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A PROCESSING SYSTEM FOR FISCHER AND PORTER PRECIPITATION GAUGE DATA

BY

D.M. POLLOCK, J. ROGALSKY and D.A. CARR

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ABSTRACT

The historical approach to handling the punched tape records from Fischer and Porter gauges has been machine translation to punched cards for computer processing. However, considerable manual intervention has been required at all stages to minimize the loss of data. In 1970, the Climatology Division of the Atmospheric Environment Service introduced a new system which minimized manual intervention without loss of data. In this new system, the tapes are corrected for errors in recording accumulated precipitation (not undercatch of precipitation by the gauge due to wind), and errors in timing.

UN SYSTÈME DE TRAITEMENT POUR LES DONNÉES DES PLUVIOMÈTRES FISCHER ET PORTER

SOMMAIRE

L'approche historique concernant la manipulation des enregistrements sur bande perforée des pluviomètres Fischer et Porter a été transposée mécaniquement en un système de cartes perforées pour traitement par ordinateur. Cependant, une intervention manuelle considérable à été nécessaire à tous les stages pour minimiser la perte de données. En 1970, la Division de Climatologie du Service de l'Environnement atmosphérique a introduit un nouveau système qui réduit l'intervention manuelle sans perte de données. Dans ce nouveau système, les bandes sont corrigées pour erreurs dans l'enregistrement des précipitations accumulées (le relevé des précipitations n'est pas tout à fait exact à cause des effets du vent sur le pluviomètre) et erreurs dans le chronométrage.

1. INTRODUCTION

The Atmospheric Environment Service first acquired Fischer and Porter digital recording precipitation gauges in 1966. The gauges were selected for the observing of precipitation in remote areas as part of A.E.S. supported projects for the International Hydrologic Decade. By 1970, over 70 gauges were being used by the A.E.S. to obtain precipitation data for a variety of projects across Canada.

To assist in the data reduction task, an automatic translator for the punched tape record of the gauges was acquired in 1967. This translator transfers the data to punch cards which serve as input to the Climatology Division computer, an IBM 360-30. To make the data available to all users in a convenient form, a semi-annual publication, "Supplementary Precipitation Data", was begun. This paper describes the processing system (Figure 1) that takes the precipitation data from recorder to the punched card archive and to the publication.

2. THE SYSTEM AND ITS OUTPUT

2.1 The Gauge

The Fischer and Porter model 35-1559 long duration precipitation gauge is shown in Figure 2. It catches all forms of precipitation and records the total weight on punched paper tape in units of 0.1" water equivalent ranging from 0.0" to 19.9". The gauge is usually installed so that the eight-inch diameter orifice is 92 inches above the ground. However, that height is increased in areas which experience heavy snowfall. Normally, Alter shields are used to reduce the effect of the wind on the catch of snow.

2.2 The Timer

An electronic timer controls the interval between the observations of accumulated precipitation. Initially, a five-minute interval was selected, but the heavy battery drain and high risk of mechanical failure were unacceptable. Most gauges are now operating on a fifteen-minute cycle. However, a few gauges continue to operate on a five-minute cycle which requires the data processing system to handle both types of data. Operating on a fifteen-minute cycle causes very little information to be lost because of the 0.1" resolution of the instrument.

2.3 Output Tape

The output tape is illustrated in the appendix. There are sixteen channels for information but the accumulated precipitation data are punched in BCD (Binary Coded Decimal) format in only nine of the channels. In addition to the nine channels, some gauges always punch the data channel on the extreme left in order to accommodate on older model translator. This punch is deleted during the computer processing of the W21 card. Two alignment channels on the tape are always punched.

2.4 Additional Information Required on the Data Tapes

Before Fischer and Porter data tapes can be processed by computer, certain information in addition to the precipitation accumulations must be available. Some of this information must be written on the data tapes in the field while other information may be added during the quality control checks just prior to the translation of the tapes.

Punched data tapes are normally removed from the Fischer and Porter precipitation gauges at irregular intervals, depending upon the accessibility of the gauge site. For this reason, certain pertinent data must be clearly indicated at both the beginning and end of each tape as it is installed or removed from the instrument. Normally this information is the station name plus the year, month, day and hour of the start and the end of each tape.

Figure 1

FISCHER AND PORTER PRECIPITATION DATA PROCESSING SYSTEM

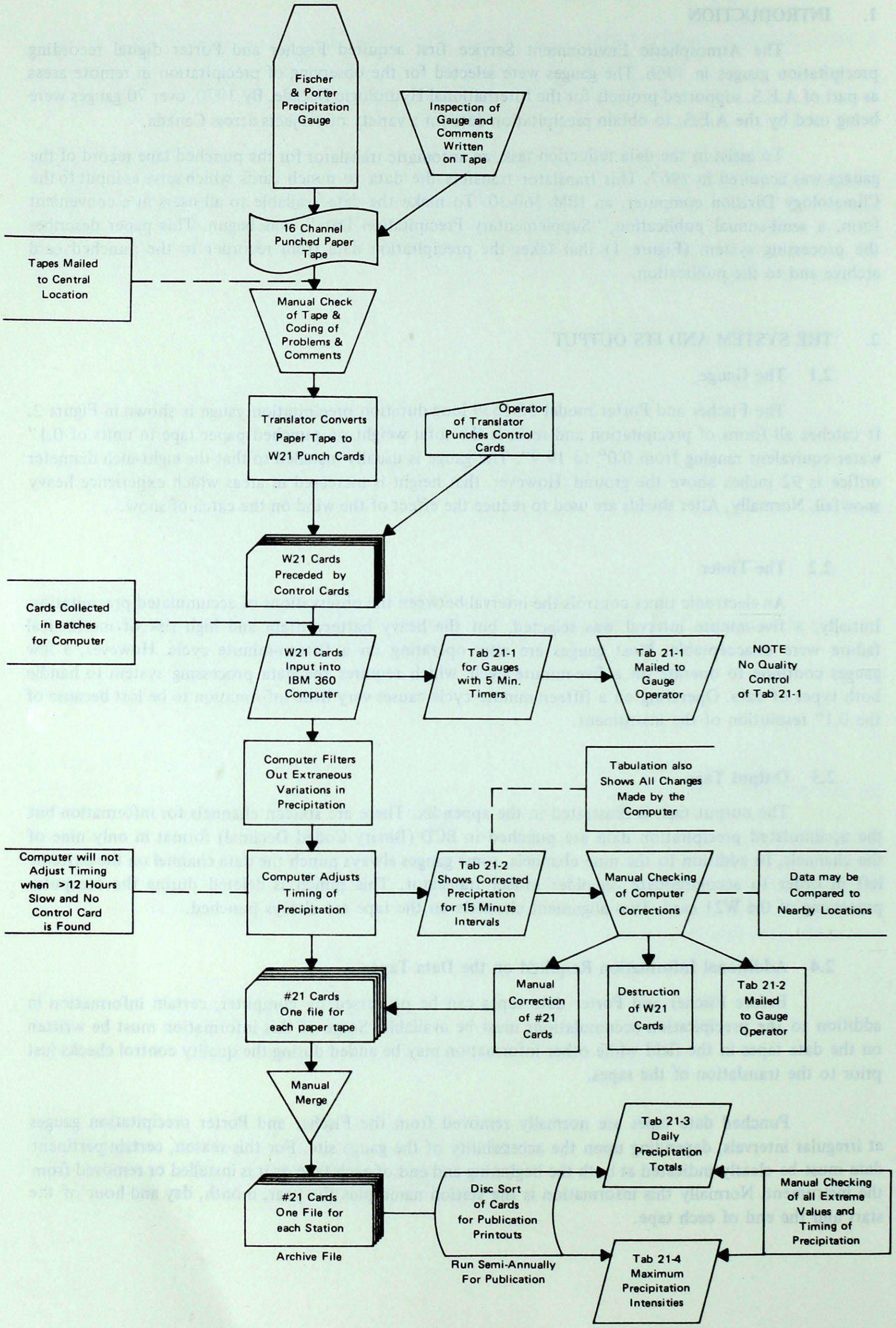


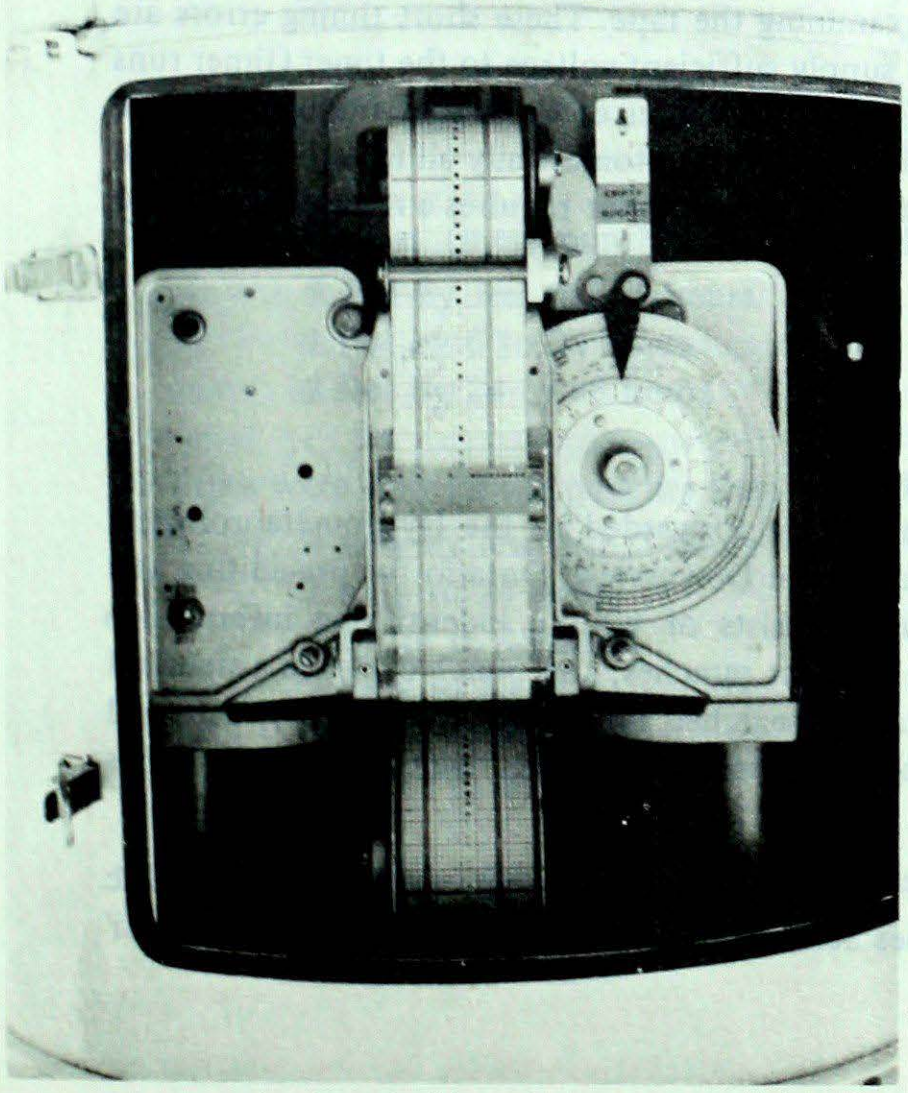
Figure 2

FISCHER AND PORTER PRECIPITATION GAUGE

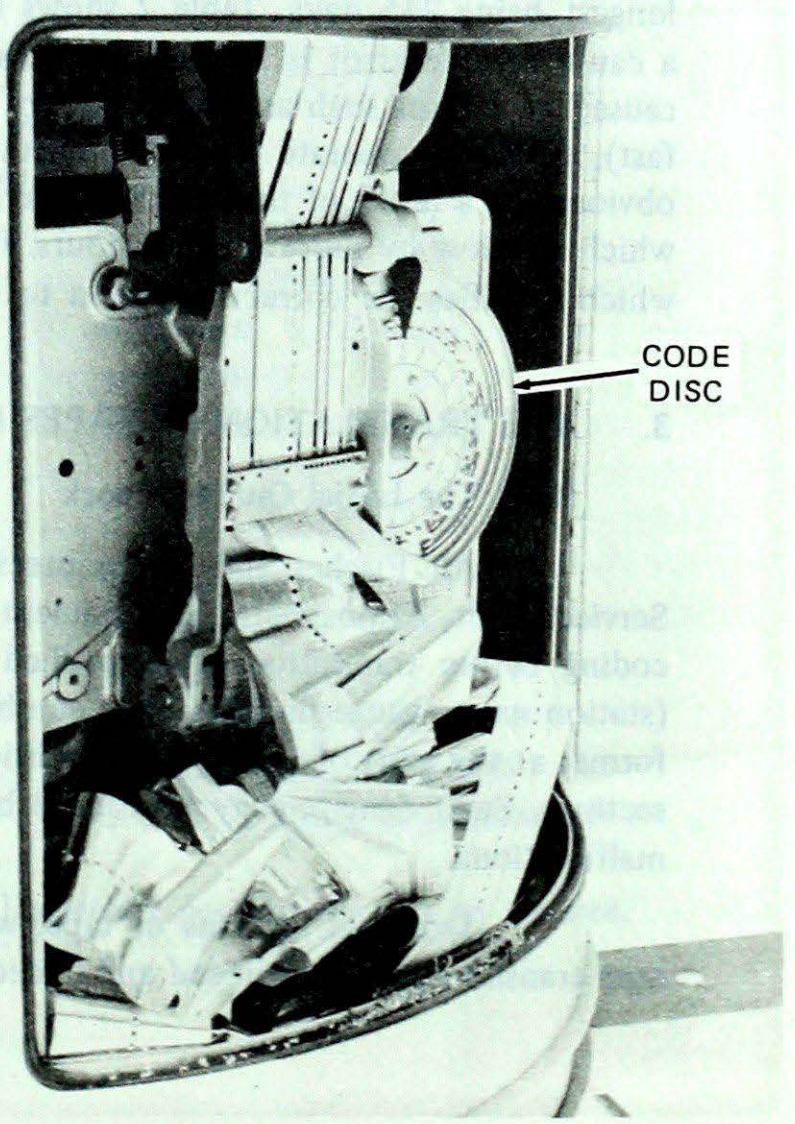
WITH ALTER SHIELD

UNSHIELDED

TAPE TRANSPORT AND PUNCH UNIT



OVERPUNCHING DUE TO TAPE MISALIGNMENT



When the gauge is visited and the tape not changed, additional information should be written on the paper tape in order to assist with the data analysis should a gauge malfunction occur. The information required is the date and time at which the gauge is visited, written beside the most recently punched holes. Any comments on gauge malfunctions or changes to the gauge are very useful when checking the tape prior to translation. If the timer is not operating when a gauge is being serviced, the punch should be actuated manually before changing the tape in order to get a reading of the accumulated precipitation. A remark to that effect should be written beside the holes punched in the tape.

2.5 Common Problems

There are three classes of problems: a) those generating errors in the amount recorded; b) those causing errors in the timing; c) those damaging the tape so that portions can not be read by the translator. The most common problems are listed in table 1; the first eight cause errors in the amount, nine through eleven affect the timing, while ten and twelve prevent the tape from being read by the translator. Of these, numbers four, seven, and eight are relatively infrequent but the others occur frequently enough that the processing system was designed to handle them automatically.

The correction of errors in the precipitation amount is done by cancelling negative values and subtracting these negative values from nearby positive values. The logic used is described more fully in section 4.3.

Time does not appear explicitly on the tapes, but must be inferred. At the end of each timing interval, the accumulated precipitation is punched. If the time of one such punch is known, then the number of subsequent punches multiplied by the punch cycle should represent the length of the interval since that known time. Before designing the processing system, a sample of ninety tapes was checked for timing accuracy. Of this sample:

60% were within one punch of the precise time
10% were fast by up to 48 hours
23% were slow by up to 90 days
7% had malfunctioned completely so no record was made

A detailed description of the time errors and their causes is given in table 2. The median length of period covered by each tape in the same was 82 days with the shortest being 24 days and the longest being 215 days. Table 2 shows that when the timing error is less than 2 days (18% of tapes), a cause for the error is not normally discernible when examining the tape. These short timing errors are caused by factors such as a weak battery which does not supply sufficient voltage to the timer (timer runs fast), or cannot operate the punch during extreme cold spells. The causes of the longer timing errors are obvious. As a result of this check, the system was designed to process automatically all tapes except those which are slow by more than 12 hours. For these latter tapes, the computer requires a reset control card which specifies the corrective action to be taken.

3. THE TRANSLATION OF TAPES INTO CARDS

3.1 The Initial Quality Check

All Fischer and Porter precipitation gauge tapes are forwarded to the Hydrometeorological Services Unit, Atmospheric Environment Service Headquarters in Downsview, Ontario for pre-editing and coding before translation into punched cards. Pre-editing consists of writing indentifying information (station name, gauge number, tape number, time of first and last punches, and punch cycle) in a standard format at the start of the tape. In addition, the enitire tape is searched for written comments or damaged sections. Such damage may be caused by tape misalignment, jammed punches, overpunching, or other malfunctions.

Damaged sections of tape, which cannot be processed by the Fischer and Porter automatic tape translator, are scrutinized and coded by drawing lines across the data tape to indicate what section of

TABLE 1
Common Problems with F&P Gauge Data

1. Fluctuations due to Wind – the precipitation reading oscillates up and down 0.1" several times per day when the accumulation is near the mid-point between two precipitation values.
2. Fluctuations due to Temperature – the precipitation reading varies up and down 0.1", once every day because of some temperature dependence in the gauge weighing mechanism.
3. Evaporation – the precipitation reading decreases 0.1" at weekly or longer intervals.
4. Leak in the Catch Bucket or Drain Tube – the precipitation reading decreases steadily and rapidly.
5. The translator misses a punched hole – the reading decreases up to 10" and then increases the same amount shortly thereafter.
6. The gauge does not cleanly punch hole – the reading may jump up and down by large amounts at irregular intervals.
7. Tampering with the Gauge – the gauge reading increases significantly within 1 punch cycle although there is no other change.
8. Draining of the Gauge – the gauge reading may drop sharply within one punch cycle. Sometimes no comment appears on the tape.
9. Clock Problems – the clock may be several hours slow or fast after operating for several months. This creates problems when joining together two consecutive tape records.
10. Overpunching – Failure of the Tape Advance Mechanism – there are many hours or days of information punched on one spot on the tape. All that can be deciphered is the total precipitation during the interval. This section of tape can not be translated.
11. Gauge Failure (dead battery, broken switch, etc.) – there is a long period with only the total precipitation known and sometimes not even that.
12. Alignment Punch Malfunction – the tape can not be processed as is. The tape is passed through a machine which punches all the alignment holes and then the tape is processed.

TABLE 2
Sample Breakdown of Timing Problems
(based on 90 tape sample)

	Cause
9 Tapes were fast (more punches than elapsed time suggests)	
5 fast by less than 6 hours	unknown
1 fast by 6 to 24 hours	unknown
3 fast by 24 to 48 hours	unknown
21 Tapes were slow (fewer punches than elapsed time suggests)	
4 slow by less than 5 hours	all unknown
1 by 6 to 24 hours	1 OVP
2 by 24 to 48 hours	both unknown
3 by 2 to 10 days	1 unknown, 2 OVP
6 by 11 to 30 days	1 unknown, 3 OVP, 2DB
5 by 31 to 90 days	3 OVP, 1 DB, 1 broken switch

NOTE: OVP: overpunching, tape slips on advance mechanism and individual punches can not be counted.
DB: dead battery

the record is to be bypassed by the translator. The bypassed section of tape is assigned one of five code-letters which the computer recognizes (Table 3). If a tape does not have the alignment holes correctly punched, they are punched by feeding the tape through a gauge which is reading zero precipitation.

Field notes provide invaluable information should any tape damage occur. They enable selection of the correct computer code, and also provide reference points for accurate time adjustments of the data. If a tape check is written on a tape in the field, this is coded as "A" and the correct time is noted. If the timer failed and the gauge began to punch at double speed, the translator operator can be instructed to skip every other punch beginning at an appropriate place on the tape.

A record is kept of each Fischer and Porter precipitation data tape received. All pertinent information, including notes on malfunctions and adjustments, is recorded in order to provide feed-back to the gauge operators and to compile a complete history of the individual gauge.

3.2 The Translator

The translator consists of:

(a) Fischer and Porter model 1551 reader – this advances the paper tape and detects the presence of any holes punched in the sixteen data channels;

(b) Fischer and Porter model 1559 time and date console – this console is set to the start time of the tape and as each punch is sensed by the reader, the timer is incremented by an amount equal to the cycle time of the gauge. Thus it keeps track of the date and time corresponding to each set of punched holes;

(c) IBM 026 printing card punch – once started, the punch is operated automatically by the translator until reaching the end of the tape, or until the operator intervenes. Prior to the start of a tape, the operator sets up a drum card in the keypunch machine to control automatic punching and skipping, and then manually punches the station number into the first data card.

The resulting data cards have been given the internal AES designation W21. They form an interim working deck. Each card contains complete indentification information – station, date and time, punch cycle, and control punches – as well as twelve 4-digit fields containing the accumulated precipitation values. The complete specification is presented in the appendix, with a card illustrated in Figure 5.

4. COMPUTER PROCESSING

4.1 Input Deck

The deck of punched cards when ready for computer processing, consists of the W21 cards from the translator preceded by a tape period control card and reset control cards (if any). The tape period card (see appendix and Figure 2) contains the station number, interpreted station name, punch cycle, gauge number, tape number, card identifier, and the times that the tape began and ended. The reset control cards are punched for each manually entered message on the paper tape. The cards contain the station number, and time on the Fischer and Porter time and date console when the operator stopped the translator in order to read the written message. Also noted is the punched card column when the automatic operation was stopped, and a code letter describing the message written on the paper tape. If the correct time was written on the paper tape during pre-editing it is also included in the reset control card.

4.2 Processing System

This system requires an IBM 360/30 computer with at least 64K byte memory, a card reader, a card punch, and a line printer.

As a preliminary step in the processing of data from gauges operating on a five-minute cycle, a special tabulation (designated 21-1) is produced. This tabulation shows all five-minute, hourly, daily, and

TABLE 3

Code		Explanation
A	YY/MM/DD/HH/mm/	– a time check has been written on the tape by the observer. YY-year, MM-month, DD-day, HH-hour, mm-minute
B		– the tape lost time exceeding one day due to over-punching at this location on the data tape
C		– the tape stopped at this point due to a power failure
D		– the gauge stopped at this point due to a mechanical failure
E		– the tape is damaged at this point due to faulty or erratic punches
F		– the tape has lost less than one day due to over-punching at this place on the tape
End		– when printed on the tape in conjunction with one of the above code letters, the tape is prematurely ended at this point

monthly precipitation amounts but only filters out obvious errors such as negative precipitation totals. Reset control messages are printed adjacent to the hour to which they apply.

The major data processing system then reads all the precipitation accumulations (5 or 15 minute cycles) for up to a 180 day period for one station and forms a contiguous matrix of 15-minute precipitation amounts in computer core. In addition, all the reset control cards are read and used as detailed in section 4.3 to correct the precipitation values. During this processing, the total time span between the start and end of tape is accounted for through corrections to the indicated date/time values.

The complete, corrected, data file is output on punch cards in the #21 card format (see appendix) with the first and last months of the paper tape period filled with missing-data cards. Each #21 card contains fifteen-minute precipitation amounts for eight hours of record and the cards are numbered 1 to 3 within each day. In addition, a tabulation (21-2) is printed. This tabulation gives fifteen-minute precipitation amounts, and indicates by means of flags all the corrections that the computer has made in order to allow clerical revision if necessary.

4.3 The Correction Logic

The main computer program corrects the precipitation record from one paper tape in two phases. First, the computer corrects the amount of precipitation by deleting all negative precipitation readings and trying to cancel out corresponding positive precipitation readings. Secondly, the program tries to adjust the timing of the data so that it matches the time the tape was on the precipitation gauge (as given by the period control card).

Corrections to Precipitation Amount

The data record is scanned from start to finish in computer core. Every time the computer encounters a negative precipitation of 0.1", it deletes it and then searches back in time for 48 hours then forward in time for 48 hours until it encounters the first positive precipitation reading. This reading (if any) is decreased by 0.1".

If a negative reading larger than 0.1" is encountered, it is deleted and subtracted from the first positive reading(s) occurring firstly within 6 hours prior to the negative value, or then within 18 hours after the negative value.

The following explains why the reduction of positive values because of large negative values was much more restricted in time than the reduction because of small negative values. Large negative values occur because of the translator missing a punched hole, the gauge not clearly punching a hole in the data tape, or the gauge being drained or leaking. The first two causes result in a comparable positive value almost immediately; the latter two never have a comparable positive value. Allowing the computer to search a long period might arase a significant precipitation event. Small negative changes are often a long time from the corresponding positive change.

Correction to Time

For the purposes of this section, a reset control card with the code "A" (time check) breaks the record into two parts which are handled independently. The philosophy behind all these time corrections is that time errors of less than one day are acceptable although undesirable; and that if an error of more than one day is possible, the data should be flagged as "Time Uncertain".

If the tape is fast (more punches than period control card allows) by 12 hours or less, and no precipitation fell in the last 12 hours; the excess punches at the end of the tape are ignored. If precipitation fell in the last 12 hours, the computer searches back in time for the first 24 hour period with no precipitation and removes the excess punches from that period. Since there was no precipitation for 24 hours, there must be at least 12 hours without precipitation after the correction (i.e. two storms will not be combined as one).

If the tape is fast by more than 12 hours, the excess punches at the end of the tape are deleted and the accumulated precipitation in that period is flagged as accumulated and placed in the last 15 minute interval of the tape. The data within five times the period, by which the tape was fast, from the end of the tape are flagged as "Time Uncertain". This was done because normally tapes which are fast give no indication of the cause (except when a timer begins to operate at double time, and this is noticed when the gauge is serviced).

If the tape is slow by 12 hours or less, the record is expanded with zero precipitation amounts until it matches the period control card.

If the tape is slow by more than 12 hours, and no reset control codes B through F are encountered, the tape is bypassed and referred back for further scanning by a technician who must determine the cause. If one or more reset control codes are encountered they are used with the following priorities to correct the record: priority 1, C or D; priority 2, B or E or F (see appendix for the meanings of the codes).

The time error is divided equally among the places where the highest priority reset control codes occurred. These corrections are then made by inserting a series of L's (indicating a period over which precipitation may have accumulated) and shifting subsequent data to a later time. If the tape was slow by more than 48 hours, all data after the first place where the computer corrected the time are flagged as "Time Uncertain".

4.4 Checking of Computer Corrections

Initially, the corrected precipitation data are printed on tabulation 21-2 which indicates precipitation amounts in units of 1/10 of an inch for each of the four, 15 minute time-periods of every hour of the day. In addition to the corrected precipitation amount, all corrections or adjustments made by the computer are clearly indicated by a code letter. A brief explanation of each code is printed on each page of the tabulation which allows easy interpretation by all potential users. The prime purpose of this tabulation is to allow verification of computer corrections and adjustments to the data, prior to publishing. Because all corrections and reset control cards are printed, one can use this tabulation to check the operation of the gauge. Time corrections are necessitated when the recording precipitation gauge is operating fast or slow. These corrections are easily checked due to the format of the tabulation and seldom need further adjustments.

Corrections to precipitation accumulations due to the deletion of negative precipitation readings, must be checked in a careful manner. Occasionally a situation will arise where the computer does not correct the precipitation record in the best manner. This is partially due to the large number of malfunctions which can cause erroneous data, and hence a computer program to meet all these contingencies would be impossible. One case where the computer corrections are not right and must be manually altered occurs when a large negative reading is followed immediately by an identical large positive reading but is preceded by 0.1" of precipitation. The computer does not cancel out the identical positive and negative values, but cancels out the negative, small positive, and all but 0.1" of the large positive value. Although this gives the correct total precipitation, it has altered the time when the precipitation occurred. Many variations of this type of problem are possible.

Careful scanning of the tabulation may reveal the obvious correction(s) to be made, however reference is often made to the original punched data tape for confirmation of any data adjustment.

Unusually large precipitation accumulations over fifteen-minute periods are checked manually because the computer cannot decide whether a large increase in precipitation is due to precipitation or some other cause. In this case, the original data tape may reveal the cause of a large increase and thus dictate the action to be taken, if any. Nearby stations can be checked to see if precipitation was occurring at that time.

All manual changes to the computer's corrections are marked on the tabulation. These changes are then made directly to the #21 archive cards which are used to produce the subsequent printouts for publication.

4.5 Publications and Data Archives

The tabulations produced semi-annually for publication provide several new opportunities for checking for errors in the final file of data. The tabulation of daily precipitation totals (21-3) places the records from neighbouring stations together, which allows easy intercomparison. Any major errors made by the timing correction logic are easily spotted. In addition, short periods of missing record which have resulted from merging the tape files can be located and converted to zero precipitation readings. These short gaps often result from the delay between the end time of one tape and the start time of the next tape due to the time taken when servicing the gauge.

The tabulation of the maximum precipitation intensities and the frequency of hourly rainfall by intensity (21-4) is computed from the #21 card file by accumulating 15-minute amounts over longer time periods. This tabulating accentuates any large rainfalls. Rainfall of more than 0.5" in one hour can be located quickly by scanning this table and then verified or rejected by comparison to other data sources including the original paper tape. Any errors found by these checks can be removed manually from the #21 card archive with little difficulty.

5. PROCESSING COSTS

A comparison of the data processing costs for data from the Fischer and Porter gauges and the ordinary recording rain gauges is shown below (based on $5/hour for wages). This comparison is of particular interest because the Fischer and Porter processing system is the first highly automated climatological data processing system area in the Atmospheric Environment Service.

Data Processing Costs Per Complete Station-Year of Data

	Fischer & Porter	Ordinary Recording Rain Gauge
Scanning of Source Document	$ 5	120
Punching Work Cards	$40*	40*
Scanning of Quality Control Listings	$ 3	12
Computer Corrections & Output Archive Cards	$10	10

It is interesting to note the substantially lower cost of processing data in the fully automated system. But the difference in cost should not be interpreted as a statement that one observing or processing system is superior to the other because the instruments are very different and the quality control of the recording rain gauge data is more strict. The recording rain gauge measures rainfall only, in increments of 0.01", costs about $300, and must have an observer to change the chart every day or at most, every week. The Fischer and Porter gauge measures all forms of precipitation in increments of 0.1" over fifteen minute intervals, costs about $1800, and can operate three months or more without any human assistance.

*NOTE: The costs of punching the work cards are similar for the two systems because the Fischer and Porter automatic system punches about six times as many cards as the other system.

6. FUTURE POSSIBILITIES FOR THE SYSTEM

The processing system was designed and constructed within a one year period. While the system was being implemented, several small improvements were considered but not implemented because of other priorities. Changes to the quality control logic in order to intercompare data from nearby stations are not contemplated because the changes would be costly and of little value due to the high spatial variability of precipitation. Below are some changes which might be made at a later date.

(a) The translator could put the data directly on magnetic tape in an image of the W21 card if a magnetic tape recorder was interfaced directly to the translator. This would substantially increase the translation speed and cut the time to read the data into the computer. In addition, a keypunch machine would not have to be dedicated to the translator.

(b) The archive file could be stored on magnetic tape with the merging of the files for each paper tape done by computer as the cards are loaded to disc for the semi-annual publication. An additional program would also be required to allow corrections found while checking the publication to be made to the computer file on disc prior to output of the data on magnetic tape.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the excellent work by Mr. F. Yates in developing the computer programs for this system. In addition, the authors wish to acknowledge many other people in the Climatic Data Processing Division whose work was essential in order to establish and operate this system successfully.

APPENDIX

1. **Fischer and Porter Precipitation Data Tape**: Identifying information is written on each data tape prior to machine processing.

Station Name and Province
Gauge and Tape Number, 5 digits
Tape on – year, month, day, hour (LST)
Tape off – year, month, day, hour, minute (LST)
Timing Cycle

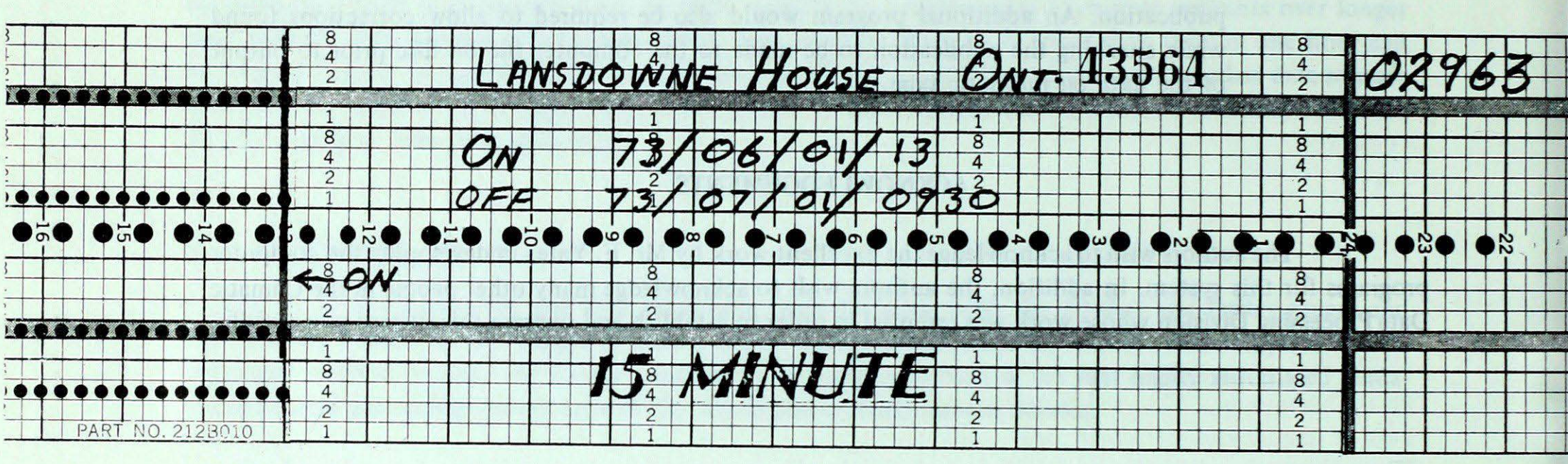


Figure 1.

2. **Tape Period Control Card**: This card precedes each physical deck of W21 cards. It is manually punched prior to the production of the W21 cards from the tape translator.

Card Column	Field	Remarks
1–7	Station listing number	assigned by A.E.S.
8–9	Listing number overpunch control code	
10–33	Station name	
34–37	Province	
38–39	Program	5 or 15 minute tape
40–42	Gauge number	written on tape
43–44	Tape number	written on tape
45	Supplementary tape number	
46–53	Time on	written on tape
54–63	Time off	written on tape
64–79	Unassigned	
80	Control punch	assigned by A.E.S. always '8'

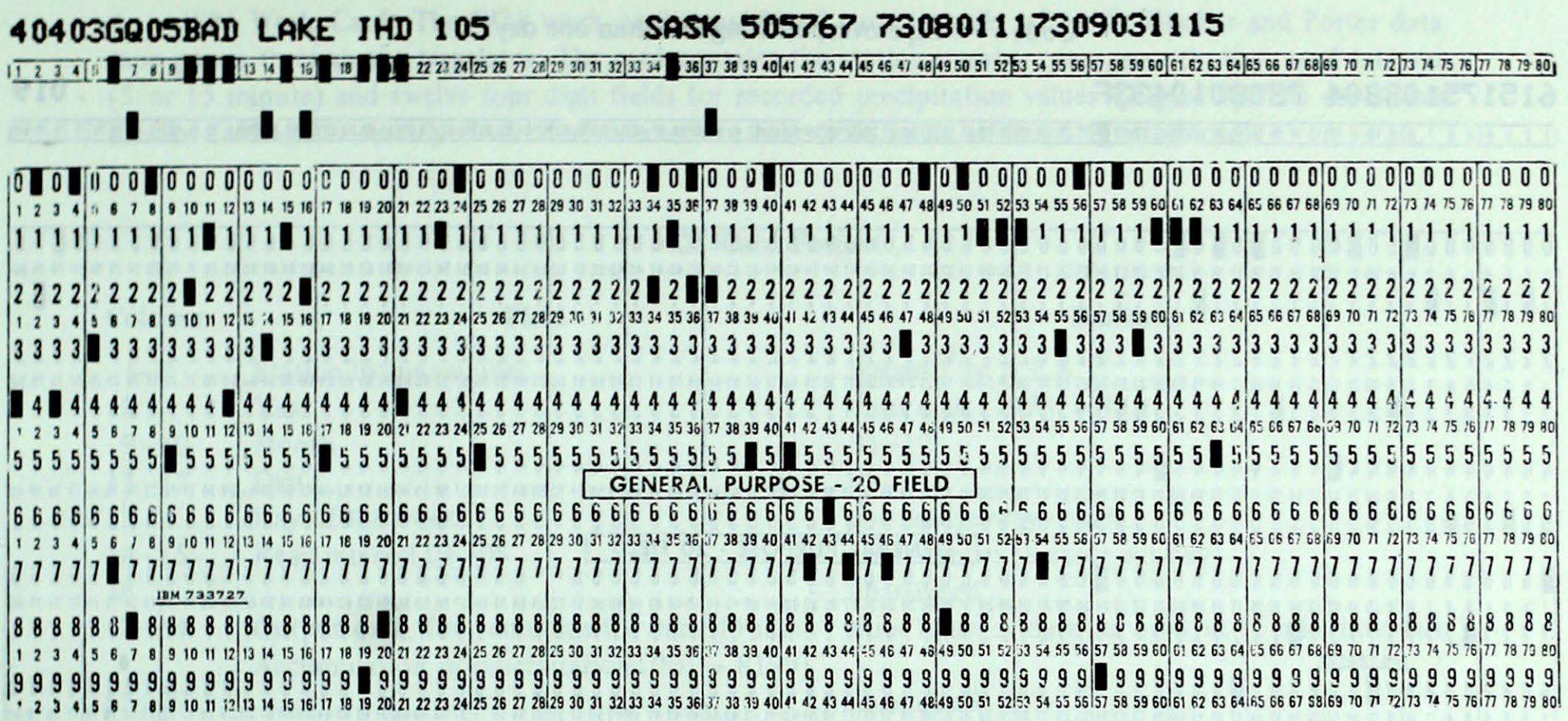


Figure 2.

3. **Reset Control Card**: The reset control card is manually punched from entries on a log sheet compiled by the Fischer and Porter translator operator. The log sheet entries are made each time a hand written code letter appears on the data tape as it passes through the automatic translator. Usually, the code will denote a tape error or an interruption in the record. (Figure 3 and Figure 4).

Reset Control Card Format

Column	Field	Remarks
1–7	Station listing number	assigned by A.E.S.
8–10	Gauge number	
11–12	Tape number	
13	Supplementary tape number	
14–15	Year	as read from translator
16–17	Month	as read from translator
18–19	Day	as read from translator
20–21	Read interval	
22–23	First Column number of next field to be punched	
24	Code letter	as written on tape
25	End	when written on tape
26–27	Year	as written with A code
28–29	Month	as written with A code
30–31	Day	as written with A code
32–33	Hour	as written with A code
34–35	Minute	normally 15 min. intervals
36–77		unassigned
78–79	Reset control card number	01 to 99
80	Control punch	always '9'

RESET CONTROL CARD

Code F – Tape overpunching less than one day.

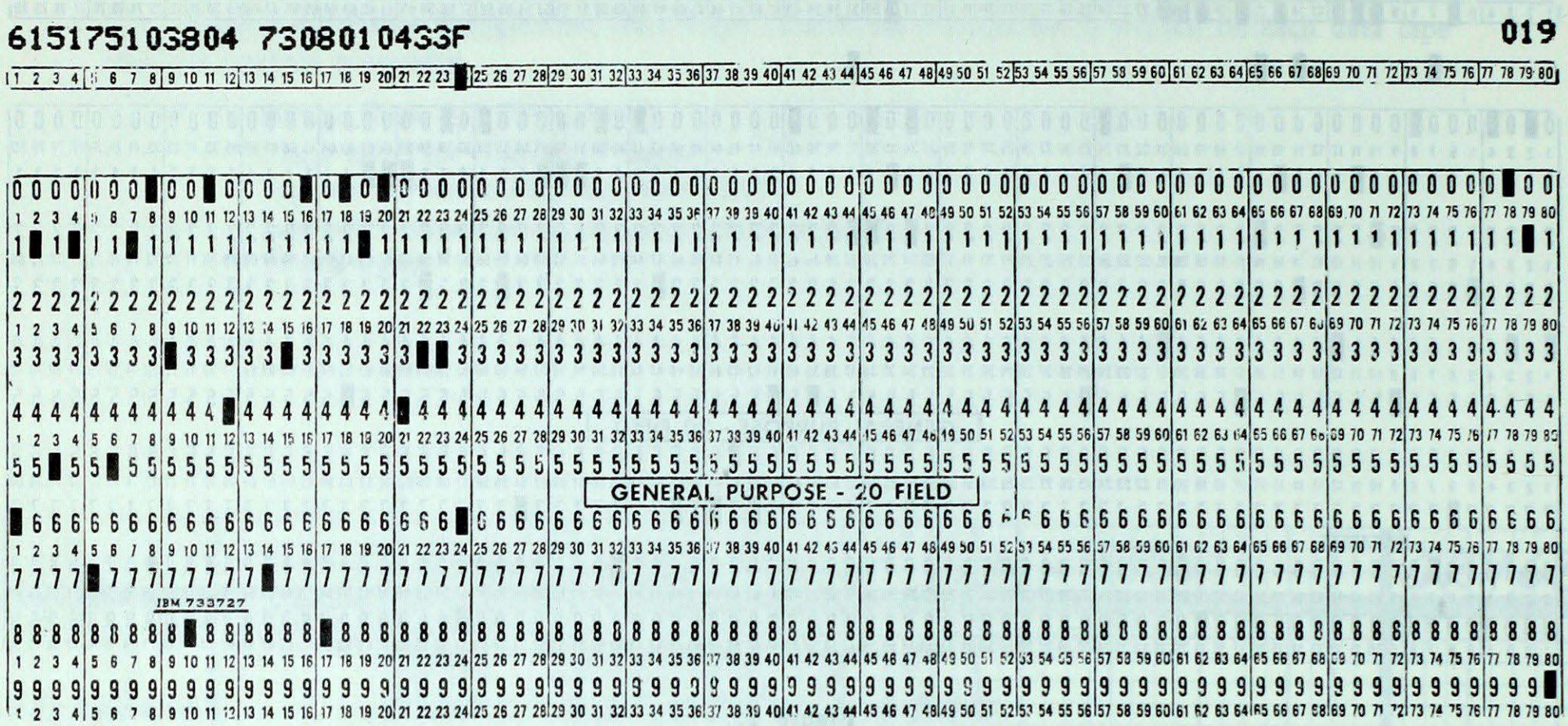


Figure 3.

RESET CONTROL CARD

Code A – Time check written on tape.

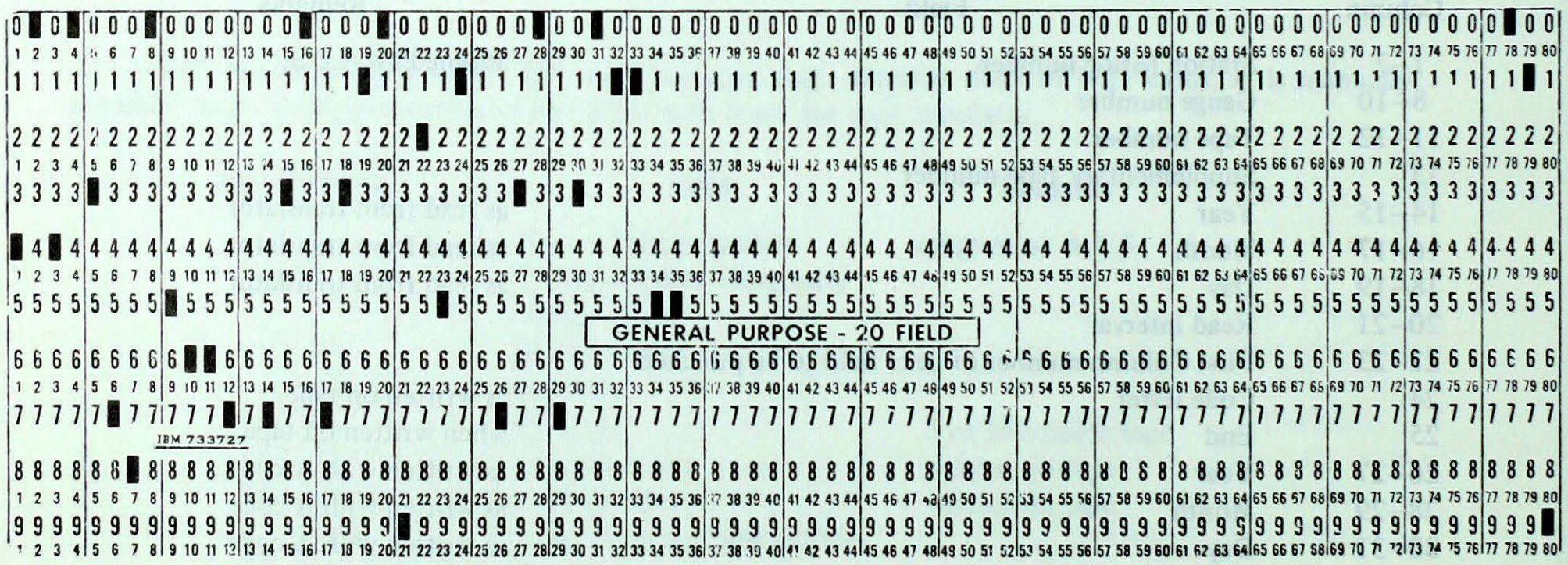


Figure 4.

4. **W21 Work Card**: The W21 work card is produced automatically when the Fischer and Porter data tape passes through the translator. The card contains the station number, year, month, day, read interval (5 or 15 minute) and twelve four digit fields for recorded precipitation values (Figure 5). The card is an interim card and is destroyed when all corrections have been made and card 21 produced.

W21 Card Format

Column	Field	Remarks
1–7	Station listing number	assigned by A.E.S.
8	Year	units digit (1973) = 3)
9–10	Month	01–12
11–12	Day	01–31
13	Day of the week	not used, always reads 1
14–15	Read interval 01–08	card number (8 cards per day)
16		unassigned
17–64	Output data, four columns for each 15 min. Accumulation of precipitation (001 – 8199)	three hours of data per card, at 15 min. intervals
65–79		unassigned
80	Control punch	manually punched in the first and last cards produced by the tape translator. – first card 'X' – last card 'Y'

Figure 5.

5. **21 Card**: This card is produced by the computer from the W21 cards and the reset control cards. The card contains the station number, year, month, day, card number and thirty-two columns for precipitation amounts from 01 to 99. Each of these columns represent the **end** of a fifteen minute period to match the fifteen minute time sequence on the Fischer and Porter data tape. Three cards are produced for each calendar day (8 hours per card) regardless of the precipitation gauges' operation. If data is missing, cards are produced for the missing period of time and 'M's are punched in the place of data. If the time during which precipitation fell is unknown, 'L's are punched in place of data and the total accumulated precipitation is punched, following the last 'L'. This amount is always preceded by 'X' (eg. LLLLLLLX12)

21 Card Format

Column	Field	Remarks
1–2	Card type	assigned by A.E.S.
3–9	Station listing number	assigned by A.E.S.
10–11	Year	
12–13	Month	
14–15	Day	
16	Card number	1, 2 or 3
17–80	32, fifteen minute precip. accumulations 2 columns per value	maximum accumulation 9.9 inches in a 15 minute period

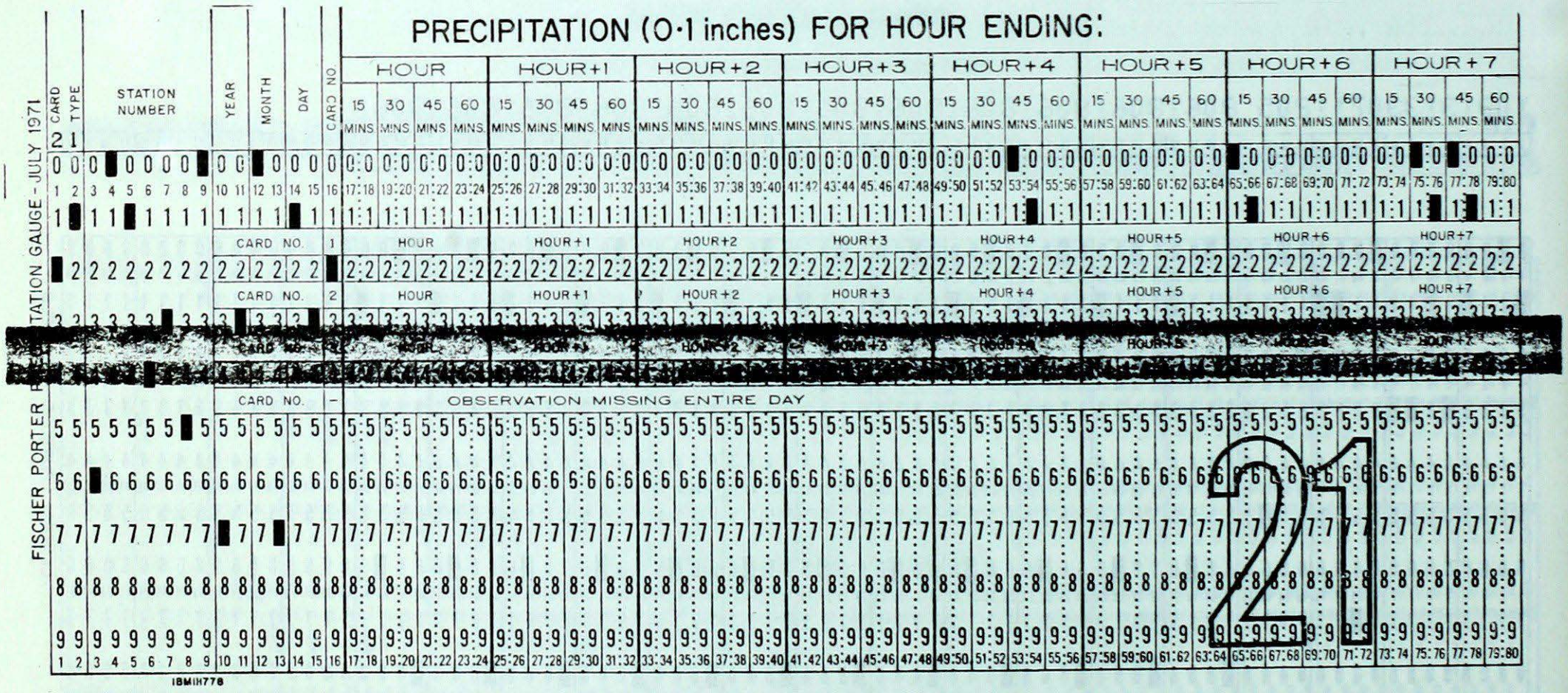


Figure 6.