OPTIONAL FORM NO. 10
5010-104

UNITED STATES GOVERNMENT

Memorandum

Memorandum

Denver, Colorado
DATE: August 6, 1964

TO : H. M. Martin
Through: J. C. Schuster
A. J. Peterka
FROM : C. E. Brockway

SUBJECT: Analysis of Cole pitometer discharge measurements using electronic digital computers

INTRODUCTION

The computation of discharges in pipes using a velocity distribution obtained from Cole pitometer measurements is very time-consuming when performed by manual methods. A program for the IBM 7090 computer has been written in Fortran II to determine average velocities and discharges from original field data. The program was written to analyze the Cole pitometer measurements obtained during the turbine acceptance tests at Green Springs Powerplant and to perfect a program for future use.

The Cole pitometer consists of two orifices mounted in a plane, one directed upstream and one directed downstream. A pressure differential between the upstream and downstream orifices is measured with a manometer and the velocity at the point is determined from

$$V = C\sqrt{2gh}$$

Where V = point velocity--ft/sec
C = pitometer coefficient--variable with $\sqrt{2gh}$
g = gravitational acceleration--ft/sec^2
h = pressure differential--feet of flowing fluid

CODE REQUIREMENTS

The ASME Test Code for hydraulic prime movers stipulates that velocity traverses will be made on at least two diameters of a pipe, 90° apart, with velocities determined at the midpoints of annular rings which divide the pipe into equal areas. The code further stipulates that the velocity traverses will be plotted and a smooth curve drawn through the test points assuming the velocity distribution follows the one-seventh power law from the pipe wall to the nearest measured velocity point. The mean of the average velocities determined on two diameters is multiplied by the corrected pipe area to determine the discharge.

Average velocity for each traverse is normally determined from the velocity profile using a planimeter. However, equivalent results can be obtained by a mathematical procedure as outlined in this memorandum.

ESSENTIALS OF COMPUTER PROGRAM

The ADP program uses the average pipe diameter, the geometry of the pitometer, and the manometer readings as input. Two traverses, A and B, are computed simultaneously in the program. Theoretical velocities, $\sqrt{2gh}$, at each point on a traverse are computed by algebraic methods. The pitometer coefficient corresponding to the theoretical velocity is determined using Newton forward difference interpolation in a difference table computed from the calibration curve for a given pitometer and stored in the computer memory. Corrected velocities for each point are then computed by multiplying the pitometer coefficient by the theoretical velocity.

The velocities at points between the wall and the nearest measured velocity point are computed from the one-seventh power law and the profiles of the computed velocities are punched on cards to be plotted by an x-y plotter. All profiles are in dimensionless form so that regardless of velocity values, all plots may be made on one paper size. The ordinate represents the pipe diameter and the abscissa values are decimal parts of the centerline velocity. A polynomial curve of degree (n-1) is fitted to the "n" measured velocity points by solving the set of simultaneous equations corresponding to the points on the traverse. The resulting n by n+1 array corresponding to the set of simultaneous equations is solved by a matrix reduction technique called a complete Gauss elimination.

The area under the velocity profile between the two measured velocity points nearest the walls is determined by infinite integration of the fitted polynomial. The areas under the velocity profile from each wall to the nearest measured velocity point are determined by integration of the curves computed by the one-seventh power law. Average velocity for each traverse is determined by dividing the total area under the velocity profile curve by the traverse diameter. The average fluid velocity is the mean of the average velocities determined for the A and B traverses.

A pipe coefficient, equal to the ratio of the average pipe velocity to the centerline velocity, is also determined. Use of the pipe coefficient permits the computation of subsequent discharges from one determination of velocity at the pipe centerline. Discharge is determined by multiplying the centerline velocity by the pipe coefficient and by the corrected pipe area. The corrected pipe area is equal to the pipe area minus 1.25 times the projected area of the pitometer when the orifices are at the pipe centerline. This area correction is specified by the ASME Test Code.

An example of the printed output for a typical traverse taken at Green Springs Powerplant is shown in Table 1. A velocity profile, plotted by an x-y plotter, corresponding to the data for Diameter B in Table 1 is shown in Figure 1. The complete program, together with a list of input variables, is included as addendum to this memorandum.

Smooth curves carefully drawn by one individual to average the measured velocity points for each Green Springs test were integrated with a planimeter to find the difference between the discharge determined by the computer and the discharge computed manually. Table 2 is a comparison of six discharges determined manually with a planimeter and by the computer. In this comparison, the average curves for the velocity profiles were drawn by one individual and the computer discharge averaged 0.10 percent higher than the discharge computed manually. Had another individual drawn the velocity curves, the difference between the discharges indicated by the two methods may have been in the opposite direction. The agreement between the two methods of discharge computation is satisfactory for velocity distributions measured by the pitometer.

Since the fitted polynomial is forced to pass through every measured point on the velocity profile, an erroneous velocity point will result in a distorted profile. However, any large velocity error can be easily detected by inspection of the profile which is plotted on the x-y plotter. Figure 2 shows the effect on the computed polynomial of an assumed error of 1 foot in the manometer differential used to calculate the velocity at Point No. 8 of a typical traverse. The dashed line in Figure 2 is the polynomial fit through the correct velocity points, and the line of circles is the resulting fitted polynomial including the erroneous velocity. The oscillations of the incorrect polynomial about the correct profile are damped out but not rapidly enough to give an accurate representation of the profile. In general, the velocity points obtained with pitometers define a smooth curve so that the mathematical fitting of an n^{th} degree polynomial is a good representation of the correct profile.

With the increase in prototype testing and the use of pitometers for field discharge measurements, this computer program should result in considerable time savings. In addition to the use on Green Springs Powerplant data, the program has been used successfully to reduce data from Fremont Canyon Power Conduit friction tests; discharge measurements for friction factor determination, Salt River Project, Arizona, and laboratory pitometer studies.

TABLE I

TRAVERSE NO = 1

POINT	UHIGH	ULOW	DELH	VU	P COEFF	VCOR
TRAVERSE ON DIAMETER A						
1	47.980	46.310	1.670	10.363	0.852	8.82
2	48.190	46.100	2.090	11.593	0.849	9.84
3	48.400	45.910	2.49C	12.653	0.847	10.71
4	48.560	45.780	2.780	13.370	0.845	11.30
5	48.720	45.620	3.10C	14.119	0.844	11.91
6	48.770	45.560	3.21C	14.367	0.844	12.12
7	48.680	45.660	3.020	13.935	0.844	11.76
8	48.570	45.770	2.80C	13.418	0.845	11.34
9	48.460	45.880	2.58C	12.880	0.846	10.90
10	48.300	46.040	2.260	12.055	0.848	10.22
11	48.050	46.240	1.81C	10.788	0.851	9.18
TRAVERSE ON DIAMETER B						
1	48.260	46.580	1.680	10.394	0.852	8.85
2	48.510	46.330	2.18C	11.840	0.849	10.04
3	48.730	46.120	2.61C	12.955	0.846	10.96
4	48.900	45.950	2.950	13.773	0.845	11.63
5	49.050	45.820	3.230	14.412	0.844	12.15
6	49.010	45.870	3.14C	14.209	0.844	11.99
7	48.900	46.020	2.88C	13.608	0.845	11.49
8	48.780	46.140	2.64C	13.029	0.846	11.02
9	48.690	46.250	2.44C	12.526	0.847	10.61
10	48.550	46.390	2.16C	11.785	0.849	10.00
11	48.370	46.590	1.78C	10.698	0.851	9.10

VELOCITY = SUM A(I) TIMES X TO THE (I)TH POWER

I	TRAVERSE ON DIAMETER A	TRAVERSE ON DIAMETER B
10	1.5775363E-02	1.7853481E-02
9	-3.3194917E-01	-3.6087587E-01
8	3.0088687E 00	3.1191080E 00
7	-1.5350647E 01	-1.5038879E 01
6	4.8270710E 01	4.4220012E 01
5	-9.6175201E 01	-8.1359546E 01
4	1.1995567E 02	9.2301848E 01
3	-8.8653655E 01	-6.0546886E 01
2	3.3000928E 01	1.7718702E 01
1	-9.5192337E-01	3.3422327E 00
0	8.6572539E 00	8.3732134E 00

AREAA = 44.251 VELOCITYA = 11.074 AREAB = 44.144 VELOCITYB = 11.047

PIPE COEFFICIENT = 0.917 AVG VELOCITY = 11.060 DISCHARGE = 138.659

Table 2

COMPARISON OF MANUAL AND COMPUTER DISCHARGES
Green Springs Powerplant, 1963

Run No.	Discharge *Qp, cfs	Discharge **Qc, cfs	Percent difference
1	138.71	138.66	-0.04
2	129.25	129.29	+0.03
15	70.37	70.26	-0.15
17	103.00	103.34	+0.33
20	87.94	87.93	-0.01
26	117.21	117.49	+0.24
		Average	+0.10

*Q_p is the discharge determined by integration of the velocity profile using a planimeter.

**Q_c is the discharge determined by the computer using an infinite integration of the polynomial fitted to the velocity profile.

FIGURE 1

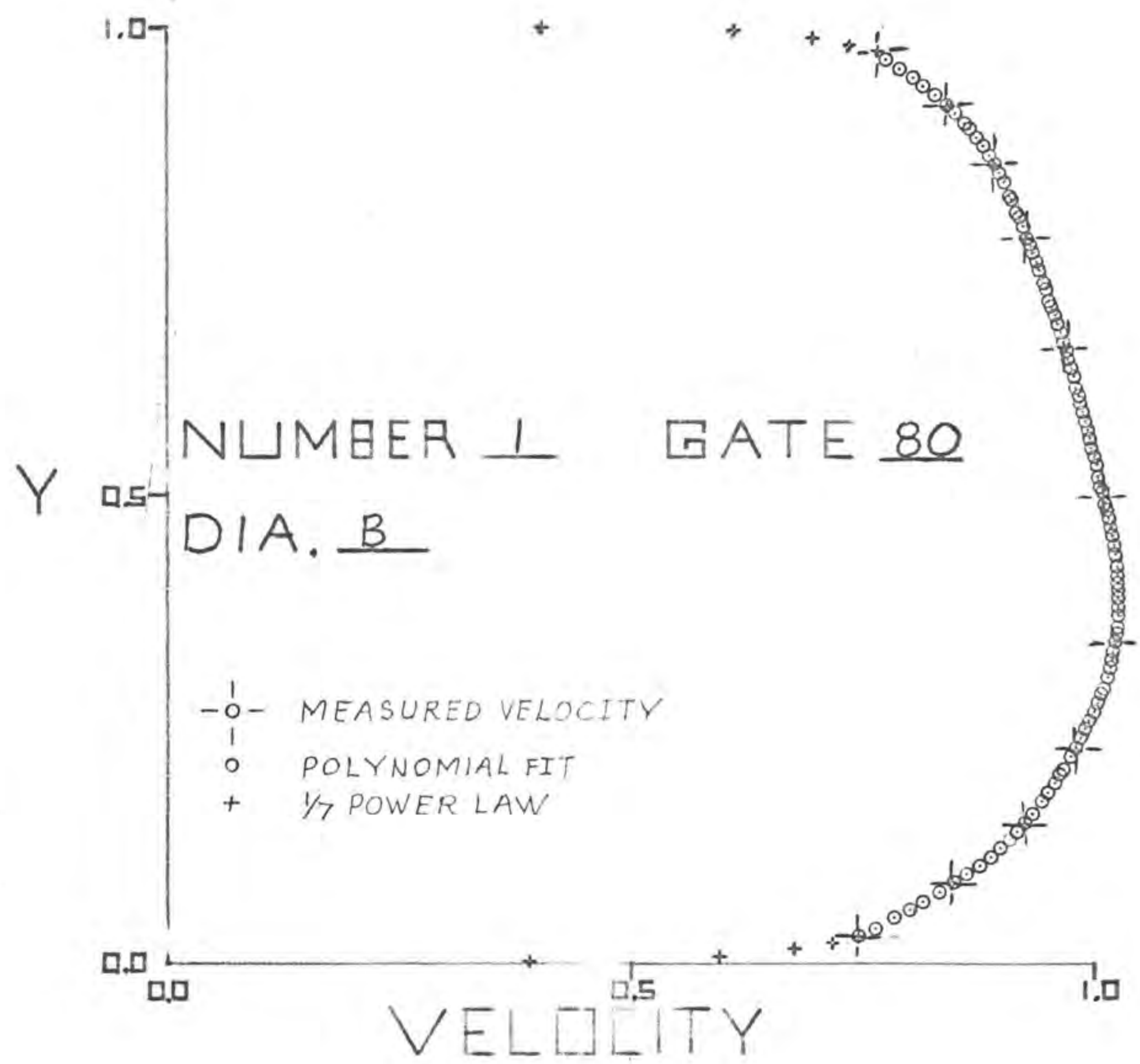
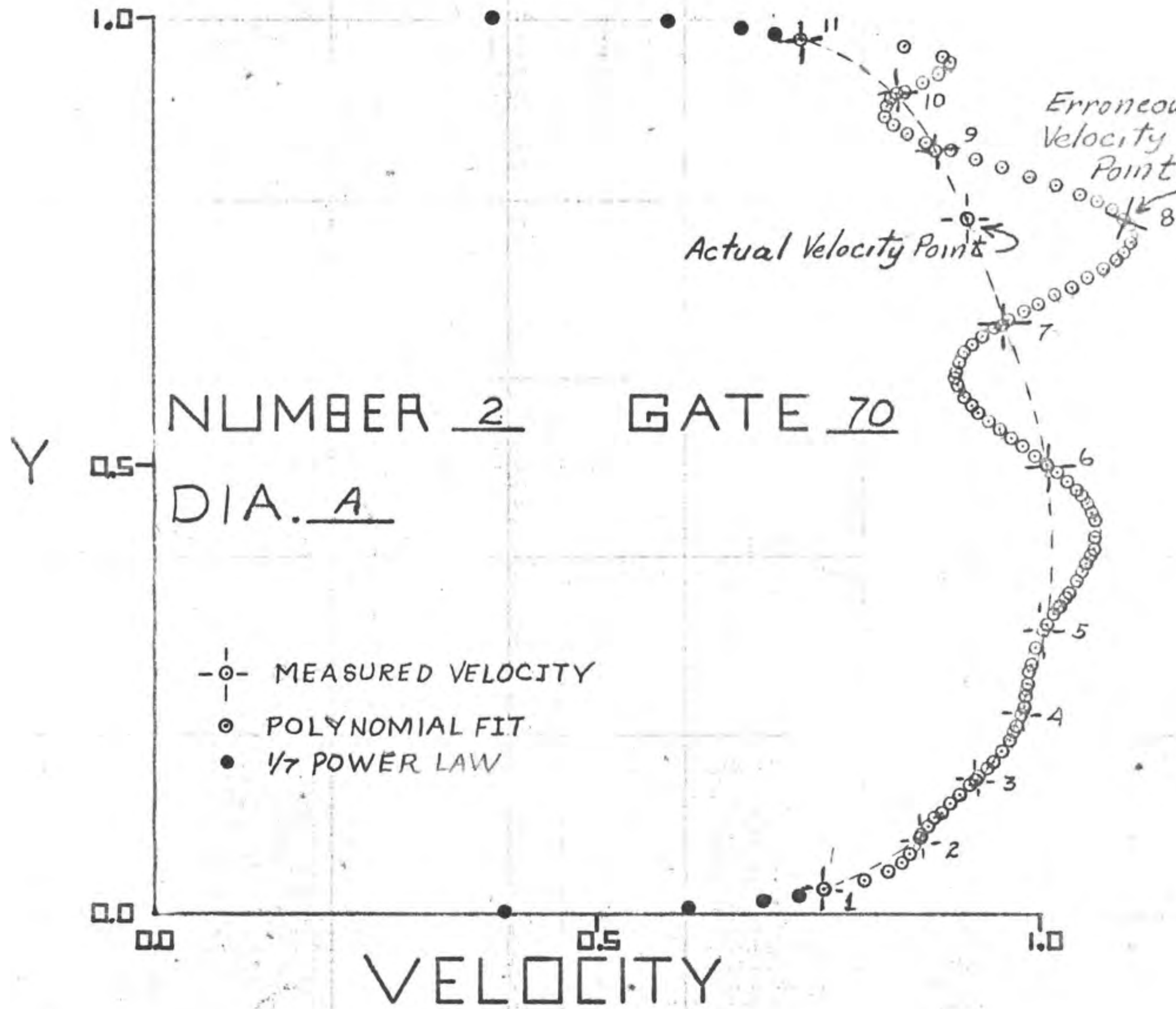

1.0
Y
0.5
0.0
NUMBER 1 GATE 80
DIA. B
MEASURED VELOCITY
POLYNOMIAL FIT
1/7 POWER LAW
0.0
0.5
1.0
VELOCITY

FIGURE 2



Y
VELOCITY
1.0
0.5
0.0
NUMBER 2 GATE 70
DIA. A
MEASURED VELOCITY
POLYNOMIAL FIT
1/7 POWER LAW
Erroneous Velocity Point
Actual Velocity Point
1
2
3
4
5
6
7
8
9
10
11

ADDENDUM

```
  0DIMENSION  UHIGHA(20), ULOWA(2C),DELHA(20),UHIGHB(20),ULOWB(20),
  1DELHB(20),PCA(20),PCB(2C),VCA(20),VCB(20),VUA(20),VUB(20),X(20),
  2TEMPX(20),VCAC(20),VCBC(20),VCACD(20),VCBCD(20),VCAD(20),VCBD(20),
  3Y(20),YD(20),VD(20),E(20,20),B(20,20), P(20),V(20),C(20),D1(20),
  4D2(20), A(20,20), Z(20), SUMP1(20),SUMP2(20),SUMP(20),R(2,200),
  5SUMV(2,100), CV(2,100)
 1 FORMAT (5F8.0, 4I4 )
81 FORMAT (10F8.C)
   READ IN DIFFERENCE TABLE FOR INTERPOLATION ON CALIBRATION CURVE
   DO 11 K=1,14
11 READ INPUT TAPE 5,1, V(K), C(K), D1(K), D2(K)
   READ INPUT TAPE 5,81, (P(N) , N = 1,11)
100 READ INPUT TAPE 5,1, AM, TD, D, G, STEM, NTRAV,NPT, MPRINT, MPUNCH
   AREA = .7854*D*D -1.25*(AM +(0.5*TD -STEM) *.0725 )
   DO 10 NJ= 1,NTRAV
   READ INPUT TAPE 5,2, SPG, GATE,KTRAV
 2 FORMAT (2F8.0, I8)
   WRITE OUTPUT TAPE 6,3, KTRAV
 3 FORMAT ( 15H1 TRAVERSE NO =, I4)
   WRITE OUTPUT TAPE 6,4
 40FORMAT ( 1H0,1X,6H POINT, 6X,6H UHIGH, 7X,5H ULOW, 7X,5H DELH,
  18X,3H VU, 5X, 8H P COEFF, 4X, 6H VCORR )
   IF (SPG -1.0)  21,22,21
21 TEMP = 2.0* G* ABSF(SPG-1.0)
   GO TO 23
22 TEMP = 2.0* G
23 DO 12  N= 1,NPT
   Z(N) = P(N) * TD
   READ INPUT TAPE 5,1, UHIGHA(N), ULOWA(N), UHIGHB(N), ULOWB(N)
   DELHA(N)= UHIGHA(N) - ULOWA(N)
   DELHB(N)= UHIGHB(N) - ULOWB(N)
   VUA(N) =  SQRTF(TEMP* DELHA(N))
   VUB(N) =  SQRTF(TEMP* DELHB(N))
   COMPUTE PITOMETER COEFFICIENT AND CORRECTED VELOCITY
   K=1
24 IF(V(K)- VUA(N))  25,26,27
25 K=K+1
   GO TO 24
26 PCA(N) = C(K)
   GO TO 28
27 S= (VUA(N) - V(K-1)) /2.0
   PCA (N) = C(K-1) + S*(D1(K-1) + (S-1.0)/2.0 * D2(K-1))
28 K=1
29 IF (V(K)- VUB(N)) 30,31,32
30 K=K+1
   GO TO 29
31 PCB(N) = C(K)
   GO TO 33
32 S= (VUB(N) -V(K-1)) /2.C
   PCB(N) = C(K-1) + S* (D1(K-1) +(S-1.0)/2.0 * D2(K-1))
33 VCA(N)= PCA(N) * VUA(N)
```

```
      VCB(N)= PCB(N) * VUB(N)
   12 CONTINUE
      WRITE OUTPUT TAPE 6,5
    5 FORMAT (24H0 TRAVERSE ON DIAMETER A)
      LC      = (NPT+1)/2
      DO 13  N= 1, NPT
      VCAD(N) = VCA(N) / VCA(LC)
   130WRITE OUTPUT TAPE 6,6,N,UHIGHA(N),ULOWA(N),DELHA(N), VUA(N),
     1PCA(N), VCA(N)
    60FORMAT (I6, 3X, F10.3, 2X, F10.3, 2X, F10.3, 2X, F10.3, 2X,
     1F10.3, 1X, F1C.3)
      WRITE OUTPUT TAPE 6,7
    7 FORMAT (24H0 TRAVERSE ON DIAMETER B)
      DO 14  N= 1, NPT
      VCBD(N) = VCB(N) / VCB(LC)
   140WRITE OUTPUT TAPE 6,6, N, UHIGHB(N), ULOWB(N),DELHB(N), VUB(N),
     1PCB(N), VCB(N)
      COMPUTE VELOCITY NEAR WALL AND AREA
      X(1)   =   .01
      X(2) = .20
      X(3) = .50
      X(4) = .75
      X(5) =1.00
      DO 15   I= 1,5
      TEMPX(I)= (X(I)**.1429)
      VCAC(I) =  VCA(1)* TEMPX(I)
      VCACD(I) = VCAC(I) / VCA(LC)
      VCBC(I) =  VCB(1)* TEMPX(I)
      VCBCD(I) = VCBC(I) / VCB(LC)
      Y(I) = X(I) * Z(1)
      YD(I) = Y(I) / TD
   15 CONTINUE
      DO 16   I = 6, 10
      M=  11 -  I
      VCAC(I) =VCA(NPT) * TEMPX(M)
      VCACD(I)= VCAC(I) /VCA(LC)
      VCBC(I) = VCB(NPT) * TEMPX(M)
      VCBCD(I) = VCBC(I) / VCB(LC)
      Y(I) = TD - X(M)* Z(1)
      YD(I) = Y(I) / TD
   16 CONTINUE
      TEMPA1 = .875*Z(1)*VCA(1)
      TEMPA2 = .875 *(TD -Z(NPT)) * VCA(NPT)
      TEMPB1 = .875*Z(1)* VCB(1)
      TEMPB2 = .875 *(TD -Z(NPT)) * VCB(NPT)
      IF (MPUNCH - 1 )  300, 301, 300
  300 ZERO = 0.0
      NSTOP = 8
      LIFT = 3
      DO 18 I = 1,4
   18 WRITE OUTPUT TAPE 7,9,       VCACD(I),YD(I)
    9 FORMAT      (2F8.3,  I4)
```

```
      DO 19  N = 1, NPT
   19 WRITE OUTPUT TAPE 7,9, VCAD(N), P(N)
      DO 20  I = 7,10
   20 WRITE OUTPUT TAPE 7,9,        VCACD(I), YD(I)
      WRITE OUTPUT TAPE 7, 9, ZERO, ZERO, LIFT
      WRITE OUTPUT TAPE 7,9, ZERO,ZERO, LIFT
      WRITE OUTPUT TAPE 7, 9, ZERO, ZERO, NSTOP
      DO 51  I= 1,4
   51 WRITE OUTPUT TAPE 7,9,        VCBCD(I), YD(I)
      DO 52  N = 1, NPT
   52 WRITE OUTPUT TAPE 7,9, VCBD(N), P(N)
      DO 53  I= 7,10
   53 WRITE OUTPUT TAPE 7,9,        VCBCD(I), YD(I)
      WRITE OUTPUT TAPE 7, 9, ZERO, ZERO, LIFT
      WRITE OUTPUT TAPE 7,9, ZERO,ZERO, LIFT
      WRITE OUTPUT TAPE 7, 9, ZERO, ZERO, NSTOP
  301 NCOL = NPT + 1
      FIT POLYNOMIAL TO VELOCITY POINTS BY GAUSS ELIMINATION
      DO 61  I = 1,NPT
      A(I,NCOL) =VCA(I)
      B(I,NCOL) =VCB(I)
      DO 61  J= 1,NPT
      A(I,J) = Z(I) ** (-J + NPT)
      B(I,J) = A(I,J)
   61 CONTINUE
      IF (MPRINT - 1)   200,201,200
  200 WRITE OUTPUT TAPE 6,151, (( A(I,J), J=1,NCOL ), I=1,NPT )
      WRITE OUTPUT TAPE 6,151, (( B(I,J), J=1,NCOL ), I=1,NPT )
  201 CONTINUE
  151 FORMAT ( 1HO, 23H MATRIX BEFORE SWEEPOUT //(12E10.3 ))
      NPTM1  = NPT-1
      DO 103  I = 1, NPTM1
      K= I+1
      DO 103  N = K, NPT
      IF (ABSF(A(I,I)) - ABSF(A(N,I))) 101 ,103, 103
  101 DO 102  J= 1, NCOL
      RT= A(I,J)
      R1=B(I,J)
      A(I,J) = A(N,J)
      B(I,J) = B(N,J)
      A(N,J) = RT
      B(N,J) = R1
  102 CONTINUE
  103 CONTINUE
      DO 63  IP = 1, NPT
      RA= A(IP,IP)
      RB= B(IP,IP)
      DO 64 J= IP, NCOL
      A(IP,J) = A(IP,J) /RA
   64 B(IP,J) = B(IP,J) /RB
      DO 63  I=1, NPT
      IF (I -IP)   66,63,66
```

```
 66 RA = A(I,IP)
    RB = B(I,IP)
    DO 67  J= IP, NCOL
    A(I,J) = A(I,J) - RA * A(IP,J)
 67 B(I,J) = B(I,J) - RB * B(IP,J)
 63 CONTINUE
    IF (MPRINT - 1)   202,203,202
202 WRITE OUTPUT TAPE 6,152, (( A(I,J), J=1,NCOL ), I=1,NPT )
    WRITE OUTPUT TAPE 6,152, (( B(I,J), J=1,NCOL ), I=1,NPT )
152 FORMAT ( 1H0, 22H MATRIX AFTER SWEEPOUT  //(12E10.3 ))
203 CONTINUE
    DO 68  J = 1, NPT
    E(1,J)= A(J,NCOL)
 68 E(2,J) = B(J, NCOL)
    PTN = NPT
    DO 70  I= 1,2
    SUMP1(I) = 0.C
    SUMP2(I) = 0.C
    DO 69  J= 1, NPT
    L=  J - 1
    VL =  L
    SUMP1(I) = SUMP1(I)+ E(I,J) * Z(1)**(-L+NPT) /(-VL+ PTN)
    SUMP2(I) = SUMP2(I)+ E(I,J) * Z(NPT)**(-L+NPT) /(-VL + PTN)
 69 CONTINUE
    SUMP(I) = SUMP2(I)- SUMP1(I)
 70 CONTINUE
    AB2  = SUMP(2) + TEMPB1 + TEMPB2
    AA2  = SUMP(1) + TEMPA1 + TEMPA2
    VELA = AA2 / TD
    VELB = AB2 / TD
    VAVGP=(VELA+ VELB) /2.0
    QP =  VAVGP * AREA
    PCOP = 2.0 * VAVGP /(VCA(LC) +VCB(LC))
    WRITE OUTPUT TAPE 6, 91
 91 FORMAT (1H0, 47H VELOCITY = SUM A(I) TIMES X TO THE (I)TH POWER )
    WRITE OUTPUT TAPE 6,92
 920FORMAT(1H0,3X,2H I,6X,23H TRAVERSE ON DIAMETER A, 5X, 23H TRAVERSE
   1 ON DIAMETER B)
    DO 73 J= 1,NPT
    IR = NPT -J
    WRITE OUTPUT TAPE 6, 93, IR, E(1,J) , E(2,J)
 93 FORMAT (2X,I4, 13X, 1PE16.7, 11X, 1PE16.7)
 73 CONTINUE
    WRITE OUTPUT TAPE 6, 94, AA2, VELA, AB2, VELB, PCOP, VAVGP, QP
 940FORMAT (1H0,1X, 7HAREAA =,F8.3,2X,11HVELOCITYA =, F8.3, 2X, 7HAREA
   1B =,F8.3, 2X, 11HVELOCITYB =,F8.3 // 1X, 18HPIPE COEFFICIENT =,
   2F8.3, 2X,14HAVG VELOCITY =, F8.3,2X,11HDISCHARGE =,F8.3 )
6010FORMAT (1H1,6X,54HDIMENSIONLESS DISTANCE AND VELOCITY FOR POLYNOMI
   1AL FIT / 6X,13HTRAVERSE NO =, I4,10HDIAMETER A)
6020FORMAT (1H1,6X,54HDIMENSIONLESS DISTANCE AND VELOCITY FOR POLYNOMI
   1AL FIT / 6X,13HTRAVERSE NO =, I4,10HDIAMETER B)
604 FORMAT(6X,8HDISTANCE,5X,8HVELOCITY,5X,8HDISTANCE,5X,8HVELOCITY)
```

```
      DO 704  M=1,2                                                  238
      IF (M-1)  612,611, 612                                         240
  611 WRITE OUTPUT TAPE 6,601, KTRAV                                 241
      GO TO 630                                                      242
  612 WRITE OUTPUT TAPE 6,602, KTRAV                                 243
  630 DO 701  J= 1,100                                               244
      IF (J-1)  621,620,621                                          245
  620 R(J) = P(1)                                                    246
      GO TO 623                                                      247
  621 R(J)= R(J-1) +(P(NPT)- P(1)) /100.0                            248
  623 ZP = R(J) * TC                                                 249
      SUMV(J) = 0.0                                                  250
      DO 701 N= 1, NPT                                               251
  624 SUMV(J) = SUMV(J) +E(M,N) *(ZP)** (NPT-N)                      253
  701 CONTINUE                                                       256
      DO 702  J = 1,100                                              257
      IF (M-1)  627,626,627                                          258
  626 DV(J) = SUMV(J) /VCA(LC)                                       259
      GO TO  702                                                     260
  627 DV(J) = SUMV(J) /VCB(LC)                                       261
  702 CONTINUE                                                       262
      WRITE OUTPUT TAPE 6, 604                                       263
      DO 703 J=1,50                                                  264
  703 WRITE OUTPUT TAPE 6,613, R(J), DV(J), R(J+50), DV(J+50)        265
  613 FORMAT (4(5X,F8.4))                                            266
      IF (MPUNCH -1)  628,629,628                                    267
  628 DO 705  J= 1,100                                               268
  705 WRITE OUTPUT TAPE 7,614, DV(J), R(J)                           269
  614 FORMAT (2F8.3, I4)                                             270
      WRITE OUTPUT TAPE 7, 614, ZERO,ZERO,LIFT                       271
      WRITE OUTPUT TAPE 7, 614, ZERO,ZERO,LIFT                       272
      WRITE OUTPUT TAPE 7, 614, ZERO,ZERO,NSTOP                      273
  629 CONTINUE                                                       274
  704 CONTINUE                                                       275
   10 CONTINUE                                                       160
      GO TO 100                                                      161
      END(1,0,0,0,0,0,1,0,0,0,0,0,0,C,0)
```

LIST OF INPUT VARIABLES
PITOMETER COMPUTER PROGRAM

Variable name	Definition
V	Theoretical velocity from pitometer coefficient curve.
C	Pitometer coefficient.
D1 or D2	First and second divided differences in forward difference table (pitometer calibration curve)
P(N)	Location of traverse point, N, as a decimal part of the traverse diameter.
AM	Projected area of the pitometer from orifices to constant area section of pitometer stem.
TD	Traverse diameter.
D	Average conduit diameter.
G	Acceleration of gravity
STEM	Distance from orifice tips to constant area section.
NTRAV	Number of traverses or number of discharges (one traverse consists of velocity measurements on two diameters, A and B).
NPT	Number of velocity points on traverse.
MPRINT	Control constant: if MPRINT $\neq$ 1, the matrix solved to fit the polynomial curve to the velocity points and the solution matrix will be printed.
MPUNCH	Control constant: if MPUNCH $\neq$ 1, the computed velocity profiles will be punched on binary coded decimal (BCD) cards for plotting on an x-y plotter.
SPG	Specific gravity of manometer liquid.

Variable name	Definition
GATE	Percent gate opening.
KTRAV	Traverse number.
UHIGHA and ULOWA	Readings of high and low side of manometer for traverse A.
UHIGHB and ULOWB	Readings of high and low side of manometer for traverse B.