P_0 = pressure in units of force, g_0.
ρ_0 = the weight of a given mass of atmosphere, $\rho_m B_n = \rho_0 l_0$.
C_p = the specific heat at constant pressure.
C_v = the specific heat at constant volume.

$$R = C_p - C_v, \qquad k = \frac{C_p}{C_v}$$

$-\dfrac{dT}{dh}$ = the temperature fall per unit height in adiabatic state.

$\dfrac{1}{A}$ = the mechanical equivalent of heat, 426.8 and 777.9.

$\dfrac{g_0}{A}$ = the factor to change mechanical units to heat units.

F = the factor connecting the thermal gradient and P_0.
θ = the number of British thermal units in 1 kilogram-degree.

VII. THE THERMODYNAMIC CONSTANTS FOR THE SUN.

There is much difficulty in passing from the thermodynamic conditions on the earth to the corresponding thermodynamic conditions on the sun. I have already approached this subject from the side of radiation in my "Eclipse Meteorology and Allied Problems," 1902, and from the method of Nipher's Formulæ, in my studies on the "Circulation of the Atmospheres of the Sun and of the Earth," 1904. I shall briefly present the same subject as the immediate development of the fundamental formulæ introduced in this paper. It is not so difficult to produce a self-consistent system of quantities as it is to find one which conforms to the actual physical state of the sun, and I conceive that it is proper to discuss this subject in several ways.

Specific heat.

From the preceding formulæ, we have,

$$(53) \qquad -\frac{dT}{dz} = \frac{g_0}{C_p} = \frac{F}{P_0} = \frac{F}{g_0 \rho_m B_n} = \frac{F}{g_0 \rho_0 l_0}. \quad \text{Hence,}$$

$$(54) \qquad C_p = \frac{\rho_m B_n}{F} \cdot g_0^2 = \frac{\rho_0 l_0}{F} \cdot g_0^2.$$

Since $\rho_m B_n = \rho_0 l_0$ is a given mass, and F is constant for a given system of units, it follows that C_p is proportional to the square of the gravity. Taking the force of gravity on the sun,

$$(55) \qquad (g)_{sun} = g_0 \times G = 9.806 \times 28.028 = 274.843$$

it follows that the specific heat on the sun is

$$(56) \qquad (C_p)\ \text{sun} = C_p \times G^2 = 993.5787 \times (28.028)^2 = 780524.$$

Adiabatic rate of temperature-fall.

$$(57) \qquad \text{For the earth} -\frac{dT}{dz} = \frac{g_0}{C_p} = 9.8695^\circ \text{ per 1000 meters.}$$

$$(58) \qquad \text{For the sun} -\left(\frac{dT}{dz}\right)_{sun} = \frac{g_0 G}{C_p G^2} = \frac{9.8695^\circ}{28.028} = 0.32862^\circ.$$

Mechanical equivalent of heat.

$$(59) \qquad \text{From} -\frac{dT}{dz} = \frac{g_0}{C_p} \text{ for the earth, we have on the sun,}$$

$$(60) \qquad -\frac{dT}{G dz} = \frac{g_0 G}{C_p G^2}. \quad \text{Hence, by integration,}$$

$$(61) \qquad -C_p G^2 \int dT = g_0 G \int G dz, \text{ or,}$$

$$(62) \qquad -C_p G^2 (T - T_0) = g_0 G (z - z_0).$$

If the change of temperature is 1° then,

$$(63) \qquad -C_p G^2 = g_0 G (z - z_0) G,$$

is the mechanical equivalent of heat, and is obtained by the fall of a mass through the height $(z - z_0) G$ under the force of gravity $g_0 G$. Whereas on the earth,

$$(64) \qquad \frac{1}{A_m} = 4185.57 = 426.8 \times 9.8060, \text{ we have}$$

$$(65) \qquad \left(\frac{1}{A_m}\right)_{sun} = 4185.57 \times (28.028)^2 = 3288046.$$

Boyle–Gay–Lussac Law.

From the formulæ of Table 14, we have,

$$(66) \qquad g_0 l_0 = \frac{P_0}{\rho_0} = RT_0 = C_p T_0 \frac{k-1}{k} = -g_0 \frac{dh}{dT} T_0 \frac{k-1}{k},$$

on the earth, and we infer that we shall have on the sun,

$$(67) \qquad g_0 G \cdot l_0 G^2 = \frac{P_0 G^3}{\rho_0} = RG^2 \cdot T_0 G = C_p G^2 \cdot T_0 G$$

$$= -g_0 G \cdot \frac{dh}{dT} G \cdot T_0 G \frac{k-1}{k}. \quad \text{Hence,}$$

$$(68) \qquad l_0 G^2 = 7991.04 \times (28.028)^2.$$

$$(69) \qquad P_0 G^3 = 101323.5 \times (28.028)^3.$$

$$(70) \qquad RG^2 = 287.0334 \times (28.028)^2.$$

$$(71) \qquad T_0 G = 273^\circ \times 28.028 = 7652^\circ,$$

if $\dfrac{k-1}{k}$ is retained a constant in both cases.

If the atmosphere of the sun is composed of some other material than ρ_0 of the earth's atmosphere, then the proper modification of the preceding quantities can be readily computed from terrestrial data.

Specific heat at constant volume.

For the earth, $C_v = C_p - R$, and hence, for the sun,

$$(72) \qquad C_v G^2 = C_p G^2 - RG^2$$

$$(73) \qquad (C_v)_{sun} = C_v G^2 = 706.5453 \times (28.028)^2 = 555040.$$

$$(74) \qquad \text{Finally, } k = \frac{C_p \cdot G^2}{C_v \cdot G^2} = 1.4062486, \text{ as a check.}$$

This system throws the entire emphasis upon a change of gravity depending upon the mass of the central body, rather than upon the change of physical conditions implied in altering the ratio of the specific heats k. Since the temperature of the photosphere may in this way be taken as about 7652°, and the temperature gradient —0.32862° per 1000 meters, it follows that the effective temperature of radiation as determined by bolometer measures, 6100°, will be reached at the height of 4418 kilometers, or 2745 miles above the surface of the photosphere. This change of 1552° may be sufficient to meet the requirements of the spectroscopic observations in regard to the absorption and reversal of the spectrum lines. The gradient, —0.32862° per 1000 meters, is 28.028 times greater than that obtained by my other methods, the difference arising from the different distribution of the gravity factor G, which seems to be fully accounted for in these formulæ.

GERMAN AERIAL RESEARCH STATION.

According to Science (April 6, 1906, p. 559), the German Government has decided to establish a meteorological station on Lake Constance, near Friedrichshafen. It will cost $15,000, the states of Bavaria, Wurttemberg, Baden, and Alsace-Lorraine joining in the expense. Extensive study of the atmosphere will be made daily by means of kites flown from specially constructed boats on the lake. Similar kite and balloon stations already exist in northern Germany, at Lindenberg and Hamburg, and plans are being made to erect still another station in the northeastern part of the Empire.

A NEW DEPARTURE IN FORECASTING.

The following statement has been sent by the Chief of Bureau in reply to a recent letter, requesting some details regarding the "new departure in forecasting weather conditions a month in advance:"

Beyond the statement made by me in New York, in March, that the Weather Bureau believes that it is in possession of a sound scientific basis on which to make forecasts for a considerable period in advance, nothing will be announced in regard to the matter for several months to come.