U. S. DEPARTMENT OF COMMERCE
LUTHER H. HODGES, Secretary
WEATHER BUREAU
ROBERT M. WHITE, Chief

KEY TO METEOROLOGICAL RECORDS DOCUMENTATION NO. 3.021

History of Weather Bureau Barometric Pressure Measurements

Washington, D. C. — 1964

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PREFACE

The Key To Meteorological Records Documentation series has been established to provide guidance information to research personnel making use of climatological data. This publication attempts to do this for pressure measuring instruments and pressure reduction systems used in the U. S. Weather Bureau.

Thanks for assistance in preparing this bulletin go to my colleagues in the Weather Bureau for suggestions, criticism, review and encouragement and to Mrs. Marcella Thom and Mrs. M. Alice Clark for assistance in preparing the copy for printing.

J. H. Hagarty
Office of Climatology
U. S. Weather Bureau

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I. INTRODUCTION

Evangelista Torricelli, reference [3], 1609-1648, first formulated the hydrostatic principle by virtue of which the pressure of the air is measured by the ordinary barometer. Torricelli, a student of Galileo, saw in Galileo's notes that a column of water could not be raised higher than about 33 feet even if, by means of an air pump, all air were removed from inside the tube. He soon found that the weight of the column of water was proportionate to the pressure of the air outside the tube.

In order to reduce the size of the apparatus, Torricelli used mercury instead of water. He found that the height of the column varied a little at different times but that it did not rise or fall to any great extent. Thus, in 1643, by the Torricellian Experiment, he discovered that it is the pressure of the atmosphere that governs the height of the mercury. He continued his research and the next year was able to state that a column of mercury such as employed in his experiment could be used to observe variations in air pressure. Thus the forerunner of the present mercurial barometer came into existence. It was to undergo numerous modifications and refinements but the basic part of the instrument was to remain essentially unchanged until the present time.

II. INCHES VS MILLIBARS

Barometric pressure observations in the Weather Bureau have always been made in inches corresponding to inches of mercury. However, beginning in 1939 reduced barometric pressure in inches was converted to millibars before being plotted on synoptic maps. The millibar has been defined as a pressure unit of 1000 dynes per cm^2, convenient for reporting atmospheric pressures. The millibar does not fit into any commonly employed system of physical units. The following table shows the relationship between millibars and inches of barometric pressure, which is 1 inch to 33.86395 mb:

Inches	Millibars	Inches	Millibars
0.0	0.00	28.0	948.2
25.0	846.6	29.0	982.1
26.0	880.5	30.0	1015.9
27.0	914.3	31.0	1049.8

III. PRESSURE MEASURING INSTRUMENTS USED IN THE WEATHER BUREAU

Mercurial Barometers

The standard mercurial barometer (Fortin type) used by the Weather Bureau has changed but little during the life of the civilian Bureau, 1891 to date. Figure 1 taken from the 1894 edition of reference [9] illustrates this barometer, and it is described in detail in the same reference. It consists of a glass tube, about one-fourth inch inside diameter, closed at the top and surrounded with a thin metal tube, through which large openings are cut on opposite sides, exposing to view the glass tube and mercurial column. A thermometer is attached to the metal tube.

The cistern is so constructed that the level of the mercury within may be changed and adjusted to a certain index point.

The readings may be estimated to the nearest one-thousandths of an inch by means of the scale and vernier.

Variations of this type of barometer are the Tuch barometer, see figure 2, and the fixed-cistern barometer, figure 3.

Aneroid Barometers

The following is taken from p. 289 of the 1886 Report of the Chief Signal Officer, War Department:

> "Aneroid and metallic barometers are useful substitutes for the mercurial barometer.
>
> "The aneroid is an instrument which has come into extensive use owing to its convenient size and portability. ...In the aneroid, atmospherical pressure is measured by its effect in altering the shape of a small, hermetically sealed, metallic box, from which almost all the air has been withdrawn, and which is kept from collapsing by a spring. The top of the box is corrugated.

"When the atmospherical pressure rises above the amount which was recorded when the instrument was made, the top is forced inward, and vice versa, when pressure falls below that amount, the top is pulled outward by the spring. These motions are transferred by a system of levers and springs to a hand which moves on a dial like that of a wheel barometer....

"...The principle of the metallic (Bourdon's) barometer is somewhat similar to that of the aneroid...."

Early aneroid barometers are described in reference [9].

Later aneroid barometers are described in reference [12].

Barographs

This instrument is a form of aneroid barometer with the addition of parts by which a continuous record of the barometric oscillations are traced hour by hour upon a sheet of moving paper, or obtained by photographic processes upon sensitized plates. Barographs used in the early days of the Weather Bureau are pictured in Figures 4 and 5.

The early barographs were so designed that 1 inch of change in pressure was reflected as a 1-inch change on the chart. However, beginning in 1936 the barographs furnished were so constructed that a 1-inch change in pressure resulted in a 2-1/2-inch change of the pen at the point where it was in contact with the paper. An additional feature of the later barographs was the addition of a damping cylinder to slow down or dampen sudden fluctuations of the pen arm. This barograph is illustrated and described in reference [12].

Altimeter

This instrument is essentially an aneroid barometer calibrated to give an approximate measure of the altitude from a pressure measurement and an assumed temperature distribution. It is used to check altimeter settings on aircraft.

Miscellaneous Barometers

A number of miscellaneous barometers are described in reference [9] with the comment that they can not be regarded as anything more than philosophical toys and curiosities. These include the water barometer; the glycerine barometer; diagonal and spiral barometers; dial barometers; the sympiesometer (in which the pressure of the air, acting through a short column of liquid of low specific gravity, is made to compress a portion of air confined within the instrument); Howson's barometer (a mercurial barometer with a curved system); and the magnifying siphon barometer.

Corrections to Reduce Pressure to a 24-Hour Mean

In order to obtain the mean diurnal barometric pressure at a station a series of corrections was compiled, reference [14], which could be applied to mean station or mean sea level pressure at 8 a.m. and 8 p.m. (also at 7a, 3p and 11p) to reduce the monthly means to corrected values. These corrections, listed in Volume II of the Report of the Chief of the Weather Bureau, 1900-1901, were put in use with 1902 data and are still in use in the Weather Bureau.

IV. SYSTEMS USED TO REDUCE STATION PRESSURE TO SEA-LEVEL

To facilitate synoptic analysis it is necessary that barometric pressure at the elevation of the station be adjusted or reduced to a common elevation.

This has posed a number of problems especially for stations with higher elevations, and several systems of reduction of pressure to sea level have been used in the Weather Bureau. These are described below:

1. Guyot's Tables and some special tables used from 1870 to June 1, 1881.

   Use of these tables, reference [14], exaggerated greatly the diurnal variations of the barometer for the more elevated stations, as they appeared when reduced to sea level, so that the isobars drawn from them were incessantly swinging up and down in value over the plateau region with the diurnal range from morning to evening. The first step toward an improvement was the introduction of the system of barometric reductions by monthly constants, described below.

2. Abbe-Upton Monthly Constants, used from June 1, 1881 to July 10, 1886, references [14 and 15].

This method of determining gradients was to advance along the meridian at sea level from a low latitude to that of the station, and then to proceed along the vertical from the sea level to the place of observation. According to Bigelow, reference [14], the use of mean gradients practically neutralizes all the local features of these gradient reductions to the extent that the gradient reductions are quite valueless.

3. Ferrel's Tables, used from July 10, 1886 to July 1887, reference [14].

These tables incorporated four important improvements on the Upton system of monthly constants. These are:

(1) Introduction of the thermal pressure term into plateau barometry.
(2) Substitution of the mean diurnal temperature, in making barometry reductions, for the local temperature at hour of observation.
(3) The introduction of a mean vertical temperature gradient to reduce surface temperature as an argument to the mean temperature of the air column.
(4) Introducing the variations produced by the change in the pressure at the station from the normal.

4. Ferrel's and Hazen's Tables in part July 1887 - January 1891.

5. Hazen's Tables January 1891 - December 31, 1901.

Prof. Ferrel's Tables (see preceding section) were used by the Signal Service from July 10, 1886 to July 1887 in their entirety. From July 1887 to January 1891 reductions seem to have been made at some stations by Ferrel's Tables and at others by Hazen's Tables, until in January 1891 Ferrel's Tables were entirely displaced, see reference [14]. Bigelow, reference [14, page 49], states that it is impossible to discover any clear line of argument which Hazen could have employed in reaching his reduction values, and that an apparent but really illusory success in practical work and simplicity in the operation of the tables seem to be their justification.

6. Morrill's Reduction Tables.

In this system (not published or widely used) an attempt was made to reintroduce reduction constants to form forecasting isobars similar to the earlier Abbe-Upton system while the more exact reductions were to be accomplished by a formula, with application to the plateau barometry through modifications of the temperature argument alone.

7. Bigelow's Tables used from January 1, 1902 to date.

Bigelow's method, reference [14, pages 119-121] contained three important departures from the preceding systems. They are:

(1) Use of station pressure rather than sea level normals.
(2) Adoption of a single epoch of reduction, January 1, 1902.
(3) Adoption of a single elevation at each station to which all observations are reduced through small differences of height.

8. Use of Pressure Reduction Computer WBAN 54-7-8.

This method was announced in Multiple Address Letter No. 55-61 dated November 2, 1961. It was inaugurated at varying times during the several months following November 2, 1961, as explained in the first paragraph of MAL 55-61, see page 11.

The pressure reduction computer, reference [16], serves to:

(1) Reduce station pressure to sea level in millibars or inches of mercury.
(2) Compute the altimeter setting from the station pressure.
(3) Compute the station pressure from the altimeter setting.
(4) Compute the pressure altitude from the station pressure or altimeter setting.

A table of "r" values must be used in conjunction with the computer to determine sea-level pressures. The "r" value is the ratio of sea-level to station pressure for each degree of temperature.

The following table illustrates the differences obtained by the two methods at high elevation and medium elevation stations, at high and at low temperatures:

	Temperature (°F.)	Station Pressure (in. of Hg)	Sea Level (in. of Hg) Old	Sea Level (in. of Hg) New ("r")	Difference New minus Old (in. of Hg)
High Level					
Big Piney, Wyo.	-40	22.20	29.37	29.41	0.04
6820 feet	-40	23.80	31.57	31.48	-0.09
	90	22.20	28.20	28.21	0.01
	90	23.80	30.21	30.24	0.03
Summit, Alaska	-60	26.10	28.98	29.26	0.28
2405 feet	-60	27.90	30.99	31.28	0.29
	80	26.10	28.47	28.37	-0.10
	80	27.90	30.42	30.32	-0.10
Medium Level					
Knoxville, Tenn.	-10	27.30	28.37	28.37	0.00
980 feet	-10	29.90	31.08	31.07	-0.01
	90	27.30	28.25	28.25	-0.005
	90	29.90	30.94	30.94	-0.005
Northway, Alaska	-60	26.80	28.84	28.97	0.13
1721 feet	-60	28.70	30.90	31.03	0.13
	80	26.80	28.53	28.48	-0.05
	80	28.70	30.55	30.50	-0.05

V. INSTRUCTIONS AND DEFINITIONS

The following is taken from page 23 of reference [14]:

"INSTRUCTIONS,)
No. 139)

UNITED STATES DEPARTMENT OF AGRICULTURE, WEATHER BUREAU,
Washington, D. C., December 2, 1899.

"After January 1, 1900, a specific elevation above sea level will be adopted for each station, and for purposes of record and publication all barometric observations will be correlated to this 'adopted or station elevation.' In case, therefore, an office is moved to new quarters, and the elevation of the barometer is thereby changed, a proper correction will be applied to the barometric readings in the new location that will reduce the observed reading to the pressure appropriate to the 'station elevation,' notwithstanding changes and removals.

"The pressure thus ascertained will be designated 'station pressure.'

"The 'station elevation' for a station in operation January 1, 1900, will be its elevation above sea level on that date. For stations closed before 1900, or subsequently established, the elevation will be, in general, the elevation above sea level of the zero point of the barometer at the date of closing or opening the respective stations.

"Reduction of current observations in accordance with the foregoing plan will, therefore, be required only when changes are made in the elevations of the barometers. In all such cases the instrument division of the Central Office will furnish a new copy of the barometer correction card (Form No. 1059-Met'1), in which a 'removal correction,' based on the change made in the elevation of the barometers, will be combined with the corrections for local gravity, scale errors, etc. The 'sum of corrections' thus determined, together with the 'correction of temperature,' will be applied to all recorded readings of barometric pressure, and the result will be regarded as the pressure of the air appropriate to the station in question.

"The barograph will be adjusted and corrected to correspond with the corrected air pressure thus obtained.

"The following example will elucidate the complete correction of observed barometer readings:

Observed barometer readings (attached thermometer, 76°.5)	30.287
Correction for temperature	-0.131
Sum of corrections (Form No. 1059-Met'1)	+0.032
Total correction	-0.099
Station pressure	30.188

"The 'total correction,' as show above, will be entered on the present edition of Form No. 1001-Met'1 in the column in which the 'correction for temperature' has been recorded heretofore, and applied to the 'observed' reading, deriving thereby the pressure of the air appropriate to the adopted elevation of the station, which pressure will be recorded in the adjoining column.

"The headings on Form No. 1001-Met'1 will be changed, when necessary, as follows:

"On page 1, for 'total correction,' substitute 'sum of corrections;' change 'Elevation, corrected, for ____ feet,' 'Station elevation,____ feet,' and, if a change in elevation of barometers is made, add 'Actual elevation, ____ feet.'

"On pages 2, 3, and 8 change 'correction for temperature' to 'total correction;' change 'Actual (corrected for temperature and instrumental error)' to 'Station (observed reading, plus total correction).'

"All pressure observations made at a station and reduced according to the foregoing plan will, therefore, be strictly comparable with each other, all being reduced to the adopted elevation. Furthermore, a change of elevation and removal of office will not, as heretofore, necessitate a new table of reductions to sea level; that is, all observations will be reduced to sea level, when required, by one and the same table of reduction, namely, that based on the adopted elevation of the station.

"In preparing Form No. 1027-Met'1 (Comparative barometer readings), the observed readings will be individually corrected for temperature only, and the 'Sum of corrections' (Form No. 1059-Met'1) will be entered, on the present edition of Form No. 1027-Met'1, under the caption 'Total correction for instrumental errors,' and will be properly applied to the mean of the readings corrected for temperature.

"The following nomenclature, embracing barometric terms, will be used, as far as practicable, in the correspondence, records, and publications of the Weather Bureau:

"Actual elevation. -- The height of the zero points of the barometers of a station above sea level.

"Station elevation. -- The elevation above sea level adopted for a station as the basis to which all pressure observations at the station are correlated.

"Observed reading.--The direct result of the reading of an instrument, uncorrected for any errors.

"Actual pressure.--Meaning the actual pressure of the air at a barometer, as obtained from the observed reading after applying the necessary corrections for temperature, gravity, and instrumental errors.

"Station pressure.--A pressure corresponding to an 'adopted or station elevation' differing slightly from the actual elevation of the barometer. When the actual elevation is the same as the station elevation the removal correction will be zero, and the actual pressure and the station pressure are then numerically equal.

"Reduced pressure.--The actual or station pressure reduced to sea level, or to some other specified plane.

"Correction for scale errors, capillarity, etc.--A mean difference between the readings of a given instrument and those of the standard barometer duly corrected. This quantity embraces all outstanding errors in the total length and in the subdivision of the scale; errors in the adjustment of the sighting edge to the zero line of the vernier; errors of capillarity, imperfect vacuum, etc.

"Correction for temperature.--The correction depending on the temperature of the mercury and the metallic scale.

"Correction for local gravity--

(a) Latitude term.--The correction based on the variation of the force of gravity with latitude.

(b) Altitude term.--The correction based on the variation of gravity with altitude above sea level.

"Removal correction.--The correction necessitated by the removal of an office, and based on the difference between the actual elevation of the barometers in the new location and the adopted elevation for the station in question.

"Sum of corrections.--A term embracing all the corrections that are practically constant for a given instrument and in a given location, namely: The correction for scale errors, capillarity, gravity, and the removal correction. This sum is given on the certificate of corrections (Form No. 1059-Met'l) furnished for each instrument.

"Total correction.--The correction for temperature, plus the 'sum of corrections' as defined above.

"Reduction to sea level.--The quantity which must be added to the 'actual' or 'station' pressure, in order to obtain the 'reduced' pressure.

"Reduction for elevation.--A quantity which must be added to or subtracted from the pressure at a given elevation in order to deduce therefrom the pressure appropriate to some other specified elevation.

"Instructions Nos. 92, 1898, and 27, 1899, are accordingly revoked.

Willis L. Moore,
Chief United States Weather Bureau"

The following instructions are self-explanatory:

"UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
Washington

CIRCULAR LETTER NO. 37-40
(For all stations)
August 21, 1940

Subject: Adjustment of Station Pressure Data.

"On July 1, 1939, certain airport stations were made official for synoptic purposes and, effective on that date, the station barometric pressure values relate to the station elevation of the barometer at the airport.

"In the Meteorological Yearbook for 1938 (not yet issued) the data on station pressure relate, as in the preceding series of years, to the station elevation of the city office (the Bigelow datum in Report of the Chief, 1900-01, Vol. II) and this is the case with pressure data for January to June, inclusive, 1939, in Forms 1002 and 1003 now being checked.

"Since it is highly desirable to maintain the homogeneity of the pressure data carried since January 1, 1900, action will be taken to reduce monthly means and extremes of airport station pressure to the former, or city station elevation. In order to do this, a table (see inclosure) has been prepared for each station giving the corrections to be applied each month to the corrected mean station pressure and station pressure extremes of the airport data to reduce them to the station elevation of the city office and thereby make them homogeneous with the data prior to July 1, 1939.

"The corrections are given for every 10 degrees of monthly mean temperature from -20° to 100° and since the change for any step is very small, except at a few places where the difference in elevation is large, interpolation to thousandths of an inch for exact determination of values to hundredths of an inch as given in the Yearbook can be made readily. These values are based on given values of station elevation at the airport and of station elevation at the old (city) office, which should be verified before the table is used. Any lack of agreement should be referred to the Climate and Crop Weather Division for adjustment.

"It is requested that each station at which such action is required report to the Climate and Crop Weather Division the corrected data for monthly values of mean and extreme station pressures for July 1939 to July 1940, inclusive, for entry on Forms 1001, 1002, and 1003. In case the change in station elevation took place after July 1, 1939, the correction will, of course, be applied only where required. Entry of the corrected data should be made on summary pages of retained Form 1001 below the values for station pressure with the note 'Reduced to the old (city) station elevation of _____ feet,' and original and retained records in Form 1001 beginning with August 1940, should conform with these instructions.

"Some stations have submitted pressure data for all months of the year 1939 based on the airport station elevation effective prior to January 1, 1939, and these data will not be reduced to the city station elevation for publication. Action on adjustments for those cases in which the airport records became official for pressure prior to January 1, 1939, will be taken soon.

"Action under the third paragraph above should be expedited in order that the completion of the checking of Forms 1002 and 1003 for 1939 may not be delayed.

F. W. Reichelderfer
Chief of Bureau"

"UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
Washington

CIRCULAR LETTER NO. 68-40
(For all stations)
November 22, 1940

Subject: Adjustment of Station Pressure Data.

"Under Circular Letter No. 37-40 dated August 21, 1940, pressure data as recorded at the Airports have been adjusted to the old (City) station elevation for all stations and for all months to which the circular applies, either by calculation at the station and check in the

Climate and Crop Weather Division or vice versa; and the adjusted values for the period July 1939 to August 1940, inclusive, (and for a few stations for an earlier period) are to be published soon in the Monthly Weather Review. Beginning with September 1940 station pressure data published in the Review are adjusted values. In order to insure correctness in the adjusted data to be published in the Review (and later as required in the Meteorological Yearbook) copy of the final check is returned for re-check at the stations and prompt action in advising the Climate and Crop Weather Division of the necessary changes to be made in the figures.

"When the values for corrected mean, high, and low station pressures, adjusted to the old (City) station elevation are finally determined, such values should be entered to thousandths of an inch in the retained copies of Form 1001 (See note in 3rd to last paragraph of Circular Letter No. 37-40), Form 1002, and these adjusted mean pressures entered on page 5 of the Climatological Record. Values of adjusted station pressure on Form 1003 are to be entered to hundredths of an inch.

"The mean station pressures observed at the Airport (and not adjusted) should be entered on page 6 of the record under the same heading as that on page 5, with a note that the data are the values observed at the Airport. Page 5 of the record to include July 1939 will contain data observed at the old (City) office and after that date the data adjusted to the old (City) office. This will give on page 5 a homogeneous record of the station pressure in the (Bigelow) datum and a notation should be made thereon that the values have been adjusted beginning with July 1939.

"Whether the record of pressure at the Airport became official prior to July 1, 1939, since then, or will become official at some future date, the method here outlined is to be followed. In this connection station officials are advised that it is absolutely necessary for proper checking of pressure data at Elkins, W. Va., and editing of copy for the Review at the Central Office, that all changes in observation of pressure be noted on Form 1001 and reported by letter to the Checking Station and to the Climate and Crop Weather Division. This can be done, of course, by carbon copies of any letter to the Central Office Division of Station Operations under which the changes are made.

Chief of Bureau"

"UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
Washington

CIRCULAR LETTER NO. 78-50
(To All First Order Stations)
November 2, 1950

Subject: Adjustment of Monthly Average Station Pressure Data.

Reference: Circular Letter No. 11-49, dated January 25, 1949.

"In the referenced Circular Letter the instructions for the preparation of Page 5 of Station Climatological Record are not complete insofar as the recording of Monthly Mean (Average) Station Pressure is concerned for those locations where barometric observations are now taken at an elevation different from that at the location as of January 1, 1900, or at its original location if station opened subsequent to that date; e.g., observations now taken at an Airport Station that were formerly taken at the City Office.

"Circular Letter No. 68-40, dated November 22, 1940, states in part that, in the above cases, mean station pressure entered on Page 5 of the Station Climatological Record should be the adjusted value, that is, it should be reduced to the station elevation as of January 1, 1900, or to the station elevation first established subsequent to that date. The proper notation should be made, of course, to show that the values were adjusted to the former assigned elevation. This Circular Letter further states that in these cases the Monthly Mean Station Pressures at the Airport (not adjusted) should be entered on page 6 of the Station Climatological Record, with the heading to show that they are values observed at the Airport.

"It is requested that the stations affected comply with the instructions stated in the above paragraph.

"Entries of Average Station Pressure in the Climatological Record 1951-1970 (Form 5311) will be made similarly to those on Page 5 of the Station Climatological Record 1931-1950, that is, the data will be adjusted to the elevation of the former location where the occasion demands, and the proper notations made accordingly. In these cases a Form 5370 will be placed following Form 5311, and will contain the actual Airport values of average station pressure (not adjusted).

"The instructions contained in Circular Letter No. 37-40, dated August 21, 1940, deal principally with action necessary on a then-current basis, and are assumed to have been properly acted upon. That Circular Letter (No. 37-40) may, therefore, be considered obsolete and should be destroyed.

"Circular Letter No. 68-40, dated November 22, 1940, concerns chiefly the entries of monthly station pressure data in the Station Climatological Record. Upon completion of all the necessary computations and entries in the Climatological Record 1931-1950, that Circular Letter (No. 68-40), too, may be considered obsolete and should then be destroyed.

F. W. Reichelderfer
Chief of Bureau"

"UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
Washington

MULTIPLE ADDRESS LETTER NO. 55-61

November 2, 1961

TO : All First Order & Select Second-Order Observing Stations

FROM : Chief, O&SF Division

SUBJECT: Pressure Reduction Computer, WBAN 54-7-8

"All stations concerned with sea-level reduction of pressure are scheduled to receive two computers which will replace the reduction tables presently in use. The computers are being inscribed with individual station elevations, and 'r' values are being prepared for each station. Since this is a laborious process, it may be six months before every station is supplied.

"The pressure reduction computer resembles the familiar psychrometric calculator and will serve three purposes. One side will reduce the station pressure to sea level in millibars or inches of mercury; the reverse side will compute both the altimeter setting and the pressure-altitude from the station pressure. Results from the computer may differ slightly from present reduction computations because of an improved method of computing sea level pressures.

"Instructions for use of the computer are printed on each side and apply to all stations. However, the individual station elevation has been inscribed on one of the two computers for ease in determining altimeter setting and pressure altitude. The extra computer may be inscribed at the station. When the computer is received, stations should check to insure the correctness of the inscribed elevation. The value of station elevation (H_p) may be found on the station Barometer Correction Card.

"Accompanying the computer will be several copies of a table of 'r' values for use in computing sea level pressures for individual stations. The 'r' value is the ratio of sea level pressure to station pressure for each degree of temperature. Since this ratio is always equal to or greater than unity, the figure '1' preceding the decimal point has been omitted. No interpolation is necessary when using the table of 'r' values.

"Many stations near sea level will not need to use the computer but will be furnished a constant for use in pressure reductions. The need for use of the computer was determined by comparing sea level reductions using extreme temperatures of record with reduction using the annual mean temperature. If the reductions using the extreme temperatures differ from the reduction using the annual mean temperature by less than .006", the computer is not necessary. Elevations of such stations may vary from 30 to 70 feet above sea level.

"The pressure reduction computer may be placed in use on the first of the month following receipt. Show beginning date by entry in Col. 90 of WBAN-10B.

"This MAL will be effective until these instructions are incorporated in Circular N. It may be destroyed when the appropriate Circular N change (probably Change 11) is received."

"UNITED STATES DEPARTMENT OF COMMERCE
WEATHER BUREAU
Washington

Amendment #1 to MAL No. 55-61

May 23, 1962

TO : All First-Order and Select Second-Order Observing Stations

FROM : Chief, Observations and Station Facilities Division

SUBJECT: Pressure Reduction Computer, WBAN 54-7-8

"Precision of Station Pressure Data for Use with Computer

Since present instructions in Circular N, Par. 7640, require the entry of station pressures in column 17 of WBAN-10B to the nearest 0.005 inch of mercury, those stations which employ the Pressure Reduction Computer, WBAN 54-7-8, should also use the station pressure arguments to the nearest 0.005" in computing the pressure reduced to sea level.

At stations equipped with an altimeter-setting indicator, the altimeter setting should be read from the instrument to the nearest 0.005 inch; and the altimeter setting thus obtained should be converted to the corresponding station pressure to the nearest 0.005 inch for use in the reduction of pressure to sea level by means of the computer.

"Determination of Pressure Altitude with Reference to Field Elevation

Special note should be made of the fact that the instructions printed on the computer WBAN 54-7-8 relating to the pressure altitude are specifically designed for the calculation of pressure altitude pertinent to the station elevation H_p. On the other hand, the military services and other agencies primarily interested in aviation require the pressure altitude with reference to the 10-foot plane above the field elevation H_a. In view of this requirement, the attached instructions should be substituted for those on the computer whenever H_p differs from H_a+10' and the pressure-altitude for H_a+10' is desired.

"This MAL will be effective until these instructions are incorporated in Circular N. It may be destroyed when the appropriate Circular N change is received."

Definitions

Actual Barometer Elevation, H_z - the height above mean sea level of the ivory point of the barometer.

Atmospheric Pressure - the pressure exerted by a column of air, of unit area, extending vertically from the reference surface to the top of the atmosphere.

Corrections to reduce pressure to a 24-hour mean are a series of monthly values for each station that, when added to the monthly mean average station or average sea-level pressure, give a result equivalent to a 24-hour monthly mean. Charts and tables of these corrections may be found in the 1900-01 Report of the Chief of the Weather Bureau, Volume II. These corrections have been in use since January 1902.

Height of the 8-Foot Plane is H_8 - the height of the plane 8 feet above field elevation or H_f.

H - the elevation of ground or the height, above mean sea level, of the ground at the station.

H_a - termed the "official altitude of the aerdrome" and represents the vertical distance above mean sea level of the official datum level of the airport.

H_{bc}, later changed to H_{pc} - the Climatological Station Elevation and represents the vertical distance above sea-level chosen as the datum level to which climatological records of barometric pressure at stations in the locality refer.

H_p (formerly H_b) - the Station Elevation and represents the vertical distance above sea-level adapted at the datum level to which barometric pressure reports at the station refer. At old established meteorological stations in the United States the elevation adapted for H_p was the elevation of the zero point of the barometer (H_z) in effect on January 1, 1900. See reference [13].

r - the ration of sea-level to station pressure for each degree of temperature.

Sea-Level Pressure - the atmospheric pressure at sea level under prevailing conditions of temperature and station pressure.

Sum of Corrections - a term embracing all the corrections that are practically constant for a given instrument and in a given location, namely the correction for scale errors, capillarity, gravity and the removal correction.

Temperature Correction - the correction for temperature of the barometer. The attached thermometer is read and recorded to the nearest half degree and used to obtain the temperature correction.

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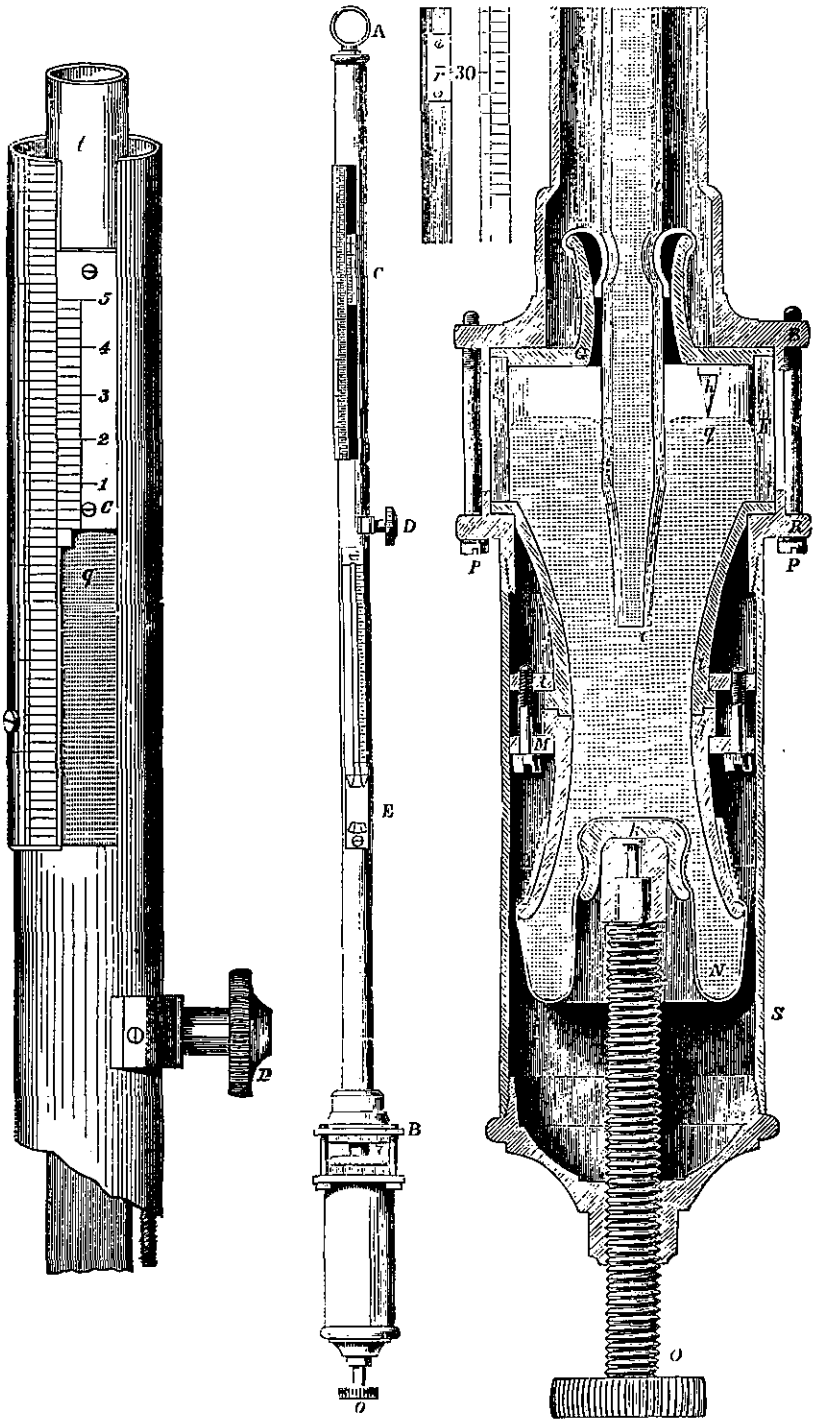
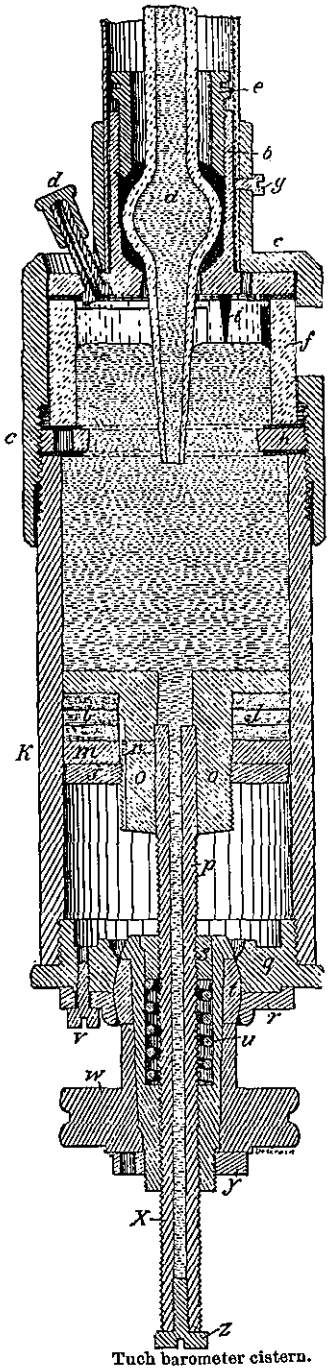


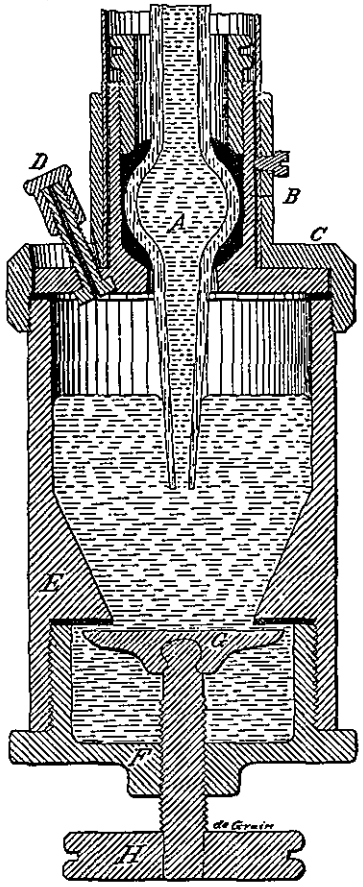
Mercurial barometer, with Fortin cistern.

FIGURE 1



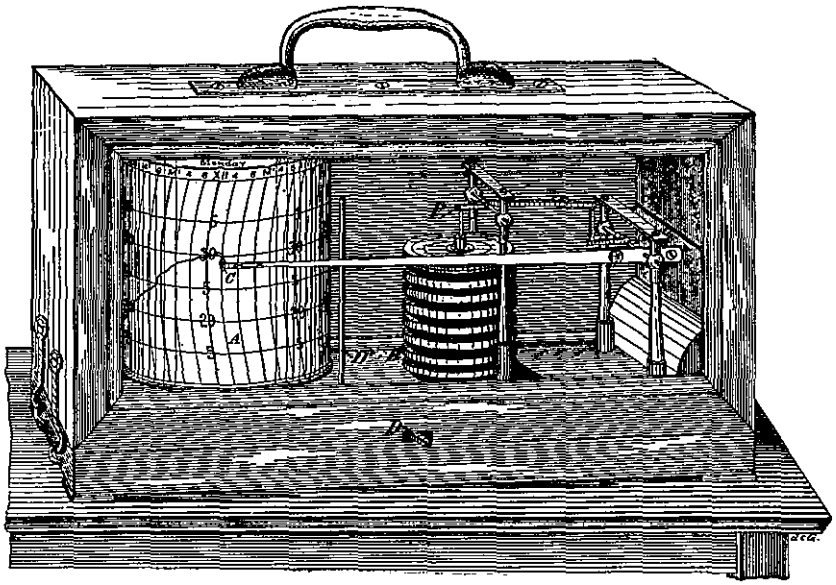
Tuch barometer cistern.

FIGURE 2



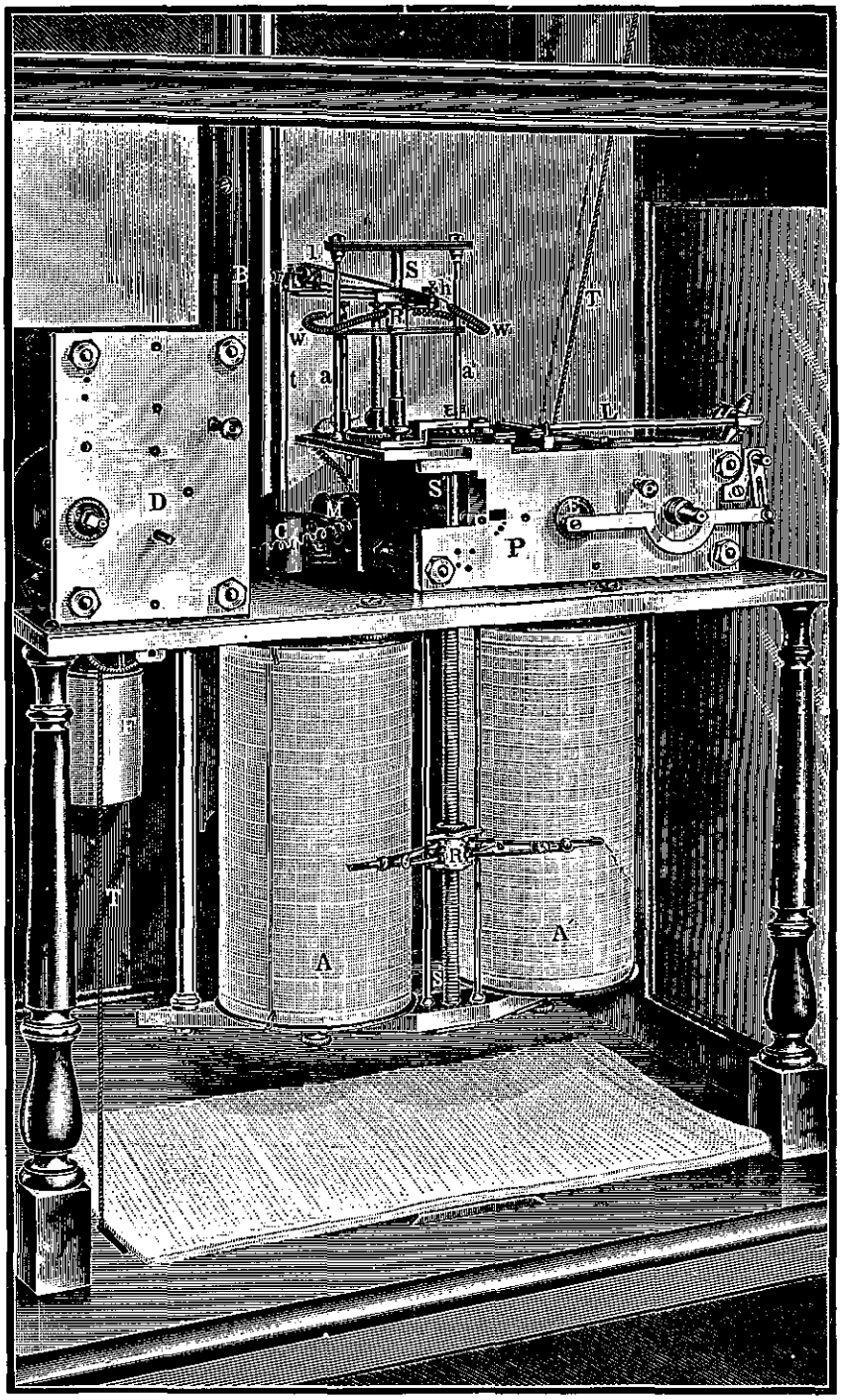
Fixed-cistern barometer.

FIGURE 3



Richard Bros.' aneroid barograph.

FIGURE 4



Foreman's barograph.

FIGURE 5

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