# No. 18.—REPORTS OF OFFICERS OF THE NAVY ON VENTILATING AND COOLING THE EXECUTIVE MANSION DURING THE ILLNESS OF PRESIDENT GARFIELD.

## REPORT OF PROF. SIMON NEWCOMB, U. S. NAVY.

NAUTICAL ALMANAC OFFICE,
BUREAU OF NAVIGATION,
*Washington, D. C., February* 28, 1882.

SIR: In compliance with your order of the 25th instant, I have the honor to present a report of my conference with the surgeons attending the late President Garfield upon ventilating the President's room with cool air, and of the operations in which I took part in pursuance of that conference.

On the evening of Saturday, July 9, Dr. Woodward, of the attending surgeons, informed me that a number of plans and machines for cooling the air of the President's chamber had been proposed and several tried, but that none had proved effective. It was therefore desired by the attending surgeons that I should examine all the plans, and report in what manner the desired result might best be reached.

Among a number of plans under trial, only three demanded serious consideration. These were:

I. A large air compresser, such as is used in the Virginia City silver mines, which was sent on by the Rand Manufacturing Company, of New York, and was being mounted by engineers from the navy-yard, under direction of Mr. Edward B. Dorsey. This machine would undoubtedly have been effective when once in operation, but several days would be required to get it to work, and it was doubtful whether an engine of sufficient power to drive it could be set up within a reasonable time. As a matter of fact, it was removed in a few days without being tried.

II. A large ice-box, which had been placed in the Executive office, and was expected to cool the air by a downward current through the ice. As the air could pass through only by descending under the influence of its own gravity it produced no appreciable cooling effect, and had to be dismissed from farther consideration.

III. A machine devised by Mr. R. S. Jennings, of Baltimore, consisting essentially of an iron box 27 inches square by 6½ feet long, provided with a great number of thin cotton screens. These screens were kept wet with ice-water percolating from a box of melting ice on the top, and the air was forced through the passages between them by a blower. This machine was operated by a portable engine supplied from the Washington navy-yard. It was, however, necessarily ineffective from the necessity of melting the ice before the latter could be used in cooling, thus wasting the cooling power to be obtained from the absorption of heat by the melting ice.

A large body of warm air passing between the wet partitions warmed them and probably absorbed moisture from them, without itself becoming sufficiently cooled. I was informed by Dr. Woodward that, by closing the doors and windows of the Executive office, a slight cooling effect could be observed with the thermometer, but, as all the air admitted was saturated with moisture, the good effect was neutralized. Besides, when the doors and windows were kept open, as was necessary in the President's chamber, no cooling effect could be perceived.

All the proposed plans being either ineffective or impracticable for the time being, it became necessary to devise a new system. The first step necessary was to ascertain, roughly, how many units of heat per day were to be abstracted from the warm air, and how much ice would have to be exposed and melted in order to abstract this amount of heat. One necessary datum in the calculation was the quantity of cool air required. This datum was supplied by Dr. Woodward, who stated that 12,000 cubic feet of cool air per hour was desirable. I then made a rough computation of the amount of ice it was necessary that air at the temperature of 95° should melt in order that it might be cooled off and deposit the greater part of its moisture. The principal parts of this calculation were: 1,000 pounds air cooled 50° would warm 270 pounds of water 50°, and would therefore melt about 100 pounds of ice per hour.

The condensation of five grains of aqueous vapor from each cubic foot of air would require the condensation of some 10 pounds per hour, which would require the melting of some 70 pounds of ice.

Therefore, making no allowance for waste, about 170 pounds of ice per hour, or, say, two tons per day, would have to be melted by a current of warm air; allowing for waste, it might be estimated that three or four tons of ice per day must be melted by the air itself.

The next problem was to determine the amount of ice surface which must be exposed in order to cool the air. This was done by taking a block of ice weighing some 200 pounds, and allowing it to stand over a large tin basin 30 minutes. The amount of water which melted from it was then weighed, and found to be six pounds. Such a block would therefore melt off 288 pounds per day. To melt three tons of ice it was necessary that at least three tons should be kept in contact with the cooling air.

These conclusions were reached about 1 o'clock on Sunday, July 10. In reaching them, and putting them into a practicable shape, I co-operated with Prof. J. W. Powell, Director of the Geological Survey. He and I conjointly devised a large ice-box, holding some six tons in all, through which the air might pass in one direction and return in the other. He took the sole charge of its construction, and had it ready next morning.

A fan blower and transmitting pipes for the air being necessary, Mr. Jennings kindly allowed his apparatus to be connected with the new box, so that the latter was put into effective operation without the necessity of additional machinery. The connection was so made that the air passed first through his box and thence into the ice-box. The objection that the air was slightly moistened and therefore injured in passing through his box was obviated by the fact that the latter would also act as an auxiliary in cooling the air, while any excess of moisture would be absorbed by the ice in the large box.

On Monday, July 11, the air from this apparatus was for the first time admitted into the President's chamber and found to be cool, dry, and ample in supply. A serious difficulty was, however, met with at first from the whirr of the engine being distinctly audible in the President's chamber, being conducted by the tin tubes through which the air passes. Mr. Jennings proposed to water-jacket the tin pipe, but I suggested that an easier method of cutting off the sound would be to remove the tin tube and substitute one of canvas. This was done and the sound entirely ceased.

Professor Powell next constructed a larger ice-box in a different part of the basement on plans of his own. This new apparatus was also supplied with an independent engine and blower from the navy-yard so as to be worked independently of the other. Being primarily intended to take the place of the first in case of accident, it was not connected directly with the President's chamber, but with the adjacent corridor.

From this point Passed Assistant Engineer William L. Bailie, U. S. N., assisted by Passed Assistant Engineers Richard Inch and William S. Moore, took charge of the operations, under orders of the department, and my active connection with them terminated. I continued, however, to inspect the working of the machinery, and held myself in constant readiness to render the engineers in charge any assistance which might be in my power.

The multiplicity of parties who took a more or less active part in proposing plans for the object in view being likely to give rise to misapprehension, it may be proper to say that the work of ventilating the Executive Mansion and the President's chamber with cool air was in all its essential features designed and executed by officers of the Navy and Director Powell, with machinery and assistance supplied by the Navy Department. The most material exception was that a fan blower and several feet of pipe for one of the ice-boxes was supplied by Mr. Jennings, who assisted in putting the plans into operation.

It may be added that the mutual relations of the naval engineers, Director Powell, and myself were those of friendly co-operators towards the end which had been set before us by the President's surgeons.

Very respectfully, your obedient servant,

SIMON NEWCOMB,
*Professor, United States Navy.*

Hon. W. H. HUNT,
*Secretary of the Navy, Navy Department.*

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REPORT OF PASSED ASSISTANT ENGINEERS W. L. BAILIE, R. INCH, AND W. S. MOORE, U. S. N.

WASHINGTON, D. C., *October* 31, 1881.

SIR: We respectfully submit the following report as the result of our observation of the operation of the cooling apparatus used at the Executive Mansion during President Garfield's illness:

There were two systems of cooling apparatus employed, one delivering the cool air directly into the President's room, and the other delivering into the corridor outside of the room.

Mr. R. S. Jennings, of Baltimore, offered, and had accepted for the purpose of cooling the room occupied by the President, a machine used by him for manufacturing purposes, and which is represented in Plate A.

This machine consisted of a cast-iron box 2′ 3″ by 2′ 3″ on the end and 6′ 6″ long, which contained a number of screens made of terry-cotton, stretched over thin iron frames, and placed in the box longitudinally and vertically and ¼ of an inch apart; suspended inside and at the top of the box was a shallow pan made of galvanized iron, which was corrugated and perforated at the bottom. On the top of the box was placed a galvanized iron tank of about 134 gallons capacity, which was filled with granulated ice and salt, composed of 64 parts cracked ice, 3 parts salt, and 33 parts water; this brine was taken from the bottom of the tank through $\frac{5}{8}$-inch pipe and delivered into the shallow pan in the top of the box, through which it percolated, and was distributed over the screens, wetting them and reducing their temperature to that due to the composition of the brine. Attached to this apparatus was a 14-inch Sturtevant blower, which was used to draw the air into the box, and between the screens, reducing it to a corresponding temperature, and delivering it at any desired point. This apparatus of Mr. Jennings was connected with the heating flue leading to the President's chamber, and the air to the box was supplied from outside through an air duct which passes along the top, and the whole length of the corridor in the basement of the Executive Mansion.

This cooling machine was soon found to be of insufficient capacity to affect the temperature of the President's room with the windows open, but with the windows and doors closed it would have reduced the air in the room to the desired temperature. As, however, it was required that the windows and doors of the sick chamber be left open, the problem of how to cool the room under those conditions was presented, and the attention of certain scientific gentlemen was called to the subject. Mr. Jennings proposed to enlarge the capacity of his apparatus by adding two additional boxes, of wood, containing the same system of screens, to the circuit of air, and by this enlargement he claimed the desired result would be effected, but in view of the necessity of supplying the cool air as quickly as possible, Prof. Simon Newcomb and Major Powell, of the United States Geodetic Survey, suggested the addition of an ice-box to the Jennings machine, of sufficient capacity to hold the amount of ice necessary to meet the emergency, and by a change of pipe connections requiring the air to pass first through the Jennings machine, and then into the ice-box at the top, and after circulating over the ice to be taken by the blower and forced up into the President's room. These suggestions were carried out, and the effect was a rapid and continuous supply of air at about 55° Fahr. at the register in the President's room, giving the air in the room an agreeable temperature during the warm weather which prevailed at the time. This apparatus is represented in Plate A, the notes on the plate indicating its different features.

Subsequently it was ascertained that when a fresh breeze from the south was blowing directly into the President's room, through the open windows which faced in that direction, it was impossible to affect the temperature of the room by the small 14-inch blower then in use. It was therefore determined to substitute a 36-inch blower, and reverse the circuit so that the air would pass first through the ice-box, then through the Jennings machine to the blower, thence up to the President's room. By this arrangement the temperature was kept at the desired point during the extremely hot weather which prevailed on August 13 and 14, which may be regarded as a good test of the efficiency of the apparatus.

By the first arrangement, represented in Plate A, it was observed that all the air delivered into the President's room did not pass through the Jennings machine, but that a large portion was drawn through the leaks in the ice-box; arrangement in Plate B obviated this difficulty, and assured the passage of the air through the pipes leading from the air-duct and not from the corridor through the leaks, and by extending the induction pipe into the box a better distribution of the air over the ice was effected.

The data taken during the running of this cooling apparatus was in-complete, as those who had constant access to the President's room were too busily occupied to take a systematic series of observations in the room, and it was not until after President Garfield was removed to Elberon that we were able to take the temperatures in the room he occupied, and this was done September 7 and 8, during a run of the apparatus for twenty consecutive hours, under circumstances as nearly as possible like those which existed during the President's illness at the Executive Mansion, excepting the last hour of the run when the windows and doors were closed.

The outside temperature during the special trial averaged 84°.9 Fahr., and running the engine at an average of 102 revolutions per minute, and forcing 22,799 cubic feet of air into the room per hour, resulted in the reduction of the temperature of the room 5°.4 Fahr., and this with one window and door open, and a southerly breeze blowing. Although this was in a measure disappointing, so far as the reduction of temperature was concerned, yet the character of the air was so greatly changed by the reduction of the relative humidity of the air that it was agreeable, and could not have been reduced to a lower degree with impunity had the patient been present.

We were told by one of the President's attending physicians that the first effect observed when the cooling machine was started was the change in the character of the air, and, even before a sensible change of temperature occurred, a benefit from the machine was experienced in the dryness of the air in the room, which reduced the temperature of the skin by a more rapid evaporation of the moisture at its surface. This effect is not the least in importance; for, as commonly observed, a warm day is not necessarily an oppressive day, if the relative humidity of the atmosphere is not great. The reduction of the relative humidity of the air in the President's room was obtained by the operation of a well-known law in physics, by which the air is deprived of a percentage of its moisture, which it contains at high temperatures, when that same air is reduced to lower temperatures.

The capacity for holding moisture, or vapor, by the atmosphere is greater at high than at low temperatures, and is consequently deprived of a part of its moisture when passed over the surfaces of the cooling machine, and this moisture the air cannot regain until it escapes from the system of pipes through which it is conducted; at the point of its escape, however, as its temperature rises, it claims that percentage of moisture of which it has been deprived in the cooling machine from the surrounding atmosphere. An examination of the accompanying Table A will demonstrate the truth of this law. The data were taken during the twenty hours' trial after President Garfield was removed. The relative humidity of the air outside averaged 60, and that of the air in the President's room after passing through the cooling apparatus averaged 54.3. This shows conclusively that the air of the room gave up a part of its moisture to supply the loss of moisture to the air entering through the cooling apparatus. What the condition and dryness would have been had the cool air been delivered into a closed room we have no means of ascertaining; but from the result of this experiment, where the relative humidity of the air in the room was maintained at a lower percentage than that of the air outside, with which it was in communication through an open window, it is safe to assert that the relative humidity of the air in a closed room can be maintained at any desired point. Charles Hood, in his book on Warming and Ventilation, says: "The most healthy state of the atmosphere will be obtained when the dew-point of the air is not less than 10° nor more than 20° Fahr. lower than the temperature of the room. When these limits are exceeded the air will be either too dry or too damp for healthy respiration." Examination of Table A shows the dew-point to average 18°.5 lower than the temperature at the center of the room, which proves by Hood to have been the most desirable condition of the atmosphere to maintain.

In order that the President's room might by no accident be deprived of its supply of cold air, Major Powell devised a second machine, which was constructed by labor and material from the navy-yard, the difference between it and the other apparatus consisting in the arrangement of the compartments of the ice-box, as shown in Plate C, and doing away with the box containing the terry-cotton screens. The ice-box was divided into three compartments, an upper, middle, and lower. The air was first taken through the induction pipe and passed over the ice in the upper compartment, from thence down through rectangular holes into the middle compartment, which it traversed, and was then drawn into the lower compartment, and at the opposite end the air was taken by a 36-inch blower and forced through a drying-box up through a system of pipes to the corridor outside of the President's chamber.

The peculiar feature of this apparatus was the drying-box, which was placed in the circuit for the purpose of drying the air. This purpose was supposed to be accomplished by cooling the bars of iron contained in the box, by causing a freezing mixture of ice and salt to fall on the ends of the bars, thereby cooling them, and by their low temperature causing the air to deposit on their surface another portion of its moisture, after having been deprived of a certain percentage in the ice-box. The purpose for which the drying-box was intended was not accomplished, as the bars could not, by the means employed, be reduced to a lower temperature than the air when it entered the box.

By examining Table B, the data for which were taken at various times as opportunity occurred during the time machine No. 2 was employed, we find that the temperatures taken just before entering the drying-box average 56° Fahr., and those temperatures taken just after the air left the box average 59° Fahr., or 3° higher, showing that no reduction of temperature was effected; the relative humidity of the air entering was 85°.8 and increased to 86°.2 on leaving the box, or 0°.4 greater on leaving than when it entered, and proving the box to be of no use as a dryer.

Comparing results at the two ice-boxes, we find the air on leaving ice-box No. 1 to be 40°.7 Fahr., and leaving ice-box No. 2 to be 53°.5 Fahr., by which we conclude that the arrangement of the box into compartments did not produce the best results, and may be accounted for by the air passing over the top surface of the ice as it lay packed upon the floors of the compartments, and not coming in contact with the other surfaces, while in the other box, which was not divided but contained shelves upon which the ice was packed, a greater surface of the ice was exposed to contact with the circulating currents of air, which was consequently more effectually cooled. Deflecting diaphragms might have been used with advantage in box No. 2, so as to cause the air to deflect from the direct course and come in contact with the sides of the ice as well as the top, and thus forcing the cold air resting between the cakes of ice into the circuit.

The effect of the air delivered by this apparatus at the average rate of 39,217.9 cubic feet per hour, was to keep the air in the corridor at a pleasant temperature, although no observations were taken, excepting at the point the air issued from the pipe, where the average temperature was 63.6° Fahr. In the effort to complete this apparatus as quickly as possible, right-angle elbows were used in all the pipe connections; the effect was to produce eddying currents at all the bends, the nature of which was noticed at the point of delivery into the corridor. This elbow was 10 inches in diameter, and the passage of the air through it produced an eddy at the point of delivery, the outer circle of which was four inches in diameter, the vertical diameter extending one inch above, and three inches inside the elbow, the horizontal diameter touching the inner bend of the elbow. This eddy is represented in plate C at N.

The eddy was due to the shape of the elbow, allowing a dead space at M, into which the emerging cold air falls. By reason of its being of greater specific gravity than the outer atmosphere, it falls until it is again taken up by the main current of air which causes it to complete the circle. When the elbow was replaced by a curved elbow the eddy disappeared.

The conditions under which the President's room was cooled precluded all considerations of economy. The experiments, therefore, are without value for the purpose of determining the cost of ice sufficient to keep the President's room at an agreeable temperature under more favorable conditions. The problem as presented was the same as to ascertain the price of coal sufficient to keep the room warm on a cold day with the windows open.

During the twenty hours' run 8,734 pounds of ice were melted, or 436.7 pounds per hour. This at $5 per ton, or one-quarter of a cent per pound, would be $1.09 per hour; or this was the cost necessary to supply 22,799 cubic feet of air at 50° Fahr. at the register per hour.

Had time been offered for experiment or had experience suggested a more economical method of cooling the President's room much of the waste of cooling material might have been avoided, as for instance, the water of liquefaction which was allowed to run to waste might have been used as a first cooling medium for the air.

The experiments were also conducted under circumstances unfavorable for determining the most accurate results, as the observations would be interrupted at any time the air became too cool for the comfort of the President, the experiments, being, of course, entirely secondary in consideration; yet a sufficient number of temperatures were observed to show the value of the cooling apparatus, not only as affecting the temperature of the room occupied by the President, but affecting the best hygrometric condition of the air in the room.

A more general system of experiments would be interesting, and would furnish most valuable information as regards the cost as well as the effects of cooling apparatus.

Our operations at the Executive Mansion have brought to our notice the great importance of a proper hygrometric condition of the atmosphere we breathe and in which we live. Great stress is laid upon the subject by various authorities upon ventilation and warming, and notwithstanding its importance appears to be so fully realized, yet but crude attempts have been made to control the hygrometric condition of the air used in ventilating and warming our houses. In summer, with the windows open, the general condition of the atmosphere outside is maintained inside our houses, but in winter, with windows closed, and the ventilation mostly dependent upon the warm air which has passed through the heaters, the conditions are entirely changed. As, for example, the temperature of the air outside we will suppose to be 20° Fahr.; it is passed through the heaters and delivered into a room where the temperature is maintained at 70° Fahr.; supposing the windows to be closed and only leakage sufficient to permit ventilation, we will have in this room air at the temperature of 70°, the dew-point of which is not above 20°; for in the manner our heaters are usually constructed there are no means by which the air can receive moisture after it has left the outside of the house.

The most healthful condition of the air is found to exist when its relative humidity is from 50 to 70 per cent. In the hypothetical case cited, the relative humidity is as low as 15 per cent., an extreme that must be not only unpleasant but injurious. Of course crude attempts have been made to remedy this evil by urns of water placed over or near the heaters, but in most instances even this is wanting. It being necessary that the dew-point should not be less than 20° below the temperature of the room, it may be increased as it enters from the outside by passing it through water at a given temperature, say 55° before entering the furnace, saturating the air and establishing the dew-point at that temperature, the relative humidity being 58.

Our operations at the Executive Mansion have proved that it is possible to place the dew-points, or relative humidity of definite quantities of air, at any desired point, and there is no reason why this hygrometric condition may not be maintained with as much certainty as the amount and temperature of air supplied for proper ventilation and warming. This field of study presents great opportunities for effecting a better condition of the atmosphere of our rooms, and our personal comfort and health may be improved in proportion to our careful observation of the hygrometric condition of air in which we live. Hospitals and public buildings ought to be especially protected from the evil results attending a vitiated condition of the air, and we can see no reason why their atmosphere may not be made comfortable and healthful at all seasons and under all conditions of the outside air.

Hoping the few results obtained from our experiments may be useful in calling more general attention to this subject, and expressing our thanks to the United States Signal Officer for valuable information and the use of instruments,

We are, very respectfully, your obedient servants,

WM. L. BAILIE,
*Passed Assistant Engineer, U. S. N.*
RICHARD INCH,
*Passed Assistant Engineer, U. S. N.*
W. S. MOORE,
*Passed Assistant Engineer, U. S. N.*

Engineer in Chief W. H. SHOCK, U. S. N.,
*Chief Bureau of Steam Engineering,*
*Navy Department, Washington, D. C.*

TABLE A.

| Date and hour. | Barometer corrected for temperature, elevation, and instrument error. | Temperatures. | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Outside. | | | | A. | | | | B. | | | | C. | | | | D. | |
| | | Dry. | Wet. | Dew point. | Rel. humidity. | Dry. | Wet. | Dew point. | Rel. humidity. | Dry. | Wet. | Dew point. | Rel. humidity. | Dry. | Wet. | Dew point. | Rel. humidity. | Dry. | At register. |
| Sept. 7, 1881. | | | | | | | | | | | | | | | | | | | |
| 4 p. m ... | 30. 040 | 98 | 76 | 64 | 34 | 83. 5 | 71. 5 | 64 | 53 | 38 | 38 | 38 | 100 | 47. 5 | 42 | 34 | 61 | 52 | 62 |
| 5 p. m ... | 30. 030 | 97 | 76 | 65 | 35 | 84 | 72 | 65 | 53 | 39 | 38 | 36 | 89 | 43 | 43 | 43 | 100 | 50 | 58 |
| 6 p. m ... | 30. 020 | 92. 5 | 76 | 68 | 46 | 85 | 73 | 66 | 53 | 40 | 39 | 37 | 89 | 42 | 42 | 42 | 100 | 49 | 57 |
| 7 p. m ... | 30. 043 | 89 | 76 | 69 | 52 | 86 | 74 | 68 | 55 | 39 | 38. 5 | 37 | 92 | 42 | 42 | 42 | 100 | 49 | 56 |
| 8 p. m ... | 30. 050 | 87. 5 | 77 | 72 | 61 | 86 | 76 | 71 | 61 | 39 | 38 | 36 | 89 | 41. 5 | 41 | 41 | 95 | 49 | 56 |
| 9 p. m ... | 30. 062 | 87. 5 | 77. 5 | 72 | 72 | 86. 5 | 73 | 66 | 51 | 39 | 38. 5 | 37 | 92 | 42 | 41 | 40 | 92 | 48. 5 | 55 |
| 10 p. m ... | 30. 080 | 84. 5 | 76 | 72 | 67 | 86. 5 | 73 | 66 | 51 | 39 | 38. 5 | 37 | 92 | 41 | 41 | 41 | 100 | 48. 5 | 55 |
| 11 p. m ... | 30. 090 | 84 | 76 | 72 | 67 | 87 | 75 | 69 | 55 | 39 | 38. 5 | 37 | 92 | 41 | 41 | 41 | 100 | 48. 5 | 54 |
| 12 mid.... | 30. 069 | 83 | 74 | 69 | 63 | 87 | 75 | 69 | 55 | 39. 5 | 38 | 37 | 92 | 41. 5 | 41. 5 | 41. 5 | 100 | 47. 5 | 54 |
| 1 a. m ... | 30. 060 | 81. 5 | 74 | 70 | 70 | 87. 5 | 75 | 69 | 55 | 39 | 38. 5 | 37 | 92 | 41. 5 | 41. 5 | 41. 5 | 100 | 47 | 54 |
| 2 a. m ... | 30. 064 | 80 | 71. 5 | 66 | 62 | 86 | 73. 5 | 66 | 51 | 39 | 38. 5 | 37 | 92 | 41 | 41 | 41 | 100 | 48 | 54 |
| 3 a. m ... | 30. 060 | 79. 5 | 72 | 68 | 69 | 86. 5 | 73 | 66 | 51 | 40 | 39 | 37 | 89 | 42 | 42 | 42 | 100 | 48 | 54 |
| 4 a. m ... | 30. 080 | 78 | 71 | 67 | 69 | 86 | 73 | 66 | 51 | 40 | 39 | 37 | 89 | 42 | 42 | 42 | 100 | 48 | 54 |
| 5 a. m ... | 30. 085 | 77 | 71 | 68 | 74 | 86 | 72 | 64 | 48 | 40 | 39 | 37 | 89 | 42 | 42 | 42 | 100 | 48 | 54 |
| 6 a. m ... | 30. 100 | 77 | 70 | 66 | 69 | 86 | 72 | 64 | 48 | 40. 5 | 40 | 37 | 89 | 42 | 42 | 42 | 100 | 48 | 54 |
| 7 a. m ... | 30. 115 | 78 | 70. 5 | 65 | 65 | 87 | 72 | 63 | 45 | 41 | 40 | 39 | 89 | 42 | 41. 5 | 41. 5 | 95 | 48 | 54 |
| 8 a. m ... | 30. 125 | 81 | 72 | 67 | 62 | 87 | 73 | 63 | 45 | 41 | 40 | 39 | 89 | 43 | 42 | 41 | 92 | 49 | 54 |
| 9 a. m ... | 30. 135 | 84 | 73. 5 | 67 | 57 | 86. 5 | 75 | 69 | 57 | 42 | 41 | 40 | 93 | 43 | 43 | 43 | 100 | 50 | 54 |
| 10 a. m ... | 30. 130 | 90 | 75 | 67 | 47 | 86 | 72 | 64 | 48 | 42 | 41. 5 | 38 | 86 | 43. 5 | 43. 5 | 43. 5 | 100 | 50 | 54 |
| 11 a. m *.. | 30. 134 | 90 | 75 | 67 | 47 | 86 | 72 | 64 | 48 | 42 | 41 | 40 | 93 | 43 | 43 | 43 | 100 | 51 | 56 |
| Averages† | ............ | 84. 6 | 73. 9 | 68. 1 | 60 | 85 | 73. 3 | 66. 2 | 51. 9 | 40. 5 | 39 | 37. 3 | 90. 7 | 42. 3 | 41. 8 | 41. 3 | 96. 5 | 48. 8 | 55. 1 |

| Date and hour. | Temperatures. | | | | | | | | Velocity of air at window of President's room, per minute. | Revolutions of engine, per minute. | Air-meter corrected for error of instrument. | Box of the Jennings machine. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Center of room. | | | | One foot from register. | | | | | | | | | |
| | Dry. | Wet. | Dew point. | Rel. humidity. | Dry. | Wet. | Dew point. | Rel. humidity. | | | | | | |
| Sept. 7, 1881. | | | | | | | | | | | | | | |
| 4 p. m | 89. 5 | 72 | 61 | 39 | .... | .... | .... | .... | 300 | 100 | 4807520 | 790 | 20 | 120 |
| 5 p. m | 82 | 72 | 66 | 59 | .... | .... | .... | .... | 75 | 100 | 4900360 | ...... | ...... | ...... |
| 6 p. m | 83 | 70 | 62 | 48 | .... | .... | .... | .... | 95 | 100 | 5013218 | ...... | ...... | ...... |
| 7 p. m | 83 | 70 | 62 | 48 | ... | .... | .... | .... | 240 | 100 | 5122266 | ...... | ...... | ...... |
| 8 p. m | 81 | 68 | 60 | 49 | .... | .... | .... | .... | 0 | 103 | 5217960 | ...... | ...... | ...... |
| 9 p. m | 81 | 70 | 63 | 54 | 59 | 53. 5 | 47 | 65 | 0 | 100 | 5316300 | ...... | ...... | ...... |
| 10 p. m | 80 | 67 | 58 | 47 | 57 | 51 | 45 | 64 | 0 | 100 | 5406438 | ...... | ...... | ...... |
| 11 p. m | 79 | 67. 5 | 59 | 51 | 56 | 52 | 48 | 74 | 0 | 107 | 5517798 | ...... | ...... | ...... |
| 12 midnight | 78 | 66 | 58 | 51 | 56. 5 | 52 | 48 | 74 | 9 | 108 | 5623552 | ...... | ...... | ...... |
| 1 a. m | 78 | 67 | 60 | 54 | 57 | 52 | 47 | 69 | — 96 | 105 | .......... | 372 | 14 | 100 |
| 2 a. m | 78 | 67 | 60 | 54 | 56 | 51 | 46 | 69 | — 95 | 108 | 5822144 | ...... | ...... | ...... |
| 3 a. m | 78 | 67 | 60 | 54 | 56 | 51 | 46 | 69 | — 96 | 102 | ..... | ...... | ...... | ...... |
| 4 a. m | 78 | 68 | 62 | 58 | 56 | 51 | 46 | 69 | — 73 | 99 | 6019572 | ...... | ...... | ...... |
| 5 a. m | 78. 5 | 68. 5 | 62 | 58 | 56 | 51 | 46 | 69 | 0 | 102 | .......... | ...... | ...... | ...... |
| 6 a. m | 78. 5 | 69 | 64 | 63 | 56 | 51 | 46 | 69 | —105 | 102 | 6226380 | ...... | ...... | ...... |
| 7 a. m | 78 | 68 | 62 | 58 | 57 | 51 | 45 | 64 | —130 | 102 | 6325740 | 200 | 14 | 80 |
| 8 a. m | 77. 5 | 68. 5 | 62 | 64 | 56 | 51 | 46 | 69 | —165 | 102 | 6417348 | ...... | ...... | ...... |
| 9 a. m | 77. 5 | 68 | 62 | 60 | ... | .... | .... | .... | —100 | 102 | 6510690 | ...... | ...... | ...... |
| 10 a. m | 77. 5 | 67 | 60 | 64 | 57 | 52 | 47 | 69 | — 66 | 102 | 6601538 | ...... | ...... | ...... |
| 11 a. m* | 74 | 63 | 55 | 51 | 58 | 52 | 46 | 64 | ....... | 102 | 6701340 | ...... | ...... | ...... |
| Averages† | 79. 7 | 68. 4 | 61. 2 | 54. 3 | 56. 5 | 51. 5 | 46. 3 | 68. 3 | ....... | ......... | .......... | ...... | ...... | ...... |

* Window and door closed.

† For the 19 hours with window and door open.

TABLE B.

| Date and hour. | Barometer corrected for temperature, elevation, and instrument error. | Temperatures. Outside. | | | | Temperatures. Induction pipe of blower. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Dry. | Wet. | Dew point. | Rel. hum. | Dry. | Wet. | Dew point. | Rel. hum. |
| July 17. 11 a. m | 29.791 | 83 | 73 | 68 | 61 | 53 | 53 | 53 | 100 |
| July 17, 3 p. m | .746 | 84 | 71 | 63 | 49 | 47 | 46 | 45 | 93 |
| July 17, 7 p. m | .725 | 81 | 70 | 67 | 62 | 47 | 46 | 45 | 93 |
| July 20, 11 p. m | .802 | 78 | 72 | 69 | 74 | 50 | 48 | 46 | 86 |
| July 21, 7 a. m | .789 | 75 | 71 | 69 | 82 | 50 | 49 | 48 | 93 |
| July 21, 11 a. m | .780 | 77 | 72 | 69 | 76 | 60 | 57 | 54 | 81 |
| July 21, 3 p. m | .741 | 83 | 75 | 71 | 67 | 58 | 58 | 58 | 100 |
| July 21, 7 p. m | .736 | 81 | 74 | 70 | 69 | 46 | 45 | 44 | 93 |
| July 22, 7 a. m | .824 | 73 | 68 | 65 | 76 | 47 | 47 | 47 | 100 |
| July 22, 11 a. m | .779 | 78 | 76 | 75 | 91 | 47 | 46 | 45 | 93 |
| July 25, 3 p. m | .895 | 87 | 75 | 69 | 55 | 48 | 48 | 48 | 100 |
| July 25, 7 p. m | .867 | 83 | 72 | 66 | 57 | 45 | 44 | 43 | 93 |
| July 26, 11 a. m | .913 | 84 | 72 | 65 | 53 | 52 | 50 | 48 | 86 |
| July 26, 3 p. m | .873 | 87 | 73 | 65 | 48 | 48.5 | 47 | 48 | 93 |
| July 27, 11 a. m | .907 | 78 | 69 | 64 | 62 | 54 | 52 | 50 | 86 |
| August 4, 11 a. m | 30.122 | 86 | 75.5 | 69 | 57 | 51.3 | 51 | 51 | 100 |
| August 6, 11 a. m | .017 | 90 | 76.5 | 69 | 50 | 73.5 | 70.5 | 68 | 84 |
| August 6, 3 p. m | 29.934 | 95 | 76 | 66 | 40 | 65 | 62 | 60 | 84 |
| August 7, 11 a. m | .923 | 80 | 74 | 71 | 74 | 55 | 54 | 53 | 93 |
| August 7, 3 p. m | .863 | 83 | 73 | 68 | 61 | 56 | 55.5 | 56 | 97 |
| August 9, 3 p. m | .876 | 87 | 76 | 70 | 57 | 56 | 55 | 54 | 93 |
| August 10, 12 m | .760 | 90 | 75 | 67 | 47 | 49 | 48 | 47 | 93 |
| August 10, 3 p. m | .736 | 91 | 75 | 66 | 44 | 48 | 47.5 | 48 | 97 |
| August 13, 11 a. m | .755 | 90 | 76 | 69 | 50 | 64 | 63 | 62 | 93 |
| August 13, 3 p. m | .710 | 96 | 78 | 69 | 41 | 67 | 66 | 65 | 93 |
| Averages | .......... | 84 | 73.5 | 68 | 59.7 | 53.5 | 52.3 | 50 | 90 |

| Date and hour. | Temperatures. At box before entering. | | | | Temperatures. At box after leaving. | | | | Temperatures. Corridor. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dry. | Wet. | Dew point. | Rel. hum. | Dry. | Wet. | Dew point. | Rel. hum. | Dry. | Wet. | Dew point. | Rel. hum. |
| July 17, 11 a. m | 56 | 54 | 52 | 86 | 56.5 | 55 | 55.5 | 96 | 61.5 | 60.5 | 61 | 97 |
| July 17, 3 p. m | 53 | 48 | 42 | 66 | 53 | 52 | 51 | 93 | 59 | 54 | 49 | 70 |
| July 17, 7 p. m | 53 | 48 | 42 | 66 | 53 | 51 | 49 | 86 | 54 | 52 | 50 | 86 |
| July 20, 11 p. m | 51 | 49 | 47 | 86 | 51.5 | 51 | 51 | 96 | 58 | 56 | 54 | 86 |
| July 21, 7 a. m | 53 | 49 | 44 | 72 | 54 | 53 | 52 | 93 | 59 | 58 | 57 | 93 |
| July 21, 11 a. m | 58 | 56 | 54 | 87 | 60 | 57 | 54 | 81 | 62 | 60 | 58 | 87 |
| July 21, 3 p. m | 61 | 60 | 59 | 93 | 62 | 61 | 60 | 93 | 67 | 65 | 64 | 90 |
| July 21, 7 p. m | 47 | 45 | 43 | 86 | 52 | 51 | 50 | 93 | 61 | 57 | 54 | 78 |
| July 22, 7 a. m | 49 | 48 | 47 | 97 | 51 | 50 | 49 | 93 | 61 | 58.5 | 56 | 84 |
| July 22, 11 a. m | 49 | 48 | 47 | 97 | 52 | 50 | 48 | 86 | 57 | 54 | 51 | 81 |
| July 25, 3 p. m | 53 | 51 | 49 | 86 | 55 | 53 | 51 | 86 | 63 | 60 | 58 | 84 |
| July 25, 7 p. m | 48 | 46 | 44 | 86 | 52 | 50 | 48 | 86 | 61 | 59 | 57 | 87 |
| July 26, 11 a. m | 53 | 51 | 49 | 86 | 55 | 52.5 | 50 | 83 | 59.5 | 55.5 | 51 | 75 |
| July 26, 3 p. m | 51 | 48 | 45 | 80 | 56 | 51 | 46 | 69 | 60 | 53.5 | 46 | 60 |
| July 27, 11 a. m | 55 | 53.5 | 52 | 90 | 57 | 54 | 51 | 80 | 62 | 58 | 55 | 78 |
| August 4, 11 a. m | 54 | 53 | 52 | 93 | 56.5 | 54 | 53 | 90 | 64 | 57.5 | 52 | 75 |
| August 6, 11 a. m | 75 | 71 | 69 | 82 | 73 | 71 | 70 | 90 | 75 | 72 | 70 | 85 |
| August 6, 3 p. m | 69 | 66 | 64 | 84 | 73 | 71 | 70 | 90 | 73 | 68 | 65 | 76 |
| August 7, 11 a. m | 58 | 56 | 54 | 87 | 64 | 61 | 59 | 85 | 66 | 62 | 59 | 78 |
| August 7, 3 p. m | 59 | 57.5 | 58 | 96 | 64 | 61.5 | 59 | 85 | 68 | 64 | 61 | 78 |
| August 9, 3 p. m | 59 | 57 | 55 | 87 | 63 | 59 | 56 | 78 | 67 | 62 | 58 | 73 |
| August 10, 12 m | 53 | 51 | 49 | 86 | 62 | 59 | 57 | 84 | 66 | 61 | 57 | 73 |
| August 10, 3 p. m | 52 | 51 | 50 | 93 | 60 | 57 | 54 | 81 | 64 | 60 | 57 | 78 |
| August 13, 11 a. m | 66 | 65 | 64 | 94 | 68 | 66 | 65 | 90 | 70 | 67 | 65 | 84 |
| August 13, 3 p. m | 68 | 66 | 65 | 90 | 70 | 67 | 65. | 84 | 72 | 67 | 64 | 76 |
| Averages | 56.1 | 53.9 | 51.8 | 85.5 | 58.9 | 56.7 | 54.9 | 85.8 | 63.6 | 60 | 57.1 | 80 |

TABLE B—Continued.

| Date and hour. | Air-meter. Lineal feet. | Air-meter. Rate per hour corrected for error of instrument. | Revolutions per minute. | Steam pressure. | Remarks. |
|---|---|---|---|---|---|
| July 17, 11 a. m | 3, 932, 748 | 69, 953 | 98. 6 | 40 | Ice in drying box. |
| July 17, 3 p. m | 4, 212, 799 | 62, 284 | 95. 3 | 40 | Do. |
| July 17, 7 p. m | 4, 494, 530 | 63, 270 | 96. 5 | 40 | Do. |
| July 20, 11 p. m | 4, 758, 650 | ........... | 87. 2 | 40 | Do. |
| July 21, 7 a. m | 5, 275, 230 | 49, 852 | 72. 1 | 40 | Do. |
| July 21, 11 a. m | 5, 594, 040 | 57, 717 | 109. 7 | 40 | No ice in drying box. |
| July 21, 3 p. m | 5, 883, 420 | 68, 253 | 98 | 40 | Do. |
| July 21, 7 p. m | 6, 196, 250 | 74, 297 | 70. 5 | 40 | Ice in drying box. |
| July 22, 7 a. m | 6, 714, 720 | 47, 418 | 70 | 40 | No ice in drying box. |
| July 22, 11 a. m | 6, 949, 060 | 55, 556 | 82. 3 | 40 | Ice in drying box. |
| July 25, 3 p. m | 7, 431, 440 | ........... | 74. 5 | 40 | Do. |
| July 25, 7 p. m | 7, 614, 730 | 43, 031 | 70 | 40 | Do. |
| July 26, 11 a. m | 8, 531, 330 | 55, 547 | 79 | 40 | No ice in drying box. |
| July 26, 3 p. m | 8, 837, 830 | 72, 784 | 102 | 40 | Do. |
| July 27, 11 a. m | 10, 260, 440 | 64, 135 | 94 | 40 | Do. |
| August 4, 11 a. m | 12, 014, 130 | 33, 701 | 49. 9 | 30 | Do. |
| August 6, 11 a. m | 13, 870, 750 | 74, 340 | 108 | 40 | Do. |
| August 6, 3 p. m | 14, 324, 130 | 107, 683 | 156. 1 | 40 | Do. |
| August 7, 11 a. m | 16, 340, 500 | 93, 777 | 147 | 40 | Do. |
| August 7, 3 p. m | 16, 753, 600 | 98, 112 | 143. 2 | 40 | Do. |
| August 9, 3 p. m | 17, 545, 820 | ........... | 97. 5 | 35 | Do. |
| August 10, 12 m | 18, 134, 200 | ........... | 131. 1 | 40 | Do. |
| August 10, 3 p. m | 18, 465, 300 | 87, 015 | 97 | 40 | Do. |
| August 13, 11 a. m | 21, 168, 970 | 64, 830 | 92. 3 | 40 | Do. |
| August 13, 3 p. m | 21, 456, 800 | 68, 360 | 103. 3 | 40 | Do. |