,16H      D.F.       16H    C.S.O.S.     ,4X,16H    EST. VA.
     216H        F.        )
      PRINT50
   50 FORMAT(76H--------------------------------------------------------
     1--------------------)
      PRINT60,QREG,SEGM1,F
    6 FORMAT(8H  REG.   ,16H          3          ,F16.8,4X,2F16.8)
      PRINT70,N4,QRES,SEGMS
   70 FORMAT(8H  RES.   ,I8,8X,F16.8,4X,F16.8)
      PRINT8,N1,Q
   80 FORMAT(8H  TOT.   ,I8,8X,F16.8/76H--------------------------------
     1--------------------------------------------)
    9 PUNCH40
      PUNCH50
      PUNCH60,QREG,SEGM1,F
      PUNCH70,N4,QRES,SEGMS
      PUNCH8,N1,Q
      GOTO1
      END
```

The results are as follows:

Case 1: TABLE OF ANALYSIS OF VARIANCE/

SOURCE	D.F.	C.S.O.S.	EST.VA.	F.
REG.	3	42.62296205	14.2076541	604.20785170
RES.	1218	28.6467811	.02351451	
TOT.	1221	71.26364017		

Case 2: TABLE OF ANALYSIS OF VARIANCE/

SOURCE	D.F.	C.S.O.S.	EST.VA.	F.
REG.	3	60.92231976	20.30743992	799.50753974
RES.	1195	3.35292289	.02539993	
TOT.	1198	91.27524265		

Case 3: TABLE OF ANALYSIS OF VARIANCE/

SOURCE	D.F.	C.S.O.S.	EST.VA	F.
REG.	3	9.93078469	3.31026156	66.19015300
RES.	282	14.10321201	.05001139	
TOT.	285	24.03399671		

Case 4: TABLE OF ANALYSIS OF VARIANCE/

SOURCE	D.F.	C.S.O.S.	EST.VA	F.
REG.	3	15.00398009	5.00132669	189.47401228
RES.	275	7.25885743	.02639584	
TOT.	278	22.26283752		

Case 5: TABLE OF ANALYSIS OF VARIANCE/

SOURCE	D.F.	C.S.O.S.	EST.VA.	F.
REG.	3	39.52481584	13.17493861	352.45607257
RES.	956	35.73563430	.03738037	
TOT.	959	75.26045015		

Case 6: TABLE OF ANALYSIS OF VARIANCE/

SOURCE	D.F.	C.S.O.S.	EST.VA.	F.
REG.	3	55.3681868	18.4566022	502.31307017
RES.	946	34.75807024	.03674214	
TOT.	949	90.12625093		

Case 7: TABLE OF ANALYSIS OF VARIANCE/

SOURCE	D.F.	C.S.O.S.	EST.VA.	F.
REG.	3	37.2228024	12.40760008	682.42259529
RES.	1162	21.12713060	.01818169	
TOT.	1165	58.34993084		

Case 8: TABLE OF ANALYSIS OF VARIANCE/

SOURCE	D.F.	C.S.O.S.	EST.VA.	F.
REG.	3	55.20251080	18.4083693	789.87149276
RES.	1138	26.51083451	.02329593	
TOT.	1141	81.71334531		

Case 9: TABLE OF ANALYSIS OF VARIANCE/

SOURCE	D.F.	C.S.O.S.	EST.VA.	F.
REG.	3	35.95598725	11.9853298	560.70477540
RES.	824	17.61338872	.02137547	
TOT.	827	53.56937597		

Case 10: TABLE OF ANALYSIS OF VARIANCE/

SOURCE	D.F.	C.S.O.S.	EST.VA.	F.
REG.	3	52.13418288	17.37806096	665.43083558
RES.	800	20.89240237	.02611550	
TOT.	803	73.2658526		

The regression component of the variance shows a very highly significant at 0.01 level of significance.

E.Z.