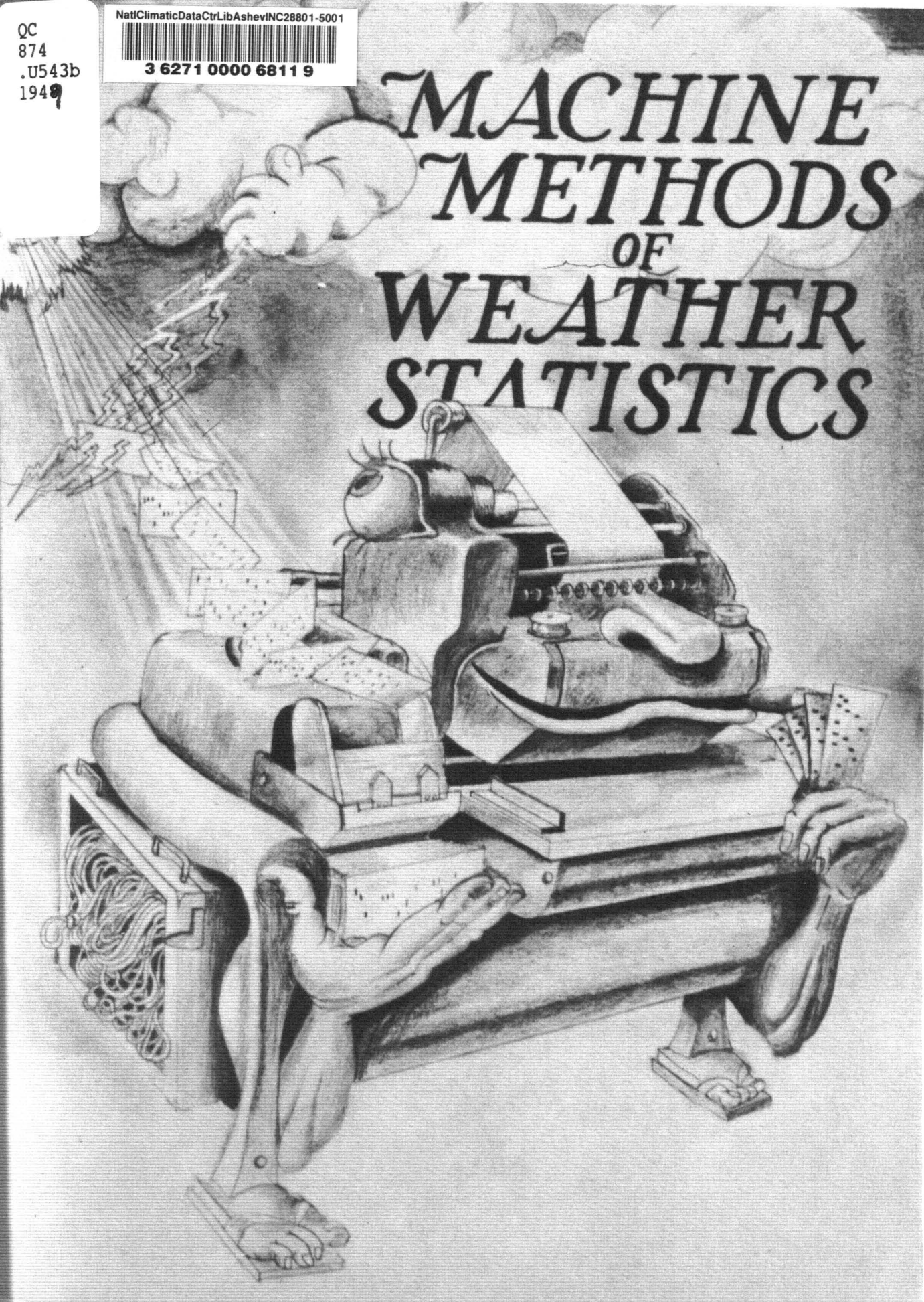
MACHINE METHODS OF WEATHER STATISTICS



MACHINE METHODS

OF

WEATHER STATISTICS

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CHAPTER I - HISTORY

The story of the development of punched card machinery to handle the 1890 national census is well known. Since that time the punched card medium has served continuously and with distinction as a major statistical tool in government and industry, in an ever-widening area of application.

About 1920 the Meteorological Office of the British Admiralty (having seen the machines grinding out British health statistics), began the use of punched cards in extracting meteorological data from ship's logs, processing the cards through the machines to get means and wind roses for 5- and 10-degree squares of ocean surface. So good were the results that in 1921 the Meteorological Office reported that "the saving of time in this operation is enormous".

In 1922, the Dutch Meteorological Institute borrowed some of the British card files, and began making their own analyses of ocean weather; Norway and France soon followed suit. By 1927, the Deutsche Seewarte (German Marine Unit) embarked similarly on the analysis of marine climates on punched-card machines.

This new approach to weather statistics developed quickly in Europe. By 1927, a Czechoslovakian meteorologist, L. W. Pollak, began to revolutionize the staid climatological statistics with inexpensive machine-produced frequency distributions of weather data, which had long been deemed desirable, but were so laborious and costly by manual methods.

At about the same time Dr. Pollak designed a small, inexpensive, punch machine. He placed this punch in every Czech weather station; and, as each observation was taken, a card was punched and sent to the central tabulating unit, for tabulation and analysis. This method of punching weather data has never been improved upon.

By the time the second World War broke out, the meteorological office of every major country in Europe was analyzing the world's weather on punched cards.

In the United States, the birthplace of the punched card method, there was early interest in the possibilities of mechanical analysis for the problem of weather statistics. However, no funds were available anywhere for the testing of machine techniques in climatology until the advent of the "make work" projects of the middle thirties.

In 1934, a CWA (later WPA) project was initiated to prepare a long-needed atlas of ocean climates. Millions of marine weather observations, taken on board ship in every corner of the oceans, had been gathering dust in Weather Bureau files; the task of sorting and summarizing the data was so great that it was impossible for the Marine Division of the Weather Bureau to summarize more than a small fraction of the observations as they were received, to say nothing of treating as a whole the mass of data accumulated but untouched through the years. Of 5 1/2 million observations, taken from 1880 through 1933, more than 2 million were punched into cards for machine sorting and summarization; the rest were transcribed onto slips for manual processing. It is noteworthy that, while the punched card project did almost half of the work, the manual half of the job used 90 percent of the labor put into the entire project.

In 1936, work was started, with WPA funds, on punched card compilation and analysis of millions of surface and upper air (pilot balloon and radiosonde) observations made at about 400 airway weather stations. By the time the United States was drawn into the war, 20 million airway observations, taken from 1928 to 1941, had been placed on punched cards; these cards had been summarized to produce a number of publications, including "Airway Meteorological Atlas"; "Normal Flying Weather for the United States"; "Temperature Frequencies in the Upper Air"; and "Low Visibility Airport Wind Rose Summaries".

Overnight Pearl Harbor made the problem of weather statistics one of first-order, top-drawer importance in the planning and prosecution of our military effort. The mechanized techniques of modern warfare, to be successful, had to master the weather. In

planning bombing missions, amphibious landing operations, and every other type of offensive operation, the planners had to turn to the weather man constantly for answers, the accuracy and timeliness of which meant the difference between success and failure. Where should air bases be located? How must transportation and communications be handled? What areas must be avoided by heavy armored units? What specifications for lubricants, for gasoline? What food-storage problems? What specifications for landing mats, for transmission poles and wires, for buildings?

What is the climate, and its myriad effects on operations, in every theater of war? When will the weather be right at this particular beach-head, not just for planes, nor for landing craft, nor transports, nor armored trucks, nor infantry, but for all of these and every other element of a complicated landing operation upon which an entire campaign depends?

Military leaders demanded - and got - the answers to these, and similar questions. Without the punched card techniques the answers in most cases would have been "too little and too late".

We had insufficient prewar information about many parts of the world, suddenly of terrific military importance. We had *no* information at all about some. Much of the world's present weather was blacked out for us by the enemy. The routine summaries, made by the traditional manual methods, even of the United States climate, were in many respects inadequate to answer the new crucial questions posed by the armed forces.

Early in 1942, the WPA punched card work sponsored by the Weather Bureau was stopped, and the entire organization placed at the disposal of the armed forces to help answer some of the questions about weather. The Weather Bureau machine installation, working under Army and Navy funds, together with installations created and supported by the Army Air Forces, punched and summarized some 20 million cards prepared from prewar observations from various foreign countries, and another 20 million cards prepared from domestic and foreign observations of weather stations operated by the military services throughout the world. By the end of the war the punched card library at the joint New Orleans machine unit contained about 80 million punched cards.

Perhaps the most important result, for the postwar peacetime world, of the impact of war on weather statistics was the rapid development of new kinds of statistics, and the machine techniques necessary to get them. Past accomplishments and future hopes of the machine climatic program may be divided into three general and overlapping phases.

Phase One of the climatological program, that is, unification of reporting forms and placement of all current observations on cards, is an accomplished fact, as far as the U. S. weather services are concerned.

Phase Two, or placing historical data on cards, is progressing quite rapidly, considering the magnitude of the task. This phase also includes indexing all climatological data, in all publication, and securing exchange of punched cards or data with other countries.

Phase Three, which is just beginning, envisions the establishment of a central weather records repository for the receipt, filing and servicing of all weather records, whatever the originating service or source. Such a repository, equipped with proper facilities, would be capable of servicing the needs of all users of weather material. This would eliminate the present confusing and time-consuming situation of having to go to several repositories, widely separated, to accumulate all available data for a specific project.

In addition, there is a requirement for the design and acquisition of modern electronic calculating equipment, of sufficient capacity and input and output speeds to handle larger masses of data than is presently possible, so that more variables may be investigated simultaneously. Even with contemporary equipment it appears that the meteorologist who must deal with climatic data has not fully adjusted his thinking to a point where he gains complete advantage of the capabilities of present day equipment. The advent of even more advanced machinery will require still further change in thinking habits if he is to exploit the potentials developed.

CHAPTER II - CARDS

To a casual observer passing through a room in which machines are compiling weather data, the most impressive sight is the operation of the electric sorting and accounting machines, just as to visitors in a machine shop the operation of large machines, punch presses, milling machines and various types of drills tends to be of greatest interest. The punched card is given very little attention and is passed by unnoticed in the same manner as are the tools and jigs and dies of manufacturing plants. To one who is interested in the details of operation, however, these seemingly unimportant items assume a leading role. For, just as the forms of the dies and jigs determine the shape of the finished manufactured product, so the punched cards control the electric accounting machine and cause it to produce accurate and complete analyses and statistical reports.

The IBM tabulating card consists of 80 columns, each containing twelve punching positions, from 0 to 9 , plus two "high punches" for alphabetic and control purposes. A numeric digit is represented by a hole punched in its proper position. An alphabetic character requires two holes in the same column, a combination of a high punch and a numeric punch, both of which are punched simultaneously on the alphabetic key punch. Several adjacent card columns used for punching a single item are referred to as a field.

The purpose of creating a unit card containing weather information is to establish a single record of a condition, which may be speedily sorted and re-sorted by means of automatic machines for the preparation of various analyses and reports on the electric accounting machines. The importance of the card in a successful installation cannot be stressed too much. The card is in reality the basic unit in the machine method of weather statistics. It is the medium which actuates the various machines and plays a part which is as essential and important as that of any machine in the operation.

The application of tabulating machines and especially the design of the tabulating cards around which the system has been developed, affords a wide range of ingenuity. The various climatic and statistical records which are compiled by means of the punched card method reach into practically every phase of modern weather techniques. The cards themselves reflect this wide variety of weather applications, and rarely are two identical card forms used for different sources, regardless of the similarity of the tabulations required.

Card Design

In order to be able to design the most effective card for a particular application, it is essential, first, that the preliminary requirements of good card design be recognized. One of the primary requisites in a general knowledge of the observing practices and the statistical methods being employed, in order to appreciate fully not only the present needs of the problem but its future possibilities. It is also essential to have a general knowledge of the rules governing the design of weather records and documents so that the proposed plan for use of accounting machines may be installed to effect a maximum benefit with a minimum of change and disruption of the associated recorders. The third factor is a knowledge of the operation of all units in the tabulating line of products so that the work may be accomplished with a minimum amount of effort. Lastly, it is essential that the person who designs and approves the card form which is proposed has an accurate detailed knowledge of the special problem to which the cards are being applied. Although there are many basic principles governing the designing of card forms, it must always be remembered that good sound common sense and practical experience will contribute much to optimum card arrangement.

The first step in card design is to determine the data which will be needed from the card in order to meet the requirements of the contemplated record routine. Of all the factors affecting card design, the most important are the requirements of the finished reports that are to be prepared. These reports should be kept in mind constantly, so that all necessary information may be included in the card and arranged to facilitate their final preparation. The factors so determined may be considered as the desired or ideal card requirements. Certain modifications may then be required to conform with any of the limiting conditions discussed later.

The factors next in importance are determined by the sources of original information. These must be studied to see whether all the desired data are available on the original documents to be used in punching. If not, or if too much labor is required to get them on these documents, it will be necessary to revise the list of card data, or use other meteorological factors which will accomplish a similar purpose. A study of the source will further show whether certain available data can be conveniently included in the card and a new use devised which was not originally planned, or which may be needed in the future. At this point, also, a study of reference punching should be made so that the card may be identified with the original record from which it is punched, if this is necessary.

Coding

Numeric codes have long been recognized as the most concise and accurate method of identifying individual items and groups of related items. Their advantages are especially obvious when observed in connection with the sorting and classifying operations of machine systems. The proper designing of codes is therefore an inherent part of the climatological program, and is of paramount importance in determining the most efficient preparation of the required reports and tabulations. In general, the coding requirements follow the same path as fundamental card design. The actual coding practice has of necessity been so voluminous that this paper cannot be concerned with the details of the actual codes used. However, a few of the types of codes used are enumerated below.

The simplest form of coding that can be utilized is the sequence method. It consists of the simple assignment of numbers, starting with one, to a list of items or elements in any order. The sequence method does not provide for any classifying of groups and cannot be used where such requirements exist. A sequence code always requires memorization or decoding; therefore, the original list to be numbered should be arranged in some logical order to aid in this process. The sequence method of coding, due to its simplicity and unlimited expansion, has been mistakenly applied again and again to long lists of items or stations, with the result that there can be no quick grouping by any classification, and reference must be made to group lists.

Block codes is the term applied to codes which utilize groups of blocks of numbers in sequence to represent classification. Block coding provides a method of coding classes where the number of digits must be limited, as it provides more groups with fewer digits than any other class coding plan. Expansion is also provided in a limited way by the reservation of vacant numbers in each group.

Group classification codes are those in which major and minor classification are represented by the succeeding digits of the numbers, and are the most efficient for ordinary coding problems. In this type of code all digits except the last represent a definite classification in such a way that a machine sort on the particular digit representing any desired classification will accomplish a complete separation. The automatic control feature of the tabulator can be used throughout, and sorting is required only as far as the digit which represents the group of controls needed for any given report.

Significant digit codes is the term which has been applied to codes wherein all or some of the digits represent temperature, pressure, wind velocity, or amount of precipitation, or any other element which has been transferred bodily into the code. In one sense this is not actual coding, as these elements determine the numbers without coding, except for negative quantities which do require a simple code. The primary object of significant digit codes is to eliminate or reduce the work of decoding by providing a code number that is directly readable, and can be used mathematically.

Such specialized cards as the WBAN No. 1 card are self coding, as the numbers printed on the card are replaced by the more common meteorological symbol. Every effort is made by such a design to eliminate reference to code sheets, manuals, etc., and to reduce the work required to punch such a card by untrained key punching personnel.

CHAPTER III - MACHINES

Almost all types of International Business Machines are used in the climatological program. The function of each machine and the manner in which it is used depend upon functions of other machines in the step-by-step processing of punched cards.

Key Punches

The IBM machine which of necessity must be used first in any punched card operation is the key punch, by which data are punched into the desired columns of the cards. Several types of key punches have been developed, and three are currently used by the weather services. The simplest of all IBM machines is the Type 001 Key Punch, the non-electric, portable, and compact key punch which is used in the field for in-station punching of Air Force and Weather Bureau observations. This machine was selected for field use because of its rugged mechanical dependability and operational simplicity; its relatively slow punching speed is sufficient for the in-station punching requirements.

Since most weather observational data to be punched are numeric, the Type 016 Motor Drive Duplicating Key Punch is used as the standard key punch machine within the processing centers. The action of the punching dies is controlled electromagnetically, rather than mechanically, and the resulting ease in key depression on the part of the operator provides a much higher punching speed. Cards are automatically fed into the machine and ejected after punching. This machine is also equipped with a duplicating device, which permits the automatic transcription of common data to more than one card, and the subsequent manual recording by an operator of specific detail pertaining to an individual card. This duplicating mechanism is extremely useful as an automatic coding device: master cards may be pre-punched with all the codes pertaining to any given group of observations, such as year; month, and day, when hourly observations are being punched. The term, master card, refers to a card especially punched to contain information which is to be common within an entire group of cards containing individual observations (detail cards). The duplicating feature is also extremely valuable for reproducing cards which have become mutilated by excessive or improper handling, or for correcting an error in a single column or field.

For the lesser requirements of punching alphabetic information the Type 031 Alphabetic Duplicating Key Punch is used. This is very similar to the Type 016 punch, except that it has an alphabetic typewriter keyboard, as well as the standard numeric keyboard. Thus, in addition to performing all the functions of the Type 016 punch, it is capable of recording alphabetic information in tabulating cards in such a manner that complete words and names, together with numeric data, can subsequently be printed by the alphabetic accounting machine.

Verifier

In the punched card method of recording and summarizing weather data there are many procedures of establishing and maintaining accuracy. Of these, one of the most important is the method of key verification, which ascertains the accuracy of the punched card immediately following its preparation. Because of the important part played by the card, it is imperative that its accuracy be established as early as possible by some accepted means of verification. Key verification is essentially a comparison of the original data with those recorded in the punched card, and can be effected at a speed equal to, or in many cases, greater than that of the punching operation.

The Type 052 Electric Punched Hole Verifier was developed simultaneously with the invention and application of the automatic feeding and ejecting mechanism for punching equipment. Its operation differs from the key punch only in that as each key is depressed, a small plunger goes through the hole in the card and permits the card to advance one column. If a key is depressed that does not correspond to the hole punched in the card, the operator readily senses the increased pressure on the key and the failure of the carriage to advance. Comparison of the punched card with the original data is then made to determine the discrepancy and the card is re-punched with the correct data.

Sorters

The various types of sorting machines built by IBM are considered to be the basic machines required in any punched card application, because they provide high speed facility for sorting the punched cards into various sequences and classifications. These machines automatically arrange punched cards into numeric order or into groups of similar classification in numeric sequence or other predetermined order. A card is read by an electric impulse passing to a single column brush through the punched hole from a conducting contact roll, which routes the card to any of twelve pockets of the sorter, depending upon the position of the punched hole in that card column. Cards that are not punched in the column being sorted are deposited in the thirteenth pocket.

By progressively sorting each column across a numeric field from the units position to the highest position punched, and removing the sorted cards from the twelve pockets in proper order, a group of cards will be arranged in numeric order. Accuracy of operation is verified by sighting through the punched holes in a group of cards as they are removed from their respective pockets. To sort alphabetic information two sorts per column are required, since two holes are punched in the same column of the card. Various short cuts in sorting are used when the card volume is extremely large, such as block sorting; i.e., first sorting on the column at the extreme left of the field, and then sorting each resulting group in the normal manner. Thus, in sorting a large number of cards by station number within region, it would be best to sort by region first, and then by station number, handling the cards for each region separately. In this manner one large group of the entire deck is made ready for further machine processing while the sorting of the balance of the deck is continued. An electric counting mechanism may also be attached to the Type 080 Horizontal Sorter, which registers a count of one for each card that passes the brush. This counter does not affect the normal operation or the speed of the machine, which is 450 cards per minute.

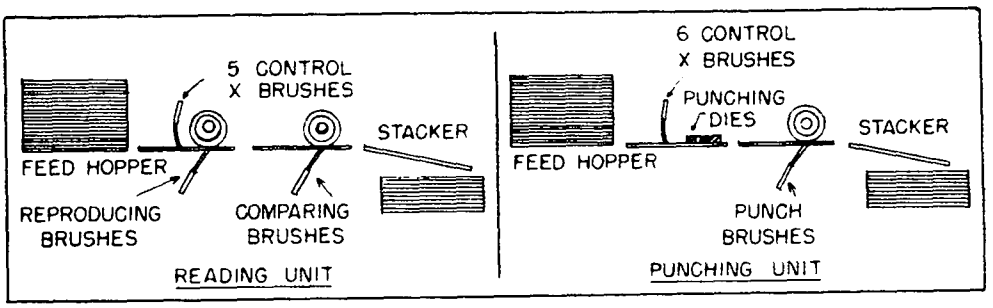
The Type 075 Card Counting Horizontal Sorter is designed for the purpose of counting the holes punched in any or all positions of a given column of a card, and also to register the number of cards not punched in that column. It will simultaneously group all cards of similar classification and arrange such classification in the numeric sequence in the same manner as the Type 080 sorter, but at the rate of 400 cards per minute. The counting mechanism is equipped with fifteen adding counters, one for each pocket, one for sub-totals, and one for grand totals. All counters can be cleared in a single operation, or the grand total may be allowed to accumulate while clearing the other counters. This machine is equipped with switches which allow the machine to count the cards without disturbing their sequence by separating them into the pockets. It can also sort the cards without counting them, or it can sort and count in all proper counters simultaneously.

Reproducing and Summary Punches

The processing of punched cards frequently requires the reproduction, re-arrangement, or addition of data in the cards. Reproducing is the operation whereby all, or any part of the information which is punched in one set of cards can be punched into another set of cards. The information can be transcribed either in the original or in an altered sequence. As the cards are reproduced, they may be verified for accuracy of the punched data. Any discrepancy between the punching of the original and new cards is automatically indicated by the machine.

Gang punching is an operation whereby identical information can be duplicated from a master card into a group of detail cards. Although gang punching is usually done column for column, with the use of a class selector, data may be punched into columns other than those punched on the master card. Any number of master cards can be interspersed throughout the set of detail cards, on the basis of information already punched in the detail cards. The information which is to be punched will change automatically each time a new master card feeds into the machine. Cards which have been gang punched can also be verified for the accuracy of the punched data. It is also possible to mechanically verify cards which are about to be gang punched, to insure correct association of master and detail cards.

Summary punching is the operation whereby total lines from printed reports prepared on the accounting machines are automatically punched into summary cards by a connected



CARD PATH THROUGH THE TYPE 513 REPRODUCING PUNCH

reproducing punch. With a connector cable between the two machines, information is summary punched from the counters of the tabulator. These summary cards are utilized to reduce the volume of cards for subsequent tabulations.

Any or all of the above described functions are performed by the Type 513 Reproducing Punch, and any, except reproduction, are performed by the Type 517 Summary Punch. Maximum flexibility of data arrangement is made possible through the wiring of the control panel, which also provides automatic control of combinations of these functions.

Gang punching and reproducing operations are done at the rate of 100 cards per minute. Summary punching requires 1.2 seconds per summary card, in addition to the time required for total printing on the accounting machine. All speeds are constant, regardless of the number of columns to be punched, since any or all of the 80 columns are punched simultaneously, from top to bottom of the card, rather than from left to right as in the key punch.

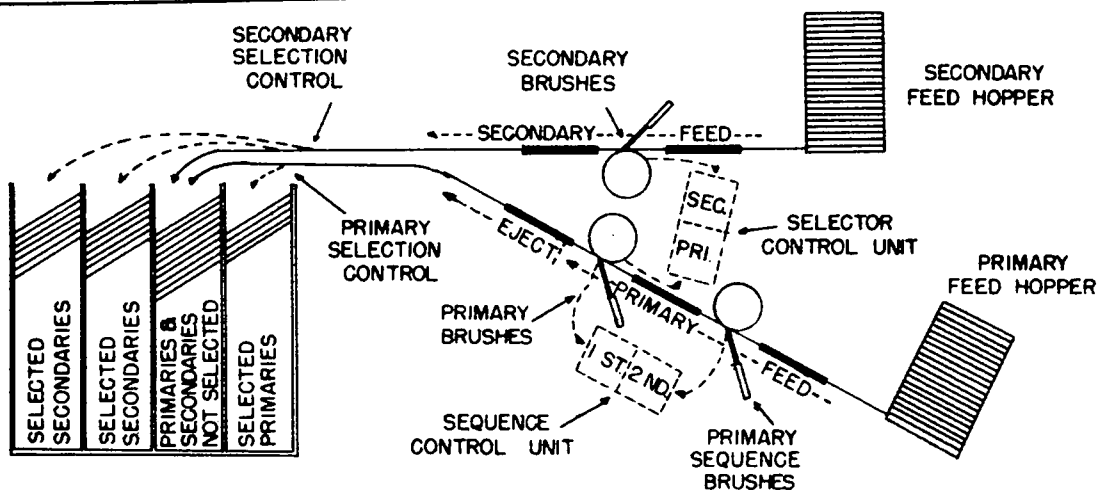
Collator

Prior to the introduction of the Type 077 Collator, the sorter was the only machine available for automatic arrangement of cards; in order to file one group of cards with another, the two were placed together and sorted on a common control field. This procedure is ideal if neither set of cards is in proper sequence, but if the groups are already in sequence, they must be sorted a second time. In merging cards by the sorting method, it is necessary to sort on each individual column of the control field separately. The collator has been designed to improve this situation by filing together, on one run through the machine, two groups of cards which are arranged in similar sequence. The speeds at which the various operations are performed on the collator vary from a minimum of 240 cards per minute to a maximum of 480 cards per minute, depending on the particular application involved. The collator can handle only numeric information, unless equipped with special devices which recognize alphabetic punching, or unless special coding arrangements are used.

As the name of the machine suggests, one of its principal functions is to collate or file two sets of cards together. This operation is known as merging; that is, two sets of cards are filed or merged together according to a control field. For example, corrected cards for observations found in error by the machine checking processes can be filed into the main card file, so that the entire deck will be in proper order. This eliminates sorting all the cards again by station number, year, month, day, and hour, a 13 column sort.

To the basic merging operation can be added the selection of particular cards. Such an operation will file corrected cards into the main deck and simultaneously select for destruction the error cards which are being replaced.

At the same time this filing or merging operation is done, the collator can perform another function, that of checking the sequence of one of the sets of cards. Checking the sequence will determine whether any cards in the group have been filed in the wrong place. If a card is out of order, the machine will stop and the error will be indicated to the operator by a red light. This operation is also used in merging the corrected cards into the original deck, as given in the example above, since the order of that deck is again checked for proper sequence.



CARD PATH THROUGH THE TYPE 077 COLLATOR

The collator is also employed in the matching of two sets of cards according to a control field. For example, a station-month of hourly observations sorted in chronological order may be matched against a master deck which is sorted in the same order, to insure that every hourly observation is present in the deck. Those master cards for which there are no corresponding detail cards will be selected, and similarly, should a master card be missing from the deck, the detail card corresponding to that master card will also be selected. The basic decks are not merged but are filed separately.

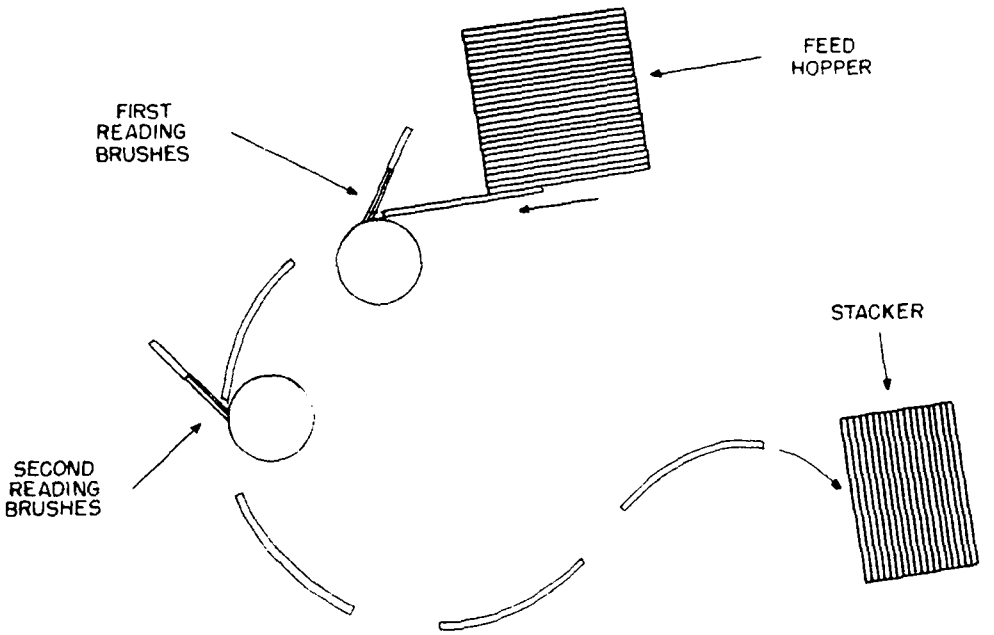
The fifth function includes a variety of operations possible on the collator, based for the most part on multiple-column selection. A file of cards, in no particular sequence, can be searched for those with a specific control number, or for cards over or under a specific control number; such as observations where the temperature is above or below a desired value. It is also possible to set up two limits for a control field, and to select all cards between these two limits. Cards on which one field exceeds another field can also be selected. This function is used, for example, to compare detail cards against a master deck, checking each observation to insure that the dew-point temperature is between the range allowed by the dry and wet bulb temperatures.

The basis of the automatic operation of the collator is found in the selector and sequence units which compare the control information punched in the cards and which then direct the movement of the cards according to predetermined conditions. These conditions vary with specific applications. The control panel is the medium through which the results of these comparisons are in turn directed to control the movement of the cards in accordance with the requirements for that particular procedure.

Accounting Machines

The major step in summarizing weather data on punched cards is accomplished with the use of the Type 405 or Type 416 Electric Accounting Machine, commonly called the tabulator. The tabulator is a combined adding, subtracting, and printing machine. The two types are very similar, except that the Type 405 is able to print alphabetic and numeric information with the first 43 type bars from the left and numeric data only with the remaining 45 type bars, at a speed of 80 cards per minute, whereas the Type 416 can print only numeric information with all of its 89 type bars, but at an increased speed of 150 cards per minute.

The control panel design permits complete flexibility in the arrangement of the compiled and printed data on the report form, because punched cards passing through the machine are directed by it to actuate the various counters, relays, and printing mechanisms. The functions of the machine are automatic, and both types tabulate cards, or accumulate information in counter groups from which totals may be printed, at a maximum rate of 150 cards per minute. At the same time that reports are prepared, the accumulated totals



CARD PATH THROUGH THE TYPE 405 OR 416 ELECTRIC ACCOUNTING MACHINE

can automatically be punched into summary cards, an operation described above in the section on the reproducing punches.

Immediately upon entering the tabulator, the cards pass two reading stations one card cycle apart, or two sets of 80 wire brushes, one for each card column. A punched hole in any column allows the corresponding brush to contact the conductor roll. This contact completes an electrical circuit, and the electrical impulse available from this circuit is directed by internal wiring to specific plug-hubs of the control panel. The type of impulse emitted is controlled by the time at which a contact is made during a card cycle. Unpunched positions on a card separate the brushes from the contact roll so that no impulses are received by the brushes. The basic principle underlying the functions of the tabulator, as in all IBM equipment, is the timing of these impulses. The control panel is the nerve center for these impulses, and by means of external wiring they may be directed to type bars, counters, comparing relays, selectors, etc., or may be eliminated entirely.

Generally, the first reading station is used to produce or alter instructions to the machine. Data are read from cards at the second station; data which are added, subtracted or otherwise processed in accordance with the instructions received. Combinational use of the two stations permits information in two adjacent cards to be compared, the result of such comparison being used to instruct the machine further.

The functions of addition and subtraction are performed by accumulators called counters. There are 80 such counters in most of the machines used in the weather records processing centers. Counters are grouped within the machine into 2, 4, 6 or 8 positions, but the size of the total is not so limited, since two or more groups may be coupled together to perform as a single unit. The columns containing data to be accumulated are wired through the control panel to the desired counters, which may be controlled to add, subtract, or ignore the data of each card by means of selectors, which are discussed below. Sub-totals and grand totals may be accumulated in separate counter groups, and printing of any class of totals may be automatically controlled. Totals may be printed in any type bars, but card feeding is suspended during total print cycles.

Information entering the counters may also be listed from each card so that the total might appear below the column of data being accumulated. Identifying information, if de-

sired, may be listed only during the first card cycle of a group of cards being accumulated, the remaining cards passing through the machine at 150 cards per minute until the signal is received to stop and print a total. Information may also be listed without being accumulated. The position of data in the card need have no relation to its position printed on the report page, for the control panel permits complete flexibility in report arrangement.

Automatic control is the function by which the machine can distinguish the cards of one classification from those of another. The cards in a single classification are referred to as a control group, e.g., all cards for a single station-month in a weather tabulation. When a difference in identifying data is recognized between the cards at the two reading station, the comparing unit emits an impulse and may be wired to cause the machine to stop and print a total. The control of the comparing relays and the definition of classes of totals are accomplished by external wiring in the control panel.

As mentioned above, the control of counters to add, subtract, or eliminate numeric information is instigated by means of the selection of the impulse which causes the counters to operate. The selector is a relay or automatic switch which may be regulated by specific punches in one or more card columns. When the control punching is sensed, the selectors channel the counter impulses to add, subtract, or eliminate the controlled data as desired. The counters will perform in a normal manner when the selectors are not controlled or "picked up". For example, the counters may be instructed to subtract information only from cards which are punched with this specific control, and to add that information from all other cards. To afford maximum flexibility in such control, the machines are equipped with digit selectors which permit control by selection of any one, or any combination, of the twelve punching positions of any card column, rather than by a single punching position in a specified card column, which is ordinarily used. This means of control by selection affords a wide variety of permissible operations that could not otherwise be accomplished.

In addition to the control of counter impulses, selectors can be used to select punched data at each reading station for addition, etc., to select the printing of totals by class so that more than one total may be printed from the same type bars on successive total cycles; to select the integrated relationships of punched data in multiple columns so that one classification of card may be listed and all other cards may pass through the machine at tabulating speed; to classify punched data and add a count of one in various counter groups, thus permitting the tabulation of frequencies of occurrences of various weather classifications. Selectors may be activated immediately upon receiving an impulse, so that remaining impulses derived from the same card may be controlled, or such activation may be delayed to receive impulses from the following card.

An attempt has been made to describe without becoming too technical the major features of the accounting machine. A description of the numerous minor features which are in frequent use is beyond the scope of this paper. It can be seen, however, that the flexibility of this machine makes it an invaluable unit in the preparation and final presentation of climatological summaries and data tables, the result toward which all other card processing is pointed. The accounting machine is undoubtedly the nucleus of any IBM machine installation. The wide variety of applications to which this machine can be placed is limited only by the availability of data, quantity of special devices present, and the imagination of the experienced machine technician.

Calculating Punches

Unless computations are to be performed upon the resulting data, the accounting machine is the final step in the processing of most climatological summaries. However, if computations are necessary, the accounting machine provides both an interim and final means of preparing and presenting the data, since computed information may be listed on the accounting machine as the finished report. Computations may be performed on the Type 602 Calculating Punch or the Type 604 Electronic Calculating Punch. These machines permit the complete mechanization of many routines which formerly necessitated manual calculating and key punching operations.

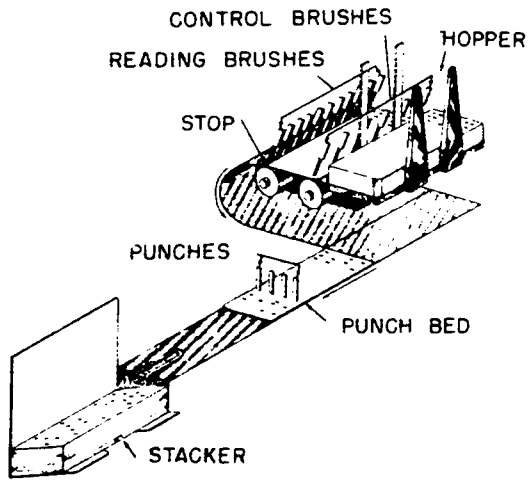
The Type 602 Calculating Punch solves all types of calculating problems. The factors of the problems are read from cards, and the flexibility provided by the control panel permits on a single run through the machine the simultaneous or successive use of all four

basic mathematical processes -- addition, subtraction, multiplication, and division -- for calculating and punching the results into each card or specific cards. Thus, various factors can be added together to obtain a multiplier, multiplicand, or divisor; a product or quotient can be further multiplied or divided by additional factors, and amounts can be added to or subtracted from calculated results. Algebraic signs may be recognized during all stages of calculations. Interim and final results of all calculating processes may be recorded in the punched card upon completion of the calculation. Any calculating problem performed by the machine may also be checked by reverse computation processes, the result of the second computation being compared against the punched result of the first. Error cards may be identified by specific punches, or the machine may be wired to stop upon detection of an error.

The speed of the Type 602 calculating punch is dependent upon the number of digits in the multiplier or quotient, as well as upon the type of operation performed. The multiplication of one factor by another varies from 1000 per hour for a 10-digit multiplier with a 20-position result, to 3000 per hour for a 1-digit multiplier with a 6-position result. Dividing speed is dependent upon the number of digits in the quotient. Speed can vary from 3000 cards per hour to 200 cards per hour. Dividing any dividend by any divisor to obtain a 5-digit quotient would be performed at the rate of approximately 540 cards per hour. The punching of the result in one card takes place simultaneously with the calculation of a result for the succeeding card.

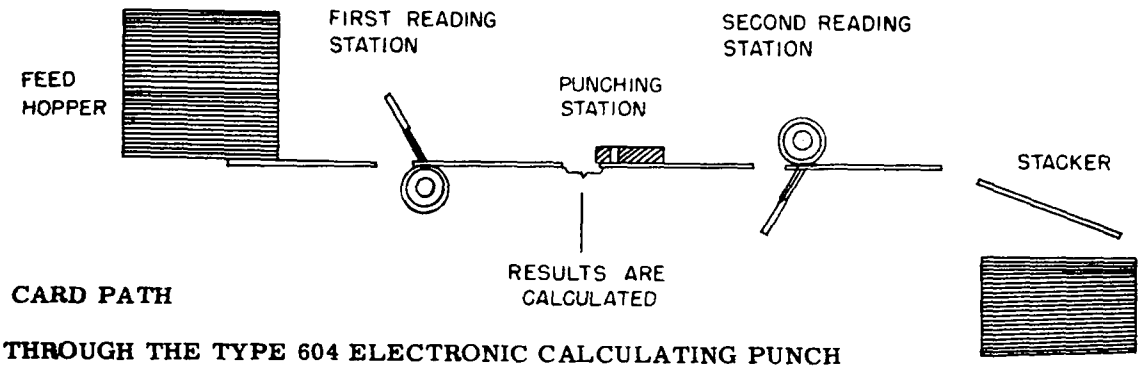
Provision is made for numerous functions which accelerate the speed of operation or insure the degree of accuracy in the calculation. Practically any arrangement of decimal accumulation can be obtained. Several types of selectors are provided for automatic selection of impulses which control operating functions, as well as for selection of factors from different card fields. The punching mechanism is similar to the Type 016 Key Punch, but punching need not be in consecutive fields; through control panel wiring and the insertion of an adjustable skip bar, any field or fields may be skipped. The algebraic signs of final results can be punched.

The major applications to which this machine is put in weather records processing centers are the computation of percentage frequency tables from absolute frequency data, the conversion of meteorological data from one system of reporting units to another, the computation of means, and the selection of extreme values. Once the problem has been established and the control panel wired to instruct the machine properly, the feeding of cards, the performance of all types of calculating operations, the recording of the results in punched form, and the ejection of the card from the machine are all automatic operations continuing without major attention from an operator other than to add cards to the hopper and to remove cards from the stacker.



CARD PATH THROUGH THE TYPE 602 CALCULATING PUNCH

The Type 604 Electronic Calculating Punch is a newer development, similarly performing all basic types of calculations. Factors are read from cards, the calculations are made by an electronic calculating unit in a fraction of a second, and the results are punched automatically in the cards. Whether single, repetitive, or combination operations are required, and whether one or more results are punched in each card, the calculations are performed at a constant operating speed of 6000 cards per hour.



THROUGH THE TYPE 604 ELECTRONIC CALCULATING PUNCH

The Type 604 consists of a punching unit and an electronic calculating unit connected to it by a cable. The calculating unit contains electronic tubes which perform the calculations in a small fraction of a second. The punching unit is similar to the Type 517 Gang Punch, which punches information successively from one card to another, punching all 80 columns of the card simultaneously. Factors are read, results are calculated and punched, and the cards are checked as they move continuously past a reading, punching, and another reading station. There are 252 electronic cycles available for the calculation of each card, regardless of the number of program steps with which the machine is equipped (the standard machine is provided with 20). This is equivalent to 420 cycles per second.

The detailed functions of the machine are, for the most part, wired internally, which eliminates the necessity for complex external control panel wiring. The increased speed of the Type 604 electronic calculating punch permits the planning of broader computational processes which cannot be economically performed either manually or by lower speed calculating punches.

Interpreter

An auxiliary machine of minor importance is the Type 552 Interpreter, with which it is possible to print, entirely automatically, descriptive words and numerals directly upon the punched card, thus translating the holes in the card into printed information which can easily be read. This printed information facilitates the manual filing or withdrawal of cards, especially when alphabetic information is used.

Card-Operated Typewriter

Another auxiliary machine of lesser but specialized importance is the Type 058 Card-Operated Typewriter. A Type 052 Verifier automatically reads the cards, selecting the proper information in accordance with control panel wiring, and transmits the impulses through a connecting cable to an IBM Electromatic Typewriter. Through the use of special punching, punctuation symbols as well as alphabetic and numeric information may be typed at the rate of approximately 120 words per minute.

Special Devices

The requirements for the machine processing of weather data into complex climatological classifications quickly exceeded the capacities of practically all types of "standard" IBM equipment. It was found that in almost all requests for data, the requirements were such that pre-processing for group classification or additional runs through the machines

were necessary, creating the problems of time sacrifice or of obtaining additional equipment, which in turn would require additional operating personnel. The problems encountered were carefully considered by experienced machine technicians and IBM representatives to determine the most efficient solutions. Recommendations were followed by the installation of numerous special devices. It may be pointed out here that the addition of these special devices, especially on the accounting machines, in many cases doubled the capacity of the machine, and constituted a great saving in personnel and time required for the production of special reports.

The addition of special devices also provides overlapping functions of the various types of equipment, and enables more efficient scheduling of many varied projects being processed simultaneously.

On the accounting machine, special devices permit such applications as the vertical classification of two or more elements, or in other words, the simultaneous production of two or more entirely distinct summaries From six to twelve card columns of data may be examined and classified separately or in conjunction with each other, an increase of at least two hundred percent over the standard machine. Automatic control can be established for groups of classifications, rather than for single classifications, permitting, for example, totals by season rather than by month. Group multiplication processes can be accomplished on the accounting machine. Selection of extreme values, with regard to algebraic sign, the listing of differences between fields within one card or from one card to the next, and the accumulation of absolute differences are other applications which are not possible on the standard machine without special pre-processing of the cards by auxiliary machines. The use of demountable type bars makes it possible to produce climatological listings using weather symbols and characters for the coded data in the punched card, which is a particular advantage in the editing and comparison of punched card data against original weather records.

The selector and sequence units of the collator, each of which are normally grouped into four units of four positions, have been changed to sixteen single-position units. The addition of seven selectors and a counting device, which may also be used as an emitter, has expanded its functions to envelop a wide range of complex relation checks in the audit of weather observations. Examples of such checking operations include the searching for illegal code possibilities, the comparison of cloud amounts at individual layers with the total cloud amount, and the comparison of ceiling with sky condition.

To the standard reproducing summary punch were added devices which permit the checking for double-punched or blank columns, and the punching of digits emitted by the machine and determined by control panel wiring. The additional selectors afford greater flexibility in reproducing, gang punching, and summary punching, as control can be accomplished to reproduce or gang punch data into a single card field from multiple card fields, and vice versa, to off-set gang punch and compare, and to control the punching of totals in summary cards.

Additional program cycles have been installed on the electronic calculating punch, bringing the total available programs to forty per card. This will permit the computation of much more complex problems, and will facilitate the calculation of the more simple type problems.

Detailed description of these devices and further enumeration of applications are too voluminous for this paper, and are therefore omitted. It soon becomes obvious that through the use of these additional devices, the processed for the solution of many problems are simplified, and hitherto impossible operations become commonplace. In summation, it may be stated that they are used extensively in the machine processing of data to establish many internal checks, to by-pass auxiliary processing, and to reduce the manual requirements of data processing to a minimum, therefore increasing the quality and quantity of production.

CHAPTER IV - SOURCES AND CARD DECKS

As one would expect to find in a library of scientific works a great variety of language and format, so do we find variety in the Joint Punched Card Library. The sources from which the punched cards are produced are as varied as the meteorological services and languages of countries all over the world. Although it would be desirable to reduce all the different codes and reporting forms into a standardized punched card code, so that working with the cards would be made easier and that machine processing would become uniform, that is hardly feasible. One is faced with the facts that there are but eighty columns in an IBM punch card, and that the variety of meteorological elements and the units in which they are reported far exceed this quantity of digits for a single type of weather observation. Another consideration is the fact that frequently the only report of an observation is already in code, such as the International code, where a single digit represents a range of values, as in visibility. To hope to expand this code to the actual value is futile; to reduce data to code when one has it in detailed form can only lead to regrets later, when the requirement develops for summaries by detailed values rather than by ranges.

Generally speaking, the greatest cost in a punched card program is the initial cost, that of transferring the data from written to punched card form. The object is to produce a single punched card containing one complete weather observation, a unit of information in itself, which may be grouped readily with other similar units in any desired classification by rapid punched card techniques. If the original observations are in a concise form which is readily punchable, the cards may be punched directly from the source. Frequently, however, the data are in forms which have been proved to be unsound for a punched card program, and they must be re-arranged. For example, one page of source material may contain only sea-level pressure for all the observations for a station during the month, with the other elements on separate pages. These data must be re-arranged by hand to a unit-observation form, and it is in this coding process that some amount of standardization is possible between various sources. However, the expense involved in transcribing volumes of observations is so great that direct punching is sought, even though it results in a multiplicity of card forms.

Each group of punched cards containing data from a single source in an established form is designated as a card deck in the Joint Punched Card Libary, and is assigned a card deck number for easy reference. Each meteorological source from which these cards are punched is likewise assigned a source number. The number of such different card decks in the library now exceeds two hundred, and one can readily see that to remember all the detailed information necessary to use the cards to produce climatological summaries is an impossibility. To solve this problem, a reference manual is written for each card deck, containing all information necessary for an individual who is versed in IBM techniques to produce from a group of cards whatever type of climatic investigation is desired, consistent with the basic data punched.

There are several standardized forms for reporting weather observations which are used internationally, such as a daily weather bulletin containing observations in International Code, or meteorological yearbooks, which follow the same general form from one country to another but differ substantially in detail. The resulting card decks can be grouped into several classifications, which are discussed below.

Hourly Observations

The hourly observations are the largest decks in card volume, but are also the most valuable. The first U. S. hourly observations to be placed on punched cards were the U. S. Weather Bureau observations from airways stations, Card Deck 131. More than 400 stations are represented, covering the general period of record from 1934 through 1941. This deck is unique in the Joint Punched Card Library, in that two observations are punched in a single card, two observations exactly six months apart. This arrangement was possible since the entire observation as reported on Form 1130-A during those years could be punched in less than 40 card columns, and is a great file-space saver as well as an advantage in sorting operations, since two months of record may be placed in the same

order simultaneously. However, the requirements for more complete observations grew through the years, so that the present hourly observations punched by the Air Force, Weather Bureau and Navy require 78 card columns.

Another deck of major importance containing hourly observations is card deck 141, consisting of all hourly observations reported by the Air Weather Service from time of station establishment through the end of 1945. These are punched on a card form designed to fit the observation as it was reported in 1943, when this punching program was conceived. Over 1000 stations throughout the world, wherever the Air Weather Service established stations during World War II, are represented and although many stations are of extremely short record, over 18,500,000 cards are contained in this deck.

With the introduction of Form WBAN-10 in 1945 and the establishment of the in-station punching programs of the Air Weather Service and the Weather Bureau, the card form was changed, creating card deck 142, which contains all hourly observations recorded by all three services on that reporting form. As further changes are made in the reporting forms, the card decks must also be revised, so, it appears, there will be an endless array of WBAN 1 cards. Although it is desirable to fit the card to the form for ease in punching, this becomes objectionable when a continuing period of record for the same station must be punched on several varieties of cards, since separate control panels and machine processing techniques become necessary to produce a single summary. At the present time, more than 45,000,000 cards are contained in the five card decks representing the hourly observations of the three services, and only a small portion of Weather Bureau observations between 1941 and 1947 and of Navy records since 1945 have been punched.

While the foregoing represents the bulk of the hourly observations on punched cards, several card decks have been created from the yearbooks of foreign countries which usually contain hourly records for one or two first order stations. These are as follows:

161 Japanese Hourly (7 stations)
171 Nanking Hourly (1 station)
201 Japanese Synoptic (hourly reports for 3 stations)
221 Hong Kong Hourly (1 station)
231 Peiping Hourly (1 station)
251 Zikawei Hourly (1 station)

Synoptic Observations

The most frequent type of foreign observation punched is the six-hourly synoptic observation in International Code. This form is represented in many different card decks, separated by reason of source. The largest of these, and the most incomplete insofar as the entire observation is concerned, is card deck 101. This deck was produced from practically every observation obtainable during the preparation of the Northern Hemisphere Historical Map Series, and covers the thirty year period from 1899 through 1928. Only the observation nearest the 1230Z map time was punched. The cards were sorted into day-station order, and listings of the observations were used for plotting the historical map series. At the completion of that project, the cards were sorted and filed by station number, and now provide a source of data for climatic summaries when no better source is available. Due to the many varieties of sources used and the speed which was necessary in its preparation, most of the observations in this deck contain a minimum amount of data. All of the observations were transcribed from their original form to an abbreviated International Code. Similar to this is card deck 102, Southwest Pacific Land Observations, prepared in the same manner for the set of historical maps for that area.

Other much more valuable card decks exist in this form. The Japanese Semi-Daily Observations (Card deck 103) which include observations for 120 stations in Japan, Korea, and near by islands were punched from the Japanese Daily Weather Chart, Central Meteorological Office, for the period 1927 through 1937. Card deck 104 consists of synoptic observations three times daily for 58 stations in French Indo-China, produced from a daily bulletin of that nation, covering the period 1937-1940. Card deck 105 is similar in nature, but more complete in data coverage, the observations extending through seven groups of International Code. The sources for these observations are the Moscow and

Leningrad Daily Bulletins for the period 1932-1937, with observations three times daily punched for almost 200 stations, giving an excellent area coverage. Many of the stations are of short record, however, and many observations are missing throughout the period.

One of the major decks, 107, Deutsche Seewarte, produced from observations published in the Deutsche Seewarte Wetterbericht and the British Daily Weather Report, for the period 1929-1939, contains data for approximately 130 stations in Europe, from Spitzbergen to Bucharest to Horta in the Azores. Again, three observations daily are punched. A small but similar deck is number 108, Greek Synoptic, consisting of three observations daily for six stations in Greece and two in Turkey, for about a seven year period. Another small deck is 109, in which are included observations for five stations in Greenland for a five year period, procured from a Danish daily bulletin and the Deutsche Seewarte Wetterbericht. This is supplemented by card deck 162, Greenland Synoptic, containing recent synoptic observations for a few Greenland stations from transcribed copies of the observations reported by the Danish weather service. Two other decks in this form are 011, Pan American Airways Surface, and 012, Argentine Synoptic, in which are punched synoptic observations from 24 stations in South America and 45 stations in Argentina, respectively. The observations for deck 012 were punched from the Carta del Tiempo, a daily bulletin published by the Argentine Republic.

All of the decks described above are punched on the same card form, and only minor changes in control panels and procedures are necessary to shift from one deck to another when tabulating similar summaries.

The above will give the reader some idea of the variety encountered without changing the card form. Similar observations are contained in the several decks used in connection with the current program of publishing a Northern Hemisphere Historical Map Series. Card deck 122 covers all surface observations used in this project for the years 1946-48, and with the change in International Code in 1949, card deck 123 was created. Card deck 152 consists of all the surface observations for 1130Z reported in the India Daily Weather Report within this same period. Although all these decks contain but one observation per day, and are produced specifically for the purpose of providing data listings to accompany the surface maps, upon completion of this stage of the project, these decks will be sorted into station order to provide data for many areas of the world which are not otherwise covered in a more convenient and accurate form.

Other observations reported in daily bulletins have been punched in somewhat different form in the following card decks:

151 British Synoptic (6 stations)
295 Turkish Synoptic (16 stations)
297 Egyptian and Mediterannean Synoptic (57 stations)

Another source for observations in a modified synoptic form are the monthly or annual publications of the various meteorological services. Through international agreement, many of these yearbooks follow the same general format, but the arrangement of data and the reporting units frequently differ from one country to another. Occasionally original records for a group of observations have been coded into this general yearbook form. Yearbook data usually are more accurate than daily bulletins because the observations are checked before publication, but only rarely does this form of observation include such operational elements as visibility, ceiling, or cloud height. This is mainly due to the fact that most yearbook data which have been available are for years before such operational elements became important, but there is a tendency even in later years to omit such data, probably to conform to the pattern established for yearbooks by an international committee many years ago.

Observations from one to eight times daily (usually three) are reported for the second order stations, and are represented in the following card decks. Some uniformity of columnar arrangement exists, but so frequently do the units of measurement vary that all may be considered as different forms.

181 Chinese Customs Stations - Synoptic (45 stations)
182 Chinese Cooperative Stations - Synoptic (59 stations)
201 Japanese Synoptic (46 stations)

210 Danish and Greenland Synoptic (59 stations)
211 Chinese Synoptic (5 stations)
212 Manchuria Synoptic (11 stations)
213 Kharbin Synoptic (1 station)
214 Tsingtau Synoptic (2 stations)
215 Russian Synoptic (188 stations)
216 Ankara Synoptic (1 station)
217 Hungarian Synoptic (1 station)
218 Egyptian Synoptic (7 stations)
219 Polish Synoptic (17 stations)
220 Finnish Synoptic (20 stations)
222 Estonian Synoptic (1 station)
241 Nantung Synoptic (1 station)
261 Chinese Air Force Synoptic (12 stations)
271 Philippine Synoptic (20 stations)
291 Canton Synoptic (1 station)
293 Christmas Island Synoptic (1 station)
294 Batavia Synoptic (1 station)

Card deck 270 has been created from the U. S. Weather Bureau Form 1083 for thirteen stations in the United States, and includes most of the elements contained in the synoptic code, but in different form.

Another deck of major importance among the synoptic observations is deck 281, containing the surface observations of the U. S. Navy which were reported on the Monthly Aerological Record, the reporting form used for the years immediately preceding the use of WBAN-10. These observations are reported from three to eight times daily, and cover approximately 250 land stations and 230 ships from as early as 1921 until 1945. The code form is a mixed modification of the former International Code and airways reports.

Despite the predominance of surface observations for land stations, the ocean areas have not been slighted. Several large decks involving millions of cards have been punched containing marine observations. Card deck 111 was punched at the same time as deck 101, and includes approximately 1,650,000 ship observations in the Northern Hemisphere for the years 1911 through 1928. This was also used in connection with the preparation of the Northern Hemisphere Historical Map Series. The Southwest Pacific Historical Map Series also made use of marine observations, and these are contained in card deck 112. Card deck 113 contains about 2,000,000 marine observations for the years 1911 through 1931, which were used by the Weather Bureau in the preparation of the Marine Atlas. All of the above marine decks use latitude and longitude or the identifying group QLL11 to locate the position at which the observation was recorded. The Deutsche Seewarte Marine Observations, deck 192, obtained from the German weather service at the conclusion of hostilities, use the Marsden square system for position location. This is a very large deck, consisting of rather complete observations, and numbering about 7,000,000 from approximately 1885 to 1936.

In addition to these decks which are an integral part of the Joint Punched Card Library, there are approximately 200,000 hydrographic observations mainly from the Sea of Japan, that were obtained from the Japanese at the close of World War II, but these must still yet be reproduced from the 45-column cards used by the Japanese and sorted into a usable order.

The land synoptic observations punched by the German weather service during the war have been obtained by the Air Weather Service, but it is not possible at present to state many definite facts about this deck, except that a great deal of work must be accomplished before it will be of major value. The station numbers are generally based on the International index system, but there are enough arbitrary station numbers to cause considerable difficulty in establishing the identity of each station. Any list which would completely tie in station numbers with station names, and most of the basic data from which the cards were punched, appear to have been destroyed by the bombing of Berlin.

Two proposed decks which will be of value when completed are 021, containing all surface observations recorded by the United States forces while based in Great Britain during World War II, and 153, to be punched from microfilm record of the airways observa-

tions taken by the Canadian meteorological service. The latter will be supplemented by deck 296, containing the six-hourly observations for these and many more second order stations.

Summary Observations

Practically all decks of hourly or synoptic observations which were punched from original or yearbook type data are accompanied by decks containing summary of day information for the same stations. Most of these are fairly uniform in nature but dissimilar in design, containing such daily elements as maximum and minimum temperatures, total precipitation amount, total snowfall amount, snow depth at a specified hour, and frequently various means of the elements recorded at the synoptic observations. The major decks of this type are as follows:

341 USAF Form 94-B (all AWS stations through 1945)
343 WBAN 3 (stations of all three U. S. services)
345 WBAN 3 (continuing with the revised WBAN-10)
371 Nanking Summary of Day (1 station)
372 Chinese Cooperative Stations - Summary (64 stations)
381 Chinese Customs Stations - Summary (45 stations)
382 USN Monthly Aerological Report Summary (all USN before WBAN)
391 Manchuria Summary of Day #2 (1 station)
392 Nantung Summary of Day #1 (1 station)
393 Nantung Summary of Day #2 (1 station)
396 Philippine Summary of Day #2 (1 station)
397 Philippine Summary of Day #2a (1 station)
401 Japanese Summary of Day (43 stations)
410 Danish and Greenland Summary of Day (19 stations)
411 Chinese Summary of Day (5 stations)
412 Manchuria Summary of Day #1 (11 stations)
413 Kharbin Summary of Day (1 station)
414 Tsingtau Summary of Day (2 stations)
415 Russian Summary of Day (188 stations)
416 Ankara Summary of Day (1 station)
417 Hungarian Summary of Day (1 station)
418 Egyptian Summary of Day (7 stations)
419 Polish Summary of Day (17 stations)
420 Finnish Summary of Day (20 stations)
422 Estonian Summary of Day (1 station)
451 Chinese Air Force Summary of Day (12 stations)
461 Philippine Summary of Day #1 (10 stations)
462 Philippine Summary of Day #1a (16 stations)
483 USWB Form 1009 (Region 4 Co-op stations, 1946-47)
486 USWB Form 1009 (All US Co-op Stations 1947 to date)
491 Canton Summary of Day #1 (1 station)
492 Canton Summary of Day #2 (1 station)
494 Hong Kong Summary of Day #1 (1 station)
495 Hong Kong Summary of Day #2 (1 station)
496 Peiping Summary of Day #1 (1 station)
497 Peiping Summary of Day #2 (1 station)
498 Zikawei Summary of Day #1 (1 station)
499 Zikawei Summary of Day #2 (1 station)

Other more specialized forms of summary of day information have been punched from time to time as required. Card deck 394, NEI Precipitation, contains no data except the 24-hour precipitation amounts for 27 stations in Java and Borneo. Card deck 484, Hawaiian Daily Rainfall, is considerably different in form, but contains only the same information for 6 stations in the Hawaiian Islands. Deck 485, Hawaiian Cumulative Rainfall, was derived from deck 484, and contains cumulative amounts of precipitation for one through five day totals. Card deck 395 is a wet and dry spell summarization for Christmas Island. Deck 487 contains weekly precipitation amounts for more than 6500 cooperative stations in the United States, for a maximum period of 30 years. All of the above decks were prepared for special climatological investigations, and are therefore very limited in scope.

Card deck 481 contains only daily maximum and minimum temperatures for thirteen stations in the United States, for a maximum period of 45 years, plus this type of data for the month of December only, for 20 additional stations, this latter part prepared specifically for one summarization project. Card deck 330 contains similar data for a great many stations in the United States, from which have been computed degree day information.

Other card decks have been punched to contain six-hourly observations or six-hourly summary data. The WBAN 2 card, in decks 342 and 344, contain the six-hourly information for all Air Force, Weather Bureau, and Navy stations, as it is recorded on the Form WBAN-10. Card deck 482 contains the six-hourly synoptic observation, but not in synoptic code, as reported on Form 1001 for a small group of Weather Bureau stations. Card deck 292 contains six-hourly precipitation amount for 46 stations in the United States for a maximum of 10 years.

Summarized data, particularly monthly summaries as recorded in various foreign yearbooks, have been punched occasionally in order that the data might be tabulated by machine methods into tables covering the entire period of record available. Such data are represented in the following card decks:

900 Netherlands East Indies Consecutive Wet and Dry Days (27 stations)
901 Netherlands East Indies Monthly Precipitation Amounts (27 stations)
902 Turkish Monthly Precipitation Amounts (84 stations)
903 Turkish Monthly Summaries (41 stations)
904 Russian Monthly Summaries (133 stations)
905 Chinese Pibal Summaries (9 stations)
906 Palestine Monthly Summaries (10 stations)

Upper Air Observations

Observations of the upper air are also well represented in the Joint Punched Card Library, but not nearly to the extent that surface observations are present. The reasons for the minority part they play in card volume are obvious; the techniques of observation are more recent and therefore of shorter period of record, the observing stations are fewer, and the processes for checking observations for accuracy before punching are so lengthy that card punching is delayed.

Pilot balloon observations for most Weather Bureau stations in the United States and Alaska, and for many ships in the Atlantic and Pacific, are punched from the beginning of their record through 1944 in card deck 511, U. S. Pibals. Direction and speed at thousand meter intervals (and intermediate intervals near the surface) as well as cloud type and direction are recorded. This record is continued in card deck 530 for Weather Bureau stations during the early use of the WBAN 22 reporting form for the years 1945-47. Pilot balloon observations of Air Weather Service stations are punched in one minute intervals of observation from the beginning of their record through approximately 1945 when the WBAN 22 form came in general use, in card deck 560, USAF Pibals. The present WBAN 4 card for winds aloft observations, card deck 531, contains continuing periods of record for all three U. S. services, with direction and speed reported at thousand meter levels. This card form permits the recording of all types of winds aloft observations, regardless of the method by which they were obtained. Thus, pibal, rawin, and rabal observations are punched. Many observations other than those taken by theodolite methods in the early stages of radio direction finding techniques have been coded and punched in this form.

Radiosonde observations reported before the advent of joint WBAN recording forms are punched in card deck 501, U. S. Radiosonde, which includes all Weather Bureau soundings, including available airplane soundings, through early 1945. Temperatures, pressures, and humidity values are punched at standard levels, thousand meter intervals. With the introduction of the form WBAN 32, a change in card form became necessary, creating card deck 541, containing the same type radiosonde data at standard levels, but in a much altered form. With the international changeover to constant pressure data in

1945-46, the reporting form WBAN 33 was devised, necessitating still another card form, the present WBAN 5 card. These observations are punched in card deck 542, and contain height, temperature, humidity, and wind velocity (if observed) at fifty millibar intervals up to 200 millibars, and at more frequent millibar intervals thereafter.

Cards punched in connection with the current publication of the Northern Hemisphere Historical Map Series, 500 Millibar, are contained in deck 522 for the years 1946 through 1948. Observations nearest 0400Z are punched in whatever upper air code is used in the teletype reporting of data. Card decks 523 and 524 are used for the 1949 data, for winds aloft and radiosonde observations, respectively. The reporting codes are abandoned in these forms, and data for definite levels are punched in specific card columns, making it possible to summarize the observations much more readily.

Upper air soundings of foreign sources are punched in several forms. Card deck 502 contains soundings from the Indian Daily Weather Report, punched in connection with the 1946-48 series of Northern Hemisphere Historical Maps. Card deck 546, when completed, will contain kite and radio soundings as reported in the Moscow and Leningrad Daily Bulletins for the years 1932-37. Many of these observations are very sketchily reported, however; each card punched will be coded from the observation as plotted on an adiabatic chart. The format of the WBAN 5 card is followed. Soundings for 15 stations in the British Isles for the war years are punched by constant pressure levels in card deck 551. Results of airplane soundings for Nanking and kite soundings for Peiping have been coded and punched for about a four year period in card deck 580. Kite soundings at Tateno, near Tokyo, have been punched in deck 594 for a thirteen year period.

Pilot balloon observations are available and punched from a great number of sources despite the fact that many are of extremely short record. Generally speaking, they follow the same form, with wind direction and speed reported at thousand meter intervals, and interim levels near the surface although many of them were coded into this form from other codes. A list of these card decks should suffice to give the reader an idea of their coverage.

512 Tateno Pibals (1 station)
513 Madagascar Pibals (4 stations)
514 Roumania Pibals (3 stations)
515 Labuan Pibals (1 station)
516 Malay Pibals (2 stations)
517 Japanese Pibals (11 stations)
518 Ilmala Pibals (1 station)
519 Vacoas Pibals (1 station)
552 Egyptian Pibals (2 stations)
553 Canary Island Pibals (2 stations)
554 Indian Daily Winds Aloft (punched in connection with the Northern Hemisphere Map Series for 1946-48)
555 Egypt and Sudan Pibals (17 stations)
579 Netherlands East Indies Pibals (15 stations)
584 Siam Pibals (3 stations)
585 Burma Pibals (1 station)
586 Pan American Airways Pibals (10 stations)
590 Russian Pibals (113 stations)
593 Korean Pibals (8 stations)
595 Zikawei Pibals (6 stations)
596 Nanking Pibals (3 stations)
599 Netherlands East Indies Pibals (2 stations)

Pilot balloon observations at hourly intervals, with readings every thirty seconds, were punched for seven stations for a seven day period, in card deck 597, in connection with the land-sea breeze projection undertaken in Puerto Rico in 1944. The results of these observations, in terms of elevation and azimuth angles and horizontal distances, for these closely spaced readings, were punched on cards, and the resultant wind velocities were computed. Observations containing only cloud information and maximum height of balloon were punched for fifteen stations in the Netherlands East Indies in card deck 592.

Special and Research Decks

Various research card decks have also been created, especially from the forty year series of Northern Hemisphere maps from January 1899 through June 1939. The type, coded position, and intensity of each pressure system is punched in deck 601, which was used for several years in the selection of analog maps for long range forecasts. The sea-level pressures at designated intersections of latitude and longitude, interpolated from isobaric patterns, are punched for each day's map in deck 621 and 625, the latter giving only a partial coverage of the hemisphere. Over a million cards are punched in deck 621, 72 cards per day at five degree intervals of longitude for the forty and one half year period. These have been summarized, producing monthly mean pressures and semi-monthly mean pressures at each intersection, the results punched in card decks 981 and 986, respectively. A similar deck, number 622, has been punched containing the three kilometer pressures at intersections, from that series of upper level charts, October 1932 through July 1940. It has been proposed that monthly and semi-monthly means be computed from these data, but this project is not completed.

Another research deck created from this map series is deck 623, containing data relative to the tracks of all pressure centers in the Northern Hemisphere during the forty years. With the aid of these cards, the speed and direction of movement, the deepening and filling of systems, acceleration of movement, and other items may be studied for a great number of pressure systems. Over 450,000 cards are required to store this information, one card for each system for every day of its existence.

Card deck 624 was created in conjunction with the project whereby computations of correlation for North Atlantic monthly mean pressures from the 1899-1939 daily maps, weighted latitudinally and longitudinally by 14 sets of coefficients to form series of products designated orthogonal polynomials, were accomplished by accounting machines. The monthly mean pressure values of 14 orthogonal polynomials were correlated with each of the 14 values for each day, within a season and zone, classified according to a number of types of pressure distribution.

In the attempt to summarize observations from aircraft in flight, a number of observations from varied reporting forms were coded into a standardized form and punched in card deck 591. This includes approximately 30,000 observations over the North Atlantic in 1942 and 1943, and in addition to the usual meteorological elements reported, the conditions under which the observations were made, the location of the aircraft, general flight conditions, fronts and disturbances encountered, and other conditions pertinent to the flight were punched.

Card deck 910 was created for use in a study of objective forecasting methods. Data for the station under study, San Antonio, Texas, were reproduced from hourly cards and punched, in addition to a number of coded items derived from synoptic maps.

Besides the many types of observational and research data which have been discussed above, the Joint Punched Card Library contains numerous and varied derived summary cards, used mainly in the preparation of routine type climatological summaries from meteorological observations. Many types of control and master decks are also retained, for use in housekeeping functions of the library and for use in machine processing of meteorological punched cards. These control decks include items such as an index to the library itself, by card deck, station and tray number, inventory of weather records available, status of completion of major projects, and name cards for all stations, giving the station name and number, location, type of data, etc. Master decks include checking decks used in the routine processing of weather records, numeric table decks, psychrometric relationship decks, and decks used for the conversion of one set of units to another. The detail and function of these many card decks hardly justify their description in a paper of this type.

The foregoing discussion of card decks and sources should give the reader an idea of the scope and variety of meteorological data available for climatological investigation by punched card methods. Any such lists as have been presented in this chapter soon become obsolete, since through the combined efforts of the Air Force, Weather Bureau, and Navy, the Joint Punched Card Library is growing at the rate of approximately two million cards per month, as the never ending search for data progresses.

CHAPTER V - OPERATIONS AND FUNCTIONS

Basically, a weather service can be divided into two main fields of effort, a current weather-forecast branch and an historical weather-climatic branch. Although they are dependent on one another, their problems are quite divergent. The current weather-forecast field is concerned with making observations, rapid communication of current weather data, preparation of synoptic maps and charts and answering questions such as, "Will I be able to fly Visual Flight Rules from here to Dayton tomorrow?", "Will I need heaters in my orange grove tonight?", or "Should my Willie take a raincoat to school today?". The historical weather-climatic effort concerns itself with collection and accumulation of weather data, tabulations of weather statistics, analysis and interpretation of weather history and answering of such questions as "How much of the time, in a given season, is the weather good enough for VFR flying between two points and what is the optimum flight path most likely to be?" or "What are the design factors for building construction in New York?" The machine tabulation unit enters into the historical weather-climatic branch as the supplier of the basic tabulated data.

The U. S. weather services, Air Force, Navy and Weather Bureau, each maintain a machine unit as a necessary adjunct to its general climatic program. These units are housed in New Orleans at the Port of Embarkation, sharing common facilities, exchanging experience and information and operating nearly as a joint unit except that each maintains separate personnel and machine equipment and has different programs. That the programs are different is a consequence of the variation in "customers", the Weather Bureau being concerned with civilian interests, the Air Force and Navy with military interests. However, for the purposes of this discussion the units may be considered collectively. While not all of the functions to be described are applicable to each unit they are applicable to one or more, or have their parallel in other units, and therefore, they are descriptive, in a broad sense, of machine unit function.

The machine units are under direction of offices in Washington which prescribe general and special work to be done, establish priority of work and maintain staffs to make final analyses and studies of the condensed data furnished by the machine units. Work of the machine units resolves itself into three main functions:

Data collection and filing

Routine data processing

Special data processing

These functions will be described below but space limitations will necessitate brevity, omission of detail, and use of typical examples to cover related studies.

Collection and Filing of Data

One of the basic requirements in a comprehensive climatic program is the acquisition of substantial amounts of weather data providing adequate coverage of the areas of interest. At present and in normal pursuit of a military climatic program the areas of interest are necessarily world-wide. The handling of the data, once acquired, has ever been in the province of the tabulation unit and the current trend is to make the acquisition itself a function of the unit.

The collection of observational data made by U. S. weather services varies from service to service. Records prepared in the U. S. Navy are collected at the Aerology Section of the Navy in Washington. These records are then transmitted to New Orleans for processing. The Weather Bureau, which operates several machine units in addition to its unit at New Orleans, collects its records at these units together with punched cards which have been prepared at the stations. The records are checked and cards punched from those records not punched in the field. The records are microfilmed at these units and then redispersed with some records going to Washington, some to New Orleans, and the surface record of first and second order stations being returned for file to the station of origin.

Periodically the punched cards and microfilm of the records are sent in to New Orleans where the cards become part of the Joint Punched Card Library and the film is incorporated in joint microfilm files. The Data Control Unit was designated several years ago as one of six or seven military records repositories for the archiving of military data, and contains all original Air Force data. Records of all stations of the Air Weather Service are forwarded direct to that unit.

Recently arrangements were made with a number of foreign nations to mail monthly transcripts of observations to the U. S. and this country also regularly receives the published data of a few foreign meteorological services. An unusually good relationship exists in exchange of information with our Canadian neighbors.

At the present time few of the foreign powers have a very comprehensive punch card program in progress. However, an increasing number of them are contemplating use of cards, and it is planned and hoped that an exchange of punched cards can be effected.

Other sources of data that have been drawn on heavily during the war and are still being utilized are the Air Force and Navy technical files, the USWB Library and the Library of Congress. These libraries have many volumes of published data in addition to volumes of tabulated data and various works and treatises covering foreign areas. Teams of searchers will explore these libraries further and it is planned that some form of extensive index to climatic summaries and data will be prepared.

Mere collection of the data does not satisfy any requirements other than simply having it on hand. It must be subjected to considerable reworking in order that it be accessible. In the case of U. S. records provision has been made for mass handling of the weather records. The records of all three U. S. services are now identified by a joint 5-digit numbering system. This numbering system simplifies many of the problems associated with filing, indexing, inventorying, and keeping track of the stages of work completion in the summarization of the records. Foreign records which are usually in a published book form must be carefully surveyed in order to determine stations included, periods of record, content of the observations, units in which elements are measured, etc.

After the data have been acquired and indexed, the next step is to get the information into punch card form. This has become a relatively routine matter for our own records since all services enter their observations in the same form of record and all employ the same form of punched cards. Records which are not punched in field stations are punched by the units in New Orleans. Foreign data present a rather complex problem as is apparent from the fact that so many different card decks have had to be created. For some records direct punching from manuscript records is possible due to simplicity of observations or use of a coded report. Other foreign data, particularly some of the older material becomes so involved that it is impossible to punch it directly and an intermediate step must be employed. This step consists of translating data from the manuscript into a straight numeric code which can then be punched. In the coding process a certain amount of checking can be accomplished by inspection of internal consistency of the data. Cards having been punched are then verified and ready for filing in the Joint Punched Card Library where they are accessible to all services.

A final step remains in the processing of the record itself. That final step is the microfilming of the record. This is done to insure them against loss and to provide ready reference by use of a microfilm viewer for records which must be returned to some library or other owner. It also enables prints to be furnished from the microfilm or duplicates of microfilm through use of photographic facilities available at the units.

Routine Data Processing

Routine operations of a weather tabulating unit are concerned with the checking of observations reported within the station network, and the summarization of these observations into sets of standardized reports.

By means of elaborate machine techniques, it is possible to check observations to determine that observing rules were followed by the stations, as well as to verify the punching of the cards, to assure that the cards actually contain the information entered

on the reporting forms. Hourly observations are subjected to a number of machine steps, which test the relationships between the various elements within each observation: dew point temperature is inspected to determine that it lies within the range allowed by dry-bulb and wet-bulb temperatures; cloud amounts, types and heights are investigated to prove consistency among the various layers; sky condition, total cloud amount, and ceilings are compared; visibility is checked against the weather and obstructions to vision reported; and a search is made for improper punching combinations. Each observation is compared with the preceding hourly observation to prove consistency in sea-level and station pressures. Those observations which fail the machine tests are listed and visually compared with the original records. Six-hourly and summary of day cards are similarly listed. A recapitulation of punching and observing errors is prepared for each station, which is furnished to the field in order to acquaint the observers with the types of errors most frequently encountered and to promote a spirit of competition among the stations so that observing techniques may constantly be improved.

The types of routine summaries prepared vary among the weather services, as do their primary missions. Tabulations produced on this basis are designed to answer the climatological questions most frequently asked.

The routine summaries for Air Force and Navy stations are generally similar, cover the entire period of record available for each station, and consist of tabulations of several elements from the hourly observations and several from the summary of day information. These include monthly wind rose data and tables by month and hour of ceiling, visibility, flying weather, sky conditions, and weather conditions, and summaries by month of maximum, minimum, and mean temperature, precipitation amount, and snow depth. Data from Weather Bureau stations are summarized and published monthly, and include mean and extreme temperature and precipitation data, as well as listings of the individual precipitation amounts and temperature extremes.

Other functions, due to their continuing nature, may be considered as routine operations. As an aid to research studies by military and civilian agencies, it is the plan of the Air Weather Service and the Weather Bureau to publish a continuation of the Northern Hemisphere Historical Map Series, for both the surface and the 500 millibar level. The analyzed maps are supplemented by listings of the data used in their preparation. For the early years of the post-war period these observations have been procured primarily from teletype data as received by the Air Weather Service in Washington. The observations are subjected to a comprehensive editing and machine processing routine, reducing the many code forms in which the observations are reported to two or three standardized codes. Beginning in 1949, the observations for domestic Weather Bureau stations are punched at the stations and forwarded to New Orleans. Observations for foreign stations are obtained mainly from mailed-in original records or daily bulletins of foreign weather services, supplemented by teletype data for the remaining portions of the hemisphere. Listings of both the surface and upper air observations are made on the accounting machines and photographically reduced in size for off-set printing.

Housekeeping functions of weather tabulation units are necessary to govern effectively the flow of work on various projects and to disseminate information to interested agencies regarding status of projects, volume of data available, etc. These operations are generally referred to as controls, and are in themselves an important part of routine processing. Large scale projects as, for example, the routine surface summary program, come to involve thousands of station-months of record which may proceed through nine or ten stages in processing, and thereby undergo constant change in status. In order to coordinate and steer such a program to fruition, it becomes necessary to know how many and what stations are involved, what period of record is covered, the stage of completion at which the various units of data have arrived, where the data may be physically located, how long it would take to complete the processing of a given station or group of stations, and things of similar nature. Other major controls include an index to the Joint Punched Card Library, inventories of all types of weather records available by station and month, status of winds aloft and radiosonde records, machine time reports, and station name listings. This type of work is particularly adaptable to the punched card method, since the basic information need be recorded but once. Additional information may be collated or sorted into the main file, and the cards automatically arranged into any desired order for listing in multiple copies. All such controls are items of proper management, and are more than justified by their frequent use.

Special Data Processing

The above term is intended to apply to the processing of observations to meet specific, one-time requirements and generally limited in volume of data involved, as opposed to processing which is repeated or continued over a period of years and meets general, continuous demands for information. Special data processing may include punching of data into IBM cards, but generally only involves machine processing and tabulation of cards into summaries which are designed to furnish weather elements in proper units and class intervals for providing an analyst with the information necessary to prepare a comprehensive answer in fulfilling the request. The equipment can perform any tabulations which can be done by human effort. Its virtue lies in the fact that it can perform its work very rapidly, does not fatigue and thereby slow down or make excessive errors, and can simultaneously consider several parameters. For these reasons it can accomplish projects that would otherwise be nearly impossible because of the time and man-power requirement. It very readily adds, subtracts, multiplies, divides, or tells frequency of occurence of a given set of conditions. Perhaps the best way to illustrate the versatility of the equipment and the scope of problems met in special data processing is to give typical examples of some of the studies which have been made.

Studies involving simultaneous weather conditions at two or more stations:

1. A tabulation showing separately by day and night for each month the number of times that the alternate landing fields of Bangor and Presque Isle, Maine, Gander and Goose Bay, Newfoundland, and Mingan Quebec, were open when Stephenville, Newfoundland, was closed due to weather. Day minima were taken as 800 feet and 1 mile, 700 feet and 1 1/2 miles, 600 feet and 2 miles, or 500 feet and 3 miles. Night minima were 1000 feet and 2 miles or 800 feet and 3 miles.

2. A tabulation of mean number of days by month with simultaneously unlimited ceilings along northern, central and southern air routes across the U. S. Determination that route ceiling was unlimited in entirety was based on simultaneous consideration of six stations along each route.

3. Mean number of days per month when all stations in Louisiana simultaneously reported cloud cover 1/10 or less for a minimum of 4 consecutive hours. Data were required for photo-reconnaissance purposes.

4. For Albrook, Howard, and France AF Bases in the Canal Zone, the number of hours and percent of time these stations had minimum flight conditions simultaneously (ceiling less than 500 feet and/or visibility less than 1 mile), and the same for instrument conditions; to secure an evaluation of possible alternate bases for incoming flights and to obtain information for adequate supervision of jet operations.

5. All combinations of contact, instrument, and closed weather conditions at Berlin and Frankfurt, simultaneously, in mean, maximum and minimum percentage of observations. Also maximum and minimum values for occurrences of fog at either station, and occurrences of snow depth greater than 6 inches, used in connection with Operation Vittles. Similar summaries for Berlin and Wiesbaden.

Frequency and duration of various weather phenomena, in terms of hours or days:

1. Frequency and duration of periods with temperature -30 degrees or below at Fairbanks, Alaska.

2. Frequency distribution of duration and magnitudes of changes in sea-level pressure at Mitchel AFB, New York. From hourly pressure values there was tabulated the constant progression, or the number of hours that the pressure rose, fell, or remained constant, which in the final report was spread by the total pressure change for each case, thus giving a tabulation of the duration of rising or falling pressure versus the amount of change in pressure.

3. Frequency and duration of fog, with various limits of visibility, for Tempelhof, Berlin, used in connection with Operation Vittles.

4. Mean percent of VFR, IFR, and closed conditions, and maximum duration in days that weather was generally less than contact, for seven stations in Germany and England, used with Operation Vittles.

Summaries particularly adaptable to the calculating facilities of IBM machines:

1. Tabulations by month of percent of night observations with cross-wind component of 5 miles per hour or less on runways 23, 27 and 31, individually, at Morrison Field, Florida, to estimate amount of night training for student pilots in B-29's.

2. Computation of monthly extremes of absolute humidity in grams per cubic meter at Muroc AFB, California.

3. Frequency distribution showing variation of pressure and density at standard levels aloft for El Paso, Texas. Densities were computed by machines from pressure and temperature, assuming dry air.

Weather summarizations which contributed to individual research projects:

1. Correlations were made to provide information for development of objective method of stratus forecasting at San Antonio, Texas. Various ranges of occurrence of ceiling and visibility were correlated against data for the preceding day, such as temperature, temperature dew-point spread, wind speed, weather phenomena, ceilings, visibilities, surface wind direction, relative humidities, and wind directions aloft, and a number of factors determined from synoptic maps and upper air charts.

2. Tabulation of data from Barksdale AFB, Louisiana, showing by month for each hour, from one hour before sunset to four hours after sunrise, the average fall in temperature and dew-point, further qualified by sky cover amounts of 0-5 tenths or 6-10 tenths, and northerly or southerly component of gradient wind.

3. Frequency distributions by 5 millibar intervals of pressure differences between all combinations of three points in the North Atlantic, prepared from the coordinate pressure deck derived from the Northern Hemisphere Historical Map Series.

4. Frequency of occurrence of low cloud type when base of lowest clouds was from 500 to 5000 feet, and also frequency of height of low clouds, for night hours only at Fort Knox, Kentucky. Summaries of extent of cloud cover, directions of cloudiness, and frequency of fog and precipitation, for purposes of studying the employment of searchlights for battlefield illumination.

5. Frequency of specific wind speeds by various intervals, for only those observations with temperatures zero degrees Fahrenheit or below, by 10 degree intervals, for 16 stations in Canada, Alaska, and Greenland.

6. Tabulation of temperature, dew-point temperature, wind velocity and tenths of clouds below 10,000 feet for observation nearest sunset at Stewart AFB, New York, In addition was shown the number of hours between sunset and time of fog formation, if fog did form. Fog was especially defined by visibility and "no precipitation" parameters. Used in applying objective statistical methods to terminal forecasting.

7. Frequency of occurrence of light, moderate and heavy fog, with temperature less than 30 degrees Fahrenheit and wind speed below 12 miles per hour for 17 stations in the U. S. and Alaska, used in connection with project to seed super-cooled fog.

8. Frequency distribution of weather elements causing obstruction to vision, to be used in connection with mathematical method of objective forecasting for Mitchel AFB, New York.

Summaries of upper air data:

1. Highest wind velocity and percentage of observations with speeds greater than 75 mph in 5000 foot intervals from surface to 30,000 feet by seasons for Annette Island, Yakutat, Cold Bay, and Kiska, Alaska.

2. Evaluation of extreme minimum temperature occurring over southern California at levels of 5, 10, 20, 30, and 40 thousand feet. Data needed in order that requirements of heating systems to be installed in research airplanes might be determined with minimum penalty in airplane performance.

3. Selected raobs for number of times with surface temperature-dew-point spread less than 20 degrees Fahrenheit for Okinawa and the Canal Zone, for study of windshield fog problems encountered by F-80 aircraft.

4. Rawin data furnished for Long Beach, California, for use in a study which correlated weather processes and average winds at the surface and aloft with peculiarities of the terrain.

5. A list of dry and wet bulb temperatures for a coastal station at the time of each pibal observation with the wind direction from north through southwest from 1000 to 20,000 feet, or from 1000 feet to the highest level attained, if below 20,000 feet.

Tabulations of flying weather conditions, which may be correlated with wind data, do not always follow the usual CAA criteria, especially where military aircraft are involved. Summaries requiring special limits of ceiling and/or visibility:

1. Frequency of days with at least 6 consecutive record observations during daylight with ceiling 2000 feet or greater and visibility 6 miles or greater at Bangor, Maine.

2. Wind rose data for observations with visibility less than 3 miles for Bremen, Germany.

3. Wind rose data for observations with ceiling 0-300 feet, 400-500 feet, and 600-1000 feet for Naknek, Alaska.

4. Frequency of hourly observations at March, Mitchel, and Maxwell AF Bases, with ceilings and visibilities of special limits, and wind rose data under various weather conditions, used by a student at Air Command and Staff School in preparing thesis concerning the last 500 feet of an instrument approach and landing.

Numerous tabulations do not fall into any of the above categories. Several examples:

1. A tabulation showing degree-days (standard reference 65 degrees Fahrenheit) by month for Peterson AFB, Colorado, with average wind velocity by month for the same period. This was used to approximate the heat consumed by this base during a period when the metering system of the local steam line was inoperative, as a basis for settlement of charges for heat.

2. For Eglin AFB, Florida, the sunrise to sunset hourly frequency of cloud amount and height in September and October, to be used for planning Operation Combine III.

3. Percentage of time that weather at Pope AFB, North Carolina,

permitted chemical warfare, parachute operations, incendiary bombing, high-level visual bombing, and other specialized military operations, based on elaborate parameters including temperature, wind speed, cloud amount, ceiling, visibility, and precipitation, used for planning Army maneuvers.

4. In order to furnish agencies participating in a research program at Holloman AFB, New Mexico, with climatological data, the following tabulations were prepared: wind rose data with special speed groups surface temperature means and extremes, relative humidity means and extremes, obstruction to vision and precipitation frequency, mean pressure, mean sky conditions and cloud cover, and summaries of other elements. Winds aloft summaries were prepared for computing ballistic winds and parachute drift.

It may be readily seen from the above that the variety of climatological investigations possible with high speed machine techniques is virtually without limit.

Conclusions

The preceding pages have been prepared with the single purpose in mind of bringing to the attention of the professional meteorologist the existence and extent of development of an important and basic meteorological facility. In contrast to the state of affairs in most other professions, it is doubtful if any single meteorologist or private meteorological group can ever afford to equip themselves with the basic climatological tools necessary to exercise the profession in its broadest sense. Perhaps the Joint Punched Card Library of the Air Force, Weather Bureau and Navy, together with the attendant machine facilities, may be the answer to the problem of handling and processing the great masses of basic weather data that are required by the operational and research people in the field of meteorology.