INLAND WATERS BRANCH

Digitizing Hydrographs and Barographs

T. W. MAXIM AND J. A. GILLILAND

TECHNICAL BULLETIN No. 15

DEPARTMENT OF ENERGY,
MINES AND RESOURCES

CANADA

TECHNICAL BULLETIN No. 15

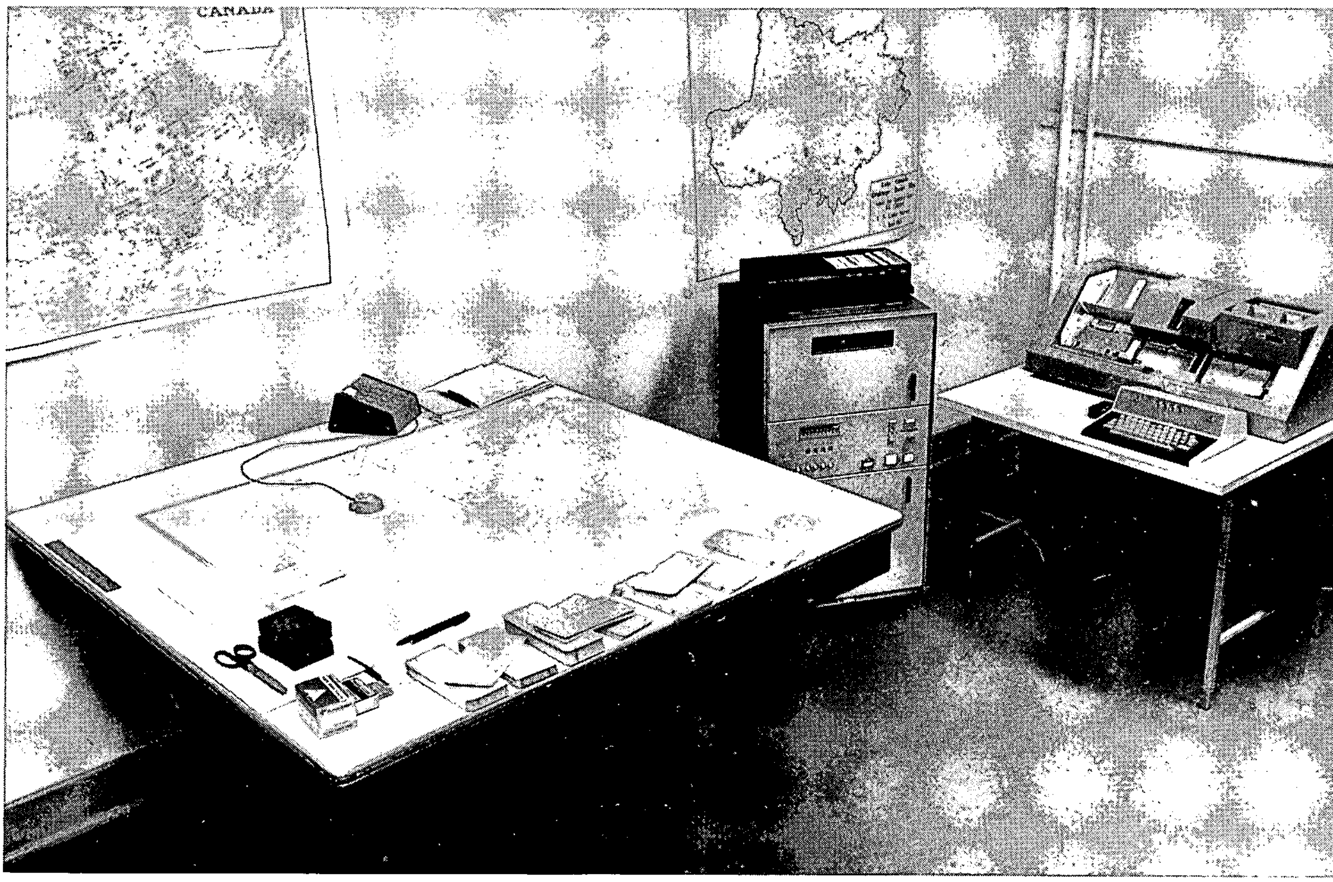
Digitizing Hydrographs and Barographs

T. W. MAXIM AND J. A. GILLILAND

INLAND WATERS BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES
OTTAWA, CANADA, 1969

Contents

ILLUSTRATIONS



Frontispiece - D-Mac Pencil Follower with console and key punch

Coding Hydrographs

MARKING HYDROGRAPH CHARTS

General

Several operations are required to be made both before and after the actual process of digitizing is performed. End points and other control data must be coded before digitizing. After the digitizing is performed, the IBM cards onto which the data were transferred must be correctly sorted and filed.

Each hydrograph chart must be oriented in the correct position. For example, consider a hydrograph chart beginning on February 27 and ending on March 3. The time readings should increase from left to right (Figure 2).

The information usually indicated on an hydrograph is as follows: the curve itself, the data, the time and the water level; when the recorder begins to plot the curve and when the chart is removed. If any of these data are not recorded on the chart they must be obtained from another source. Note that a decrease in water level reading indicates that the water level in the well is rising as shown in Figure 1.

To mark up hydrograph charts it is convenient to use felt-tip pens with colours of red, blue and green. Red is used to mark the beginning and ending points of the curve and to write the beginning and ending dates and water levels. Green is used to mark the control points on the chart, and blue to number the charts 1, 2, etc. and indicate the "up" direction on the chart. The "up" direction on the chart refers to the direction in which the line would move if the water level were rising.

Dates on the hydrograph are coded in the following manner.

Example: 6802271605;

68 refers to the year
02 the month of the year
27 the day of the month
1605 the time in the 2400-hour system

The following steps should be followed when coding the control data:

Step 1 - Ensure that the hydrographs are in correct order.
Step 2 - Number the hydrographs, page 1, page 2, etc., in blue.
Step 3 - Mark an arrow to indicate the "up" direction, in blue.
Step 4 - Mark the beginning and ending points of the curve with an "x" in red. Write the beginning and ending dates. Also write the beginning and ending water levels.
Step 5 - Mark the control points in green.
Step 6 - Place the necessary information on the coding sheet.

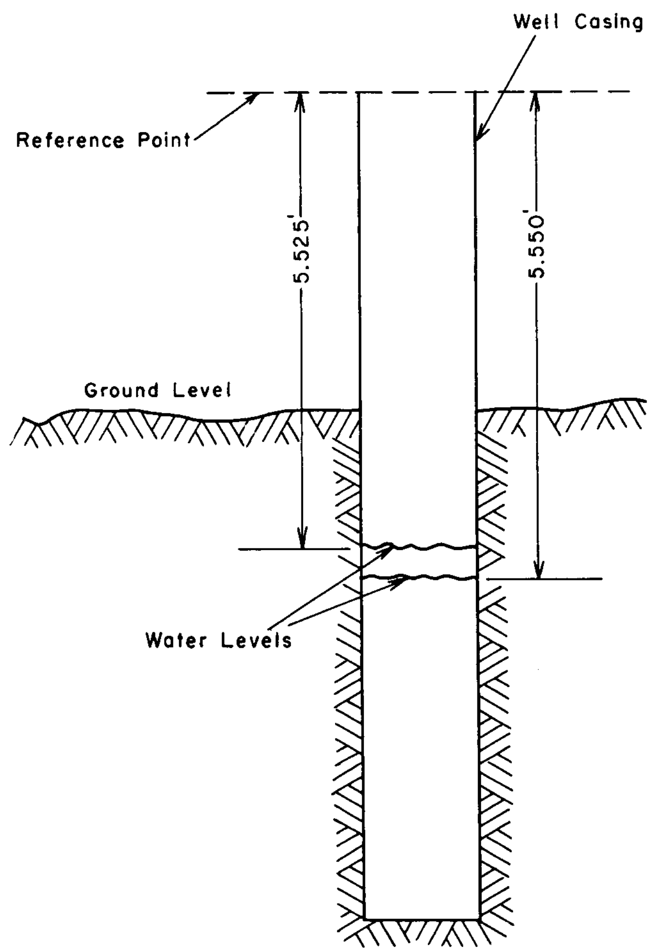


Figure 1. Cross section of an observation well

Refer to Figure 2.

The water level at February 27 is 5.55 feet. The date is 6802271605. At the end of the graph the footage is determined by finding the

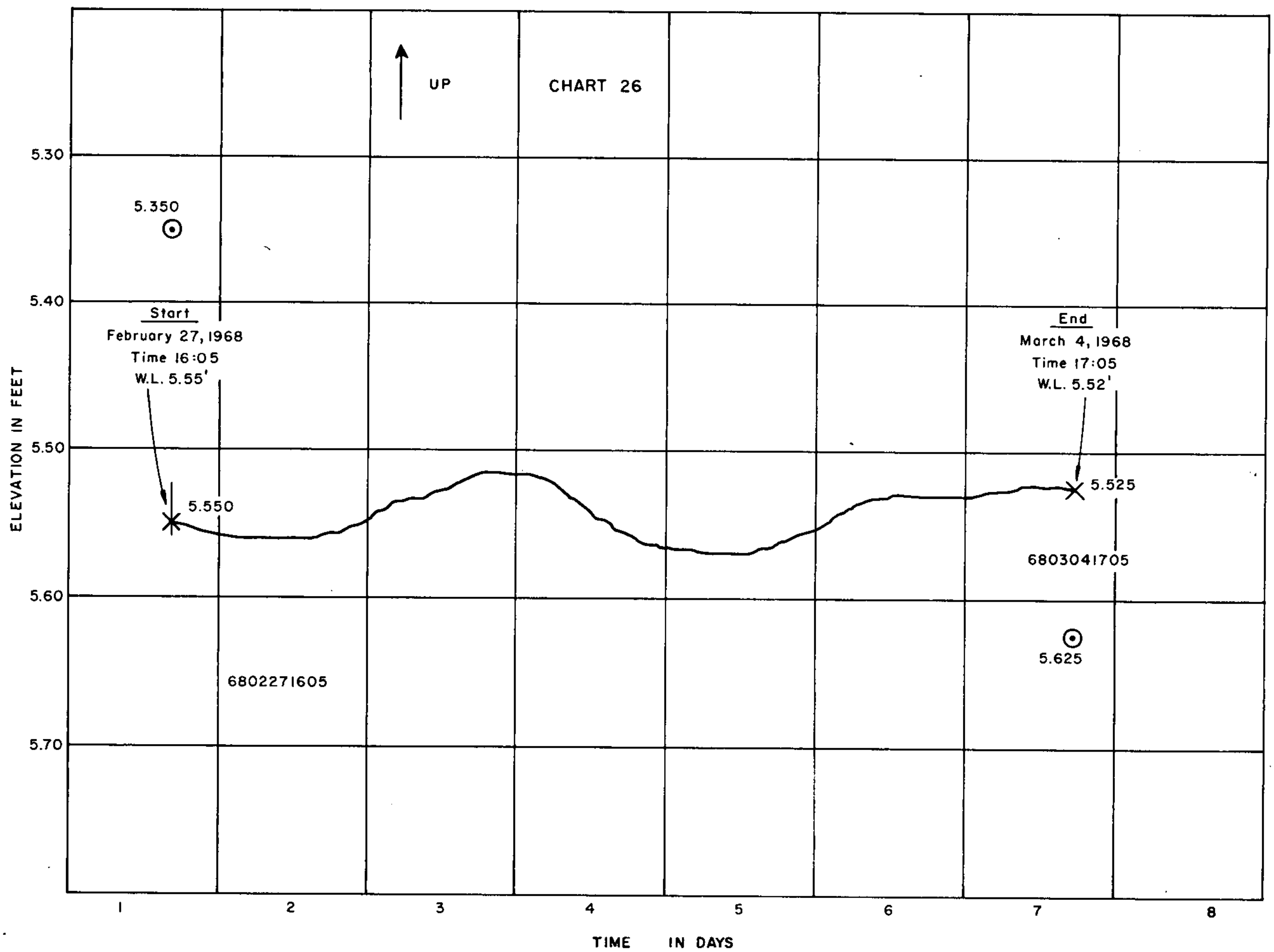


Figure 2. Example of a hydrograph chart

difference in the number of divisions between the beginning and ending levels of the curve.

For the purpose of digitizing, the observer's measured water levels are ignored. If a gap should occur, the starting water level is assumed to be the level that the observer measured, and subsequent levels are determined by measured differences on the chart.

Gaps and Control Points

Definition: "Gap" is a term applied to data that are missing for any reason; gaps may also be used to omit data which cannot be interpreted.

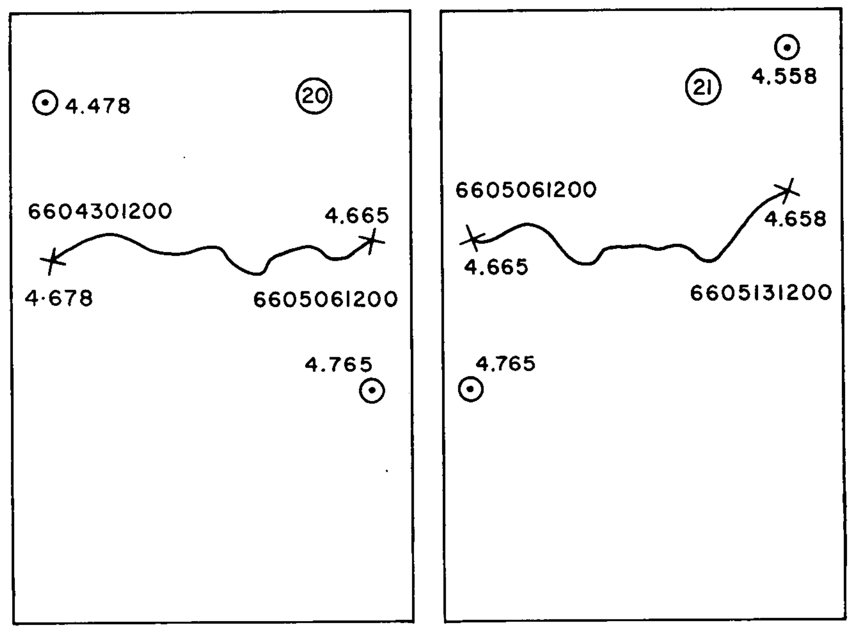
Definition: A Control Point is a level marked on the hydrograph chart by the individual who is coding the hydrographs.

A control point is placed vertically above and below the beginning and ending point of the curve. Control points are necessary on every hydrograph chart. In Figure 2, 5.350 and 5.625 are the control points. One control point is always below the curve and the other is always above the curve. Control points allow the alignment of the chart vertically and horizontally. This enables the computer program to convert from the arbitrary coordinates of the pencil follower to the correct water level versus time coordinate system. The control points must be correctly assigned.

Consider two charts, say numbers 20 and 21 in Figure 3. Notice that the control points at the junction point of the two charts are identical. If a gap occurs, then the control points at a junction will be different both in water level and time.

Figure 4 shows how a gap is handled. The curve from February 25 on, appears as a straight line. Either the chart is caught or the well is frozen and the data in this interval should be omitted. The time scale is 2 hours per small division, so that the end point for the curve can be determined as shown on Figure 4.

Figure 3. Two marked up hydrograph charts in correct time sequence



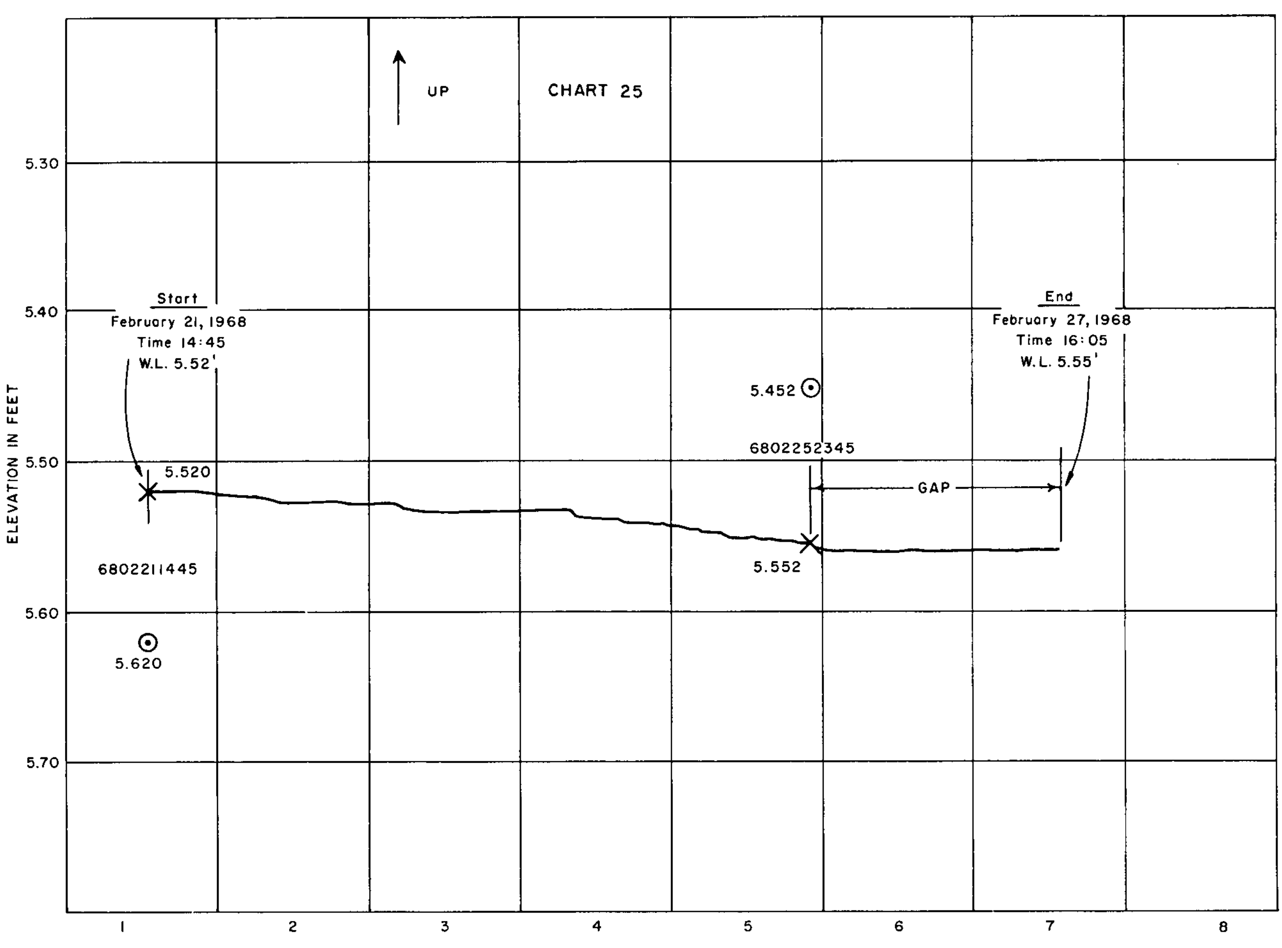


Figure 4. An example of a hydrograph chart

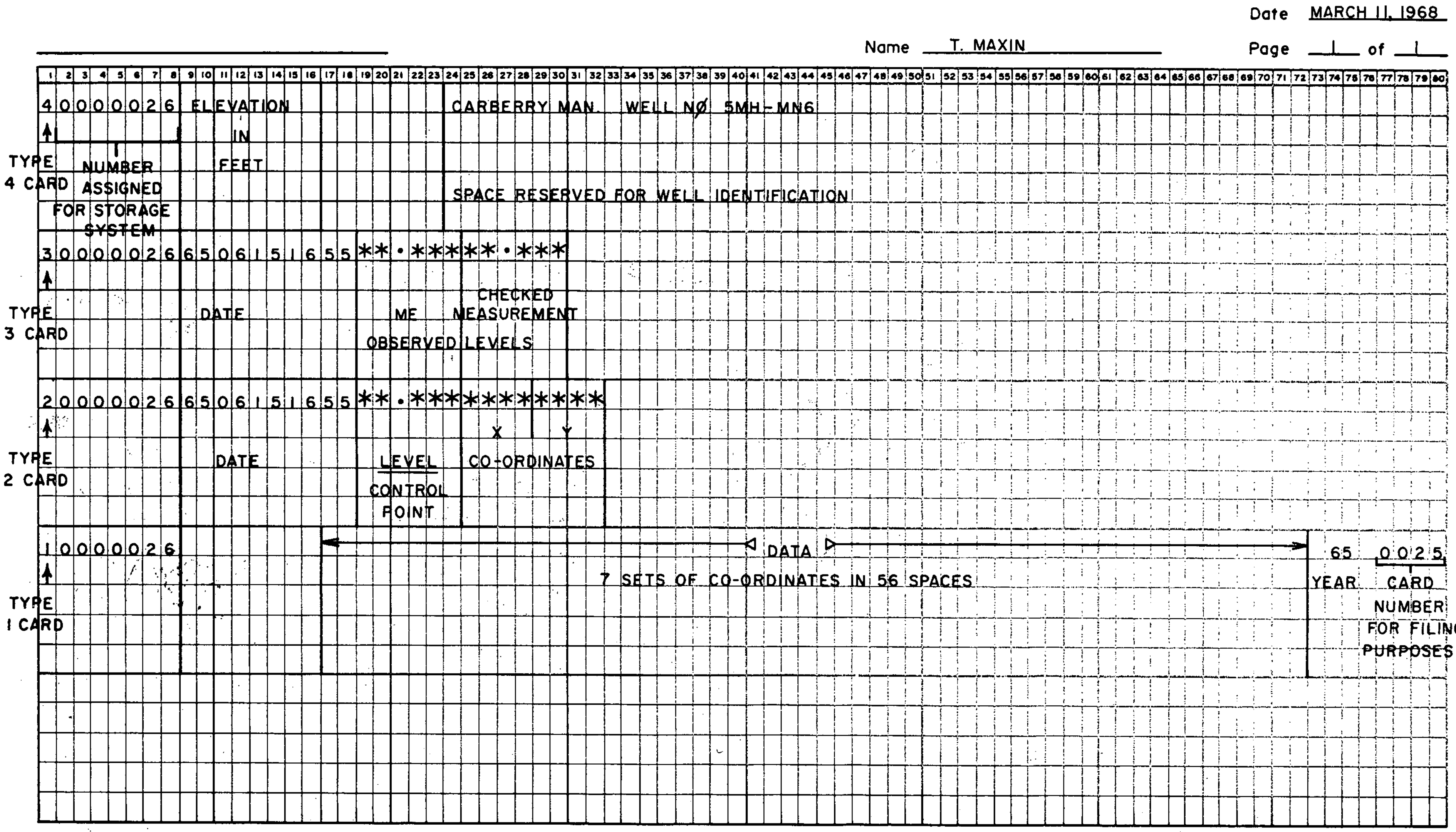
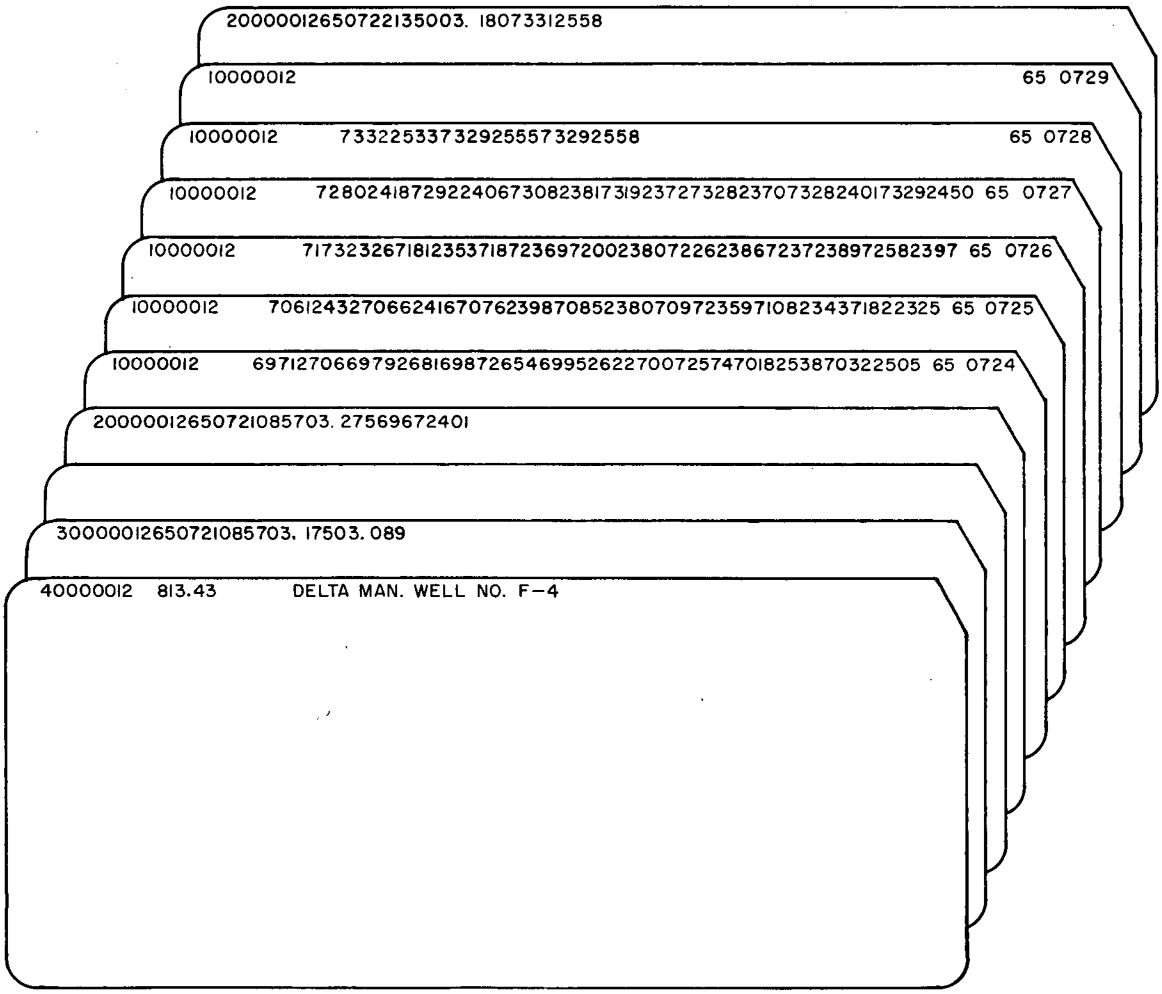


Figure 5. Formats for four card types



NOTE: A blank card must follow the last Type 3 card in the Data Deck

Figure 6. A sample data deck

CARD TYPES

General

Four different card types are required for computer processing of the hydrograph data. These four cards are termed Type 1, Type 2, Type 3 and Type 4.

Figure 5 shows the four card types. Column 1 in all four types is reserved for identifying the card type. The number in columns 2 to 8 inclusive is identical in all four card types. In Figure 5 the number 0000026 is the number assigned to a particular well, so that all data relating to this well will be indexed with this number. Whenever additional data from the same well are to be stored, they will be stored with the appropriate existing data.

Card Type 4 and Type 3

One card of Type 4 is always placed at the beginning of a data deck. Cards of Type 3 have a special purpose and are used as a method of applying corrections. As shown in Figure 5, columns 9 - 18 contain the date/time at which the correction applies. Columns 19 to 24 contain the level measured on the hydrograph chart, and columns 25 to 30 contain the true level (the check measurement). If a reliable check measurement is made at a well during a particular week and if it differs from the measurement obtained from the hydrograph charts, then a card Type 3 can be inserted to correct either the whole hydrograph or a portion of it. If correction is desired for only one hydrograph chart, then two cards of Type 3 are necessary, the first must have the date, time and water level corresponding to the beginning date of the hydrograph chart and the second must contain a date, time and water level corresponding to the end of the chart.

Card Type 2

Card Type 2 is called the control card. When a chart is digitized, a control card must be inserted before the data deck of the digitized hydrograph chart, and another inserted after the data deck. The data on the first control card must correspond to the date at which the chart begins, and the level punched on the control card must be the level of the control point. The X-Y coordinates of the control point as indicated by the D-Mac pencil follower are punched last. The second control card must correspond to the ending date of the hydrograph chart, the level of the ending control point, and the corresponding X-Y coordinates of that ending control point (see Figure 5).

Card Type 1 and Sample Data Deck

Figure 6 shows an example of a data deck. Note the card preceding the last card in the data deck, is called a "skip card" and must always be present at the end of a data deck of a digitized hydrograph chart. This card indicates that there are no more digitized data from this chart, and that a control card should follow it.

The next digitized hydrograph chart is placed behind the data deck shown in Figure 6 with its beginning and ending control cards. Note that every digitized hydrograph chart must have two control cards and that all Type 3 cards must follow the Type 4 card in the data deck.

The Type 1 card contains the digitized data of the analogue curve. There are 7 sets of X-Y coordinates per card (see Figure 6). As shown on card number 0724, the X and Y coordinates both comprise four digits. These digits are punched by the key-punch when the pencil-follower control button on the stylus or "bug" is depressed.

Time Factor

Important: All dates in digitized hydrographs and barographs must be in standard time. Thus, it is necessary to make the proper corrections of all times during the summer months when Daylight Saving Time is in effect.

Section 2

Digitizing

THE DIGITIZER

The digitizer consists of two main units: the pencil follower and an output device, the IBM 026 key-punch. The D-Mac Pencil Follower Type PF 10000 consists of two units: the reading table and the Electronic Console (readout panel).

The reading table is approximately 4-1/3 feet long by 2-1/2 feet wide. On the table, a rectangle is distinctly marked by four black lines. Hydrograph charts that are to be digitized must be confined within the area of the rectangle. In the X coordinate direction, the table is dimensioned from 0000 to 9999 and in the Y coordinate direction, the table is dimensioned from 0000 to 4750. Each increment of X or Y is equal to 0.1 mm. (see Figure 7).

THE STYLUS

The stylus (or "bug") is a small tracking device used to trace the curve. The "bug" consists of cross-hairs mounted in a small frame to which is attached the trigger button. If the "bug" is placed anywhere within the rectangle and the trigger button depressed, the key-punch will punch out the coordinates of that particular point onto the IBM computer card.

The "bug" is connected to the reading table and a follower inside the reading table signals the position of "bug" on the table, this position is displayed on the console. The console also converts the position signals to a suitable form to feed the output device which in this case is the 026 key-punch. Whenever a reading is taken, the display indicators are frozen until the co-ordinate position on the reading table has been transferred onto the computer card.

Important: The "bug" must slide on the surface of the table; do not lift it off the table surface and move it or the "following" action will be lost. Always be sure that the "bug" is working properly by moving it over the surface of the

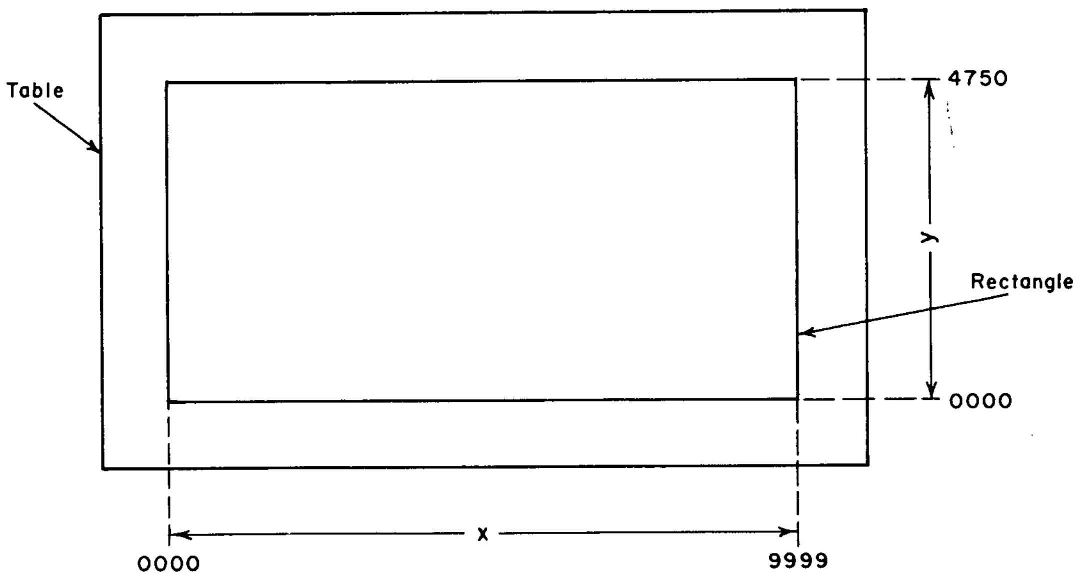


Figure 7. Coordinate range of the pencil follower reading table

plastic which covers the hydrograph charts. If the "bug" has not engaged the follower inside the table, a white spot of light will appear at the upper part of the table. If the "bug" is engaged properly, the X-Y coordinates on the readout panel will change as the "bug" is moved.

In addition to the trigger button there is a foot pedal which may be used as an alternative to trigger the digitizer.

LINE/POSITION SWITCH

A two-position switch allows the operator to use either the "Line" mode of operation or the "Position" mode of operation. If the switch is in the "Position" mode and the button on the tracking "bug" is depressed, the digitizer will take the co-ordinates of that point once and only once. In the "Line" mode of operation, the digitizer will take readings at a set time interval governed by the setting on a readout rate potentiometer (electronic timer) for as long as the trigger button is depressed. In the "Line" mode the "bug" must be moved along the chart continuously while the trigger button is depressed.

It is left to the discretion of the operator as to which mode of operation is used. The "Position" mode of operation, however, is mandatory if coordinates at set time intervals on hydrograph charts are required.

DRUM CARD

The drum card fulfils an important part in the digitizer operation (Figure 8). This card programs the key-punch to duplicate from columns 1 to 15, skip column 16 and punch out 7 sets of X-Y coordinates from the pencil follower. After the year in which the data is from and the card number are punched, the computer card is released and another blank computer card is fed in and the process repeated.

LIMIT

The maximum number of data points is 350 sets of X-Y coordinates per chart. This is the equivalent to 50 cards including the skip card. The average number of cards for a hydrograph chart from a Stevens F-type recorder is about 25, depending on the amplitude of the water-level fluctuations.

DIGITIZING PROCEDURE

Here is a step by step approach to digitizing:

Step 1 - Switch on the key-punch. Press the POWER switch on the Electronic Console and then the RESET switch.

Step 2 - Insert the drum card on the drum and replace the drum in the key-punch. Put the key-punch on automatic feed and automatic duplication.

Step 3 - On the Electronic Console, set the year that the data refer to, say 65, i.e. the year 1965, and also an arbitrary card number.

Step 4 - Select the "line/position" mode of operation on the Electronic Console.

Step 5 - Punch out a one in column 1 to indicate card type 1 and the identification number, say 0000012, in columns 2 to 8. Engage the drum by means of the switch located underneath the drum. Make sure there are sufficient cards in the card hopper.

Step 6 - Press the release button on the key-punch. This will release the card already punched and duplicate the number 10000012 onto the next card. At the end of each card, the year will be punched in columns 74 and 75 and the card number in columns 77 to 80 inclusive. Discard the first card.

Step 7 - Insert the hydrograph charts under the clear plastic within the confines of the rectangle. Align the charts by eye to coincide approximately with the pencil follower axis. There is sufficient room to accommodate three hydrograph charts side by side. Place the charts from left to right in the order they were coded to avoid later confusion. These charts must be secured to avoid any movement (e.g., by the use of masking tape).

Step 8 - Digitizing may now begin. Slide the "bug" onto the initial control point at the left of the graph. When the cross-hairs are directly above the control point, write the X-Y coordinates of that point in the appropriate place on your coding sheet.

Step 9 - Slide the "bug" to the red "X" which marks the beginning of the curve. Depress the trigger button on the "bug" to commence digitizing. When 7 sets of coordinates, the year and the card number have been punched onto the computer card, the computer card is released, a new card is fed into the key-punch and the process continued.

Step 10 - When the operator reaches the end of the curve, he must move the "bug" to the ending control point and write the X-Y coordinates of that control point on the coding sheet. After this is done, the operator must depress the skip button on the key-punch twice. In Figure 6, the last card in the data deck was not completed because it has only three sets of X-Y coordinates on it. Notice that the following card has no data on it. It is called a "skip" card and one skip card must follow the end of the digitized hydrograph chart.

Step 11 - The procedure is repeated from Step 8 on, for each succeeding chart. To stop digitizing, shut off the pencil follower by pressing the POWER button. Disengage the drum on the key-punch by changing the drum switch to the OFF position and remove the drum card.

Step 12 - The operator must punch out the control cards from the coding sheet and then insert them into the Type 1 card data deck at the proper places. An example of a coding sheet is shown in Figure 9.

Step 13 - Place the digitized hydrograph data deck into the appropriate filing cabinet. It is convenient to use different coloured computer cards for each card types. Use one colour for Type 1 cards, a second colour for Type 2 (control) cards and so on. Cards corresponding to a particular hydrograph chart can then be easily located.

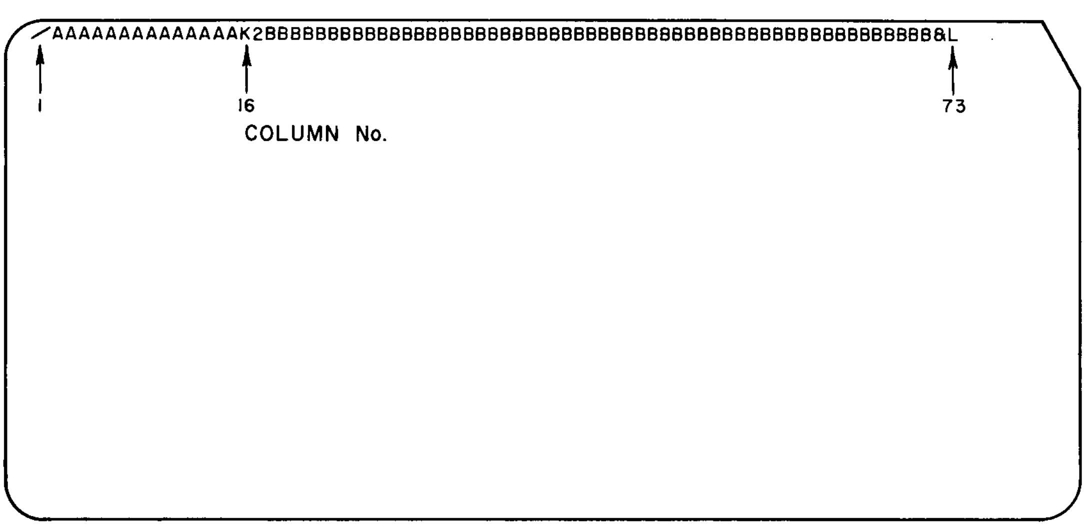


Figure 8. Drum card for the IBM 026 key punch

Date MARCH 11, 1968

Name T. MAXIN   Page 1 of 2

```
40000011  815.92        DELTA MAN.  WELL NØ E-I

20000011670621094505.76010702112
                         DATA
20000011670629093006.28531590831
20000011670629093006.28537940701
                          DATA
20000011670706130006.06559541374
20000011670706130006.06564972453
                           DATA
20000011670713100006.65586140659    ↓ start
20000011670713100006.65506371347    new
                           DATA
20000011670720124506.66027941293
20000011670720124506.66032862492
                           DATA
20000011670727101006.55053882856
20000011670727101006.55058722441
                           DATA
20000011670803131506.77580421739
20000011670803131506.77507782733
                           DATA
20000011670810082006.74028522837
20000011670810082006.74033342117
                           DATA
```

Figure 9. Sample hydrograph coding sheet

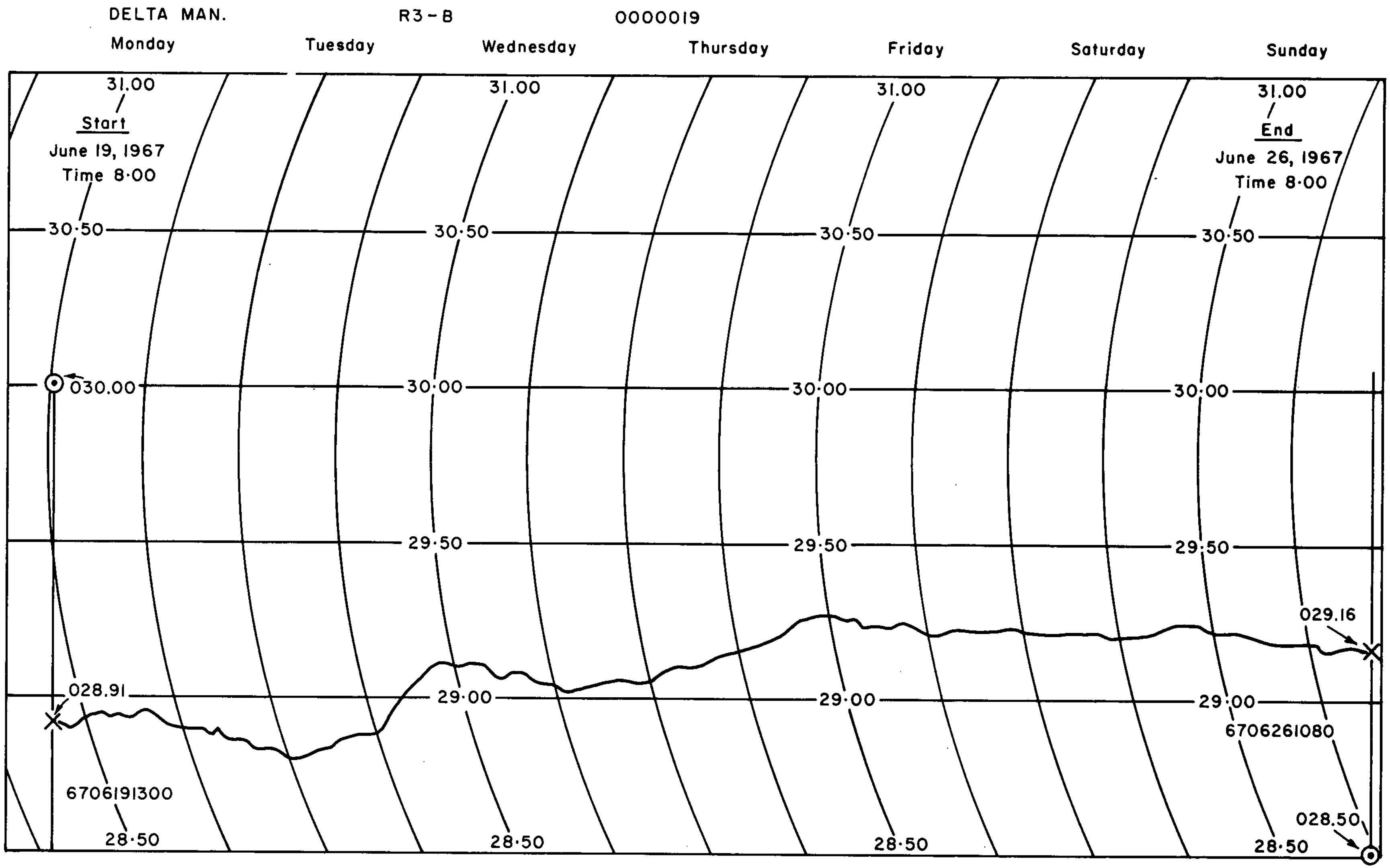


Figure 10. Chart of recording barometer

Coding Barographs

BAROGRAPH CHART STRUCTURE

A recording barometer produces barograph charts. Figure 10 is the chart of a Short and Mason "Micro-Barograph".

The procedure for coding barograph charts is similar to that for coding hydrograph charts with two exceptions. First, barograph charts have one curved axis and, second, barograph units are in millibars rather than feet of water.

PROJECTED TIME AND CARD TYPES

Since the barograph charts have one curved axis and the digitizer operates in rectangular coordinates only, it is necessary to calculate the time at the center of the chart. In Figure 10 the observer indicated that the recorder was put into operation at 0800 hours. A vertical line must therefore be projected through the starting point of the plotted curve until it intersects the center of the chart at 29.75 mb.

The time at the intersection of the vertical line and the center of the barograph chart will be the time which is used as the date of the control point at the beginning of the chart. The time at this intersection is 1300 hours. The control point must be marked on this vertical line and, in this particular case, it is assigned the value 030.00 mb.

The same procedure is followed in determining the ending time which is 1030 hours. The format for the control card (Type 2 card) is the same and the only difference is that the control point is 030.00 mb instead of, say, 05.658 feet. The control point 030.00 will be placed in the same columns as shown on the coding sheet of Figure 5 and only the decimal point will be shifted to the right by one column.

Type 4 cards in barograph charts are identical to those in hydrograph charts but no elevation is recorded. It is left blank.

The Type 1 card format is the same as for hydrograph charts.

The card Type 3, unlike card Type 2, does not use the projected vertical line time in the date when making a correction. The actual time is used. For example, perhaps a correction is necessary at the beginning of the chart in Figure 10. The date on the Type 3 card will be 6706190800. The time is taken from the intersection of the barometric curve and the curved axis time scale.

GENERAL

It is convenient to paste barograph charts together to make one smooth curve and so reduce the number of control points. This is done by matching the end of one chart exactly with the beginning of a second chart and thus producing a smooth curve for two weeks. The reading table is large enough to accommodate three charts. Thus, only two control points will be necessary instead of the six required if the charts were handled separately. This is assuming that there are no gaps in this 3-week period.

The limit on the number of cards between two control points is still 50. In digitizing barograph charts, it is strongly advised that the "Position" mode of operation of the digitizer be used.

Other procedures for digitizing barograph charts are the same as for digitizing hydrograph charts.

Data Processing

GENERAL

The purpose of digitizing hydrographs or any other time series is to convert the data into a form which is readily processable by a computer. Users of the procedures described in this report will generally require considerable volumes of data so that the standard medium on which the hydrographs are presented is magnetic tape.

The program is designed to run on the Department's CDC 3100 computer and the data are written on tape in the binary mode. The program used for conversion, TAPREP2, is written in FORTRAN IV (CDC version) and therefore cannot be directly used on other computers, although special CDC features such as EOFCKF and ENCODE/DECODE have been avoided. However, logical IF statements are used. A listing of TAPREP2, with subroutines is given in Appendix A.

TAPE FORMAT

The tape output by TAPREP2 is in the following format:

Record No.	Contents
1	Tape identification (fixed point)
2	Hydrograph/barograph identification (fixed point)
3	Hyd/bar ident (fixed point), elevation of measuring point (floating point)
4 - N	Hyd Id (fixed point), year (fixed point), minute (floating point), gauge height (floating point) x 18
N + 1	same as for 4th and subsequent records except that last fields with no data are filled with zeros.
N + 2	next hydrograph ID.
last record on tape	(0 0 0.0 0.0) x 18

Gaps within a particular hydrograph are signified by a value of -100 for the minute field of one time/water level recording.

INPUT TO TAPREP2

Digitized data may be input to TAPREP2 in three possible ways:

1. No existing tape,
2. Old tape exists, new data <u>are not</u> from a well already on tape,
3. Old tape exists, new data <u>are</u> from a well for which records already <u>exist</u> on the old tape.

In each case a new tape is produced, containing the old data, if any, and the new data are inserted at the appropriate point if it continues pre-existing data.

CARD SEQUENCES

1. No pre-existing tape. Only one hydrograph/barograph can be processed in any one run.

Card No.	Contents[1]	Format[2]
1	IBAROM, BARTIMF, BARPF, SENCHAR, PENRAD	120 (I5,4F5.0)
2	I, IDREEL (I = 2)	100 (I1,I7)
3	Card type 4*	110 (I1,I7,F8.3)
4 - K	Card type 3*	103 (I1,I7,5I2,2F6.3)
K + 1	blank	
K + 2	Card type 2*	107 (I1,I7,5I2,F6.3,2F4.0)
K + 3 - N	Card type 1*	111 (I1,I7,8X,14F4.0)
N + 1	Card type 2	107

At the end of a set of hydrograph data, place two blank cards after last card type 2.

1. Variable names correspond to those in the program listing.
2. Format numbers are statement numbers and correspond to FORMAT statements in the program listing.

* See Figure 7.

2. Old tape exists. New data are not from a well already on tape. Only one hydrograph/ barograph can be processed in any one run. Card sequence is same as for 1 above except that on card 2, I = 1, and a blank card must be inserted between cards 2 and 3.

3. Old tape exists, new data are from a well or wells for which data already exist on old tape. Any number of hydrographs can be processed in one run, as long as the card data are presented in the same order as the wells on the tape, and data exist for all wells.

   Card sequence, same as for 1 above except that on card 2, I = 1, and between cards 2 and 3 must be inserted a card containing IDADD in format 130. Each set of hydrograph data is finished with one blank card, then the next IDADD. IDADD is the identification of the hydrograph or barograph to which data are being added. The last set of hydrograph data is followed by one blank card, then a card with "5" in col. 1, then another blank card.

OPERATION OF THE PROGRAM

Using the control points the program calculates the time/water level values for each point digitized, correcting for non-parallelism of digitizer and chart axis, curved axis on barographs and incorrect chart-time scaling. The computed values are checked against the observed check values and adjusted. The fully corrected values are output as water level, year and time in minutes within the year. Data from up to two consecutive years can be handled and leap years are automatically allowed for. The existence of gaps in the record is detected and indicated in the output. Editing for correct card type, incorrect control points, etc. is carried out and appropriate error messages are printed. After the hydrograph has been written on tape, a subroutine prints out the new data to facilitate checking. It is strongly recommended that all hydrographs and barographs be edited, using program PLOT, J10017, which produces a plot of the hydrograph.

Program Listing of TAPREP2

```
      PROGRAM TAPREP2
C CONVERTS  DATA FROM HYDROGRAPH  EASURED ON PENCIL FOLLOWER TO MAGNETIC
C TAPE FORMAT. INCLUDES CHECK LEVEL MEASUREMENTS. MORE THAN ONE HYDROGRAPH
C CAN BE STORED ON SAME TAPE
     ODIMENSION IDENP(20),KPR(20),PMIN(20),WWL(20),IDENT(20),XT(350),
     1YL(350),ACLEV(350),ACMIN(350),TIMC(100),IYRAC(350),IYRT(20),
     2ACLEVT(20),ACMINT(20),IDENTT(20),F(10),IDDD(20),IDTEST(20)
     OCOMMON OLEV(020),ALEV(020),MTHCK(020),IDAYCK(020),KHRCK(020),
     1MINCK(020),KYRCK(020),CORR(020),L1,L2,L3,L4,L5,TIM(020)
      INTEGER Z,Q,G,GG,END
C ASSIGN LOGICAL UNIT NUMBERS 02 = OLD TAPE , 03 = NEW TAPE
      L1=03
      L2=02
      L3 = 60
      L4 = 61
      L5 = 59
      REWIND L2
      REWIND L1
      NBEG = 1
      END = 1
      JJJJ=1
      IDADD = 0
C READ BAROGRAPH/HYDROGRAPH CONTROL CARD. IF DATA IS BAROMETRIC IBAROM = 1
C  IF DATA IS HYDROGRAPHIC IBAROM= 2  FOR BAROGRAPHS,BARTIMF = TIME SCALE ,
C  INCHES/DAY ,BARPF = PRESSURE SCALE ,LINEAR INCHES/INCH PRESSURE ,SENCHAR
C  =CHART CENTRE IN INCHES OF PRESSURE ,PENRAD = PEN RADIUS, INCHES.
      READ (L3,120) IBAROM,BARTIMF,BARPF,SENCHAR,PENRAD
      BARTIMF = BARTIMF/1440.
C CHECK OLD TAPE IDENT.
      READ (L3,100) I, IDREEL
C I = 1 IF TAPE ALREADY EXISTS. I = 2 IF NO TAPE
      GO TO (1,2) I
    1 L8 = L5
    3 READ (L1) IDCHK
      IF (IDCHK.EQ.IDREEL)2,4
    4 WRITE (L8,101) L1
      PAUSE 1
      IF(L8.EQ.L4) 5,6
    6 L8 = L4
      GO TO 3
    2 WRITE (L2) IDREEL
C TRANSFER OLD DATA FROM L1 TO L2
      GO TO (7,12)I
    7 READ (L1) IDENTK
      READ (L1) IDENTK,ELEV
      WRITE (L2) IDENTK
      WRITE (L2) IDENTK,ELEV
  515 READ (L3,130) IDADD
   13 READ (L1) (IDENP(J),KPR(J),PMIN(J),WWL(J),J=1,18)
      IF (IDENTK.EQ.IDENP(1)) 9,10
    9 IF (IDADD) 519,509,519
  519 DO 511 J = 2,18
      IF (IDENP(J).EQ.0) 512,511
  511 CONTINUE
      GO TO 509
  512 IF (IDENP(J-1).EQ.IDADD) 513,509
  513 K = J-1
      DO 510 J = 1,K
      IDDD(J) = IDENP(J)
```

```
      IYRT(J) = KPR(J)
      ACMINT(J) = PMIN(J)
  510 ACLEVT(J) = WWL(J)
      K = K+1
      IDDD(K) = IDDD(K-1)
      IYRT(K) = IYRT(K-1)
      ACLEVT(K) = ACLEVT(K-1)
      ACMINT(K) = -100.
      NBEG = K+1
      GO TO 12
  509 WRITE (L2) (IDENP(J),KPR(J),PMIN(J),WWL(J),J=1,18)
      GO TO 13                                                          T 38
   10 IF (IDENP(1).GT.0) 11,12                                          T 39
   11 DO 14 J = 1,18                                                    T 40
      IDENT(J) = KPR(J) = 0                                             T 41
   14 PMIN(J) = WWL(J) = 0.0                                            T 42
      IDENT(1)=IDENP(1)
      WRITE (L2) (IDENT(J),KPR(J),PMIN(J),WWL(J),J=1,18)                T 44
      READ (L1) IDENTK,ELEV                                             T 45
      WRITE (L2) IDENTK,ELEV                                            T 46
      GO TO 13                                                          T 47
C OLD DATA TRANSFERRED
C READ NEW IDENTIFICATION AND M.P. ELEVATION
   12 READ (L3,110) K,IDENTK,ELMP                                       T 48
      IDTEST(JJJJ)=IDENTK
      JJJJ=JJJJ+1
      Z = 0
C  FOR BAROGRAPHS ELMP=0.0
      IF (K.EQ.4) 15,16                                                 T 49
   16 IF (K.EQ.5) 92,526
  526 WRITE (L4,102)
      GO TO 5                                                           T 51
   15 GO TO (163,164) IBAROM                                            T 52
  163 WRITE (L4,121) IDENTK                                             T 53
      GO TO 162                                                         T 54
  164 WRITE (L4,122) IDENTK                                             T 55
  162 IF(IDENTK.EQ.IDADD) 601,1162
  601 WRITE (L4,131)
      GO TO 602
 1162 WRITE (L2) IDENTK
      WRITE (L2) IDENTK,ELMP                                            T 57
C READ CHECK LEVEL MEASUREMENTS
  602 N = 0
      DO 30 J = 1,20                                                    T 59
      OLEV(J) = ALEV(J) = 0.0                                           T 60
   30 MTHCK(J) = KYRCK(J) = IDAYCK(J) = KHRCK(J) = MINCK(J) = 0         T 61
   23 READ (L3,103) K,ID     ,KYR,MTH,IDAY,KHR,MIN,OBLEV,ABLEV          T 62
C                                                           CARD TYPE 3
C                                                  LAST CARD 3 IS BLANK
      IF (K.EQ.0) 17,18                                                 T 63
   17 IF (KYR.EQ.0) 19,20                                               T 64
   18 IF (K.EQ.3) 21,22                                                 T 65
   21 N = N +1                                                          T 66
      OLEV(N) = OBLEV                                                   T 67
      ALEV(N) = ABLEV                                                   T 68
      KYRCK(N) = KYR                                                    T 69
      MTHCK(N) = MTH                                                    T 70
      IDAYCK(N)= IDAY                                                   T 71
      KHRCK(N) = KHR                                                    T 72

      MINCK(N) = MIN                                                    T 73
      GO TO 23                                                          T 74
   20 WRITE (L4,104)                                                    T 75
      GO TO 5                                                           T 76
   22 WRITE (L4,105)                                                    T 77
```

```
      GO TO 5                                                            T 78
   19 WRITE (L4,106)                                                     T 79
C LEVEL CHECK CARDS SUCCESSFULLY READ
  130 FORMAT (I7)
  100 FORMAT (I1,I7)                                                     T 80
  101 FORMAT (35H1WRONG TAPE MOUNTED ON LOGICAL UNIT,I3)                 T 81
  110 FORMAT (I1,I7,    F8.3)                                            T 82
  102 FORMAT (51H WRONG CARD NUMBER ON TYPE 4 CARD OR NO TYPE 4 CARD)    T 83
  103 FORMAT (I1,I7,5I2,2F6.3)                                           T 84
  104 FORMAT (33H WRONG NUMBER ON LEVEL CHECK CARD)                      T 85
  105 FORMAT (28H NO YEAR ON LEVEL CHECK CARD)                           T 86
  106 FORMAT (28H LEVEL CHECK CARDS ACCEPTED )                           T 87
  120 FORMAT(I5,4F5.0)                                                   T 88
  121 FORMAT(1H1,60X,13HBAROGRAPH NO ,I7)                                T 89
  122 FORMAT(1H1,60X,14HHYDROGRAPH NO ,I7)                               T 90
  131 FORMAT(41H THIS RUN IS AN ADDITION TO EXISTING DATA )
C COMPUTE CORRECTION FACTORS FOR WATER LEVELS FROM LEVEL CHECK CARDS
      CALL CORRFAC                                                       T 91
C CORRECTION FACTORS NOW IN CORE
C READ FIRST CARD TYPE 2
   91 MN = 1                                                             T 92
      Q=1                                                                T 93
      READ (L3,107) K,ID,KYR,MTH,IDAY,KHR,MIN,BLEV,XTB,YLB               T 94
      IF (K.EQ.2) 40,41                                                  T 95
   41 IF (XTB.EQ.0.0.AND.YLB.EQ.0.0)142,141                              T 96
  141 WRITE (L4,108)                                                     T 97
      GO TO 5                                                            T 98
  142 END = 2
      IF (IDADD) 889,889,516
  516 END = 3
      GO TO 889                                                          T100
   40 IF (ID.EQ.IDENTK) 42,43                                            T101
   43 WRITE (L4,109) KYR,MTH,IDAY,KHR,MIN,ID                             T102
      GO TO 5                                                            T103
   42 CALL TIMCON (KYR,MTH,IDAY,KHR,MIN,BT)                              T104
      IF (Z) 998,151,998                                                 T105
  998 IF (BT.EQ.ET)151,152                                               T106
  152 MN = 2                                                             T107
      XT(1) = -100.                                                      T108
      ACMIN(1) = -100.                                                   T109
      Q=2                                                                T110
  151 KBYR = KYR                                                         T111
C READ SET OF HYDROGRAPH VALUES
      Z=1                                                                T112
      N = MN                                                             T113
   50 NU = N+6                                                           T114
      READ (L3,111) K,ID,(XT(IN),YL(IN),IN=N,NU)                         T115
      IF(XT(N).EQ.0.0)44,45                                              T116
   45 IF(K.EQ.1) 46,47                                                   T117
   47 WRITE (L4,112) KYR,MTH,IDAY                                        T118
      GO TO 5                                                            T119
   46 IF(ID.EQ.IDENTK) 48,49                                             T120
   49 WRITE (L4,113) KYR,MTH,IDAY                                        T121
      GO TO 5                                                            T122

   48 N = N+7                                                            T123
      GO TO 50                                                           T124
C ONE SET OF HYDROGRAPH DATA READ IN
C READ SECOND TYPE 2 CARD
   44 READ(L3,107) K,ID,KYR,MTH,IDAY,KHR,MIN,CLEV,XTE,YLE                T125
      IF(K.EQ.2) 51,52                                                   T126
   52 WRITE (L4,108)                                                     T127
      GO TO 5                                                            T128
   51 IF (ID.EQ.IDENTK) 53,54                                            T129
   54 WRITE (L4,109) KYR,MTH,IDAY,KHR,MIN,ID                             T130
      GO TO 5                                                            T131
   53 CALL TIMCON (KYR,MTH,IDAY,KHR,MIN,ET)                              T132
      KEYR = KYR                                                         T133
```

```
      DUM1 = FLOATF ((KBYR+1900)/4)                                      T134
      DUM2 = FLOATF(KBYR +1900)/4.                                       T135
      IF (KBYR - KEYR ) 55,56,57                                         T136
C ACLEV(IB),ACMIN(IB),IYRAC(IB) NOW CONTAIN COMPLETELY CORRECTED HYDROGRAPH SET
C TRANSFER HYDROGRAPH TO TAPE L2 (03)
C                                               ARE ENDPOINTS IN SAME YEAR
C CALCULATE LEVEL/TIME PAIRS FROM MEASUREMENTS
   57 WRITE (L4,114) KYR,MTH,IDAY                                        T137
      GO TO 5                                                            T138
   55 IF(DUM1.EQ.DUM2) 58,59                                             T139
   58 TET = ET + 527040.                                                 T140
      GO TO 60                                                           T141
   59 TET = ET + 525600.                                                 T142
      GO TO 60                                                           T143
   56 TET = ET                                                           T144
   60 TBT = BT                                                           T145
C ENDPOINTS NOW CALCULATED TO SAME YEAR
      IN=Q                                                               T146
  263 IF (XT(IN).EQ.0.0)261,262                                          T147
  262 IN = IN + 1                                                        T148
      GO TO 263                                                          T149
  261 LAST = IN-1                                                        T150
      IN=Q                                                               T151
      G=0                                                                T152
C COMPUTE ANGLE BETWEEN CHART AND DIGITIZER AXES , ALPHA
      DIFF1 = SQRTF((XTB-XT(Q))**2+(YLB-YL(Q))**2)                       T153
      DIFF2=SQRTF((XTE-XT(LAST))**2 +(YLE-YL(LAST))**2)                  T154
      IF(DIFF1.GT.10.) 700,701                                           T155
  700 IF(DIFF2.GT.10.) 702,704                                           T156
  703 WRITE (L4,135) KBYR,BT,KEYR,ET                                     T157
  135 FORMAT(/// 60H BOTH CONTROL POINTS LESS THAN 1 MM. FROM GRAPH IN I T158
     1NTERVAL ,/,10X,2(I7,F10.0), 20HPROCESSING CONTINUED)               T159
      GO TO 702                                                          T160
  701 IF(DIFF2.GT.10.) 705,703                                           T161
  704 ALPHA = ATANF((XT(Q)-XTB)/(YL(Q)-YLB))                             T162
      GO TO 63                                                           T163
  705 ALPHA = ATANF((XT(LAST)-XTE)/(YL(LAST)-YLE))                       T164
      GO TO 63                                                           T165
  7020ALPHA=(ATANF((XT(Q)-XTB)/(YL(Q)-YLB))                              T166
     1+ATANF((XT(LAST)-XTE)/(YL(LAST)-YLE)))/2.                          T167
   63 IF(XT(IN).EQ.0.0)61,62                                             T168
COMPUTE INDIVIDUAL POINTS
   62 DELTA = ATANF((YL(IN)-YLB)/(XT(IN)- XTB))                          T169
      IF (XT(IN).LE.XTB) 751,752                                         T170
  751 G=G+1                                                              T171
  752 DD = SQRTF((YL(IN)-YLB)**2+(XT(IN)-XTB)**2)                        T172

      YY = YLB + DD*SINF(DELTA+ALPHA)                                    T173
      TT = XTB + DD*COSF(DELTA+ALPHA)                                    T174
      ACLEV(IN) = BLEV + (CLEV-BLEV)*(YY-YLB)/(YLF-YLB)                  T175
      ACMIN(IN) = TBT + (TET-TBT)*(TT-XTB)/(XTE-XTB)                     T176
      GO TO (160,161) IBAROM                                             T177
  160 H = ABSF(ACLEV(IN)-SENCHAR)*BARPF/PENRAD                           T178
      THETA = ATANF (H/SQRTF(1.-H**2))                                   T179
      TTT = ACMIN(IN)-PENRAD*(1.-COSF(THETA))/BARTIMF                    T180
      ACMIN(IN) = TTT                                                    T181
  161 IN = IN + 1                                                        T182
      GO TO 63                                                           T183
C LEVEL/TIME NOW CALCULATED TO SAME YEAR
   61 IN = IN-1                                                          T184
      IF (DUM1.EQ.DUM2) 64,65                                            T185
   64 ENDYR = 527040.                                                    T186
      GO TO 66                                                           T187
   65 ENDYR = 525600.                                                    T188
C CALCULATE CORRECTION FACTORS TO SAME YEAR
   66 J = 1                                                              T189
   75 IF (CORR(J).EQ.-100.) 67,68                                        T190
   68 IF (KYRCK(J)-KBYR) 71,69,70                                        T191
   71 DOM1=FLOAT((KYRCK(J)+1900)/4)
```

```
      DOM2=FLOAT(KYRCK(J)+1900)/4.
      IF (DOM1.EQ.DOM2)771,772
  771 TIMC(J)=TIM(J)-527040.
      GO TO 74
  772 TIMC(J)=TIM(J)-525600.
      GO TO 74
   70 IF (DUM1.EQ.DUM2) 72,73
   72 TIMC(J) = TIM(J) + 527040.
      GO TO 74
   73 TIMC(J) = TIM(J) + 525600.
      GO TO 74
   69 TIMC(J) = TIM(J)
   74 J = J+1
      GO TO 75
C CORRECT WATER LEVELS
   67 DO 76 IB =Q,IN
      IF (CORR(1).EQ.-100.) 76,77
   77 IF (CORR(2).EQ.-100.) 78,79
   78 ACLEV(IB)= ACLEV(IB)+ CORR(1)
      GO TO 76
   79 J = 1
      IF (ACMIN(IB).LT.TIMC(J)) 80,81
   800ACLEV(IB) = ACLEV(IB) +(ACMIN(IB)-TIMC(J))*(CORR(J+1)-CORR(J))
     1/(TIMC(J+1)-TIMC(J)) +CORR(J)
      GO TO 76
   81 IF (CORR(J+1).EQ.-100.)82,83
   83 IF (ACMIN(IB).LT.TIMC(J+1)) 80,84
   84 J = J+1
      GO TO 81
   820ACLEV(IB) = ACLEV(IB) + (ACMIN(IB)-TIMC(J-1))*(CORR(J)-CORR(J-1))/
     1(TIMC(J)-TIMC(J-1)) + CORR(J-1)
   76 CONTINUE
C ACLEV(IB),ACMIN(IB), IB=Q,IN NOW CONTAIN TRUE VALUES OF TIME AND WATER LEVEL
C  FOR ONE SET OF DATA. TIME STILL IN TERMS OF KBYR.
C CHANGE ACMIN(IB) TO SEPARATE YEARS
      DO 85 IB=Q,IN
      IYRAC(IB) = KBYR

      IF(ACMIN(IB).GT.ENDYR) 86,85
   86 IYRAC(IB) = KBYR + 1
      ACMIN(IB) = ACMIN(IB) - ENDYR
   85 CONTINUE
      IN = IN-1-G
      GG = G+1
      DO 440 IB=Q,IN
      IQ=IB+GG
      IYRAC(IB) = IYRAC(IQ)
      ACMIN(IB) = ACMIN(IQ)
  440 ACLEV(IB) = ACLEV(IQ)
      IC = 1
   90 IYRT(NBEG) = IYRAC(IC)
      ACLEVT(NBEG)= ACLEV(IC)
      ACMINT(NBEG)= ACMIN(IC)
      IDDD(NBEG)= IDENTK
      IC = IC + 1
      IF (IC.GT.IN) 87,88
   88 NBEG = NBEG + 1
      IF (NBEG.GT.18) 89,90
  889 DO 500 IZ=NBEG,18
      IDDD(IZ)=IYRT(IZ)=0
  500 ACMINT(IZ)=ACLEVT(IZ)=0.0
   89 WRITE(L2) (IDDD(IZ) ,IYRT(IZ),ACMINT(IZ),ACLEVT(IZ),IZ=1,18)
      NBEG = 1
      GO TO (90,92,515) END
   87 NBEG = NBEG + 1
      IF (NBEG.GT.18) 999,91
  999 WRITE(L2) (IDDD(IZ),IYRT(IZ),ACMINT(IZ),ACLEVT(IZ),IZ=1,18)
      NBEG = 1
      GO TO 91
```

```
   92 DO 93 IZ = 1,18
      IDENTT(IZ) = IYRT(IZ) = 0
   93 ACMINT(IZ) = ACLEVT(IZ) =0.0
      WRITE (L2) (IDENTT(IZ),IYRT(IZ),ACMINT(IZ),ACLEVT(IZ),IZ=1,18)
      READ (L3,118)(F(KI),KI=1,8)
      DO 94 KI=1,8
      IF (F(KI).EQ.0.0)94,96
   94 CONTINUE
      WRITE (L4,119)
      GO TO 97
   96 WRITE (L4,115)
   97 JJJJ=JJJJ-1
      DO 190 JJ=1,JJJJ
      CALL TEST(IDTEST(JJ))
  190 REWIND L2
      STOP
    5 READ (L3,116) IA,IB
      IF (IA.EQ.0.AND.IB.EQ.0) 98,5
   98 READ (L3,116) IC,IE
      IF (IC.EQ.0.AND.IF.EQ.0) 99,5
   99 WRITE (L4,117)
  107 FORMAT(I1,I7,5I2,F6.3,2F4.0)
  108 FORMAT(52H WRONG CARD NO ON TYPE 2 CARD OR MISSING TYPE 2 CARD)
  109 FORMAT(41H WRONG WELL IDENTIFICATION ON TYPE 2 CARD,5I2,5X,I7)
  111 FORMAT(I1,I7,8X,14F4.0)
  1120FORMAT(65H HYDROGRAPH CARD NOT TYPE 1 OR MISSING, AFTER TYPE 2 CAR
     1D, DATE   ,3I2)
  1130FORMAT(57H WRONG IDENT ON HYDROGRAPH CARD AFTER TYPE 2 CARD, DATE

     1 ,3I2)
  114 FORMAT(34H TYPE 2 CARDS NOT IN SEQUENCE AT   ,3I2)
  118 FORMAT(8F10.0)
  119 FORMAT(///21H PROCESSING COMPLETED)
  115 FORMAT(20H LAST CARD NOT BLANK)
  116 FORMAT(I1,I7)
  117 FORMAT(///35H PROCESSING TERMINATED DUE TO ERROR)
      REWIND L2
      REWIND L1
      STOP
      END

      SUBROUTINE CORRFAC
     0COMMON OLEV(020),ALEV(020),MTHCK(020),IDAYCK(020),KHRCK(020),
     1MINCK(020),KYRCK(020),CORR(020),L1,L2,L3,L4,L5,TIM(020)
      DIMENSION N(15)
      DO 99 J=1,20
   99 CORR(J) = -100.0
      M = 0
      DO 1 J = 1,20
      IF (KYRCK(J).EQ.0) 2,3
    3 M = M + 1
    1 CONTINUE
    2 IF (M.EQ.0) 4,5
    4 WRITE (L4,100)
      CORR(1) = -100.0
      KYRCK(1) = -1
      TIM(1) = 0.0
      M = 1
      GO TO 7
    5 IF(M.EQ.1) 6,14
    6 WRITE (L4,101)
C CONVERT TIME VALUES TO MINUTES
   14 DO 9 J=1,M
    9 CALL TIMCON (KYRCK(J),MTHCK(J),IDAYCK(J),KHRCK(J),MINCK(J),TIM(J))
C PUT OBSERVATIONS IN TIME SEQUENCE
      IF (M.EQ.1)47,43
   43 DO 10 J1= 1,M
      DO 10 J = 2,M
```

```
      IF (KYRCK(J).LT.KYRCK(J-1)) 12,11
   12 IT1 = KYRCK(J)
      TEMOL = OLEV(J)
      TEMAC = ALEV(J)
      TEMTIM = TIM(J)
      KYRCK(J) = KYRCK(J-1)
      TIM(J) = TIM(J-1)
      OLEV(J) = OLEV(J-1)
      ALEV(J) = ALEV(J-1)
      KYRCK(J-1) = IT1
      TIM(J-1) = TEMTIM
      OLEV(J-1) = TEMOL
      ALEV(J-1) = TEMAC
      GO TO 10
   11 IF (KYRCK(J).EQ.KYRCK(J-1))13,10
   13 IF (TIM(J).LT.TIM(J-1))15,10
   15 IT1 = KYRCK(J)
      TEMTIM = TIM(J)
      TEMOL = OLEV(J)
      TEMAC = ALEV(J)

      KYRCK(J) = KYRCK(J-1)
      TIM(J) = TIM(J-1)
      OLEV(J) = OLEV(J-1)
      ALEV(J) = ALEV(J-1)
      KYRCK(J-1) = IT1
      TIM(J-1) = TEMTIM
      OLEV(J-1) = TEMOL
      ALEV(J-1) = TEMAC
   10 CONTINUE
C WATER LEVEL CHECKS NOW IN TIME AND YEAR SEQUENCE
C CALCULATE CORRECTION FACTORS
   47 DO 16 J = 1,M
   16 CORR(J) = ALEV(J) - OLEV(J)
C PRINT CORRECTION FACTORS
    7 DO 17 J = 1,M
   17 WRITE (L4,102) KYRCK(J),TIM(J),ALEV(J),OLEV(J),CORR(J)
  100 FORMAT(/46H NO LEVEL CHECKS. NO CORRECTION TO LEVELS MADE)
  101 FORMAT(/43H ONE LEVEL CHECK. CONSTANT LEVEL CORRECTION)
  102OFORMAT(///5H YEAR,I7, 6HMINUTE,F8.0,12HACTUAL LEVEL,F10.4,14HOBSER
     1VED LEVEL,F10.4,16HLEVEL CORRECTION,F10.4)
      RETURN
      END

      SUBROUTINE TIMCON (IJYR,IJMTH,IJDAY,IJHR,IJMIN,TIM)
      DIMENSION N(15)
      N(1)=N(3)=N(5)=N(7)=N(8)=N(10)=N(12)=31
      N(4)=N(6)=N(9)=N(11)= 30
      N(2)= 28
      DUM1 = FLOATF((IJYR+1900)/4)
      DUM2 = FLOATF(IJYR+1900)/4.
      IF (DUM1.EQ.DUM2) 10,11
   10 N(2) = 29
   11 ITOP = IJMTH -1
      IDAY = 0
      L=0
   14 IF (L.GT.ITOP) 13,121
  121 IF(L.EQ.0)15,12
   12 IDAY = IDAY + N(L)
   15 L=L+1
      GO TO 14
   13 IDAY = IDAY + IJDAY -1
      TIM = 1440.*FLOATF(IDAY)+60.*FLOATF(IJHR)+FLOATF(IJMIN)
      RETURN
      END

      SUBROUTINE TEST (IDENTK)
      DIMENSION ID(20),KYR(20),TIM(20),WL(20)
      REWIND 02
```

```
      READ (02) IDT                                                      TS  4
      WRITE (61,2) IDT                                                   TS  5
   17 READ (02) IDW
  115 IF (IDW.EQ.IDENTK) 15,17
   15 WRITE (61,2) IDW
      READ (02) IDW, EL                                                  TS  8
      WRITE (61,3) IDW,EL                                                TS  9
   13 READ (02) (ID(J),KYR(J),TIM(J),WL(J),J=1,18)                       TS 10
      IF (ID(1).EQ.0) 16,12                                              TS 11
   12 IF (ID(1).EQ.IDW) 112,14
   14 IDW = ID(1)

      GO TO 115
  112 WRITE (61,4) (ID(J),KYR(J).TIM(J),WL(J),J=1,18)
      GO TO 13                                                           TS 13
   16 REWIND 2                                                           TS 14
      RETURN                                                             TS 15
    2 FORMAT (I7)                                                        TS 16
    3 FORMAT (I7,F10.3)                                                  TS 17
    4 FORMAT ((4(2I7,2F9.2)))                                            TS 18
      END                                                                TS 19
         FINIS
```

Addendum

The D-Mac pencil follower, Model PF 10, is a more recent instrument style than the D-Mac PF 10,000. The working area on the reading table is larger, having dimensions of 40 inches by 40 inches and the digitizer coordinates vary from 0000 to 9999 in both the X and Y coordinate directions. The pencil follower interfaces with an IBM 029 key-punch.

The standard 8-digit electronic console has an additional feature, an incremental control for x axis. The incremental control is activated by an ON-OFF switch and a selector switch located inside the front display panel. The selector switch has positions from 1 to 9 and presets the interval of X required before a reading is taken. The X coordinate display on the console consists of four digits and the selector switch affects the "tens" digit. For example, if the selector switch is in position 2, this means that if the stylus moves a distance of 20 units horizontally, the digitizer will automatically take a reading. This feature is in addition to the line/position mode of operation. The stylus also has a better "following" action than the Model PF 10,000. This "following" action will prevail unless the operator has moved the stylus off the working area.

Due to the change in the key-punch model, a different drum card is used (because some operational codes have been changed), see Figure 11. The drum card performs the same function as the other drum card for the 026 key-punch. The patch cords in the back of the console must also be connected in the correct fashion for this particular drum card. The key-punch must operate in the prog. 1 mode position.

As to digitizer operation, this is identical to that described in Part 2 of the report.

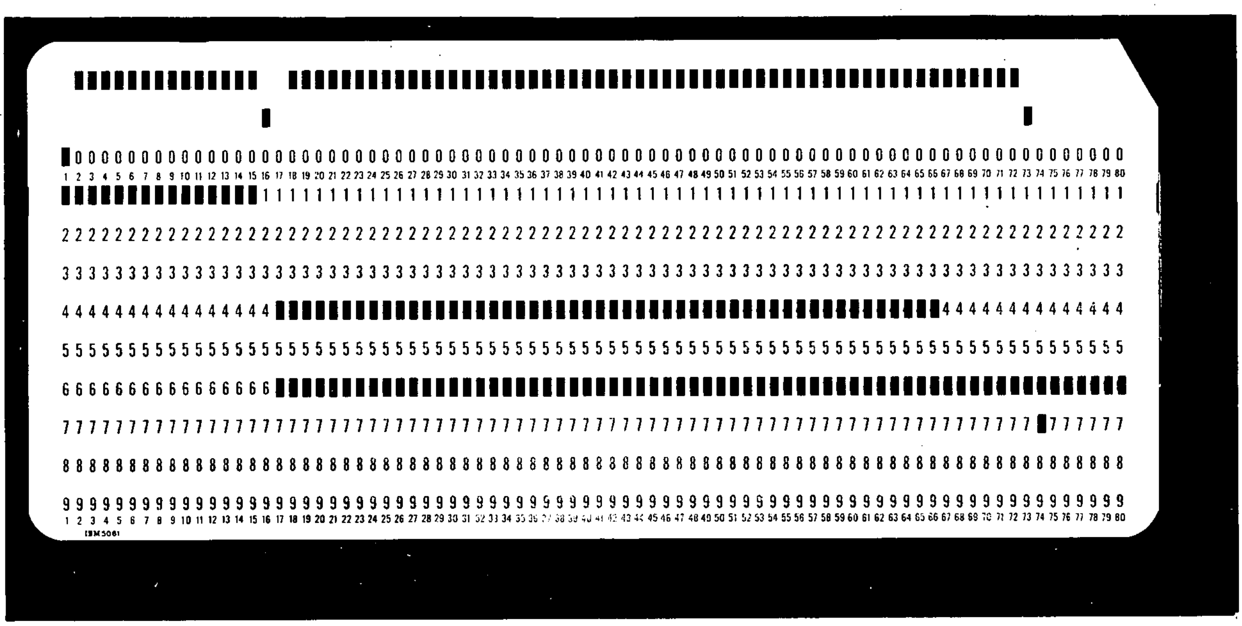


Figure 11. Drum card for IBM 029 key punch

TECHNICAL BULLETIN SERIES

No. 1 Natural flow of North Saskatchewan River at Alberta - Saskatchewan boundary by the rim station method. E. P. Collier and A. Coulson, October 1965.*

Discusses methods of estimating the natural flow of the North Saskatchewan River at the provincial boundary by simple regression with the flow at Rocky Mountain House and also by multiple regression techniques involving precipitation.

No. 2 LACOR - Program for streamflow correlation. R. O'N. Lyons, November 1965.*

A program for the IBM 1620 computer to correlate streamflow records in terms of deviations in log units from the geometric mean of each calendar month's discharges.

No. 3 Tables for computing and plotting flood frequency curves. A. Coulson, 1966.

A compilation of tables for the computation and plotting of flood frequency curves according to the first asymptotic distribution of extreme values (the Gumbel method). A worked example of the use of the tables is included.

No. 4 Flood frequencies of Nova Scotia streams. A. Coulson, 1967.*

Recorded flood flow have been analysed on a regional basis and a method for estimating the flood frequency curve for any stream in Nova Scotia is outlined.

No. 5 Measurement of the physical characteristics of drainage basins. A. Coulson and P. N. Gross, 1967.

Methods of obtaining quantitative descriptions of certain physical characteristics of drainage basins are outlined using as examples Marmot Creek and Streeter Creek two of the experimental basins of the East Slopes (Alberta) Watershed Research Program.

No. 6 Hydrologic zones in the headwaters of the Saskatchewan River. D. A. Davis and A. Coulson, 1967.

The Saskatchewan River headwaters area of Alberta has been divided into seven by hydrological similar zones, based on correlations of mean monthly recorded stream discharge.

No. 7 Estimating runoff in Southern Ontario. A. Coulson, 1967.

Methods of estimating the runoff and its distribution in ungauged streams and in streams with short periods of record in the area of Southern Ontario south of the Canadian shield.

No. 8 Tables for computing and plotting drought frequency curves. W. Q. Chin, 1967.

A compilation of tables for the computation and plotting of low flow frequency curves by both the third asymptotic distribution and the Pearson Type III distribution. Worked examples are included.

No. 9 Flood Frequency analysis for the New Brunswick - Gaspé region. E. P. Collier and G. A. Nix.

Presents a method of estimating the flood frequency curve from basin characteristics for any stream in a large part of New Brunswick and the Gaspé area of Quebec.

No. 10 Diefenbaker Lake - Effects of bank erosion on storage capacity. R. O. Van Everdingen.

Discussion of the factors causing bank erosion on Diefenbaker Lake and their effect on the storage capacity of the lake.

* Out of print. Photo copies will be provided, if requested.

TECHNICAL BULLETIN SERIES (Cont'd)

No. 11 Some uses of a digital graph plotter in hydrology. G. W. White.

Applications of computer-digital graph plotters in the preparation of graphical representation of large quantities of related data. Includes some programs and examples.

No. 12 Sediment surveys in Canada. W. Stichling and T. F. Smith.

An outline of the Sediment Survey Program of the Water Survey of Canada, including methods, instrumentation and data available.

No. 13 Climatology studies of Baffin Island, Northwest Territories. R.G. Barry and S. Fogarasi.

A report of the results of a program of climatological investigations in Baffin Island.

No. 14 Hydrogeological data for Good Spirit Lake Drainage Basin, Saskatchewan. R.A. Freeze.

Presents the first water balance for the Good Spirit Lake Drainage Basin and a discussion of the methods used in the investigations.

Copies of this bulletin may be obtained by writing to:

Director,
Inland Waters Branch,
Department of Energy,
Mines and Resources,
588 Booth Street,
Ottawa, Ont.