UNIVERSITY OF ARIZONA

Institute of Atmospheric Physics

# SECOND ANNUAL PROGRESS REPORT

# COOPERATIVE PUNCHCARD CLIMATOLOGICAL PROGRAM

Conducted by the University of Arizona

in cooperation with the United States Weather Bureau

Robert B. DesJardins

November 15, 1956

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SECOND ANNUAL PROGRESS REPORT

Institute of Atmospheric Physics Punchcard
Climatological Program

## I. INTRODUCTION.

On November 15, 1954, the University of Arizona and the U.S. Weather Bureau entered into a cooperative program for converting to punchcard form a large part of the U.S. Weather Bureau climatological data for the State of Arizona. The objectives of this program were outlined in detail in the first annual progress report.[1] The purposes of the present report are, 1) to report on the progress made since November 15, 1955, on the punching phase of the program, 2) to report on the numerous changes in punching, verifying and processing procedures which have been made during the year, 3) to describe briefly the climatological studies which have been made from the punched cards, and 4) to outline plans for the coming year.

## II. SUMMARY OF PROGRESS DURING PAST YEAR.

A. Staff. At the present time five persons devote full time to the Institute's punchcard program. Direct supervision of all of the work is the responsibility of Mr. Robert B. DesJardins. Miss Celia R. Davis, Mrs. Emily Preskar, Mrs. Gwendolyn Moore, and Mrs. Kathleen N. Walker edit, punch, verify and process the data. In addition, Mrs. Joan P.. Tinson, the Institute's programmer for the IBM 650 computer, spends approximately three-fourths of her time on climatological problems. Dr. Reid A. Bryson, is in charge of all phases of the climatological program

[1]Copies of this report may be obtained from the Institute of Atmospheric Physics.

of the Institute. Dr. James E. McDonald, Scientific Director of the Institute, has maintained general cognizance of the program, particularly with respect to the relation between the IBM program and the other portions of the Institute Research Program.

B. Equipment and facilities. The Institute currently has the following card processing equipment:

| | | | |
|---|---|---|---|
| 3 | Type | 016 | Punches |
| 2 | Type | 024 | Punches |
| 1 | Type | 056 | Verifier |
| 1 | Type | 075 | Sorter |
| 1 | Type | 514 | Reproducer |
| 1 | Type | 419 | Tabulator |
| 1 | Type | 077 | Collator |
| 1 | Type | 602-A | Calculator |

Our experience with some of these machines is summarized below. All climatological data is now punched on the 024 punches. The first IBM Progress Report stated that the 016 Punch was used because of its low cost and because the climatological data, which is often difficult to read, did not enable operators to attain the high speed of which the new, more costly, punches are capable. Experience with the type 024 Punch has proven that this idea was erroneous; the 024 Punch is much superior to the 016 Punch for punching climatological data. The increased speed and flexibility of the 024 Punch greatly outweigh the increased cost.

The Type 075 Sorter is to be replaced by an 082 Sorter with a card counting device as soon as possible. The need for a faster sorter is becoming more apparent every day.

Our Type 077 Collator has a completely split comparing unit and a card counting device. So far we have not had a problem for the collator which could not have been solved with a partially split machine. Since the completely split machine is much more difficult to wire than a partially split collator we presently feel it was a poor choice.

Our Type 602-A Calculator is to be replaced by a Type 650 Electronic data processing machine on March 1, 1957. The major program we have planned for the 650, at this time, is discussed in Appendix D. Some of the difficulties we have encountered in programming the 650 to read and punch standard Weather Bureau cards are discussed in Appendix E.

C. Editing and punching procedures. During the year all of our editing and punching procedures have been greatly revised. These revisions were made for several reasons:

1. The decision to generate monthly summary cards on the 650 enabled us to cut out a large part of our editing and punching.

2. Analysis of the miscellaneous phenomena data indicated that most of these data probably were not worth punching, and definitely were not worth hours of labor trying to interpret illegible writing.[1]

3. The decision to machine-verify a large part of the data enabled us to eliminate part of the verifying procedure.

Our present editing procedures are in Appendix A and the punching rules are in Appendix B of this report. All of the changes from the previous rules are noted and the reasons for the changes are explained.

Because of these changes in procedure, and because of the use of the new type punches, the rate of punching has been greatly increased.

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[1] A summary of this study is presented in Appendix C of this report.

Experienced operators can easily complete 8 years a day (if the data are in fair shape) and can punch 10-12 years a day if the data are in good shape.

Our present punching and processing cost varies from 1.0 to 1.5 cents per card.

D. Inventory of card decks at the Institute.

1. 1009 climatological data. Figure 1 shows the locations of all of the stations in Arizona for which climatological data will be placed on punched cards by the Institute. As of November 15, 1956 we have completed approximately 60 per cent of this punching. The stations which have been completed, and their periods of records are listed below. The punched record for each station ends at 6/48 unless otherwise indicated.

| Stn. | No. | Record Starts | No. of Yrs. Punched | Remarks |
|---|---|---|---|---|
| Aguila | 0060 | 01/24 | 24½ | |
| Ajo | 0080 | 01/14 | 34½ | |
| Alpine | 0159 | 10/04 | 39 | 1905-1911 missing |
| Apache Powder Co. | 0309 | 07/23 | 25 | No temps. until 1/44 |
| Bartlett Dam | 0632 | 09/39 | 9 | |
| Blue | 0855 | 11/05 | 26 | Record ends 12/30, 1907 missing |
| Bowie | 0958 | 01/99 | 48½ | 1946 missing |
| Buckeye | 1026 | 01/93 | 55 | 2/48-6/48 missing |
| Casa Grande | 1306 | 06/98 | 47 | 1915, 16, 24 missing Many months missing in other years |

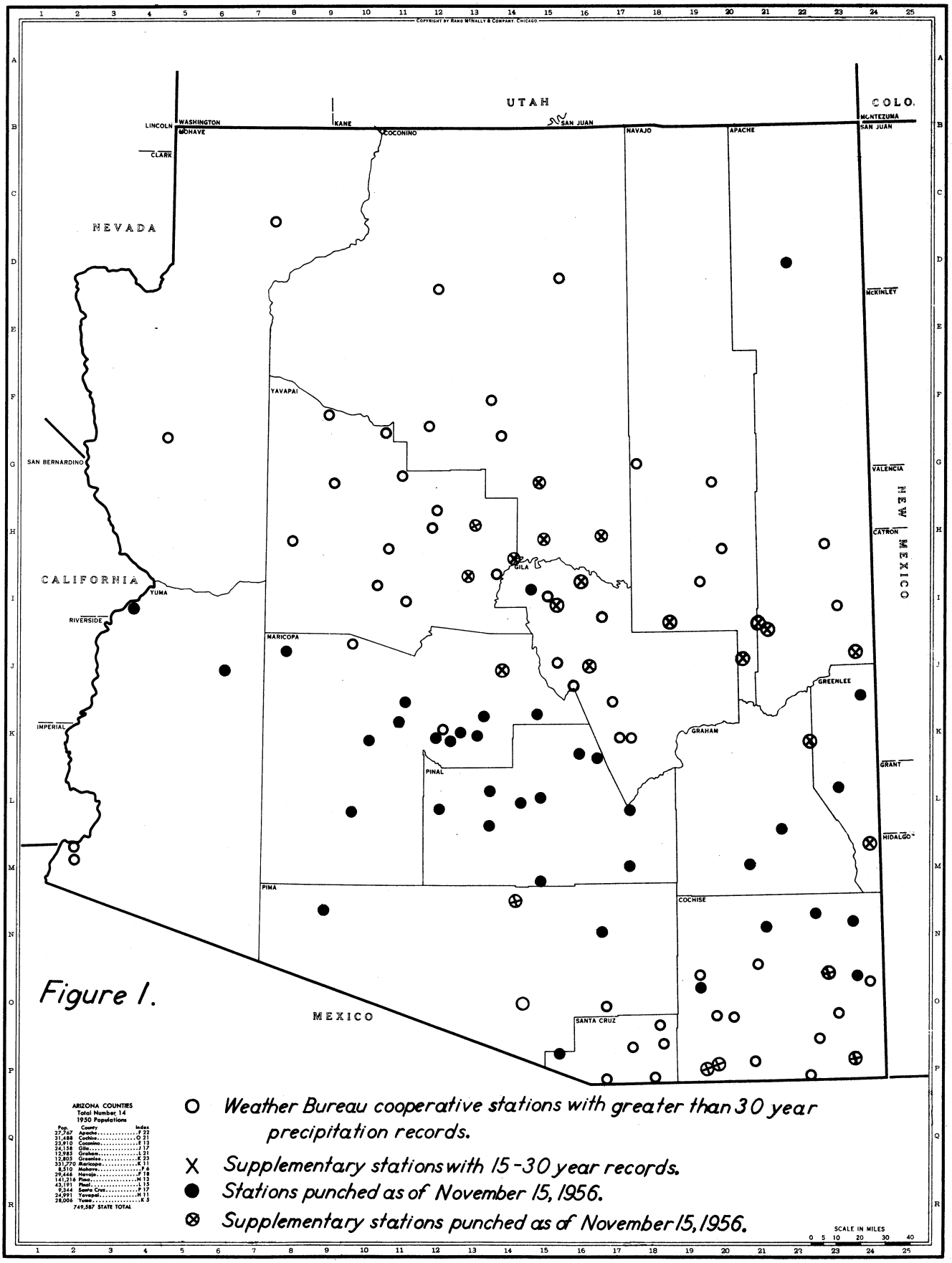


Figure 1.

ARIZONA COUNTIES
Total Number, 14
1950 Populations

| Pop. | County | Index |
|---|---|---|
| 27,767 | Apache | F 22 |
| 31,488 | Cochise | O 21 |
| 23,810 | Coconino | E 13 |
| 24,158 | Gila | J 17 |
| 12,985 | Graham | L 21 |
| 12,803 | Greenlee | K 23 |
| 331,770 | Maricopa | K 11 |
| 8,510 | Mohave | F 6 |
| 29,446 | Navajo | F 18 |
| 141,216 | Pima | M 13 |
| 43,191 | Pinal | L 15 |
| 9,344 | Santa Cruz | P 17 |
| 24,991 | Yavapai | H 11 |
| 28,006 | Yuma | K 5 |

749,587 STATE TOTAL

○ Weather Bureau cooperative stations with greater than 30 year precipitation records.

X Supplementary stations with 15-30 year records.

● Stations punched as of November 15, 1956.

⊗ Supplementary stations punched as of November 15, 1956.

SCALE IN MILES
0 5 10 20 30 40

1. 1009 climatological data (Cont.)

| Stn. | No. | Record Starts | No. of Yrs. Punched | Remarks |
|---|---|---|---|---|
| Casa Grande Ruins | 1314 | 09/06 | 27 | 1907, 1917-1930 missing |
| Chinle | 1634 | 12/08 | 33½ | 1929-34 missing |
| Cibecue | 1749 | 06/27 | 21 | |
| Clifton | 1849 | 01/93 | 55½ | |
| Dudleyville | 2730 | 01/93 | 32½ | Record ends 5/25 |
| Duncan | 2754 | 01/01 | 14½ | 1908-1940 missing |
| Eagle Creek | 2779 | 01/28 | 20½ | No temperatures |
| Florence | 3027 | 12/92 | 41½ | 1895-1907, 1920 missing |
| Fort Grant | 3110 | 01/00 | 35½ | 1906-1917, 1945 missing |
| Gila Bend | 3393 | 12/92 | 54 | 1897, many months missing |
| Gisela | 3448 | 04/95 | 36 | 1899-1915 missing, no temps. |
| Gould's Ranch | 3573 | 01/15 | 33½ | |
| Granite Reef Dam | 3621 | 01/93 | 55½ | Temp. data missing throughout record |
| Kingman | 4639 | 05/01 | 47 | |
| Litchfield Park | 4977 | 08/17 | 31 | |
| Maricopa | 5274 | 06/98 | 48 | 1909-1910 missing |
| Marinette | 5282 | 07/13 | 31½ | Record ends 12/45 1919 missing |
| McNary | 5412 | 08/33 | 15 | |
| Mesa | 5467 | 03/96 | 50 | 1913-1914 missing |
| Montezuma Castle | 5635 | 10/38 | 10 | |
| Mormon Flats | 5700 | 08/23 | 25 | |

1. 1009 climatological data (Cont.)

| Stn. | No. | Record Starts | No. of Yrs. Punched | Remarks |
|---|---|---|---|---|
| Natural Bridge | 5825 | 01/93 | 55½ | |
| Oracle | 6116 | 01/93 | 52½ | 1920-1922 missing |
| Paradise | 6242 | 01/06 | 31½ | Record ends 8/37 |
| Parker | 6250 | 10/93 | 54½ | |
| Pinal Ranch | 6561 | 03/95 | 50½ | 1943-1945 missing |
| Red Rock | 7058 | 01/93 | 31 | Record ends, 12/35 1896-1907 missing |
| Ruby | 7326 | 04/95 | 28 | 1902-15, 1919-1929 missing |
| Sacaton | 7370 | 04/08 | 40 | |
| Safford | 7388 | 08/98 | 50 | |
| Salone | 7460 | 01/08 | 40½ | |
| San Simon | 7560 | 03/98 | 44½ | 1901-02, 1917-1920 |
| Santa Marguerita | 7583 | 06/17 | 31 | No temperatures |
| Sentinel | 7876 | 11/13 | 18½ | 1919-1934 missing |
| Silverbell | 7915 | 02/06 | 15 | Record ends 12/20 |
| Sycamore R.S. | 8319 | 07/19 | 29 | No temperatures |
| Superior | 8348 | 01/21 | 27½ | |
| Tempe | 8489 | 01/26 | 22½ | |
| Tempe Date Farm | 8494 | 01/05 | 43½ | |
| Tucson (U. of A.) | 8815 | 09/94 | 54 | |
| Wallace R.S. | 9150 | 05/16 | 29 | 1946 missing |
| White River (Ft. Apache) | 9271 | 01/00 | 43½ | 1935-39 missing |

1. 1009 climatological data (Cont.)

| Stn. | No. | Record Starts | No. of Yrs. Punched | Remarks |
|---|---|---|---|---|
| Wickenberg | 9287 | 03/08 | 39 | 1909 missing |
| Willcox | 9334 | 06/98 | 50 | |
| Wittman | 9464 | 12/23 | 24½ | |
| | | | 1952½ | Total yrs. punched for stations in Arizona |

In addition, the data have been punched for the following stations in New Mexico.

| | | | | |
|---|---|---|---|---|
| Agricultural College | 0131 | 01/92 | 56½ | |
| Cimarron | 1813 | 05/05 | 44 | |
| Ft. Bayard | 3265 | 02/97 | 51½ | |
| Hood R.S. | 4101 | 12/06 | 35½ | 1910-1915 missing |
| | | | 187½ | Total yrs. punched for stations in New Mexico |

We have received the 1009 cards for the following stations from the Weather Bureau. These cards were punched by the Weather Bureau for the U. S. Army Electronic Proving Ground at Ft. Huachuca. They were reproduced and sent to the University at the expense of Ft. Huachuca.

| | | | | |
|---|---|---|---|---|
| Benson | 0680 | 06/94 | 50½ | 1895-1897 missing |
| Bisbee | 0768 | 12/96 | 55½ | |
| Canelo R.S. | 1231 | 01/10 | 37½ | 1922 missing |
| Chiricihua | 1664 | 12/09 | 10½ | 1920-1947 missing |
| Cochise | 1870 | 01/99 | 31 | 6/25-11/43 - station moved and known as Cochise Stronghold (1874) |

1. 1009 climatological data (Cont.)

| Stn. | No. | Record Starts | No. of Yrs. Punched | Remarks |
|---|---|---|---|---|
| Cochise Stronghold | 1874 | 06/25 | 18 | See Cochise |
| Douglas | 2669 | 12/03 | 44½ | |
| Ellin | 2797 | 10/12 | 35½ | |
| Fairbank | 2902 | 07/09 | 39 | |
| Ft. Huachuca | 3120 | 02/00 | 22½ | Record ends 5/40 1921-1938 missing |
| Helvetia | 3981 | 06/16 | 32 | After 5/19/50 station was called Santa Rita Exp. Range and was assigned No. 7593 |
| Leslie Canyon | 4864 | 05/16 | 32 | |
| Nogales | 5922 | 12/92 | 46½ | 1896-1898; 1905-1908; 1911-1912: missing |
| Patagonia | 6280 | 07/21 | 27 | |
| Portal | 6706 | 01/14 | 33½ | 1943 missing |
| Rucker Canyon | 7334 | 01/93 | 36½ | 1898-1916 missing |
| San Rafael Ranch | 7555 | 12/92 | 31½ | 1895; 1900-1922 missing |
| Stephens Ranch | 8206 | 12/28 | 19½ | |
| Tombstone | 8619 | 07/93 | 52 | 1894-1896 missing |
| Y-Lightning Ranch | 9562 | 01/39 | 9½ | |
| | | | 664½ | Total yrs. reproduced for stations in Arizona |

In addition to the 1009 climatological data, the Institute has several other decks of punched cards which contain various types of meteorological and hydrological data. The stations for which these data are available are listed below for each of these decks. All of the cards in decks 2-7 were reproduced by the Weather Bureau and sent to the University of Arizona at no cost to the University.

2. WBAN hourly surface observations.

| Stn. | Stn. No. | Period of Record |
|---|---|---|
| Flagstaff, Arizona | 23166<br>03103 | 1/48-1/50<br>1/50-12/55 |
| Phoenix, Arizona | 23183 | 1/48-12/55 |
| Prescott, Arizona | 23184 | 1/48-12/55 |
| Tucson, Arizona | 23193<br>23160 | 1/48-10/48<br>9/48-12/55 |
| Winslow, Arizona | 23194 | 1/48-9/48<br>9/48-12/55 |
| Yuma, Arizona | 93145<br>23195 | 1/48-9/48<br>9/48-12/55 |

3. WBAN summary of the day.

| | | |
|---|---|---|
| Flagstaff, Arizona | 23166<br>03103 | 1/1/48-1/11/50<br>1/12/48-12/31/55 |
| Phoenix, Arizona | 23183 | 1/1/48-12/31/55 |
| Prescott, Arizona | 23184 | 1/1/48-12/31/55 |
| Tucson, Arizona | 23193<br>23160 | 1/1/48-10/14/48<br>10/15/48-12/31/55 |
| Winslow, Arizona | 23194 | 1/1/48-12/31/55 |
| Yuma, Arizona | 23195 | 10/11/48-12/31/55 |

4. WBAN winds aloft.

| Stn. | Stn. No. | Period of Record |
|---|---|---|
| Albuquerque, New Mexico | 23050 | 1/48-8/55 |
| El Paso, Texas | 23044 | 1/48-9/55 |
| Ely, Nevada | 23154 | 1/48-9/55 |
| Grand Junction, Colorado | 23066 | 1/48-9/55 |
| Las Vegas, Nevada | 23173<br>23169<br>23112 | 1/48-12/48<br>1/48-8/53; 2/54-9/55<br>8/50-2/54 |
| Phoenix, Arizona | 23183 | 1/48-6/55 |
| Tucson, Arizona | 23109 | 1/48-7/55 |

5. Radiosonde data.

| | | |
|---|---|---|
| Albuquerque, New Mexico | 23050 | 1/48-12/55 |
| El Paso, Texas | 23044 | 1/48-12/55 |
| Ely, Nevada | 23154 | 1/48-12/55 |
| Grand Junction, Colorado | 23066 | 1/48-12/55 |
| Las Vegas, Nevada | 23173<br>23169 | 1/48-12/48, 7/50-7/52<br>1/49-12/49, 8/52-12/55 |

6. Daily solar radiation data.

| | | |
|---|---|---|
| Albuquerque, New Mexico | 23050 | 7/52-5/55 |
| Phoenix, Arizona | 23183 | 7/52-1/55 |

7. Hourly solar radiation data.

| | | |
|---|---|---|
| Albuquerque, New Mexico | 23050 | 7/52-6/55 |
| Phoenix, Arizona | 23183 | 7/52-6/55 |

8. Monthly precipitation cards. The Institute has punched monthly and annual precipitation cards from Bulletin "W" for the following stations in the Southwest:

| Colorado | Record Starts[1] | | Record Starts[1] |
|---|---|---|---|
| Burlington | 1891 | La Veta Pass | 1909 |
| Collbran | 1892 | Leadville | 1908 |
| Delta | 1888 | Montrose No. 2 | 1900 |
| Denver | 1872 | Paonia 1 S | 1900 |
| Durango | 1895 | Pueblo | 1887 |
| Ft. Collins | 1887 | Rocky Ford 2ESE | 1889 |
| Grand Junction | 1892 | Silverton 2NE | 1907 |
| Gunnison | 1901 | Steamboat Springs | 1909 |
| Hartsel | 1909 | Telluride 2WNW | 1912 |
| Lake Moraine | 1895 | Trout Lake | 1914 |
| Las Anias 1N | 1867 | Yuma | 1890 |
| Texas | | | |
| Abilene | 1886 | Del Rio | 1906 |
| Amarillo | 1892 | El Paso | 1850 |
| Austin | 1856 | Galveston | 1872 |
| Brownsville | 1871 | Laredo | 1877 |
| Corpus Christi | 1887 | Lubbock | 1912 |
| Dallas | 1888 | | |
| Utah | | | |
| Blanding | 1905 | Levan | 1890 |
| Cedar City | 1910 | Logan, Utah State Ag. College | 1891 |
| Corinne | 1870 | Moab | 1890 |
| Desert | 1900 | Modena | 1901 |

[1]All records end with 1955.

8. Monthly precipitation cards (Cont.)

| | Record Starts[1] | | Record Starts[1] |
|---|---|---|---|
| Duchesne | 1906 | Ogden Pioneer P.H. | 1870 |
| Emery | 1901 | Parowan | 1891 |
| Farmington | 1900 | Provo Radio (KOVO) | 1891 |
| Fillmore | 1892 | St. George P.H. | 1890 |
| Ft. Duchesne | 1888 | Salt Lake City | 1874 |
| Heber | 1893 | Silver Lake, Brighton | 1916 |
| Ibaplah | 1913 | Tooele | 1897 |
| Laketown | 1900 | | |
| New Mexico | | | |
| Agricultural College | 1851 | Las Vegas | 1892 |
| Albuquerque | 1892 | Lordsburg | 1881 |
| Aztec | 1911 | Roswell | 1878 |
| Carlsbad | 1894 | Santa Fe | 1850 |
| Cimmaron | 1904 | Santa Rosa | 1908 |
| Cloudcroft 1 | 1902 | Socorro | 1905 |
| Fort Bayard | 1867 | Springer | 1904 |
| Hood R.S. | 1917 | Taos | 1901 |

In addition to punching precipitation data for these stations in the Southwest we are currently punching monthly and annual precipitation totals for about 150 U. S. stations for the period 1905-1955. Thus far, we have completed this punching for two stations, Mobile, Alabama and Little Rock, Arkansas.

9. Daily runoff data. The Institute has punched daily runoff data for the following stations.

| Stn. No. | Station Name | Period of Record |
|---|---|---|
| 764 | Salt River near Roosevelt, Arizona | 1901-1907<br>1913-1954 |
| 692 | Gila River at Head of Safford Valley near Solomon, Arizona | 1914-1954 |
| 766 | Tonto Creek near Roosevelt, Arizona | 1913-1940 |
| 765 | Tonto Creek above Gun Creek near Roosevelt, Arizona | 1941-1954 |
| 785 | Verde River below Bartlett Dam, Arizona | 1890, 1895-1938 |
| 784 | Verde River above Bartlett Reservoir near Cave Creek, Arizona | 1939-1945 |
| 782 | Verde River below Tangle Creek above Horseshoe Dam, Arizona | 1946-1954 |

The number of cards in each of these decks is summarized in Table 1.

E. Plans for increasing card file in 1957.

1. 1009 climatological cards. During the coming year we plan to punch 1009 climatological cards for 36 stations in Arizona and 1 station in New Mexico. These stations comprise approximately 1650 station years of data of approximately 600,000 cards. This will complete our presently planned program for back-punching 1009 data. The Weather Bureau will reproduce for the University approximately 350,000 cards which have been punched since July 1948, for the 115 stations in Arizona and New Mexico which we have back-punched. Hence, our file of 1009 climatological cards will approach 2,000,000 cards by the end of the year.

2. Summary cards generated from daily 1009 cards. On March 1, 1957, when the Type 650 Computer will be available to the Institute, we will begin making 5-day and monthly summary cards from the daily 1009 cards, as a part of one 650 program. (Described in Appendix D).

Table 1

Summary of Punched Card Decks at the Institute of Atmospheric Physics

| Deck No. | Deck Name | Punched at Institute | Duplicated by Weather Bureau |
|---|---|---|---|
| 1 | 1009 Climatological Cards | 780,000 | 240,000[1] |
| 2 | WBAN Hourly Surface Obs. | | 395,000 |
| 3 | WBAN Summary of Day | | 18,000 |
| 4 | WBAN-22 Winds Aloft | | 110,000 |
| 5 | WBAN-33 Radiosonde Data | | 250,000 |
| 6 | Hourly Solar Radiation | | 28,000 |
| 7 | Daily Solar Radiation | | 2,000 |
| 8 | Monthly Precip. Totals | 62,000 | |
| 9 | Runoff Data | 70,000 | |
| | Miscellaneous Decks | 22,000 | |
| | Trigometric Deck | 6,000 | |
| | | 940,000 | 1,043,000 |

Total no. of punched cards as of 11/15/56, 1, 983,000.

[1]Duplication of these 1009 cards was paid for by Ft. Huachuca.

Five-day summary cards are being made instead of weekly summary cards because the data for mean 5-day surface maps of the northern hemisphere are available on punched cards. Since our 5-day periods are the same as the 5-day periods used in preparing the mean surface maps, studies of the relationship between the circulation of the northern hemisphere and the weather in Arizona can be made by machine.

3. Monthly precipitation cards. During the year the Institute plans to expand the deck of monthly precipitation cards which have been punched for stations in the Southwest by punching monthly precipitation data for the period from 1905-1955 for approximately 150 stations throughout the United States.

4. Upper air data. We plan to expand our upper air card decks to include daily radiosonde and winds aloft data for approximately 30 stations in the western United States and Mexico and mean monthly radiosonde data for all of the radiosonde stations in the United States and Mexico. These cards will be used in a study of the water vapor transport over the United States. The Institute hopes to receive the support of the Office of Naval Research and the Weather Bureau in this vapor-flux research.

## III. PUNCHCARD CLIMATOLOGICAL STUDIES.

A. Progress made during the past year. Most of the punchcard studies made at the Institute during the year have been pilot studies, designed to aid in planning large studies which will be made when the punching phase of our program is completed. In addition to guiding our planning, these studies have, in general, indicated many other unanswered problems, which need to be investigated.

Each of the studies which have been made during the past year has been, or will be, published as an Institute report in the near future. Hence, each study will be only briefly described here.

1. A preliminary study was made of the precipitation characteristics which might have an effect on amounts of runoff, using nine stations in the Salt River Watershed. The precipitation parameters which were studied were: the percent of precipitation which occurs as snow, the distribution of 24 hour precipitation amounts and the amount of precipitation per rainy day.

2. A general study of the climatology of the state included preliminary investigations of the following climatological features:

a. The correlations between seasonal precipitation amounts at individual stations in Arizona,

b. The correlations between groups of stations in different sections of Arizona,

c. The autocorrelations between seasonal precipitation amounts,

d. The secular trends in the seasonal and annual precipitation,

e. The frequency distribution of seasonal precipitation amounts. This has included an analysis of various methods of normalizing the precipitation data,

f. An analysis of individual station records for homogeneity.

A large amount of time has been spent in studying different analysis techniques to see which are best suited for machine analysis. This part of the study has involved a comparison of product moment correlation coefficients, tetrachoric correlation coefficients and rank-difference

correlation coefficients. Heteroscedasticity of Arizona precipitation has also been examined as part of this exploratory study. All of these exploratory studies will be reported shortly, as Institute scientific and technical reports growing out of the Weather Bureau-University of Arizona cooperative program.

B. Studies planned for 1957. The punched card climatological studies planned for 1957 can be outlined as follows:

1. Preparation of monthly and 5-day summary cards, frequency distributions of the maximum and minimum temperatures and an analysis of the precipitation data.

2. Studies of the homogeneity of the data for individual stations.

3. Studies of the relationships between Arizona stations. If possible, we plan to determine the climatologically homogeneous regions within Arizona.

4. A study of methods which can be used to interpolate missing data. We hope to improve on the most commonly used method of linear interpolation from surrounding stations.

5. After the data have been analyzed and adjusted, and missing data estimated, we will begin a complete analysis of the climate of Arizona and the Southwest. This analysis will include extensions of the studies made last year and studies of the type outlined in our first annual IBM report.

## APPENDIX A. PROCEDURES FOR EDITING 1009 FORMS.

General Discussing. The editing procedures currently used by our IBM operators at the Institute have been greatly reduced from the procedures reported in the first annual report because of our present plans to generate monthly summary cards by machine methods. The editing procedures which our operaters no longer perform have not been eliminated but have been transferred to the IBM Type 650 data processing machine.

Editing rules. The following list comprises the present group of rules for editing original 1009's in the Arizona program.

### I. GENERAL.

A. Use only blue pencil when marking 1009 forms.

B. Make all entries as light as possible but be sure they are dark enough to be easily readable by the punch operator.

C. Handle the 1009 forms as carefully as possible; always replace the forms in the same envelope from which they were taken.

### II. TEMPERATURE.

In general, all observations are entered for the "observational day" (the 24-hour period between observations), the date being that on which the observational period ends. For example, if the temperature and precipitation are read at 8 AM on the 1st; the 2nd "observational day" begins at 8 AM on the 1st and ends at 8 AM on the 2nd, etc.

The use of the "observational day" creates a problem in recording the maximum temperature since the maximum temperature read at 8 AM is actually the maximum temperature for the preceding day. The correct procedures for handling the maximum temperature observations at "AM" stations are discussed in full in the punching instructions.

Steps 1 to 3 of the old procedure for editing temperature data have been transferred to the 650.

A. If the observer has entered the temperature range of the mean temperature, delete these values with a light blue line in order to eliminate any possible confusion when the temperature readings are punched.

III. PRECIPITATION.

A. Since the daily precipitation amounts are now verified by machine and the total monthly precipitation is computed on the 650, the accuracy of the total monthly precipitation amount is no longer checked as the data are edited. However, the other checks in Step 1 are still made. Namely, whenever snowfall is reduced there should also be an entry for precipitation. If there is an entry in the snowfall column but not in the precipitation column the amount of precipitation should be estimated using the standard 10 to 1 ratio, i.e., the amount of precipitation is estimated to be 1/10 of the amount of snowfall.

B. Occasionally the observer enters two rainfall entries in one day (i.e., two entries on one daily line). Evidently, this is done to denote that two separate showers occurred during the observational day. Whenever this occurs the amounts should be combined so that there will be only one entry for each observational day.

C. If there are any missing data the total monthly precipitation should be deleted unless there is very good reason to believe that no precipitation occurred during the period of missing data. Except in rare cases which the editor may wish to refer to the supervisor, "good reason" will exist only if the original observer had made an entry somewhere on the 1009 to the effect that he was certain no precipitation had occurred

on the dates of missing entries or if the editor in the Phoenix Weather Bureau office who originally edited the 1009 has entered a similar note based upon comparison with concurrent reports from nearby stations. Any monthly total, however, which contains interpolated amounts should be treated as incomplete and entered as missing.

D. If the record states rain and snow and there is a trace in the precipitation column, put a "T" in snowfall. If there is more than a trace of precipitation, leave the snowfall amount missing unless reported. If the record states rain and snow, snow melted as it fell, and there is an amount in the precipitation column, put a "T" in snowfall. If the record states snow flurries and there is an amount in the precipitation column, enter a "T" in snowfall. For snow flurries and no amount of precipitation or snowfall, enter a "T" in both.

E. This step was rewritten to make it more explicit and, in accordance with present Weather Bureau procedure, to eliminate entering a trace of snow for occurrances of hail. The present procedure is:

If rain, snow, drizzle, sprinkle, shower, mist, sleet, glaze, hail or freezing rain is entered in the remarks column be sure that there is an entry of at least a trace in the precipitation column. If there is no amount of precipitation entered, mark it as missing. If sleet is reported, enter "T" in snowfall column unless the amount seems clearly more than a trace, in which case the snowfall is marked as missing.

F. Almost all of the 1009 forms have a column to record the depth of snow on the ground at the time of observation. In addition, many forms have a place at the right side of the form to indicate the depth of snow on the 15th and at the end of the month. This latter information is often useful in interpolating the depth of snow when the observer did

not make daily entries. Whenever snowfall occurs, the depth of snow should be edited in the following manner.

Whenever the amount of snowfall is less than 1.0 inches the depth on ground should be edited as 0 inches unless there is a good reason (temperatures below freezing, remark by observer, etc.) to believe that there was snow on the ground. Whenever the snowfall is greater than 1.0 inches the depth on ground should be edited as missing (M) unless there is a good reason (very high temperatures, observers remark that snow melted as fell or that snow melted before observation time, etc.) to believe that there was no snow on the ground.

It is sometimes necessary to interpolate snow depth values for days after a snowfall. For example, the observer records a snowfall of 3.0 inches on the 12th and records 2.0 inches on the ground. On the right side of the form he records a trace of snow on the ground on the 15th. The problem of interpolating the snow depth for the 13th and 14th calls for considerable judgement on the part of the editor. If it is not possible to reach a reasonable conclusion after studying the temperatures the snow depth for the 13th and 14th would be marked as missing (M).

G. Check all precipitation entries and edit them so that the amount of precipitation is entered to hundredths of an inch, snowfall to tenths of an inch and depth of snow on ground to whole inches. For example, if precipitation is recorded as .5 (or $\frac{1}{2}$ inch) make the entry .50. If snowfall is recorded as .25 (or $\frac{1}{4}$ inch) make the entry .2. If depth of snow on ground is recorded as 1.5 inches make the entry 2 inches. After rounding off, entries must be checked for consistency, e.g., and entry of 1.5 in

snowfall and 1.5 in depth on ground would after editing, read: snowfall 1.5, depth on ground 2.0. As shown in step 6, these entries would be inconsistent, hence the depth on ground would be changed to 1.0 inches.

H. "Precipitation on subsequent day" must be edited whenever there is only one precipitation entry to record an amount of precipitation which occured during several days. Examples showing the procedure to be used in editing subsequent day precipitation can be found in Appendix "A", pp. 50-51, of the First Annual IBM Progress Report.

IV. MISCELLANEOUS PHENOMENA.

The current procedure for editing "miscellaneous phenomena" or "days with" is the same as reported last year, however, only certain phenomena are now edited and punched. These phenomena, and the instructions for editing them are:

High Wind.....Underline or edit High Wind if observer reports high wind, windstorm, strong wind, severe wind, hard wind, damaging wind, stiff wind, heavy wind, dust storm, gales, blizzard, or squalls. Do not underline wind, windy, breezy, hot wind, mountain wind, or brisk wind. If other terms are used check with supervisor.

Dust Storm.....Underline or edit Dust Storm and High Wind if observer reports dust storm, sand storm, dust and high wind, or blowing dust. Do not underline dust devils, dusty, dust in air, or dust.

Hail.....Underline only when hail is reported.

Sleet.....Underline only when sleet is reported.

Do not edit or punch any other forms of frozen precipitation.

Thunder.....Underline or edit Thunder if observer reports thunderstorm, thunder, lightning, electrical storm, or thunder shower, or if he uses the symbol "⚡". Do not edit anything if he states that thunderstorms occurred everyday during the month.

Fog.....Underline or edit Fog if observer reports fog, foggy, light fog, ground fog, etc. Do not edit fog for haze, mist or drizzle.

Tornado.....Underline Tornado and edit high wind (must have occurred within sight of station). Make sure observer does not use term tornado to indicate high wind.

## APPENDIX B. INSTRUCTIONS FOR PUNCHING DAILY CARDS FROM WEATHER BUREAU FORM 1009.

The current punching instructions are essentially the same as reported in the First IBM Progress Report. They are reproduced here with a few minor additions, clarifications, and corrections.

### I. STATION IDENTIFICATION AND DATE.

General Instructions. Punch the station identification and date on all cards for all days of missing data unless both the precipitation and temperature data are missing for an entire calendar year.

Specific Instructions.

| Cols. | Item | Remarks and Examples |
|---|---|---|
| 1-2 | State No. | Punch Weather Bureau code number for state name. Example, punch 02 for Arizona; 29 for New Mexico. |
| 3-6 | Alpha Order No. | Punch Weather Bureau code number for each station. Example, punch 9334 for Willcox, Arizona. |
| 7-8 | Year | Punch last two digits of year. Example, for 1935 punch 35; for 1898 punch 98. |
| 9-10 | Month | Punch two digit code number for month. Example, punch 01 for January, 02 for February.....12 for December. |
| 11-12 | Day | Punch calendar-day numbers: 01, 02.....30, 31. Make sure February has 29 observations on leap years, any year whose last two digits (cols 7-8) are divisible by 4. |
| 13 | Division | Punch Weather Bureau division number for each station. There are 7 divisions in Arizona. |
| 13 | Time of Observation (AM or PM) | The time of observation is determined from the time of the temperature observation. If the time of observation has not been entered on the 1009 form, try to determine it from preceding and following observations. Old observations, on which the time of observation was not recorded will be punched as PM observations. If observations were made in the AM, "X" overpunch column 13. If observations were made in the PM no additional punch is required. |

II. TEMPERATURE DATA.

General Instructions. Punch the maximum temperature, the minimum temperature and the temperature at the time of observation (set max) whenever they are recorded unless the Weather Bureau (or the original observer) has indicated that the temperature data are not reliable or that they have been interpolated from surrounding stations.

Check old records (prior to 1905) to make sure that the observers recorded the maximum and minimum temperatures and not the 7 AM, 2 PM and 9 AM temperatures. Leave all temperature columns blank if the latter types of temperatures were recorded.

On some of the 1009 forms the observers, or the Weather Bureau editors, have entered the temperature range and/or the daily mean temperature. These values are often helpful in interpreting illegible maximum and minimum temperature entries. The relationships between these temperature quantities are:

1. (Max. Temp.) - (Min. Temp.) = Temp. Range
2. (Max. Temp.) + (Min. Temp.) = 2 X (Mean Temp.)

The temperature at the time of observation (set max) is also useful in interpreting illegible temperature entries. The set max must be less than (or equal to) the maximum temperature and greater than (or equal to) the minimum temperature. For example, if the maximum is 65F, the set max is 37F and the minimum is illegible but seems to be either 29F or 39F, it would be possible to eliminate the minimum of 39F because it would be higher than the set max temperature.

If you happen to notice any discrepancies in the relationship between the maximum, minimum and set max temperatures (such as, set max higher than maximum or set max lower than minimum) refer them to the

supervisor. It is not necessary to check this relationship carefully because it will be machine checked when the cards are processed.

Specific Instructions.

| Cols. | Item | Remarks and examples |
|---|---|---|
| 14-16 | Maximum Temp. | Punch temperature as recorded on 1009 form. If temperature is lower than 0°F punch "X" in column 14. Leave all columns blank if maximum temperature is missing or not reported. Examples: Punch 35 degrees as 035, 110 degrees as 110, -14 degrees as X14, etc. See note below regarding special procedures for punching maximum temperatures at AM stations. |
| 17-19 | Minimum Temp. | Punch minimum temperature as recorded on 1009 form using same procedure as used for maximum temperature. If negative, punch "X" in column 17. Leave all columns blank if minimum temperature is missing or not reported. The special procedures used for punching maximum temperatures at AM stations do not apply to minimum temperatures. |
| 20-22 | Temperature at time of Observation (Set Max) | Punch temperature as recorded on 1009 form. If negative punch "X" in column 20. Leave all columns blank if missing or not reported. Be sure you do not punch "range" or "mean temperature" in place of set max. |

Punching of Maximum temperatures at AM stations. The temperature data are to be punched on the "observational day" (not the "calendar day") on which they occurred in accordance with the practice of the Weather Bureau WRPC's since 1948. There is no difficulty in punching the minimum temperature since it usually occurs on the same observational and calendar day. However, at AM stations the maximum temperature which is recorded in the morning (say, on the 8th observational day) is actually the maximum for the previous afternoon (the 7th calendar day). Since two different procedures have been used in the past by Weather Bureau observers to record maximum

temperatures at AM stations, it is necessary for us to divide the AM stations into two groups and punch the maximum temperatures accordingly.

A. If the 1009 form is stamped "Maximum generally on date preceding entry" or if the 1009 form is not stamped at all, punch the maximum temperature on the date on which it was recorded by the observer.

B. If the 1009 form is stamped "Maximum temperature recorded on date of actual occurrence", all of the maximum temperatures for that month should be punched on the day following the date on which the maximum was recorded by the observer. For example, the data sheet shown on the left would be punched as shown on the right:

| 1009 Form | | | | IBM Card | | | |
|---|---|---|---|---|---|---|---|
| Day | Max. | Min. | Set Max | Cols. | Day 11-12 | Max. 14-16 | Min. 17-19 | Set Max 20-22 |
| 1 | 69°F | 40°F | 50°F | | 01 | * | 040 | 050 |
| 2 | 75 | 55 | 63 | | 02 | 069 | 055 | 063 |
| 3 | 76 | 52 | 61 | | 03 | 075 | 052 | 061 |

*The maximum temperature for the 1st would be left blank on the first month for which the maximum temperatures were "brought down" but on subsequent months the maximum temperature for the 1st is the maximum temperature for the last day of the preceding month.

III. PRECIPITATION DATA.

General Instructions. Precipitation data, like temperature data, are punched for the observational day and not the calendar day. Since precipitation amounts are generally recorded on the observational day, they should be punched as recorded unless the Weather Bureau editor has indicated that the data are not reliable or that the precipitation data had been interpolated from surrounding stations. If the precipitation data are reliable or are interpolated the precipitation columns are to be punched as if the data were missing.

Specific Instructions.

| Cols. | Item | Remarks and Examples |
|---|---|---|
| 23-26 | Precipitation | (a) The amount of precipitation is punched in INCHES AND HUNDREDTHS. Example: 0.01 inches is punched 0001; 0.57 inches, 0057; one inch, 0100; ten inches, 1000; etc.<br>(b) A trace of precipitation (T) is punched 000X.<br>(c) Precipitation on subsequent day (see editing instructions) is marked by a red or blue asterisk and should be punched 00X-. (A"-" is used to indicate that a column is to be left blank)<br>(d) No precipitation (i.e., there is no precipitation entry on the 1009 form and no statements that precipitation occurred but was not measured), punch X---.<br>(e) If the amount of precipitation is definitely missing (so stated by note from observer or from Weather Bureau editor), or if value is illegible, leave all columns blank. |
| 27-29 | Snowfall | (a) The amount of snowfall for the 24-hour period ending at the observation time is punched in INCHES AND TENTHS. Example: 0.5 inches is punched 005; 5 inches, 050; 50 inches, 500; etc. If an amount of snowfall is punched an amount of precipitation must be punched in the same card. If the 1009 form records an amount of snowfall but no precipitation check with the supervisor.<br>(b) A trace of snowfall (T) is punched 00X.<br>(c) Precipitation on subsequent day (see editing instructions) is marked on 1009 form by a red or blue asterisk in the snowfall column and should be punched 0X-.<br>(d) No snowfall (i.e., there is no snowfall entry on the 1009 form and no statements that snowfall occurred but was not measured). Punch X--.<br>(e) If the amount of snowfall is definitely missing leave all columns blank. |
| 30-32 | Depth of snow on ground | (a) The amount on the ground at the time of observation is punched in WHOLE INCHES. Example: One inch of snow is punched 001; ten inches, 010; one hundred inches, 100; etc.<br>(b) If there is one half inch or less snow on the ground (including a trace), punch 00X.<br>(c) If no snow depth has been reported and if the snow depth is not missing, punch X--.<br>(d) If the snow depth is missing leave all columns blank. |

## IV. MISCELLANEOUS PHENOMENA

General Instructions. Miscellaneous phenomena, that are to be punched, have been underlined in blue pencil or entered on the proper daily line in blue pencil by the editor. (See editing instructions).

Specific Instructions.

| Cols. | Item | Remarks and Examples |
|---|---|---|
| 33-45 | Days with | Punch a "1" in the appropriate column for each occurrence, otherwise leave these columns blank. Always leave columns 33 and 34 unpunched. If a "1" is punched for drizzle, sleet, glaze or hail (columns 37, 38, 39 and 41 respectively) there must be at least a trace punched in the amount of precipitation. In addition, there must be at least a trace punched in the amount of snowfall if sleet occurred. |

APPENDIX C. STUDY OF THE COMPLETENESS OF THE "DAYS WITH" DATA.

The following study was made to estimate the completeness, and consistency (hence the usefulness) of the "days with" data. Only the thunderstorm occurrence data was studied because the occurrence of thunderstorms could be subjectively verified from the precipitation data. The following tabulation of the data for 10 stations indicates the total number of station years of record, and the number of station years for which the thunderstorm occurrence data appeared to be complete. Although the evaluation of the completeness of the data was only subjective it was based on a careful analysis of the precipitation data, the observer's remarks and data for surrounding stations.

| Station | Total Stn.Yrs. of Report | Stn. Yrs. With Complete Thunderstorm Data | Remarks |
|---|---|---|---|
| Aguila | 30 | 10 | 10 consecutive years, 1925-1934 |
| Ajo | 39 | 14 | 6 consecutive years, 1917-22; 5 consecutive years, 1946-50. |
| Casa Grande | 52 | 2 | |
| Kingman | 47 | 11 | 4 consecutive years, 1903-06; 5 consecutive years, 1940-44 (obs. made by C.A.A.). |
| Paradise | 30 | 1 | Useable entries scattered throughout records. |
| Ruby | 32 | 12 | 3 consecutive years, 1934-36; 4 consecutive years, 1938-41. |
| San Simon | 45 | 5 | |
| Superior | 34 | 10 | 7 consecutive years, 1947-53. |
| Tempe 3S | 47 | 2 | |
| Wickenburg | 44 | 0 | |
| | 400 | 67 | Totals |

At the best station (Ruby) only 37% of the thunderstorm occurrence data was complete. For the 10 station samples, as a whole, only 17% of the thunderstorm occurrence data was complete. As a result of this study the Institute adopted the following policy regarding the punching of "days with" data.

Only the following "days with" data will be punched: sleet, hail, glaze, high wind, dust storm, thunder, fog and tornado. In general, only those data that are easily read will be punched, however, an effort will be made to decipher illegible writing and codes if the station has a good "days with" data record in other years. The "days with" data will not be verified except for those stations with long useable records.

## APPENDIX D. THE 650 PROGRAM FOR COMPUTING 5-DAY AND MONTHLY SUMMARY CARDS.

The purpose of this program is to summarize the daily 1009 climatological cards. The summarized data will be punched on six different kinds of cards.

A. Monthly summary cards containing temperature data in the standard Weather Bureau form.

B. Monthly summary cards containing precipitation data which are punched in the standard Weather Bureau form.

These two cards will be used to reproduce (column for column) a standard Weather Bureau monthly summary card. It is necessary to produce two summary cards on the 650 because of the limitation on the number fields and columns, which the 650 can punch selectively with digits, signs or blanks. This problem is discussed in detail in Appendix E.

C. Monthly summary cards which contain the mean maximum temperature, the mean minimum temperature, the mean monthly temperature, totals of precipitation and snowfall, counts of missing data and a frequency distribution of the daily precipitation amounts. This card is designed so it can be easily read into the 650, hence, it will be used in future analyses instead of the standard Weather Bureau card.

D. Monthly summary cards containing frequency distributions of both the maximum and minimum temperatures. These distributions are at one degree intervals with the maximum ranging from 0F to 140F and the minimum ranging from -40F to 100F. Any temperatures falling outside these limits will be counted in a special group. (Such occurrences are very rare in Arizona).

E. Five day summary cards containing the same information as the monthly summaries (card type 3) except for the frequency distribution of the daily precipitation amounts.

F. At the end of each station record a group of summary cards will be punched, which contain an analysis of the precipitation data. For each calender day in the year (except February 29) the 650 will sum and punch the total amount of precipitation, the number of days of record, the number of days with precipitation and the percent of days which had precipitation.

This program will be completed, debugged and completely tested.

A detailed description of this program and the program cards will be available to anyone interested in using them, about June 1, 1957.

## APPENDIX E. DIFFICULTIES ENCOUNTERED IN WIRING THE 650 TO READ DAILY 1009 CARDS AND TO PUNCH THE STANDARD WEATHER BUREAU MONTHLY SUMMARY CARDS.

General. Although this discussion is concerned with reading and punching Weather Bureau cards, the problems discussed apply to all cards, and therefore, should be considered in designing any card which is to be processed on the 650. Careful design of the card, based on the requirements of the 650 first, and the punching efficiency second, will not only reduce to a minimum the number of hours required for programming, wiring and checking, but will also save many hours of running time.

Reading. The internal checking features of the 650 make it stop every time it reads a blank. Therefore, whenever it is necessary to read-in a group of independent fields which are designed so that part of each field may be blank, or punched with digits, it becomes necessary to run every column that might be blank, through a selector to prevent the machine from stopping each time it encounters a blank column. For example, if one-half inch of precipitation occurred columns 23-26 are punched 0050. However, if zero precipitation occurred these columns are punched X---. Unless selection is used the blanks in columns 24-26 would stop the 650 for each card with zero precipitation. Reading-in is further complicated by the numerous "X" punches, which are also read as blanks in all digit positions, that must be read into the machine to represent negative numbers, traces, zeros and subsequent days.

Almost all of the reading problem would be eliminated if zero precipitation was punched "0000" and if all "X" punches were punched over zeros. Of course, this change would make the original punching a little more difficult and costly, however, the decreased time required for data processing would probably offset the increased punching cost many times.

Punching. Cards which involve blank fields and numerous "X" punches are also difficult to punch from data summarized or computed by the 650. For each field which can contain digits (for recorded data) or blanks (for missing data) one bit of control information must be used to control selectors because the machine can not automatically differentiate between blanks and zeros in a computed number. In addition, one bit of control information or a sign position, is required to control the punching of each "X" punch used to indicate negatives, traces, zeros, etc. Since the standard 650 contains only 10 bits of control information and 10 sign positions, the number of "X's" and blank fields which can be punched on one card is limited. For example, in punching-out the standard Weather Bureau monthly summary cards, there are 16 fields which may be punched with digits, (if the data are present), or left blank, (if the data are missing). Each of these fields requires one bit of control information to control a selector. There are 12 columns that may contain an "X" or a digit or a blank. Each of these columns requires two selectors and two bits of control information, or sign positions. There are 9 columns that may have "X" overpunches and 3 columns that may have "Y" overpunches, each of which requires one bit of control information or a sign position to control punching. This very quickly adds up to more bits of control information and sign positions than are available. Hence, the results must be punched on more than one card. Fortunately, all of the fields on the monthly summary cards are not independent, hence only 40 bits of control information and sign positions are required to control the punching of the cards. Unfortunately, this is twice the number of bits available. Hence, it is necessary to punch-out two monthly summary cards (which are later reproduced into one card) instead of punching the desired card immediately.

In addition to complicating the board wiring and necessitating the punching of two different types of cards, the frequent use of zeros, blanks and "X" punches greatly complicates the 650 programming. In the program for preparing 5-day and monthly summary cards about half of the instructions do nothing but prepare the data for punching. Hence, careful card design not only reduces costs by eliminating a large part of the check-out time but also releases storage locations (used to store the extra instructions) for additional computations on the same run.

Once again a large part of the wiring and programming difficulties would be eliminated if zero precipitation was punched "0000" and if the punches for traces, subsequent days, etc. were punched over zeros. Then no selectors would be required to control the punching of blanks, and the selectors could be used to pick out those columns which are to be overpunched. In this particular application, this one change would enable the 650 to punch directly, a standard Weather Bureau monthly summary card.

Summary. It is clear that the present design of the Weather Bureau cards cannot be changed just to eliminate some of the problems which they present to one type of data processing machine. However, in view of the increasing use of high speed data processing machines in climatological research, future changes in card design should consider the requirements of these machines as well as the requirements of the punched card machines, and whenever possible, changes, which will eliminate unnecessary complications in programming and wiring, should be adopted.