INDOOR HUMIDITY

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Much has been written in recent years about the low indoor humidity prevalent throughout the winter months when artificial heat is required. The evil effects of low indoor humidity (and the consequent rapid evaporation from every moist surface) upon health have frequently been discussed. Much has been said in commendation of a dry climate, such as that of the southwestern United States, with moderate winter temperatures enabling the residents to live practically out of doors the year around; little has been said in favor of the winter climate of northeastern United States. The change from the outdoor air with its low temperature and high humidity, to the indoor air with its high temperature and low humidity, or *vice versa,* is generally conceded to be a trying ordeal. Many suggestions have been offered for controlling the humidity of residences, school-rooms and public halls. In some instances efforts in this direction have been more or less successful; it is to be feared that in most cases they have been less successful.

It was the writer's purpose to make a study of the possibilities of controlling indoor humidity of an ordinary furnace-heated residence located in central Illinois during a cold spell.

The residence used for this study is a frame structure approximately 22 by 42 feet, two stories, eight rooms, all rooms in daily use. The air supply for the furnace is fresh, outside air and is ample and the circulation is perfect. The abundance of air supplied the furnace prevents overheating; it is

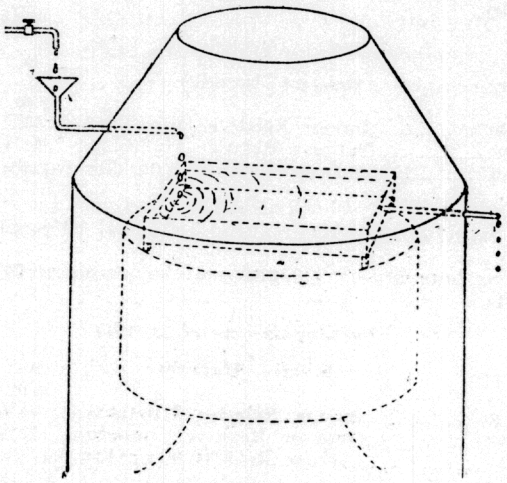

Fig. 1. The Humidifier

a *warm air* system, not a *hot air* system. The humidifier consists of a seamless copper tray or pan, 18 by 36 inches (4.5 square feet of evaporating surface) supported about 2 inches above the radiator and within the jacket. (Fig. 1.). The water for the humidifier is secured from the city supply and is controlled by means of a needle valve. The humidifier is provided with an overflow pipe. The furnace dampers are controlled by an automatic heat regulator which operates the dampers on a change of two degrees, or less, in the temperature of the living rooms. During this test the temperature was maintained at 70° at the warmest part of the living rooms, and about 65° at the coolest portions.

The data were taken during the nine days from December 20 to December 28, inclusive, 1914. This was probably the coldest week of that winter in this region.

Record of Outdoor and Indoor Humidity

Sunday, December 20, 1914

Temperature	Relative Humidity	1 a.m.	11:30 a.m.	8:30 p.m.
Maximum, 21°	Indoor Relative Humidity	36%	38%	33%
Minimum, 4°	Outdoor Relative Humidity	82%	81%	80%
Average, 12.5°	Average Outdoor Relative Humidity for the Day.			81%

Calculation

Absolute humidity of outdoor air at 12.5° and 81% = .710 grains per cu. ft.

An absolute humidity of .710 grains of indoor air at 70° = 9% − relative Humidity.

Monday, December 21, 1914

Temperature	Relative Humidity	7 a.m.	12 m.	7 p.m.
Maximum, 20°	Indoor Relative Humidity	35%	34%	32%
Minimum, 5°	Outdoor Relative Humidity	94%	72%	80%
Average, 12.5°	Average Relative Humidity for the Day			82%

Calculation

Absolute humidity of outdoor air at 12.5° and 82% = .719 grains per cu. ft.

An absolute humidity of .719 grains of indoor air at 70° = 9% + relative humidity.

Tuesday, December 22, 1914

Temperature	Relative Humidity	9 a.m.	12 m.	2 p.m.
Maximum, 19°	Indoor Relative Humidity	35%	38%	35%
Minimum, 0°	Outdoor Relative Humidity	77%	64%	58%
Average, 9.5°	Average Relative Humidity for the Day			66%

Calculation

Absolute humidity of outdoor air at 9.5° and 66% = .500 grains per cu. ft.

An absolute humidity of .500 grains of indoor air at 70° = 6.3% relative humidity.

Wednesday, December 23, 1914

Temperature	Relative Humidity	8:40 a.m.	12:15 p.m.	4:30 p.m.	7 p.m.	9:45 p.m.
Maximum, 22°	Indoor Rel. Humid.	34%	33%	33%	34%	32%
Minimum, 5°	Outdoor Rel. Humid.	79%	76%	76%	86%	86%
Average, 13.5°	Average Relative Humidity for the Day					81%

Calculation

Absolute humidity of outdoor air at 13.5° and 81% = .744 grains per cu. ft.

An absolute humidity of .744 grains at 70° of indoor air = 9.3% relative humidity.

Thursday, December 24, 1914

Temperature	Relative Humidity	9 a.m.	10:30 a.m.	11 p.m.	4 p.m.
Maximum, 30°	Indoor Rel. Humid.	40%	40%	45%	35%
Minimum, 7°	Outdoor Rel. Humid.	98%	95%	92%	82%
Average, 18.5°	Average Relative Humidity for the Day				92%

Calculation

Absolute humidity of outdoor air at 18.5° and 92% = 1.062 grains per cu. ft.

An absolute humidity of 1.062 grains of indoor air at 70° = 13.3% relative humidity.

Friday, December 25, 1914

Temperature	Relative Humidity	9 a.m.	11 a.m.	1 p.m.	3:30 p.m.	8 p.m.
Maximum, 15°	Indoor Rel. Humid.	38%	35%	35%	31%	28%[1]
Minimum, -1°	Outdoor Rel. Humid.	78%	64%	57%	62%	72%
Average, 7°	Average Relative Humidity for the Day					67%

Calculation

Absolute humidity of outdoor air at 7° and 67% = .447 grains per cu. ft.

An absolute humidity of indoor air of .447 grains at 70° = 5.6% relative humidity.

Saturday, December 26, 1914

Temperature	Relative Humidity	7 a.m.	11 a.m.	12 m.	2:30 p.m.	4:30 p.m.	6:30 p.m.
Maximum, 14°	Indoor Rel. Hum.	34%	33%	33%	35%	30%	32%
Minimum, -13°	Outdoor Rel. Hum.	74%	54%	53%	64%	68%	72%
Average, .5°	Average Relative Humidity for the Day						64%

Calculation

Absolute humidity of outdoor air at .5° and 64% = .376 grains per cu. ft.

An absolute humidity of indoor air of .376 grains at 70° = 4% — relative humidity.

Sunday, December 27, 1914.

Temperature	Relative Humidity	9 a.m.	11:45 a.m.	4 p.m.	9:30 p.m.
Maximum, 27°	Indoor Relative Humidity	33%	33%	33%	33%
Minimum, 12°	Outdoor Relative Humidity	80%	74%	78%	84%
Average, 19.5°	Average Relative Humidity for the Day				79%

Calculation

Absolute humidity of ourdoor air at 19.5° and 79% = .954 grains per cu. ft.

An absolute humidity of .954 grains of indoor air at 70° = 11.9% relative humidity.

Monday, December 28, 1914

Temperature	Relative Humidity	8:30 a.m.	11 a.m.
Maximum, 28°	Indoor Relative Humidity	32%	33%
Minimum, 23°	Outdoor Relative Humidity	82%	76%
Average, 25.5°	Average Relative Humidity for the Day		79%

Calculation

Absolute humidity of outdoor air at 25.5° and 79% = 1.253 grains per cu. ft.

An absolute humidity of 1.253 grains of indoor air at 70% = 15.7% relative humidity.

1. The humidifier ran dry at this point. The drop in temperature necessitated more heat and this produced more rapid evaporation. It was necessary to open the needle valve wider.

Additional Facts

Average outdoor temperature for the period = 13.3° or 12° below normal.

Average outdoor relative humidity (daytime only) = 77%.

Average indoor relative humidity (daytime only) = 34.5% with maximum of 45% and minimum of 28%.

Average calculated indoor humidity for the period = 9.3%.

The windows on the west and north side were provided with storm windows and the inside windows did not frost over; the single windows were covered with frost and much ice accumulated at the bottom of each. The outside wall of one west room showed considerable moisture on Saturday, December 26th.

On Saturday, December 26th, about six gallons of water were evaporated by the humidifier. On the average, probably about four gallons were evaporated daily. The water in the humidifier boiled on several occasions and stood near the boiling point frequently.

While the data given cover a period of nine days only, the humidifier has been in use for several years and I am confident that these data indicate correctly the usual operation of the plant when low temperature prevails. (Fig. 2).

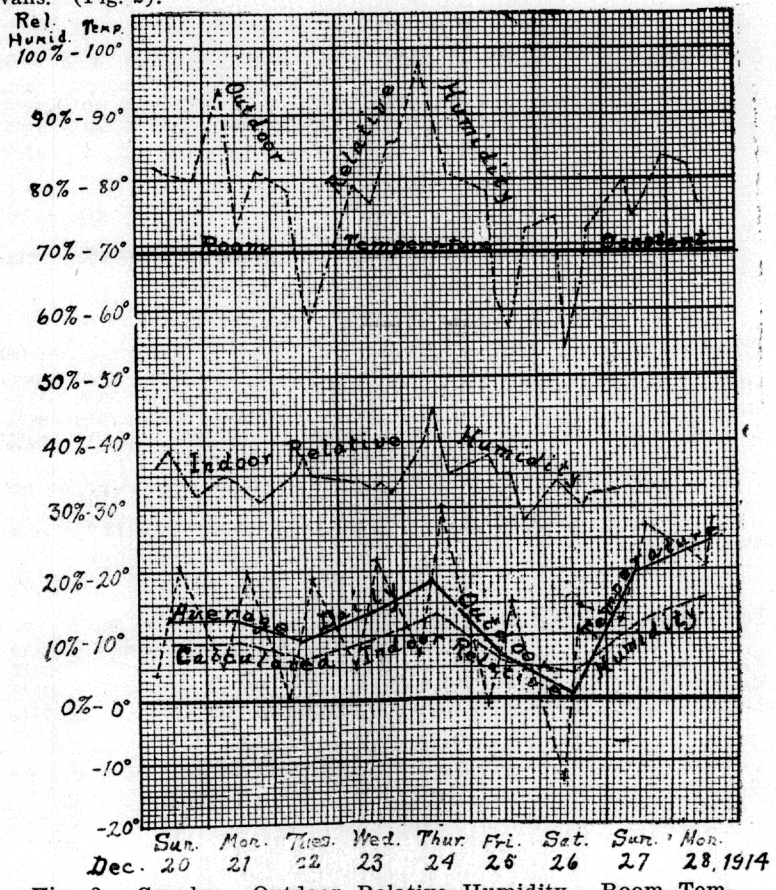

Fig. 2. Graphs: Outdoor Relative Humidity. Room Temperature, constant at 68°. Indoor Relative Humidity. Average Outdoor Temperature, $\frac{\text{Max.} + \text{Min.}}{2}$ Calculated Indoor Humidity.

CONCLUSIONS

1. This device is nearly automatic in its operation and does control the humidity of indoor air, maintaining a fairly constant relative humidity of about 35 per cent. during both moderate and extreme outdoor temperatures.

2. It is folly to talk of materially increasing the indoor humidity of a well-ventilated residence by using the common furnace water pan or even by suspending vessels of water within registers. Any device which does not evaporate several gallons of water daily in a well-ventilated residence is nearly useless.

3. It is not practical to attempt to maintain a relative humidity of more than about 35 or 40 per cent. during cold weather. A higher humidity, if obtainable, results in excessive frosting of windows and the "sweating" of walls during zero weather.

4. While granting that the *calculated* relative humidity given above is considerably lower than actually would have prevailed but for the humidifier, it still is true that the thirsty air would have stolen the additional moisture from every available source such as the building itself, the furniture and the skin and mucous membrane of the residents.

5. A temperature of 65° to 68° in the living room or library is entirely adequate for most people if the relative humidity is maintained at 35 per cent or more.

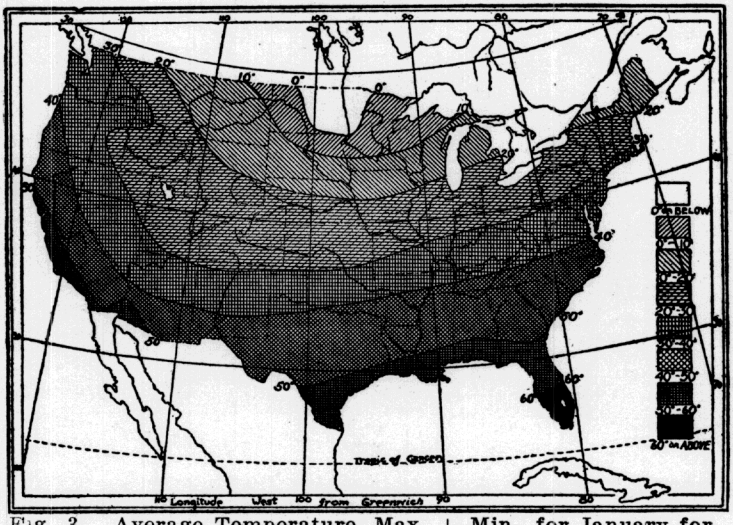

Fig. 3. Average Temperature, $\frac{\text{Max.} + \text{Min.}}{2}$, for January for 25 years.

6. The records of the Weather Bureau show that the average temperature for January, for eastern Iowa, southern Wisconsin, the Lower Michigan Peninsula, Northern Illinois, Indiana, Ohio, Pennsylvania, New York, New Jersey, and most of New England is from 20° to 30°, while the average relative humidity of this region for January is from 75 per cent to 85 per cent. (Figs. 3 and 4). In this region live nearly one-half of the population of the United States and here is found more than one-half of the wealth and resources of the nation. If the control of indoor climate during the winter months is as important for human health and vitality as recent writers assert, we certainly need more information concerning the methods by which it may be obtained.

An outdoor temperature of 25° with a relative humidity of 80 per cent means an absolute humidity of 1.241 grains of moisture per cubic foot. If this air is admitted to the residence, school or counting room heated to 70° without the addition of moisture, a relative humidity of 15.5 per cent results. This is a much lower relative humidity than is to be found in outdoor air in any inhabitable region on the face of the earth.

The effect of frequently passing from indoor air at a temperature of 70° and a humidity of 20 per cent or lower into outdoor air at 25° and 80 per cent humidity is a matter which should receive more attention.

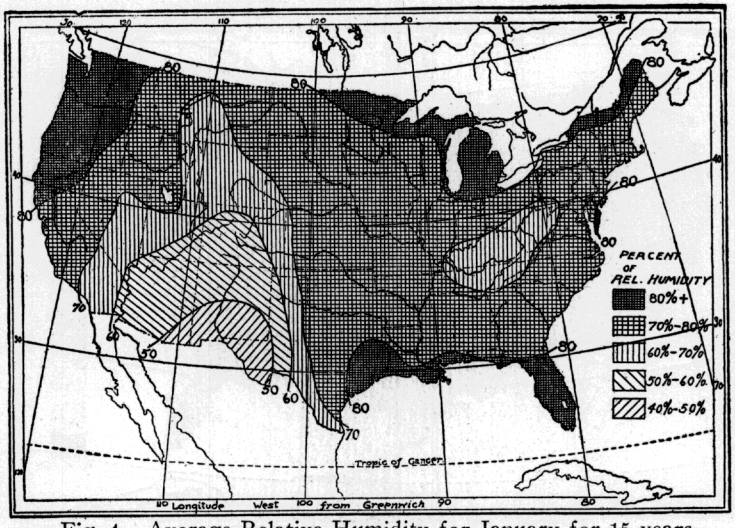

Fig. 4. Average Relative Humidity for January for 15 years.