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TAPE KEY

Tape 1	Source
Tape 2	Object

WATER HAMMER

by:

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QUEEN'S UNIVERSITY COMPUTING CENTRE

ONTARIO, CANADA

TITLE: WATER HAMMER

TYPE: CIVIL ENGINEERING

EQUIPMENT AFFECTED: IBM 1620, 20^k, TAPE, DIVIDE HARDWARE

SUBROUTINES USED: FLOATING POINT SUBROUTINES

PREPARED BY:

Dr. J. A. N. Lee

PROJECT NO.: 34

DATE: APRIL 1962

DISCLAIMER

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INTRODUCTION

Under steady conditions of flow, in a pipeline fed from a constant level reservoir controlled by a valve at a lower end, closure of the valve initiates a change in pressure which may give rise to "water-hammer" effects. This program performs a numerical step method of integration to compute the pressure developed at the valve (or gate) due to the closure of that gate. Only a single pipeline of uniform dimensions is considered. Friction in the system is ignored.

Mathematical Method

Whilst the exact mathematical treatment of the pressure changes in a conduit under the influence of instantaneous valve closure is well established, that for slow gate closure is only soluble by a numerical integration procedure. The method used in the program described herein assumes that the valve closes slowly, but in small instantaneous steps. When the valve closes instantly the velocity of the layer of water next to it must be reduced from some value V_o to zero. As a result an elastic pressure wave is transmitted toward the reservoir at a velocity of 'a' ft/sec. At the instant L/a seconds after valve closure, the velocity of flow is everywhere equal to zero while the pressure in the pipe is Δh_t above that in the reservoir at the same level. Water immediately tries to move from the high pressure area to the low pressure area so that an expansion wave proceeds towards the valve arriving there at time $2L/a$. If the gate has not closed further since the wave was initiated, another wave will travel to the reservoir and return this time reducing the head in the pipeline and at time $4L/a$ the conditions will be identical to those at the start (i.e. time $t = 0$).

If the valve had been closed slowly, in a time exceeding $2L/a$ seconds, the reflected expansion wave would have relieved the increasing pressure to some extent before the full theoretical Δh_t had built up. If a particular velocity change Δv occurs in a shorter time than $2L/a$ it causes the same pressure increment as an instantaneous velocity change of the same magnitude, namely $-\frac{a}{g}\Delta v$: if the velocity change occurs in a time exceeding $2L/a$ seconds the pressure increment is affected by the reflected elastic waves.

The following assumptions simplify the solution and have little effect on the results:

1. The pipe is assumed to be frictionless.

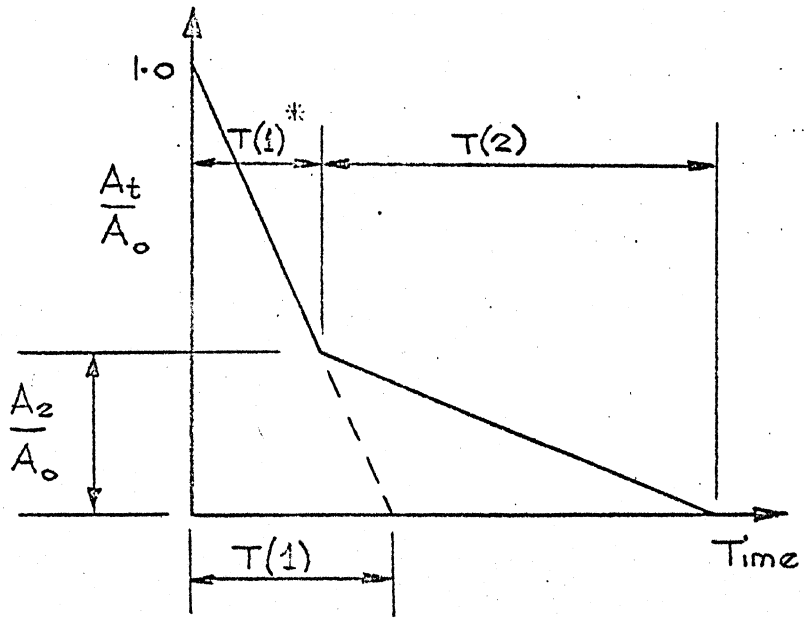
2. The coefficient of contraction for the resulting orifice as the valve (or gate) closes is unchanged so that the discharge at any time t may be defined as

$$Q_t = Q_o \frac{A_t}{A_o} \sqrt{\frac{H_t}{H_o}}$$

3. The gates are imagined to close in a number of instantaneous steps at time intervals of

$$\Delta_t = \frac{2L}{a} \text{ secs}$$

4. The ratio of gate opening to full opening may be expressed graphically by the form.



If h_{r_t} is the pressure increment of the wave generated $2L/a$ seconds previously, returning to the gate at some time t then the total head H_t may be written as

$$H_t = \sum_{t=0}^{n(2L/a)} (\Delta h_t + h_{r_t}) + H_o$$

Rewriting the equation for discharge at any time t as

$$H_t = H_o \left[\left(\frac{A_o}{A_t} \cdot \frac{Q_t}{Q_o} \right)^2 - 1 \right]$$

and assuming a trial value of Q_t, a trial value of H_t may be obtained. By successive computations another value of Q_t is calculated and compared with the original assumption. If the two agree within 0.1% the results are printed and the next step computed for time $(t + 2L/a)$. If there is no such agreement, the new value of Q_t is taken as a new trial value and the computations repeated.

It occasionally happens, that with exceptionally small gate openings, the accuracy of solution does not allow convergence to conform with the desired 0.1% accuracy. In this instance the operator is provided with a means of forced output.

Input Format

Input format is in a fixed point form using the record mark as the decimal point. Since the floating point subroutines use a 8 digit mantissa, it is pointless to input more than 8 digits. However, if the operator does exceed this figure, the program will truncate data to the desired level. Since the input area is filled with record marks before input is gated, an integer may be entered without definition of the decimal point. To aid the operation, all input is in numerical mode and consequently negative input data is unacceptable. All input data is expressed in feet - second - pound units. Prior to entry of the data a description of the required information is typed:

DISCHARGE	The initial steady state flow through the pipeline and valve in cusecs.
HEAD	The initial head at the gate (or valve) neglecting losses. Note that for large gates use the head at the centre line of the gate (ft).
C.S. AREA	The cross sectional area of the conduit (ft^2).

LENGTH — The length of the pipeline (ft).

VELOCITY — The velocity of wave propagation in the pipeline (ft/ sec). This quality will vary according to the elastic properties of the conduit and fluid. In general,

$$a = \sqrt{\frac{12}{\frac{w}{g}\left(\frac{1}{K} + \frac{D}{tE}\right)}}$$

where a is the velocity of the pressure wave in ft/ sec.

K is the bulk modulus of the fluid in lb/ in^2.

E is the Young's Modulus of the material of the pipe in lb/ in^2.

D is the internal diameter of the pipe in inches.

t is the wall thickness of the pipe in inches.

and w is the specific weight of the fluid.

T(1), RATIO, T(2) — Gate closure characteristics except that with See Fig. 1. SW3 ON T(1) is accepted as T(1)*.

Output

The output consists of eight columns of data without headings these are:

t (Secs)	Δht (ft)	Δv (ft/ sec)	hrt (ft)	Ht (ft)	Gate Opening (--)	Vt (ft/ sec)	Qt (cusecs)

All output is in fixed point notation and requires a minimum 11" wide sheet.

OPERATING PROCEDURE

1. Clear Memory R/I 160001000000 R/S.
   Wait 3 seconds, depress Instant Stop.
2. Load the program tape in the photo reader, and
   R/I 36000000300 R/S.
   The tape will be read into the 1620 and eventually computation will halt.
3. Depress START.
   The computer will type:
   WATER HAMMER
   DISCHARGE

and gate type-in. Enter the data in fixed point notation using the record mark as a decimal point. Depress RELEASE & START after entry. An echo will be typed out in the same format followed by the next request for data. Note that at the instant where T(1) is requested SW3 should be set to indicate actually whether T(1) or T(1)* has been typed in

SW3	ENTRY
ON	T(1)*
OFF	T(1)

Errors in typing may be corrected before RELEASE & START have been depressed by putting SW4 ON first and then releasing this information. If an error is detected only after release to the computer depress RESET, INSERT, RELEASE & START to recommence the program. Note that a zero entry is merely RELEASE/START.

4. Immediately after the entry and echo of the last piece of input data, five carriage returns will occur followed by the first line of output data. At approximately 12 second intervals this procedure will be repeated.
5. To terminate computation at any time put SW1 ON and the computer will halt after the next line of type-out. Depress START to return to Step 3.

6. With very small gate openings, convergence to a satisfactory degree may not be reached. After a period of at least 30 seconds, put SW 2 ON to force output. As soon as the output commences, put SW 2 OFF so as to not force output on the next time step.

HASH TOTALS

SOURSE TAPE 72969.28941.91479.85604
OBJECT TAPE 59560.10747.71397.16064

```
*  WATER HAMMER
00020        DC    10,0,                          02187 00010   0000000000
*  FIXED POINT OUTPUT ROUTINE
00040TYPED   TF    FIXED-8,ZERO,                  02188 26 02929 19120
00050        TF    FIXED+2,ZERO,                  02200 26 02939 19120
00060        SF    SF+10,                         02212 32 02330 00000
00070        AM    SF+9,50,10                     02224 11 02329 00050
00080        TF    *+23,SF+9,                     02236 26 02259 02329
00090        CM    TYPED-9,60,10,                 02248 14 02179 00060
00100        BH    FLPT,                          02260 46 02982 01100
00110        AM    SF+11,50,10                    02272 11 02331 00050
00120        TF    *+23,SF+11,                    02284 26 02307 02331
00130        CM    TYPED-9,48,10,                 02296 14 02179 00048
00140        BL    TEST,                          02308 47 02612 01300
00150SF      SF    TYPED-8,                       02320 32 02180 00000
00160        TFM   *+30,FIXED+50,                 02332 16 02362 02987
00170        S     *+18,TYPED-9,                  02344 22 02362 02179
00180        TF    ,TYPED-1,                      02356 26 00000 02187
00190SET     TFM   N,17,10,                       02368 16 02555 00017
00200        TFM   M,0,10,                        02380 16 02867 00000
00210        TFM   *+35,FIXED,                    02392 16 02427 02937
00220        S     *+23,N,                        02404 22 02427 02555
00230BRD     BD    DI,,0,                         02416 43 02484 00000
00240        BNF   DI,BRD,                        02428 44 02484 02416
00250        TFM   *+30,OUTPUT,                   02440 16 02470 02941
00260        A     *+18,M,                        02452 21 02470 02867
00270        TFM   ,0,10,                         02464 16 00000 00000
00280        B     N8,                            02476 49 02556 00000
00290        DORG  *-3,                           02484
00300DI      TF    *+23,BRD+11,                   02484 26 02507 02427
00310        TD    *+47,,                         02496 25 02543 00000
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00320          TFM   *+30,OUTPUT,                02508 16 02538 02941
00330          A     *+18,M,                     02520 21 02538 02867
00340          TFM   ,70,10,                     02532 16 00000 00070
00350          CF    BRD,,                       02544 33 02416 00000
00360N8        CM    N,8,10,                     02556 14 02555 00008
00370          BE    DECI,                       02568 46 02644 01200
00380          SM    N,1,10,                     02580 12 02555 00001
00390          AM    M,2,10,                     02592 11 02867 00002
00400          B     BRD-24,,                    02604 49 02392 00000
00410          DORG  *-3,                        02612
00420TEST      TF    TYPED-1,ZERO,               02612 26 02187 19120
00430          TDM   TYPED-10,-5,                02624 15 02178 00005
00440          B     SF,,                        02636 49 02320 00000
00450          DORG  *-3,                        02644
00460DECI      TFM   *+30,OUTPUT+22,             02644 16 02674 02963
00470          TFM   *+23,FIXED-7,               02656 16 02679 02930
00480          TD    ,,                          02668 25 00000 00000
00490          CM    *-1,FIXED+2,                02680 14 02679 02939
00500          BE    *+44,                       02692 46 02736 01200
00510          AM    *-25,1,                     02704 11 02679 00001
00520          AM    *-42,2,                     02716 11 02674 00002
00530          B     *-60,                       02728 49 02668 00000
00540          DORG  *-3,                        02736
00550          MM    SF+9,-2,10,                 02736 13 02329 00002
00560          SF    98,                         02748 32 00098 00000
00570          TFM   M1+6,OUTPUT+20,             02760 16 02874 02961
00580          A     M1+6,99,                    02772 21 02874 00099
00590          SM    SF+11,50,10,                02784 12 02331 00050
00600          MM    SF+11,-2,10,                02796 13 02331 00002
00610          SF    98,                         02808 32 00098 00000
00620          TFM   *+30,OUTPUT+22,             02820 16 02850 02963
00630          A     *+18,99,                    02832 21 02850 00099
00640          TD    ,400,                       02844 25 00000 00400
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00650          SF    BRD,                                  02856 32 02416 00000
00660M1        WATY  ,,                                    02868 39 00000 00100
00670          BNF   *+26,TYPED-1,                         02880 44 02906 02187
00680          WATY  MINUS,,                               02892 39 03153 00100
00690          BB                                          02904 42 00000 00000
00700          DORG  *-9,                                  02906
00710          SPTY                                        02906 34 00000 00101
00720          BB                                          02918 42 00000 00000
00730          DORG  *-9,                                  02920
00740FIXED     DC    18,0,                                 02937 00018   Ø000000000000000000
00750          DC    2,0,                                  02939 00002   Ø0
00760OUTPUT    DAC   21,          .000000000@              02941 00021X2           .000000000‡
00770N         DC    2,0,N8-1,                             02555 00002   Ø0
00780M         DC    2,0,M1-1,                             02867 00002   Ø0
*  FLOATING POINT OUTPUT ROUTINE
*  EXPONENT GREATER THAN 10
00810FLPT      BNF   *+36,TYPED-1,                         02982 44 03018 02187
00820          WATY  MINUS,                                02994 39 03153 00100
00830          B     *+24,                                 03006 49 03030 00000
00840          SPTY                                        03018 34 00000 00101
00850          CF    TYPED-1,                              03030 33 02187 00000
00860          TD    *-1,TYPED-8,                          03042 25 03041 02180
00870          TD    TYPED-8,400,                          03054 25 02180 00400
00880          CF    TYPED-10,                             03066 33 02178 00000
00890          WNTY  TYPED-10,                             03078 38 02178 00100
00900          WATY  DECPT,,                               03090 39 03157 00100
00910          TD    TYPED-8,FLPT+59,                      03102 25 02180 03041
00920          TD    TYPED,400,                            03114 25 02188 00400
00930          WNTY  TYPED-8,                              03126 38 02180 00100
00940          TDM   TYPED,2,                              03138 15 02188 00002
00950          BB                                          03150 42 00000 00000
00960          DORG  *-9,                                  03152
00970MINUS     DAC   2,-@                                  03153 00002X2 -‡
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00980DECPT  DAC  2,.@                                  03157 00002X2 .‡
*  FIXED POINT INPUT ROUTINE
01000IN     DAS  10,                                  03161 00010X2
01010EX50   DS   10,                                  03189 00010
01020ALPHA  DAC  10,DISCHARGE@                        03191 00010X2 DISCHARGE‡
01030       DAC  10,HEAD      @                       03211 00010X2 HEAD      ‡
01040       DAC  10,C.S.AREA  @                       03231 00010X2 C.S.AREA  ‡
01050       DAC  10,LENGTH    @                       03251 00010X2 LENGTH    ‡
01060       DAC  10,VELOCITY  @                       03271 00010X2 VELOCITY  ‡
01070       DAC  10,T(1)      @                       03291 00010X2 T(1)      ‡
01080       DAC  10,RATIO     @                       03311 00010X2 RATIO     ‡
01090       DAC  10,T(2)      @                       03331 00010X2 T(2)      ‡
01100       DC   5,0,                                 03354 00005   00000
01110READ   TFM  N,0,10,                              03356 16 02555 00000
01120       TFM  *+30,IN,                             03368 16 03398 03161
01130       A    *+18,N,                              03380 21 03398 02555
01140       TD   ,400,                                03392 25 00000 00400
01150       CM   N,19,10,                             03404 14 02555 00019
01160       BE   *+32,                                03416 46 03448 01200
01170       AM   N,1,10,                              03428 11 02555 00001
01180       B    *-72,                                03440 49 03368 00000
01190       DORG *-3,                                 03448
01200       TF   EX50,READ-1,                         03448 26 03189 03355
01210       SM   EX50,18000,                          03460 12 03189 18000
01220       MM   EX50,2,10,                           03472 13 03189 00002
01230       SF   95,                                  03484 32 00095 00000
01240       RCTY                                      03496 34 00000 00102
01250       TFM  *+30,ALPHA,                          03508 16 03538 03191
01260       A    *+18,99,                             03520 21 03538 00099
01270       WATY                                      03532 39 00000 00100
01280       TBTY                                      03544 34 00000 00108
01290       RNTY IN,                                  03556 36 03161 00100
01300       BC4  READ,                                03568 46 03356 00400
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01310          TFM   N,1,10,                    03580 16 02555 00001
01320          BNR   BNR-24,iN,                 03592 45 03636 03161
01330          BNR   LESS,iN+1,                 03604 45 03970 03162
01340          TF    EX50,ZERO,                 03616 26 03189 19120
01350          B     STORE-12,                  03628 49 03912 00000
01360          DORG  *-3,                       03636
01370          TFM   *+35,iN,                   03636 16 03671 03161
01380          A     *+23,N,                    03648 21 03671 02555
01390BNR       BNR   AD1,                       03660 45 03950 00000
01400          TFM   EX50-8,50,10,              03672 16 03181 00050
01410          A     EX50-8,N,                  03684 21 03181 02555
01420          SF    iN,                        03696 32 03161 00000
01430          TF    M,N,                       03708 26 02867 02555
01440          AM    N,1,10,                    03720 11 02555 00001
01450          TFM   *+35,iN,                   03732 16 03767 03161
01460          A     *+23,N,                    03744 21 03767 02555
01470          BNR   *-36,,                     03756 45 03720 00000
01480          TFM   *+30,iN,                   03768 16 03798 03161
01490          A     *+18,N,                    03780 21 03798 02555
01500          TDM   ,0,                        03792 15 00000 00000
01510          CM    N,8,10,                    03804 14 02555 00008
01520          BL    *-96,                      03816 47 03720 01300
01530          TFM   *+54,iN,                   03828 16 03882 03161
01540          TFM   *+47,iN+1,                 03840 16 03887 03162
01550          A     *+30,M,                    03852 21 03882 02867
01560          A     *+23,M,                    03864 21 03887 02867
01570          TR    ,,                         03876 31 00000 00000
01580          TF    EX50,iN+7,                 03888 26 03189 03168
01590          CF    EX50-7,                    03900 33 03182 00000
01600          TF    *+18,READ-1,               03912 26 03930 03355
01610STORE     TF    ,EX50,                     03924 26 00000 03189
01620          TBTY                             03936 34 00000 00108
01630          BB                               03948 42 00000 00000
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01640          DORG *-9,                                  03950
01650AD1       AM   N,1,10,                               03950 11 02555 00001
01660          B    BNR-24,                               03962 49 03636 00000
01670          DORG *-3,                                  03970
01680LESS      TFM  N,0,10,                               03970 16 02555 00000
01690          TR   iN,iN+1,                              03982 31 03161 03162
01700          TFM  *+35,iN,                              03994 16 04029 03161
01710          A    *+23,N,                               04006 21 04029 02555
01720          BD   *+32,,                                04018 43 04050 00000
01730          AM   N,1,10,                               04030 11 02555 00001
01740          B    *-60,                                 04042 49 03982 00000
01750          DORG *-3,                                  04050
01760          TFM  EX50-8,50,10,                         04050 16 03181 00050
01770          S    EX50-8,N,                             04062 22 03181 02555
01780          TFM  N,0,10,                               04074 16 02555 00000
01790          AM   N,1,10,                               04086 11 02555 00001
01800          TFM  *+35,iN,                              04098 16 04133 03161
01810          A    *+23,N,                               04110 21 04133 02555
01820          BNR  *-36,                                 04122 45 04086 00000
01830          CM   N,9,10,                               04134 14 02555 00009
01840          BE   *+56,                                 04146 46 04202 01200
01850          TFM  *+30,iN,                              04158 16 04188 03161
01860          A    *+18,N,                               04170 21 04188 02555
01870          TDM  ,0,                                   04182 15 00000 00000
01880          B    *-108,                                04194 49 04086 00000
01890          DORG *-3,                                  04202
01900          SF   iN,                                   04202 32 03161 00000
01910          B    STORE-36,                             04214 49 03888 00000
01920          DORG *-3,                                  04222
01930ACC       DC   10,0,19160                            19160 00010    0000000000
01940SPEC      DC   10,0,                                 04231 00010    0000000000
01950ZERO      DC   10,0,19120,                           19120 00010    0000000000
01960ONE       DC   10,5110000000,19130,                  19130 00010    5110000000
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```
01970TEN     DC    10,5210000000,19140,
01980PI      DC    10,5131415926,19150,
01990DIGIT   DC    1,0,
02000IRA     DC    5,0,
02010HEAD    DAC   13,WATER HAMMER@
02020        RCTY
02030        WATY  HEAD,
02040A09000  TFM   WB1,00000,
02050A09010  TFM   WD1,00010,
02060A09020  TFM   WL1,00070,
02070A09030  TFM   *+35,18000,
02080        A     *+23,WB1,
02090        BTM   READ,
02100        TF    *+25,*-1,
02110        TFM   SF+11,703,811,
02120        BT    TYPED,
02130A09040  A     WB1,WD1,
02140        C     WL1,WB1,
02150        BL    *+20,
02160        B     A09030,
02170        DORG  *-3,
02180A09050  TFM   WB1,00000,
02190A09060  TFM   WL1,00200,
02200A09070  TFM   WB2,00000,
02210A09080  TFM   WD2,00010,
02220A09090  TFM   WL2,00030,
02230A09100  RCTY
02240        RCTY
02250        RCTY
02260        RCTY
02270        RCTY
02280        BCR   A10780,
02290A09110  TF    ACC,19120,
```

```
19140 00010   5210000000
19150 00010   5131415926
04232 00001   0
04237 00005   00000
04239 00013X2 WATER HAMMER‡
04264 34 00000 00102
04276 39 04239 00100
04288 16 09240 00000
04300 16 09245 00010
04312 16 09250 00070
04324 16 04359 18000
04336 21 04359 09240
04348 17 03356 00000
04360 26 04395 04359
04372 16 02331 00703
04384 27 02188 00000
04396 21 09240 09245
04408 24 09250 09240
04420 47 04440 01300
04432 49 04324 00000
04440
04440 16 09240 00000
04452 16 09250 00200
04464 16 09255 00000
04476 16 09260 00010
04488 16 09265 00030
04500 34 00000 00102
04512 34 00000 00102
04524 34 00000 00102
04536 34 00000 00102
04548 34 00000 00102
04560 46 09024 00300
04572 26 19160 19120
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```
02300A09120 TFM  *+30,18100,          04584 16 04614 T8100
02310       A    *+18,WB1,            04596 21 04614 09240
02320       TF   ,ACC,                04608 26 00000 19160
02330A09130 A    WB1,WD1,             04620 21 09240 09245
02340       C    WL1,WB1,             04632 24 09250 09240
02350       BL   *+20,                04644 47 04664 01300
02360       B    A09120,              04656 49 04584 00000
02370       DORG *-3,                 04664
02380A09140 TFM  WL1,00030,           04664 16 09250 00030
02390A09150 TFM  WB1,00000,           04676 16 09240 00000
02400A09160 TFM  *+30,18900,          04688 16 04718 T8900
02410       A    *+18,WB1,            04700 21 04718 09240
02420       TF   ,ACC,                04712 26 00000 19160
02430A09170 A    WB1,WD1,             04724 21 09240 09245
02440       C    WL1,WB1,             04736 24 09250 09240
02450       BL   *+20,                04748 47 04768 01300
02460       B    A09160,              04760 49 04688 00000
02470       DORG *-3,                 04768
02480A09180 TF   ACC,18010,           04768 26 19160 18010
02490A09190 TF   18940,ACC,           04780 26 18940 19160
02500A09200 TF   ACC,19130,           04792 26 19160 19130
02510A09210 TF   18950,ACC,           04804 26 18950 19160
02520A09220 TF   ACC,18000,           04816 26 1960  18000
02530A09230 TF   18970,ACC,           04828 26 18970 19160
02540A09240 TF   18350,ACC,           04840 26 18350 19160
02550A09250 FD   ACC,18020,           04852 16 00469 04887
                                      04864 26 01260 19160
                                      04876 49 01422 T8020
02560       TF   ACC,99,              04888 26 19160 00099
02570A09260 TF   18340,ACC,           04900 26 18340 19160
02580A09270 TF   18960,ACC,           04912 26 18960 19160
02590A09280 TF   ACC,18030,           04924 26 19160 18030
02600A09290 FD   ACC,18040,           04936 16 00469 04971
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                                                    04948 26 01260 19160
                                                    04960 49 01422 T8040
02610           TF    ACC,99,                       04972 26 19160 00099
02620A09300     FD    ACC,17960,                    04984 16 00469 D5019
                                                    04996 26 01260 19160
                                                    05008 49 01422 T7960
02630           TF    ACC,99,                       05020 26 19160 00099
02640A09310     TF    18360,ACC,                    05032 26 18360 19160
02650A09320     TF    ACC,ZERO,                     05044 26 19160 19120
02660           S     ACC,18050,                    05056 22 19160 18050
02670A09330     FM    ACC,18060,                    05068 16 00469 D5103
                                                    05080 26 01260 19160
                                                    05092 49 01262 T8060
02680           TF    ACC,99,                       05104 26 19160 00099
02690A09340     FA    ACC,18050,                    05116 16 00469 D5151
                                                    05128 16 00445 T9160
                                                    05140 49 00422 T8050
02700A09350     TF    18390,ACC,                    05152 26 18390 19160
02710A09360     TF    ACC,17990,                    05164 26 19160 17990
02720A09370     FD    ACC,18040,                    05176 16 00469 D5211
                                                    05188 26 01260 19160
                                                    05200 49 01422 T8040
02730           TF    ACC,99,                       05212 26 19160 00099
02740A09380     TF    18320,ACC,                    05224 26 18320 19160
02750A09390     B     A10690,                       05236 49 08820 00000
02760           DORG  *-3,                          05244
02770A09400     TF    ACC,18900,                    05244 26 19160 18900
02780A09410     FA    ACC,18360,                    05256 16 00469 D5291
                                                    05268 16 00445 T9160
                                                    05280 49 00422 T8360
02790A09420     TF    18900,ACC,                    05292 26 18900 19160
02800A09430     FS    ACC,18390,                    05304 16 00469 D5339
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                                                05328 49 00402 T8390
02810A09440 C     ACC,ZERO                      05340 24 19160 19120
02820       BNN   A10030                        05352 46 07244 01300
02830A09450 TF    ACC,ZERO,                     05364 26 19160 19120
02840       S     ACC,18360,                    05376 22 19160 18360
02850A09460 FD    ACC,18050,                    05388 16 00469 D5423
                                                05400 26 01260 19160
                                                05412 49 01422 T8050
02860       TF    ACC,99,                       05424 26 19160 00099
02870A09470 FA    ACC,18950,                    05436 16 00469 D5471
                                                05448 16 00445 T9160
                                                05460 49 00422 T8950
02880A09480 TF    18950,ACC,                    05472 26 18950 19160
02890A09490 TF    ACC,ZERO,                     05484 26 19160 19120
02900       S     ACC,18360,                    05496 22 19160 18360
02910A09500 FD    ACC,18050,                    05508 16 00469 D5543
                                                05520 26 01260 19160
                                                05532 49 01422 T8050
02920       TF    ACC,99,                       05544 26 19160 00099
02930A09510 FM    ACC,18000,                    05556 16 00469 D5591
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                                                05580 49 01262 T8000
02940       TF    ACC,99,                       05592 26 19160 00099
02950A09520 FA    ACC,18350,                    05604 16 00469 D5639
                                                05616 16 00445 T9160
                                                05628 49 00422 T8350
02960A09530 TF    18370,ACC,                    05640 26 18370 19160
02970A09540 TF    ACC,18370,                    05652 26 19160 18370
02980A09550 FD    ACC,18950,                    05664 16 00469 D5699
                                                05676 26 01260 19160
                                                05688 49 01422 T8950
02990       TF    ACC,99,                       05700 26 19160 00099
03000A09560 FD    ACC,18000,                    05712 16 00469 D5747
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			05736 49 01422 T8000
03010	TF	ACC,99,	05748 26 19160 00099
03020A09570	FM	ACC,19160,	05760 16 00469 05795
			05772 26 01260 19160
			05784 49 01262 T9160
03030	TF	ACC,99,	05796 26 19160 00099
03040A09580	FS	ACC,19130,	05808 16 00469 05843
			05820 16 00445 T9160
			05832 49 00402 T9130
03050A09590	FM	ACC,18010,	05844 16 00469 05879
			05856 26 01260 19160
			05868 49 01262 T8010
03060	TF	ACC,99,	05880 26 19160 00099
03070A09600	TF	18400,ACC,	05892 26 18400 19160
03080A09610	FS	ACC,18300,	05904 16 00469 05939
			05916 16 00445 T9160
			05928 49 00402 T8300
03090A09620	TF	18310,ACC,	05940 26 18310 19160
03100A09630	TF	ACC,ZERO,	05952 26 19160 19120
03110	TFM	*+35,18200,	05964 16 05999 T8200
03120	A	*+23,WB2,	05976 21 05999 09255
03130	S	ACC,00000,	05988 22 19160 00000
03140A09640	FM	ACC,17960,	06000 16 00469 06035
			06012 26 01260 19160
			06024 49 01262 T7960
03150	TF	ACC,99,	06036 26 19160 00099
03160A09650	TFM	*+59,18100,	06048 16 06107 T8100
03170	A	*+47,WB2,	06060 21 06107 09255
03180	FS	ACC,	06072 16 00469 06107
			06084 16 00445 T9160
			06096 49 00402 00000
03190A09660	TF	18930,ACC,	06108 26 18930 19160

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03210       S    ACC,18930,                   06132 22 19160 18930
03220A09680 FA   ACC,18310,                   06144 16 00469 T6179
                                              06156 16 00445 T9160
                                              06168 49 00422 T8310
03230A09690 TF   18910,ACC,                   06180 26 18910 19160
03240A09700 TF   ACC,ZERO,                    06192 26 19160 19120
03250       S    ACC,18910,                   06204 22 19160 18910
03260A09710 FM   ACC,18320,                   06216 16 00469 T6251
                                              06228 26 01260 19160
                                              06240 49 01262 T8320
03270       TF   ACC,99,                      06252 26 19160 00099
03280A09720 TF   18920,ACC,                   06264 26 18920 19160
03290A09730 FA   ACC,18340,                   06276 16 00469 T6311
                                              06288 16 00445 T9160
                                              06300 49 00422 T8340
03300A09740 TF   18960,ACC,                   06312 26 18960 19160
03310A09750 FM   ACC,18020,                   06324 16 00469 T6359
                                              06336 26 01260 19160
                                              06348 49 01262 T8020
03320       TF   ACC,99,                      06360 26 19160 00099
03330A09760 TF   18380,ACC,                   06372 26 18380 19160
03340A09770 FS   ACC,18370,                   06384 16 00469 T6419
                                              06396 16 00445 T9160
                                              06408 49 00402 T8370
03350A09780 TF   17980,ACC,                   06420 26 17980 19160
03360A09790 TF   ACC,17980,                   06432 26 19160 17980
03370       CF   ACC,                         06444 33 19160 00000
03380A09800 FM   ACC,17950,                   06456 16 00469 T6491
                                              06468 26 01260 19160
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03390       TF   ACC,99,                      06492 26 19160 00099
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03600A09910     FM      ACC,18370,                  06936 16 00469 D6971
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03610           TF      ACC,99,                     06972 26 19160 00099
03620A09920     TF      18500,ACC,                  06984 26 18500 19160
03630A09930     FM      ACC,18370,                  06996 16 00469 D7031
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03640           TF      ACC,99,                     07032 26 19160 00099
03650A09940     TF      17980,ACC,                  07044 26 17980 19160
03660A09950     TF      ACC,ZERO,                   07056 26 19160 19120
03670           S       ACC,17980,                  07068 22 19160 17980
03680A09960     FA      ACC,18380,                  07080 16 00469 D7115
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                                                    07104 49 00422 T8380
03690A09970     TF      18510,ACC,                  07116 26 18510 19160
03700A09980     TF      ACC,19130,                  07128 26 19160 19130
03710A09990     FS      ACC,18500,                  07140 16 00469 D7175
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                                                    07164 49 00402 T8500
03720A10000     FD      18510,ACC,                  07176 16 00469 D7211
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                                                    07200 49 01422 T9160
03730           TF      ACC,99,                     07212 26 19160 00099
03740A10010     TF      18370,ACC,                  07224 26 18370 19160
03750A10020     B       A09540,                     07236 49 05652 00000
03760           DORG    *-3,                        07244
03770A10030     FS      ACC,18070,                  07244 16 00469 D7279
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03780A10040     C       ACC,ZERO                    07280 24 19160 19120
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03790          BE    A10240,                    07292 46 07848 01200
03800A10050    C     ACC,ZERO                   07304 24 9160  19120
03810          BNN   A10480                     07316 46 08432 01300
03820A10060    TF    ACC,18070,                 07328 26 19160 18070
03830A10070    FS    ACC,18900,                 07340 16 00469 07375
                                                07352 16 00445 T9160
                                                07364 49 00402 T8900
03840A10080    FA    ACC,18390,                 07376 16 00469 07411
                                                07388 16 00445 T9160
                                                07400 49 00422 T8390
03850A10090    FD    ACC,18070,                 07412 16 00469 07447
                                                07424 26 01260 19160
                                                07436 49 01422 T8070
03860          TF    ACC,99,                    07448 26 19160 00099
03870A10100    FM    ACC,18060,                 07460 16 00469 07495
                                                07472 26 01260 19160
                                                07484 49 01262 T8060
03880          TF    ACC,99,                    07496 26 19160 00099
03890A10110    TF    18950,ACC,                 07508 26 18950 19160
03900A10120    TF    ACC,18900,                 07520 26 19160 18900
03910A10130    FS    ACC,18390,                 07532 16 00469 07567
                                                07544 16 00445 T9160
                                                07556 49 00402 T8390
03920A10140    FS    ACC,18360,                 07568 16 00469 07603
                                                07580 16 00445 T9160
                                                07592 49 00402 T8360
03930A10150    C     ACC,ZERO                   07604 24 19160 19120
03940          BNP   A10180,                    07616 47 07660 01100
03950A10160    TF    ACC,ZERO,                  07628 26 19160 19120
03960          S     ACC,18360,                 07640 22 19160 18360
03970A10170    B     A10190,                    07652 49 07696 00000
03980          DORG  *-3,                       07660
03990A10180    FA    ACC,18360,                 07660 16 00469 07695
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                                                    06516 16 00445 T9160
                                                    06528 49 00402 T8380
03410           C     ACC,ZERO,                     06540 24 19160 19120
03420           BNP   A10540,                       06552 47 08536 01100
03430           BC2   A10540,                       06564 46 08536 00200
03440A09830     TF    ACC,ZERO,                     06576 26 19160 19120
03450           S     ACC,17960,                    06588 22 01960 17960
03460A09840     FM    ACC,18020,                    06600 16 00469 06635
                                                    06612 26 01260 19160
                                                    06624 49 01262 T8020
03470           TF    ACC,99,                       06636 26 19160 00099
03480A09850     FM    ACC,18320,                    06648 16 00469 06683
                                                    06660 26 01260 19160
                                                    06672 49 01262 T8320
03490           TF    ACC,99,                       06684 26 19160 00099
03500A09860     FM    ACC,18010,                    06696 16 00469 06731
                                                    06708 26 01260 19160
                                                    06720 49 01262 T8010
03510           TF    ACC,99,                       06732 26 19160 00099
03520A09870     FD    ACC,18950,                    06744 16 00469 06779
                                                    06756 26 01260 19160
                                                    06768 49 01422 T8950
03530           TF    ACC,99,                       06780 26 19160 00099
03540A09880     FD    ACC,18950,                    06792 16 00469 06827
                                                    06804 26 01260 19160
                                                    06816 49 01422 T8950
03550           TF    ACC,99,                       06828 26 19160 00099
03560A09890     FD    ACC,18000,                    06840 16 00469 06875
                                                    06852 26 01260 19160
                                                    06864 49 01422 T8000
03570           TF    ACC,99,                       06876 26 19160 00099
03580A09900     FD    ACC,18000,                    06888 16 00469 06923
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                                                    07672 16 00445 T9160
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04000A10190 FD   ACC,18070,                         07696 16 00469 D7731
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                                                    07720 49 01422 T8070
04010       TF   ACC,99,                            07732 26 19160 00099
04020A10200 FM   ACC,18350,                         07744 16 00469 D7779
                                                    07756 26 01260 19160
                                                    07768 49 01262 T8350
04030       TF   ACC,99,                            07780 26 19160 00099
04040A10210 FA   ACC,18350,                         07792 16 00469 D7827
                                                    07804 16 00445 T9160
                                                    07816 49 00422 T8350
04050A10220 TF   18370,ACC,                         07828 26 18370 19160
04060A10230 B    A09540,                            07840 49 05652 00000
04070       DORG *-3,                               07848
04080A10240 TF   ACC,ZERO,                          07848 26 19160 19120
04090       S    ACC,18340,                         07860 22 19160 18340
04100A10250 TF   18920,ACC,                         07872 26 18920 19160
04110A10260 TF   ACC,ZERO,                          07884 26 19160 19120
04120       S    ACC,18920,                         07896 22 19160 18920
04130A10270 FD   ACC,18320,                         07908 16 00469 D7943
                                                    07920 26 01260 19160
                                                    07932 49 01422 T8320
04140       TF   ACC,99,                            07944 26 19160 00099
04150A10280 TF   18910,ACC,                         07956 26 18910 19160
04160A10290 TF   ACC,19120,                         07968 26 19160 19120
04170A10300 TF   18950,ACC,                         07980 26 18950 19160
04180A10310 TF   18960,ACC,                         07992 26 18960 19160
04190A10320 TF   18970,ACC,                         08004 26 18970 19160
04200A10330 TF   18340,ACC,                         08016 26 18340 19160
04210A10340 TF   18350,ACC,                         08028 26 18350 19160
04220A10350 TF   ACC,ZERO,                          08040 26 19160 19120
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04230          TFM   *+35,18200,                08052 16 08087 T8200
04240          A     *+23,WB2,                  08064 21 08087 09255
04250          S     ACC,00000,                 08076 22 19160 00000
04260A10360    FM    ACC,17960,                 08088 16 00469 08123
                                                08100 26 01260 19160
                                                08112 49 01262 T7960
04270          TF    ACC,99,                    08124 26 19160 00099
04280A10370    TFM   *+59,18100,                08136 16 08195 T8100
04290          A     *+47,WB2,                  08148 21 08195 09255
04300          FS    ACC,                       08160 16 00469 08195
                                                08172 16 00445 T9160
                                                08184 49 00402 00000
04310A10380    TF    18930,ACC,                 08196 26 18930 19160
04320A10390    TFM   *+30,18100,                08208 16 08238 T8100
04330          A     *+18,WB2,                  08220 21 08238 09255
04340          TF    ,ACC,                      08232 26 00000 19160
04350A10400    TF    ACC,18910,                 08244 26 19160 18910
04360A10410    TFM   *+30,18200,                08256 16 08286 T8200
04370          A     *+18,WB2,                  08268 21 08286 09255
04380          TF    ,ACC,                      08280 26 00000 19160
04390A10420    FA    ACC,18930,                 08292 16 00469 08327
                                                08304 16 00445 T9160
                                                08316 49 00422 T8930
04400A10430    FA    ACC,18300,                 08328 16 00469 08363
                                                08340 16 00445 T9160
                                                08352 49 00422 T8300
04410A10440    TF    18300,ACC,                 08364 26 18300 19160
04420A10450    FA    ACC,18010,                 08376 16 00469 08411
                                                08388 16 00445 T9160
                                                08400 49 00422 T8010
04430A10460    TF    18940,ACC,                 08412 26 18940 19160
04440A10470    B     A10470,                    08424 49 08764 00000
04450          DORG  *-3,                       08432
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                                            08444 16 00445 T9160
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04470A10490 C     ACC,ZERO                  08468 24 19160 19120
04480       BNP   A10240,                   08480 47 07848 01100
04490A10500 TF    ACC,19120,                08492 26 19160 19120
04500A10510 TF    18910,ACC,                08504 26 18910 19160
04510A10520 TF    18920,ACC,                08516 26 18920 19160
04520A10530 B     A10300,                   08528 49 07980 00000
04530       DORG  *-3,                      08536
04540A10540 TF    ACC,18930,                08536 26 19160 18930
04550A10550 TFM   *+30,18100,               08548 16 08578 T8100
04560       A     *+18,WB2,                 08560 21 08578 09255
04570       TF    ,ACC,                     08572 26 00000 19160
04580A10560 TF    ACC,18910,                08584 26 19160 18910
04590A10570 TFM   *+30,18200,               08596 16 08626 T8200
04600       A     *+18,WB2,                 08608 21 08626 09255
04610       TF    ,ACC,                     08620 26 00000 19160
04620A10580 TF    ACC,18400,                08632 26 19160 18400
04630A10590 TF    18300,ACC,                08644 26 18300 19160
04640A10600 FA    ACC,18010,                08656 16 00469 08691
                                            08668 16 00445 T9160
                                            08680 49 00422 T8010
04650A10610 TF    18940,ACC,                08692 26 18940 19160
04660A10620 TF    ACC,18960,                08704 26 19160 18960
04670A10630 TF    18340,ACC,                08716 26 18340 19160
04680A10640 TF    ACC,18380,                08728 26 19160 18380
04690A10650 TF    18970,ACC,                08740 26 18970 19160
04700A10660 TF    18350,ACC,                08752 26 18350 19160
04710A10670 A     WB2,WD2,                  08764 21 09255 09260
04720       C     WL2,WB2,                  08776 24 09265 09255
04730       BL    *+20,                     08788 47 08808 01300
04740       B     A10690,                   08800 49 08820 00000
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04750          DORG *-3,                          08808
04760A10680    TFM  WB2,00000,                    08808 16 09255 00000
04770A10690    TFM  WB1,00000,                    08820 16 09240 00000
04780A10700    TFM  WL1,00060,                    08832 16 09250 00060
04790A10710    TFM  SF+11,703,811,                08844 16 02331 00703
04800          TFM  *+35,18900,                   08856 16 08891 18900
04810          A    *+23,WB1,                     08868 21 08891 09240
04820          BT   TYPED,00000,                  08880 27 02188 00000
04830          TBTY                               08892 34 00000 00108
04840A10720    A    WB1,WD1,                      08904 21 09240 09245
04850          C    WL1,WB1,                      08916 24 09250 09240
04860          BL   *+20,                         08928 47 08948 01300
04870          B    A10710,                       08940 49 08844 00000
04880          DORG *-3,                          08948
04890A10730    TFM  SF+11,701,811,                08948 16 02331 00701
04900          BT   TYPED,18970,                  08960 27 02188 18970
04910          RCTY                               08972 34 00000 00102
04920A10740    BC1  A10760,                       08984 46 09004 00100
04930A10750    B    A09400,                       08996 49 05244 00000
04940          DORG *-3,                          09004
04950A10760    H                                  09004 48 00000 00000
04960A10770    B    A09000,                       09016 49 04288 00000
04970          DORG *-3,                          09024
04980A10780    NOP                                09024 41 00000 00000
04990A10790    TF   ACC,19130,                    09036 26 19160 19130
05000A10800    FS   ACC,18060,                    09048 16 00469 09083
                                                  09060 16 00445 19160
                                                  09072 49 00402 18060
05010A10810    FD   18050,ACC,                    09084 16 00469 09119
                                                  09096 26 01260 18050
                                                  09108 49 01422 19160
05020          TF   ACC,99,                       09120 26 19160 00099
05030A10820    FM   ACC,18060,                    09132 16 00469 09167
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05040          TF    ACC,99,                        09168 26 19160 00099
05050A10830    FA    ACC,18050,                     09180 16 00469 09215
 09192 16 00445 T9160
                                                    09204 49 00422 T8050
05060A10840    TF    18050,ACC,                     09216 26 18050 19160
05070A10850    B     A09110,                        09228 49 00572 00000
05080          DORG  *-3,                           09236
05090          DC    10, 5450000000,17950           17950 00010  5450000000
05100          DC    10, 5120000000,17960           17960 00010  5120000000
05110          DC    10, 5110000000,17970           17970 00010  5110000000
05120          DC    10, 4711809340,17980           17980 00010  4711809340
05130          DC    10, 5232200000,17990           17990 00010  5232200000
05140          DC    10, 0000000000,18000           18000 00010  0000000000
05150          DC    10, 0000000000,18010           18010 00010  0000000000
05160          DC    10, 0000000000,18020           18020 00010  0000000000
05170          DC    10, 0000000000,18030           18030 00010  0000000000
05180          DC    10, 0000000000,18040           18040 00010  0000000000
05190          DC    10, 0000000000,18050           18050 00010  0000000000
05200          DC    10, 0000000000,18060           18060 00010  0000000000
05210          DC    10, 0000000000,18070           18070 00010  0000000000
05220          DC    10, 0000000000,18080           18080 00010  0000000000
05230          DC    10, 0000000000,18090           18090 00010  0000000000
05240          DC    10, 0000000000,18100           18100 00010  0000000000
05250          DC    10, 0000000000,18110           18110 00010  0000000000
05260          DC    10, 0000000000,18120           18120 00010  0000000000
05270          DC    10, 0000000000,18130           18130 00010  0000000000
05280          DC    10, 0000000000,18140           18140 00010  0000000000
05290          DC    10, 0000000000,18150           18150 00010  0000000000
05300          DC    10, 0000000000,18160           18160 00010  0000000000
05310          DC    10, 0000000000,18170           18170 00010  0000000000
05320          DC    10, 0000000000,18180           18180 00010  0000000000
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05330      DC    10, 0000000000,18190          18190 00010  Ø0000000000
05340      DC    10, 0000000000,18200          18200 00010  Ø0000000000
05350      DC    10, 0000000000,18210          18210 00010  Ø0000000000
05360      DC    10, 0000000000,18220          18220 00010  Ø0000000000
05370      DC    10, 0000000000,18230          18230 00010  Ø0000000000
05380      DC    10, 0000000000,18240          18240 00010  Ø0000000000
05390      DC    10, 0000000000,18250          18250 00010  Ø0000000000
05400      DC    10, 0000000000,18260          18260 00010  Ø0000000000
05410      DC    10, 0000000000,18270          18270 00010  Ø0000000000
05420      DC    10, 0000000000,18280          18280 00010  Ø0000000000
05430      DC    10, 0000000000,18290          18290 00010  Ø0000000000
05440      DC    10, 0000000000,18300          18300 00010  Ø0000000000
05450      DC    10, 0000000000,18310          18310 00010  Ø0000000000
05460      DC    10, 0000000000,18320          18320 00010  Ø0000000000
05470      DC    10, 0000000000,18330          18330 00010  Ø0000000000
05480      DC    10, 0000000000,18340          18340 00010  Ø0000000000
05490      DC    10, 0000000000,18350          18350 00010  Ø0000000000
05500      DC    10, 0000000000,18360          18360 00010  Ø0000000000
05510      DC    10, 0000000000,18370          18370 00010  Ø0000000000
05520      DC    10, 0000000000,18380          18380 00010  Ø0000000000
05530      DC    10, 0000000000,18390          18390 00010  Ø0000000000
05540      DC    10, 0000000000,18400          18400 00010  Ø0000000000
05550      DC    10, 0000000000,18410          18410 00010  Ø0000000000
05560      DC    10, 0000000000,18420          18420 00010  Ø0000000000
05570      DC    10, 0000000000,18430          18430 00010  Ø0000000000
05580      DC    10, 0000000000,18440          18440 00010  Ø0000000000
05590      DC    10, 0000000000,18450          18450 00010  Ø0000000000
05600      DC    10, 0000000000,18460          18460 00010  Ø0000000000
05610      DC    10, 0000000000,18470          18470 00010  Ø0000000000
05620      DC    10, 0000000000,18480          18480 00010  Ø0000000000
05630      DC    10, 0000000000,18490          18490 00010  Ø0000000000
05640      DC    10, 0000000000,18500          18500 00010  Ø0000000000
05650      DC    10, 0000000000,18510          18510 00010  Ø0000000000
```

```
05660        DC    10, 0000000000,18520        18520 00010  Ø000000000
05670        DC    10, 0000000000,18530        18530 00010  Ø000000000
05680        DC    10, 0000000000,18540        18540 00010  Ø000000000
05690        DC    10, 0000000000,18550        18550 00010  Ø000000000
05700        DC    10, 0000000000,18560        18560 00010  Ø000000000
05710        DC    10, 0000000000,18570        18570 00010  Ø000000000
05720        DC    10, 0000000000,18580        18580 00010  Ø000000000
05730        DC    10, 0000000000,18590        18590 00010  Ø000000000
05740        DC    10, 0000000000,18600        18600 00010  Ø000000000
05750        DC    10, 0000000000,18610        18610 00010  Ø000000000
05760        DC    10, 0000000000,18620        18620 00010  Ø000000000
05770        DC    10, 0000000000,18630        18630 00010  Ø000000000
05780        DC    10, 0000000000,18640        18640 00010  Ø000000000
05790        DC    10, 0000000000,18650        18650 00010  Ø000000000
05800        DC    10, 0000000000,18660        18660 00010  Ø000000000
05810        DC    10, 0000000000,18670        18670 00010  Ø000000000
05820        DC    10, 0000000000,18680        18680 00010  Ø000000000
05830        DC    10, 0000000000,18690        18690 00010  Ø000000000
05840        DC    10, 0000000000,18700        18700 00010  Ø000000000
05850        DC    10, 0000000000,18710        18710 00010  Ø000000000
05860        DC    10, 0000000000,18720        18720 00010  Ø000000000
05870        DC    10, 0000000000,18730        18730 00010  Ø000000000
05880        DC    10, 0000000000,18740        18740 00010  Ø000000000
05890        DC    10, 0000000000,18750        18750 00010  Ø000000000
05900        DC    10, 0000000000,18760        18760 00010  Ø000000000
05910        DC    10, 0000000000,18770        18770 00010  Ø000000000
05920        DC    10, 0000000000,18780        18780 00010  Ø000000000
05930        DC    10, 0000000000,18790        18790 00010  Ø000000000
05940        DC    10, 0000000000,18800        18800 00010  Ø000000000
05950        DC    10, 0000000000,18810        18810 00010  Ø000000000
05960        DC    10, 0000000000,18820        18820 00010  Ø000000000
05970        DC    10, 0000000000,18830        18830 00010  Ø000000000
05980        DC    10, 0000000000,18840        18840 00010  Ø000000000
```

```
05990          DC    10, 0000000000,18850          18850 00010   Ø000000000
06000          DC    10, 0000000000,18860          18860 00010   Ø000000000
06010          DC    10, 0000000000,18870          18870 00010   Ø000000000
06020          DC    10, 0000000000,18880          18880 00010   Ø000000000
06030          DC    10, 0000000000,18890          18890 00010   Ø000000000
06040          DC    10, 0000000000,18900          18900 00010   Ø000000000
06050          DC    10, 0000000000,18910          18910 00010   Ø000000000
06060          DC    10, 0000000000,18920          18920 00010   Ø000000000
06070          DC    10, 0000000000,18930          18930 00010   Ø000000000
06080          DC    10, 0000000000,18940          18940 00010   Ø000000000
06090          DC    10, 0000000000,18950          18950 00010   Ø000000000
06100          DC    10, 0000000000,18960          18960 00010   Ø000000000
06110          DC    10, 0000000000,18970          18970 00010   Ø000000000
06120          DC    10, 0000000000,18980          18980 00010   Ø000000000
06130          DC    10, 0000000000,18990          18990 00010   Ø000000000
06140WB1       DC    5,0,                          09240 00005   Ø0000
06150WD1       DC    5,0,                          09245 00005   Ø0000
06160WL1       DC    5,0,                          09250 00005   Ø0000
06170WB2       DC    5,0,                          09255 00005   Ø0000
06180WD2       DC    5,0,                          09260 00005   Ø0000
06190WL2       DC    5,0,                          09265 00005   Ø0000
06200          DEND  A09000-24,                    04264
LOAD SUBROUTINES
END OF PASSII
```

WATER HAMMER

DISCHARGE	200	200.000
HEAD	100	100.000
C.S.AREA	19‡66	19.660
LENGTH	2900	2900.000
VELOCITY	3196	3196.000
T(1)	5	5.000
RATIO	‡5	.500
T(2)	15	15.000

.000	.000	.000	.000	100.000	1.000	10.172	200.0
.453	16.931	.170-	.000	116.931	.909	10.002	196.6
.907	21.250	.214-	.000	138.182	.818	9.788	192.4
1.361	27.018	.272-	.000	165.201	.727	9.516	187.0
1.814	34.811	.350-	.000	200.013	.637	9.165	180.1
2.268	67.152	.676-	33.863-	233.301	.546	8.488	166.8
2.722	58.004	.584-	42.501-	248.804	.492	7.904	155.3
3.175	42.332	.426-	54.036-	237.100	.477	7.477	147.0
3.629	51.455	.518-	69.623-	218.932	.462	6.959	136.8
4.083	70.296	.708-	100.441-	188.788	.447	6.251	122.8
4.536	53.550	.539-	73.507-	168.831	.432	5.711	112.2
4.990	26.546	.267-	30.629-	164.748	.416	5.444	107.0
5.444	28.022	.282-	33.287-	159.482	.401	5.161	101.4
5.897	31.988	.322-	40.151-	151.319	.386	4.839	95.1
6.351	27.763	.279-	33.594-	145.489	.371	4.559	89.6
6.805	20.858	.210-	22.463-	143.884	.356	4.349	85.5
7.259	20.943	.211-	22.756-	142.070	.341	4.138	81.3
7.712	21.479	.216-	23.825-	139.724	.326	3.922	77.1
8.166	20.267	.204-	21.933-	138.058	.311	3.718	73.0
8.620	18.672	.188-	19.253-	137.477	.295	3.529	69.3
9.073	18.547	.186-	19.129-	136.895	.280	3.343	65.7
9.527	18.543	.186-	19.132-	136.305	.265	3.156	62.0
9.981	18.230	.183-	18.601-	135.934	.250	2.972	58.4
10.434	17.948	.180-	18.091-	135.791	.235	2.791	54.8
10.888	17.877	.180-	17.964-	135.704	.220	2.611	51.3
11.342	17.866	.180-	17.953-	135.617	.205	2.431	47.8
11.795	17.817	.179-	17.858-	135.575	.190	2.252	44.2
12.249	17.791	.179-	17.806-	135.560	.175	2.072	40.7
12.703	17.783	.179-	17.790-	135.553	.159	1.893	37.2
13.157	17.778	.179-	17.778-	135.553	.144	1.714	33.7
13.610	17.777	.179-	17.775-	135.555	.129	1.535	30.1
14.064	17.778	.179-	17.776-	135.557	.114	1.356	26.6
14.518	17.779	.179-	17.776-	135.559	.099	1.177	23.1
14.971	17.781	.179-	17.778-	135.562	.084	.998	19.6
15.425	17.774	.179-	17.779-	135.557	.069	.819	16.1
15.879	17.778	.179-	17.780-	135.556	.054	.639	12.5
16.332	17.779	.179-	17.781-	135.553	.038	.460	9.0
16.786	17.781	.179-	17.784-	135.550	.023	.281	5.5
17.240	17.776	.179-	17.768-	135.558	.008	.102	2.0
17.693	10.175	.102-	17.777-	127.956	.000	.000	.0
18.147	.000	.000	17.776-	110.179	.000	.000	.0
18.601	.000	.000	17.778-	92.401	.000	.000	.0
19.055	.000	.000	17.784-	74.616	.000	.000	.0
19.508	.000	.000	2.573-	72.043	.000	.000	.0
19.962	.000	.000	17.776	89.820	.000	.000	.0
20.416	.000	.000	17.778	107.598	.000	.000	.0

THE COMPUTER HISTORY MUSEUM
1 026 2898 4

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COMMON USERS GROUP PROGRAM REVIEW AND EVALUATION

(fill out in typewriter, ink or pencil)

Program No._____ Date_____

Program Name:_____

1. Does the abstract adequately describe what the program is and what it does? Yes____ No____
   Comment_____

2. Does the program do what the abstract says? Yes____ No____
   Comment_____

3. Is the description clear, understandable, and adequate? Yes____ No____
   Comment_____

4. Are the Operating Instructions understandable and in sufficient detail? Yes____ No____
   Comment_____
   Are the Sense Switch options adequately described (if applicable)? Yes____ No____
   Are the mnemonic labels identified or sufficiently understandable? Yes____ No____
   Comment_____

5. Does the source program compile satisfactorily (if applicable)? Yes____ No____
   Comment_____

6. Does the object program run satisfactorily? Yes____ No____
   Comment_____

7. Number of test cases run_____. Are any restrictions as to data, size, range, etc. covered adequately in description? Yes____ No____
   Comment_____

8. Does the Program meet the minimal standards of COMMON? Yes____ No____
   Comment_____

9. Were all necessary parts of the program received? Yes____ No____
   Comment_____

10. Please list on the back any suggestions to improve the usefulness of the program. These will be passed onto the author for his consideration.

Please return to:

Mr. Richard L. Pratt
Data Corporation
7500 Old Xenia Pike
Dayton, Ohio 45432

Your Name _____
Company _____
_____
Address _____
_____
Users Group Code _____

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11/1/65

WATER HAMMER

by:

J. A. N. Lee
Associate Professor of Computer Science
The Commonwealth of Massachusetts
University of Massachusetts
Amherst, Massachusetts

Modifications or revisions to this program, as they occur, will be announced in the appropriate Catalog of Programs for IBM Data Processing Systems. When such an announcement occurs, users should order a complete new program from the Program Information Department.

TAPE KEY

Tape 1	Source
Tape 2	Object

QUEEN'S UNIVERSITY COMPUTING CENTRE

ONTARIO, CANADA

TITLE: WATER HAMMER

TYPE: CIVIL ENGINEERING

EQUIPMENT AFFECTED: IBM 1620, 20^{k}, TAPE, DIVIDE HARDWARE

SUBROUTINES USED: FLOATING POINT SUBROUTINES

PREPARED BY:

Dr. J. A. N. Lee

PROJECT NO.: 34

DATE: APRIL 1962

DISCLAIMER

Queen's University Computing Centre takes no responsibility for any errors, mistakes or imperfections in this program nor for any erroneous results obtained in the running of the program.

INTRODUCTION

Under steady conditions of flow, in a pipeline fed from a constant level reservoir controlled by a valve at a lower end, closure of the valve initiates a change in pressure which may give rise to "water-hammer" effects. This program performs a numerical step method of integration to compute the pressure developed at the valve (or gate) due to the closure of that gate. Only a single pipeline of uniform dimensions is considered. Friction in the system is ignored.

Mathematical Method

Whilst the exact mathematical treatment of the pressure changes in a conduit under the influence of instantaneous valve closure is well established, that for slow gate closure is only soluble by a numerical integration procedure. The method used in the program described herein assumes that the valve closes slowly, but in small instantaneous steps. When the valve closes instantly the velocity of the layer of water next to it must be reduced from some value V_o to zero. As a result an elastic pressure wave is transmitted toward the reservoir at a velocity of 'a' ft/sec. At the instant L/a seconds after valve closure, the velocity of flow is everywhere equal to zero while the pressure in the pipe is Δh_t above that in the reservoir at the same level. Water immediately tries to move from the high pressure area to the low pressure area so that an expansion wave proceeds towards the valve arriving there at time $2L/a$. If the gate has not closed further since the wave was initiated, another wave will travel to the reservoir and return this time reducing the head in the pipeline and at time $4L/a$ the conditions will be identical to those at the start (i.e. time $t = 0$).

If the valve had been closed slowly, in a time exceeding $2L/a$ seconds, the reflected expansion wave would have relieved the increasing pressure to some extent before the full theoretical Δh_t had built up. If a particular velocity change Δv occurs in a shorter time than $2L/a$ it causes the same pressure increment as an instantaneous velocity change of the same magnitude, namely $-\frac{a}{g}\Delta v$: if the velocity change occurs in a time exceeding $2L/a$ seconds the pressure increment is affected by the reflected elastic waves.

The following assumptions simplify the solution and have little effect on the results:

1. The pipe is assumed to be frictionless.

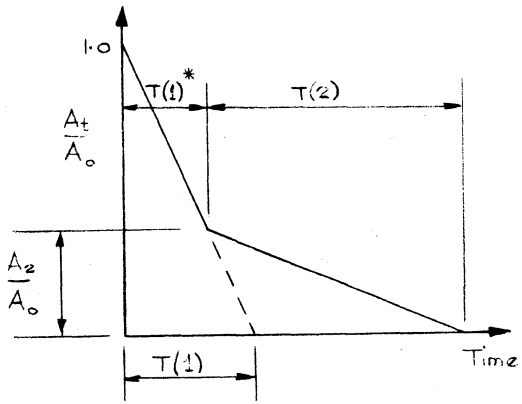
2. The coefficient of contraction for the resulting orifice as the valve (or gate) closes is unchanged so that the discharge at any time t may be defined as

$$Q_t = Q_o \frac{A_t}{A_o} \sqrt{\frac{H_t}{H_o}}$$

3. The gates are imagined to close in a number of instantaneous steps at time intervals of

$$\Delta_t = \frac{2L}{a} \text{ secs}$$

4. The ratio of gate opening to full opening may be expressed graphically by the form.



If h_{r_t} is the pressure increment of the wave generated $2L/a$ seconds previously, returning to the gate at some time t then the total head H_t may be written as

$$H_t = \sum_{t=0}^{n(2L/a)} (\Delta h_t + h_{r_t}) + H_o$$

Rewriting the equation for discharge at any time t as

$$H_t = H_o\left[\left(\frac{A_o}{A_t}\cdot\frac{Q_t}{Q_o}\right)^2 - 1\right]$$

and assuming a trial value of Q_t, a trial value of H_t may be obtained. By successive computations another value of Q_t is calculated and compared with the original assumption. If the two agree within 0.1% the results are printed and the next step computed for time $(t + 2L/a)$. If there is no such agreement, the new value of Q_t is taken as a new trial value and the computations repeated.

It occasionally happens, that with exceptionally small gate openings, the accuracy of solution does not allow convergence to conform with the desired 0.1% accuracy. In this instance the operator is provided with a means of forced output.

Input Format

Input format is in a fixed point form using the record mark as the decimal point. Since the floating point subroutines use a 8 digit mantissa, it is pointless to input more than 8 digits. However, if the operator does exceed this figure, the program will truncate data to the desired level. Since the input area is filled with record marks before input is gated, an integer may be entered without definition of the decimal point. To aid the operation, all input is in numerical mode and consequently negative input data is unacceptable. All input data is expressed in feet - second - pound units. Prior to entry of the data a description of the required information is typed:

DISCHARGE	The initial steady state flow through the pipeline and valve in cusecs.
HEAD	The initial head at the gate (or valve) neglecting losses. Note that for large gates use the head at the centre line of the gate (ft).
C.S. AREA	The cross sectional area of the conduit (ft^2).

LENGTH	The length of the pipeline (ft).
VELOCITY	The velocity of wave propagation in the pipeline (ft/sec). This quality will vary according to the elastic properties of the conduit and fluid. In general,

$$a = \sqrt{\frac{12}{\frac{w}{g}\left(\frac{1}{K} + \frac{D}{tE}\right)}}$$

where a is the velocity of the pressure wave in ft/sec.
K is the bulk modulus of the fluid in lb/in^2.
E is the Young's Modulus of the material of the pipe in lb/in^2.
D is the internal diameter of the pipe in inches.
t is the wall thickness of the pipe in inches.
and w is the specific weight of the fluid.

T(1), RATIO, T(2)	Gate closure characteristics except that with See Fig. 1. SW3 ON T(1) is accepted as T(1)*.

Output

The output consists of eight columns of data without headings these are:

t (Secs)	Δht (ft)	Δv (ft/sec)	hrt (ft)	Ht (ft)	Gate Opening (--)	Vt (ft/sec)	Qt (cusecs)

All output is in fixed point notation and requires a minimum 11" wide sheet.

OPERATING PROCEDURE

1. Clear Memory R/I 160001000000 R/S.
   Wait 3 seconds, depress Instant Stop.
2. Load the program tape in the photo reader, and
   R/I 36000000300 R/S.
   The tape will be read into the 1620 and eventually computation will halt.
3. Depress START.
   The computer will type:
   WATER HAMMER
   DISCHARGE

and gate type-in. Enter the data in fixed point notation using the record mark as a decimal point. Depress RELEASE & START after entry. An echo will be typed out in the same format followed by the next request for data. Note that at the instant where T(1) is requested SW3 should be set to indicate actually whether T(1) or T(1)* has been typed in

SW3	ENTRY
ON	T(1)*
OFF	T(1)

Errors in typing may be corrected before RELEASE & START have been depressed by putting SW4 ON first and then releasing this information. If an error is detected only after release to the computer depress RESET, INSERT, RELEASE & START to recommence the program. Note that a zero entry is merely RELEASE/START.

4. Immediately after the entry and echo of the last piece of input data, five carriage returns will occur followed by the first line of output data. At approximately 12 second intervals this procedure will be repeated.
5. To terminate computation at any time put SW1 ON and the computer will halt after the next line of type-out. Depress START to return to Step 3.

6. With very small gate openings, convergence to a satisfactory degree may not be reached. After a period of at least 30 seconds, put SW 2 ON to force output. As soon as the output commences, put SW 2 OFF so as to not force output on the next time step.

HASH TOTALS

SOURSE TAPE 72969.28941.91479.85604
OBJECT TAPE 59560.10747.71397.16064

```
*  WATER HAMMER
00020        DC    10,0,
*  FIXED POINT OUTPUT ROUTINE
00040TYPED   TF    FIXED-8,ZERO,
00050        TF    FIXED+2,ZERO,
00060        SF    SF+10,
00070        AM    SF+9,50,10
00080        TF    *+23,SF+9,
00090        CM    TYPED-9,60,10,
00100        BH    FLPT,
00110        AM    SF+11,50,10
00120        TF    *+23,SF+11,
00130        CM    TYPED-9,48,10,
00140        BL    TEST,
00150SF      SF    TYPED-8,
00160        TFM   *+30,FIXED+50,
00170        S     *+18,TYPED-9,
00180        TF    ,TYPED-1,
00190SET     TFM   N,17,10,
00200        TFM   M,0,10,
00210        TFM   *+35,FIXED,
00220        S     *+23,N,
00230BRD     BD    DI,,0,
00240        BNF   DI,BRD,
00250        TFM   *+30,OUTPUT,
00260        A     *+18,M,
00270        TFM   ,0,10,
00280        B     N8,
00290        DORG  *-3,
00300DI      TF    *+23,BRD+11,
00310        TD    *+47,,
```



```
02187 00010   0000000000

02188 26 02329 19120
02200 26 02339 19120
02212 32 02330 00000
02224 11 02329 00050
02236 26 02259 02329
02248 14 02179 00060
02260 46 02982 01100
02272 11 02331 00050
02284 26 02307 02331
02296 14 02179 00048
02308 47 02612 01300
02320 32 02180 00000
02332 16 02362 02987
02344 22 02362 02179
02356 26 00000 02187
02368 16 02555 00017
02380 16 02867 00000
02392 16 02427 02937
02404 22 02427 02555
02416 43 02484 00000
02428 44 02484 02416
02440 16 02470 02941
02452 21 02470 02867
02464 16 00000 00000
02476 49 02556 00000
02484
02484 26 02507 02427
02496 25 02543 00000
```

```
00320        TFM   *+30,OUTPUT,
00330        A     *+18,M,
00340        TFM   ,70,10,
00350        CF    BRD,,
00360N8      CM    N,8,10,
00370        BE    DECI,
00380        SM    N,1,10,
00390        AM    M,2,10,
00400        B     BRD-24,,
00410        DORG  *-3,
00420TEST    TF    TYPED-1,ZERO,
00430        TDM   TYPED-10,-5,
00440        B     SF,,
00450        DORG  *-3,
00460DECI    TFM   *+30,OUTPUT+22,
00470        TFM   *+23,FIXED-7,
00480        TD    ,,
00490        CM    *-1,FIXED+2,
00500        BE    *+44,
00510        AM    *-25,1,
00520        AM    *-42,2,
00530        B     *-60,
00540        DORG  *-3,
00550        MM    SF+9,-2,10,
00560        SF    98,
00570        TFM   M1+6,OUTPUT+20,
00580        A     M1+6,99,
00590        SM    SF+11,50,10,
00600        MM    SF+11,-2,10,
00610        SF    98,
00620        TFM   *+30,OUTPUT+22,
00630        A     *+18,99,
00640        TD    ,400,
```



```
02508 16 02538 02941
02520 21 02538 02867
02532 16 00000 00070
02544 33 02416 00000
02556 14 02555 00008
02568 46 02644 01200
02580 12 02555 00001
02592 11 02867 00002
02604 49 02392 00000
02612
02612 26 02187 19120
02624 15 02178 00005
02636 49 02320 00000
02644
02644 16 02674 02963
02656 16 02679 02930
02668 25 00000 00000
02680 14 02679 02939
02692 46 02736 01200
02704 11 02679 00001
02716 11 02674 00002
02728 49 02668 00000
02736
02736 13 02329 00002
02748 32 00098 00000
02760 16 02874 02961
02772 21 02874 00099
02784 12 02331 00050
02796 13 02331 00002
02808 32 00098 00000
02820 16 02850 02963
02832 21 02850 00099
02844 25 00000 00400
```

```
00650        SF   BRD,
00660M1      WATY ,,
00670        BNF  *+26,TYPED-1,
00680        WATY MINUS,,
00690        BB
00700        DORG *-9,
00710        SPTY
00720        BB
00730        DORG *-9,
00740FIXED   DC   18,0,
00750        DC   2,0,
00760OUTPUT  DAC  21,          .000000000@
00770N       DC   2,0,N8-1,
00780M       DC   2,0,M1-1,
*  FLOATING POINT OUTPUT ROUTINE
*  EXPONENT GREATER THAN 10
00810FLPT    BNF  *+36,TYPED-1,
00820        WATY MINUS,
00830        B    *+24,
00840        SPTY
00850        CF   TYPED-1,
00860        TD   *-1,TYPED-8,
00870        TD   TYPED-8,400,
00880        CF   TYPED-10,
00890        WNTY TYPED-10,
00900        WATY DECPT,,
00910        TD   TYPED-8,FLPT+59,
00920        TD   TYPED,400,
00930        WNTY TYPED-8,
00940        TDM  TYPED,2,
00950        BB
00960        DORG *-9,
00970MINUS   DAC  2,-@
```



```
02856 32 02416 00000
02868 39 00000 00100
02880 44 02906 02187
02892 39 03153 00100
02904 42 00000 00000
02906
02906 34 00000 00101
02918 42 00000 00000
02920
02937 00018   0000000000000000000
02939 00002   00
02941 00021X2          .000000000‡
02555 00002   00
02867 00002   00


02982 44 03018 02187
02994 39 03153 00100
03006 49 03030 00000
03018 34 00000 00101
03030 33 02187 00000
03042 25 03041 02180
03054 25 02180 00400
03066 33 02178 00000
03078 38 02178 00100
03090 39 03157 00100
03102 25 02180 03041
03114 25 02188 00400
03126 38 02180 00100
03138 15 02188 00002
03150 42 00000 00000
03152
03153 00002X2 -‡
```

```
00980DECPT   DAC  2,.@
*  FIXED POINT INPUT ROUTINE
01000IN      DAS  10,
01010EX50    DS   10,
01020ALPHA   DAC  10,DISCHARGE@
01030        DAC  10,HEAD      @
01040        DAC  10,C.S.AREA  @
01050        DAC  10,LENGTH    @
01060        DAC  10,VELOCITY  @
01070        DAC  10,T(1)      @
01080        DAC  10,RATIO     @
01090        DAC  10,T(2)      @
01100        DC   5,0,
01110READ    TFM  N,0,10,
01120        TFM  *+30,IN,
01130        A    *+18,N,
01140        TD   ,400,
01150        CM   N,19,10,
01160        BE   *+32,
01170        AM   N,1,10,
01180        B    *-72,
01190        DORG *-3,
01200        TF   EX50,READ-1,
01210        SM   EX50,18000,
01220        MM   EX50,2,10,
01230        SF   95,
01240        RCTY
01250        TFM  *+30,ALPHA,
01260        A    *+18,99,
01270        WATY
01280        TBTY
01290        RNTY IN,
01300        BC4  READ,
```



```
03157 00002X2 .‡

03161 00010X2
03189 00010
03191 00010X2 DISCHARGE‡
03211 00010X2 HEAD      ‡
03231 00010X2 C.S.AREA  ‡
03251 00010X2 LENGTH    ‡
03271 00010X2 VELOCITY  ‡
03291 00010X2 T(1)      ‡
03311 00010X2 RATIO     ‡
03331 00010X2 T(2)      ‡
03354 00005   00000
03356 16 02555 00000
03368 16 03398 03161
03380 21 03398 02555
03392 25 00000 00400
03404 14 02555 00079
03416 46 03448 01200
03428 11 02555 00001
03440 49 03368 00000
03448
03448 26 03189 03355
03460 12 03189 18000
03472 13 03189 00002
03484 32 00035 00000
03496 34 00000 00102
03508 16 03538 03191
03520 21 03538 00099
03532 39 00000 00100
03544 34 00000 00108
03556 36 03161 00100
03568 46 03356 00400
```

```
01310          TFM  N,1,10,
01320          BNR  BNR-24,iN,
01330          BNR  LESS,iN+1,
01340          TF   EX50,ZERO,
01350          B    STORE-12,
01360          DORG *-3,
01370          TFM  *+35,iN,
01380          A    *+23,N,
01390BNR       BNR  AD1,
01400          TFM  EX50-8,50,10,
01410          A    EX50-8,N,
01420          SF   iN,
01430          TF   M,N,
01440          AM   N,1,10,
01450          TFM  *+35,iN,
01460          A    *+23,N,
01470          BNR  *-36,,
01480          TFM  *+30,iN,
01490          A    *+18,N,
01500          TDM  ,0,
01510          CM   N,8,10,
01520          BL   *-96,
01530          TFM  *+54,iN,
01540          TFM  *+47,iN+1,
01550          A    *+30,M,
01560          A    *+23,M,
01570          TR   ,,
01580          TF   EX50,iN+7,
01590          CF   EX50-7,
01600          TF   *+18,READ-1,
01610STORE     TF   ,EX50,
01620          TBTY
01630          BB
```



```
03580 16 02555 00001
03592 45 03636 03161
03604 45 03970 03162
03616 26 03189 19120
03628 49 03912 00000
03636
03636 16 03671 03161
03648 21 03671 02555
03660 45 03950 00000
03672 16 03181 00050
03684 21 03181 02555
03696 32 03161 00000
03708 26 02867 02555
03720 11 02555 00001
03732 16 03767 03161
03744 21 03767 02555
03756 45 03720 00000
03768 16 03798 03161
03780 21 03798 02555
03792 15 00000 00000
03804 14 02555 00008
03816 47 03720 01300
03828 16 03882 03161
03840 16 03887 03162
03852 21 03882 02867
03864 21 03887 02867
03876 31 00000 00000
03888 26 03189 03168
03900 33 03182 00000
03912 26 03930 03355
03924 26 00000 03189
03936 34 00000 00108
03948 42 00000 00000
```

```
01640          DORG *-9,
01650AD1       AM   N,1,10,
01660          B    BNR-24,
01670          DORG *-3,
01680LESS      TFM  N,0,10,
01690          TR   iN,iN+1,
01700          TFM  *+35,iN,
01710          A    *+23,N,
01720          BD   *+32,,
01730          AM   N,1,10,
01740          B    *-60,
01750          DORG *-3,
01760          TFM  EX50-8,50,10,
01770          S    EX50-8,N,
01780          TFM  N,0,10,
01790          AM   N,1,10,
01800          TFM  *+35,iN,
01810          A    *+23,N,
01820          BNR  *-36,
01830          CM   N,9,10,
01840          BE   *+56,
01850          TFM  *+30,iN,
01860          A    *+18,N,
01870          TDM  ,0,
01880          B    *-108,
01890          DORG *-3,
01900          SF   iN,
01910          B    STORE-36,
01920          DORG *-3,
01930ACC       DC   10,0,19160
01940SPEC      DC   10,0,
01950ZERO      DC   10,0,19120,
01960ONE       DC   10,5110000000,19130,
```



```
03950
03950 11 02555 00001
03962 49 03636 00000
03970
03970 16 02555 00000
03982 31 03161 03162
03994 16 04029 03161
04006 21 04029 02555
04018 43 04050 00000
04030 11 02555 00001
04042 49 03982 00000
04050
04050 16 03181 00050
04062 22 03181 02555
04074 16 02555 00000
04086 11 02555 00001
04098 16 04133 03161
04110 21 04133 02555
04122 45 04086 00000
04134 14 02555 00009
04146 46 04202 01200
04158 16 04188 03161
04170 21 04188 02555
04182 15 00000 00000
04194 49 04086 00000
04202
04202 32 03161 00000
04214 49 03888 00000
04222
19160 00010  0000000000
04231 00010  0000000000
19120 00010  0000000000
19130 00010  5110000000
```

```
01970TEN    DC    10,5210000000,19140,
01980PI     DC    10,5131415926,19150,
01990DIGIT  DC    1,0,
02000IRA    DC    5,0,
02010HEAD   DAC   13,WATER HAMMER@
02020       RCTY
02030       WATY  HEAD,
02040A09000 TFM   WB1,00000,
02050A09010 TFM   WD1,00010,
02060A09020 TFM   WL1,00070,
02070A09030 TFM   *+35,18000,
02080       A     *+23,WB1,
02090       BTM   READ,
02100       TF    *+25,*-1,
02110       TFM   SF+11,703,811,
02120       BT    TYPED,
02130A09040 A     WB1,WD1,
02140       C     WL1,WB1,
02150       BL    *+20,
02160       B     A09030,
02170       DORG  *-3,
02180A09050 TFM   WB1,00000,
02190A09060 TFM   WL1,00200,
02200A09070 TFM   WB2,00000,
02210A09080 TFM   WD2,00010,
02220A09090 TFM   WL2,00030,
02230A09100 RCTY
02240       RCTY
02250       RCTY
02260       RCTY
02270       RCTY
02280       BCR   A10780,
02290A09110 TF    ACC,19120,
```



```
19140 00010   5210000000
19150 00010   5131415926
04232 00001   0
04237 00005   00000
04239 00013X2 WATER HAMMER‡
04264 34 00000 00102
04276 39 04239 00100
04288 16 09240 00000
04300 16 09245 00010
04312 16 09250 00070
04324 16 04359 18000
04336 21 04359 09240
04348 17 03256 00000
04360 26 04395 04359
04372 16 02331 00703
04384 27 02188 00000
04396 21 09240 09245
04408 24 09250 09240
04420 47 04440 01300
04432 49 04324 00000
04440
04440 16 09240 00000
04452 16 09250 00200
04464 16 09255 00000
04476 16 09260 00010
04488 16 09265 00030
04500 34 00000 00102
04512 34 00000 00102
04524 34 00000 00102
04536 34 00000 00102
04548 34 00000 00102
04560 46 09024 00300
04572 26 19160 19120
```

```
02300A09120 TFM   *+30,18100,
02310       A     *+18,WB1,
02320       TF    ,ACC,
02330A09130 A     WB1,WD1,
02340       C     WL1,WB1,
02350       BL    *+20,
02360       B     A09120,
02370       DORG  *-3,
02380A09140 TFM   WL1,00030,
02390A09150 TFM   WB1,00000,
02400A09160 TFM   *+30,18900,
02410       A     *+18,WB1,
02420       TF    ,ACC,
02430A09170 A     WB1,WD1,
02440       C     WL1,WB1,
02450       BL    *+20,
02460       B     A09160,
02470       DORG  *-3,
02480A09180 TF    ACC,18010,
02490A09190 TF    18940,ACC,
02500A09200 TF    ACC,19130,
02510A09210 TF    18950,ACC,
02520A09220 TF    ACC,18000,
02530A09230 TF    18970,ACC,
02540A09240 TF    18350,ACC,
02550A09250 FD    ACC,18020,

02560       TF    ACC,99,
02570A09260 TF    18340,ACC,
02580A09270 TF    18960,ACC,
02590A09280 TF    ACC,18030,
02600A09290 FD    ACC,18040,
```



```
04584 16 04614 18100
04596 21 04614 09240
04608 26 00000 19160
04620 21 09240 09245
04632 24 09250 09240
04644 47 04664 01300
04656 49 04584 00000
04664
04664 16 09250 00030
04676 16 09240 00000
04688 16 04718 18900
04700 21 04718 09240
04712 26 00000 19160
04724 21 09240 09245
04736 24 09250 09240
04748 47 04768 01300
04760 49 04688 00000
04768
04768 26 19160 18010
04780 26 18940 19160
04792 26 19160 19130
04804 26 18950 19160
04816 26 1960  18000
04828 26 18970 19160
04840 26 18350 19160
04852 16 00469 04887
04864 26 01260 19160
04876 49 01422 18020
04888 26 19160 00099
04900 26 18340 19160
04912 26 18960 19160
04924 26 19160 18030
04936 16 00469 04971
```

```
02610          TF    ACC,99,
02620A09300    FD    ACC,17960,


02630          TF    ACC,99,
02640A09310    TF    18360,ACC,
02650A09320    TF    ACC,ZERO,
02660          S     ACC,18050,
02670A09330    FM    ACC,18060,


02680          TF    ACC,99,
02690A09340    FA    ACC,18050,


02700A09350    TF    18390,ACC,
02710A09360    TF    ACC,17990,
02720A09370    FD    ACC,18040,


02730          TF    ACC,99,
02740A09380    TF    18320,ACC,
02750A09390    B     A10690,
02760          DORG  *-3,
02770A09400    TF    ACC,18900,
02780A09410    FA    ACC,18360,


02790A09420    TF    18900,ACC,
02800A09430    FS    ACC,18390,
```



```
04948 26 01260 19160
04960 49 01422 T8040
04972 26 19160 00099
04984 16 00469 05019
04996 26 01260 19160
05008 49 01422 T7960
05020 26 19160 00099
05032 26 18360 19160
05044 26 19160 19120
05056 22 19160 18050
05068 16 00469 05103
05080 26 01260 19160
05092 49 01262 T8060
05104 26 19160 00099
05116 16 00469 05151
05128 16 00445 T9160
05140 49 00422 T8050
05152 26 18390 19160
05164 26 19160 17990
05176 16 00469 05211
05188 26 01260 19160
05200 49 01422 T8040
05212 26 19160 00099
05224 26 18320 19160
05236 49 08820 00000
05244
05244 26 19160 18900
05256 16 00469 05291
05268 16 00445 T9160
05280 49 00422 T8360
05292 26 18900 19160
05304 16 00469 05339
05316 16 00445 T9160
```

```
02810A09440    C     ACC,ZERO
02820          BNN   A10030
02830A09450    TF    ACC,ZERO,
02840          S     ACC,18360,
02850A09460    FD    ACC,18050,


02860          TF    ACC,99,
02870A09470    FA    ACC,18950,


02880A09480    TF    18950,ACC,
02890A09490    TF    ACC,ZERO,
02900          S     ACC,18360,
02910A09500    FD    ACC,18050,


02920          TF    ACC,99,
02930A09510    FM    ACC,18000,


02940          TF    ACC,99,
02950A09520    FA    ACC,18350,


02960A09530    TF    18370,ACC,
02970A09540    TF    ACC,18370,
02980A09550    FD    ACC,18950,


02990          TF    ACC,99,
03000A09560    FD    ACC,18000,
```



```
05328 49 00402 T8390
05340 24 19160 19120
05352 46 07244 01300
05364 26 19160 19120
05376 22 19160 18360
05388 16 00469 05423
05400 26 01260 19160
05412 49 01422 T8050
05424 26 19160 00099
05436 16 00469 05471
05448 16 00445 T9160
05460 49 00422 T8950
05472 26 18950 19160
05484 26 19160 19120
05496 22 19160 18360
05508 16 00469 05543
05520 26 01260 19160
05532 49 01422 T8050
05544 26 19160 00099
05556 16 00469 05591
05568 26 01260 19160
05580 49 01262 T8000
05592 26 19160 00099
05604 16 00469 05639
05616 16 00445 T9160
05628 49 00422 T8350
05640 26 18370 19160
05652 26 19160 18370
05664 16 00469 05699
05676 26 01260 19160
05688 49 01422 T8950
05700 26 19160 00099
05712 16 00469 05747
```

```
03010          TF    ACC,99,
03020A09570    FM    ACC,19160,


03030          TF    ACC,99,
03040A09580    FS    ACC,19130,


03050A09590    FM    ACC,18010,


03060          TF    ACC,99,
03070A09600    TF    18400,ACC,
03080A09610    FS    ACC,18300,


03090A09620    TF    18310,ACC,
03100A09630    TF    ACC,ZERO,
03110          TFM   *+35,18200,
03120          A     *+23,WB2,
03130          S     ACC,00000,
03140A09640    FM    ACC,17960,


03150          TF    ACC,99,
03160A09650    TFM   *+59,18100,
03170          A     *+47,WB2,
03180          FS    ACC,


03190A09660    TF    18930,ACC,
```



```
05724 26 01260 19160
05736 49 01422 T8000
05748 26 19160 00099
05760 16 00469 05795
05772 26 01260 19160
05784 49 01262 T9160
05796 26 19160 00099
05808 16 00469 05843
05820 16 00445 T9160
05832 49 00402 T9130
05844 16 00469 05879
05856 26 01260 19160
05868 49 01262 T8010
05880 26 19160 00099
05892 26 18400 19160
05904 16 00469 05939
05916 16 00445 T9160
05928 49 00402 T8300
05940 26 18310 19160
05952 26 19160 19120
05964 16 05999 T8200
05976 21 05999 09255
05988 22 19160 00000
06000 16 00469 06035
06012 26 01260 19160
06024 49 01262 T7960
06036 26 19160 00099
06048 16 06107 T8100
06060 21 06107 09255
06072 16 00469 06107
06084 16 00445 T9160
06096 49 00402 00000
06108 26 18930 19160
```

```
03200A09670    TF    ACC,ZERO,
03210          S     ACC,18930,
03220A09680    FA    ACC,18310,


03230A09690    TF    18910,ACC,
03240A09700    TF    ACC,ZERO,
03250          S     ACC,18910,
03260A09710    FM    ACC,18920,


03270          TF    ACC,99,
03280A09720    TF    18920,ACC,
03290A09730    FA    ACC,18340,


03300A09740    TF    18960,ACC,
03310A09750    FM    ACC,18020,


03320          TF    ACC,99,
03330A09760    TF    18380,ACC,
03340A09770    FS    ACC,18370,


03350A09780    TF    17980,ACC,
03360A09790    TF    ACC,17980,
03370          CF    ACC,
03380A09800    FM    ACC,17950,


03390          TF    ACC,99,
03400A09810    FS    ACC,18380,
```



```
06120 26 19160 19120
06132 22 19160 18930
06144 16 00469 06179
06156 16 00445 T9160
06168 49 00422 T8310
06180 26 18910 19160
06192 26 19160 19120
06204 22 19160 18910
06216 16 00469 06251
06228 26 01260 19160
06240 49 01262 T8320
06252 26 19160 00099
06264 26 18920 19160
06276 16 00469 06311
06288 16 00445 T9160
06300 49 00422 T8340
06312 26 18960 19160
06324 16 00469 06359
06336 26 01260 19160
06348 49 01262 T8020
06360 26 19160 00099
06372 26 18380 19160
06384 16 00469 06419
06396 16 00445 T9160
06408 49 00402 T8370
06420 26 17990 19160
06432 26 19160 17980
06444 33 19160 00000
06456 16 00469 06491
06468 26 01260 19160
06480 49 01262 T7950
06492 26 19160 00099
06504 16 00469 06539
```

```
03410          C     ACC,ZERO,
03420          BNP   A10540,
03430          BC2   A10540,
03440A09830 TF       ACC,ZERO,
03450          S     ACC,17960,
03460A09840 FM       ACC,18020,

03470          TF    ACC,99,
03480A09850 FM       ACC,18320,

03490          TF    ACC,99,
03500A09860 FM       ACC,18010,

03510          TF    ACC,99,
03520A09870 FD       ACC,18950,

03530          TF    ACC,99,
03540A09880 FD       ACC,18950,

03550          TF    ACC,99,
03560A09890 FD       ACC,18000,

03570          TF    ACC,99,
03580A09900 FD       ACC,18000,
```



```
06516 16 00445 T9160
06528 49 00402 T8380
06540 24 19160 19120
06552 47 08536 01100
06564 46 08536 00200
06576 26 19160 19120
06588 22 19160 17960
06600 16 00469 07635
06612 26 01260 19160
06624 49 01262 T8020
06636 26 19160 00099
06648 16 00469 07683
06660 26 01260 19160
06672 49 01262 T8320
06684 26 19160 00099
06696 16 00469 07731
06708 26 01260 19160
06720 49 01262 T8010
06732 26 19160 00099
06744 16 00469 07779
06756 26 01260 19160
06768 49 01422 T8950
06780 26 19160 00099
06792 16 00469 07827
06804 26 01260 19160
06816 49 01422 T8950
06828 26 19160 00099
06840 16 00469 07875
06852 26 01260 19160
06864 49 01422 T8000
06876 26 19160 00099
06888 16 00469 07923
06900 26 01260 19160
```

```
03590          TF    ACC,99,
03600A09910 FM       ACC,18370,

03610          TF    ACC,99,
03620A09920 TF       18500,ACC,
03630A09930 FM       ACC,18370,

03640          TF    ACC,99,
03650A09940 TF       17980,ACC,
03660A09950 TF       ACC,ZERO,
03670          S     ACC,17980,
03680A09960 FA       ACC,18380,

03690A09970 TF       18510,ACC,
03700A09980 TF       ACC,19130,
03710A09990 FS       ACC,18500,

03720A10000 FD       18510,ACC,

03730          TF    ACC,99,
03740A10010 TF       18370,ACC,
03750A10020 B        A09540,
03760          DORG  *-3,
03770A10030 FS       ACC,18070,

03780A10040 C        ACC,ZERO
```



```
06912 49 01422 T8000
06924 26 19160 00099
06936 16 00469 07971
06948 26 01260 19160
06960 49 01262 T8370
06972 26 19160 00099
06984 26 18500 19160
06996 16 00469 07031
07008 26 01260 19160
07020 49 01262 T8370
07032 26 19160 00099
07044 26 17980 19160
07056 26 19160 19120
07068 22 19160 17980
07080 16 00469 07115
07092 16 00445 T9160
07104 49 00422 T8380
07116 26 18510 19160
07128 26 19160 19130
07140 16 00469 07175
07152 16 00445 T9160
07164 49 00402 T8500
07176 16 00469 07211
07188 26 01260 18510
07200 49 01422 T9160
07212 26 19160 00099
07224 26 18370 19160
07236 49 05652 00000
07244
07244 16 00469 07279
07256 16 00445 T9160
07268 49 00402 T8070
07280 24 19160 19120
```

```
03790          BE    A10240,
03800A10050    C     ACC,ZERO
03810          BNN   A10480
03820A10060    TF    ACC,18070,
03830A10070    FS    ACC,18900,

03840A10080    FA    ACC,18390,

03850A10090    FD    ACC,18070,

03860          TF    ACC,99,
03870A10100    FM    ACC,18060,

03880          TF    ACC,99,
03890A10110    TF    18950,ACC,
03900A10120    TF    ACC,18900,
03910A10130    FS    ACC,18390,

03920A10140    FS    ACC,18360,

03930A10150    C     ACC,ZERO
03940          BNP   A10180,
03950A10160    TF    ACC,ZERO,
03960          S     ACC,18360,
03970A10170    B     A10190,
03980          DORG  *-3,
03990A10180    FA    ACC,18360,
```



```
07292 46 07848 01200
07304 24 19160 19120
07316 46 08432 01300
07328 26 19160 18070
07340 16 00469 07375
07352 16 00445 T9160
07364 49 00402 T8900
07376 16 00469 07411
07388 16 00445 T9160
07400 49 00422 T8390
07412 16 00469 07447
07424 26 01260 19160
07436 49 01422 T8070
07448 26 19160 00099
07460 16 00469 07495
07472 26 01260 19160
07484 49 01262 T8060
07496 26 19160 00099
07508 26 18950 19160
07520 26 19160 18900
07532 16 00469 07567
07544 16 00445 T9160
07556 49 00402 T8390
07568 16 00469 07603
07580 16 00445 T9160
07592 49 00402 T8360
07604 24 19160 19120
07616 47 07660 01100
07628 26 19160 19120
07640 22 19160 18360
07652 49 07696 00000
07660
07660 16 00469 07695
```

```
04000A10190    FD    ACC,18070,

04010          TF    ACC,99,
04020A10200    FM    ACC,18350,

04030          TF    ACC,99,
04040A10210    FA    ACC,18350,

04050A10220    TF    18370,ACC,
04060A10230    B     A09540,
04070          DORG  *-3,
04080A10240    TF    ACC,ZERO,
04090          S     ACC,18340,
04100A10250    TF    18920,ACC,
04110A10260    TF    ACC,ZERO,
04120          S     ACC,18920,
04130A10270    FD    ACC,18320,

04140          TF    ACC,99,
04150A10280    TF    18910,ACC,
04160A10290    TF    ACC,19120,
04170A10300    TF    18950,ACC,
04180A10310    TF    18960,ACC,
04190A10320    TF    18970,ACC,
04200A10330    TF    18340,ACC,
04210A10340    TF    18350,ACC,
04220A10350    TF    ACC,ZERO,
```



```
07672 16 00445 T9160
07684 49 00422 T8340
07696 16 00469 07731
07708 26 01260 19160
07720 49 01422 T8070
07732 26 19160 00099
07744 16 00469 07779
07756 26 01260 19160
07768 49 01262 T8350
07780 26 19160 00099
07792 16 00469 07827
07804 16 00445 T9160
07816 49 00422 T8350
07828 26 18370 19160
07840 49 05652 00000
07848
07848 26 19160 19120
07860 22 19160 18340
07872 26 18920 19160
07884 26 19160 19120
07896 22 19160 18920
07908 16 00469 07943
07920 26 01260 19160
07932 49 01422 T8320
07944 26 19160 00099
07956 26 18910 19160
07968 26 19160 19120
07980 26 18950 19160
07992 26 18960 19160
08004 26 18970 19160
08016 26 18340 19160
08028 26 18350 19160
08040 26 19160 19120
```

```
04230          TFM   *+35,18200,
04240          A     *+23,WB2,
04250          S     ACC,00000,
04260A10360    FM    ACC,17960,

04270          TF    ACC,99,
04280A10370    TFM   *+59,18100,
04290          A     *+47,WB2,
04300          FS    ACC,

04310A10380    TF    18930,ACC,
04320A10390    TFM   *+30,18100,
04330          A     *+18,WB2,
04340          TF    ,ACC,
04350A10400    TF    ACC,18910,
04360A10410    TFM   *+30,18200,
04370          A     *+18,WB2,
04380          TF    ,ACC,
04390A10420    FA    ACC,18930,

04400A10430    FA    ACC,18300,

04410A10440    TF    18300,ACC,
04420A10450    FA    ACC,18010,

04430A10460    TF    18940,ACC,
04440A10470    B     A10670,
04450          DORG  *-3,
```



```
08052 16 08087 T8200
08064 21 08087 09255
08076 22 19160 00000
08088 16 00469 08123
08100 26 01260 19160
08112 49 01262 T7960
08124 26 19160 00099
08136 16 08195 T8100
08148 21 08195 09255
08160 16 00469 08195
08172 16 00445 T9160
08184 49 00402 00000
08196 26 18930 19160
08208 16 08238 T8100
08220 21 08238 09255
08232 26 00000 19160
08244 26 19160 18910
08256 16 08286 T8200
08268 21 08286 09255
08280 26 00000 19160
08292 16 00469 08327
08304 16 00445 T9160
08316 49 00422 T8930
08328 16 00469 08363
08340 16 00445 T9160
08352 49 00422 T8300
08364 26 18300 19160
08376 16 00469 08411
08388 16 00445 T9160
08400 49 00422 T8010
08412 26 18940 19160
08424 49 08764 00000
08432
```

```
04460A10480    FS    ACC,18360,

04470A10490    C     ACC,ZERO
04480          BNP   A10240,
04490A10500    TF    ACC,19120,
04500A10510    TF    18910,ACC,
04510A10520    TF    18920,ACC,
04520A10530    B     A10300,
04530          DORG  *-3,
04540A10540    TF    ACC,18930,
04550A10550    TFM   *+30,18100,
04560          A     *+18,WB2,
04570          TF    ,ACC,
04580A10560    TF    ACC,18910,
04590A10570    TFM   *+30,18200,
04600          A     *+18,WB2,
04610          TF    ,ACC,
04620A10580    TF    ACC,18400,
04630A10590    TF    18300,ACC,
04640A10600    FA    ACC,18010,

04650A10610    TF    18940,ACC,
04660A10620    TF    ACC,18960,
04670A10630    TF    18340,ACC,
04680A10640    TF    ACC,18380,
04690A10650    TF    18970,ACC,
04700A10660    TF    18350,ACC,
04710A10670    A     WB2,WD2,
04720          C     WL2,WB2,
04730          BL    *+20,
04740          B     A10690,
```



```
08432 16 00469 08467
08444 16 00445 T9160
08456 49 00402 T8360
08468 24 19160 19120
08480 47 07848 01100
08492 26 19160 19120
08504 26 18910 19160
08516 26 18920 19160
08528 49 07980 00000
08536
08536 26 19160 18930
08548 16 08578 T8100
08560 21 08578 09255
08572 26 00000 19160
08584 26 19160 18910
08596 16 08626 T8200
08608 21 08626 09255
08620 26 00000 19160
08632 26 19160 18400
08644 26 18300 19160
08656 16 00469 08691
08668 16 00445 T9160
08680 49 00422 T8010
08692 26 18940 19160
08704 26 19160 18960
08716 26 18340 19160
08728 26 19160 18380
08740 26 18970 19160
08752 26 18350 19160
08764 21 09255 09260
08776 24 09265 09255
08788 47 08808 01300
08800 49 08820 00000
```

```
04750          DORG *-3,
04760A10680 TFM  WB2,00000,
04770A10690 TFM  WB1,00000,
04780A10700 TFM  WL1,00040,
04790A10710 TFM  SF+11,703,811,
04800          TFM  *+35,18900,
04810          A    *+23,WB1,
04820          BT   TYPED,00000,
04830          TBTY
04840A10720 A    WB1,WD1,
04850          C    WL1,WB1,
04860          BL   *+20,
04870          B    A10710,
04880          DORG *-3,
04890A10730 TFM  SF+11,701,811,
04900          BT   TYPED,18970,
04910          RCTY
04920A10740 BC1  A10760,
04930A10750 B    A09400,
04940          DORG *-3,
04950A10760 H
04960A10770 B    A09000,
04970          DORG *-3,
04980A10780 NOP
04990A10790 TF   ACC,19130,
05000A10800 FS   ACC,18060,

05010A10810 FD   18050,ACC,

05020          TF   ACC,99,
05030A10820 FM   ACC,18060,
```



```
08808
08808 16 09255 00000
08820 16 09240 00000
08832 16 09250 00060
08844 16 02331 00703
08856 16 08891 18900
08868 21 08891 09240
08880 27 02188 00000
08892 34 00000 00108
08904 21 09240 09245
08916 24 09250 09240
08928 47 08948 01300
08940 49 08844 00000
08948
08948 16 02331 00701
08960 27 02188 18970
08972 34 00000 00102
08984 46 09004 00100
08996 49 05244 00000
09004
09004 48 00000 00000
09016 49 04288 00000
09024
09024 41 00000 00000
09036 26 19160 19130
09048 16 00469 09083
09060 16 00445 19160
09072 49 00402 18060
09084 16 00469 09119
09096 26 01260 18050
09108 49 01422 19160
09120 26 19160 00099
09132 16 00469 09167
```

```
05040          TF   ACC,99,
05050A10830 FA   ACC,18050,
 09192 16 00445 19160

05060A10840 TF   18050,ACC,
05070A10850 B    A09110,
05080          DORG *-3,
05090          DC   10, 5450000000,17950
05100          DC   10, 5120000000,17960
05110          DC   10, 5110000000,17970
05120          DC   10, 4711809340,17980
05130          DC   10, 5232200000,17990
05140          DC   10, 0000000000,18000
05150          DC   10, 0000000000,18010
05160          DC   10, 0000000000,18020
05170          DC   10, 0000000000,18030
05180          DC   10, 0000000000,18040
05190          DC   10, 0000000000,18050
05200          DC   10, 0000000000,18060
05210          DC   10, 0000000000,18070
05220          DC   10, 0000000000,18080
05230          DC   10, 0000000000,18090
05240          DC   10, 0000000000,18100
05250          DC   10, 0000000000,18110
05260          DC   10, 0000000000,18120
05270          DC   10, 0000000000,18130
05280          DC   10, 0000000000,18140
05290          DC   10, 0000000000,18150
05300          DC   10, 0000000000,18160
05310          DC   10, 0000000000,18170
05320          DC   10, 0000000000,18180
```



```
09144 26 01260 19160
09156 49 01262 18060
09168 26 19160 00099
09180 16 00469 09215

09204 49 00422 18050
09216 26 18050 19160
09228 49 04572 00000
09236
17950 00010 5450000000
17960 00010 5120000000
17970 00010 5110000000
17980 00010 4711809340
17990 00010 5232200000
18000 00010 0000000000
18010 00010 0000000000
18020 00010 0000000000
18030 00010 0000000000
18040 00010 0000000000
18050 00010 0000000000
18060 00010 0000000000
18070 00010 0000000000
18080 00010 0000000000
18090 00010 0000000000
18100 00010 0000000000
18110 00010 0000000000
18120 00010 0000000000
18130 00010 0000000000
18140 00010 0000000000
18150 00010 0000000000
18160 00010 0000000000
18170 00010 0000000000
18180 00010 0000000000
```

```
05330    DC   10, 0000000000,18190
05340    DC   10, 0000000000,18200
05350    DC   10, 0000000000,18210
05360    DC   10, 0000000000,18220
05370    DC   10, 0000000000,18230
05380    DC   10, 0000000000,18240
05390    DC   10, 0000000000,18250
05400    DC   10, 0000000000,18260
05410    DC   10, 0000000000,18270
05420    DC   10, 0000000000,18280
05430    DC   10, 0000000000,18290
05440    DC   10, 0000000000,18300
05450    DC   10, 0000000000,18310
05460    DC   10, 0000000000,18320
05470    DC   10, 0000000000,18330
05480    DC   10, 0000000000,18340
05490    DC   10, 0000000000,18350
05500    DC   10, 0000000000,18360
05510    DC   10, 0000000000,18370
05520    DC   10, 0000000000,18380
05530    DC   10, 0000000000,18390
05540    DC   10, 0000000000,18400
05550    DC   10, 0000000000,18410
05560    DC   10, 0000000000,18420
05570    DC   10, 0000000000,18430
05580    DC   10, 0000000000,18440
05590    DC   10, 0000000000,18450
05600    DC   10, 0000000000,18460
05610    DC   10, 0000000000,18470
05620    DC   10, 0000000000,18480
05630    DC   10, 0000000000,18490
05640    DC   10, 0000000000,18500
05650    DC   10, 0000000000,18510
```

```
18190 00010 0000000000
18200 00010 0000000000
18210 00010 0000000000
18220 00010 0000000000
18230 00010 0000000000
18240 00010 0000000000
18250 00010 0000000000
18260 00010 0000000000
18270 00010 0000000000
18280 00010 0000000000
18290 00010 0000000000
18300 00010 0000000000
18310 00010 0000000000
18320 00010 0000000000
18330 00010 0000000000
18340 00010 0000000000
18350 00010 0000000000
18360 00010 0000000000
18370 00010 0000000000
18380 00010 0000000000
18390 00010 0000000000
18400 00010 0000000000
18410 00010 0000000000
18420 00010 0000000000
18430 00010 0000000000
18440 00010 0000000000
18450 00010 0000000000
18460 00010 0000000000
18470 00010 0000000000
18480 00010 0000000000
18490 00010 0000000000
18500 00010 0000000000
18510 00010 0000000000
```



```
05660    DC   10, 0000000000,18520
05670    DC   10, 0000000000,18530
05680    DC   10, 0000000000,18540
05690    DC   10, 0000000000,18550
05700    DC   10, 0000000000,18560
05710    DC   10, 0000000000,18570
05720    DC   10, 0000000000,18580
05730    DC   10, 0000000000,18590
05740    DC   10, 0000000000,18600
05750    DC   10, 0000000000,18610
05760    DC   10, 0000000000,18620
05770    DC   10, 0000000000,18630
05780    DC   10, 0000000000,18640
05790    DC   10, 0000000000,18650
05800    DC   10, 0000000000,18660
05810    DC   10, 0000000000,18670
05820    DC   10, 0000000000,18680
05830    DC   10, 0000000000,18690
05840    DC   10, 0000000000,18700
05850    DC   10, 0000000000,18710
05860    DC   10, 0000000000,18720
05870    DC   10, 0000000000,18730
05880    DC   10, 0000000000,18740
05890    DC   10, 0000000000,18750
05900    DC   10, 0000000000,18760
05910    DC   10, 0000000000,18770
05920    DC   10, 0000000000,18780
05930    DC   10, 0000000000,18790
05940    DC   10, 0000000000,18800
05950    DC   10, 0000000000,18810
05960    DC   10, 0000000000,18820
05970    DC   10, 0000000000,18830
05980    DC   10, 0000000000,18840
```

```
18520 00010 0000000000
18530 00010 0000000000
18540 00010 0000000000
18550 00010 0000000000
18560 00010 0000000000
18570 00010 0000000000
18580 00010 0000000000
18590 00010 0000000000
18600 00010 0000000000
18610 00010 0000000000
18620 00010 0000000000
18630 00010 0000000000
18640 00010 0000000000
18650 00010 0000000000
18660 00010 0000000000
18670 00010 0000000000
18680 00010 0000000000
18690 00010 0000000000
18700 00010 0000000000
18710 00010 0000000000
18720 00010 0000000000
18730 00010 0000000000
18740 00010 0000000000
18750 00010 0000000000
18760 00010 0000000000
18770 00010 0000000000
18780 00010 0000000000
18790 00010 0000000000
18800 00010 0000000000
18810 00010 0000000000
18820 00010 0000000000
18830 00010 0000000000
18840 00010 0000000000
```

```
05990        DC    10, 0000000000,18850
06000        DC    10, 0000000000,18860
06010        DC    10, 0000000000,18870
06020        DC    10, 0000000000,18880
06030        DC    10, 0000000000,18890
06040        DC    10, 0000000000,18900
06050        DC    10, 0000000000,18910
06060        DC    10, 0000000000,18920
06070        DC    10, 0000000000,18930
06080        DC    10, 0000000000,18940
06090        DC    10, 0000000000,18950
06100        DC    10, 0000000000,18960
06110        DC    10, 0000000000,18970
06120        DC    10, 0000000000,18980
06130        DC    10, 0000000000,18990
06140WB1     DC    5,0,
06150WD1     DC    5,0,
06160WL1     DC    5,0,
06170WB2     DC    5,0,
06180WD2     DC    5,0,
06190WL2     DC    5,0,
06200        DEND  A09000-24,
LOAD SUBROUTINES
END OF PASSII
```

```
18850 00010  0000000000
18860 00010  0000000000
18870 00010  0000000000
18880 00010  0000000000
18890 00010  0000000000
18900 00010  0000000000
18910 00010  0000000000
18920 00010  0000000000
18930 00010  0000000000
18940 00010  0000000000
18950 00010  0000000000
18960 00010  0000000000
18970 00010  0000000000
18980 00010  0000000000
18990 00010  0000000000
09240 00005  00000
09245 00005  00000
09250 00005  00000
09255 00005  00000
09260 00005  00000
09265 00005  00000
04264
```



```
WATER HAMMER
DISCHARGE   200      200.000
HEAD        100      100.000
C.S.AREA    19‡66     19.660
LENGTH      2900     2900.000
VELOCITY    3196     3196.000
T(1)        5        5.000
RATIO       ‡5        .500
T(2)        15       15.000
```

.000	.000	.000	.000	100.000	1.000	10.172	200.0
.453	16.931	.170-	.000	116.931	.909	10.002	196.6
.907	21.250	.214-	.000	138.182	.818	9.788	192.4
1.361	27.018	.272-	.000	165.201	.727	9.516	187.0
1.814	34.711	.350-	.000	200.013	.637	9.165	180.1
2.268	67.152	.676-	33.863-	233.301	.546	8.488	166.8
2.722	58.004	.584-	42.501-	248.804	.492	7.904	155.3
3.175	42.332	.426-	54.036-	237.100	.477	7.477	147.0
3.629	51.455	.518-	69.623-	218.932	.462	6.959	136.8
4.083	70.296	.708-	100.441-	188.788	.447	6.251	122.9
4.536	53.550	.539-	73.507-	168.831	.432	5.711	112.2
4.990	26.546	.267-	30.629-	164.748	.416	5.444	107.0
5.444	28.022	.282-	33.287-	159.482	.401	5.161	101.4
5.897	31.988	.322-	40.151-	151.319	.386	4.839	95.1
6.351	27.763	.279-	33.594-	145.489	.371	4.559	89.6
6.805	20.858	.210-	22.463-	143.884	.356	4.349	85.5
7.259	20.943	.211-	22.756-	142.070	.341	4.138	81.3
7.712	21.479	.216-	23.825-	139.724	.326	3.922	77.1
8.166	20.267	.204-	21.933-	138.058	.311	3.718	73.0
8.620	18.672	.188-	19.253-	137.477	.295	3.529	69.3
9.073	18.547	.186-	19.129-	136.895	.280	3.343	65.7
9.527	18.543	.186-	19.132-	136.305	.265	3.156	62.0
9.981	18.230	.183-	18.601-	135.934	.250	2.972	58.4
10.434	17.948	.180-	18.091-	135.791	.235	2.791	54.8
10.888	17.877	.180-	17.964-	135.704	.220	2.611	51.3
11.342	17.866	.180-	17.953-	135.617	.205	2.431	47.8
11.795	17.817	.179-	17.858-	135.575	.190	2.252	44.2
12.249	17.791	.179-	17.806-	135.560	.175	2.072	40.7
12.703	17.783	.179-	17.790-	135.553	.159	1.893	37.2
13.157	17.778	.179-	17.778-	135.553	.144	1.714	33.7
13.610	17.777	.179-	17.775-	135.555	.129	1.535	30.1
14.064	17.778	.179-	17.776-	135.557	.114	1.356	26.6
14.518	17.779	.179-	17.776-	135.559	.099	1.177	23.1
14.971	17.781	.179-	17.778-	135.562	.084	.998	19.6
15.425	17.774	.179-	17.779-	135.557	.069	.819	16.1
15.879	17.778	.179-	17.780-	135.556	.054	.639	12.5
16.332	17.779	.179-	17.781-	135.553	.038	.460	9.0
16.786	17.781	.179-	17.784-	135.550	.023	.281	5.5
17.240	17.776	.179-	17.768-	135.558	.008	.102	2.0
17.693	10.175	.102-	17.777-	127.956	.000	.000	.0
18.147	.000	.000	17.776-	110.179	.000	.000	.0
18.601	.000	.000	17.778-	92.401	.000	.000	.0
19.055	.000	.000	17.784-	74.616	.000	.000	.0
19.508	.000	.000	2.573-	72.043	.000	.000	.0
19.962	.000	.000	17.776	89.820	.000	.000	.0
20.416	.000	.000	17.778	107.598	.000	.000	.0