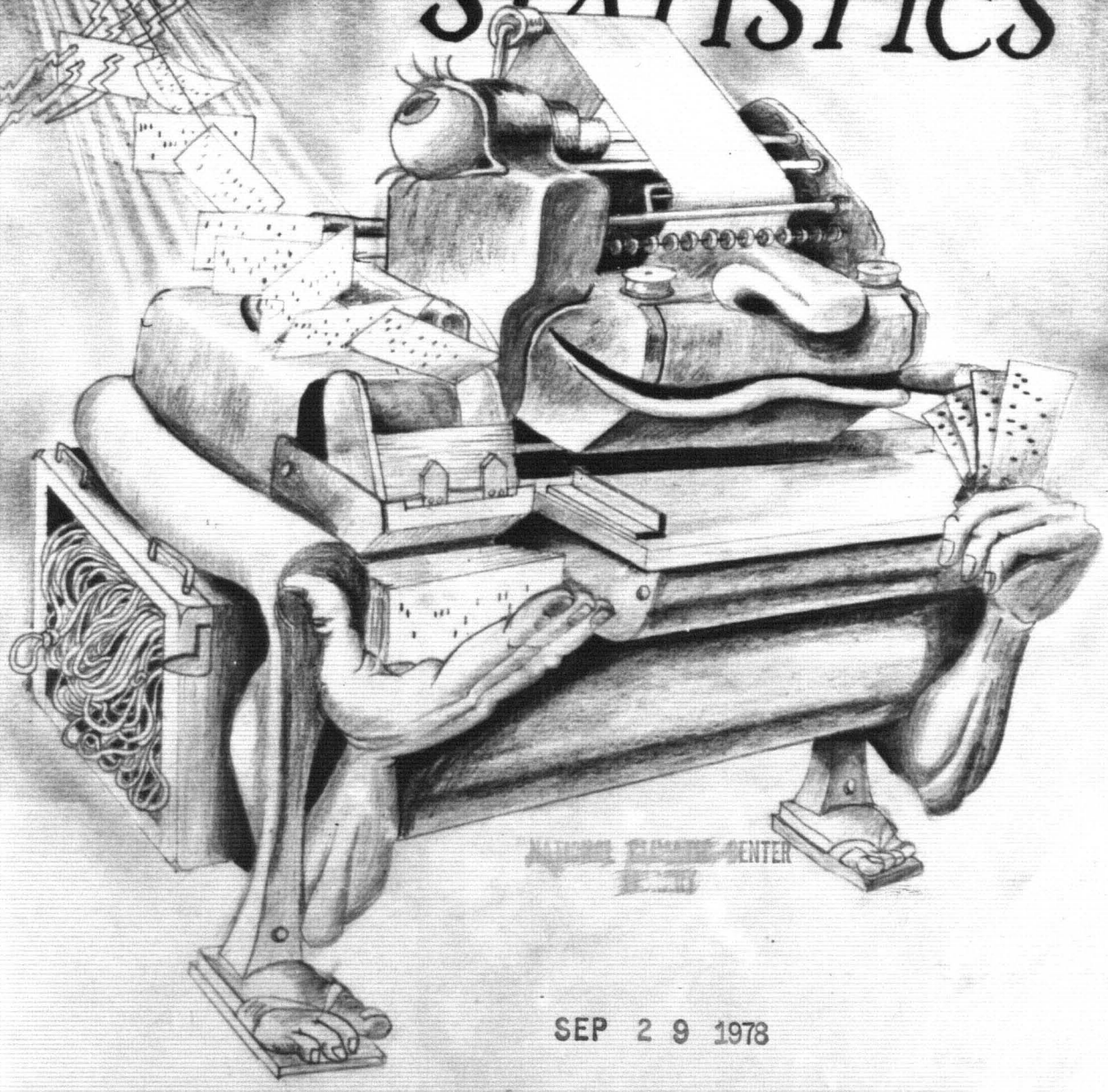
MACHINE METHODS OF WEATHER STATISTICS



AIR FORCE DATA CONTROL UNIT

MACHINE METHODS OF WEATHER STATISTICS

Prepared by the

AIR FORCE DATA CONTROL UNIT

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PREFACE

The reader of this volume will perhaps be disappointed in not finding a given special method explained as fully as he would desire. It is regrettable that this is the case. If it is realized that almost three thousand different and unrelated requests have been handled by this unit in the past four years, and that the tools required for these requests had to be created, then perhaps it will be understood why each particular application was made brief.

Another problem to be considered is the experience level of the reader. Two complex and heretofore separate fields have to be brought together, both with their own limitations, and both pushing into the fields of research. A compromise was found at the point where the meteorologist could go no further, and the machine technician could go no further, without becoming intimately acquainted with each other's problems.

If further details about a specific problem are required, it is recommended that use be made of the files of Data Control Unit, which contain the complete history, including wiring diagrams, sorting procedures, etc., for each request.

Moreover, this report is intended to present only a system of methods which facilitate the steps from the qualitative to the quantitative. Many ways are offered for attaining this purpose, and they all should lead to not only a more complete description of the weather and climate, but in the end to a physical explanation.

Thus a new field in the science of meteorology has been opened, the field of applied theory and meteorological engineering. This is a field where all branches of meteorology, mathematics, and electrical engineering meet with one common goal, that of solving the problem of the mechanics of the earth's weather.

The writers of this volume, who worked as a team in its preparation, are indebted to all those who spent thought and care in the writing of procedures, and to others who have worked with this unit and took careful notes. Without these it could not have been written. Particular indebtedness is acknowledged to the International Business Machines Corporation, many of whose manuals were used in the description of the functions of the machines and cards.

Just as this book was written as a team, and the individual and developmental problems of the past were solved as a team, so will it be necessary that the meteorological and climatological problems of the future and the continued development of this modern technique be conducted in a spirit of teamwork and cooperation. Such has been the keynote of the unit throughout its history.

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1. Card Design.

a. 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 the operation of large machines, punch presses, milling machines and various types of drills tends to be the most impressive sight to visitors in a machine shop. The punched card is given very little attention and is passed by unnoticed in the same manner as the tools and jigs and dies of manufacture plants are passed by. 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.

b. 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.

c. 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 essential and important as that of any machine in the operation.

d. 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.

e. 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 tabulation required.

f. 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 is a general knowledge of the observing practice 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 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 machine 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.

g. 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 the selection of the one best way to do the work.

h. 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. In order to accomplish this, all of the following factors must be considered in the order presented.

(1) 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.

(2) The factors next in importance are determined by the sources of the 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.

2. Coding.

a. Numerical 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.

b. The proper designing of codes is therefore an inherent part of the Data Control Unit, 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:

(1) Sequence Codes - The simplest form of coding that can be utilized is the sequence method. It consists of the simple assignment of numbers, starting with 1, 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. The last three digits of the International station numbers are a good example. The Army system of station numbers for punched card data, avoids this pitfall by grouping stations by latitude and longitude therefore avoids repetive and non-grouping of station numbers.

(2) Block Codes - This term applies to codes which utilize groups or 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 less digits than any other class coding plan. Expansion is also provided in a limited way by the reservation of vacant numbers in each group. The first digit of the International station numbering system is an example.

(3) Group Classification Codes - Group classification codes are those codes 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 or controls needed for any given report.

(4) Significant Digit Codes - This term 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.

(5) Self Coding Cards. Such specialized cards as the WBAN Card No. 1 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.

MACHINES

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

2. Key Punches. a. General. The IBM machine which of necessity must be used first in any punched card operation is the key punch, with which data are punched into the desired columns of the cards. Several types of key punches have been developed, but three are used by this unit.

b. The simplest of all IBM machines is the Type 001 Key Punch, the non-electric, portable, and the compact key punch which is used in the field for in-station punching of Air Force and Weather Bureau observations.

(1) This machine has twelve perforating keys, one for each punching position of a column. Ten keys are numbered from 0 to 9. The eleventh is marked "X" and punches directly above the 0. It is used to record a detail or, at times, it may be arranged to cause a field to be skipped in which no information is to be punched. The twelfth key has no distinguishing mark, but punches a hole in the position directly above the "X". A space key is also provided on the upper right corner of the keyboard which, when depressed, advances the card one column without punching a hole. An additional key on the upper left corner of the keyboard, when depressed, releases the carriage for its return to the point where the card can be removed.

(2) Each individual card is placed by the operator in the carriage of the machine prior to punching. This is accomplished by placing the card on the bed of the machine after the carriage has been released to the extreme left, and then inserting the card to its proper position in the machine by pressure against the thumb lever.

(3) As each key is depressed the carriage automatically advances one column; except when X-skipping is effected. In that event the card may advance several columns to some predetermined point governed by the size and position of the skipped fields. When the proper information has been recorded, the operator removes the punched card, inserts another blank card, and repeats the process on another observation.

(4) Several features have been included in the design of the machine to facilitate the punching operation. A carriage stop is provided so that punching may be begun at any column of the card. After each key has been depressed, the card column punched becomes visible to the operator, permitting one to see what has been punched.

(5) When necessary, more than one key may be depressed to effect simultaneous punching of two or more holes in the same column. This punch, like all numerical key punches, may be built to punch one or two identical cards in a single operation. Change from one - to two - card capacity can easily be made.

c. The key punch which is most used within the Data Control Unit, however, is the Type 016 Motor Drive Duplicating Key Punch.

(1) The keyboard of this machine is exactly like that of the Type 001 punch. In this machine the holes are perforated by the action of an electromagnet, which is governed by the closing of an electrical contact by the depression of a key. It naturally follows that very little effort is required and that three fingers can advantageously be used to utilize the touch system of operation. As each punching key is depressed the card is automatically advanced to the next punching position and the column just punched becomes visible, thus permitting the operator to see what has been recorded.

(2) The punch is equipped with automatic card feeding and card ejecting devices, which are so arranged that after a punched card has been ejected, a card from the magazine is automatically fed into the punching position. Cards may be also fed into the punch by hand from the left without removing or in any way disturbing those in the magazine. The motor drive key punch is equipped with a key interlocking device which prevents the accidental punching of more than one hole in a single column. If it is desired to punch more than one hole in a single column, the space key may be depressed and held down while the regular numerical keys are being struck for the holes required for the column. This key interlocking device may be made permanently inoperative for certain keys or combinations of keys.

(3) This type of punch is provided with a means for skipping certain groups of columns, similar in function to a tabular device on a typewriter. The key marked "X", operating in connection with an especially cut skip bar, operates this mechanism. It is necessary to provide a separate X-skip bar for each design of card with different columnar arrangement of fields if this type of skipping is to be employed. The depression of the "X" key punches a hole in the X-position of the first column of the field being skipped.

(4) In this machine is also incorporated the 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. All, or any portion, of the punched data appearing in a tabulating card may be automatically reproduced in other tabulating

cards by this device at a speed of ten columns a second. This duplicating feature is extremely useful as an automatic coding device. Master cards may be prepunched with all the codes pertaining to any given group of observations, such as year, month, and day, when hourly observations are being punched. This card may be placed in the master card bed or the duplicating punch to effect the automatic transfer of these codes in punched form to the detail cards. The duplicating feature is also extremely valuable for reproducing cards which may have become mutilated by excessive or improper handling. The automatic duplicating mechanism serves as a medium for the accurate and rapid transcription of data from the damaged card to the new tabulating card which is to replace it. The card from which data are to be transcribed is placed in the master card bed, and the duplicating door is closed by pushing it down to the latched position. This raises a set of brushes which will complete an electrical circuit through the punched hole appearing in each column of the master card, and results in the automatic successive operation of the proper punching keys, after the card to be punched has been fed into the machine. All duplicated data are transcribed from a column of the master card to the corresponding column of the detail card. No transferral of punched data to other columns is possible.

d. The other type of key punch which is used by Data Control Unit is the Type 031 Alphabetic Duplicating Key Punch. This machine is very similar to the Type 016 punch, in that it is motor driven and that the duplicating feature is also present. However, in addition to the numerical keyboard of the Type 016 punch, the Type 031 punch is equipped with an alphabetical keyboard arranged like a typewriter 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 numerical data, can subsequently be printed by the Alphabetic Accounting Machine. The accounting machine operation necessitates the punching of two holes in a single column of the card if the printing of an alphabetic character is to be effected. The two holes appearing in each column of the alphabetic description are punched simultaneously by the depression of a single alphabetic key. The keys of both keyboards are interlocked to prevent the accidental simultaneous depression of two keys.

3. Verifier. a. General. 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 establishes the accuracy of the punched card immediately following its preparation. The term "verification" as used here is limited to the proving of the accuracy of the punching of the card. Because of the important part played by the card, it is essential that its accuracy be established as early

as possible by some accepted system of verification. The punched card method has only one manual transcription of data. Consequently, only one verifying operation is required. The theory of key verification is identical with that of any checking procedure--that repetition of work by a different person reveals any errors which may have been made by the person who originally performed the task. Such a method of verification is essentially a comparison of the original data with those recorded on the punched card. Key verification reduces the human element hazard in the checking procedure and gives definite assurance that the punched hole records are correct. Key verification can be effected at a speed equal to or in many cases, greater than that of the punching operation.

b. The Electric Punched Hole Verifier (Type 052) was developed simultaneously with the development and application of the automatic feeding and ejecting mechanism for punching equipment. The operation of the electric verifier is exactly like that of the motor driven key punch. It is the function of the machine which is different; 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, thus becoming aware of an error. Comparison of the punched card with the original data is then made to determine what correction is necessary. Naturally, an error cannot be corrected in a card which is mis-punched. The card must be punched again, making the correction during the re-punching of the card.

4. Sorters. a. General. After a group of cards have been punched and verified, they must be sorted into the classifications desired before any other processing can be accomplished.

b. (1) The Type 080 Horizontal Sorter affords a speedy and accurate method of arranging cards into any desired sequence. This machine automatically arranges punched cards into numerical order or into groups of similar classification in numerical sequence or other predetermined order. The sorting operation is performed at the speed of 400 cards per minute for each column sorted. All of the steps in the operation of the horizontal sorter are simple, making it a unit extremely easy to operate. In certain operations of Data Control Unit, however, the proper sequence of columns to sort, and the proper disposition of cards which have been sorted, require the operator to be very alert, despite the simplicity of the machine.

(2) Cards must be placed in the feed hopper and the start button depressed, after the sorting brush has been set on the column to be sorted. Thirteen pockets receive the cards during the sorting operation--one pocket is for the rejected cards (those having no hole punched in the column being sorted) and

each of the other twelve pockets corresponds to one of the punching positions on the card. Cards are automatically taken, one at a time, from the bottom of the pack and fed past the sorting brush which determines the pockets into which they are to be deposited. Continuously turning rollers then carry the cards to their proper pockets where they are stacked. The machine will automatically stop if a pocket becomes too full, or if the supply of cards in the feed hopper is exhausted.

(3) An electric counting mechanism may also be attached to the sorter, which registers "1" for each card that passes the brush. The counter does not affect the normal speed or operation of the machine. By progressively sorting across a numerical field from the units position to the highest position punched, and taking the sorted cards out of the twelve pockets in the proper order, a group of cards will be sorted in numeric order. This requires one sort per column. 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 sometimes 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 sort by station number within region, sorting the cards for each region separately. In this manner one large group of the entire deck is made ready for further processing while the sorting of the balance of the deck is continued.

c. The Card Counting Horizontal Sorter (Type 075) 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 the column. It will simultaneously group all cards of similar classification and arrange such classification in numerical sequence in the same manner as the Type 080 sorter. The counting mechanism is equipped with fifteen adding counters of five digit capacity each, one for each of the twelve punching positions, one for unpunched cards (rejects), one for sub-totals, and one for grand totals. All counters can be cleared in a single operation. The grand total may be allowed to accumulate if desired, however, while clearing the other counters. This machine is equipped with switches which allow the machine to count the cards but not actually separate them into the pockets; it can also sort the cards without counting them; or it can sort and count in all proper counters simultaneously.

5. Reproducer. a. General. Among the marked advances made in the punched card method of handling data are the machines which can automatically transcribe repetitive data. Originally, the copying of punched holes had to be done by a manual or semi-automatic method. The automatic punching of repetitive data means increased speed and accuracy in tabulating procedure. The Type 513 Reproducing Punch is a valuable machine in the Data Control Unit because it can perform the functions of reproducing, gang punching, and summary punching, thereby eliminating the necessity of having more than one machine to perform all three operations. Reproducing and gang punching can be performed at the same time as summary punching; and, while a card is being punched from a counter of the accounting machine, it can be punched from master cards in the reading and punch units of the type 513 punch.

b. Features of the Reproducer. There are two feed mechanisms, one in the reading unit and one in the punching unit. The feeding is continuous, and if either hopper should become empty, or if a card should fail to feed, the machine will automatically stop.

(1) Six Punch X brushes are the first card station of the punching unit, and they can be set to read any six columns of a card. The punching mechanism follows, and there are 80 punch magnets corresponding to the 80 card columns. Since there is a separate punch for each column of the card, and since each card passes the punch dies with its top edge first, the "12" position is the first punching to take place. All "12" positions are punched at one time, followed by the "11" positions, etc., through the last, or "9" position. Thus, the card is punched completely in twelve stations of the card cycle. The 80 Punch Brushes, which read the holes that have been punched and compare against the reading of the comparing brushes, represent the last card station in the punch unit.

(2) Five Reading X brushes are the first card station of the reading unit. They can be set to read any five columns of a card. Eighty Reproducing Brushes are the next card station, which read the information to be punched and transmit this information to the punch magnets, which activate the punching dies as described above. The 80 Comparing Brushes are the last card station in the reading unit.

(3) There are two stackers, one for each unit, with a capacity of 1000 cards. If either stacker should be filled to capacity, the machine will automatically stop.

(4) Gang punching and reproducing operations are done at the rate of 100 cards per minute. Summary punching requires 1.2 seconds per summary card. All speeds are constant, regardless of the number of columns to be punched. The time required for summary punching is in addition to the

total print and reset time of the accounting machine involved.

(5) The operation of the Type 513 Punch is controlled by a single panel automatic plugboard. The board can be either fixed or manual.

c. Gang Punching. Gang Punching is the operation whereby identical information can be copied from a master card into a group of detail cards. Although the gang punching is usually column for column, with the use of a class selector, information 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. 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 be verified for the accuracy of the punched data. It is also possible to verify cards which are about to be gang punched to insure correct association of master and detail cards. An example of interspersed gang punching as used by Data Control Unit is the punching of relative humidity values into the detail cards (hourly observations) after those detail cards have been properly sorted behind master cards containing the correct relative humidity value for each temperature and dew point temperature.

d. Reproducing. 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. At the same time as the reproducing operation, the cards can be verified for accuracy of the punched data. Any discrepancy between the punching of the original and new cards is indicated to the operator by an automatic machine stop, a signal light, and a compering magnet indicator. One of the large projects of Data Control Unit is the straight reproducing of the captured German weather punched cards, the "Kopenhagener Schlussel" deck. There are about seven million of these cards to be reproduced. When this operation is completed, the United States will have a vast store of observations taken by the German weather service in Europe and the Middle East during the war years. The original cards will then be forwarded to other allied nations for their reproducing.

e. Summary Punching. The manual punching of total cards from data appearing in tabulated reports was formerly a time-consuming operation. Summary punches automatically prepare total or new balance cards simultaneously with the accumulation of totals and printing of reports. These summary cards are utilized to reduce the volume of cards in the current file in order to speed up the tabulation of later weather summarizations. With the connector cable attached to the accounting machine, information can be summary punched from the counters. Plus or minus totals can be identified by X punching in any desired column of the summary card. The primary example of this function of the

reproducer as used by Data Control Unit is the punching of summary cards as the six basic surface weather summaries are produced from Army Form 94-A and WBAN No.1 cards (hourly observations), whereby the file is reduced from 31 cards to 1 summary card. Thus, when later months of record are added to the files, it is unnecessary to re-tabulate all the detail cards for the earlier periods of record. Summary cards are cut for each month of record, and only the summary cards are tabulated to produce the final reports.

6. Collator. a. General. The fundamental advantage of the IBM methods in the weather data summarization is the use of an IBM card as a unit record. These IBM cards can be arranged early in any sequence required for the summarization of the information punched in them. 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 will 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 correct sequence. The speeds at which various operations are performed on the collator vary from a minimum of 240 to a maximum of 480 cards per minute, depending on the particular application involved. Either feed, when operating independently, will feed cards at the rate of 240 per minute.

b. Functions of the Collator. The applications of the collator generally can be classified according to one of the following groups. In any operation, however, only numerical information can be handled.

(1) The collator can be used to file two sets of cards together. This operation is referred to 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 deck of cards containing errors originally, 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.

(2) To the basic merging operation can be added the selection of particular cards. This operation is used un preparing the Army Surface Weather Records Status Report whereby corrected cards are filed into the major deck, and those cards in error which are being replaced, are selected from the major deck.

(3) At the 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 (Error Light). This operation is also used in merging the corrected cards into the major deck, as given in the example above, for then the order of the large deck is again checked for correct order.

(4) Another function of the collator is the matching of two sets of cards according to a control field. For example, a station-month of hourly observation may be matched against a master deck 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 filed separately.

(5) The fifth classification includes a variety of operations possible on the collator based for the most part on multiple column selection. A file of cards, which is not in any particular sequence, can be searched for a specific control number or for cards over or under a specific control number, such as observations where the temperature is over or under a specific value. It is also possible to set up two limits for a control field, an upper and lower, and to select all cards between these two limits. Cards on which one field exceeds another field also can be selected. This function is used 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. Cards on which one field exceeds another field can also be selected. This might be used to determine that the cloud amount in each individual cloud field is not greater than the total cloud amount reported.

c. Principle of Operation. A collating operation, whether manual or automatic, is accomplished by means of comparing two control numbers.

(1) If the two sets of cards to be merged are in numerical sequence, the number on the first card of one group can be compared with that on the first card of the second group. The comparison will have one of three results: the number on the first card is lower than that on the second; the number on the second card is lower than that on the first; or the numbers on the two cards are equal. The card of the lower number is placed in front of the

merged file; the comparison then continues and the two files are arranged together in an ascending numerical sequence.

(2) In a manual collating operation, the cards from the two files are compared and placed together in proper sequence. Through the use of the collator this operation becomes fully automatic. The two sets of cards are placed in the machine and the control numbers are read from the punched holes in the cards into a comparing unit. In this comparing unit the two control numbers are compared, and the result of the comparison is used in turn to direct the machine to file the cards together in their proper sequence.

d. Machine Features. (1) The collator contains two separate feed units; the lower feed unit is referred to as the Primary Feed unit and the upper as the Secondary Feed Unit. Cards placed in the primary hopper are called primary cards, and those placed in the secondary hopper are called secondary cards.

(2) As cards are fed from the primary feed hopper, they pass two reading stations. Each reading station consists of 80 single brushes, one brush for each card column. The brushes of the first reading station are called the Primary Sequence Brushes and those at the second reading station are called the Primary Brushes. As cards are fed from the secondary feed hopper, they pass only one reading station, the Secondary Brushes, which consist of 80 single brushes, one for each card column.

(3) After being read by the brushes, the cards pass into one of four pockets or stackers. Each pocket will hold 1000 cards, and is equipped with a contact to stop the machine when the pocket is full. Pocket 1 is for selected primary cards; Pocket 2 is for merged cards; and Pockets 3 and 4 are for selected secondary cards. Primary cards can enter either Pocket 1 or 2, but not 3 or 4. Secondary cards can enter only Pockets 2, 3, and 4. If two sets of cards are to be merged, the merged cards will fall in Pocket 2.

(4) The basis of the automatic operation of the collator is found in the units which compare the control information punched in the cards and which then directs the movement of the cards according to predetermined conditions. These conditions vary with the specific application involved. The plugboard is the medium through which the comparing units are controlled, and 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 of the specific application. The terminology used in describing the various plughubs is based almost entirely upon the functions which these plughubs perform in the operation of merging two groups of cards. A discussion of the plugboard however, is beyond the scope of this report.

7. Multiplying Punch. a. General. One of the most valuable machines used in research projects at Data Control Unit is the Automatic Multiplying Punch. This machine permits the complete mechanization of many routines which formerly necessitated manual calculating and key punching operations. The Type 601 Multiplying Punch automatically multiplies factors punched in tabulating cards, adjusts the products to the nearest decimal point desired, punches the resultant products into the cards, and accumulates product totals.

b. Functions of the Multiplier. (1) General. The machine consists of a card reading unit; multiplying, transferring, and storing counters; and a punching unit. The principle underlying the multiplying operation is extremely simple. As each card feeds into the machine, the multiplicand and multiplier are read from the card and set up in the machine. The multiplication operation is then performed and the card feeds into punching position. The product of the multiplication is transmitted to the punching mechanism and simultaneously is registered in the summary counter. While the card is being punched and ejected, the reading operation is being performed for the next card. The machine is equipped with an automatic plugboard which makes it entirely flexible for the reading, multiplying, and punching of data as desired.

(2) In multiplying operations, the multiplicand factor is always set up from individual cards. The multiplier factor, however, may be set up under either the Individual Multiplier Method or the Group Multiplier Method.

(a) The Individual Multiplier Method provides for setting up the multiplier factor from the individual cards in the same manner as the multiplicand factor. It is used when the multiplier has been punched in each card. This operation is used to obtain cross products in any job requiring the computation of correlation coefficients, for example.

(b) The group multiplier method provides for setting up common multipliers for groups of detail cards. The multipliers are set up from X-master cards sorted in front of the groups of detail cards to be extended by the common multipliers. This operation is used when computing means of elements in large projects, such as computing the mean of sea level pressure. The sum of daily pressure

values is punched into the cards, and this total of all cards which have the same number of observations is multiplied by the reciprocal of that number, thus actually obtaining the quotient: sum of pressures divided by the number of observations.

(3) When it is imperative that the operation of the multiplying punch be checked, one of the following methods may be used:

(a) Reverse Calculation Switch. This automatically reverses the position of the multiplier and multiplicand without re-wiring those fields. The second run of the cards is not just a repetition of the first, but involves a different and entirely independent calculation. Therefore, when cards are re-extended, any error which may have occurred in the first multiplication will be detected in the second because a different total will have been accumulated in the summary counter.

(b) Comparative Check Method. Under this method of checking, the detail cards are re-extended. Comparison of the summary counter totals provides a proof of the extending operation. The amount accumulated in the summary counter is checked against a tabulation of the punched products in an accounting machine. This provides a proof of the punching operation.

(c) Parallel Balance Method. In this method, the original extending and punching operation is repeated, the product being punched in a different field. The proof of both extending and punching operations is accomplished by balancing the totals of the two product fields in separate counters of an accounting machine.

(d) Digiting Method. Extensions and punching of extensions may be checked simultaneously by either of the two methods known as progressive digiting, or digiting without sorting.

(e) Group Total Extension Method. This method of checking may be used where multipliers are set up on a group basis. Under this method, the detail cards are extended only once. For proof of both extending and punching operations, the cards are tabulated in an accounting machine, controlling on classification, indicating multipliers, and adding multiplicands and products. The totals of the multiplicands are extended by the common multipliers, and the results checked against the product totals. This method also provides a proof of the correct insertion of master cards.

c. Automatic Cross-Footing Multiplying Punch. In addition to the foregoing features of the Multiplying Punch, this machine is arranged to perform certain cross-adding and cross-subtracting operations, either in combination with multiplying operations, or separately, as required. The results of such computations are punched in the card, and totals or net totals of the results may be accumulated in the summary counter. In addition to performing the regular multiplying functions, this machine is capable of performing the following cross-footing operations, which are expressed here as formulae. The letters A, B, C, and D represent fields in a tabulating card; E represents the total or net total to be computed and punched.

A + B	= E
A - B	= E
(A x B) + C	= E
(A x B) + C + D	= E
A + B + C	= E
A - B - C	= E
A + B - C	= E

In combinational multiplying and cross-footing operations, the factor A may be set up as a group multiplier. With the Additional Cross-footing Device, numerous other formulae can be accomplished. If one or more of the fields to be cross-added have extra decimal positions which are to be dropped in the total, it is possible to add these amounts and adjust the total to the nearest whole number in the units position. This is accomplished by the use of the 1/2 pick-up, a feature which is used to round off fractions by adding 1/2 unit in which every decimal position is desired.

8. Interpreter. a. General. Through the use of the Type 552 Interpreter, it is possible to print, entirely automatically, descriptive words and numerals directly upon the punched-card record, thus translating the holes in the card into printed information which can easily be read. This printed information facilitates the manual filing and pulling of cards.

b. Features. The machine is equipped with a horizontal feed similar to that of the sorter. Cards feed at a speed of 60 cardsper minute. Interpreted characters may be printed along the top of the card above the "12" position, or between the "12" and "11" positions, according to the setting of the printing position. There is only one set of brushes on this machine, consisting of 80. From this set come the zone and numerical impulses for alphabetical printing. When X-punching is recorded over a numerical field, and it is desired to interpret only the numerical information, the X-Eliminator must be used. With this feature, only the impulses for the numerical positions will reach the type bars. The printing mechanism consists of 60 type bars, each bar containing 38 positions - 10 numerical, 26 alphabetical, and 2 special characters. The printing capacity is 60 characters in one line on the card in one run. If 60 columns of interpreted information are sufficient,

the printing may be accomplished on one run. If it is necessary to interpret more than 60 columns, the cards must be run through again, using the other printing position for the additional interpretation. It is necessary to rewire the plugboard to make the second run. All setups and setup changes are accomplished through the use of an automatic plugboard.

c. Operation. As the cards are fed, "12"'s first, under the single set of brushes, the type bars are positioned to the proper groups of type corresponding to the "12", "11", "0", or numerical zone selected. The card continues to move under the brushes to read the numerical punching, thus positioning the type bars in the proper printing position within the group already selected. Thus, when the card reaches the proper stage of the feed cycle, the bars are activated, and the information printed on the card.

9. Electric Accounting Machine. a. General. The final step in processing weather data on punched cards is accomplished with the use of the Electric Accounting Machine, commonly called the Tabulator. The Tabulator is a combined adding, subtracting, and printing machine. Punched cards passing through this machine actuate the various counters and printing mechanisms. The tabulator is so designated that it provides complete flexibility in the arrangement of the compiled and printed data on the report form. The machine is entirely automatic and operates at the maximum speed of 150 cards per minute. Summary cards can be punched simultaneously with the printing of reports. This machine, which handles either numerical or alphabetical information, is the most complex and most flexible IBM machine which the Data Control Unit uses.

b. Card Feed. (1) General. The cards, placed in the feed hopper of the tabulator, pass two sets of brushes. The brushes read the information which is punched and can direct the type bars or adding mechanism to print or accumulate the data. After passing the two reading station, the cards enter the stacker.

(2) Brushes. Each reading station consists of 80 wire brushes, one for each card column. At the first reading station are the upper or control brushes, and at the second reading station are the lower or add brushes. 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 can be used to actuate the type bars or adding mechanism. 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 can be emitted by the brushes. The purpose of the upper set of brushes is to read the card as it passes

the first reading station in order to determine what is to be done with the information punched in the card; that is, should it be printed, added, subtracted, or compared with information on the preceding card? Then when the card reaches the lower set of brushes, the information is read to be printed, added, subtracted, or compared.

(3) Card Cycle. The time required for the reading of a card by a set of brushes is referred to as a "card cycle" or a "feed cycle" The term "list cycle" implies printing or the possibility of printing information punched in a card during a feed cycle. The terms "total or reset cycle" infer the possibilities of printing totals from counters. During a total cycle, cards will not feed through the machine. The speed of the tabulators used by Data Control Unit is 80 cards per minute for list cycles and 150 cards per minute during tabulation, except the completely numeric machines which list or tabulate at the rate of 150 cards per minute.

c. Plugboard The basis of the automatic operation of the tabulator can be found in the plugboard and the controlling switches. The plugboard fits into a rack on the left side of the machine.

(1) Plugboard wiring is similar in principle to the operation of a telephone switchboard in that electrical impulses are picked up and directed to specific places in the machine. Because of the fact that the plug board acts as the "brain" of the machine, flexibility of machine operation is obtained. By making various connections on the plugboard, the operator directs the machine and tells it which operations to perform. Therefore, once a knowledge of the plugboard is gained, the operator can produce innumerable reports.

(2) As the brush makes contact through the punched hole with the contact roller, the impulse which is produced travels to the plugboard. By means of external wires, this impulse can be directed to a type bar, counter, or comparing relay, or can be eliminated entirely. Hubs on the plugboard are divided into two classifications, inlet and outlet hubs, depending on thier function. Some hubs can be inlets or outlets, depending upon specific conditions. Generally, outlets give the signal and inlets do the work.

d. Type Bars. The print unit of the machine is referred to as the type bars; it can perform three functions: listing, printing totals and printing symbols. There are 88 type bars on the tabulators used by Data Control Unit, 43 of which are able to print both alphabetic or numeric information, and 45 of which can print numeric information only. All type bars have places for a special character which will print under certain desired conditions. In a listing operation, the upward movement of the type bars is synchronized with the reading of a card. As the brush is reading from the "9" to the "12" position, the bars are moving up.

As soon as a brush senses a punched hole, the type bars stop moving. After the brushes have read all of the punching positions, the type bars have been properly positioned for printing. Each type bar has a hammer which, when moved forward pushes out the printing type located at the printing position. The firing of these hammers against the type bar causes printing to take place. All of the hammers are fired at one time. The Alphamerical type bar, containing alphabetic and numeric positions, is zoned into position as the card passes the upper brushes, depending upon the "12", "11", or "0" punch present in the card. Then as that card passes the lower brush, the type bar is moved into the proper printing position within the selected zone. Since the numeric type bars cannot print alphabetic information, no such zoning can take place.

o. Counters. The functions of addition and subtraction are performed by accumulators called counters. There are 80 such counters in most of the tabulators used at this Unit, with the exception of one, which has 120 counters. The size of the total is not limited by the number of counter positions in a group, as they are arranged within the machine, for two or more groups not necessarily adjacent may be connected or coupled together to act as a single unit. There are four basic steps in plugging for accumulation:

(1) What information, that is, card columns, is to be accumulated? The field to be added is connected from the lower brushes to the counter entry hubs.

(2) Which cards are to be added, subtracted, or eliminated? Each counter group has a series of plus and minus hubs. Whenever the plus hubs are impulsed, the counter will add. An impulse in the minus hubs will tell the counter to subtract. An outlet hub, called "Plug to C", and given to the counters by certain control punches in the cards, will tell the counter when to add or when to subtract.

(3) When is the total desired, that is, is it a sub-total or final total? Each counter has a counter total control hub which, when impulsed, will restore all the wheels of that counter group back to zero. Clearing the counter makes it possible to print the total held by the counter and to restore that counter back to normal. This information can be given to the counters from the comparing relays if desired, or from control punches in the cards.

(4) Where should the total be printed? Each counter has a row of hubs labelled counter total exit hubs, at which the impulses for total printing are available. These hubs are plugged to the type bar total entry hubs for total printing. The type bars are selected according to the position on the report where the total is to be printed. Information entering the counters may also be listed from each card, so that the total might appear below the report column of data being added or subtracted.

f. Automatic Control Automatic control is the function by means of which the machines 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. The machine by the use of the upper and lower sets of brushes can read at one time the holes punched in two successive cards. Each card when it is at the upper brushes is compared with the preceding card which is at the lower brushes. When a card passes the lower brushes, it is compared with the succeeding card which is at the upper brushes. Thus, each card passing through the machine, except the first and the last, is compared both with the card ahead of it and the card following it. If the fields are the same, thus indicating that the cards are of the same control group, the machine will continue to feed cards. When the punching in one card does not compare with the punching in a field in the card preceding it, the machine will automatically stop to print the totals for the control group. There can be three classes of Control Groups: minor, intermediate, and the major. The controlling of the comparing relays is accomplished by external wires in the plugboard.

g. Listing and Tabulating. Listing is the printing of information from each individual card as it passes through the reading unit of the machine. A card can be listed only during a "list" cycle, which involves synchronous operation of reading and printing units. When a machine is set to LIST by positioning the LIST-Tab switch, every card-feed cycle is a list cycle and the information punched into the cards may be printed in any desired form except that the punching of alphabetic information is limited to the first 43 type-bars of the type 405 Tabulator. Tabulation is, of course, an accumulation of information in counter groups from which totals may be printed for any desired classification When the machine is set to TABULATE, the first card-feed cycle is a list cycle which enables the identifying information for each classification to be printed. Automatic control of desired classification causes the machine to print or "clear" the total accumulated in the counters. The counters of this machine may be controlled to add, subtract or eliminate the accumulation of numerical information according to the method in which the counters are controlled. The counters may also be controlled to print totals at the end of any one of four total classification - - minor, intermediate, major or final.

h. Selectors. Class Selectors and "X" Distributors. The control of counters to add subtract or eliminate numerical information is accomplished by means of the selection of the impulse which causes the counters to operate. The selector is a switch-like mechanism which may be controlled 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 and the counters will function in a normal manner when the selectors are not controlled or "picked-up", i.e., the counters may be controlled to eliminate, subtract on cards containing specific control punching and add all other cards or perform any combination of these functions. The means of control by selection affords a wide variety of permissable operations that could not be otherwise accomplished. In addition to the control of counter impulses, selectors can be used to select punched data at each reading station for addition, subtraction or indication; to select the printing of totals by class so that more than one class of totals may be printed in the same type

bars on successive total cycles; to select the integrated relationships of punched data in multiple columns so that cards in error may be listed and all other cards may pass through the machine at tabulating speed; to classify punched data and add "1" in various counter groups, thus permitting the tabulation of frequencies of occurrences of various classification

i. Digit Selectors. As previously mentioned, the control of information or impulses may be accomplished by selection dependent upon specific control punching. To afford maximum flexibility in such control the machines are equipped with digit selectors which permit the selection of any one, or any combinations, of the twelve possible punched positions of the card for control of the selectors. Through these digit selectors, any card column or combination of card columns may be read from either reading station for selection control, the limitations being dependent upon the operation. These digit selectors may also be used as emitters when impulsed with a Unit Constant Impulse.

j. Summary Punching. At the same time that new reports are prepared, summary punches can automatically punch the totals that are printed in the report. This permits subsequent tabulation from summary cards without necessitating a re-run of the original or detail file. Summary carding usually reduces the detail card volume greatly and such practices generally result in a considerable saving of time if subsequent tabulations are desired In a summary punching operation the summary punch is attached to the accounting machine by the connector cable which transmits the counter totals of the accounting machine on each control change. The plugboard of the summary punch contains plug-hubs corresponding to the counter total exits of the accounting machine from which the totals are wired to the punchmagnets for punching into any desired card form. Indicative information is wired into a counter of the accounting machine and added once for each control change and is transmitted through the connector cable to the summary punch in the same manner as other totals The accounting machine is equipped with summary punch switches which permit the punching of a summary card on either a minor, intermediate or major control change; only one class of total can be summarized. Also, information can be gang-punched into summary cards while summary punching. The connector cable causes an interlock of the two machines and both machines must be switched on to operate; if the feed hopper of either machine is exhausted or either machine fails to feed both machines will stop automatically

10 Special Devices. a. General The requirements for the machine processing of complex climatological studies for military classification quickly exceeded the capacities of practically all types of "standard" IBM equipment then in use. It was found that, in practically all requests the requirements were such that would necessitate preprocessing for group classification or additional runs through the machine creating the problem of time sacrifice or of obtaining additional equipment which would also require additional personnel. The problems encountered were carefully considered by experienced machine technicians and IBM representatives to determine the most efficient solutions. Recommendations were made and installation completed on numerous special devices whose purpose and functions are enumerated in later paragraphs. It may be pointed out here that the addition of these special devices, especially, on the alphabetic accounting machine in many cases doubled the capacity of the machine and constituted a great saving in personnel and time required for their operation.

b Automatic Reproducing Summary Punch-Type 513. To the standard automatic reproducing summary punches were added two additional column splits increasing the capacity to ten, a gang punch emitter, two ten-position class selectors, twenty positions of double punch and blank column detection and 27 columns of mark sensing. The additional column splits provide a total of ten positions for control of "X" or "12" punching or elimination and permit the summary X-punch control of ten counter groups in net-balance summary punching. The gang punch emitter permits the punching of any of the twelve card positions in any column of the card on each card cycle; this device has a special advantage in that punching may be added to a card column containing previously punched data without "lacing" the punching into succeeding cards. The 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 three card fields, to offset gang punch and compare, and to control the punching of true or complement values in non net-balance summary punching. The mark sensing device permits the punching of data into a card that has been marked with a special pencil. Information can be transcribed onto a card and subsequently punched into the same card, thus eliminating the manual key-punching of data from a source document. The double punch and blank column detection device is used in conjunction with mark sensing to check that all marked columns have been punched and are not double-punched; such errors will cause the machine to stop and indicate the error by a red light. This device is also used in certain checking operations in the auditing of cards received from Army weather stations.

c Type 077 Collator. The limitations and capacity of the collator have been expanded greatly by the addition of the collator counter devices and the splitting of the single 16-position selector and sequence units into four 4-position units with switches enabling the use of any combination of the four units. The collator counting device makes possible certain collating operations which involve a count of cards and saves the pre processing which would otherwise be required for such operations. Through use of this device, it is practicable to insert a fixed or variable number of cards behind a single master card; to insert initial or overflow heading cards for continuous form listing and two column consecutive number checking. The split sequence and selector units permit increased capacity for a variety of operations, for example; any of eight numbers may be selected at one time; combined operations such as sequence checking and the selection of given numbers; the selection of given numbers and a given range of numbers; the selection of a range of numbers within a range of numbers and many other specific operations that would require description too detailed for inclusion in this paper.

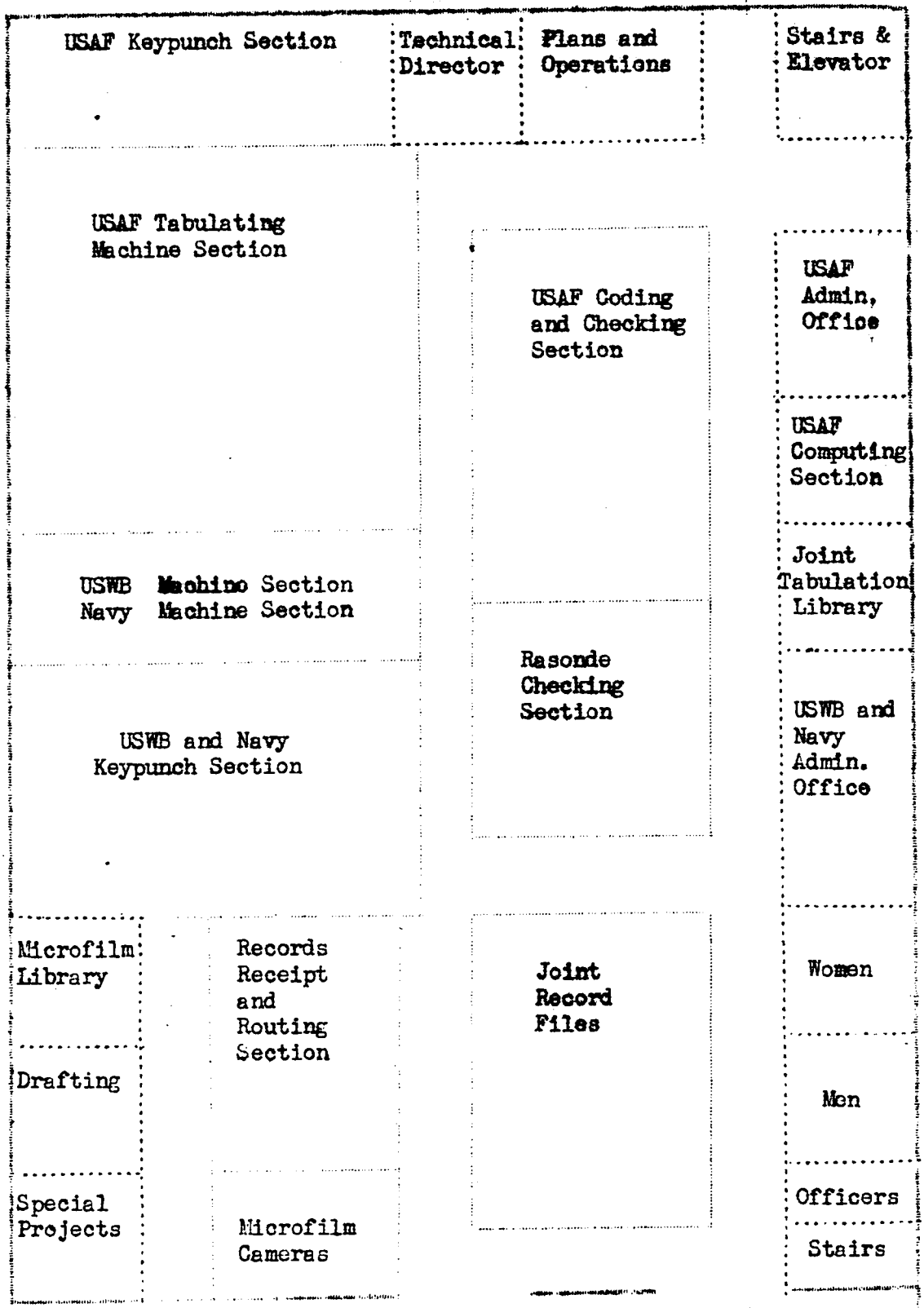
d. Type 601 Multiplying Punch The wartime requirements of weather statistics included many research problems, the solving of which necessitated thousands of computations. Manual computation was too slow and therefore impractical in view of the time requirements. Such problems presented a challenge to the ingenuity of meteorologists and machine technicians, who were searching for formulas and methods of computing accurately such difficult concepts as ballistic winds, long range forecasts, correlations of weather elements, etc. The more simple sounding requirement of the computing of relative humidity from the temperature and dew point, becomes complex when the number of observations is only one fiftieth the volume of the possibilities and the equations are curvilinar.

The modified 601 multiplying punch was applied to these problems. It is able to multiply two or more factors in the same card, whose products do not exceed twelve positions, and punch their products into the same card, or to add or subtract and punch sums or differences also into the same card. To accomplish division, the reciprocal of the multiplier is used. However, even though the type 601 multiplying punch is faster than manually operated computers, its speed is slow, relative to other IBM equipment. It was observed that frequently a re-run of the cards through the multiplier was necessary, due to the twelve position limit on sums or products, and that there was the possibility of a product "overlap" in the multiplication of two or more multiplicands by a single multiplier, which of course is dependent on the number of positions in the combined factors. The solving of weather equations by machine also interposed the problem of adding or subtracting factors algebraically. These and many other problems were carefully studied by experienced machine technicians and IBM engineers. An installation was made of unique devices, which added greatly to the capacity and flexibility of these machines. These devices were additional crossfooting and class selectors, which permitted the introduction of additional factors into the summary products counter for crossfooting, and control for the addition or subtraction of the right hand components counter, controlling on the algebraic sign of the factors. Also balance control was added, which permitted the conversion of complement totals and "X" punching to identify positive or negative products. The addition of four extra counters in the right and left hand components counters expanded their product capacity to 16 positions. The split multiplication device provides dual control of the right and left hand components counter exits, and permits the transferring of products which would normally overlap in the multiplier, of two or more factors at one time. With the above device, it is possible to multiply four 2-position multiplicands by one 2-position multiplier, where normally, only two 2-position multiplicands can be multiplied by one 2-position multiplier, thus doubling the capacity of the machine for this type of operation. A checking device permits the checking of the product against a second computation for "zero balance". All correct cards are identified by a "12" overpunch, and cards in error cause the machine to stop, so that they may be inspected. This device insures the maximum accuracy of the punched product. These machines are also equipped with a decimal accumulating device which permits the correction, or rounding off, of a group product total, which is accurate to within one half of one unit of the right hand significant digit. However, even with the flexibility of these machines, the wide range of requirements presents many problems, whose solution are impractical on present day equipment. A representative sample of these problems has been brought to the attention of IBM representatives for presentation to their engineering staff with the hope that they will favorably consider engineering new and special equipment with the required features for the solution of such problems. The new type 602 calculating punch, with direct division, is a closer approach to the problem, but is still far short of the complete statistical machine.

e. Type 552 Interpreter. The interpreters are equipped with a digit emitter. The digit emitter is used primarily to print identifying information on cards without sacrificing card columns to punch such information as card deck number, summary number, etc.

f. Type 405 and 416 Accounting Machines. To the accounting machines were added four additional digit selectors; the six 10-position class selectors were split into twelve 5-position selectors, and six additional 5-position selectors were added, making a total of eighteen class selectors. The X-distributors were split, making a total of sixteen single position selectors with "ZFS" pickups, instead of eight triple-position selectors with only "X" and digit pickups, thus quadrupling the capacity of the machine for multiple column selection. The four 8-position counter groups were split into 4-position groups, increasing the counter groups from 16 to 20. Two column splits were added, which increased the selection variations of analogues to a maximum of six systems. The card-cycle transfer device was added to 80 counters, which permitted the performance of such operations as first and last card indication, eight field cross-footing, group multiplication, determining the maximum and minimum values of a control group, summation of absolute differences, the solving of simultaneous equations, and many other complex problems. All machines were equipped with demountable type bars, making it possible to produce climatological listings using weather symbols and characters from the coded data in the punched card; this is of particular advantage in the editing of punched card data against original weather records. A re-conversion circuit has been added, which permits the conversion of complement progressive totals to true figures and the subsequent reconversion to the complement for further progression of totals. The description of the advantages of these special devices could be expanded, but it soon becomes obvious that by the addition of this extra equipment the solution of many problems is simplified, and that hitherto impossible operations become commonplace.

FLOOR PLAN OF DATA CONTROL UNIT



Master Punched Card Library in Section B, and Warehouse Space in Section C, each cover the same amount of space as Section A shown above. The total space utilized is 84,000 square feet.

OPERATIONS

1. General. a. Thus far we have discussed the two components upon which machine methods of weather statistics are based, cards and machines. Volumes could be written concerning the detail of operations performed by these components; technical files of Data Control Unit can testify to that. For the purpose of this paper, however, an attempt will be made to describe the major operation of the Unit which will satisfy the reader.

b. The functions of Data Control Unit can best be divided into two categories - routine and special operations. Routine operations are concerned with the coding or editing, punching, and checking of Air Force weather observations, both surface and upper air, and the summarization of these observations into a uniform group of weather summaries. The special operations consist mainly of preparing weather statistics to fit the needs of individual users, for such purposes as the regular summaries do not suffice.

2. Routine Operations. a. General and Historical

(1) The inception of a program of routine summaries was made necessary by the frequent requests and growing demand for summaries of Air Force weather data. That such a summarization program be accomplished by punched card methods was dictated by the facts that repetitive use of the certain elements of the observations would be required and that, since at the time most Air Force records were of short period of record, frequent resummarizations to extend the records would be required. Also, it was anticipated and eventually became reality that inter-relationships of several stations would be studied in connection with special requests.

(2) The program itself was aimed at getting as much as possible, if not all Air Force hourly weather data into punched card form and preparing certain standard summaries which would fill the greater part of the requirements for climatic information. This involved the collection, from the world-wide field, of the source documents, their coding into form suitable for punching on cards, the punching, the verifying of the punching, the summarizing of the cards and the tremendous amount of record keeping associated with the control of thousands of station-months of record and millions of punched cards.

(3) In the early stages, the program involved some 13,000 station months of record and the 9 million or so punched cards which were to be derived therefrom. Thru the war years the passage of time and the expansion of USAF activities has resulted in the increase of the number of station months involved to some

26,000 station months of record, from which some 20,000,000 punched cards have been made.

(4) Initially the weather records were all collected in Washington and there turned over to the Statistics Division of the U. S. Weather Bureau which then completely processed the data, operating on transferred Army funds. The data was forwarded from Washington to Pittsburgh where it was coded. It was then sent to New Orleans where the data was punched and summaries prepared. The coding, punching and summarizing consumed the major portion of the efforts of some 300 people.

(5) Early in 1945 the Army changed its reporting from Form 94 to WBAN-10A in joint agreement with the Navy and U. S. Weather Bureau. At that time the WBAN punched card forms had not as yet been created and the In-Station Punching Program was barely beginning to take form on paper. This necessitated the continued use of the Form 94 card forms and these were and are used for all Army weather records covering the period thru December 1945. Beginning with the records of 1 January 1946 the WBAN card forms have been used. The same form of final summaries are prepared from both card forms.

b. The Card Forms

(1) In setting up the program to be operated on a punched card basis it was necessary to design two detail card forms. One of these cards contains the hourly observation and the other contains the Summary of the Day information. When Form WBAN-10A came into use, another card was added, the 6-hourly observation.

(2) Once a station's records had been summarized and it became necessary to add to the period of record if only the detail cards were available, it would mean that the initial detail cards would have to be included with the new ones in the processing to obtain summaries. This meant duplication of the initial effort - a very undesirable feature. To greatly reduce this duplication, summary cards were designed. Each of these would contain, for one of the standard summaries, the summarized information from one of the hours of each day of a calendar month. Using these summary cards it meant that in re-summarization the original machine processing is only one thirtieth duplicated since 24 cards will furnish the hourly summary information for a calendar month of 30 days in place of 720 hourly detail cards.

(3) The Hourly Observation. These cards (Form 94-A and WBAN 1) are by far the greatest portion of all cards

punched from Air Force weather records. It is from these decks that most weather summaries for Air Force installations are prepared. For each record observation the complete airways observation is punched, containing the following elements: ceiling height, sky condition, cloud forms, heights and amounts, visibility, weather, obstructions to vision, pressure, temperature, dew point, and wet bulb temperatures, and wind velocity. The WBAN 1 card contains more information than the Form 94A, due to more complete observing practices which were established with the use of the new reporting form.

(4) The Six-Hourly Observation. These cards (WBAN 2) contain all the weather data transmitted via teletype for synoptic maps which are not included in the corresponding hourly observation, such as six-hourly maximum and minimum temperatures, precipitation and snowfall amounts, snow depth, and three-hourly pressure change and tendency.

(5) The Summary of Day Information. These cards (Form 94B and WBAN 3) contain only information which applies to the weather from midnight to midnight: maximum and minimum temperatures, precipitation and snowfall amounts, maximum wind velocity, hours of fog, etc. As in the comparison between Form 94A and WBAN 1, the WBAN 3 card is more complete than Form 94B, due to recording practices.

(6) Winds Aloft. All winds aloft observations presently being recorded are punched on a standard card form, WBAN 4. Wind direction and speed are punched for standard levels above sea-level. As is the case with surface observations, different card forms were used prior to the use of WBAN reporting forms.

(7) Radiosonde Observations. Pressure, temperature, relative humidity, and wind velocity at standard constant pressure levels are punched on the WBAN 5 card. Due to the length of each observation, reporting data at many standard levels, as many as eight cards may be required to punch a single observation.

(8) The "A" Summary Card. Inasmuch as summary cards are necessary to avoid excessive repetition of effort in preparation of routine summaries, a standard card form was developed. The cards for all routine surface summaries follow the same pattern, and each contains the same information as is shown on the final tabulation, but for a single station-year-month-hour. (An exception to this is made in the case of surface wind summaries, which are not prepared by hour, but by wind direction.)

(9) The "B" Summary Card. For the temperature summaries prepared, the frequency and sums of temperatures are punched in semi-annual cards. For the precipitation and snow depth summaries, the frequency of observations falling within the various class intervals of the summaries are punched by month; these cards also contain the total precipitation amounts for each month.

c. Punching, Editing, and Checking. (1) General. At some point early in the processing of a newly punched card, a check must be made to determine the accuracy of transcribing the data to the card. It has been customary practice to check the accuracy of key punching of all cards by verifying them on machines similar to key punches, machines which simply test for the punched hole instead of punching it. This method is used for many card forms punched by Data Control Unit. Due to the volume of WBAN 1 cards, however, elaborate machine methods have been devised, so that complete manual verification is no longer necessary. This method searches not only for punching errors, but for observing errors as well.

(2) During the war, time was the major factor in getting weather data onto punched cards for the tabulation of staff studies, intelligence information, and for the solution of other Weather Service problems. On a peace time basis, the major factor in most operations becomes that of cost. It has been found by time-study and cost accounting that in the past about half of the expenditures of this unit have gone into the punching at the original observational cards. Under the old procedure the original Army weather records (Form 94 and later WBAN-10A) were mailed to the Data Control Unit, where a large crew of trained key punch operators encoded and punched the weather observations. Toward the end of the war, the Air Weather Service, foreseeing a necessary reduction in the cost of operations, formulated plans to have the observations punched in the weather stations by the weather observers. Numerous difficulties were encountered: the procurement of key punches, designing a card that would simplify its punching by inexperienced personnel, yet contain all the climatologically important parts of the observations, training personnel in the field to think in terms of punched holes together with written materials, and the establishing of a system for supplying those stations with key punches and cards.

(3) Only selected stations began punching their own observations in the early part of 1946. Now all stations in the continental United States are participating in the program. Stations outside the Zone of the Interior continue to send their original records to the Data Control Unit where the cards are punched by key punch

operators. Through months of experimenting with the in-station punching program, it appears that its establishment has decided advantages over the former method of obtaining the data on punched cards. Since the observer not only has to write the observation on the original record, but punch it as well, this double scrutiny enables him to catch his observational errors easier than heretofore. When the observers have had sufficient experience in recording data in punched card form, their accuracy will probably equal that of a trained key punch operator. The lesser cost of punching cards by this method has already been mentioned, the reasons being that the Type 001 punches are cheaper than the electric punches, which are used in a tabulating unit, and that the existing key punch operators are made available for other important punching work.

(4) For years the accuracy of Army weather observations was checked at Group Headquarters. This was a tedious job, involving visual inspection of all the elements of each observation, numbering 720 hourly observations per month per station. This function has been assumed by the Data Control Unit. It is expected that the weather records will continue to be checked by the chief observer, or other supervisor, in the individual weather stations to remedy obvious errors; this checking will assist in in-station training programs and in maintaining observer efficiency.

(5) The first step in determining the accuracy of the surface weather observations is the editing. The editing procedure consists of preliminary visual checks by the manual checking section to verify the completeness and correctness of all entries except those in columns 1-30 in the body of the form. Columns 1-30 are scanned only for flagrant discrepancies and omissions, since the data punched from these columns are checked more in detail later by International Business Machines.

(a) Entry Check. Each sheet is reviewed for proper entries of station name, station number, latitude, longitude, date, height of barometer, and the time meridian for reporting. The station name and date on each sheet are indispensable for a statistical record of this nature

(b) Time Check. Since the records forwarded have originated from all parts of the world, it is obvious that the time differences are many and varied. For this reason, all incoming records must include the correct meridional time, which is verified by using the standard 15 degree longitudinal differences from 0 degrees, or Greenwich.

(c) Six-Hourly Check. The additional data recorded at the six-hourly periods are checked against the record observations. Time headings are checked on all six-hourly reports insuring that a six-hourly interval is actually observed. A check is made to determine if maximum temperature or minimum temperature entered is simply copied from hourly observations, or whether it is measured from max/min thermometers. This will be noted where all maximum and minimum temperatures agree exactly with the temperatures at the appropriate record observations. The observations will be considered correct if this condition occurs occasionally, but not if it occurs in all cases. Snow depth is checked as this entry is not likely to increase from one observation to the next unless snowfall has been entered for that period in record or special observations. The presence of blowing or drifting snow however, may cause the snow depth to increase without actual snowfall. The precipitation entries should contain some notation other than 0.00 if the entries under "Present Weather" for record or special observations indicates occurrence of rain, snow, snow pellets, drizzle, or associated phenomena.

(d) Summary Check. All stations recording "Summary of the Day" information must have been in operation during the entire 24-hours. A summary card can not be punched completely if there are not 24-hourly observations entered on the form. It is possible for a station to have recording instruments that measure maximum and minimum temperature, 24-hour precipitation, 24-hour snowfall and extreme wind speed, so that these entries may appear on the form without having 24 record observations. Maximum Temperature and Minimum Temperature in the Summary should agree with the highest maximum and lowest minimum reported by 6-hourly observations. Temperatures should be to the nearest whole degree Fahrenheit and include only the period from 0000 to 2359 local time. (Should not include data of previous day). Precipitation occurring during the day should be entered to the nearest hundredths of an inch. "Present Weather" columns will indicate whether or not an entry should be made. The record is considered only from 0000 to 2359 local time of the present date, and no previous observations should be considered. The amount of snowfall from midnight to midnight is reported to the nearest tenth of an inch if any occurrence is noted in column, "Present Weather".

(e) Total Cloudiness Check. When the entry of total cloudiness has been left out, the appropriate entries will be made in column 29.

(6) A number of machine tests have been designed to inspect each hourly observation to determine if it is consistent within itself and if it adheres to the instructions of TM 1-235, "Weather Station Handbook for the Observer". These observations which fail the machine tests are listed, and the listing routed to the manual checking unit, where they are compared visually with the original reports. Cards routed to the tabulating section for machine processing are checked in six separate operations, in which the following elements are checked:

(a) Temperature - wet bulb - dew point. Not only is relationship between these temperatures tested (i.e., that the wet-bulb temperature lies between the dew point and air temperatures in proper order) but the computed dew point temperature is checked to determine if it lies within the range allowable for the observed air temperature and wet-bulb temperature. These ranges were computed for two standard elevations from the psychrometric tables and punched in two master decks. The deck corresponding to the elevation nearest that of the station being tested is matched against the hourly observations on the collator, and those observations apparently having dew point temperatures in error are selected and investigated by the manual checking unit. The master deck contains all expected combinations of wet-bulb and air temperature

(b) Cloud amount - type - height. The cloud field checking accomplished by sorting progressively across the cloud fields from low to high clouds. Sight checking is combined with sorting to detect and eliminate cards with inconsistencies due to incorrect observing or coding and punching practices. Since the cloud fields on the WBAN Card 1 total 23 of the 63 columns used for the actual weather data, it could be expected that they are the source of most difficulties in coding, punching and checking of observations. This has proved to be true, and the test described briefly herein is so complex that no method has been devised at present to perform this checking procedure on the tabulator. It is believed to be economically impossible to check these fields on the tabulators used by the Data Control Unit, despite the many non-standard devices attached to the machines for other complicated operations.

(c) Wind direction and visibility codes. The hourly observations are checked on a tabulator to find impossible punches for wind direction, such as NSW or EN, and to find illegal visibility values, such

as 3 1/2 or 18 miles. Only those visibility values that can be reported according to TM 1-235 are allowed to pass. These errors are also listed and routed to the manual checking unit for analysis.

(d) Sky condition - total cloud amount - ceiling. The symbols and values for sky condition are checked against the reported ceiling and total cloud amount for agreement according to TM 1-235. If sky condition is reported as "clear", total cloud amount of zero tenths must be given. ("Few" is punched as zero on the card.) Similarly, sky conditions of "scattered", "broken", and "overcast" must have total cloud amounts of one through five tenths, six through nine tenths, and ten tenths, respectively. (Nine plus is punched as ten tenths.)

(e) Visibility versus weather conditions and obstructions to vision. This is an elaborate checking procedure accomplished in one run of the cards through the tabulator to determine that the visibility value reported is in agreement with the weather and/or obstructions to vision observed, according to TM 1-235. For every observation where the visibility is equal to or less than six miles some type of weather or obstruction to vision must be recorded. This test requires the comparison of nine columns on the card (weather and/or obstructions to vision) against three columns (visibility), and necessitates the use of practically every non-standard device on the alphabetical accounting machine. This check is designed to detect not only those observations which are inconsistent with the provisions of TM 1-235, but also to focus attention, for scrutiny, on observations which, while they are allowable, appear to be very unlikely.

(f) Station pressure - sea level pressure. Cards are listed in chronological order on the tabulator, and using the consecutive number control device, duplicate and missing cards are indicated. These errors are referred to the manual checking unit, where missing observations are supplied, and duplicates inspected to determine which is correct. (When duplicate cards occur, usually one is in error, having been left in the file by mistake.) At the same time, the machine is checking the continuity of pressure from hour to hour. As it lists the current sea-level and station pressure, it also lists the difference between two adjacent pressures; if this difference between pressures at two consecutive hours is unreasonably larger than adjacent differences, these observations are scrutinized for errors.

(7) The manual check procedure for WBAN-10A is supplementary to the machine check performed by the IBM machines. The errors and inconsistencies pointed out by the machine check are corrected at this time and are summarized on the Error Summary Form provided. When the manual check is performed, the clerk has available the actual Form WBAN-10A in question, the tabulated error listing and the pressure listing. When the tabulated error listing is prepared on the IBM machines, the cards which have been proven to be correct do not print. The cards which may have errors do print in a form very much like a teletype weather report. The tabulated error listing is the basis of most of the manual check. The remarks of the incorrect or incomplete observation will frequently give useful data. The manual check clerk compares such observation on the tabulated error listing sheet against the original observation on the Form WBAN-10A. Punching and observational errors are designated and corrected on both the listing and the form. Where there is no apparent error, the test number designating the type of error on the listing sheet is encircled. When errors are found on the form, when not appearing on the listing, the observation is corrected on the form, and the date and time are noted at the bottom of the last observation on the listing.

(8) Error Summary. The punching and observational errors are summarized and entered on error summary form. The remarks contain information about errors outstanding and recurrent found throughout the period, illegible and too-light handwriting and other pertinent comments. After all observations for a month have been processed through the machine and manual tests, a tally of all errors noted is made. This summary is furnished to Group Commanders who inform the various Station Weather Officers of the accuracy of observational techniques at their respective stations. It is hoped that not only will this information in itself bring to the attention of the observers the type of error most frequently made in order to render them more careful, but that the relative status of the observing and punching accuracy of each station within Weather Groups will inspire the personnel of the lower ranking stations to improve materially their techniques. It is further desired to use this information as a guide in planning or revising training programs in observing and punching methods.

d. The Routine Summaries. (1) In designing summaries to be prepared routinely, an attempt was made to furnish the elements of observation most frequently requested, in ranges most often desired and in such manner that a majority of climatic questions can be answered by reference to these standard summaries for the given station. The passage of time and hundreds of requests for information have proven that the summaries eventually arrived at have fulfilled this requirement.

(2) There are two main divisions of the summary. The larger,

referred to as Part A, is a collection of six tabulations prepared from the hourly cards. The second or Part B consists of five tabulations prepared from summary of the day information. In addition to these summaries prepared by machine, a recap summary is hand prepared and shows percentage frequency by month of all elements of the A summary.

(3) The A summary is in six parts, as stated above, and consists of the following for each station completed:

(a) Flying Weather - This shows by month and by hour within month the number of occurrences of closed, instrument and contact weather classifications and also, for those observations in which the visibility was less than one mile, shows the number of occurrences of obstructions to vision in the category of fog, smoke and haze, blowing snow or dust, precipitation and unknown. Shows number of observations with visibility less than one mile and also total number of significant observations.

(b) Ceiling Height - Shows by month and by hour within month the number of occurrences of ceilings in each of the ranges of 0-450 ft., 451-950 ft., 951-2050 ft., 2051-3050 ft., 3051-5250 ft., 5251-9750 ft., 9751 ft. and over. Shows also the number of significant observations.

(c) Visibility - Shows by month and by hour within month the occurrence of visibilities falling within the ranges, in miles, of 0 - 1/8, 3/16 - 1/4, 5/16-1/2, 5/8 - 3/4, 1 - 2 1/4, 2 1/2, 3 - 6, 7 - 9, 10 and over. Shows total number of significant observations.

(d) Sky Conditions - Shows by month and by hour within month the number of occurrences of sky conditions reported as clear, scattered, high broken or overcast with or without lower scattered, low broken and low overcast. Also shows total significant observations. Distinction between high or low in this case is whether at or above 10,000 ft. or below 10,000 ft.

(e) Weather Conditions - Shows by month and by hour within month the number of occurrences in present weather of thunderstorms, rain and/or drizzle, freezing rain, snow and/or sleet, hail. Also gives total number of observations with precipitation and total number of significant observations.

(f) Surface Winds - This summary is prepared for each month and for overall annual. The vertical spread is by wind direction to 16 points and the horizontal spread shows the occurrence of observations falling into the velocity groups, in miles per hour of 1-3, 4-12, 13-24, 25-31, 32-46, 47 and over. Shown also by

direction is the number of observations of 4 mph and over, total significant observations and total of all velocities which is later divided by total observations to show average velocity by direction. The number of occurrences of calm is also shown.

(4) The B summary is in five parts each of which requires but a single sheet. The summary parts are as follows:

(a) Frequency of Daily Maximum Temperature - Shows for each month and annually the frequency of occurrence of maximum temperature by two-degree ranges. Also shows total number of significant observations and the sum of the temperatures from which is computed and entered the average daily value by month and annually.

(b) Frequency of Daily Minimum Temperatures - Shows minimum temperatures distributed in same manner as indicated above for maximum.

(c) Frequency of Daily Mean Temperatures - Shows mean temperatures distributed in same manner as for maximum

(d) Frequency of Daily Precipitation Amounts - Shows by month and annually the frequency of occurrence of 24 hour precipitation amounts in the intervals, in inches of zero, trace, .01, .02-.05, .06-.10, .11-.25, .26-.50, .51-1.00, 1.01-2.50, 2.51-5.00, 5.01-10.00, 10.01-20.00, over 20.00. Also shows by month and annually the number of significant observations and the sum of the precipitation amounts from which are computed and entered the mean precipitation amounts. Also shown is the mean number of days per month and annually in which .01 inches or more of precipitation occurred.

(e) Frequency of Daily Snow Depths - Shows by month and annually the frequency of occurrence of amounts of snow on the ground at 0800 IST in the intervals of 0.1-0.5 in., 0.6-1.0 in., 1.1-2.0 in., 2.1-6.0 in., 6.1-12.0 in., 1-2 ft., 2-3 ft., 3-4 ft., 4-5 ft., 5-10 ft., over 10 ft. Also shown are total number of daily observations and the mean number of days per month and per year with a measurable depth.

e. Analogue Selection. (1) Analogue selection is a method of long range forecasting, and is the processing of choosing weather maps from the past which are similar in several respects to the current map, on the theory that like causes produce like results. However, sea-level pressure is the sole factor considered. Analogues are selected daily upon receipt from the Master Analysis Central in Washington of the criteria defining the current map.

(2) A file of weather maps, known as the Daily Synoptic Series of Historical Weather Maps of the Northern Hemisphere, was constructed from weather information traded among nations, from information in ship's logs and data on record at the United States Weather Bureau, and it consists of one map per day from January 1899 through June 1939, a period of forty and one-half years. In order to search this file

rapidly for maps similar to the current day's, a plan was devised of coding and punching a description of each map into IBM cards. Since the 80 columns are insufficient to describe the map of the entire Northern Hemisphere, the map has been broken down into six overlapping major divisions: Atlantic, East Atlantic, Northwest (Continental), Pacific, Asia, and West Asia. Each of these subdivisions has been further subdivided by meridians and parallels into 73 zones, which, when punched, leave six columns of the card for the date, and one column for identification of the major division.

(3) After analyzing the current map, the forecaster in Washington places over it a transparent template, showing all the areal subdivisions. He notes the location and intensities of the major pressure cells. This information is transmitted to the Data Control Unit, where a portion of the analogue card deck is run through the tabulator in search for cards with identical data. Ordinarily about two months of each year's cards are used, approximately one month of every year before the current date, and one month after. The cards pass through the tabulator with no apparent result, until the machine detects a card containing the correct criteria. At that point, it stops and lists the date of that map similar to the current one, whereupon the cards continue to feed through the machine until another card is detected that meets the requirements. Some days as many as two hundred maps are listed, and sometimes no maps at all are selected. These dates are transmitted to Washington where the forecasters visually check the historical maps, choosing the ones which most closely resemble the current map for aid in making their long range forecasts. In the cases where a great number of maps are selected, only a few dates are transmitted, twenty at the most for each analogue, using the most recent dates, since data coverage is better on the later maps of the series. If no maps are selected, the criteria are altered slightly, by the forecasters, and the deck is re-run.

(4) In addition to selecting maps which fit the current map with respect to certain pressure systems, the machine indicates the degree of similarity to the current map by the use of additional systems, called options. Thus, many maps may be selected which are similar in general to the current map, but of these, some maps may more closely approach the current pattern. As many as three options are usually furnished by the forecasters.

(5) When the Data Control Unit was in Washington, the Forecast Branch simply telephoned their criteria, the cards were tabulated, and the dates telephoned back to the forecasters. The teletypewriter is now used as a cheaper method of communication. The use of a Model 19 tape-cutting teletypewriter and IBM Type 060 Card-To-Tape Machine permits summary

cutting of cards during analogue selection, containing the analogue date and area. These cards are used to cut a teltype tape with the Card-To-Tape machine, which is then used for transmission of the message, thus eliminating the chance of manual transcribing error. The time required to select analogues for four areas (Northwest North America, Continental North America, Atlantic, and Pacific) is usually slightly under two hours, including receipt of criteria from Washington, and transmission of the final results.

f. Controls. (1) General. The term "controls", as we use it, refers to the card decks numbers, listings, tabulations, etc., employed by this unit in effectively governing the flow of work on various projects and in disseminating information to interested agencies, regarding status of projects, volume of data available, etc. Large scale projects as, for example, the routine surface summary program, come to involve millions of items of information which may proceed through seven or eight 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. It also becomes necessary that affiliated agencies be furnished with the same up-to-date information in order that they may intelligently conduct their own programs and make their requests for information logically. With the status of many items constantly changing and with multiple copies required, the adoption of punched card methods is most logical. Also, in the case of static volumes of data and punched cards, the volume of data is great and is so varied that in order merely to catalog the data and know its physical location it is desirable to have it indexed in many ways such as numerically by station number, alphabetically by station name, geographically, according to data content, according to source, etc. To do this by hand means wallowing through the information many times whereas in the punched card method the data is gone through but once and complete information for each unit recorded. It is then possible to index and cross reference in any number of ways mechanically thereby effecting tremendous savings, time, money, and effort. All of these controls then are nothing more than items required in good management. Their preparation and upkeep consume 2 to 3% of the machine time and personnel effort of Data Control Unit and their value, in preventing duplication and wasted effort as well as saving management time, is a large multiple of the cost.

(2) Major Controls of the Data Control Unit. The Data Control Unit employs a fairly large number of devices in the con-

trol of its projects and data. A few of the more important ones will be briefly discussed below:

(a) Weather File Control.

1. This control is designed to be an index of the punched card library. It was originally set up to keep track of what weather cards were available in the Pentagon. With the Data Control Unit's move to New Orleans the files of cards became scrambled and so the control was disrupted. As time and personnel permit the loose ends will be picked up and the index will be extended to include the entire Master Punched Card Library which involves more than 100 million punched cards. The index itself contains the station number and names of all stations for which there are punched cards, together with indication of the card deck identification, total number of years in the record, the earliest year, the latest year, the number of observations per day, the card volume and the card tray number. This control serves the purpose of collecting into one document information which gives a complete listing of all the stations for which there are punched card data, tells through card deck identification what elements are in the cards, gives the period of record, the usual number of observations per day, what the card volume is and exactly where the cards are to be found. The cards are obtained originally and added to the deck by numbering the trays of a block of card file cabinets in which cards have been filed in some logical, predetermined order. Then for each tray is coded a line of information relative to what cards are in the tray. This information is then key punched and verified. Machine work on this control consists of sorting the file control cards into various orders and listing on multiple-part paper. Revised listings are prepared by sorting or collating new cards into the deck. New listings are made only as the need is indicated by the volume of new data to be added.

(b) Inventory of Air Force Weather Records. At the time this control was initiated the Data Control Unit had on hand from various stations such items as:

1. Hourly records on Form 94.
2. Hourly records on WBAN-10A.
3. Hourly records in notebooks (AAF in Great Britain).
4. Winds aloft on Form 201

5 Winds aloft on Form WBAN 20.
6 Pibal graphs (WBAN 20A)
7 Pibal summary sheets (WBAN 22)
8 Older rawin forms.
9 Rawins on WBAN 20.
10 Rawin graphs (WBAN 20A)
11 Rawin summary sheets (WBAN 22)
12 Various rabal data.
13 Raob data on forms both prior to and after the inception of WBAN forms.
14 ~~6-Hourly~~ observations ~~(Form 2)~~.
15 Monthly summaries (Form 1).
16 Barograph, microbarograph, thermograph and hygrograph traces.

With such a variety of records and the desirability of knowing for each station just what records are available, what period of record is covered, whether the month is nearly complete for days, whether 24 hourly observations were taken per day and for upper air stations the number of runs per day, it then becomes apparent that the index will be more flexible and more easily kept on punched cards. Further, the information can be more readily furnished to other agencies and readily appended or revised. The inventory shows for every Air Force station from which data have been received the station's number as assigned by Data Control Unit, the location by name, the airfield name if any, and, by calendar month, all of the various types of data received. It shows for the hourly observations if the month is represented by less than 21 days, or if there are fewer than 24 observations per day, or both. It also shows for the upper air stations the usual number of runs per day and the total number of observations available. The inventory serves as a ready, single-volume, and fairly current source of information for this and other units as to just what data are available for each operating location at which the USAF has had weather facilities. The original deck ~~of cards for the inventory~~ were obtained by coding and punching the information which had been kept entirely by hand in Washington. New cards are added from time to time by punching from code sheets which are made up daily, based on the current receipts as checked in at the records section. In preparing a report each new card must have punched into it all the other information for the station month. The new details and the main deck are then collated and the new cards automatically filed into position. Cards in the main deck which have the same identification as some of the new cards are automatically removed. The cards are then listed and in addition a count of 1 is put into counters for ~~each month~~ of each type of data.

Minor totals are then made by station so that the number of months of each type of record is given.

(c) Surface Weather Records Report. This report is designed to furnish complete information on the status of each unit of data (a station-month) in the routine surface summarization program. It was necessitated originally because data were being coded and punched in Pittsburgh and some punching and all the summarizing done in New Orleans while the program was being managed from Washington. Because of special request and priority indications which had to come from Washington, based on field requirements, it was necessary to know what data for each station was available and how far it had advanced in the processing in order to establish suspense dates and advise the field when certain items could be furnished. The report also served in a manner as a progress report from the processing units. The frequent reference to the report has dictated its continuance. The report shows for each unit of data by station what of the following operations in the processing have been completed.

1 Receipt of records in New Orleans.
2 Microfilming of record.
3 Punching.
4 Verifying.
5 "A" summary card punching.
6 "A" summary preparation.
7 "B" summary card punching.
8 "B" summary preparation.

It further shows by station the number of months of record which have completed each phase. The report furnishes this unit with the information necessary to proper guidance of the entire program. And since copies can readily be furnished and kept up-to-date for other units it supplies them with a ready source of information as to what Army hourly data are available, whether routine summaries have been prepared and for what period. It also gives a rough idea of how soon routine summaries can be prepared, based on the status of the records, or whether special summaries are possible by reason of the fact that the records have been processed to a point where cards have been punched and are ready to go. Cards are prepared by punching from status code sheets prepared daily by the supervisor of each phase who enters the necessary information relative to the units which have completed that phase during the day. The report is prepared by collating the new details with the main deck and thereby placing new information in the deck and replacing the card for a given station-month with

a new card where necessary. The deck is then listed with the digits indicating the completion of a phase being spread horizontally. Minor totals are given by station showing the number of station months having completed each phase

(3) A number of other controls are maintained by the Data Control Unit by punched card methods but involve smaller projects or are less detailed or voluminous. Some examples of these are:

(a) Winds Aloft Status.

(b) Personnel Time Study.

(c) Machine Time Report.

(d) WBAN Error Analysis Report.

(e) Master Name Cards.

3. Special Operations. a. General. A large portion of machine time is devoted to special projects and requests. These jobs have been likened to a production line, upon which line are manufactured training ships, fighters, very heavy bombers, and helicopters. It is impossible to foresee from day to day just what type of assembly will be next. This great divergence of type of project makes the work interesting, but very demanding. A nimble mind, and a lot of experience, back-breaking work, plus a forgiving soul, are all that are required.

b. Climatological Studies. (1) Since this unit is the only source in the Air Force for climatological summaries involving machine tabulations, requests are received from a great many offices, both military and civilian. Requests from military agencies are correctly routed to this unit through Headquarters, Air Weather Service. Civilian requests are usually forwarded to the U. S. Weather Bureau, the only exceptions being those especially authorized by Headquarters, Air Weather Service.

(2) Just as the number and type of units requesting such data are varied, so are the requests. It is impossible, in a paper of this nature, to describe the many different types of climatological summaries which have been prepared in the last few years. Also, the size of each job may vary from one requiring only a simple reference to a weather record, to one requiring the tabulation of several millions of cards, involving thousands of man- and machine-hours of work.

(3) Some of the more frequent types of requests are enumerated below:

(a) Flying Weather Wind Rose Data: Wind summaries prepared separately by contact, instrument, and closed weather conditions.

(b) Air Traffic Survey Meteorological Data: Summaries for the last calendar year of temperature, precipitation, relative humidity, flying weather conditions, and winds.

(c) Alternate Airport Studies: Summaries showing the percentage of time that conditions at nearby fields are instrument or contact simultaneously with closed conditions at the primary field.

(d) High Level Radar Bombing Studies: Summaries showing the probability of cloud cover over targets, with contact conditions at the take-off base.

(e) Upper Air Wind Rose Data, at various levels aloft.

(f) Mean Temperatures and Dew Points.

(g) Mean Relative Humidity: Since relative humidity is not reported hourly by Air Force weather stations, it must be computed for each observation from temperature and dew point, a lengthy machine operation.

(4) The above list is very abbreviated. Indeed, this whole volume could be devoted to special requests alone, as the technical files of Data Control Unit can testify. With the use of punched cards and machines, the variety of such climatological summaries can be limited only by the amount and type of data available and the imagination of all interested people.

c. Joint Army-Navy Intelligence Service Reports. (1) Comprehensive climatological studies of large sections of the earth are periodically required by the Joint Army and Navy Intelligence Service. The entire report is lengthy, covering all types of information about the area concerned. One chapter of each report is devoted to weather statistics, and this one chapter is often a volume in itself, depending upon the availability of data for the area.

(2) Data for such foreign areas are gathered from whatever sources are available, usually publications, yearbooks or daily bulletins published by foreign governments in earlier years, borrowed from the Weather Bureau Library or the Library of Congress. Synoptic and summary of day observations are coded when available, into standard forms, if possible, or into new card forms if no similar data had ever been punched by Data Control Unit. For

the normal JANIS report, about half a million observations are coded and punched, requiring several thousands of man-hours. Coverage is attempted usually for from twenty to sixty stations distributed throughout the area with as long a period of record as is possible, up to ten years. Both surface and upper air observations are used, when available.

(3) After coding, punching and verifying, the cards are put through a comprehensive summary program in the machine section, now requiring several thousands of machine hours in processing and tabulating. Most often temperatures are in degrees Centigrade, which must be summarized in Fahrenheit, or wind speeds in meters per second, which must be converted to miles per hour, etc. This requires ingenuity on the part of those who plan and carry out the machine summarization end of the project. Usually it is possible to convert such units directly in the tabulation of the cards, avoiding a separate step, but it involves elaborate criteria and difficult control panel wiring for the IBM machines. Almost twenty separate summaries would be produced for the ideal JANIS report, if all types of data desired were available. Usually, about fifteen of the summaries are tabulated.

(4) After tabulation, such summaries must be computed, converting the raw frequencies into percentages, or into mean number of days per month, etc. This step involves many man-hours again before the final result is accomplished. In one particular JANIS, more than 4700 pages of summaries were prepared. The average probably is about 3000 pages.

(5) Such computed summaries are finally forwarded to Headquarters, Air Weather Service, where the Writers Section of Military Climatology write the final climatology for inclusion in the published report.

d. Research Studies. (1) Research with the assistance of Data Control Unit consists of weather statistical data prepared in compliance with requests for data for use in meteorology or other fields. This section will present a description of projects believed to comprise research at this unit, both in Washington and New Orleans. The description will not include the manner of accomplishing the work by means of tabulating equipment, but will explain only what results were obtained since the use of the equipment is explained in other sections of this paper. Two kinds of research are treated, one pertaining to research data used to assist forecasting analysis with rules of thumb for a small geographical area, and the other pertaining to research data used to develop general rules or theories of forecasting.

(2) Enumeration of the local studies follows:

(a) Frequencies of wind force intervals at Tokyo, Japan, (CL 888) were tabulated by wind direction according to three high altitude bombing criteria based on sky coverage. Surface winds were converted to gradient winds by a multiplier of 1.5. Whether direction was altered to compensate for backing due to surface fraction is not known at this unit, the work having been completed in Washington.

(b) Persistence of gradient wind at Iwo Jima and Naha (CL 1226) was expressed by probabilities in percentages that the gradient wind for one day will persist for a given number of days, or that one day will be followed by a certain sequence of daily gradient wind resultant over a given period. Gradient winds were tabulated to obtain frequencies distributed horizontally by eight overlapping 112 sectors (DD_{16} = 16-04, 02-06, 04-08, 06-10, 08-12, 10-14, 12-16, and 14-02) and vertically by two overlapping inclusive groups ($F > 5$ and $F > 6$), greater than 24 miles per hour, and greater than 31 miles per hour.

(c) Precipitation forecasting equipations for the western Pacific Ocean areas (CL 1571) were derived from totals by month of product of each daily precipitation amount by each other daily precipitation amount.

(d) Precipitation and pressure studies in the Caribbean area (CL 1753) used tabulations by month of 6-hourly precipitation amounts, of pressure, and of wind velocity at 9000 feet.

(e) Fog and stratus studies for San Antonio, Texas, (CL 2448) using both observeddata and items coded from synoptic maps, was an objective approach to the prediction of fog and low stratus between 0400 and 1000 each morning, one, six, and eighteen hours in advance.

(3) Enumeration of the general studies follows:

(a) For general research on the formation of stratus diurnal heating curves for San Diego, Burbank, and Oakland (CLs 1017, 1018) were obtained by a plot from a tabulation of dry-bulb hourly temperatures by season.

(b) The effect of water vapor on radar operation at

Tateno, Japan (CL 1350) was estimated by an analysis of the probably water vapor content of a column of air for six types of air mas (cP, mP, mT, ncP, $\frac{mT}{cP}$, and $\frac{mP}{cP}$).

The constituent elements considered indicative of water vapor content, cloud type, and cloud amount, precipitation, and radiosonde relative humidity, were combined in 15 ways to determine intervals of water vapor content for the separate air masses.

(c) Ballistic wind computations (CLs 1393 and 1492) were used to derive mean wind velocities, by season and altitude, by means of a rectilinear curve of regression: $y = ax + b$, determined by the least squares method, where x = mean velocity and y = a ratio of the wind at each level to the wind at bombing level (3, 6, and 9 km) from a tabulation of punched cards processed by the multiplier machine.

(d) Center of Gravity (pressure laminae) distribution of latitudinal, longitudinal, and pressure parameters (CL 1535) as described in report Weather Division Forecast Section, 1 March 1945, subject: Center of Gravity Analogue Technique, and used to index map type, were arranged by sorting and cumulative tabulating into deciles to facilitate statistical manipulation.

(e) For research on the land and sea breeze in Puerto Rico (CL 1537), resultant winds (F) were obtained from punched cards multiplied in accordance with the formula $F = u \csc [\tan^{-1}(u/v)]$, where u = the x-component and v = the y-component of the wind between levels, both calculated from elevation, elevation angle, and azimuth angle, read by theodolite.

(f) Computations of correlation for North Atlantic monthly mean pressures from 1899 to 1939 daily maps weighted latitudinally and longitudinally by 14 sets of coefficients to form series of products designated orthogonal polynomials (CLs 1896, 2009, 2019, 2059) were accomplished by accounting machines. The monthly mean pressure values of each of 14 orthogonal polynomials were correlated, with each of the 14 values for each day, within a season and zone, classified according to 41 (later 15) types of pressure distribution. Correlation coefficients obtained by a simplification of the method of least squares were reduced in value by a divisor which prevented any such coefficient from exceeding unity in absolute value. Coefficients

of the polynomials were selected to place the axes of pressure variables at right angles to each other.

(g) Pressure center track study for the Northern Hemisphere (CL 2056) places on punched cards for every day (1899-1939) each weather system existent designated by the date of origin or of first appearance of the system. Systems are identified by frontal criteria and type of pressure center. Direction criteria and type of pressure center. Direction of movement and location are also included. Tabulation by 5° and 10° geographical coordinate squares of frequencies, intensities, direction, and speeds of these systems is planned.

(h) Forecaster stability study (CL 2078) used punched cards to divide forecaster scores in the Short Range Verification Program into 8 groups (2 groups for each type of forecast) of 10 staggered weeks each, in the calculation of variances between sections of the groups determined by splitting each group of forecasters into quartiles according to number of forecasts in order to determine the stability of a forecaster (reliability of his forecasts), with relation to the number of forecasts and to his standing. Originally the variances were to be used as weights in the scoring of the above Short Range program.

e. Northern Hemisphere Map Project. (1) As an aid to research studies by military and civilian agencies, it is the plan of the Air Weather Service and United States Weather Bureau to publish a continuation of the Daily Synoptic Series of Historical Weather Maps of the Northern Hemisphere on a current basis, both the surface map and 500 millibar chart. In addition to the printed analysis of the daily weather maps, it is desired that a listing of the data from which the maps are spotted should also appear. It might seem at first glance that this should be an easy task, but the difficulties encountered are numerous.

(2) The first attempt to present these data was made by photographing the actual signals as received by teletype, after being arranged on the page for publication. This, however, did not prove satisfactory, mainly because it was almost impossible to identify the stations with only the three-digit International Index Number, and because the data were in a great variety of codes, and still contained garbled and duplicate material. It was therefore decided to apply the punched card method to the

solution of the problem.

(3) The first difficulty to be overcome was the identification of the reporting station by its three-digit station number. This was done with the help of two publications: the AACS Weather Transmission Handbook and the Radio Weather Aids to Navigation. For stations not listed in either of these books, information concerning the location is obtained from whatever other source is available. For stations without index numbers, arbitrary numbers must be assigned. Master name cards, containing name and number are punched and listed alphabetically, and numerically within area, presenting a complete station list for all stations reporting regularly. Only stations that report consistently are used for the listing.

(4) The synoptic observations as received via teletype in the Master Analysis Central, Washington, are sent to Data Control Unit, where they are edited by a staff of clerks so that the data appear in uniform codes. The observations are then punched into cards. The cards are listed by day in numeric order within area, the data appearing in the five-digit groups, so familiar to meteorologists. The maps and the data for each day in the month are published in one book, with the station lists appearing as an index.

(5) The United States Weather Bureau code is used as a basis for editing observations, but separate codes are used for land and ship stations. Editing of surface reports consists of three main steps: correcting obvious transmission or observation errors; assigning to the three-digit International Index Number an additional two-digit code so that stations may be sorted under their respective countries; and reducing the various land codes into one standard code for columnar listing. (The problem of converting temperatures is handled by machine operation, but the indication of the presence of Centigrade values must be done manually.)

(6) Preparing upper air teletype reports for card punching and listing is similar to the preparation of the surface reports. Correction of errors and designation of station numbers is handled the same way. In addition, pibal stations that use alphabetic designators must be assigned numeric ones. This very often entails considerable research into lists of stations and maps to get the correct numeric designators. In the upper air reports, the codes used are too various and dissimilar to attempt to reduce them to one code, such as is done for the surface reports, but all observations are given a number, indicating the type of observation and code used. These codes with their interpretation are given in the preface to the data.

(7) After the cards have been punched and verified, they must be processed by machines. Land and ship observations must be separated. Cards for land stations that contain various codes are reproduced, so that all may be listed in columnar order as one code. Selected hours of observations are made, duplicate observations are removed, and listed separately for further comparison, and all observations matched against the master deck so that only those reporting consistently are listed. The above description of machine procedures is only a very brief outline; the actual processing involves almost fifty distinct steps, much too complicated to discuss in this paper.

(8) A proof listing is then made. This, together with the listing of duplicate observations, is checked by the editing section for both machine error and meteorological dependability. In this operation the use of good common sense and meteorological experience are requisites. Cards in error are indicated, repunched, and finally the entire month's cards are listed for publication.

(9) Throughout our experience with this project, it appears that machine methods are better in several important respects than other methods formerly used to prepare such data for publication. The arrangement of data into uniform codes and the manner of identification of stations used are far superior to the haphazard way found in the original teletype reports. The amount of work required to prepare one day's observations, however, is quite extensive, and only with a large staff of editors and checkers, all familiar with the meteorological codes, and an efficient and closely coordinated tabulating machine section, can it be done.

f. Captured Enemy Weather Records. (1) General. Representatives of Data Control Unit were sent to both Germany and Japan at the end of the war, to survey and obtain captured enemy weather records. The German Weather Service had developed the punched card technique to the point where their work was approximately on the level of ours, as of 1945. Consequently, there were a great many punched cards available to the United States from this source. The Japanese Weather Service was doing a small amount of work with punched cards, but their progress along these lines was practically nil, and no punched cards were captured.

(2) German Records. (a) Two important card decks of weather observations were captured, one now in the possession of the British, and the other at Data Control Unit. It is planned that the British deck (called Meteorologie) will be reproduced by them for their use, and the original deck forwarded

to this unit for further reproduction for our use. The deck in New Orleans (called Kopenhagener Schluessel) will be reproduced three times by Data Control Unit, one deck for our use, one for the British, and one to replace the deck for the Germans, since the original deck is in such poor condition.

(b) There are approximately seven million cards in the Kopenhagener Schluessel deck, a net weight of about twenty-one tons. The main reproducing problem is to get the cards through the machines. Despite a supposedly waterproof packing, the cards were received after their ocean voyage in a waterlogged state. It was also learned that they were left standing outside in the weather for a number of weeks, before being shipped to the United States. Their condition would be bad enough if they were merely damp, but as much as half an inch of water was found in some of the cartons upon arrival. These cards must be allowed to dry, and even then, some become so warped that they will not feed through the reproducer, or they feed partly through, causing a jam which stops the operation. Badly warped cards and damaged cards must be reproduced manually on the key punch machine, a method much slower than that of the reproducing punch.

(c) Another difficulty is that the cards are slightly thinner than cards made in the United States, so that two cards often feed into the machine simultaneously, causing a jam. This was overcome by having the card feed aperture narrowed slightly on the reproducers being used for this job.

(d) Many of the German cards are off-punched, that is, the holes in the card are not parallel to the edge of the card. This causes faulty reproduction, thus making the work go even slower. At times, the reproducer stops (for incorrect reproduction) about every five or six cards. Yet some of the cards are in good enough condition that several hundred cards feed through the machine without stopping it.

(e) In addition to the cards, microfilm of the source material has been obtained, numbering almost 700 reels of film. These films contain the equivalent of our WBAN-10A, and will prove valuable as a source of data in years to come. The Kopenhagener Schluessel cards and accompanying microfilm consist of records gathered by the Germans in occupied countries during the war, and will eventually be

used for producing varied climatological summaries for a number of European and Middle East stations, not obtainable from any other source available in the United States.

(3) Japanese Records. Since no cards were available from Japan, an effort is being made to obtain weather records from the Central Meteorological Office for punching, to fill in gaps in areas and periods of record for which the United States has no data. Two representatives were sent to Japan to arrange the program of punching these data, since it was deemed impractical to transport the original records to the United States. The 20th Statistical Control Unit is punching such observations in Tokyo forwarding the completed cards to Data Control Unit. A number of Type 001 key punch machines were forwarded to the 43d Weather Wing, in Tokyo, with the intention of using Japanese nationals as key punch operators. It is expected that a valuable group of cards will be obtained, but no estimate of the card volume can be made at this writing.

g. Future Projects Contemplated. The following are a few applications of this valuable tool, the punched card, to further weather studies. The sheer volume of statistical computations necessary to compile enough data to prove or disprove a theory in the field of meteorology, is so enormous to dismay the person who is faced with hand tabulation. Now for the first time it is possible to explore the many paths that will eventually lead us to the best answer. A new field of applied meteorology has developed from the war, that of the meteorological engineer, who translates the architect's idea into the solid structure of application.

(1) Computation of secondary land fields. (a) It is possible and feasible to compute the chances in a hundred of finding secondary fields which have ceilings and visibility above minimums when the primary landing field is closed. In this operation a time lag can be introduced which would permit the slowest or fastest aircraft to reach this second field, and/or require that the second field remain above minimums for any specified length of time.

(b) The meteorological explanation of this condition is that due to the orographic effect, under certain wind streams a station will be subjected to upslope winds while another station, due to its locality, will have downslope winds.

(c) This information is particularly valuable in the Arctic and sub-Arctic regions, where during the course of a flight the Aurora Borealis may completely interfere with radio reception. It would also be valuable for flight planning to make gasoline allowance for alternate airports.

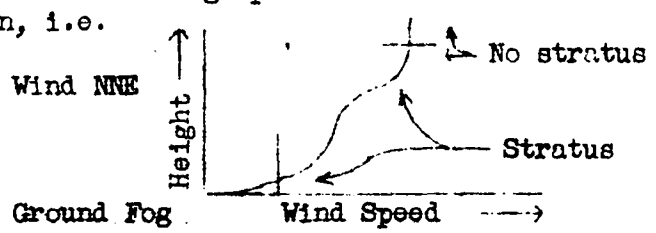
(2) Computation of the isochronic coefficient for Analogues.

(a) The present method of selecting analogues, although a valuable tool in the hands of the forecaster, has certain limitations. The most outstanding is its inability to match systems with different accelerations. That is, if the analogue selected has systems undergoing deceleration while the current map has systems accelerating, the present method is unable to compensate for this effect. If, however, the historical maps have previously computed values for acceleration or deceleration, and three current maps are compared against these values, it will be possible to determine whether, for example, five analogue maps must be used for the next five days, or whether four or six are necessary. This will place the emphasis on the behavior of the systems rather than on the precise location of the systems.

(b) The present IBM equipment can be adapted to handle simple behavior patterns, but for more advanced and multiple correlations, a machine will have to be built using electronic counters and memory tubes in order that this information will be available within one hour after basic data are received from the forecasters. The requirements for such a machine and basic design are being prepared. This machine will also embrace features which will enable this unit to handle more voluminous and complex tabulations in a shorter time than they are now being done.

(3) Computations of roughness parameter. (a) The roughness parameter is a factor, peculiar to each station, wind direction, and speed, which when empirically derived gives the height of the turbulence inversion.

(b) This derived figure enables a forecaster to tell the critical speed for each direction at which radiational, advectional, or ground fog will lift to low stratus, the height to which it will lift, and the upper limit of velocity at which no fog will form, regardless of radiational effects. These values can be shown in graphical form for each wind direction, i.e.



(c) If the temperature - dewpoint depression and sky condition indicate the liklihood of radiational fog, then by forecasting the gradient or geostrophic wind by Petterssen's method or any desired means, the height of the ceiling will be determined by the roughness parameter for that field and that direction. Since the roughness parameter will be derived from actual cases of wind and ceiling height, such factors as adiabatic cooling, or heating, lake effects, etcetera will be included in the curve.

(d) This method has been used to a limited degree from hand computed curves by Eastern Air Lines for a number of years and has been found to be very accurate for stations within 200 miles of the coast. By using machine methods a longer period of record can be used, with resulting greater accuracy of curve definition. Machine applications of this sort take one tenth the time of hand tabulations.

(4) Single or multiple station study. (a) Each weather station has peculiarities of exposure, terrain and location which make it a different forecasting problem from any other station, irrespective of distance to that other station. By means of IBM equipment it is possible to guide the research worker in his efforts to solve these peculiarities. For example, if one is interested in the courses of low visibility so as to formulate forecasting rules, it is possible to select out all those cases, where low visibilities did not occur, and eliminate the greater bulk of material to be handled and concentrate only on those cases where low visibilities did occur.

(b) By making a frequency distribution of elements or difference in elements, one can further refine the search and on this first run, through the tabulator, find the positive or negative dependence of these elements. It is also feasible to check interdependence between stations for the same or different elements, thus proving or disproving rapidly the existence of scattered Key Stations.

(c) Since all meteorological elements are more or less dependent upon one another, and that degree of dependence is a variable between stations, a new forecaster who has had little or no experience working at a station, will unless otherwise advised, bring with him a sum of his previous experience, which may lead him to erroneous conclusions, until he gains experience at this new station. If, however, a comprehensive study

that is uniform within the weather service, is prepared for each station, then when a man is transferred he will be able to tell wherein this new station differs from the old, and how much the difference is, and the reason for this difference.

(5) Comparative flyability for U. S. stations. (a) The standard summary of Army stations includes a summary of contact instrument and closed weather based upon simultaneous ceiling and visibility observations. With this information it is possible to make a listing by months in order of flyability of all Air Force airfields.

(b) This listing could also be prepared on an annual basis, or a summation of all months, or years of operations.

(6) Time of fog formation curves. (a) Similarly to the explanation in paragraph (3), curves can be computed showing the time fog formation as derived from such factors as temperature - dew point depression at sunset. These curves can also be refined by such corrective factors as the amount of insolation, computed from the hourly cloud amount.

(b) These curves can be constructed in several ways, by using only temperature - dew point depression and time of fog formation, with a corrective factor for insolation, or the insolation factor can be made part of the curve.

(c) The time that fog forms is a function of the radiation and of advection of moist air. The radiation portion is a sum of positive radiation during the day and is proportional to the hours of direct sunlight, and the negative radiation during the night. These two radiations are functions of the amount and thickness of the cloud layer. The thickness of the cloud layer can be approximated from the cloud type. The temperature and dew point are indicative of the advection factor, and the difference between the two show the amount of radiational cooling that is necessary to produce fog.

(d) These curves together with the roughness parameter curves, enable a forecaster to give a very good estimate of the time that fog will occur, and whether the fog that does occur, will be ground fog or stratus, and if it is stratus at what height it will form.

(7) Computations of gradient wind from unanalyzed data.

(a) The isobaric weather map represents the contour lines of the hills and valleys of the air mass that lies over the earth's surface. The distance between the isobars is inversely proportional to the slope of this pressure surface. These isobaric lines are approximates of this surface, as they are sketched in by hand by visual inspection from the pressure values, as reported by the stations. From these lines the equation $2\omega \sin x$ is applied to determine the gradient or geostrophic wind. This wind is the wind at the lowest level at which the surface friction has no effect. The arithmetical value of this wind may better be determined by reference directly to the pressures reported by surrounding stations, rather than to the sketched lines.

(b) The slope of a plane surface can be completely defined by means of three points on that surface. If values of the slope of this surface are correlated against roughness parameter, then more accuracy can be expected from them, than by going through an intermediate approximate step of drawing the pressure fields. These values can be presented either by nomograms or in tabular form.

(c) These correlated values, if computed for foreign areas will also enable reconnaissance aircraft by taking three pressure readings while flying in a "u" shaped pattern, to make a gradient wind forecast, for an area without actually flying over that target area. The above of course, assumes that the pressure planes are laminar, which is not strictly true; therefore, the limits of accuracy will decrease with altitude.

(8) Pressure Center Track Studies. (a) This unit has a deck of cards which, when checked give for each high and low in the Northern Hemisphere, for each day from 1899, to June 1939; the location, intensity, axis, type, speed in the past 24 hours, speed in the next 24 hours, and the acceleration or deceleration of each system, as well as the date, latitude and longitude of the system on the first date it was located. With these cards the following studies can be prepared:

1 Locations of zones of acceleration or deceleration on the earth's surface.

2 Frequencies of highs and lows of various intensities for 5° squares.

3 Origin of highs and lows crossing a specified area.

4 Velocity roses for each 5° square.

5 Characteristic weather by area for each type of system.

6 Paths of various systems from a point of origin.

7 Construction of new Analogue card decks.

8 Route studies to determine most satisfactory flight path or ship route.

9 Military studies involving sea conditions.

(b) This data would most satisfactorily be shown by means of charts, although the tabular form would necessarily have to be prepared first. Therefore, the results could be used by meteorologists before the charts were prepared.

(9) New upper air normals. (a) Prior to 1946 upper air data was compiled on a basis of constant levels, After that time, data has been recorded by means of constant pressures aloft. The previously compiled normals do not reflect these new values, therefore, the past data must be recomputed, to allow comparison with the current observational practice.

(b) These normals should be shown by means of charts, so that the information may be readily inspected.

(10) Upper Air Flight Path Analysis. (a) By the use of data observed over the earth during the war, it is now possible for the first time to prescribe optimum flight paths for aircraft operating over large areas outside the U. S. These paths could be found not only with respect to best horizontal location but also the best altitude to fly.

(b) The number of possible routes are so numerous, it would be better to leave the data in the tabular form, and request information from a central agency who could take this information and interpret it for the user.

(11) Comparison of normal wind rose data with overcast wind frequencies.

(a) Prior to the development of radar winds aloft and

radio direction finding equipment for winds aloft, it was not possible to observe with any degree of regularity the winds above an overcast; as a result the upper levels wind normals were distorted, due to the fact that they could only be observed during good weather. But with the use of radio wind data it is possible to compute the factor of distortion due to bad weather. With this corrective figure, new frequencies can be computed which are nearer to the true normal.

APPENDIX

Samples of the Uniform Summaries

The following illustrations show for a typical Air Force station a sample page from each type of the uniform summaries described on page 35.

The A Summary begins with the recapitulation sheet, which shows the percentage frequency by month of all parts of the A Summary except Surface Winds. The annual summary of Surface Winds is shown, and each of the other five summaries is represented by the month of January. These consist of summaries of

1. Flying Weather
2. Ceiling Height
3. Visibility
4. Weather Conditions
5. Sky Conditions

The complete B Summary is shown, since it consists of but four pages. Summaries are shown for each month and annually for

1. Maximum Temperature
2. Minimum Temperature
3. Mean Temperature
4. Snow Depth
5. Precipitation Amounts

ANNETTE ISLAND, ALASKA (STATION NAME) — AUG 1941 THRU JAN 1947 (PERIOD) — OF ALL OBSERVATIONS

STATION NUMBER	MONTH	FLYING WEATHER: WEA. CLASSIFICATION 1 CLOSED	2 INSTR.	3 CONTACT	OBSTRUCTIONS TO VISION IV < 1 MILE: FOG	SMOKE AND/OR HAZE	BLOWING SNOW AND/OR DUST	PRECIP.	CAUSE UNKNOWN	TOTAL OBS. < 1 MILE	VISIBILITY (MILES): ≤ ⅛	≤ ¼	≤ ½	≤ ¾	≤ 2¼	≤ 2½	≤ 6	≤ 9	10 and Over
85301	JAN	38	116	846	09	00	01	15	00	25	06	13	19	29	100	109	313	447	553
	FEB	32	85	883	09	00	05	08	00	22	06	09	19	23	73	80	243	345	655
	MAR	23	105	872	02	00	00	15	00	17	*	02	12	20	83	88	255	340	660
	APR	11	66	923	05	00	00	03	00	07	02	04	06	08	29	33	214	299	701
	MAY	30	55	915	14	00	00	02	00	16	08	10	14	16	38	40	126	179	821
	JUN	43	82	875	14	00	00	03	00	18	01	04	13	18	50	53	168	160	840
	JUL	63	87	850	17	00	00	07	00	24	06	09	15	26	66	70	160	206	794
	AUG	74	80	846	30	00	00	03	00	33	16	21	27	34	86	88	177	227	773
	SEP	84	112	804	41	00	00	02	00	44	21	29	38	44	110	116	248	304	696
	OCT	53	127	820	18	00	00	03	00	21	03	05	13	22	101	112	269	359	641
	NOV	38	97	865	10	00	00	11	00	21	03	06	12	22	83	92	203	316	684
	DEC	35	104	861	09	00	00	10	00	19	01	04	13	23	87	89	291	412	588

MONTH	SKY CONDITION: CLEAR	SCATTERED	HI SKN OR HI OVC WITH SCTC OR NO LOW CLOUDS	LOW BROKEN	LOW OVERCAST	CEILING HEIGHT (FEET): ≤ 450	≤ 950	≤ 2050	≤ 3050	≤ 5250	≤ 9750	Over 9750	WEATHER CONDITIONS: THUNDER-STORMS	RAIN AND/OR DRIZZLE	FREEZING RAIN	SNOW AND/OR SLEET	HAIL	TOTAL OBS. W/PRECIP.
JAN	75	118	67	141	599	216	113	420	573	683	742	258	010	360	011	83	010	414
FEB	86	148	84	172	510	26	85	333	490	610	682	318	010	278	010	53	010	325
MAR	85	137	93	201	484	18	96	341	500	614	683	317	*	285	010	83	010	350
APR	52	146	118	196	489	08	65	331	506	616	686	314	010	344	*	16	010	351
MAY	117	178	183	176	346	27	76	233	343	446	528	472	010	231	010	00	010	231
JUN	50	147	121	231	451	36	114	249	379	551	685	315	010	221	010	00	010	221
JUL	60	129	125	184	502	57	143	286	403	557	690	310	010	252	010	*	010	252
AUG	131	200	102	158	409	63	135	270	351	471	573	427	010	308	010	00	010	308
SEP	133	158	102	141	466	73	165	290	388	518	604	396	010	261	010	*	010	261
OCT	45	138	100	193	524	42	146	357	501	632	713	287	010	375	010	03	00	378
NOV	96	116	88	149	551	24	108	362	518	627	700	300	01	364	01	50	02	408
DEC	72	109	77	170	572	28	113	419	587	681	743	257	010	304	00	97	*	388

1 CLOSED - CEILING < 451 FT AND OR VISIBILITY < 1 MILE.
2. INSTRUMENT - CEILING 451 TO 950 FT WITH VISIBILITY ≥ 1 MILE AND/OR VISIBILITY 1 MILE BUT < 3 MILES WITH CEILING ≥ 451 FT.
3. CONTACT - CEILING ≥ 950 FT. WITH VISIBILITY ≥ 3 MILES.

Form 10-405-47

AIR WEATHER SERVICE
DATA CONTROL UNIT

SURFACE WINDS
FREQUENCY OF DIRECTIONS BY VELOCITY GROUPS

WIND SUMMARY

ANNETTE ISLAND ALASKA (STATION NAME) — ANNAUG 1941 THRU JAN 1947 (PERIOD) — FT. (UPPER LIMIT OF CIG. AND VISIBILITY IF USED) MI.

STATION	YEAR	MONTH	CODE	VEL. / DIR	1-3 MPH	4-12 MPH	13-24 MPH	25-31 MPH	32-46 MPH	47 & OVER	TOTAL 4 MPH & OVER OBS.	TOTAL 4 MPH & OVER %	TOTAL ALL OBS. OBS.	TOTAL ALL OBS. %	TOTAL VEL.	AV. VEL.
25301		1	36	N	564	1163	143	2			1308	28	1872	40	11573	6.2
			02	NNE	202	439	87	12	5		543	12	745	16	5846	7.8
			04	NE	454	775	208	24	5		1012	22	1466	31	10639	7.3
			06	ENE	205	608	408	69	12		1097	24	1302	28	14560	11.2
			08	E	284	819	606	123	31	.	1579	34	1863	40	22519	12.1
			10	ESE	202	2437	3020	523	78	2	6060	130	6262	134	93026	14.9
			12	SE	459	3558	2225	487	271	6	6547	140	7006	151	92117	13.1
			14	SSE	209	2457	1897	472	198	9	5033	107	5242	112	75673	14.4
			16	S	361	2373	898	108	29		3408	73	3769	81	39188	10.4
			18	SSW	136	1226	363	17	7		1613	35	1749	38	16850	9.6
			20	SW	218	1091	183	9	4		1287	28	1505	32	12031	8.0
			22	WSW	95	760	130	5			895	19	990	21	8383	8.5
			24	W	209	966	81	1			1048	22	1257	27	8678	6.9
			26	WNW	235	1448	113	6			1567	34	1802	39	12834	7.1
			28	NW	536	2705	327	1			3033	65	3569	77	26370	7.4
			30	NNW	513	2665	632	15	2		3314	71	3827	82	31916	8.3
			40	CALM									2387	51		
TOTALS →					2387	4883	25490	11321	1874	642	17	39344	XXXX XXXX	46613	XXXX XXXX	481891	10.3
PERCENT →					5.1	10.5	54.7	24.3	4.0	1.4	*		84.4		100.0	XXXXXXXX XXXXXXXX	XXXXX XXXXX

ANNETTE ISLAND ALASKA — STATION NAME

JAN — PERIOD

STATION	YEAR	MONTH	HR (L.S.T.)	WEATHER CLASSIFICATION			OBS. WITH VISIBILITY < 1 MI., CAUSED BY:						TOTAL
				CLOSED [1]	INSTRUMENT [2]	CONTACT [3]	FOG	SMOKE AND/OR HAZE	BLOWING SNOW AND/OR DUST	PRECIPITATION	CAUSE UNKNOWN	TOTAL OBS. < 1 MILE	
25301		01	01	5	15	166	2			2		4	186
			02	4	18	164	1			2		3	186
			03	1	21	164							186
			04	5	17	164				4		4	186
			05	7	19	160	1			5		6	186
			06	6	18	162	2			3		5	186
			07	7	17	162	4			2		6	186
			08	7	20	159	3		1	2		6	186
			09	8	21	157	3		1	2		6	186
			10	12	16	158	5			3		8	186
			11	9	23	154	2			3		5	186
			12	10	26	150	3			3		6	186
			13	9	28	149	3			4		7	186
			14	11	32	143				5		5	186
			15	9	27	150				4		4	186
			16	12	18	157	3			2		5	186
			17	7	24	155	2			3		5	186
			18	5	19	162	2		1	2		5	186
			19	6	23	157	1			4		5	186
			20	8	22	156	1			3		4	186
			21	5	24	157	1			2		3	186
			22	6	21	159	1		1	1		3	186
			23	6	24	156	1		1	2		4	186
			24	6	23	157	1			2		3	186
TOTALS →				171	516	3778	48		5	65		118	4464

[illegible] FEET AND OR VISIBILITY < MILE

2 INSTRUMENT [illegible] FT WITH VIS ≥ MI AND OR VIS [illegible] MI BUT < 3 MI WITH CEILING ≥ 431 FT.

3 CONTACT [illegible] WITH VIS ≥ 3 MI

FORM [illegible]

AIR WEATHER SERVICE
DATA CONTROL UNIT

FREQUENCY OF OCCURRENCE BY HOURS

CEILING HEIGHT (FEET)

ANNETTE ISLAND ALASKA — STATION NAME

JAN — PERIOD

STATION	YEAR	MONTH	HOUR (L.S.T.)	0-450	451-950	951-2050	2051-3050	3051-5250	5251-9750	9751 & OVER	TOTAL
25301		01	01	4	9	54	27	26	8	55	185
			02	3	12	48	27	26	13	55	186
			03	1	13	54	30	25	9	54	186
			04	1	10	58	34	20	6	57	186
			05	1	11	59	32	18	9	56	186
			06	3	10	58	29	20	7	59	186
			07	3	9	63	31	16	6	58	186
			08	3	16	61	35	20	10	41	186
			09	7	15	69	23	15	14	43	186
			10	9	13	66	26	17	16	39	186
			11	8	20	60	25	20	16	37	186
			12	8	24	57	25	13	17	42	186
			13	6	25	59	25	14	20	37	186
			14	9	28	53	25	17	16	38	186
			15	8	20	54	32	14	10	48	186
			16	9	16	53	33	18	15	42	186
			17	5	22	64	27	16	13	39	186
			18	3	15	63	27	22	14	42	186
			19	3	17	58	26	21	11	50	186
			20	6	15	55	29	25	2	54	186
			21	4	18	48	30	26	10	50	186
			22	4	13	56	29	27	8	49	186
			23	4	19	47	28	27	7	54	186
			24	4	16	50	29	28	6	53	186
TOTALS →				116	386	1367	684	495	263	1152	4463

AIR WEATHER SERVICE
DATA CONTROL UNIT

FREQUENCY OF OCCURRENCE BY HOURS

VISIBILITY (MILES)

ANNETTE ISLAND ALASKA — STATION NAME

JAN — PERIOD

STATION	YEAR	MONTH	HR. G.C.T.	0, 1/16, 1/8	3/16, 1/4	5/16, 3/8, 1/2	5/8, 3/4	1 THRU 2 1/4	2 1/2	3 THRU 6	7 THRU 9	10 & OVER	TOTAL
25301		01	01		1		3	12		36	28	106	186
			02		1	1	1	11		43	22	107	186
			03					14		46	21	105	186
			04		1	1	2	12		42	26	102	186
			05		3	2	1	12	3	37	30	98	186
			06	2			3	12		33	34	102	186
			07	1	1	2	2	12	1	38	30	99	186
			08		4	1	1	12		41	26	101	186
			09	1	2	1	3	12	1	38	25	103	186
			10	1	2	3	2	11	1	35	24	107	186
			11		4	1		13	1	44	22	101	186
			12		1	4	1	11		49	20	100	186
			13	2		1	6	12		44	27	94	186
			14	2		2	3	17	3	45	19	95	186
			15	1	2		2	18	3	39	25	96	186
			16	1	2	1	3	9	3	44	22	101	186
			17	1	3	1	2	14	3	37	25	100	186
			18		1	2	2	13	1	35	29	103	186
			19	2		2	2	15	3	36	22	104	186
			20	2		1	2	15	4	31	27	104	186
			21	3	1			14	3	30	27	108	186
			22	2	1		1	16	3	26	25	112	186
			23	3		1	1	14	2	32	21	112	186
			24	2			2	17	3	31	21	110	186
TOTALS →				26	30	27	45	318	38	912	598	2470	4464

NOTE COLUMN HEADINGS ARE THOSE VISIBILITY VALUES USED IN ORDINARY REPORTING PRACTICES. UNDER THESE PRACTICES, WHERE VISIBILITIES ARE ACTUALLY BETWEEN REPORTABLE VALUES THE LOWER VALUE IS RECORDED

1

FORM 10-57-45

DATA CONTROL UNIT

FREQUENCY OF OCCURRENCE BY HOURS

WEATHER CONDITIONS

ANNETTE ISLAND ALASKA — STATION NAME

JAN — PERIOD

STATION	YEAR	MONTH	HR. (L.S.T.)	THUNDERSTORMS	RAIN AND/OR DRIZZLE	FREEZING RAIN	SNOW AND/OR SLEET	HAIL	TOTAL OBS. WITH PRECIP.	TOTAL
25301		01	01		59		15		70	186
			02		60		12		70	186
			03		61	1	17		76	186
			04		61	1	14		76	186
			05		64	1	11		75	186
			06		60	1	13		73	186
			07		64		17		79	186
			08		64		13		77	186
			09		65		17		80	186
			10		57		17		72	186
			11		71		15		85	186
			12		65		18		83	186
			13		65		20		84	186
			14		66		20		85	186
			15		64		17		79	186
			16		68		16		81	186
			17		73		16		87	186
			18		64	1	13		76	186
			19		63		15		76	186
			20		63	1	13		73	186
			21		63		14		75	186
			22		57		14		70	186
			23		59		16		71	186
			24		59		18		73	186
TOTALS →					1515	6	371		1846	4464

AIR WEATHER SERVICE
DATA CONTROL UNIT

FREQUENCY OF OCCURRENCE BY HOURS

SKY CONDITIONS

ANNETTE ISLAND ALASKA — STATION NAME

JAN — PERIOD

STATION	YEAR	MONTH	HOUR (L.S.T.)	CLEAR	SCATTERED	HI BKN OR HI OVC WITH SCTD OR NO LOW CLOUDS	LOW BROKEN	LOW OVERCAST	TOTAL
25301		01	01	18	23	15	24	106	186
			02	16	26	12	21	111	186
			03	16	26	13	15	116	186
			04	20	19	18	19	110	186
			05	23	22	11	18	112	186
			06	23	25	11	16	111	186
			07	20	24	14	16	112	186
			08	13	16	13	30	114	186
			09	10	19	15	31	111	186
			10	11	18	11	36	110	186
			11	13	11	13	35	114	186
			12	10	15	18	32	111	186
			13	8	17	12	40	109	186
			14	6	19	13	28	120	186
			15	5	28	14	25	114	186
			16	5	26	11	34	110	186
			17	6	18	16	32	114	186
			18	7	25	11	28	115	186
			19	8	30	12	28	108	186
			20	16	28	10	22	110	186
			21	17	23	10	20	116	186
			22	19	22	8	24	113	186
			23	23	22	9	26	106	186
			24	20	24	9	28	105	186
TOTALS →				333	526	299	628	2678	4464

NOTE: LOW CLOUDS ARE HEREIN DEFINED AS THOSE REPORTED BELOW 9731 FEET. HIGH CLOUDS ARE HEREIN DEFINED AS THOSE REPORTED AT OR ABOVE 9731 FEET.

FORM 05-13-11

AIR WEATHER SERVICE
DATA CONTROL UNIT

FREQUENCY OF DAILY MAXIMUM TEMPERATURES

ANNETTE ISLAND ALASKA — OCT 41 THRU DEC 46 LESS 7/46

STATION NAME — PERIOD

STATION	YEARS	MAX TEMP (°F)	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	TOTALS
25301		014–015	1												1
25301		016–017	1												1
25301		018–019	2												2
25301		020–021	2												2
25301		022–023	2												2
25301		024–025											1		1
25301		026–027												2	2
25301		028–029		1											1
25301		030–031	3	2									5	5	15
25301		032–033		1	1								2	3	7
25301		033–035	3		2								1	5	11
25301		034–035	9	6	5								6	15	41
25301		036–037	15	9	7								9	21	61
25301		038–039	11	14	17	2						2	15	26	87
25301		040–041	17	17	32	5						1	15	23	110
25301		042–043	18	26	39	13						3	13	21	133
25301		044–045	27	34	27	26	1					10	13	33	171
25301		046–047	26	15	10	33	6					12	13	17	132
25301		048–049	10	10	7	22	16				1	17	30	12	125
25301		050–051	4	4	4	22	19	6				34	21		114
25301		052–053	1		1	15	21	6	3	1	13	51	6	2	120
25301		054–055				5	14	19	11	2	19	28	2		100
25301		056–057	3	1	2	2	12	21	8	13	31	12	2		107
25301		058–059		1		1	12	24	17	22	20	9		1	107
25301		060–061				2	14	20	19	21	21	2			99
25301		062–063			1	1	9	11	15	18	13	3			77
25301		064–065					8	11	12	23	6	2			62
25301		066–067					4	8	9	18	6				45
25301		068–069					7	6	8	10	4				35
25301		070–071				1	3	2	7	8	9				30
25301		072–073					4	2	6	6	4				22
25301		074–075					1	3	3	3	3				13
25301		076–077					2	1	1	5					9
25301		078–079						2	2	1					5
25301		080–081						1	2	1					4
25301		082–083						1	1	1					3
25301		084–085								1					1
25301		086–087								1					1
TOTAL NO OF DAYS			155	141	155	150	153	150	124	155	150	186	154	186	1859
SUM OF TEMPERATURES			6394	5999	6572	7177	8700	9063	7837	9958	8957	9628	6777	7574	94630
MEAN DAILY MAX TEMP			41.3	42.5	42.4	47.9	56.9	60.4	63.2	64.2	59.7	51.7	44.0	40.7	50.9

AIR WEATHER SERVICE
DATA CONTROL UNIT

FREQUENCY OF DAILY MINIMUM TEMPERATURES

OCT 41 THRU DEC 46 LESS 7/46

STATION NAME

STATION	YEAR	MIN TEMP (°F)	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	TOTALS
			PERIOD												
25301		004 - 005	1												1
25301		006 - 007	2												2
25301		010 - 011	2												2
25301		012 - 013	1												1
25301		014 - 015	1											1	2
25301		016 - 017	1										1		2
25301		018 - 019	1										1	1	5
25301		020 - 021	3										3	7	18
25301		022 - 023	2	6									6	15	30
25301		024 - 025	5	1	5								6	10	32
25301		026 - 027	5	5	6							2	8	16	52
25301		028 - 029	9	8	15							1	10	42	101
25301		030 - 031	11	23	28	6						2	8	13	71
25301		032 - 033	9	12	17	10						2	17	15	79
25301		034 - 035	11	10	17	6	1					7	22	25	143
25301		036 - 037	13	24	23	21	2				1	16	13	19	151
25301		038 - 039	17	24	24	33	4				1	16	14	15	121
25301		040 - 041	17	15	8	24	11				5	28	11	5	134
25301		042 - 043	16	7	4	30	27	1			7	27	15	15	135
25301		044 - 045	17	4	6	14	22	7	1		14	24	19	6	128
25301		046 - 047	5	2	2	5	36	6	1	2	25	24	2		101
25301		048 - 049	1			1	20	22	3	3	25	18	4	1	168
25301		050 - 051					22	48	16	22	35	10			162
25301		052 - 053					5	50	38	29	30	8			158
25301		054 - 055					1	11	37	55	20	1			63
25301		056 - 057					1	4	14	33	10				19
25301		058 - 059					1		7	9	2				7
25301		060 - 061							5	1					3
25301		064 - 065						1	2						1
										1					
TOTAL NO. OF DAYS			155	141	155	150	153	150	124	155	150	186	154	186	1859
SUM OF TEMPERATURES			5231	4755	5149	5621	6707	7325	6438	8067	7283	7980	5569	6152	76277
MEAN DAILY MIN TEMP			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	48.8	51.9	52.0	48.6	42.9	36.2	33.1	41.0

Form 02 8 [illegible]

AIR WEATHER SERVICE
DATA CONTROL UNIT

FREQUENCY OF DAILY MEAN TEMPERATURES

ATTU I. ISLAND, ALASKA — STATION NAME

OCT 41 THRU DEC 46 LESS 7/46 — PERIOD

STATION	YEAR	MEAN TEMP (°F)	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	TOTALS
25301		008-009	1												1
25301		012-013	1												1
25301		014-015	3												3
25301		016-017	2												2
25301		020-021	1										1		2
25301		022-023	1												1
25301		024-025	1											2	3
25301		026-027	2	3									4	4	13
25301		028-029	3	4	2								4	11	24
25301		030-031	7	3	4								6	12	32
25301		032-032	5	3	3								5	13	29
25301		033-033	6	5	5								1	7	24
25301		034-035	14	14	27	2						2	10	30	99
25301		036-037	20	17	37	7						3	20	18	122
25301		038-039	15	31	33	16		1				3	19	27	145
25301		040-041	18	38	21	32	2					8	6	22	147
25301		042-043	22	14	12	33	5					18	23	17	144
25301		044-045	23	5	6	34	16				1	30	17	14	146
25301		046-047	6	2	2	18	19	1			3	26	24	6	107
25301		048-049	2		1	3	33	7			9	34	10	2	101
25301		050-051	2	2	1	4	18	19	3	2	20	31	4		106
25301		052-053					21	34	17	6	39	16			133
25301		054-055			1		17	36	22	22	32	8		1	139
25301		056-057					13	26	28	44	19	5			135
25301		058-059				1	3	12	18	34	12	2			82
25301		060-061					2	6	12	22	7				49
25301		062-063					1	2	9	11	5				28
25301		064-065					3	2	7	7	3				22
25301		066-067						2	5	4					11
25301		068-069						2	3	1					6
25301		070-071								2					2
TOTAL NO. OF DAYS			155	141	155	150	153	150	124	155	150	186	154	186	1859
SUM OF TEMPERATURES			5810	5369	5858	6386	7689	8157	7136	9007	8109	8789	6181	6853	85344
MEAN DAILY TEMP.			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	54.4	[illegible]	58.1	54.1	47.2	40.1	36.8	45.9

Form 31A 4-46

STATION NAME ANNETTE ISLAND A A F S

PERIOD NOV 41 THRU DEC 46 LESS 7/46

FREQUENCY OF DAILY SNOW DEPTHS

AS MEASURED AT 0000 LST.

AIR WEATHER SERVICE
DATA CONTROL UNIT

STATION	YEAR	Month	FREQUENCY OF OCCURRENCE: NONE	TRACE	.01 - .05 INCHES	.06 - 1.0 INCHES	1.1 - 3.0 INCHES	2.1 - 6.0 INCHES	6.1 - 12.0 INCHES	1.1 - 3.0 FEET	2.1 - 3.0 FEET	3.1 - 4.0 FEET	4.1 - 5.0 FEET	5.1 - 10.0 FEET	OVER 10 FEET	TOTAL NO. OF DAYS	MEAN NO. OF DAYS WITH MEASURABLE SNOW DEPTH
85301		01	101	26	6	10	7	5								155	5.6
85301		02	112	12	4	2	3	5	2	1						141	3.4
25301		03	119	21	2	1	2	9								154	2.8
25301		04	146	2			1	1								150	0.4
25301		05	155													155	0.0
25301		06	150													150	0.0
85301		07	124													124	0.0
85301		08	155													155	0.0
85301		09	150													150	0.0
25301		10	154	1												155	0.0
25301		11	134	17	2			1								154	0.6
25301		12	136	16	6	6	8	10	4							186	5.7
TOTALS	➡		1636	95	20	19	21	31	6	1						1829	18.5

FREQUENCY OF DAILY PRECIPITATION AMOUNTS

PERIOD DEC 41 THRU DEC 46 LESS 10/44 11/45 7/46

STATION	YEAR	Month	FREQUENCY OF OCCURRENCE: NONE	TRACE	.01 INCHES	.02 - .05 INCHES	.06 - .10 INCHES	.11 - .25 INCHES	.26 - .50 INCHES	.51 - 1.00 INCHES	1.01 - 2.50 INCHES	2.51 - 5.00 INCHES	5.01 - 10.00 INCHES	10.01 - 20.00 INCHES	OVER 20.00 INCHES	TOTAL NO. OF DAYS	SUM OF PRECIPITATION AMOUNTS	MEAN MONTHLY PRECIPITATION	MEAN NO. OF DAYS WITH PRECIPITATION OF .06 INCHES
85301		01	30	12	2	15	12	26	26	20	12					155	4802	9.60	22.6
25301		02	36	18	3	13	8	15	25	14	8	1				141	3776	7.55	17.4
25301		03	25	15	2	24	9	26	20	22	12					155	4659	9.32	23.0
25301		04	32	13	6	12	7	29	21	25	5					150	3872	7.74	21.0
25301		05	64	22	5	11	6	15	19	9	4					155	2262	4.52	13.8
25301		06	53	31	8	14	6	12	18	4	4					150	1818	3.64	13.2
25301		07	44	19	6	7	11	11	14	5	7					124	2180	5.45	15.3
25301		08	63	26	7	11	7	17	10	8	6					155	2035	4.07	13.2
25301		09	60	20	5	8	8	6	11	18	13	1				150	4094	8.19	14.0
25301		10	20	13	2	11	10	14	15	23	15	1				124	5010	12.53	22.8
25301		11	37	10		8	9	12	15	28	9	2				120	4630	11.58	20.8
25301		12	37	17	8	12	12	34	24	30	12					186	5527	9.21	22.0
TOTALS	➡		491	216	54	146	105	217	218	206	107	5				1765	44665	9.34	19.1

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