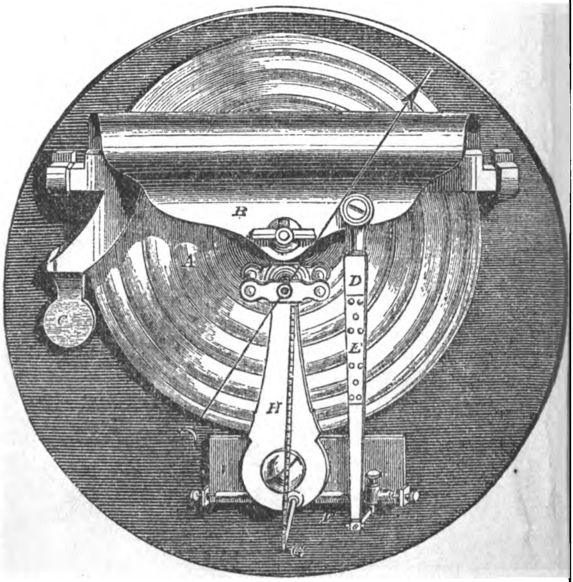

Fig. 1 (See Page 12).

THE

ANEROID BAROMETER,

ITS

CONSTRUCTION

AND

USE.

COMPILED FROM SEVERAL SOURCES.

G. W. P.

REPRINTED FROM VAN NOSTRAND'S MAGAZINE.

NEW YORK:
D. VAN NOSTRAND, PUBLISHER,
23 MURRAY AND 27 WARREN STREET.
1878.

PREFACE.

THE following pages have been compiled from several sources. The shorter tables and the explanatory text are with slight modifications from Engineering. The principal table, Prof. Airy's, is from a pamphlet entitled "The Aneroid, How to buy and How to use it," by a Fellow of the Meteorological Society, London.

For the portion relating to diurnal variations of pressure the compiler is indebted to Buchan's excellent treatise on "Meteorology."

The Formulas and final Tables are from Williamson's work on the "Barometer," and from Sonnet's "Dictionaire de Mathematique Appliqueé."

The hints about purchasing an Aneroid are quoted from Gen. Ellis's excellent paper read before the American Society of Engineers in January, 1871.

G. W. P.

THE ANEROID BAROMETER.

Two forms of Barometer are used by physicists for measuring the pressure of the atmosphere: the Mercurial and the Aneroid. The first was invented by Toricelli in 1643. It is too well known to require description; it will be sufficient to say that it measures the varying pressure of the air by the varying length of a column of mercury which balances the pressure.

The Aneroid was invented about the beginning of this century, but was not brought to a serviceable form until within the last thirty years when M. Vidi of Paris succeeded in conquering the difficulties of construction and produced an instrument which has of late been steadily gaining in the estimation of scientists. Meteorologists, geographical explorers, and civil engineers alike concur in praising the usefulness and accuracy of the more portable forms of this instrument. It is, however, only the best and latest improved construction that will justify such confidence.

Captain R. H. Fawcett, who has had much practice in contouring, writes in the *United Service Journal*, vol. xvi.: "The value of the Aneroid as a handy and portable instrument for rapidly obtaining relative heights in surveys, has, I think, been under-rated. It is of great value, especially in cases of military surveying, where time is frequently priceless. The points chiefly valuable in an aneroid are its portability, as in the pocket it takes up no more room than a watch, and the observations and calculations can be done so quickly that a staff officer riding from one hill to another can readily obtain their relative heights. In a survey readings may be noted down in a pocket-book, or even on the margin of the sketch, and calculated out on return at leisure. When there is plenty of time and the ground is practicable, leveling or contouring would certainly be adopted in preference; but even then the occasional consultation of the Aneroid might be an advantageous check to error. But if pressed for time, or contouring be impracticable or extremely difficult, the Aneroid gives heights with sufficient accuracy for ordinary military operations, and is far more accurate than the eye; moreover, the reading may be taken in equal, or less, time than it would require in most cases to make a good judgment of height. . . . Though it cannot show the height with the accuracy of leveling or contouring, yet its indications may be generally relied on to ten feet or twenty feet. . . . It is of course in abrupt, hilly and almost mountainous countries that the Aneroid is most useful. For heights of fifty feet or sixty feet above the plain varying slightly in their relative heights, the reading of the pocket Aneroid might be difficult, and the slightest error important. . . . It almost invariably happens that such small heights can be contoured or leveled quickly, but the case is different with hills of 300 feet or 400 feet above points in the survey. The contouring of these would take up much time, and the advantage of the Aneroid, as far as this reason goes, increases with the height."

Thus the traveler, amid snowy peaks and glaciers, on plateau or prairie, can tell within a hundred feet his elevation above the sea; a triumph of science no less wonderful than that by which he ascertains his latitude by means of the sextant. With due precautions the Aneroid will measure heights with surprising accuracy, as has been repeatedly proved by trigonometrical measurements. For rough practical purposes it is all that can be desired for contouring mountains and hilly districts with rapidity. It is unnecessary to dwell upon the value of these results to the sciences of geography and topography. Sir J. Herschel in his treatise on "Physical Geography" remarks on this subject: "Barometrical observations, both stationary and itinerant, assisted of late by that very useful and portable form of the barometer called the Aneroid, which can be read off in a carriage or on horseback, have been now so far extended over the whole accessible surface of the globe, as to afford ground for a reasonable conclusion respecting the average elevation of the surface of the land above the sea level, and a very accurate one as to the heights of mountain chains and summits."

The Aneroid depends for its action upon the changes in form of a thin metallic box partially exhausted of air, as the pressure of the atmosphere varies. In Vidi's Aneroid the metallic box was cylindrical in shape with thin corrugated ends. In some later forms the box is crescent or Ω shaped.

The following diagrams exhibit the mechanism of the instrument:

FIG. 1 (See Frontispiece).

The vacuum chamber, A (Fig. 1) is flat and circular, having its top and bottom corrugated in concentric circles, to render them more elastic. In the best constructed Aneroids the top of the chamber is, in a certain degree, held up in opposition to the pressure of the atmosphere by the elasticity of a folded lamina of spring steel, B, the pull of which on the chamber is regulated by the pressure of a screw beneath the arm, C; by means of this screw, which is reached from an aperture in the bottom of the case, the index error may be corrected whenever such is found to exist; and it may be here remarked that small index errors will occasionally arise, until by a little time and use, the numerous moveable parts of the instrument have assumed their permanent bearings; when, however, it is duly seasoned, it may, if originally well constructed, be carried about with ordinary care in traveling, without undergoing any sensible change.

The folded spring, B, is firmly connected with a stud on the center of the vacuum chamber (which has been carefully exhausted by an air-pump, and the aperture soldered up), and rises and falls with it in obedience to atmospheric pressure. An arm, D, is attached to the spring, at the further extremity of which the actual movements of B are considerably amplified.

The end of D is connected by a link with a short arm proceeding from a transverse bar, F, which is movable on its axis. A long arm proceeding upwards from F, is attached by its extremity, G, to the end of a steel chain (similar to the fusee chain of an English watch), which is wound round a small pulley on the axis of the hand or index. A spiral balance-spring, attached by one end to the pulley, and by the other to the framework, opposes the pull on the chain at G, and causes the index to retreat when the chain is relaxed.

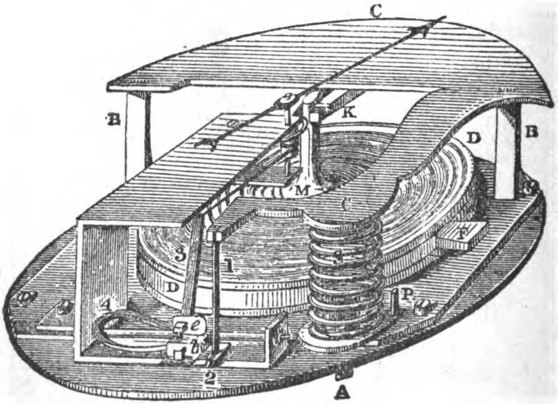

Fig. 2.

Fig. 2 exhibits in perspective a form slightly different; the spiral-spring S performing the same function as the laminated spring B in Fig 1.

The errors to which the Aneroid is subject arise from the property of the metals used in construction to vary their dimensions with every change of temperature, and thus introduce motions into the mechanism which are independent of atmospheric pressure.

The mercurial barometer is subject to fluctuations due to temperature, but these are easily allowed for as the possible changes are few and simple; but in the Aneroid, where metals whose elasticity is not constant are under tension, it is readily comprehended that skillful adjustment is needed to secure *compensation* as it is termed. This is partly effected by the residue of air in the sealed box, but a further adjustment of a compound spring is also required. The Aneroid requires occasional comparison with a standard mercurial barometer and a correction when it varies, to make it agree.

When the barometer is employed for the purposes of meteorology only, the following facts are taken into consideration. We quote from Buchan's "Handy Book of Meteorology":

Variations of the Barometer.—The variations observed in the pressure of the air may be divided into two classes—viz., periodical and irregular; the periodical variations recurring at regular intervals, whilst the irregular variations observe no stated times. The most marked of the periodical variations is the *daily variation*, the regularity of which in the tropics is so great that, according to Humboldt, the hour may be ascertained from the height of the barometer without an error of more than 15 or 17 minutes on the average. This horary oscillation of the barometer is masked in Great Britain by the frequent fluctuations to which the atmosphere is subjected in these regions. It is, however, detected by taking the mean of a series of hourly observations conducted for some time. The results show two maxima occurring from 9 to 11 A.M. and from 9 to 11 P.M., and two minima occurring from 3 to 5 A.M. and from 3 to 5 P.M.:

TABLE SHOWING THE DAILY VARIATIONS AND RANGE OF THE BAROMETER IN DIFFERENT LATITUDES.

	LAT.	A.M.		P.M.		RANGE.
		MIN.	MAX.	MIN.	MAX.	
		Inches.	Inches	Inches.	Inches	Inches.
Atlantic Ocean........	0 0	—.056	+.069	—.045	+.045	.125
Pacific Ocean.........	0.0	—.032	+.040	—.045	+ 028	.085
Sierra Leone..........	8.28 N.	—.022	+.032	—.038	+.031	.070
Lima................	12.3 S.	— 071	+.065	—.067	+.050	.136
Calcutta.........	22.36 N.	—.017	+.052	—.038	+.018	.090
Pekin	39.53 N.	—.038	+ 047	—.052	+.014	.099
Great St. Bernard.....	45.51 N.	—.010	+.005	—.003	+.012	.022
Plymouth (England)...	50.21 N.	—.007	+.006	—.010	+.010	.020
St. Petersburg	59.58 N.	—.003	+.008	—.004	+.002	.012

The maxima occur when the temperature is about the mean of the day, and the minima when it is at the highest and lowest respectively.

This daily fluctuation of the barometer is caused by the changes which take place from hour to hour of the day in the temperature, and by the varying quantity of vapor in the atmosphere.

The surface of the globe is always divided into a day and night hemisphere, separated by a great circle which revolves with the sun from east to west in twenty-four hours. These two hemispheres are thus in direct contrast to each other in respect of heat and evaporation. The hemisphere exposed to the sun is warm, and that turned in the other direction is cold. Owing to the short time in which each revolution takes place, the time of greatest heat is not at noon, when the sun is in the meridian, but about two or three hours thereafter; similarly, the period of greatest cold occurs about four in the morning. As the hemisphere under the sun's rays becomes heated, the air, expanding upwards and outwards, flows over upon the other hemisphere where the air is colder and denser. There thus revolves round the globe from day to day a wave of heat, from the crest of which air constantly tends to flow towards the meridian of greatest cold on the opposite side of the globe.

The barometer is influenced to a large extent by the elastic force of the vapor of water invisibly suspended in the atmosphere, in the same way as it is influenced by the dry air (oxygen and hydrogen). But the vapor of water also exerts a pressure on the barometer in another way. Vapor tends to diffuse itself equally through the air; but as the particles of air offer an obstruction to the watery particles, about 9 or 10 A.M., when evaporation is most rapid, the vapor is accumulated or pent up in the lower stratum of the atmosphere, and being impeded in its ascent its elastic force is increased by the reaction, and the barometer consequently rises. When the air falls below the temperature of the dew-point, part of its moisture is deposited in dew, and since some time must elapse before the vapor of the upper strata can diffuse itself downwards to supply the deficiency, the barometer falls—most markedly at 10 P.M., when the deposition of dew is greatest.

Hence, as regards temperature, the barometer is subject to a maximum and minimum pressure each day,—the maximum occurring at the period of greatest cold, and the minimum at the period of greatest heat. And as regards vapor in the atmosphere, the barometer is subject to two maxima and minima of pressure—the maxima occurring at 10 A.M., when, owing to the rapid evaporation, the accumulation of vapor near the surface is greatest, and about sunset, or just before dew begins to be deposited, when the relative amount of vapor is great; and the minima in the evening, when the deposition of dew is greatest, and before sunrise, when evaporation and the quantity of vapor in the air is least.

Thus the maximum in the forenoon is brought about by the rapid evaporation arising from the dryness of the air and the increasing temperature. But as the vapor becomes more equally diffused, and the air more saturated, evaporation proceeds more languidly; the air becomes also more expanded by the heat, and flows away to meet the diurnal wave of cold advancing from the eastwards. Thus the pressure falls to the afternoon minimum about 4 P.M. From this time the temperature declines, the air approaches more nearly the point of saturation, and the pressure being further increased by accessions of air from the warm wave, now considerably to the westward, the evening maximum is attained. As the deposition of dew proceeds, the air becomes drier, the elastic pressure of the vapor is greatly dminished, and the pressure falls to a second minimum about 4 A.M.

The amount of these daily variations diminishes from the equator to wards either pole, for the obvious reason that they depend, directly, or indirectly, on the heating power of the sun's rays. Thus, while at the equator the daily fluctuation is 0.125 inch, in Great Britain it is only a sixth part of that amount. It is very small in the high latitudes of St. Petersburg and Bossekop; and in still higher latitudes, at that period of the year when there is no alternation of day and night, the diurnal variation probably does not occur. In the dry climate of Barnaul, in Siberia, there is no evening maximum; the lowest minimum occurs as early as midnight, and the only maximum at 9 A.M.

Since the whole column of the atmosphere, from the sea-level upwards, expands during the heat of the day, thus lifting a portion of it above all places at higher levels, it is evident that the afternoon minimum at high stations will be less than at lower stations, especially when the ascent from the one to the other is abrupt. Thus, at Padua, in Italy, the afternoon minimum is 0,014 inch, but at Great St. Bernard it is only 0.003 inch.

Annual Variation.—When it is summer in the one hemisphere, it is winter in the other. In the hemisphere where summer prevails, the whole air being warmer than in the other hemisphere, expands both vertically and laterally. As a consequence of the lateral expansion there follows a transference of part of the air from the warm to the cold hemisphere along the earth's surface; and, as a consequence of the vertical expansion, an overflow in the upper regions of the atmosphere in the same direction. Hence, in so far as the dry air of the atmosphere is concerned, the atmospheric pressure will be least in the summer and greatest in the winter of each hemisphere. But the production of aqueous vapor by evaporation being most active in summer, the pressure on the barometer will be much increased from this cause. As the aqueous vapor is transferred to the colder hemisphere it will be there condensed into rain, and being thereby withdrawn from the atmosphere, the barometer pressure will be diminished;

but the dry air which the vapor brought with it from the warm hemisphere will remain, thus tending to increase the pressure.

In the neighborhood of the equator there is little variation in the mean pressure from month to month. Thus, at Cayenne, the pressure in January is 29.903 inches, and in July 29.957 inches.

At Calcutta, 22° 36′ N. lat., the pressure is 29.408 in July, and 30.102 in January, thus showing a difference of 0.694; and at Rio de Janeiro, 22° 57′ S. lat., it is 29.744 in January (summer), and 29.978 in July (winter), the difference being 0.234. The large annual variation at Calcutta is caused jointly by the great heat in July, and by the heavy rains which accompany the south-west monsoons at this season; while in January the barometer is high, owing to the north-east monsoons, by which the dry cold dense air of Central Asia is conveyed southward over India.

At places where the amount of

vapor in the air varies little from month to month, but the variations of temperature are great, the difference between the summer and winter pressures are very striking. Thus, at Barnaul and Irkutsk, both in Siberia, the pressures in July are respectively 29.243 and 28.267, and in January 29.897 and 28.865, the differences being upwards of six-tenths of an inch. The great heat of Siberia during summer causes the air to expand and flow away in all directions, and the diminished pressure is not compensated for by any material accessions being made to the aqueous vapor of the atmosphere; and, on the other hand, the great cold and little rain in that region during winter causes high pressures to prevail during that season. The same peculiarity is seen, though in a modified degree, at Moscow, St. Petersburg, and Vienna.

At Reykjavik, in Iceland, the pressure in June is 29.717, and in December 29.273; at Sandwich, Orkney, 29.775, and 29.586; and at Sitcha, in

Russian America, 29.975, and 29.664. In all these places the distribution of the pressure is just the reverse of what obtains in Siberia, being least in winter and greatest in summer. The high summer pressures are due to the cool summer temperatures as compared with surrounding countries, thus causing an *inflow from these regions*, and to the large amount of vapor in the atmosphere, thus still further raising the barometric column. On the other hand, the low winter pressures are due to the comparatively high winter temperatures causing an *outflow towards adjoining countries*, and the large winter rainfall which, by setting free great quantities of latent heat, still further augments and accelerates the outflow.

The variations in mean pressure are very slight, and not marked by any very decided regularity in their march through the seasons, at Dublin, Glasgow, London, Paris, and Rome. As compared with Barnaul and Reykjavik their temperature is at no season very different from that of surrounding countries, and the vapor and rainfall are at no time much in excess or defect, but are more equally distributed over the different months of the year.

At the Great St. Bernard, 8174 feet above the sea, the pressure in summer is 22.364 inches, while in winter it is only 22.044. At Padua, there is scarcely any difference in the pressure between summer and winter. The increase in the summer pressure at the Great St. Bernard is no doubt due to the same cause already referred to in art. 65—viz., the expansion of the air upward during the warm summer months, thus raising a larger portion of it above the barometer at the highest station. But at St Fe de Bogota, 8615 feet high, near the equator, and where, consequently, the difference between the temperature in July and January is very small, the difference in the pressures of the same months is also very small, being only 0.035.

Distribution of Atmospheric Pressure over the globe, as determined by the

Annual Means.—Though much additional observation is required, especially in Africa, Asia, and South America, before the isobarometric lines can be laid down on a map of the world, yet many important conclusions regarding the mean barometric pressure have been arrived at from the results already obtained. We have seen that the daily and monthly variations of pressure observed at different places are modified by the variations of the temperature of the air, the amount of vapor, and the rainfall. Since these are in their turn greatly modified by the unequal distribution of land and water on the earth's surface, we should expect to find the pressure, and the variations in the pressure, most regular in the southern hemisphere. Accordingly, there is a remarkable regularity observed in the distribution of the pressure from about 40° N. lat. southwards to the Antartic Ocean, with the exception of the region of the monsoons in Southern Asia.

The mean pressure in the equatorial regions is about 29.90; at 20° N. lat. it rises to 30.00, and at 35° N. lat. to 30.20, from which northwards the pressure is diminished. The same peculiarity is seen south of the equator, but it is not so strongly marked. At 45° S. lat. it falls to 29.90, and from this southwards it continues steadily and rapidly to fall to a mean pressure of 28.91 at 75° S. lat. This extraordinary depression of the barometer in the Antarctic Ocean, being one inch less than at the equator, and 1.326 inches less than at Algiers, is perhaps the most remarkable fact in the meteorology of the globe.

The pressure in the north temperate and frigid zones is in striking contrast to the above. From Athens, in a north-eastern direction, a high isobarometric line traverses Asia, passing in its course Tiflis, Barnaul, Irkutsk, and Yakutsk. To the east of the northern, part of this area of high mean pressure around the peninsula of Kamtschatka, there is a region of low barometer, the mean pressure being only 29.682. There is another remarkable area of low pressure around Iceland, the center being probably in the south-west of the island near Reykjavik, where the mean is 29.578. As observations are more numerous in Europe and North America, the dimensions of this depression may be defined with considerable precision by drawing the isobarometric of 29.90, which is about the mean atmospheric pressure. This line passes through Barrow Straits in North America, thence south-eastward toward Newfoundland, then eastward through the north of Ireland, the south of Scotland, and the south of Sweden, whence it proceeds in a north-easterly direction to Spitzbergen. The following mean annual pressures will show the nature of the depression:—New York, 30.001; Paris, 29.988; London, 29.956; Glasgow, 29.863; Orkney, 29.781; Bergen, 29.804; Spitzbergen, 29.794; Reykjavik, 29.578; Godthaab in S. Greenland, 29.605; Upernavik in N. Greenland, 29.732; and Melville Island, 29.807. A depression also occurs in

India, where the mean is only about 29.850, whereas in the same latitudes elsewhere it is about 30.100.

There are thus four areas of low pressure on the globe, the extent of each being nearly proportioned to the depth of the central depression—viz., Antarctic Ocean, the least pressure being 28.910; Iceland, 29.578; Kamtschatka, 29.682; and India, 29.850; and three areas of high pressure, one lying between latitudes 20° and 40° N., another between 15° and 35° S., and the third in Central Asia, from south-west to north-east. These low mean pressures are by no means constant in all cases during the months of the year. In the Antarctic Ocean they are nearly constant during the months, with perhaps a slight tendency to an increase in winter. In the region of low pressure round Iceland, the pressure is a little less than elsewhere in summer; but in winter, when the rainfall is heaviest, it is very much less, being 0.251 inch less in winter than in summer at Reykjavik, and 0.189 at

Sandwich, in Orkney. Similarly at Petropaulovski, in Kamtschatka, the pressure in winter is 0.323 less than in summer. Hence the low mean annual pressures in the North Atlantic and the North Pacific are chiefly brought about by the low pressure during the cold months of the year, and are doubtless caused by the copious rainfall during that season. On the other hand, in Southern Asia, the lowest pressures occur in summer. Thus, at Calcutta it is 29.408 in July, while in January it is 30.102—the average pressure for that degree of north latitude. Hence, in Hindostan, the low mean annual pressure arises from the very low pressure in summer caused by the heavy rains falling at that season, particularly on the south slope of the Himalayas. Generally the pressure is low wherever a copious rainfall prevails over a considerable portion of the earth's surface, owing to the large quantity of caloric set free as the vapor is condensed into rain.

It is scarcely necessary to point

out how important it is to keep in mind these facts of the pressure of the atmosphere, it being evident, for instance, that a pressure of 29.00 in the North Atlantic would portend stormy winds, while the same pressure south of Cape Horn, being the mean pressure there, would indicate settled weather.

The readings of the mercurial barometer are subjected in nice observations to several corrections:

1st. To 32° F. allowance being made for expansion of both mercury and scale for all observations above that temperature. A barometric pressure of thirty inches at 32° would be indicated by a height of $30\frac{1}{10}$ inches at 70°.

2d. For decrease of gravitation at stations above the level of the sea, acting on both the mercury and the air.

3d. For increase of gravity with increase of latitude.

4th. For temperature of air; the density decreasing as temperature rises.

5th. For humidity of the air which also influences its density.

6th. For capillary attraction of the tube.

The Aneroid requires when properly constructed a less number of corrections.

Many of them are so compensated as to require no correction for temperature of the instrument.

A correction for temperature of the air above or below some conventional standard is the only one usually applied to the best Aneroids, and the corrections for decreased force of gravity and for humidity are the only other corrections required for the most refined observations.

MEASUREMENT OF ALTITUDES.

It is in the measurement of heights that the Aneroid is most highly appreciated. Its portability and the ease and rapidity with which it affords accurate results, render it one of the most satisfactory of scientific instruments.

The text books in physics present formulas for computing heights from barometric observations, based on physical laws which we will briefly give.

If the density of the air were constant throughout, the measurement of heights would be a problem of the simplest character; for as mercury weighs 10,500 times as much as air at the sea level, the mercurial column would fall one inch for every 10,500 inches of ascent above the sea. But air is compressible, and, in accordance with Boyle's law, its density varies with the pressure to which it is subjected.

Now suppose the atmosphere divided into layers of uniform thickness, but so thin that the density may be considered uniform throughout.

Let h=the thickness of each layer.

W=weight of a cubic foot of air at pressure H.

W_1=weight of a cubic foot of air at H.

H_0 H_1, &c.=pressures measured in inches of mercury.

Then the pressure upon the unit of surface of any layer is greater than that upon the surface of next higher layer, by the weight of a volume of air whose base is the unit of surface and whose height is the thickness of the layer. If one foot be the unit of surface, then this quantity would be hW. And to express it by height of mercury column, it is necessary to multiply by $\frac{30}{2157}$ which gives $\frac{hW30}{2157}$

$$\text{But } W : W_0 :: H : 30$$

W_0 being the weight of a cubic foot air at the level of the sea (=.0807 at 32° F).

We have from the above $W \times 30 = W_0 \times H$, and the above expression for diminution may be written $\frac{hW_0H}{2157}$.

If H_0 H_1 H_2 represent the pressures at the surfaces of the successive layers, we shall have

$$H_1=H_0-\frac{hW_0H_0}{2157}=H_0\left(1-\frac{hW_0}{2157}\right)$$

$$H_2=H_1-\frac{hW_0H_1}{2157}=H_1\left(1-\frac{hW_0}{2157}\right)$$

$$H_3=H_2-\left(1-\frac{hW_0}{2157}\right)$$

$$H_n=H_{n-1}\left(1-\frac{hW_0}{2157}\right)$$

Multiplying these equations and suppressing common factors, we get

$$H_n=H_0\left(1-\frac{hW_0}{2157}\right)^n$$

If h be taken at one foot then n would represent the number of feet vertically between two stations at which the barometric pressures are H_n and H_0 respectively.

By substituting for W_0 its value and taking logarithms we have

$$\log.\frac{H_0}{H_n}=n.\log.\left(\frac{2157}{2156.9193}\right)$$

whence

$$n = 60135.4 \times \log. \frac{H}{H_1}$$

For use in accurate observations, corrections are required for temperature, humidity and variation in the force of gravity.

La Place's formula which includes terms derived from the consideration of these conditions is obtained as follows :

Suppose a portion of the atmosphere included between two stations at different altitudes to be divided into very thin laminæ.

Let z be the distance of one of these from the surface of the globe and dz its thickness.

Let P be the pressure upon a unit of surface upon the lower side of this layer; and W the weight per cubic meter of the air at this pressure.

Then the pressure on the upper side will be less than P by an amount equal to the weight of a column of air whose base is a unit and height is equal to dz. Whence

$$dP = -W dz. \qquad (1)$$

If W_0 be the weight of a cubic meter of air at the temperature $o°$C and a barometric pressure of $0.^{m}76$, the weight of this same volume at pressure P and temperature θ would be

$$=W_0 \cdot \frac{P}{0.76} \cdot \frac{1}{1+a\theta}$$

a being the coefficient of dilatation of air which is here taken at .004 in consequence of the constant pressure of watery vapor.

This expresses the weight at the surface of the globe. If transferred to the height z, the weight would be diminished in the ratio of the squares of the distances from the center of the earth. We should then have

$$W=W_0 \cdot \frac{P}{0.76} \cdot \frac{1}{1+a\theta} \cdot \frac{R^2}{(R+z)^2}$$

Substituting in equation 1, dividing by P and integrating between o and z, we get, by calling the pressure at the lower station P_0

$$\log. \frac{P_0}{P} = \frac{W_0 R}{0.76. \, (1+a\theta)} \cdot \frac{z}{R+z}$$

the logarithm being Napierian.

From this we obtain

$$z = \frac{0.76\ (1+a\theta)}{W} \log. \frac{P_0}{P} \left(1+\frac{z}{R}\right)$$

But the pressures P_0 and P are in direct ratio of the mercury columns which we will designate by h_0 and h. These columns also vary in weight in accordance with the law of inverse squares of distance from the earth's center, so that

$$\frac{P_0}{P} = \frac{h_0}{h} \cdot \frac{(R+z)^2}{z^2} = \frac{h_0}{h} \left(1+\frac{z}{R}\right)^2$$

Substituting in the value of z, we have

$$z = \frac{0.76.\ (1+a\theta)}{W_0}$$

$$\left\{ \log. \frac{h_0}{h} + 2 \log. \left(1+\frac{z}{R}\right) \right\} \times \left(1+\frac{z}{R}\right)$$

But as z is so very small compared with R_1 we may replace $\log. \left(1+\frac{z}{R}\right)$ by $\frac{z}{R}$.

Also $\frac{z^1}{R^2}$ may be neglected.

We shall then have

$$z = \frac{0.76\ (1+a\theta)}{W_0} \left\{ \left(1+\frac{z}{R}\right) \log. \frac{h_0}{h} + \frac{2z}{R} \right\}$$

The weight W_0 refers to the height h, the lower of the two stations. At the surface of the earth, this weight would be greater in the ratio of $\frac{(R)^2}{(R-h)^2}$. But as h is always small compared with R this correction may be neglected.

But there is another of more importance which should be taken into account. On account of the spheroidal form of the globe weight varies with the latitude. If G represent the weight of a body at latitude 45°, then at any other latitude l its weight is found by multiplying G by

$$1-.00265 \cos. 2\,l$$

This factor is to be applied to W_0 in the formula. This is accomplished by multiplying the above value of z by $1+00265 \cos. 2l$.

In order to simplify the expression we will substitute θ the mean between the temperatures of the upper and lower stations, designated by t_0 and t. The factor $1+a\theta$ then becomes

$$1+\frac{2(t_0+t)}{1{,}000} \text{ since as } a = .004;$$

and the value of z may be written

$$z=\frac{0.76}{W_0}\left\{1+\frac{2(t_0+t)}{1000}\right\}$$

$$\times\left\{\left(1+\frac{z}{R}\right)\log.\frac{h_0}{h}+\frac{2z}{R}\right\}\times$$

$$(1+.00265 \cos. 2l)$$

If M be used to represent the modulus of the Napierian logarithms we may write

$$z=\frac{0.76}{MW_0}\left\{1+\frac{2(t_0+t)}{1000}\right\}$$

$$\times\left\{\left(1+\frac{z}{R}\right)\log.\frac{h_0}{h}+\frac{2Mz}{R}\right\}\times$$

$$(1+0.00265 \cos. 2l)$$

in which the logarithms are of the common kind.

This is La Place's formula. h in the expression is not the barometric height directly observed at the upper station, but this height reduced to the temperature of the lower station.

The value of $\frac{0.76}{MW_0}$ has been determined by trial of the formula upon known altitudes. Ramond in his survey of the Pyrenees determined its value to be 18336.

The unknown term z in the second member is determined by successive approximations.

The first value being

$$z_1' = 18336. \log. \frac{h_0}{h} \text{ (meters)}$$

This being substituted, we may have

$$z_2 = z_1 + \frac{2(t_0 + t)}{1000} z_1.$$

Finally, these being substituted in the above value of z we get

$$z_1 = 18336 \log. \frac{h_0}{h} + \frac{2(t_0 + t)}{1000} z_1$$

$$+ z_2 .00265 \cos. 2l$$

$$+ (z^2 + 2M.\ 18336) \frac{z^2}{R}$$

The terms of this formula are generally reduced to tabular form for practical use.

Guyot's formula which is derived from this, reducing meters to feet and the constants depending on temperature being changed to accord with Fahrenheit's scale, is

$$z = 60158.6 \log. \frac{h_0}{h} \left\{ \begin{array}{l} \left(1 + \frac{t_0 + t - 64}{900}\right) \\ (1 + .00260 \cos. 2l) \\ \left(1 + \frac{z + 52252}{20886860} + \frac{s}{10443430}\right) \end{array} \right.$$

The three terms after the first are the corrections. The first being that for the temperature at the two stations. The second is the correction for the force of gravity depending on the latitude.

The third contains, first the correction for action of gravity on the mercury column at the elevation z, and second a correction required for decrease in density of air owing to decrease in action of gravity at the greater elevation. The factor s being the approximate difference in altitude of the stations.

Plantamour's formula, which has been much used, differs slightly from Guyot's. The first coefficient is 60384.3. The denominator of temperature term is 982.26 and a separate correction is used for humidity of the air.

To use either of these formulas elaborate tables are necessary, of which those prepared by Lieut. Col. Williamson* are the most elaborate.

For the Aneroid in ordinary practice, formulas of much less complexity may be profitably used. The corrections depending upon the gravity of the mercury column would, in any case, be omitted. The other corrections may in very nice work be retained. But a correction depending on the effect of changes of temperature on the metallic work of the instrument should be carefully remembered. First class Aneroids claim to be *compensated*, but a greater portion will need a correction which the purchaser

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* The Use of the Barometer on Surveys and Reconnoissances. By R. S. Williamson. New York: D. Van Nostrand. London: Trubner & Co.

can determine for himself, by subjecting the instrument to different temperatures while the pressure remains constant.

Approximate formulas to be used when no tables are at hand have been presented by various writers.

In *Engineering* for October, 1877, we get the following:

"For measuring heights not exceeding a quarter of a mile above the sea by means of the Aneroid, Admiral Fitzroy proposed the following method. Divide the difference between the readings at the lower and upper station by 0.011, the quotient is the approximate height in feet. Thus, Aneroid reading at:

Lower station.......	30.385 inches.
Upper station.......	30.025 "
Difference......	.360÷.0011=327 ft.

Another very simple rule was proposed by Mr. R. Strachan in the *Horological Journal* for 1866. Read the Aneroid to the nearest hundredth of an inch; subtract the reading at the upper station from that at the lower, neglecting the decimal point: multiply the difference by 9; the product is the elevation in feet. Example :

Lower station........... 30.25
Upper station........... 29.02

$123 \times 9 = 1107$ ft.

The following short method has been proposed for altitudes not much exceeding half a mile above the sea, where extreme accuracy may not be desired. Take from the subjoined Table the value corresponding to the mean reading of the Aneroid at the upper and lower stations, and the mean temperature (which may be guessed at when not observed) ; then divide the difference of the Aneroid readings by it; the quotient will be the height in feet.

Mean of Aneroid at Two Stations.	Mean temperature.		
	25 deg.	50 deg.	75 deg.
in.			
27	.00104	.00099	.00094
28	.00108	.00103	.00098
29	.00112	.00107	.00102
30	.00115	.00110	.00105

Example:

Aneroid at base of Ben Lomond...	29.890	mean temperature of the air 50 deg.
Aneroid at summit of Ben Lomond.	26.656	
Difference..	3.234	=quotient 3110 ft.
Divisor found in Table...........	.00104	

Mr. J. M. Heath has proposed the following short method: When the mean temperature at the stations is {less / greater} than 62 deg. {increase / decrease} both the readings of the Aneroid at the rate of 1 inch for every 15 deg. {below / above} 62 deg., or 0.2 for every 3 deg. The difference of the tabular numbers opposite these reduced readings is the vertical altitude in feet.

Aneroid.	No.		Aneroid.	No.	
		90			99
30.9	4824		28.1	2170	
		91			100
30.5	4460		27.8	1870	
		92			101
30.2	4184		27.5	1567	
		93			102
29.9	3905		27.3	1363	
		94			103
29.6	3623		27.0	1054	
		95			104
29.2	3243		26.7	742	
		96			105
28.9	2955		26.5	532	
		97			106
28.7	2761		26.2	214	
		98			107
28.4	2467		26.0	0	

Example: The last given, worked by this method.

Base..................	29.890 summit	26.656
Temp. 62 deg.—50 deg. =12, gives +........	.800	+ .800
	30.690	27.456
Tabular No...........	4633	1522
Difference.....	3111 ft.	

All the foregoing rules are mere simplifications of Laplace's formula, but are useful to travelers, tourists, military and civil engineers who require to obtain rapid results from their contouring observations.

Still another simple rule is based on the fact that in the logarithmic term of the complete formula the Napierian logarithm of $\frac{H}{h} = 2\frac{H-h}{H+h}$ very nearly. Applying to the result thus obtained a temperature correction for an average of 55° F. we obtain for an approximate value of difference of level between two observed stations.

$$D=55032\frac{H-h}{H+h}.$$

A formula which we find in an excellent paper by Gen. Theo. G. Ellis, presented to the Am. So. of Civil Engineers, in January 1871, and credited to Sir George Schuckburg.

Gen. Ellis suggests a modification of this, which the writer has found to give good results recently in some topographical surveys in the Catskill Mountains.

The form proposed is:

$$D = 55000 \frac{H - h}{H + h}$$

This gives the altitude very nearly when the average temperature of the upper and lower stations is 55°F. When it is higher add $\frac{1}{500}$ of the calculated value for each degree above 55°, and subtract a like amount when the temperature is lower.

In the above formula H and *h* are the barometric heights at the lower and upper stations respectively, and D is the difference in altitude in feet.

Prof. Airy's formula is, omitting the more refined corrections of the formulas of La Place and Plantamour,

$$D = 60500\ (\log. H - \log. h)\left(1 + \frac{T + t - 64}{964}\right)$$

Gen. Ellis offers as a convenient modification.

$$D = 60000\ (\log. H - \log. h)\left(1 + \frac{T + t - 60}{900}\right)$$

The direct use of a formula being in

general too laborious to be satisfactory, tables for facilitating the computations have been constructed. Of these there are many sets by different authors. Guyot's, Williamson's and Loomis's are well known and have been much used.

Many observers however desire to avoid even the amount of labor which such tables and formulas involve. To meet such a want, in 1867 Prof. Airy prepared a table for the use of the manufacturers of Aneroids, to be employed in the graduation of a circle of feet measures, concentric with the circle of inches. This table extended by interpolation is given further on.

When the Aneroid has a *fixed circle of feet* engraved on it in accordance with this table, the approximate height is obtained by subtracting the reading in feet at the lower station from that at the upper.

If the average temperature is 50° Fahrenheit no correction is required. But in all cases observe the temperatures at both stations. Add them together;

if the sum is greater than 100° *increase* the height by $\frac{1}{1000}$th part for every degree above 100°. If the sum of the temperatures is less than 100°, then *diminish* the estimated height by $\frac{1}{1000}$th part for every degree below 100°.

It is evident from the construction of the table that it may be used with Aneroids which have no scale of feet. A correct graduation of the scale corresponding to the mercurial barometer is all that is required. The corresponding heights in feet taken from the table are then to be used as above.

The makers of Aneroids have endeavored to improve on Prof. Airy, and have made his scale of feet movable, "showing on the dial, without the aid of pencil and tables the height of any given place above another." The observer is directed to bring the 0 point of the movable rim or scale to the point of the index when at the lower station, then at the upper station the altitude is indicated at once by the pointer.

The use of such a scale leads only to

rough approximations, as it is based on the assumption that certain differences of pressure correspond at all heights with the same differences of elevation. The writer of a recent article in *Engineering* (Oct., 1877), says of these scales:

"However advantageous it might be to have so simple a means of observing heights, truth compels the assertion that this movable scale is unscientific and misleading. Its effect is to make the second differences of barometric inches, for equal elevations, a decreasing series instead of an increasing one; in fact, to reverse the character of the serial differences. The heights are only likely to be correct when the scale is adjusted to 30 inches at the sea level. As the adjustment is made further from 30, so the elevations are given more and more inaccurate, always in defect as the heights increase. Thus from 26, at zero, to 15, it gives 12,300 feet, being 2000 in defect from 16, at zero, to 15 1000 feet: or nearly 700 in defect! It is evident that this movable scale is a gross misconception, and must generally give erroneous measurements."

Mr. Rogers Field, C.E., in 1873, applied the movable scale to the Aneroid so as to covert it from being a source of inaccuracy into an aid towards accuracy. He employs the altitude scale proposed by Sir G. Airy for temperature 50° but he makes it movable so as to adjust it for any other *temperature.* The shifting of the scale into certain fixed positions is made to answer the same purpose as if the original scale were altered to suit various temperatures of the air. In the *Journal of the Meteorological Society* for 1874, January, Mr. Field says:

"The object aimed at in designing this improved form of Aneroid was, to simplify the correct determination of altitudes in cases such as ordinarily occur in England, and the instrument is therefore arranged to suit moderate elevations, say of 2000 feet and under, and is not intended for more considerable heights.

"The Aneroid is graduated for inches

in the usual way on the face, but the graduation only extends from 31 inches to 27 inches so as to preserve an open scale. The outer movable scale is graduated in feet for altitudes, and this graduation is laid down by fixing the movable scale with the zero opposite 31 inches. This is the normal position of the scale and it is then correct for a temperature of 50°. For temperatures below 50° the zero of the scale is moved below 31 inches for temperatures above 50° the zero of the scale is moved above 31 inches. The exact position of the scale for different temperatures has been determined partly by calculation and partly by trial, and marked by figures engraved on the outside of the Aneroid. In order to insure the altitude scale not being shifted after it has once been set in its proper position there is a simple contrivance for locking it in the various positions. This consists of a pin, which fits into a series of notches on the outside of the ring carrying the glass. By slightly raising the glass it is freed from this locking pin, and can be turned until the figures corresponding to the air temperature are opposite to the pin, when the glass should be depressed so as to relock it, and the scale becomes correct for that temperature. The altitudes are in all cases determined by taking two readings one at each station, and then subtracting the reading at the lower station from that at the upper.

"It will be seen from the foregoing description that the movable scale of the instrument requires to be set for temperatures before taking any observations, and must not be shifted during the progress of the observations.

"This may appear at first sight as a defect inasmuch as the temperature of the air may alter during the progress of the observations; but practically it will not be found to be any drawback in the case of moderate altitudes, as small variations of temperature will not appreciably affect the result. A variation of 5° of temperature gives only about 1 per cent. variation in the altitude, an amount that would under ordinary circumstances be inappreciable, so that as long as the temperature does not vary during the course of the observations more than 5° from that at which the instrument is set, the results may be accepted as correct, and, generally speaking, even a greater variation than this, say 6° or 8°, would be practically of no importance. Of course, if it should be found at any time that the temperature has varied considerably during the course of the observations from that at which the instrument was set, this variation can be allowed for by calculation in the usual way."

The principle of allowing for variation of temperatures of the air by shifting the altitude scale is not theoretically accurate, but sufficiently so for practical purposes. For altitudes within the range of the instrument (say 3000 feet and under) and temperatures between 30° and 70°, the maximum error from using the shifted scale, instead of the calculation, is only 2 feet, which is inappreciable on the scale. The same principle might even be applied to altitudes up to 6000 feet, as the maximum error would be only 10 feet. For considerable elevations, however, the variations of the temperature between the base and the summit would interfere with the application of the principle.

Nevertheless the best plan is to dispense with altitude scales, whether fixed or movable, and to calculate the heights. Simple rules, giving more reliable results than the attached scales, are at the service of those who need easy processes.

SUMMARY OF RULES AND DIRECTIONS FOR USING THE ANEROID IN MEASURING ALTITUDES.

1st. In the absence of a table to aid in computation, but having an Aneroid with the scale of feet, use the formula,

$$D=55000\frac{H-h}{H+h}$$

adding $\frac{1}{500}$ of the estimated altitude for every degree, the *average* temperature is above 55°, and subtracting a like amount when it is below. D, is the difference of altitude in feet; H and h are the readings *in feet* from the Aneroid scale. This gives fair approximations up to 3000 feet.

2d. Having Airy's table, and an Aneroid carefully graduated to inches; take the reading in inches of the barometric scale at both lower and upper stations, also the temperature at both stations. Find from the table the heights in feet corresponding to the barometer readings. Subtract them and correct the remainder by $\frac{T+t-100}{1000}$

The complete formula is

$$D=(H-h)\left(1+\frac{T+t-100}{1000}\right)$$

T and t are the observed temperatures; H and h are the heights in feet taken from the table.

3d. In the absence of this table, but with a table of logarithms at hand, the barometric heights in inches are to be taken, and the following formula used,

$$D = 60000\,(\log. B - \log. b)\left(1 + \frac{T + t - 60}{900}\right).$$

B and b are the barometric readings in inches; D, T and t as in the other formulas.

To avoid error from the constant changes in barometric pressure, the observations should be simultaneous. This is accomplished in the best manner by using two instruments, and requires, when the distance between the stations is considerable, two observers. With one instrument only, large errors are avoided by repeating the observation at the first station after taking that at the 2d station, and assuming that any change in barometric pressure that has occurred has been gradual during the absence.

Many Aneroids marked "compensated" exhibit a sensible change when the temperature is varied; such instruments may be serviceable and quite accurate if allowance be made for the error of the instrument. This correction the owner had better determine by experiment. It is easy to subject the Aneroid to such variation of temperature as shall embrace the range at which it is likely to be used, and the movement of the index for each 10° or 20° of temperature recorded.

Aneroids require to be compared from time to time with a good mercurial barometer. While making such comparisons, it is well to remember that the mercurial column and the scale by which it is measured both require correcting, and that during times of rapid changes, in atmospheric pressure, the Aneroid shows such changes more readily than the mercurial barometer.

In measuring heights with the Aneroid care should be taken that the instrument is not influenced by the heat of the hand nor by the direct rays from the sun.

The instrument should always be tapped gently with the finger at the moment of taking an observation.

Considerable care is also required to determine exactly where the index points. It is best accomplished by sighting along the pointer, using one eye only for the purpose.

The following example will illustrate the use of the table.

Barometer at Station A	30.04	Thermometer	78°
" " " B	28.68	"	65°

From the table we find height corresponding to reading at A is 858 feet. The height for B is 2120 feet.

The approximate height is 2120—858 =1262 feet; but the sum of the temperatures is 143°. An additional correction of $\frac{43}{1000}$ is, therefore, to be applied to the above difference; this is 54 feet. The total estimated difference of altitude is then 1262+54=1316 feet.

The formula directly applied is

$$D=(2120-858)\left(1'+\frac{78+65-100}{1000}\right)$$

$$=1316.26$$

Applying the 3d method we should get, using logarithms

$$\text{Log. B } 30.04=1.477700$$
$$\text{" } b \ 28.68=1.457579$$

$$\text{Log. B—Log. } b=0.020121$$

$$D=60000(.020121)\left(1+\frac{78+65-60}{900}\right)$$

$$=1207.26\times 1\tfrac{83}{900}=1318 \text{ feet.}$$

The following suggestions to buyers of Aneroids we take from Gen. Ellis's pamphlet :

"If you are not a good judge of the instrument, go to the best maker or seller.

"If you want accuracy prefer a brass case. The back plate of the mechanism being secured to the case, if they are of different metals, as brass and silver, the different rate of expansion by heat sometimes causes error.

"Examine the dial and see if the divisions are *engraved.* If they are *stamped* upon it the instrument is probably worthless for accurate observations. The dial should be electro-plated, and not washed. See that the index is fine and slender, and lies close to the dial. It is best of blued steel. Have no central pointer for showing the position of the index. There should be a small steel pointer attached to the rim, as has been described. See that the dial has the number of inches you desire. From six to ten inches is a good range for engineering purposes. About three quarters of the circumference can be made to read accurately.

"For a pocket Aneroid buy the largest that can be conveniently carried in the pocket, and not the very smallest size. Two to two and one-fourth inches is a convenient size, and can be made accurate.

"If the dial has a scale of feet, see that it is graduated according to some correct formula, by taking off the numbers corresponding to each inch and comparing them with some known table or formula.

"The instrument should have a case, so that the heat of the hand shall not derange it when observing.

"It is better also to have a thermometer in the dial inside the scale, and dropped lower down, so as not to interfere with the index.

"Instruments that have the zero of the foot scale at thirty inches, particularly those having movable scales, are generally erroneously graduated, the same scale being commenced at thirty that should be commenced at thirty-one inches; they are moreover inconvenient to use."

RULES FOR FORETELLING THE WEATHER ADAPTED FOR USE WITH ANEROID BAROMETERS.

A Rising Barometer.

A "rapid" rise indicates unsettled weather.

A "gradual" rise indicates settled weather.

A "rise" with dry air, and cold increasing in summer, indicates wind from Northward; and if rain has fallen better weather is to be expected.

A "rise" with moist air, and a low temperature, indicates wind and rain from Northward.

A "rise" with southerly wind indicates fine weather.

A Steady Barometer,

With dry air and seasonable temperature, indicates a continuance of very fine weather.

A Falling Barometer.

A "rapid" fall indicates stormy weather.

A "rapid" fall, with westerly wind, indicates stormy weather from Northward.

A "fall," with a northerly wind, indicates storm, with rain and hail in summer, and snow in winter.

A "fall," with increased moisture in the air, and the heat increasing, indicates wind and rain from Southward.

A "fall" with dry air and cold increasing (in winter) indicates snow.

A "fall" after very calm and warm weather indicates rain with squally weather.

The following are a few of the more marked signs of weather, described in the late Admiral Fitzroy's valuable Weather Book:

Whether clear or cloudy, a rosy sky at sunset presages fine weather; a sickly-looking *greenish* hue, wind and rain; a dark (or *Indian*) red, rain; a red sky in the morning, bad weather or much wind (perhaps rain); a grey sky in the morning, fine weather; a high dawn, wind; a low dawn, fair weather.

Soft-looking or delicate clouds foretell fine weather, with moderate or light breezes; hard-edged, oily-looking clouds, wind. A dark, gloomy blue sky is windy, but a light, bright blue sky indicates fine weather. Generally, the *softer* clouds look, the less wind (but perhaps more rain) may be expected; and the harder, more "greasy," rolled, tufted, or ragged, the stronger the coming wind will prove. Also—a bright yellow sky at sunset presages wind, a pale yellow, wet: therefore by the prevalence and kind of red, yellow, or other tints, the coming weather may be foretold very nearly; indeed, if aided by instruments, almost exactly.

Small inky-looking clouds foretell

rain; light scud clouds driving across heavy masses show wind and rain; but if alone may indicate wind only.

High upper clouds crossing the sun, moon, or stars, in a direction different from that of the lower clouds, or the wind then felt below, foretell a change of wind *toward their direction.*

After fine clear weather, the first signs in the sky of a coming change are usually light streaks, curls, wisps or mottled patches of white distant clouds, which increase, and are followed by an overcasting of murky vapor that grows into cloudiness. This appearance, more or less oily or watery, as wind or rain will prevail, is an infallible sign.

Usually, the higher and more distant such clouds seem to be, the more gradual, but general, the coming change of weather will prove.

Light, delicate, quiet tints or colors, with soft undefined forms of clouds, indicate and accompany fine weather; but unusual or gaudy hues, with hard, definitely outlined clouds, fortell rain, and probably strong wind.

Misty clouds, forming or hanging on heights, show wind and rain coming, if they remain, increase, or descend. If they rise, or disperse, the weather will improve or become fine.

Dew is an indication of fine weather, so is fog. Neither of these two formations occur under an overcast sky, or when there is much wind. One sees fog occasionally rolled away, as it were, by wind, but seldom or never *formed* while it is blowing.

Remarkable clearness of atmosphere near the horizon,—distant objects such as hills unusually visible, or raised (by refraction)—and what is called "a good *hearing* day"—may be mentioned among signs of wet, if not wind, to be expected.

More than usual twinkling of the stars, indistinctness or apparent multiplication of the moon's horns; haloes, "wind dogs" and the rainbow, are more or less significant of increasing wind, if not approaching rain with or without wind.

Observers should be advised to *mark* a true E. and W. line, *about the time of the equinox*, by the sun at rising or setting, and by it give their bearings or directions of wind. And they should take its direction from that of the *lower* clouds (when they are not very distant), compared with that of vanes and smoke in preference to any other indication.

Much more care is required in noticing the veering, backing, shift, turn, or gyration of the wind, than has usually been thought necessary. Very rarely has the way the wind *went round* been noticed in ordinary registers, though of material consequence.

Table for Estimating Heights by the Aneroid.

Having read both barometer and thermometer at both stations—Find in the table the altitudes corresponding to the barometric readings. Subtract them and multiply the remainder by $1+\frac{T+t-100}{1000}$. T and t being the temperatures.

Barometer Readings.	Heights.	Barometer Readings.	Heights.
Inches.	Feet.	Inches.	Feet.
31.00	00	30.81	168
30.99	9	30.80	177
30.98	18	30.79	186
30.97	27	30.78	195
30.96	35	30.77	203
30.95	44	30.76	212
30.94	53	30.75	221
30.93	62	30.74	230
30.92	71	30.73	239
30.91	80	30.72	247
30.90	88	30.71	256
30.89	97	30.70	265
30.88	106	30.69	274
30.87	115	30.68	283
30.86	124	30.67	292
30.85	133	30.66	301
30.84	142	30.65	310
30.83	151	30.64	318
30.82	160	30.63	327

Barometer Readings.	Heights.	Barometer Readings.	Heights.
Inches.	Feet.	Inches.	Feet.
30.62	336	30.30	622
30.61	345	30.29	631
30.60	354	30.28	640
30.59	363	30.27	649
30.58	372	30.26	658
30.57	381	30.25	667
30.56	390	30.24	676
30.55	399	30.23	685
30.54	407	30.22	694
30.53	416	30.21	703
30.52	425	30.20	712
30.51	434	30.19	721
30.50	443	30.18	730
30.49	452	30.17	740
30.48	461	30.16	749
30.47	470	30.15	758
30.46	479	30.14	767
30.45	488	30.13	776
30.44	497	30.12	785
30.43	506	30.11	794
30.42	515	30.10	803
30.41	524	30.09	812
30.40	533	30.08	821
30.39	542	30.07	830
30.38	551	30.06	839
30.37	559	30.05	849
30.36	569	30.04	857
30.35	578	30.03	866
30.34	587	30.02	875
30.33	596	30.01	884
30.32	605	30.00	893
30.31	613	29.99	903

Barometer Readings.	Heights	Barometer Readings.	Heights.
Inches.	Feet.	Inches.	Feet.
29.98	911	29.66	1205
29.97	920	29.65	1214
29.96	929	29.64	1224
29.95	938	29.63	1233
29.94	947	29.62	1242
29.93	956	29.61	1251
29.92	965	29.60	1260
29.91	976	29.59	1269
29.90	985	29.58	1278
29.89	994	29.57	1287
29.88	1002	29.56	1296
29.87	1012	29.55	1305
29.86	1021	29.54	1314
29.85	1030	29.53	1324
29.84	1039	29.52	1333
29.83	1049	29.51	1342
29.82	1058	29.50	1352
29.81	1067	29.49	1361
29.80	1076	29.48	1370
29.79	1085	29.47	1379
29.78	1094	29.46	1389
29.77	1103	29.45	1398
29.76	1113	29.44	1408
29.75	1122	29.43	1417
29.74	1132	29.42	1426
29.73	1141	29.41	1435
29.72	1150	29.40	1445
29.71	1159	29.39	1454
29.70	1169	29.38	1464
29.69	1177	29.37	1473
29.68	1186	29.36	1482
29.67	1195	29.35	1491

Barometer Readings.	Heights.	Barometer Readings.	Heights.
Inches.	Feet.	Inches.	Feet.
29.34	1500	29.02	1799
29.33	1509	29.01	1809
29.32	1519	29.00	1818
29.31	1528	28.99	1827
29.30	1537	28.98	1837
29.29	1546	28.97	1846
29.28	1556	28.96	1856
29.27	1565	28.95	1865
29.26	1574	28.94	1875
29.25	1583	28.93	1884
29.24	1593	28.92	1894
29.23	1603	28.91	1903
29.22	1612	28.90	1913
29.21	1621	28.89	1922
29.20	1630	28.88	1931
29.19	1639	28.87	1941
29.18	1649	28.86	1950
29.17	1658	28.85	1960
29.16	1668	28.84	1969
29.15	1677	28.83	1979
29.14	1687	28.82	1988
29.13	1696	28.81	1998
29.12	1706	28.80	2007
29.11	1715	28.79	2016
29.10	1725	28.78	2026
29.09	1734	28.77	2035
29.08	1743	28.76	2044
29.07	1752	28.75	2054
29.06	1762	28.74	2063
29.05	1771	28.73	2073
29.04	1781	28.72	2082
29.03	1790	28.71	2091

Barometer Readings.	Heights.	Barometer Readings.	Heights.
Inches.	Feet.	Inches.	Feet.
28.70	2101	28.38	2407
28.69	2111	28.37	2416
28.68	2120	28.36	2426
28.67	2129	28.35	2435
28.66	2139	28.34	2445
28.65	2148	28.33	2455
28.64	2158	28.32	2464
28.63	2168	28.31	2474
28.62	2177	28.30	2483
28.61	2186	28.29	2493
28.60	2196	28.28	2503
28.59	2205	28.27	2512
28.58	2215	28.26	2522
28.57	2224	28.25	2531
28.56	2234	28.24	2541
28.55	2243	28.23	2551
28.54	2253	28.22	2561
28.53	2263	28.21	2570
28.52	2272	28.20	2580
28.51	2282	28.19	2590
28.50	2291	28.18	2600
28.49	2301	28.17	2609
28.48	2310	28.16	2619
28.47	2320	28.15	2628
28.46	2329	28.14	2638
28.45	2339	28.13	2648
28.44	2349	28.12	2658
28.43	2358	28.11	2667
28.42	2368	28.10	2677
28.41	2378	28.09	2687
28.40	2387	28.08	2696
28.39	2397	28.07	2706

Barometer Readings.	Heights.	Barometer Readings.	Heights.
Inches.	Feet.	Inches.	Feet.
28.06	2715	27.74	3029
28.05	2726	27.73	3039
28.04	2735	27.72	3048
28.03	2745	27.71	3058
28.02	2755	27.70	3068
28.01	2765	27.69	3078
28.00	2774	27.68	3087
27.99	2784	27 67	3097
27.98	2794	27.66	3107
27.97	2804	27.65	3117
27.96	2813	27.64	3126
27.95	2823	27.63	3136
27.94	2833	27.62	3146
27.93	2843	27.61	3156
27.92	2853	27.60	3166
27.91	2863	27.59	3176
27.90	2873	27.58	3186
27 89	2882	27.57	3196
27.88	2892	27.56	3206
27.87	2901	27.55	3216
27.86	2911	27.54	3225
27 85	2921	27.53	3235
27.84	2930	27.52	3245
27.83	2940	27.51	3255
27.82	2950	27.50	3265
27.81	2960	27 49	3275
27.80	2969	27.48	3285
27.79	2979	27.47	3295
27.78	2989	27.46	3305
27.77	2999	27.45	3315
27.76	3009	27.44	3325
27.75	3019	27.43	3335

Barometer Readings.	Heights.	Barometer Readings.	Heights.
Inches.	Feet.	Inches.	Feet.
27.42	3345	27.10	3665
27.41	3355	27.09	3675
27.40	3365	27.08	3685
27.39	3375	27.07	3695
27.38	3384	27.06	3705
27.37	3394	27.05	3715
27.36	3404	27.04	3725
27.35	3414	27.03	3735
27.34	3424	27.02	3745
27.33	3434	27.01	3755
27.32	3444	27.00	3765
27.31	3454	26.99	3775
27.30	3464	26.98	3785
27.29	3474	26.97	3795
27.28	3484	26.96	3806
27.27	3494	26.95	3816
27.26	3504	26.94	3826
27.25	3514	26.93	3836
27.24	3524	26.92	3846
27.23	3534	26.91	3856
27.22	3544	26.90	3866
27.21	3554	26.89	3876
27.20	3564	26.88	3886
27.19	3574	26.87	3897
27.18	3584	26.86	3907
27.17	3594	26.85	3917
27.16	3604	26.84	3927
27.15	3614	26.83	3938
27.14	3624	26.82	3948
27.13	3634	26.81	3958
27.12	3644	26.80	3968
27.11	3654	26.79	3978

Barometer Readings.	Heights.	Barometer Readings.	Heights.
Inches.	Feet.	Inches.	Feet.
26.78	3988	26.46	4315
26.77	3999	26.45	4326
26.76	4009	26.44	4336
26.75	4019	26.43	4347
26.74	4030	26.42	4357
26.73	4040	26.41	4368
26.72	4050	26.40	4378
26.71	4060	26.39	4388
26.70	4070	26.38	4399
26.69	4081	26.37	4409
26.68	4091	26.36	4419
26.67	4101	26.35	4430
26.66	4111	26.34	4440
26.65	4122	26.33	4450
26.64	4132	26.32	4461
26.63	4142	26.31	4472
26.62	4152	26.30	4482
26 61	4163	26.29	4492
26.60	4173	26.28	4502
26.59	4183	26.27	4513
26.58	4193	26.26	4523
26.57	4203	26.25	4533
26.56	4213	26.24	4544
26.55	4223	26.23	4554
26.54	4233	26.22	4565
26.53	4244	26.21	4575
26.52	4254	26.20	4585
26.51	4264	26.19	4596
26.50	4274	26.18	4606
26.49	4284	26.17	4617
26.48	4294	26.16	4627
26.47	4304	26.15	4638

Barometer Readings.	Heights.	Barometer Readings.	Heights.
Inches.	Feet.	Inches.	Feet.
26.14	4648	25.82	4983
26.13	4658	25.81	4994
26.12	4669	25.80	5004
26.11	4679	25.79	5014
26.10	4690	25.78	5025
26.09	4700	25.77	5036
26 08	4711	25.76	5046
26.07	4721	25.75	5057
26.06	4731	25.74	5067
26.05	4742	25.73	5078
26.04	4753	25.72	5088
26.03	4763	25.71	5099
26.02	4773	25.70	5110
26.01	4784	25.69	5121
26.00	4794	25.68	5132
25.99	4805	25.67	5142
25.98	4815	25.66	5153
25.97	4826	25.65	5164
25.96	4836	25.64	5174
25.95	4847	25.63	5185
25.94	4857	25.62	5195
25.93	4868	25.61	5206
25.92	4878	25.60	5216
25.91	4889	25.59	5227
25.90	4899	25.58	5237
25.89	4910	25.57	5248
25.88	4920	25.56	5259
25.87	4931	25.55	5270
25.86	4941	25.54	5281
25.85	4952	25.53	5291
25.84	4962	25.52	5302
25.83	4973	25.51	5312

Barometer Readings.	Heights.	Barometer Readings.	Heights.
Inches.	Feet.	Inches.	Feet.
25.50	5323	25.18	5668
25.49	5333	25.17	5679
25.48	5344	25.16	5689
25.47	5355	25.15	5700
25.46	5365	25.14	5711
25.45	5376	25.13	5722
25.44	5387	25.12	5733
25.43	5397	25.11	5744
25.42	5408	25.10	5754
25.41	5419	25.09	5765
25.40	5429	25.08	5776
25.39	5440	25.07	5787
25.38	5451	25.06	5798
25.37	5462	25 05	5809
25.36	5473	25.04	5820
25.35	5483	25.03	5831
25.34	5494	25.02	5842
25.33	5505	25.01	5853
25.32	5516	25.00	5863
25.31	5527	24.99	5874
25.30	5537	24.98	5885
25.29	5548	24 97	5896
25.28	5559	24.96	5907
25.27	5570	24.95	5918
25.26	5581	24.94	5929
25.25	5592	24.93	5940
25.24	5602	24.92	5950
25.23	5613	24.91	5962
25.22	5624	24.90	5972
25.21	5635	24.89	5983
25.20	5646	24.88	5994
25.19	5657	24.87	6005

Barometer Readings.	Heights.	Barometer Readings.	Heights.
Inches.	Feet.	Inches.	Feet.
24.86	6016	24.54	6368
24.85	6027	24.53	6379
24.84	6038	24.52	6390
24.83	6049	24.51	6401
24.82	6060	24.50	6412
24.81	6071	24.49	6424
24.80	6082	24.48	6435
24.79	6093	24.47	6446
24.78	6104	24.46	6458
24.77	6115	24.45	6469
24.76	6126	24.44	6480
24.75	6137	24.43	6491
24.74	6148	24.42	6503
24.73	6159	24.41	6514
24.72	6170	24.40	6525
24.71	6181	24.39	6536
24.70	6192	24.38	6547
24.69	6203	24.37	6559
24.68	6214	24.36	6570
24.67	6225	24.35	6581
24.66	6236	24.34	6592
24.65	6247	24.33	6603
24.64	6258	24.32	6615
24 63	6269	24.31	6626
24.62	6280	24.30	6637
24.61	6291	24.29	6648
24.60	6302	24.28	6659
24.59	6313	24.27	6671
24.58	6324	24.26	6682
24.57	6335	24.25	6693
24.56	6346	24.24	6705
24.55	6357	24.23	6716

Barometer Readings.	Heights.	Barometer Readings.	Heights.
Inches.	Feet	Inches.	Feet.
24.22	6727	23.90	7090
24.21	6738	23.89	7101
24.20	6750	23.88	7113
24.19	6761	23.87	7124
24.18	6772	23.86	7135
24.17	6783	23.85	7146
24.16	6795	23.84	7157
24.15	6806	23.83	7168
24.14	6817	23.82	7180
24.13	6828	22.81	7191
24.12	6840	23.80	7203
24.11	6851	23.79	7214
24.10	6862	23.78	7226
24.09	6873	23.77	7237
24.08	6885	23.76	7249
24.07	6896	23.75	7261
24.06	6907	23.74	7272
24.05	6919	23.73	7283
24.04	6930	23.72	7294
24.03	6941	23.71	7305
24.02	6953	23.70	7316
24.01	6964	23.69	7327
24.00	6976	23.68	7339
23.99	6987	23.67	7350
23.98	6999	23.66	7362
23.97	7010	23.65	7374
23.96	7022	23.64	7386
23.95	7033	23.63	7398
23.94	7045	23.62	7409
23.93	7056	23.61	7421
23.92	7068	23.60	7433
23.91	7079	23.59	7445

Barometer Readings.	Heights.	Barometer Readings.	Heights.
Inches.	Feet.	Inches.	Feet.
23.58	7456	23.26	7829
23.57	7468	23.25	7841
23.56	7480	23 24	7853
23.55	7492	23.23	7865
23.54	7503	23.22	7876
23.53	7515	23.21	7888
23.52	7527	23.20	7900
23.51	7539	23.19	7912
23.50	7550	23.18	7923
23.49	7562	23.17	7935
23.48	7574	23.16	7946
23.47	7585	23.15	7958
23.46	7597	23.14	7969
23.45	7609	23.13	7981
23.44	7621	23.12	7992
23.43	7633	23.11	8004
23.42	7644	23.10	8015
23.41	7656	23.09	8027
23.40	7667	23.08	8039
23.39	7679	23.07	8051
23.38	7690	23.06	8063
23.37	7702	23.05	8075
23.36	7713	23.04	8086
23.35	7725	23.03	8098
23.34	7736	23.02	8110
23.33	7748	23.01	8122
23.32	7759	23.00	8134
23.31	7771	22.99	8146
23.30	7782	22.98	8158
23.29	7893	22.97	8170
23.28	7805	22.96	8182
23.27	7817	22.95	8194

Barometer Readings.	Heights.	Barometer Readings.	Heights.
Inches.	Feet.	Inches.	Feet.
22.94	8206	22.62	8591
22.93	8218	22.61	8603
22.92	8230	22.60	8615
22.91	8242	22.59	8627
22.90	8254	22.58	8638
22.89	8266	22.57	8650
22.88	8278	22.56	8661
22.87	8290	22.55	8673
22.86	8302	22.54	8685
22.85	8314	22.53	8697
22.84	8326	22.52	8709
22.83	8338	22.51	8721
22.82	8350	22.50	8733
22.81	8362	22.49	8745
22.80	8374	22.48	8757
22.79	8386	22.47	8769
22.78	8398	22.46	8781
22.77	8410	22.45	8793
22.76	8422	22.44	8806
22.75	8434	22.43	8818
22.74	8446	22.42	8830
22.73	8458	22.41	8842
22.72	8470	22.40	8855
22.71	8482	22.39	8867
22.70	8495	22.38	8879
22.69	8507	22.37	8891
22.68	8519	22.36	8904
22.67	8531	22.35	8916
22.66	8543	22.34	8928
22.65	8555	22.33	8941
22.64	8567	22 32	8953
22.63	8579	22.31	8965

Barometer Readings.	Heights.	Barometer Readings.	Heights.
Inches.	Feet.	Inches.	Feet.
22.30	8977	21.98	9372
22.29	8990	21.97	9384
22.28	9002	21.96	9397
22.27	9014	21.95	9410
22.26	9026	21.94	9422
22.25	9039	21.83	9435
22.24	9051	21.92	9447
22.23	9063	21.91	9460
22.22	9075	21.90	9472
22.21	9088	21.89	9485
22 20	9100	21.88	9497
22.19	9113	21.87	9510
22.18	9125	21.86	9522
22.17	9138	21.85	9535
22.16	9150	21.84	9547
22.15	9162	21.83	9560
22.14	9174	21.82	9572
22.13	9187	21.81	9585
22.12	9199	21.80	9597
22.11	9212	21.79	9610
22.10	9224	21.78	9622
22.09	9236	21.77	9635
22.08	9249	21.76	9647
22.07	9262	21.75	9660
22.06	9274	21.74	9672
22.05	9286	21.73	9685
22.04	9298	21.72	9697
22.03	9311	21.71	9710
22.02	9323	21.70	9722
22.01	9336	21.69	9735
22.00	9348	21.68	9747
21.99	9360	21.67	9760

Barometer Readings.	Heights.	Barometer Readings.	Heights.
Inches.	Feet.	Inches.	Feet.
21.66	9772	21.34	10176
21.65	9785	21.33	10189
21.64	9797	21.32	10202
21.63	9810	21.31	10214
21.62	9822	21.30	10228
21.61	9835	21.29	10241
21.60	9848	21.28	10253
21.59	9861	21.27	10266
21.58	9873	21.26	10278
21.57	9886	21.25	10291
21.56	9898	21.24	10304
21.55	9111	21.23	10317
21.54	9923	21.22	10330
21.53	9936	21.21	10343
21.52	9949	21.20	10355
21.51	9962	21.19	10368
21.50	9974	21.18	10381
21.49	9987	21.17	10394
21.48	9999	21.16	10407
21.47	10012	21.15	10420
21.46	10025	21.14	10432
21.45	10038	21.13	10445
21.44	10050	21.12	10458
21.43	10063	21.11	10471
21.42	10075	21.10	10484
21.41	10088	21.09	10497
21.40	10101	21.08	10509
21.39	10114	21.07	10522
21.38	10126	21.06	10535
21.37	10139	21.05	10548
21.36	10151	21.04	10561
21.35	10164	21.03	10574

Barometer Readings.	Heights.	Barometer Readings.	Heights.
Inches.	Feet.	Inches.	Feet.
21.02	10587	20.70	11006
21.01	10600	20.69	11019
21.00	10613	20.68	11032
20.99	10627	20.67	11045
20.98	10640	20.66	11058
20.97	10654	20.65	11071
20.96	10667	20.64	11084
20.95	10681	20.63	11097
20.94	10694	20.62	11110
20.93	10707	20.61	11123
20.92	10720	20.60	11136
20.91	10733	20.59	11149
20.90	10746	20.58	11163
20.89	10759	20.57	11176
20.88	10772	20.56	11190
20.87	10785	20.55	11204
20.86	10798	20.54	11217
20.85	10811	20.53	11230
20.84	10824	20.52	11243
20.83	10837	20.51	11257
20.82	10850	20.50	11270
20.81	10863	20.49	11284
20.80	10876	20.48	11297
20.79	10889	20.47	11311
20.78	10902	20.46	11324
20.77	10915	20.45	11338
20.76	10928	20.44	11351
20.75	10941	20.43	11364
20.74	10954	20.42	11377
20.73	10967	20.41	11391
20.72	10980	20.40	11404
20.71	10993	20.39	11418

Barometer Readings.	Heights.	Barometer Readings.	Heights.
Inches.	Feet	Inches.	Feet.
20.38	11431	20.18	11700
20.37	11444	20.17	11714
20.36	11457	20.16	11727
20.35	11470	20.15	11741
20.34	11483	20.14	11754
20.33	11496	20.13	11768
20.32	11509	20.12	11781
20.31	11523	20.11	11795
20.30	11536	20.10	11808
20.29	11550	20.09	11821
20.28	11563	20.08	11835
20.27	11577	20.07	11859
20.26	11591	20.06	11863
20.25	11605	20.05	11877
20.24	11618	20.04	11891
20.23	11632	20.03	11905
20.22	11645	20.02	11918
20.21	11659	20.01	11932
20.20	11673	20.00	11945
20.19	11687		

The following table is to be used when applying the formula of the 3d method (page 61).

The formula is

$$D = 60000\,(\log. B - \log. b)\left(1 + \frac{T + t - 60}{900}\right)$$

Rule.—Find in the table the logarithms of the barometer readings to hundredths of an inch. Subtract these logarithms and multiply the remainder by 60000. The product is the approximate difference in altitude between the two stations. To apply the corrections for temperature, add the temperatures of the two stations and subtract 60°. Increase the above approximate value by $\frac{1}{900}$ of itself for each degree of excess above 60°. If the sum of the temperatures is *less* than 60° diminish the value by a like amount.

The table may also be used to apply Guyot's formula (page 44), or Prof. Airy's (page 51). But probably the first table (page 72) and its formula will give the most satisfactory results.

Logarithmic Table.

Bar. Height.	Log.	Bar. Height.	Log.
2200	3.34242	2231	3.34850
01	.34262	32	.34869
02	.34282	33	.34889
03	.34301	34	.34908
04	.34321	35	.34928
05	.34341	36	.34947
06	.34361	37	.34967
07	.34380	38	.34986
08	.34400	39	.35005
09	.34420	40	.25025
10	.34439	41	.35044
11	.34459	42	.35064
12	.34479	43	.35083
13	.34498	44	.35102
14	.34518	45	.35122
15	.34537	46	.35141
16	.34557	47	.35160
17	.34577	48	.35180
18	.34596	49	.35199
19	.34616	50	.35218
20	.34635	51	.35238
21	.34655	52	.35257
22	.34674	53	.35276
23	.34694	54	.35295
24	.34713	55	.35315
25	.34733	56	.35334
26	.34753	57	.35353
27	.34772	58	.35372
28	.34792	59	.35392
29	.34811	60	.35411
30	.34830	61	.35430

Bar. Height.	Log.	Bar. Height.	Log.
2262	3.35449	2295	3.36078
63	.35468	96	.36097
64	.35488	97	.36116
65	.35507	98	.36135
66	.35526	99	.36154
67	.35545	2300	.36173
68	.35564	01	.36192
69	.35583	02	.36211
70	.35603	03	.36229
71	.35622	04	.36248
72	.35641	05	.36267
73	.35660	06	.36286
74	.35679	07	.36305
75	.35698	08	.36324
76	.35717	09	.36342
77	.35736	10	.36361
78	.35755	11	.36380
79	.35774	12	.36399
80	.35793	13	.36418
81	.35813	14	.36436
82	.35832	15	.36455
83	.35851	16	.36474
84	.35870	17	.36493
85	.35889	18	.36511
86	.35908	19	.36530
87	.35927	20	.36549
88	.35946	21	.36568
89	.35965	22	.36586
90	.35984	23	.36605
91	.36003	24	.36624
92	.36021	25	.36642
93	.36040	26	.36661
94	.36059	27	.36680

Bar. Height.	Log.	Bar. Height.	Log.
2328	3.36698	2361	3.37310
29	.36717	62	.37328
30	.36736	63	.37346
31	.36754	64	.37365
32	.36773	65	.37383
33	.36791	66	.37401
34	.36810	67	.37420
35	.36829	68	.37438
36	.36847	69	.37457
37	.36866	70	.37475
38	.36884	71	.37493
39	.36903	72	.37511
40	.36922	73	.37530
41	.36940	74	.37548
42	.36959	75	.37566
43	.36977	76	.37585
44	.36996	77	.37603
45	.37014	78	.37621
46	.37033	79	.37639
47	.37051	80	.37658
48	.37070	81	.37676
49	.37088	82	.37694
50	.37107	83	.37712
51	.37125	84	.37731
52	.37144	85	.37749
53	.37162	86	.37767
54	.37181	87	.37785
55	.37199	88	.37803
56	.37218	89	.37822
57	.37236	90	.37840
58	.37254	91	.37858
59	.37273	92	.37876
60	.37291	93	.37894

Bar. Height.	Log.	Bar. Height.	Log.
2394	3.37912	2427	3.38507
95	.37931	28	.38525
96	.37949	29	.38543
97	.37967	30	.38561
98	.37985	31	.38579
99	.38003	32	.38596
2400	.38021	33	.38614
01	.38039	34	.38632
02	.38057	35	.38650
03	.38075	36	.38668
04	.38093	37	.38686
05	.38112	38	.38703
06	.38130	39	.38721
07	.88148	40	.38739
08	.38166	41	.38757
09	.38184	42	.38775
10	.38202	43	.38792
11	.38220	44	.38810
12	.38238	45	.38828
13	.38256	46	.88846
14	.38274	47	.38863
15	.38292	48	.38881
16	.38310	49	.38899
17	.38328	50	.38917
18	.38346	51	.38934
19	.38364	52	.38952
20	.38382	53	.38970
21	.38399	54	.38987
22	.38417	55	.39005
23	.38435	56	.39023
24	.38453	57	.39041
25	.38471	58	.39058
26	.38489	59	.39076

Bar. Height.	Log.	Bar. Height.	Log.
2460	3.39094	2493	3.39672
61	.39111	94	.39690
62	.39129	95	.39707
63	.39146	96	.39724
64	.39164	97	.39742
65	.39182	98	.39759
66	.39199	99	.39777
67	.39217	2500	.39794
68	.39235	01	.39811
69	.39252	02	.39829
70	.39270	03	.39846
71	.39287	04	.39863
72	.39305	05	.39881
73	.39322	06	.39898
74	.39340	07	.39915
75	.39358	08	.39933
76	.39375	09	.39950
77	.39393	10	.39967
78	.39410	11	.39985
79	.39428	12	.40002
80	.39445	13	.40019
81	.39463	14	.40037
82	.39480	15	.40054
83	.39498	16	.40071
84	.39515	17	.40088
85	.39533	18	.40106
86	.39550	19	.40123
87	.39568	20	.40140
88	.39585	21	.40157
89	.39602	22	.40175
90	.39620	23	.40192
91	.39637	24	.40209
92	.39655	25	.40226

Bar. Height.	Log.	Bar. Height.	Log.
2526	3.40243	2559	3.40807
27	.40261	60	.40824
28	.40278	61	.40841
29	.40295	62	.40858
30	.40312	63	.40875
31	.40329	64	.40892
32	.40346	65	.40909
33	.40364	66	.40926
34	.40381	67	.40943
35	.40398	68	.40960
36	.40415	69	.40976
37	.40432	70	.40993
38	.40449	71	.41010
39	.40466	72	.41027
40	.40483	73	.41044
41	.40500	74	.41061
42	.40518	75	.41078
43	.40535	76	.41095
44	.40552	77	.41111
45	.40569	78	.41128
46	.40586	79	.41145
47	.40603	80	.41162
48	.40620	81	.41179
49	.40637	82	.41196
50	.40654	83	.41212
51	.40671	84	.41229
52	.40688	85	.41246
53	.40705	86	.41263
54	.40722	87	.41280
55	.40739	88	.41296
56	.40756	89	.41313
57	.40773	90	.41330
58	.40790	91	.41347

Bar. Height.	Log.	Bar. Height.	Log.
2592	3.41364	2625	3.41913
93	.41380	26	.41929
94	.41397	27	.41946
95	.41414	28	.41963
96	.41430	29	.41979
97	.41447	30	.41996
98	.41464	31	.42012
99	.41481	32	.42029
2600	.41497	33	.42045
01	.41514	34	.42062
02	.41531	35	.42078
03	.41547	36	.42095
04	.41564	37	.42111
05	.41581	38	.42127
06	.41597	39	.42144
07	.41614	40	.42160
08	.41631	41	.42177
09	.41647	42	.42193
10	.41664	43	.42210
11	.41681	44	.42226
12	.41697	45	.42243
13	.41713	46	.42259
14	.41731	47	.42275
15	.41747	48	.42292
16	.41764	49	.42308
17	.41781	50	.42325
18	.41797	51	.42341
19	.41814	52	.42357
20	.41831	53	.42374
21	.41847	54	.42390
22	.41863	55	.42406
23	.41880	56	.42423
24	.41896	57	.42439

Bar. Height.	Log.	Bar. Height.	Log.
2658	3.42455	2691	3.42991
59	.42472	92	.43008
60	.42488	93	.43024
61	.42504	94	.43040
62	.42521	95	.43056
63	.42537	96	.43072
64	.42553	97	.43088
65	.42570	98	.43104
66	.42586	99	.43120
67	.42602	2700	.43136
68	.42619	01	.43152
69	.42635	02	.43169
70	.42651	03	.43185
71	.42667	04	.43201
72	.42684	05	.43217
73	.42700	06	.43233
74	.42716	07	.43249
75	.42732	08	.43265
76	.42749	09	.43281
77	.42765	10	.43297
78	.42781	11	.43313
79	.42797	12	.43329
80	.42813	13	.43345
81	.42830	14	.43361
82	.42846	15	.43377
83	.42862	16	.43393
84	.42878	17	.43409
85	.42894	18	.43425
86	.42911	19	.43441
87	.42927	20	.43457
88	.42943	21	.43473
89	.42959	22	.43489
90	.42975	23	.43505

Bar. Height.	Log.	Bar. Height.	Log.
2724	3.43521	2757	3.44044
25	.43537	58	.44059
26	.43553	59	.44075
27	.43569	60	.44091
28	.43584	61	.44107
29	.43600	62	.44122
30	.43616	63	.44138
31	.43632	64	.44154
32	.43648	65	.44170
33	.43664	66	.44185
34	.43680	67	.44201
35	.43696	68	.44217
36	.43712	69	.44232
37	.43727	70	.44248
38	.43743	71	.44264
39	.43759	72	.44279
40	.43775	73	.44295
41	.43791	74	.44311
42	.43807	75	.44326
43	.43823	76	.44342
44	.43838	77	.44358
45	.43854	78	.44373
46	.43870	79	.44389
47	.43886	80	.44404
48	.43902	81	.44420
49	.43917	82	.44436
50	.43933	83	.44451
51	.43949	84	.44467
52	.43965	85	.44483
53	.43981	86	.44498
54	.43996	87	.44514
55	.44012	88	.44529
56	.44028	89	.44545

Bar. Height.	Log.	Bar. Height.	Log.
2790	3.44560	2823	3.45071
91	.44576	24	.45086
92	.44592	25	.45102
93	.44607	26	.45117
94	.44623	27	.45133
95	.44638	28	.45148
96	.44654	29	.45163
97	.44669	30	.45179
98	.44685	31	.45194
99	.44700	32	.45209
2800	.44716	33	.45225
01	.44731	34	.45240
02	.44747	35	.45255
03	.44762	36	.45271
04	.44778	37	.45287
05	.44793	38	.45301
06	.44809	39	.45317
07	.44824	40	.45332
08	.44840	41	.45347
09	.44855	42	.45362
10	.44871	43	.45378
11	.44886	44	.45393
12	.44902	45	.45408
13	.44917	46	.45423
14	.44932	47	.45439
15	.44948	48	.45454
16	.44963	49	.45469
17	.44979	50	.45484
18	.44994	51	.45500
19	.45010	52	.45515
20	.45025	53	.45530
21	.45040	54	.45545
22	.45056	55	.45561

Bar. Height.	Log.	Bar. Height.	Log.
2856	3.45576	2889	3.46075
57	.45591	90	.46090
58	.45606	91	.46105
59	.45621	92	.46120
60	.45637	93	.44135
61	.45652	94	.46150
62	.45667	95	.46165
63	.45682	96	.46180
64	.45698	97	.46195
65	.45712	98	.46210
66	.45728	99	.46225
67	.45743	2900	.46240
68	.45758	01	.46255
69	.45773	02	.46270
70	.45788	03	.46285
71	.45803	04	.46300
72	.45818	05	.46315
73	.45834	06	.46330
74	.45849	07	.46344
75	.45864	08	.46359
76	.45879	09	.46374
77	.45894	10	.46389
78	.45909	11	.46404
79	.45924	12	.46419
80	.45939	13	.46434
81	.45954	14	.46449
82	.45969	15	.46464
83	.45984	16	.46479
84	.46000	17	.46494
85	.46015	18	.46509
86	.46030	19	.46523
87	.46045	20	.46538
88	.46060	21	.46553

Bar. Height.	Log.	Bar. Height.	Log.
2922	3.46568	2955	3.47056
23	.46583	56	.47070
24	.46598	57	.47085
25	.46613	58	.47100
26	.46627	59	.47114
27	.46642	60	.47129
28	.46657	61	.47144
29	.46672	62	.47159
30	.46687	63	.47176
31	.46702	64	.47188
32	.46716	65	.47202
33	.46731	66	.47217
34	.46746	67	.47232
35	.46761	68	.47246
36	.46776	69	.47261
37	.46790	70	.47276
38	.46805	71	.47290
39	.46820	72	.47305
40	.46835	73	.47319
41	.46849	74	.47334
42	.46864	75	.47349
43	.46879	76	.47363
44	.46894	77	.47378
45	.46909	78	.47392
46	.46923	79	.47407
47	.46938	80	.47422
48	.46953	81	.47436
49	.46967	82	.47451
50	.46982	83	.47465
51	.46997	84	.47480
52	.47012	85	.47494
53	.47026	86	.47509
54	.47041	87	.47524

Bar. Height.	Log.	Bar. Height.	Log.
2988	3.47538	3021	3.48015
89	.47553	22	.48030
90	.47567	23	.48044
91	.47582	24	.48058
92	.47596	25	.48073
93	.47611	26	.48087
94	.47625	27	.48101
95	.47640	28	.48116
96	.47654	29	.48130
97	.47669	30	.48144
98	.47683	31	.48159
99	.47698	32	.48173
3000	.47712	33	.48187
01	.47727	34	.48202
02	.47741	35	.48216
03	.47755	36	.48230
04	.47770	37	.48244
05	.47784	38	.48259
06	.47799	39	.48273
07	.47813	40	.48287
08	.47828	41	.48302
09	.47842	42	.48316
10	.47857	43	.48330
11	.47871	44	.48344
12	.47886	45	.48359
13	.47900	46	.48373
14	.47914	47	.48387
15	.47929	48	.48402
16	.47943	49	.48416
17	.47958	50	.48430
18	.47972	51	.48444
19	.47986	52	.48458
20	.48001	53	.48473

Bar. Height.	Log.	Bar. Height.	Log.
3054	3.48487	3078	3.48827
55	.48501	79	.48841
56	.48515	80	.48855
57	.48530	81	.48869
58	.48544	82	.48883
59	.48558	83	.48897
60	.48572	84	.48911
61	.48586	85	.48926
62	.48601	86	.48940
63	.48615	87	.48954
64	.48629	88	.48968
65	.48643	89	.48982
66	.48657	90	.48996
67	.48671	91	.49010
68	.48686	92	.49024
69	.48700	93	.49038
70	.48714	94	.49052
71	.48728	95	.49066
72	.48742	96	.49080
73	.48756	97	.49094
74	.48770	98	.49108
75	.48785	99	.49122
76	.48799	3100	.49136
77	.48813		

In comparing the Aneroid with a Mercurial Barometer, correct the latter by the following table, *subtracting* the corrections.

TABLE III.

Reduction of Mercurial Column to 32° Fahr.

Brass scale to barometer correct at 62° Fahr.

Temp.	30″	25″	20″
32°	.009	.008	.006
35	.017	.015	.012
40	.031	.026	.021
45	.044	.037	.030
50	.058	.048	.038
55	.071	.059	.047
60	.084	.070	.056
65	.098	.082	.065
70	.111	.093	.074
75	.125	.104	.083
80	.138	.115	.092
85	.151	.126	.101
90	.164	.137	.110
95	.178	.148	.118
100	.191	.159	.127

TABLE IV.

Latitude Correction for Heights of Barometer.

Correction additive for latitudes below 45°; subtractive from 45 to 90°.

Lat.	Lat.	30″	20″
° 0	° 90	.080	.053
5	85	.079	.052
10	80	.075	.050
15	75	.069	.046
20	70	.061	.041
25	65	.051	.034
30	60	.040	.027
35	55	.027	.018
40	50	.014	.009
45	45	.000	.000