TABLE 2.—*Correlation between the rainfall of May and June, the temperature of June, and the yield of spring wheat per acre, in South Dakota.*

Year.	Precipitation.			Temperature.			Yield.					
	Amt.	Departure p.	p^2.	Mean.	Departure t.	t^2.	Amt.	Departure y.	y^2.	pt.	py.	ty.
	In.			°*F.*			*Bus. acre.*					
1891..	6.5	−0.3	0.09	64.2	−1.7	2.89	15.2	+4.0	16.00	+0.51	−1.20	−6.80
1892..	9.5	+2.7	7.29	63.9	−2.0	4.00	12.5	+1.3	1.69	−5.40	+3.51	−2.60
1893..	4.5	−2.3	5.29	70.3	+4.4	19.36	8.5	−2.7	7.29	−10.12	+6.21	−11.88
1894..	3.7	−3.1	9.61	70.6	+4.7	22.09	6.6	−4.6	21.16	−14.57	+14.26	−21.62
1895..	6.9	+0.1	0.01	63.7	−2.2	4.84	12.0	+0.8	0.64	−0.22	+0.08	−1.76
1896..	6.6	−0.2	0.04	67.0	+1.1	1.21	11.2	0	0	−0.22	0	0
1897..	4.6	−2.2	4.84	65.0	−0.9	0.81	8.0	−3.2	10.24	+1.98	+7.04	+2.88
1898..	6.8	0	0	67.3	+1.4	1.96	12.4	+1.2	1.44	0	0	+1.68
1899..	8.1	+1.3	1.69	66.4	+0.5	0.25	10.7	−0.5	0.25	+0.65	−0.65	−0.25
1900..	3.5	−3.3	10.89	69.4	+3.5	12.25	6.9	−4.3	18.49	−11.55	+14.19	−15.05
1901..	8.1	+1.3	1.69	66.3	+0.4	0.16	12.9	+1.7	2.89	+0.52	+2.21	+0.68
1902..	6.0	−0.8	0.64	62.6	−3.3	10.89	12.2	+1.0	1.00	+2.64	−0.80	−3.30
1903..	7.0	+0.2	0.04	65.0	−0.9	0.81	13.8	+2.6	6.76	−0.18	+0.52	−2.34
1904..	6.5	−0.3	0.09	64.5	−1.4	1.96	9.6	−1.6	2.56	+0.42	+0.48	+2.24
1905..	11.6	+4.8	23.04	64.4	−1.5	2.25	13.7	+2.5	6.25	−7.20	+12.00	−3.75
1906..	8.4	+1.6	2.56	63.9	−2.0	4.00	13.4	+2.2	4.84	−3.20	+3.52	−4.40
1907..	7.7	+0.9	0.81	64.2	−1.7	2.89	11.2	0	0	−1.53	0	0
1908..	10.0	+3.2	10.24	63.7	−2.2	4.84	12.8	+1.6	2.56	−7.04	+5.12	−3.52
1909..	9.0	+2.2	4.84	66.9	+1.0	1.00	14.1	+2.9	8.41	+2.20	+6.38	+2.90
1910..	3.9	−2.9	8.41	68.3	+2.4	5.76	12.8	+1.6	2.56	−6.96	−4.64	+3.84
1911..	3.6	−3.2	10.24	73.4	+7.5	56.25	4.0	−7.2	51.84	−24.00	+23.04	−54.00
1912..	3.8	−3.0	9.00	64.8	−1.1	1.21	14.2	+3.0	9.00	+3.30	−9.00	−3.30
1913..	6.0	−0.8	0.64	69.6	+3.7	13.69	9.0	−2.2	4.84	−2.96	+1.76	−8.14
1914..	8.1	+1.3	1.69	67.5	+1.6	2.56	9.0	−2.2	4.84	+2.08	−2.86	−3.52
1915..	9.0	+2.2	4.84	60.4	−5.5	30.25	17.0	+5.8	33.64	−12.10	+12.76	−31.90
1916..	8.2	+1.4	1.96	61.5	−4.4	19.36	6.3	−4.9	24.01	−6.16	−6.86	+21.56
1917..	5.3	−1.5	2.25	62.7	−3.2	10.24	14.0	+2.8	7.84	+4.80	−4.20	−8.96
Sums.	....	−0.7	122.73	....	−1.8	237.78	.....	+1.6	251.04	−94.31	+82.87	−151.31
Means	6.8	−0.02	.....	65.9	−0.07	.....	11.2	+0.06	.....	.....	.....	.....

Table 2—computations.

$[p]=-0.7$; $[t]=-1.8$; $[y]=+1.6$;
$[p^2]=122.73$; $[t^2]=237.78$; $[y^2]=251.04$;
$[py]=82.87$; $[ty]=-151.31$; $[pt]=-94.31$;
$n=27$;

$$\sigma_p=\sqrt{\frac{[p^2]-\frac{[p]^2}{n}}{n}}=\sqrt{\frac{122.73-\frac{(-0.7)^2}{27}}{27}}$$

$$=\sqrt{\frac{122.71}{27}}=\sqrt{4.54}=2.1$$

$$\sigma_t=\sqrt{\frac{237.78-\frac{(-1.8)^2}{27}}{27}}=\sqrt{\frac{237.66}{27}}=\sqrt{8.80}=3.0$$

$$\sigma_y=\sqrt{\frac{251.04-\frac{(1.6)^2}{27}}{27}}=\sqrt{\frac{250.95}{27}}=\sqrt{9.29}=3.0$$

$$r_{py}=\frac{[py]-\frac{[p][y]}{n}}{n\,\sigma_p\sigma_y}=\frac{82.87-\frac{(-0.7)(1.6)}{27}}{27\times2.1\times3.0}$$

$$=\frac{82.87+.04}{170.10}=\frac{82.91}{170.10}=+0.487$$

$$r_{ty}=\frac{-151.31-\frac{(-1.8)(1.6)}{27}}{27\times3.0\times3.0}=-\frac{151.31+0.10}{243.00}$$

$$=\frac{-151.21}{243.00}=-0.622.$$

$$r_{pt}=\frac{-94.31-\frac{(-0.7)(-1.8)}{27}}{27\times2.1\times3.0}=\frac{-94.31-0.05}{170.10}$$

$$=\frac{-94.36}{170.10}=-0.555$$

$$Er_{py}=\pm0.6745\frac{1-r_{py}^2}{\sqrt{n}}=\pm\frac{0.6745}{5.2}\times0.7629=\pm0.099$$

$$Er_{ty}=\pm\frac{0.6745}{5.2}\times0.6131=\pm0.080$$

$$Er_{pt}=\pm\frac{0.6745}{5.2}\times0.6920=\pm0.090$$

NOMENCLATURE OF THE UNIT OF ABSOLUTE PRESSURE.

By CHARLES F. MARVIN.
[Weather Bureau, Washington, Mar. 30, 1918.]

While scientists are striving to secure international uniformity of units, nevertheless, right in our midst we find growing up a diversity of practice which all must deplore, regarding the nomenclature of pressure in absolute units, and which if not soon remedied will result in much future confusion. Pressure can be conceived only with reference to some area over which it acts, and pressure multiplied by area is a force. Since the dyne is the standard unit of force, a pressure of 1 dyne per square centimeter seems to constitute the logical unit of pressure. Indeed, since the concept pressure is inseparable from some area, science might be willing to grant that expressions like "a pressure of 1 dyne" has the same meaning as "a pressure of 1 dyne *per square centimeter*", etc., unless some other area is named. In other words, a unit of pressure is a unit of force on a unit area, and no particular name for this unit is really required. The practice and usage through the course of the last decade or more relative to the introduction of the names "barad", "barye", "bar", etc., as names for absolute units of pressure is briefly indicated in the following statement from notes furnished by C. F. Talman and Cleveland Abbe, jr., United States Weather Bureau.

A committee on uniformity of units of the British Association for the Advancement of Science recommended (see report of the Association for 1888, p. 28):

> The unit of pressure on the C. G. S. system of units, i. e., the pressure of 1 dyne per square centimeter, to be called 1 barad.

At the International Physics Congress at Paris, 1900, M. Guillaume proposed that the name *barye* be applied to the megadyne per square centimeter. His proposal was referred to a committee on units, of which he was a member. This committee unanimously recommended that the name *barye* be applied to the dyne, instead of the megadyne, per square centimeter. The report of the committee was presented at the final session of the congress, but, *so far as appears from the procès-verbaux, no action was taken on it.*

T. W. Richards [1] and A. E. Kennelly [2] employed the term "bar" to signify a pressure of 1 dyne per square centimeter, having either selected the term independently or taken it as an abbreviated variation of the terms "barad" (British Association committee) or "barye" (Physicists' Congress, 1900). Other instances of restricted use of the terms barad and megabar are found; e. g., Tables of Physical and Chemical Constants, by Kaye and Laby (1911), page 5 and page 27, and Smithsonian Physical Tables, fifth and sixth editions, pages 309 and 346, respectively.

Meteorologists have long had occasion to express atmospheric pressures in absolute terms,[3] but it remained for Bjerknes to recognize the peculiar convenience in hydrodynamics and atmospherics of the megadyne per square centimeter as a unit of pressure, and, through his pupil J. W. Sandström,[4] to introduce it—without assigning it a special name at the time—in his epochal investigations into the hydrodynamics of the sea and the atmos-

[1] Richards, T. W., *in* Carnegie Institution of Washington, Publication No. 7. Washington, 1903. pp. 42–43.
[2] Kennelly, A. E., *in* Proc. Am. instit. elect. eng., 1909, **28**: 706.
[3] e. g., *Abbe, C.* Preparatory studies for deductive methods in storm and weather predictions. Washington, 1890. p. 62. (Ann. rpt., C. S. O., 1889, App. 15.)
[4] *Sandström, J. W., & Helland-Hansen, B.* Ueber die Berechnung von Meeresströmungen. Bergen, 1903. 8°. pp. 2, 14–15. (Report on Norwegian fishery and marine investigations, v. 2, 1902, No. 4.)

phere. It soon became desirable to avoid the circumlocution of calling the unit "one million dynes per square centimeter", and Bjerknes proposed to call it the "bar" =1 megadyne per square centimeter, with its subdivisions of decibar, centibar, millibar, etc., in accordance with the method of numeration of the C. G. S. system.[5] Prof. Bjerknes' own account of the origin of this unit, the "bar", follows.[6]

When fourteen years ago I began to occupy myself with problems concerning the dynamics of the atmosphere and the sea, I encountered many difficulties of terminology. Cumbrous expressions such as: "Pressure at that height where gravity potential is $x.10^5$ C. G. S.-units", or "gravity-potential at that height where pressure is $y.10^5$ C. G. S.-units", as well as the corresponding expressions concerning dynamic conditions at different depths in the sea, recurred again and again, often on the same page. I therefore coined the terms "bar", "decibar", "centibar", and "millibar", as names for the units of pressure; "dynamic height", "dynamic depth", as synonyms for gravity-potential, and finally "dynamic metre", "dynamic decimetre", etc., for the units of this quantity. In place, then, of the cumbrous expressions which prevailed formerly, we now have "Pressure at the height of x dynamic metres", "Dynamic height of the pressure y mbar" with respect to the atmosphere, and with respect to the sea "Pressure at the depth of x dynamic metres", "dynamic depth of the pressure y dbar".

I employed these expressions for the first time in a paper published in 1906,[7] and expected that criticism would be directed against them, as the use of new terms usually provokes opposition; but they passed without comment, and consequently a discussion which might have proved fruitful did not arise. On the contrary, other writers found the expressions convenient and adopted them. They will be found throughout a series of important papers bearing upon hydrography by Sandström, V. W. Ekman, and Helland-Hansen, and they have, further, been regularly employed in the official publications of the "Conseil permanent International pour l'exploration de la mer" in Copenhagen.

No protests having appeared,[8] I did not scruple to make use of this terminology in my book "Dynamic Meteorology and Hydrography", of which the first two volumes have appeared both in English and in German. Should this book and its annexed numerical tables have given rise to a more extended use of the terminology from year to year, I am no longer able to prevent it. * * *

This system of nomenclature, according to which the millibar = 1,000 dynes per square centimeter, was urged upon meteorologists in 1909 by W. Köppen[9] also; and was formally adopted in 1912 for use in *aerology* by a recommendation of the International Commission for Scientific Aeronautics, at a meeting in Vienna in 1912, an action later approved by the International Meteorological Committee at the Rome session in 1913.

In the meantime the new units were introduced extensively into international statistical meteorology, as shown by the following statement.

The British Meteorological Office has used millibars in recording upper-air observations since 1907, and for general observations at "observatories" (i. e., certain first-order stations) since 1911. They have been used on the British daily weather map (Daily Weather Report) since May 1, 1914. All the regular British stations were equipped with barometers for reading to millibars during the year 1914. The Royal Meteorological Society has been engaged for some years in preparing new normals of atmospheric pressure for the British Isles, and has used the millibar in this compilation, which has not yet been published. (Ninth Annual Report Meteorological Committee, 1914, p. 63–65; Tenth Annual Report, 1915, p. 30). Millibars are used in the important international publications of the British Meteorological Office known as "Réseau Mondial", of which the first annual volume, corresponding to the year 1911, appeared in 1917.

Millibars have been used on the French daily weather map (Bulletin International Météorologique) since January 1, 1917, and it is understood that they have been adopted for general use by the French meteorological service (Bureau Central Météorologique de France) in publications of data for 1917 et seq. (None of these, except the weather map, has reached us.) Millibars have been adopted for official meteorological observations in the British colonies of Mauritius and British Guiana (Nature, London, Dec. 28, 1916, p. 332).

Millibars were used by the United States Weather Bureau on its Weather Map of the Northern Hemisphere, published January 1 to August 6, 1914. They have been used in the upper-air observations of the bureau since the publication, in 1916, of the data for 1915 (Monthly Weather Review Supplement No. 3, p. 5).

The International Meteorological Committee, at its meeting in Rome, 1913, requested the International Commission for Scientific Aeronautics to publish upper-air data in both millimeters and millibars, beginning with the observations for the year 1913.

The publication of aerological observations has been greatly delayed by the present war, but reports of kite and balloon observations now being received from the Canadian Meteorological Office, give pressures in conformity with the vote of the International Meteorological Committee.

[So far as known to the Weather Bureau, the Blue Hill Observatory, whose reports are published in the Annals of Harvard College Observatory, is the only meteorological institution in the world that publishes its pressure observations in units of 1 bar=1 dyne per square centimeter.]

Committees of the British Association and of the International Physical Congress of 1900 voted in favor of the names *barad* and *baryc*, respectively, for the unit 1 dyne per square centimeter. The growing tendency among chemists and physicists seems to be, however, to neglect these names proposed by their own conventions and to employ the terms *bar* adopted by the International Meteorological Committee, but giving to it a new value only one-millionth as large as that voted by the Committee which adopted it.

The confusion arising from this diversity of usage could, of course, be partly avoided by a strict discrimination between the terms "bar" on the one hand and

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[5] *Bjerknes, V., & Sandström, J. W.* Hilfsgrössen zur Berechnung der Druckverteilung in der Atmosphäre an der internationalen Tagen 1900–1903. Beiträge zur Physik d. fr. Atmosphäre, Strassburg, 1906, **2**, heft 1, 1–17, 2 plates.

Knudsen, Martin, in Bull. trimestr., Permanent. internat. conseils f. Meeresforsch., København, 1905–6, No. 1, Pt. B, p. 65 and charts. [Knudsen here simply states "As the unit of pressure has been chosen a pressure of 10^5 C. G. S. units, it is nearly equal to 1/10 atmosphere and is called a decibar . . ." This publication has continued the use of the unit to date.]

[6] Quarterly journal, Royal meteorological society, London, April 1914, **40**: 160, fig.

[7] *Bjerknes, V., & Sandström, J. W.*, op. cit., Beitr. z. Phys. d. freien Atmosphäre, 1906, **2**:1, where they write as follows: ". . . Da unser Ziel eine weitergehende Diskussion der Dynamik der Atmosphäre ist, können wir uns nur mit absoluter Masse bedienen. Daher muss die gewöhnliche irrationelle Druckeinheit, das mm Hg., aufgeben und durch eine entsprechende, dem absoluten Masssysteme angehörende Einheit ersetzt werden. Als solche praktische Einheit ist oft die Megadyne pro Quadratzentimeter vorgeschlagen worden. Diese Einheit werden wir ein *Bar* nennen. Das Bar wird in Dezi-, Zenti-, und Millibar geteilt, und das *Millibar* ersetzt das mm Hg. Das Millibar beträgt sehr nahe ¾ oder genauer 0.75006 mm Hg." [They continue with a description of the "dynamic meter" and its advantages.] —C. A., jr.

[8] The protest published by A. E. Kennelly, this REVIEW, March, 1914, **42**: 141, came too late; and the proposal by T. W. Richards there quoted probably escaped the attention of all meteorologists because not earlier published in a meteorological journal.—C. A., jr.

[9] *Köppen, Wladimir.* Vorschlag, alle Luftdruckmessungen in allgemeinem Kraftmass anzugeben. Meteorol. Ztschr., Braunschweig, Mai, 1909, **26**: 198–201.

Do. Express all barometric measurements by ordinary general units of force. MONTHLY WEATHER REVIEW, Washington, March, 1909, **37**: 92–93.

"barad" or "barye" on the other. This discrimination is seemingly as justifiable as that now fully established and familiar to all in the signification of such prefixes as deci- and deka-.

For the purpose of contrasting the application of the dual system of terminology to the various requirements of science, I tabulate below the names and magnitudes of certain of the more familiar pressures dealt with by meteorologists, physicists, and others.

Comparison of scales of pressure now in use and their terminologies.

Nature of the pressure.	Meteorological scale. 1 bar=1 megadyne per square centimeter.	Physical scale. 1 barad / 1 barye = 1 dyne per square centimeter.
Residual gas pressure in highly exhausted vacua, as in electric-light bulbs, X-ray tubes, etc.	Very high vacua=0.01 microbar.	=1 centibarad.
	Ordinary vacua=1 to 100 microbars.	=1 to 100 barads.
Pressure in highest regions of the atmosphere yet attained by sounding balloons (33 kilometers).	=10 millibars	=10 kilobarads.
Pressure of a wind blowing about 50 miles per hour against a wall, a person walking, etc.	=4 millibars	=4 kilobarads.
Sustaining pressure on the supporting wing of airplanes (approximate).	=2 to 2.5 millibars	=2 to 2.5 kilobarads.
Atmospheric pressure at about 100 meters above mean sealevel.	=1 bar=1,000 millibars.	=1 megabarad=1,000 kilobarads=1,000,000 barads.
Pressure of water vapor at its critical temperature.	=220 bars	=220 megabarads.
Pressures at the greatest depths of the sea (10 kilometers).	=1 megabar=1,000,000 bars.	=1,000,000 megabarads. (No customary prefix of higher significance than "mega-" is available.)
Still greater pressures within the domain of geophysics and elsewhere.	Conveniently expressed in terms of megabars with *convenient* numerical factors.	No convenient term available. Requires the term "megabarad" with *large* numerical factors.

It is apparent from this table that probably little or no occasion will ever arise in science to make practical use of the subdivisions micro-, milli-, and centi*barad* of the physical scale, which moreover affords no convenient prefixes or terms to designate the very great pressures. In other words the unit, *barad*=1 dyne per square centimeter, is too small to conveniently meet the general requirements of all branches of science.

On the other hand, in the meteorological scale the submultiples micro-, milli-, centi-, and the unit itself, *bar*, are available to the fullest extent for the small pressures encountered in nature and the great multiples, expressed by the prefixes kilo- and mega-, are needed and available to designate the really great pressures with which science must also deal.

Consistency.—It is claimed the name *bar* must be consistently applied to the basic unit of the C. G. S. system. This argument from consistency loses force when it is noted that the whole C. G. S. system involves a kind of inconsistency of this character.[10]

The *meter* is the international standard of length, but the *centimeter* is adopted as the more convenient unit of length for the basis of the C. G. S. system.

The Director of the United States Bureau of Standards has kindly called my attention to a remedy for the inconvenience in practical science growing out of the size of the units of the C. G. S. system, which remedy was proposed by the International Association on Refrigeration meeting at Paris in June, 1909, and later considered and elaborated by the International Bureau of Weights and Measures.[11] This proposal offers a supplemental system of practical units based, like the C. G. S. system, on the fundamental units of length, mass and time, the units chosen being the meter, kilogram, and second, Here, again, the kilogram in this M.K.S. system introduces an inconsistency of the kind mentioned above for the C. G. S. system.[12] Entire consistency with an arbitrary ideal obviously can not be realized without radical changes in and modification of well-established nomenclature. Several important practical units conforming to the M. K. S. system have been defined and sanctioned by international convention.

The derived units in the C. G. S. system by convention are given names based on Greek roots, whereas the names of the derived units in the M. K. S. system are proposed to be based on the names of great scientists, as illustrated by Volt, Ampére, Watt, etc., and Pascal has been proposed as the name of the unit of pressure.

Summarizing the foregoing we may say that the International Committee on Scientific Aeronautics and the International Meteorological Committee formally adopted and recommended for international use the term *bar*, meaning a pressure of one megadyne per square centimeter, whereas the terms *barad* and *barye*, meaning a pressure of one dyne per square centimeter, have little or only a slender basis of international sanction and appear to be less acceptable to the physicists than the term *bar*, which they use with a different meaning than that sanctioned by international convention. Obviously, therefore, a condition of serious confusion exists in these matters, and it is earnestly hoped that means may be found whereby international action on the part of all interests concerned in this new pressure unit, can be secured at an early date in order to avoid the confusion that must otherwise result.

In the meantime, the U. S. Weather Bureau has no choice but to continue, and doubtless increase, its use of the *bar* as a unit of pressure, in accordance with international convention.

UNITED STATES DAYLIGHT SAVING ACT OF MARCH 19, 1918.

(The U. S. Weather Bureau is so deeply affected by the daylight-saving act that it seems desirable to reprint the text for convenience of future reference.—C. A., jr.)

AN ACT To save daylight and to provide standard time for the United States.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That for the purpose of establishing the standard time of the United States, the territory of continental United States shall be divided into five zones in the manner hereinafter provided. The standard time of the first zone shall be based on the mean astronomical time of the seventy-fifth degree of longitude west from Greenwich; that of the second zone on the ninetieth degree; that of the third zone on the one hundred and fifth degree; that of the fourth zone on the one hundred and twentieth degree; and that of the fifth zone, which shall include only Alaska, on the one hundred and fiftieth degree. That the limits of each zone shall be defined by an order of the Interstate Commerce Commission, having regard for the convenience of commerce and the existing junction points and division points of common carriers engaged in commerce between the several States and with

[10] See also the discussion of consistency in MONTHLY WEATHER REVIEW, March, 1914, **42**: 142.

[11] Procès-Verbaux. 1911. p. 209. Comptes Rendus of the Conférence Générale des Poids et Mesures. 1913. p. 14; 51–60.

[12] See discussions of the proposed units of acceleration and geopotential. "gal", "leo", "leometer", etc., in this REVIEW, January, 1914, **42**: 6, 142. 539. *Also* The Observer's Handbook (Met'l. Off. no. 191), 1913 ed., p. xxiii; 1917 ed., p. xxiii, xxv.