DEPARTMENT OF COMMERCE

CIRCULAR

OF THE

BUREAU OF STANDARDS

S. W. STRATTON, DIRECTOR

No. 65

GAS CALORIMETER TABLES

[1st Edition]

Issued July 23, 1917

PRICE, 5 CENTS

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INTRODUCTION

This publication is in response to numerous requests for a brief and concise set of operating directions for a gas calorimeter, and for a convenient set of correction tables. It may be regarded as a supplement to Bureau Circular No. 48 on "Standard Methods of Gas Testing." It is hoped that this will promote greater uniformity in operating methods and in records and facilitate the application of proper corrections.

It is assumed that the operator is thoroughly familiar with directions and precautions as outlined in Circular No. 48. The directions given here are a brief summary of the full instructions contained in that circular, together with the tables needed for daily laboratory use.

The correction charts are arranged in a sequence most convenient for use in connection with the proposed forms of record sheet, starting from the upper left-hand corner of the sheet and continuing in the normal order of application of the corrections.

The larger form recommended for calorimeter test records has been in use for some time and has been found to be complete and convenient. The three tests called for on it are recommended whenever possible, but when numerous tests are taken daily, as for control purposes at the gas works, the small form may be preferred. The smaller form contains all the essential data of the larger, but can be used for a single test only.

There is also included the summary taken from Circular No. 48 of the procedure for recording and computing a test. From this summary the exact application of the blank forms and correction tables will be evident.

SUMMARIZED OPERATING DIRECTIONS FOR FLOW CALORIMETERS

(1) Purge gas lines from old gas and burn one burner from this time continuously throughout the period of test.

(2) Observe temperature of laboratory.

(3) Adjust the gas meter for temperature, level, position of index relative to drum, water level, saturation of water with gas.

(4) Test for gas leaks.

(5) Adjust temperature of water in supply tank.

(6) Start flow of water through calorimeter and expel air from water circulation system.

(7) Light gas, adjust rate of gas consumption, adjust air mixer on burner, and insert burner into calorimeter.

(8) Adjust water flow and set damper.

(9) Allow time for establishment of a condition of thermal equilibrium.

(10) Prepare record sheet and make the preliminary observations of temperature and height of barometer, pressure and temperature of gas in meter, wet and dry bulb thermometer readings, temperature of products, and time of revolution of meter index.

(11) Begin collection of condensate and record meter reading.

(12) Take the first series of observations as follows: Make preliminary notation of water temperatures, shift water, observe series of water temperatures, shift water, make supplemental notation of water temperatures, and weigh the water.

(13) Take the second (and later) series of observations.

(14) Stop collection of condensate and record meter reading and amount of condensate.

(15) Repeat the preliminary observations of operation (10).

(16) Turn off gas and then turn off water.

Barometer Certificate Correction.....

Corrections for Reductions of Barometric Heights to Standard Temperature (32° F)

[In the table are given, for barometric heights of 24, 26, 28, and 30 inches, the amounts, in inches, to be subtracted from the observed readings of a barometer with brass scale, to reduce the heights, observed at various temperatures, to inches of mercury at 32° F]

Temperature, ° F	Observed barometric height, inches			
	24.0	26.0	28.0	30.0
40	0.03	0.03	0.03	0.03
45	.04	.04	.04	.05
50	.05	.05	.05	.06
55	.06	.06	.07	.07
60	.07	.07	.08	.09
65	.08	.09	.09	.10
70	.09	.10	.11	.11
75	.10	.11	.12	.13
80	.11	.12	.13	.14
85	.12	.13	.14	.15
90	.13	.14	.16	.17
95	.14	.16	.17	.18
100	.15	.17	.18	.19

Equivalent Pressures, Inches Water—Inches Mercury

Water	1.00	1.36	1.50	2.00	2.50	2.70	3.00
Mercury	0.07	0.10	0.11	0.15	0.18	0.20	0.22

Scale Correction

Meter Thermometer No.....

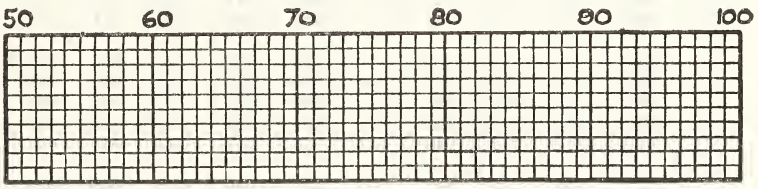


FIG. 1

Correction Factors for Gas Volume

[Multiply observed volume of saturated gas by factor to correct to volume of saturated gas at 30 inches of mercury pressure (32° F) and 60° F]

Temperature, ° F	Total gas pressure—Inches of mercury										
	28.0	28.2	28.4	28.6	28.8	29.0	29.1	29.2	29.3	29.4	29.5
99	0.825	0.831	0.837	0.844	0.850	0.856	0.859	0.863	0.866	0.869	0.872
98	.828	.834	.841	.847	.853	.860	.863	.866	.869	.872	.875
97	.831	.838	.844	.850	.856	.863	.866	.869	.872	.876	.879
96	.834	.841	.847	.853	.860	.866	.869	.872	.876	.879	.882
95	.837	.844	.850	.856	.863	.869	.872	.876	.879	.882	.885
94	.841	.847	.853	.860	.866	.872	.876	.879	.882	.885	.888
93	.844	.850	.856	.863	.869	.876	.879	.882	.885	.888	.892
92	.847	.853	.860	.866	.872	.879	.882	.885	.888	.891	.895
91	.850	.856	.862	.869	.875	.882	.885	.888	.891	.894	.898
90	.853	.859	.866	.872	.878	.885	.888	.891	.894	.898	.901
89	.856	.862	.868	.875	.881	.888	.891	.894	.897	.901	.904
88	.859	.865	.872	.878	.884	.891	.894	.897	.900	.904	.907
87	.861	.868	.874	.881	.887	.894	.897	.900	.903	.907	.910
86	.864	.871	.877	.884	.890	.897	.900	.903	.906	.910	.913
85	.867	.874	.880	.887	.893	.900	.903	.906	.909	.912	.916
84	.870	.876	.883	.890	.896	.902	.906	.909	.912	.915	.919
83	.873	.879	.886	.892	.899	.905	.909	.912	.915	.918	.922
82	.876	.882	.889	.895	.902	.908	.911	.915	.918	.921	.924
81	.878	.885	.891	.898	.904	.911	.914	.918	.921	.924	.927
80	.881	.888	.894	.901	.907	.914	.917	.920	.924	.927	.930
79	.884	.890	.897	.904	.910	.916	.920	.923	.926	.930	.933
78	.887	.893	.900	.906	.913	.919	.923	.926	.929	.932	.936
77	.889	.896	.902	.909	.916	.922	.925	.929	.932	.935	.938
76	.892	.898	.905	.912	.918	.925	.928	.931	.935	.938	.941
75	.894	.901	.908	.914	.921	.928	.931	.934	.937	.941	.944
74	.897	.904	.910	.917	.924	.930	.933	.937	.940	.943	.947
73	.900	.906	.913	.920	.926	.933	.936	.939	.943	.946	.949
72	.902	.909	.916	.922	.929	.936	.939	.942	.945	.949	.952
71	.905	.912	.918	.925	.931	.938	.941	.945	.948	.951	.955
70	.907	.914	.921	.927	.934	.941	.944	.947	.951	.954	.957
69	.910	.917	.923	.930	.937	.943	.947	.950	.953	.957	.960
68	.912	.919	.926	.932	.939	.946	.949	.952	.956	.959	.962
67	.915	.922	.928	.935	.942	.948	.952	.955	.958	.962	.965
66	.917	.924	.931	.938	.944	.951	.954	.958	.961	.964	.968
65	.920	.927	.933	.940	.947	.954	.957	.960	.964	.967	.970
64	.922	.929	.936	.943	.949	.956	.959	.963	.966	.970	.973
63	.925	.932	.938	.945	.952	.959	.962	.965	.969	.972	.975
62	.927	.934	.941	.948	.954	.961	.964	.968	.971	.975	.978
61	.930	.936	.943	.950	.957	.964	.967	.970	.974	.977	.980
60	.932	.939	.946	.953	.959	.966	.969	.973	.976	.980	.983

Formula used: $\text{Correction factor} = \frac{(P-E)\,(60+459.4)}{(t+459.4)\,(30-0.5170)}$

P=total gas pressure
E=vapor pressure of water at $t°$
t=temperature of gas (°F)

Correction Factors for Gas Volume—Continued

[Multiply observed volume of saturated gas by factor to correct to volume of saturated gas at 30 inches of mercury pressure (32° F) and 60° F]

Temperature, °F	Total gas pressure—Inches of mercury—Continued.									
	29.6	29.7	29.8	29.9	30.0	30.1	30.2	30.3	30.4	30.5
99	0.875	0.878	0.882	0.885	0.888	0.891	0.894	0.897	0.900	0.904
98	.879	.882	.885	.888	.891	.894	.898	.901	.904	.907
97	.882	.885	.888	.891	.894	.898	.901	.904	.907	.910
96	.885	.888	.891	.895	.898	.901	.904	.907	.910	.914
95	.888	.892	.895	.898	.901	.904	.907	.911	.914	.917
94	.892	.895	.898	.901	.904	.907	.911	.914	.917	.920
93	.895	.898	.901	.904	.908	.911	.914	.917	.920	.923
92	.898	.901	.904	.907	.911	.914	.917	.920	.923	.927
91	.901	.904	.907	.910	.914	.917	.920	.923	.926	.930
90	.904	.907	.910	.914	.917	.920	.923	.926	.930	.933
89	.907	.910	.914	.917	.920	.923	.926	.930	.933	.936
88	.910	.913	.916	.920	.923	.926	.929	.933	.936	.939
87	.913	.916	.920	.923	.926	.929	.932	.936	.939	.942
86	.916	.919	.922	.926	.929	.932	.935	.939	.942	.945
85	.919	.922	.925	.929	.932	.935	.938	.942	.945	.948
84	.922	.925	.928	.932	.935	.938	.941	.945	.948	.951
83	.925	.928	.931	.934	.938	.941	.944	.948	.951	.954
82	.928	.931	.934	.937	.941	.944	.947	.950	.954	.957
81	.930	.934	.937	.940	.944	.947	.950	.953	.957	.960
80	.933	.937	.940	.943	.946	.950	.953	.956	.960	.963
79	.936	.940	.943	.946	.949	.952	.956	.959	.962	.966
78	.939	.942	.946	.949	.952	.955	.959	.962	.965	.968
77	.942	.945	.948	.952	.955	.958	.961	.965	.968	.971
76	.944	.948	.951	.954	.958	.961	.964	.968	.971	.974
75	.947	.950	.954	.957	.960	.964	.967	.970	.974	.977
74	.950	.953	.957	.960	.963	.966	.970	.973	976	.980
73	.953	.956	.959	.963	.966	.969	.972	.976	.979	.982
72	.955	.959	.962	.965	.969	.972	.975	.978	.982	.985
71	.958	.961	.965	.968	.971	.975	.978	.981	.985	.988
70	.961	.964	.967	.971	.974	.977	.981	.984	.987	.991
69	.963	.967	.970	.973	.977	.980	.983	.987	.990	.993
68	.966	.969	.973	.976	.979	.983	.986	.989	.993	.996
67	.968	.972	.975	.979	.982	.985	.989	.992	.995	.999
66	.971	.974	.978	.981	.984	.988	.991	.995	.998	1.001
65	.974	.977	.980	.984	.987	.990	.994	.997	1.001	1.004
64	.976	.980	.983	.986	.990	.993	.996	1.000	1.003	1.007
63	.979	.982	.986	.989	.992	.996	.999	1.002	1.006	1.009
62	.981	.985	.988	.992	.995	.998	1.002	1.005	1.008	1.012
61	.984	.987	.991	.994	.997	1.001	1.004	1.008	1.011	1.014
60	.986	.990	.993	.997	1.000	1.003	1.007	1.010	1.014	1.017

Formula used: Correction factor $= \frac{(P-E)\,(60+459.4)}{(t+459.4)\,(30-0.5170)}$

P=total gas pressure
E=vapor pressure of water at $t°$
t=temperature of gas (°F)

Relative Humidity from Wet and Dry Bulb Thermometer Readings in Still Air

[Calculated for a barometer height of 755 mm. At altitudes of 6000 feet or over the reduction in barometric pressure will cause an error of 5 per cent or over at very low humidities]

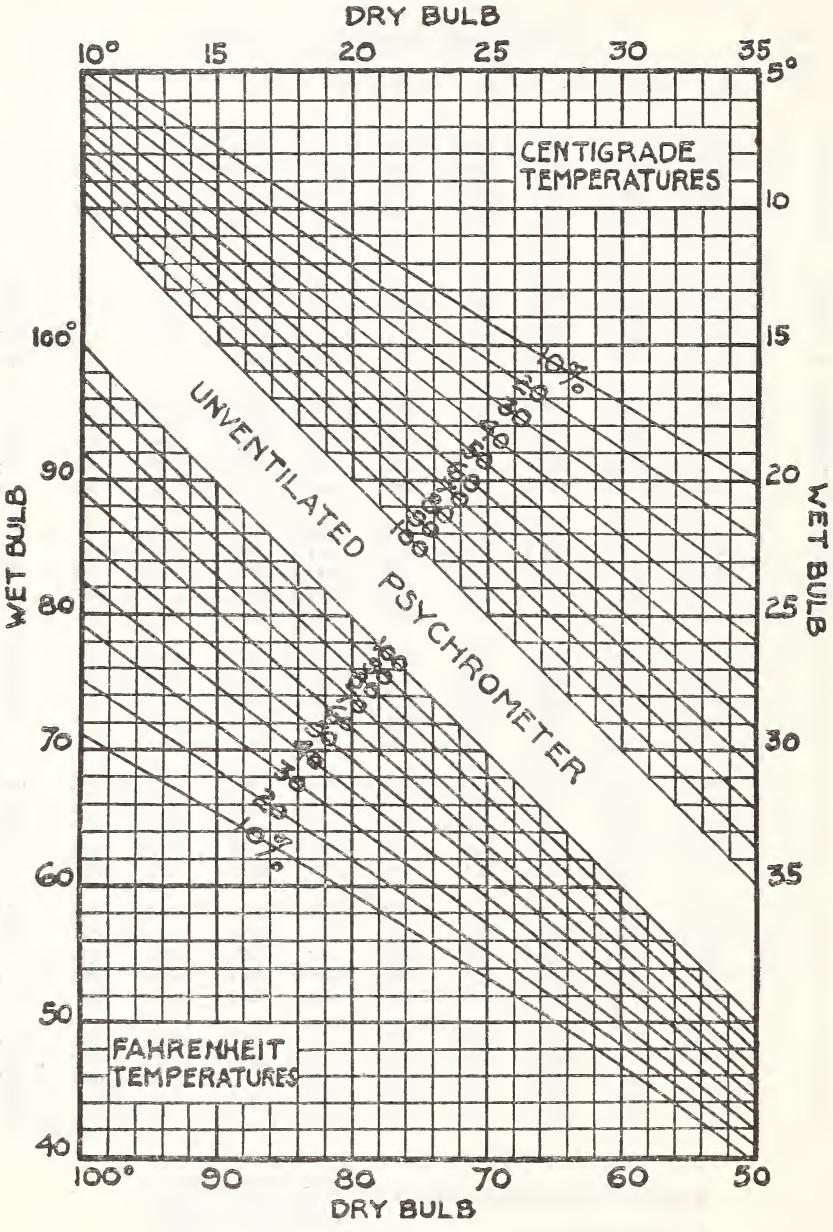


FIG. 2

Relative Humidity from Wet and Dry Bulb Thermometer Readings for Psychrometer with Rapid Ventilation

[Calculated for a barometer height of 755 mm. At altitudes of 6000 feet or over the reduction in barometric pressure will cause an error of 5 per cent or over at very low humidities]

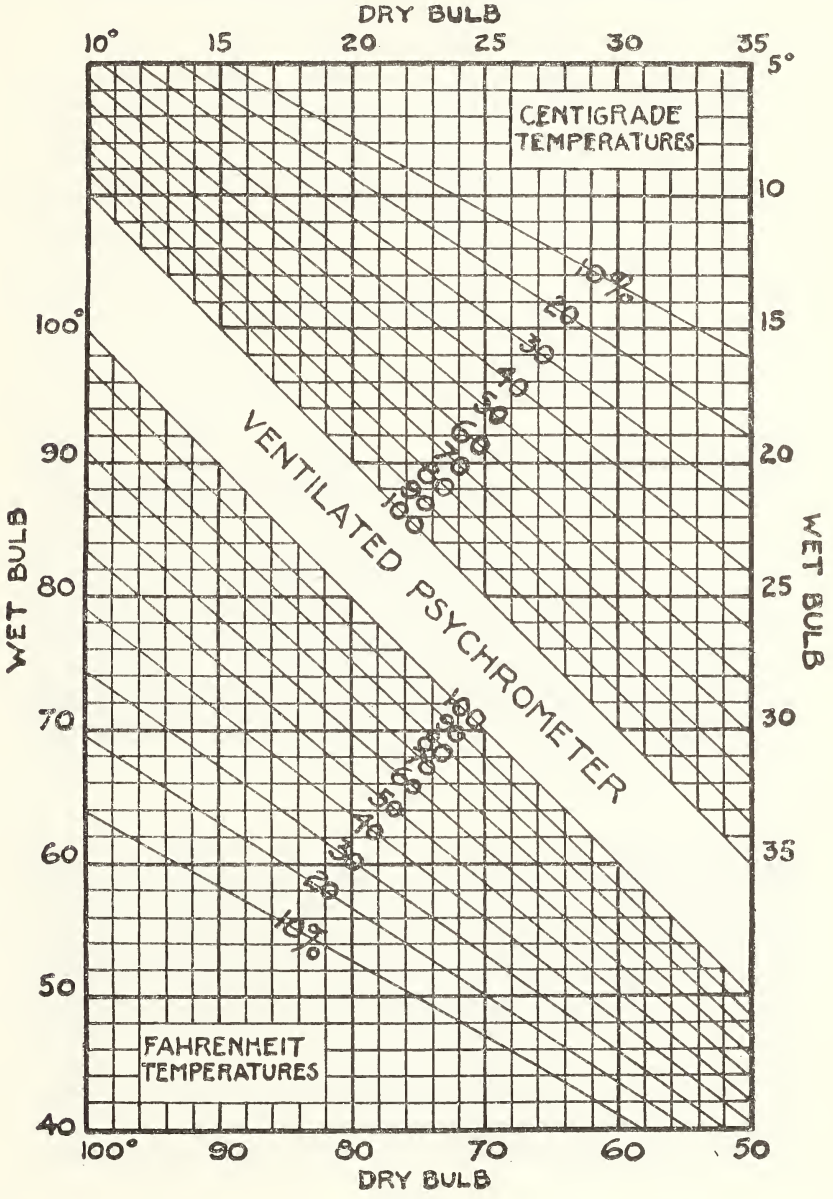


FIG. 3

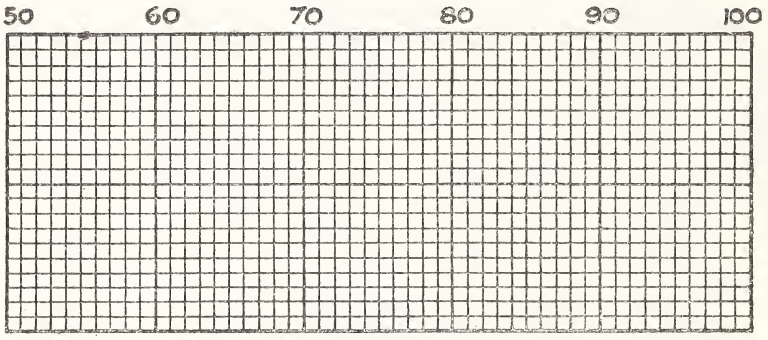
Gas Rate Per Hour For One-Tenth Cubic-Foot Meter

Seconds per revolution	Cubic feet per hour	Seconds per revolution	Cubic feet per hour	Seconds per revolution	Cubic feet per hour
40	9.0	50	7.2	60	6.0
41	8.8	51	7.1	61	5.9
42	8.6	52	6.9	62	5.8
43	8.4	53	6.8	63	5.7
44	8.2	54	6.7	64	5.6
45	8.0	55	6.5	65	5.5
46	7.8	56	6.4	66	5.5
47	7.7	57	6.3	67	5.4
48	7.5	58	6.2	68	5.3
49	7.3	59	6.1	69	5.2

Scale Correction for Thermometers

Calibration by.....

Inlet Thermometer No. .....



Outlet Thermometer No. .....

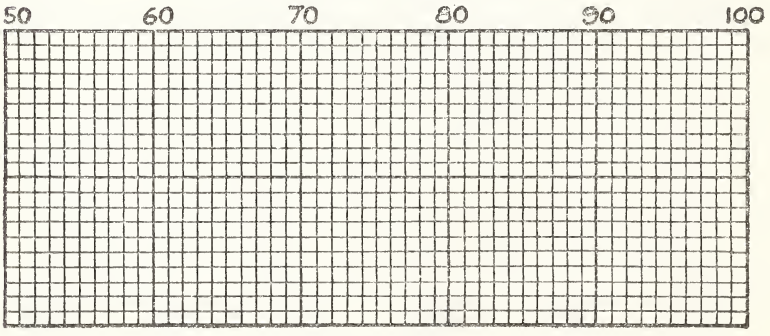
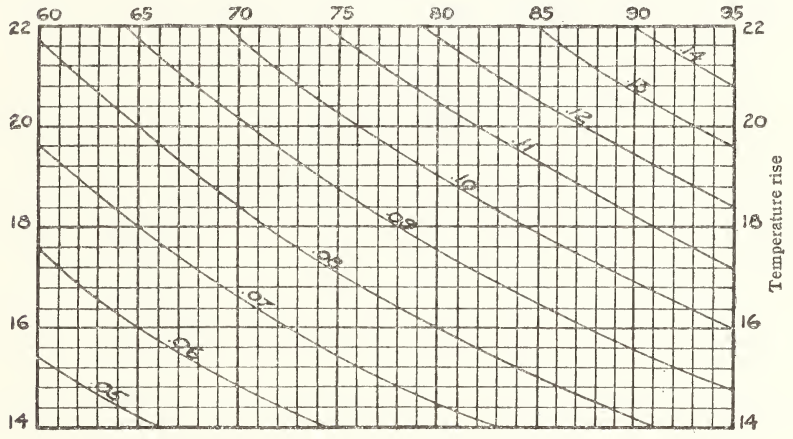


FIG. 4

Emergent Stem Corrections to Readings of Outlet-Water Thermometers for Different Immersions of Thermometers in Calorimeter

[Table applicable when temperature of inlet water is approximately equal to room temperature, but is not applicable if the emergent portion of the stem includes an enlargement in the capillary]

Thermometer immersed to 32° F



Thermometer immersed to 65° F

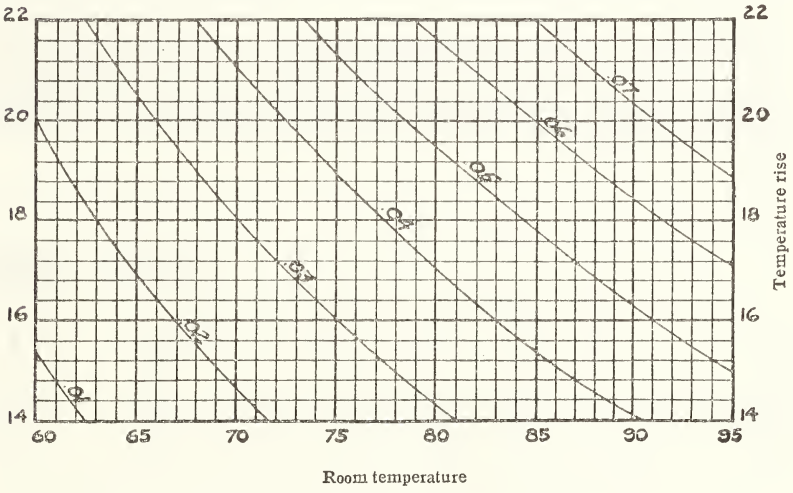


FIG. 5

Differential Correction

Date	Difference (degrees)

Meter Calibration

Date	One revolution equals—
	Cubic feet
	Cubic feet
	Cubic feet
	Cubic feet
	Cubic feet

Corrections for Difference Between Inlet-Water Temperature and Room Temperature

[In this table are given the data from which to determine the amounts by which the total and the net heating values, calculated from the observed heating value as if the inlet water had been at room temperature, must be corrected on account of any difference in temperature between inlet water and room. The correction calculated from this table may be applied without sensible error to heating values of illuminating gas of about 600 Btu as determined with any of the flow calorimeters listed in Circular No. 48 except the Doherty calorimeter. The correction is added if the inlet water is warmer than the room; subtracted if the inlet water is colder. In calculating the observed heating value, the stem corrections to both the inlet and outlet water thermometers must be taken into account when the inlet-water temperature differs much from room temperature]

Room temperature, ° F	Corrections in Btu per 1° F	
	For calculating total heating value	For calculating net heating value
50	0.5	0.4
60	.6	.4
70	.7	.4
80	.8	.4
90	.9	.5
100	1.0	.5

Corrections for Humidity, in Btu, to be Applied to Observed Heating Values in Calculating Total Heating Values of Illuminating Gas (About 600 Btu)

[The tabular corrections are applicable when inlet water, air, gas, and products are all at approximately the same temperature and when the calorimeter is operated at normal rate of gas consumption]

Temperature of room, etc., ° F	Relative humidity of air									
	10 per cent	20 per cent	30 per cent	40 per cent	50 per cent	60 per cent	70 per cent	80 per cent	90 per cent	100 per cent
40	+ 2	+ 2	+ 1	+1	+1	+1	0	0	0	−1
45	+ 2	+ 2	+ 2	+1	+1	+1	0	0	0	−1
50	+ 3	+ 3	+ 2	+2	+1	+1	0	0	0	−1
55	+ 3	+ 3	+ 3	+2	+1	+1	+1	0	0	−1
60	+ 4	+ 4	+ 3	+2	+2	+1	+1	0	0	−1
65	+ 5	+ 4	+ 4	+3	+2	+2	+1	0	−1	−1
70	+ 6	+ 5	+ 4	+3	+3	+2	+1	0	−1	−2
75	+ 7	+ 6	+ 5	+4	+3	+2	+1	0	−1	−2
80	+ 8	+ 7	+ 6	+5	+4	+3	+1	0	−1	−2
85	+10	+ 9	+ 7	+6	+4	+3	+2	0	−1	−3
90	+12	+10	+ 9	+7	+5	+4	+2	0	−2	−3
95	+14	+12	+10	+8	+6	+4	+2	0	−2	−4

Corrections for Humidity, in Btu, to be Applied to Observed Heating Values in Calculating Total Heating Value of Natural Gas (About 1000 Btu)

[The tabular corrections are applicable when inlet water, air, gas, and products are all at approximately the same temperature and when the calorimeter is operated at normal rate of gas consumption. (See T. P. 36, for discussion of these corrections)]

Temperature of room, etc., ° F	Relative humidity of air									
	10 per cent	20 per cent	30 per cent	40 per cent	50 per cent	60 per cent	70 per cent	80 per cent	90 per cent	100 per cent
40	+ 4	+ 3	+ 3	+ 2	+ 2	+1	+1	0	0	−1
45	+ 4	+ 4	+ 3	+ 3	+ 2	+1	+1	0	0	−1
50	+ 5	+ 5	+ 4	+ 3	+ 3	+2	+1	0	0	−1
55	+ 6	+ 6	+ 5	+ 4	+ 3	+2	+1	0	−1	−1
60	+ 8	+ 7	+ 6	+ 4	+ 3	+2	+1	0	−1	−2
65	+ 9	+ 8	+ 7	+ 5	+ 4	+3	+2	0	−1	−2
70	+11	+ 9	+ 8	+ 6	+ 5	+3	+2	+1	−1	−2
75	+13	+11	+10	+ 8	+ 6	+4	+3	+1	−1	−3
80	+15	+13	+11	+ 9	+ 7	+5	+3	+1	−1	−3
85	+18	+16	+13	+11	+ 9	+6	+4	+1	−2	−4
90	+21	+19	+16	+13	+10	+7	+4	+1	−2	−5
95	+25	+22	+19	+15	+12	+8	+5	+1	−2	−6

HEATING VALUE TEST RECORD.

Place Bureau Stds Date Oct. 8, 1913 Time 10 a.m. Gas Gtwn.
Calorimeter No. T 1209 Meter No. 6312 Thermometer No.: Inlet 5781 A Outlet 5781 B.
Gas line purged Yes/No Meter adjusted Yes/No Leak test Yes/No Water valve 65 Damper closed.
Differential therm. corr'n. det'd Oct. 1 1913 (date). Last meter calibration Sept. 4, 1913 (date)

	START.	END.
Temp. of barometer	68°	68°
Barometer reading	29.52	29.51
Certif. corr'n	−.01	
Temp. corr'n	−.10	
Corr'd barom. height	29.40	
Pressure at meter (inches of water)	1.5	
Equiv. (inches of mercury)	.11	
Total gas pressure	29.51	
Meter therm. reading	68.1	68.3
Certif. corr'n	−.3	
Meter temp.	67.9	
Reduction factor F	0.963	
Psychrometer dry bulb	68.0	68.5
Psychrometer wet bulb	53.0	53.0
Humidity	35 %	
Temp. of products	69	
Time of 1 meter rev.	52″	
Equiv. rate (cu. ft. per hr.)	6.9	

Condensed Water Collected.	Test 1.	Test 2.
Meter reading: start	18.1	19.4
" " end	191	20.4
Condensate (cc)	21.6	21.2
" per cu. ft. (60° 30 in.)	22.3	21.9
Average A	22.1	

Net Heating Value.	
Observed heating value average	644
Corr'n for heat loss	+ 1
Reduction to net (A × 2.3)	− 51
Net heating value	594

Certified as correct.
E. F. M.
Observer.

	Series No. 1. Inlet.	Series No. 1. Outlet.	Series No. 2. Inlet.	Series No. 2. Outlet.	Series No. 3. Inlet.	Series No. 3. Outlet.
Preliminary.	67.94	86.54	67.93	86.40	67.90	86.40
		50		45		45
		50		49		48
		43		40		40
		36		43		39
		43		47		43
		54		50		49
Used in averaging.	67.93	49	67.93	50	67.90	52
		50		41		50
		50		40		40
		47		48		42
		40		38		46
Supplementary.		49		41		46
	67.93	36	67.92	41	67.90	47
Average	67.93	86.46	67.93	86.45	67.90	86.45
Certificate corr'n	−.18	−.25				
Differential corr'n		−.02	−.18	−.19	−.18	−.19
Emergent stem corr'n		+.08				
Corrected temp.	67.75	86.27	67.75	86.26	67.72	86.26
Temp. rise T		18.52		18.51		18.54
Water heated W		6.74		6.74		6.72
No. of rev. of meter		2				
Meter calib. 1 rev. =		0.1006				
Gas volume V		0.2012				
Observed heating value $\frac{W \times T}{V \times F}$		644		644		643
Corr'n for atmos. humid.		+1				
Corr'n for heat loss		+1				
Total heating value		649		649		648
Average		649				Btu per cu. ft. (60°, 30 in.).

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FIG. 6

NOTE.—The dimensions of this form, as used by the Bureau, are 8 by 10½ inches.

RECORDS AND COMPUTATIONS

(1) Enter from page 5 the *certificate correction* and the *temperature correction* to the barometer. The corrections thus entered are added to (or subtracted from) the *barometer readings* to find the *corrected barometric height*, the *average* obtained from the barometer readings being entered on the record.

(2) Enter the *equivalent, in inches of mercury*, of the pressure at meter inlet, and add this to the *corrected barometric height* to find the *total gas pressure.*

By using a regulator on gas line before the meter, the inlet pressure of the gas may be permanently adjusted to give a constant and convenient figure to add to barometer pressure, eliminating all calculations or conversion tables, for example:

1.36 inches water pressure=0.10 inch mercury pressure
2.0 inches water pressure=0.15 inch mercury pressure
2.7 inches water pressure=0.20 inch mercury pressure

(3) Enter from page 5 the *certificate correction* to meter thermometer; and calculate the corrected *meter temperature*, only the average calculated from the readings of the meter thermometer being entered on the record.

(4) From page 6 or 7 enter the *reduction factor, F* (to the third decimal place), corresponding to the *total gas pressure* and the *meter temperature.*

(5) From page 8 or 9 enter on the record the relative atmospheric *humidity* (to the nearest 5 per cent) corresponding to the recorded *dry bulb* and *wet bulb* thermometer readings of the ventilated *psychrometer.*

(6) From page 10 enter the *rate* in *cubic feet per hour* corresponding to the *time* in seconds *of one revolution* of the meter index.

(7) Average separately, for each series, the *readings of the inlet and of the outlet water thermometers*, omitting the *preliminary* and *supplementary* readings, and enter these *averages* on the record.

(8) Enter from page 10 the *certificate corrections* corresponding to the average readings of the inlet and outlet water thermometers.

From thermometer calibration certificate the points may be plotted on page 10 and the points connected by lines to give the correction for any intermediate reading. The same scale should be used for both thermometers, if possible, in order to avoid confusion in use. Should another thermometer be substituted, a new set of corrections can be pasted over the old one.

(9) Enter from page 12 the *differential correction* to the reading of the outlet-water thermometer.

This correction, determined as described on page 58 of Circular No. 48, is applied in order to correct for any relative change that may have occurred in the thermometers since the determination of their certificate corrections.

(10) Enter on the record from page 11 the *emergent stem correction* to the average readings of the outlet-water thermometer.

Correction for emergent stem of thermometer.—If the mercury thread of a thermometer is not at the same temperature as the bulb, the emergent stem correction may be too large to be neglected. The correction for emergent stem may be computed from the formula:

Stem correction $=K\times n\,(T°-t°)$.

K=factor for relative expansion of mercury in glass; 0.00015 to 0.00016 for centigrade thermometers, 0.000083 to 0.000089 for Fahrenheit thermometers, at ordinary temperatures, depending upon the glass of which the stem is made. For ordinary calorimetric thermometers graduated on the Fahrenheit scale, the value K=0.000085 may be used.

n=number of degrees emergent from the bath.

T=temperature of the water.

t=mean temperature of the emergent stem.

Page 11 shows emergent stem corrections for two depths of immersion, which are most common. The thermometer with the larger immersion is regularly supplied for calorimeter work, and on account of its more open scale is more desirable and should be used. If a thermometer with any other immersion point is used, the data can be calculated from the formula given. The mean temperature of outlet thermometer is slightly above room temperature, and some allowance was made for this In the curves shown.

(11) Enter on the record the *corrected temperature* of the inlet and of the outlet water for each series by applying the several corrections to the averages of the readings of the inlet and outlet water thermometers.

(12) Subtract the corrected temperature of the inlet water from the corrected temperature of the outlet water for each series, and enter this *temperature rise*, T, on the record.

(13) The weight of *water collected*, W, is corrected if calibration has shown any error in the weights used.

Such correction, however, should not be necessary. In general, the correction for buoyancy and the correction for the variation of the specific heat of water may be neglected, since both corrections are small and are, for the conditions under which flow calorimeters are used, of opposite sign. If the water is measured volumetrically, the observed volume corrected for error of the graduate must be multiplied by a factor taken from Appendix 8, Circular No. 48.

(14) Opposite *number of revolutions of meter* enter on the record the number of revolutions made by the meter index during the time the effluent water for each series was being collected.

(15) Enter from page 12 the meter calibration constant, viz, the number of *cubic feet corresponding to one revolution* of the meter.

(16) Enter on the record the *gas volume, V*, which is the product of the number of revolutions of the meter and the meter calibration constant.

(17) Calculate and enter on the record for each series the observed heating value found from the following equation:

$$\text{Observed heating value} = \frac{\text{Water heated } (W) \times \text{Temp rise } (T)}{\text{Gas volume } (V) \times \text{Reduction factor } (F)}$$

Heating-Value Computer.—The arithmetical work involved in the computations may be greatly diminished by the use of the heating value computer, which is illustrated in the Proceedings of the American Gas Institute, volume 3, page 373, 1908. The computer is a circular slide rule with which the observed heating value may be read directly when the temperature and the total pressure of the gas, the volume of gas indicated by the meter, the weight of water heated, and the rise of temperature of the water are known. The computer can be read with an accuracy of 1 or 2 Btu, and if a few check computations are made occasionally no significant error should be introduced due to the use of the computer. The computer is published by the United Gas Improvement Co., Broad and Arch Streets, Philadelphia, Pa.

(18) Enter from page 12 the *correction for heat loss.*

If the inlet water is at room temperature, there will be some heat losses from the calorimeter, due to the fact that the average temperature of the surface is above that of the room, that the products of combustion are not cooled quite to room temperature, etc. These losses when the inlet water is at room temperature and the temperature rise is 15° to 20° F is of the order of 0.1 to 0.2 per cent of the total heating value of the gas for the Junkers (original and new types), Hinman-Junkers, Sargent, and Simmance Abady (English type) calorimeters. If one of these calorimeters is used in testing illuminating gas, a correction of 1 Btu for this heat loss should be added. For the Boys calorimeter the heat loss amounts to 10 or 15 Btu.

If the inlet water is not at room temperature, another correction (to be added if the water is warmer and subtracted if colder than the room) is necessary.

On page 12 are given the data from which to determine the amounts by which the total and the net heating values, calculated from the observed heating value as if the inlet water had been at room temperature, must be corrected on account of difference between inlet-water and room temperatures. For example, if the room temperature were 80° F and the inlet-water temperature were 76° F, the total heating value, calculated in the usual way, is too high by 0.8 Btu per 1° difference; i. e., the value is too high by $4 \times 0.8 = 3$ Btu. Similarly the net heating value is too high by $4 \times 0.4 = 2$ Btu.

(19) Enter from page 13 the *correction for effect of atmospheric humidity*, using the correction corresponding to the room temperature (reading of dry bulb thermometer of psychrometer) and to the percentage *humidity* as entered on the record.

The tabular values apply for the condition that room temperature, inlet-water temperature, gas temperature, and products temperature are all equal. In using the table the correction corresponding to room temperature is taken, since if the inlet-water temperature differs appreciably from room temperature, an additional correction must be applied, as explained on page 199, Circular No. 48.

(20) Calculate the *total heating values* by applying to the *observed heating values* the *correction for heat loss*, including the correction for the effect of difference between inlet-water temperature and room temperature, and the *correction for effect of atmospheric humidity*. The *average* of the *total heating values* found from all the series is then entered on the record.

(21) If it is desired to find the *net heating value*, proceed as follows:

(*a*) Subtract the *meter reading at the start* from the *meter reading at end* of *collection of condensate*. This difference gives approximately the number of cubic feet of gas (measured at *meter temperature* and under a pressure equal to that entered above as the *total gas pressure*) burned during the collection of the recorded *condensate* (*cc*). Multiply this difference, as found above, by the *factor*, F, to find the volume of the gas under standard conditions (i. e., 60° F, 30 inches pressure), and divide the *condensate* (*cc*) collected by this product and enter the resulting quotient on the record as the *condensate per cubic foot* of gas measured at 60° F and 30 inches pressure. Enter on the record the average, A, of the two values found as above from the two tests for condensed water collected.

(*b*) Enter on the record the *average* of the *observed heating values*.

(*c*) Enter on the record the *correction for heat loss*, as already used in calculating the total heating value.

(*d*) Multiply the *condensate per cubic foot* of the gas (measured at 60° F and 30 inches), entered opposite A in the record, by 2.3, and enter the product thus found as the *reduction to net*.

(*e*) To the *observed heating value* add the *correction for heat loss*, including the correction taken from page 12 for the effect of difference between inlet-water temperature and room temperature, and subtract the number derived as explained above, representing the *reduction to net*, and enter the result as the *net heating value*.

HEATING VALUE TEST RECORD

(Single Test Form)

Place..... Date..... Time.....

Meter adjusted Yes / No Leak test Yes / No Gas.....

Temp. of barometer.....
Barometer reading.....
Certif. corr'n.....
Temp. corr'n.....
Corr'd barom. height.....

Pressure at meter (inches of water).....
Equiv. (inches of mercury).....
Total gas pressure.....

Meter therm. reading.....
Certif. corr'n.....
Meter temp.....

Reduction factor **F**.....

Psychrometer { dry bulb..... / wet bulb.....
Humidity.....

Temp. of products.....
Rate (cu. ft. per hr.).....
Gas volume **V**.....
Water heated **W**.....

Thermometer No.		
Readings	Inlet	Outlet
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
Average.....		
Certificate corr'n.....		
Differential corr'n.....		
Emergent stem corr'n		
Corrected temp.....		

Net Heating Value

Observed heating value:
Average.....

Corr'n for heat loss.....

Reduction to net:
cc per cu. ft. $\times 2.3 \div F$.....

Net heating value.....

Temp. rise **T**.....

Observed heating value.....

Corr'n for atmos. humid.....

Corr'n for heat loss.....

Total heating value.....

Certified as correct.

.....
Observer.

Note.—The dimensions of this form, as used by the Bureau, are 5 by 8 inches.