The cases just given particular attention were observations in HIGHS coming from the northwest. Pressure areas originating in other places, especially in the southwest, probably have different properties. Unfortunately, no observations were made in pronounced LOWS. However, during the international month of January 1934, sounding-balloon observations were made approximately every three hours during the passage of the southern sector of a well-defined LOW. These data will be studied in detail and the results published as soon as possible.

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THE EFFECT OF TEMPERATURE ON THE PRESSURE ELEMENTS OF THE FRIEZ AEROMETEOROGRAPH

By J. C. BALLARD and W. B. DRAWBAUGH

[Aerological Division, Weather Bureau, Washington, D.C.]

The classical work on the effect of temperature on pressure elements appears to have been that of Hergesell and Kleinschmidt (Beit. z. Physik der freien Atmos., I Bd., 108–119 and 208–210 (1904–05)). Since that time little has been added of theoretical interest, the equation in general usage for computing the effect of temperature on Aneroid and Bourdon elements still having the form

$$\delta p = -\Delta t\ (A + \alpha p) \qquad (1)$$

where δp is the error in the recorded pressure, Δt is the temperature of the pressure element at the time the record was made minus its temperature during the calibration, A and α are constants, and p is the recorded pressure.

The value of α depends upon the metal of which the element is constructed, and accordingly should be constant for elements of a uniform and standard make. The value of A depends, for any particular make of element, upon the quantity of air left inside the chamber. Consequently, A can vary considerably for different elements and can even change with time for a given element. The values of these two constants can be found simultaneously for any element from pressure tests made at two different temperatures by plotting $\delta p/-\Delta t$ against p. The slope of the line drawn through these points obviously gives the value of α and its intercept on the $\delta p/-\Delta t$ axis gives the value of A. Theoretically, at least, A can be determined for any particular element from tests made by subjecting the element to temperature extremes at constant pressure, once the value of α has been determined for that particular make of element.

The latter are the type of tests which are made by the Weather Bureau to determine the effect of temperature and the method of correction has been equivalent to assuming that α was zero, it being believed that α is very small. It has been frequently observed, however, in these tests that the position of the pressure pen changed with a change in temperature (pressure remaining constant) until some temperature in the region of 0° C. to −10° C. was reached, after which a further decrease of temperature caused little or no further variation in the position of the pressure pen. This performance was in direct disagreement with the assumption made in using equation 1 that the effect of temperature is linear with respect to temperature. The tests described below were made for the purpose of verifying or disproving the applicability of this equation to the Friez aerometeorograph, and if the equation were found applicable to determine the value of α for several instruments.

Two series of pressure tests were made in which five aerometeorographs were tested sufficiently to permit several values of α to be obtained for each instrument. In the first series, tests were made at approximately 28°, −4°, −15°, and −35°C. The second series was made at approximately 28.5°, 18.5°, 14.5°, 9°, 4.6°, −0.3°, −8.5°, and −22.4° C. During the second series of tests care was taken to keep the relative humidity 100 percent inside the bell-jars. For each test the pressure pen deflection was plotted against observed pressure in the bell-jar (measured with a mercurial barometer) and a straight line drawn through the points. This line is called the test curve.

The first series of tests thus furnished four test curves for each instrument. The slopes of these curves were plotted against temperature. For each instrument the three slopes at the low temperatures fell near a straight line which did not pass near the point, showing the slope of the test curve at room temperature. These results were thus in agreement with those indicated by the tests described above at constant pressure but were so unsound theoretically that it seemed apparent that some extraneous factor was producing spurious results. The only apparent difference between the test at room temperature and the others, besides temperature, was the relative humidity in the jar, which was low during the former test but was 100 percent during the latter tests because the temperature inside the jar was lowered below the dew-point. It was therefore decided to make the second series of tests keeping the humidity constant at 100 percent during the tests at relatively high temperatures.

The slopes of the test curves obtained in the second series of tests were plotted along with those of the first series and both sets of points clustered about a common straight line, which, as before, was well removed from the point representing the slope at low humidity.

The results indicated that the effect of humidity on the paper record sheet can be of the same order of magnitude as the effect of temperature on the pressure element.

The mean value of α weighted on the basis of the scatter of the points in the graph just described was found to be −0.00013, the individual values ranging between −0.00004 and −0.00018.

Since the compensation pressure (i.e., that pressure at which the temperature effect is zero) of most of these elements is near normal surface pressure, it is quite obvious that the errors in the pressures recorded at the higher levels in airplane flights, on the average, are of the order of 4 mb., if it is assumed that α is zero. However, if the compensation pressure were about 600 mb., it can easily be shown that the errors in the recorded pressures would very seldom be larger than 1 mb. at any pressure if no correction were applied for temperature effect. In view of this fact it was recommended that further investigations be carried out to determine the amount of residual air which should be left inside the pressure elements in order to obtain a compensation pressure of about 600 mb. This work is now being done at the Weather Bureau and the results will appear shortly. If this work gives satisfactory results, it is planned to recompensate the elements now in use and then to omit the temperature correction since it will, in general, be small in comparison to other uncertainties present.

The authors desire to acknowledge the helpful suggestions of Dr. W. G. Brombacher, in charge of the Aeronautic Instrument Section, United States Bureau of Standards, where these tests were carried out.

BATTLE OF THE CHINOOK WIND AT HAVRE, MONT.

By Frank A. Math

[Weather Bureau office, Havre, Mont., January 1934]

Apparently Havre, Mont., was on the battle front between cold polar air and warm Pacific air during most of December 1933. During the first week the weather was generally fair and mild, and the ground bare of snow. From the night of December 9 to December 12 a spell of cloudy weather with light-to-heavy snowfall prevailed. The temperatures were below normal, ranging between 3° and 11° F., and the winds generally from the east, while the ground in the surrounding country became covered with freshly-fallen snow from 6 to 9 inches deep. The 12th to the 16th had much below-normal temperature and more or less overcast skies and light snow flurries. The lowest temperature registered was −13° on the 15th. However, on December 16, with clear sky, falling temperature and dry, cold air moving from the northeast, suddenly at 7:19 p.m., almost like a shot from a cannon, a southwest chinook wind struck the station. The temperature jumped from −9° to 18° almost instantly. The thermometer and the thermograph moved upward 27° in 5 minutes. The wind velocity increased from 5 to 25 and 30 miles per hour, blowing and whirling the fresh snow about the streets in a boisterous, blinding manner, while some exposed places were swept clean, others were packed with heavy drifts. The temperature continued to rise steadily during the next 36 hours, reaching 23° at midnight of the 16th and a maximum of 44° about 11 p.m. of the 17th. It continued in the 40's until 4 a.m. of the 18th when a cold wave swept over the station and forced the mercury down to zero. The sharpest fall, 40° in 2 hours, was from 43° at 4 a.m. to 3° at 6 a.m.

During the period of rising temperature, from the night of the 16th until the morning of the 18th, the wind was blowing strongly from the southwest, averaging 23 miles per hour during the entire 17th, with a maximum of 35 miles per hour. This forceful wind packed the snow so hard in drifted areas that transportation was difficult. Automobiles were stalled for hours along the highway, and trains were many hours late. Drifting stopped about 9 a.m. of the 17th and by late afternoon the snow had softened and thawing begun. Water was running off the roofs all night and pools were standing in the streets. The sky was partly cloudy to cloudy, but no precipitation fell.

The morning map of December 16 showed that Havre lay in a trough of quiet polar air, but conditions changed rapidly during the next 24 hours. As the map of the 17th indicates an intense low centered off the north Pacific coast and reached inland to Alberta, with high pressure over the Plateau—a typical chinook map for this section. This explains Havre's strong chinook on the night of the 16th–17th.

During the 33 hours following 4 a.m. of the 18th moderate to fresh easterly winds caused a westward surface drift of cold polar air (from a high-pressure area that moved over from Alberta and Manitoba) which underran warm Pacific air and kept the temperatures at Havre down between zero and 19° F. Then at 6:55 p.m. of the 19th the drift from the east gave way to a northerly wind and the full force of a west-southwest chinook struck at 7:40 p.m. The velocities ranged from 20 to 33 miles per hour during the next 2 hours with a temperature rise to 41° by 8:15 p.m., a jump of 27° in 1 hour and 15 minutes. A dash of rain fell between 7:30 and 8 p.m. but otherwise the sky was mostly clear. The chinook continued less than 2 hours, but thawing was in progress with water in the streets. Shortly before 10 p.m. a sharp increase in atmospheric pressure brought a cold northwest wind, attended by a corresponding fall in temperature from 38° at 10 p.m. to 7° at midnight and −1° by 5 a.m. the next day (December 20). This cold polar air coming down from a Saskatchewan HIGH, held until 7:30 p.m., when a wind controlled by a Plateau HIGH and a LOW over Washington caused another chinook from the southwest, blowing from 25 to 35 miles per hour and bringing a rise in temperature even greater than that on the preceding date. This rise was from 14° at 7 p.m. to 48° at 8:30 p.m., or 34° in 1½ hours. The daily range in temperature for the 20th was 51°, from −1° to 50°. The remaining snow dwindled rapidly and water from melting ran in the streets in the early morning.

This chinook, however, lasted only 11 hours. The center of the Washington LOW in its eastward drift passed slightly north of Havre between midnight and 2 a.m. The pressure rose slowly from 3 to 6 a.m., then rapidly, 0.3 inch in about 4 hours, to 10 a.m., accompanied by decreasing wind which veered from southwest through west, northwest, north, to northeast in 30 minutes. The temperature fell 23° in 2 hours to a minimum of 22° at 9 a.m.

Following this, conditions were about normal for the season for 15 hours, but in the meantime a strong wind developed aloft, as indicated by the 4 p.m. pilot-balloon observation, 29 miles per hour southwest at 1,500 feet above the ground. That started another chinook at this station about 10 p.m., December 21. A strong 26 mile-per-hour wind, accompanied by a temperature rise of 24° in 1½ hours to 48°, drove into our midst to the bewilderment of the inhabitants. This was the fourth chinook of Pacific air in a period of 5 days. It held sway for 11 hours, thawing and melting the snow and ice as usual. The accompanying fourth wave of diminished air pressure passed rapidly eastward and at its rear the pressure rose rapidly again, 0.2 inch in 2 hours, bringing the cold polar air back over this station where it continued with subzero temperatures for 4 days, reaching a low of −18° on December 26.

"All was quiet" in north-central Montana for 6 days when another chinook began at 1 p.m., December 29, with a rise in temperature of 27° in 2¼ hours, to 51° at 3:30 p.m., and a southwest wind that increased to 28 miles per hour. It was followed in 18 hours by a shift of wind through northwest to northeast accompanied by a sharp