

## A STUDY OF SCHOOLROOM VENTILATION INVOLVING A COMPARISON OF TWO TYPES OF HEATING AND VENTILATING PLANTS.

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The purpose of this study is to determine the relative value of two distinctly different types of schoolroom ventilating systems.

For a number of years school authorities have been concerned with the physical surroundings of children under their care and supervision. The National Education Association has had a sub-committee on ventilation. They found there has been a change in the point of view of educators in general on this question, from the attitude which considered only the needs of frail children to a realization that all children in all schools must have provisions for better air conditions in order to insure good health. The story of the boy who brought his frail undernourished friend to the open-air school doctor with the query, "Say, doctor, how sick has a feller got to be to get in this here school?", continues to be a challenge.

The New York State Commission on Ventilation reported in 1922 the following results of experiments extending over a long period and checked by many tests.

1. Ordinary effects of stale air have nothing to do with the oxygen or carbon dioxide content but vitiated air has a distinct influence upon appetite and the inclination to physical work.

2. The factors in ventilation which produce bad effects are over-heating, excessive humidity and lack of air movement.

3. Comparatively slight degrees of over-heating produce derangements in the circulatory system, lowers efficiency and tend to promote susceptibility to respiratory infection.

Various methods of ventilation were tested, including window and fan ventilation, humidification and re-circulated air with the following results:

1. Modified window ventilation alone without suitable means of exhaust was unsatisfactory, but with provisions for outlet through gravity ducts was found satisfactory.

2. Ventilation by plenum fans with gravity exhaust was satisfactory from the standpoint of aeration, but this system necessitates a higher temperature and provides, as well, relatively constant temperature.

3. Re-circulated air was found economical and harmless to health but the humidity necessary produced discomfort and the air was stale.

Two experiments in New York City, one lasting eight weeks and the other 12 weeks made to test the relative merits of fan and window ventilation showed a definite excess of respiratory diseases among chil-

dren in the fan ventilated room. The warmer fan ventilated room averaged 18 per cent more absences due to respiratory illness and 70 per cent more respiratory illness among the children in attendance. The study indicated that the slightly higher temperature and more uniform air conditions of the fan ventilated room tend to promote susceptibility to respiratory disease. It found in brief, the most harmful air to be over-heated air, that when a great volume of air is pumped through a room by mechanical measure it must be heated beyond a point compatible with health or comfort in order to ensure an even temperature and avoid drafts, and it recommended for schools and similar buildings a system of open windows protected by deflectors to send the cool air upward, and a gravity exhaust system to carry out the hot and vitiated air. It concluded, "and however simple or complex an apparatus may be installed for air conditioning, a constant and intelligent vigilance in regard to operation and over-heating is the price of health and comfort."

Schools generally are indifferent to room temperature, in only 38 per cent of the schoolrooms visited by the New York Commission were there thermometers. Trouble lies in the belief that ventilation is automatic. No system can be automatic, neither can the average janitor supervise the ventilation in every room.

"A study of the ventilation practices in ninety-six cities distributed in thirty-one states recently revealed that in 79 per cent of the representative schools of these cities mechanical systems of ventilation have been installed. However, it was further discovered that in many of the schools the ventilating systems were used merely as adjuncts to heating. There is an investment of millions of dollars in idle split-plenum-fan ventilation equipment in certain cities of the United States."

In the January, 1926, number of the American Journal of Public Health we find that the construction costs of fan systems with supply ducts exceeds the window systems from 22 to 85 per cent in cost of construction. Then since the use of the fan system at once implies over-heating of enormous volumes of air which are almost immediately blown out through the roof of the school houses, it must be obvious that this method costs more for operation than the window method.

Yet we find more than half the states of the United States requiring by law the fan type of system. This traces its ancestry to the last decades of the 19th Century when German and British investigators set up the theory that adequacy of ventilation was to be measured by the carbon dioxide content of the air and adequate ventilation required that 30 cubic feet of air per person per minute be pumped into a room. When the American Society of Heating and Ventilating Engineers was formed in 1895, it naturally put its support behind the accepted theory of ventilation and beginning with 1900 it wrote it into the statute books with a force quite unjustified by its scientific validity. That scientific validity was completely discredited by the New York State Commission in its report. This commission recommended a type of ventilation as follows:

1. A thermometer with a danger signal at 68° F.
2. Windows open at the bottom.

3. Deflecting boards at the bottom of the window.
4. Radiators extending the entire width of the windows equipped with hand control valves.
5. Exhaust ducts equipped with dampers located near the ceiling on the wall opposite the windows. Two ducts to the average school room.

With these things in mind the American Public Health Association in 1926 passed resolutions including the following statement:

"That the system of ventilating schoolrooms by fresh untreated outdoor air, admitted at the window with gravity exhaust ducts for removing vitiated air from near the ceiling is the most generally satisfactory method of school ventilation, and that state laws and city regulations interfering with such scientific and economical methods of school ventilation should be repealed in the interest of public health."

**Method of Study.** Two schools from Delaware County, Indiana, were chosen. Both schools receive their pupils chiefly from the surrounding farms. The Harrison Township school was located about four miles from Gaston while the Liberty Township school is at Selma.

The Harrison building is equipped with a hot water system of heating. The radiators are all situated along the outside wall of the rooms and under large windows. These windows are divided into numerous small panes and may be opened in small sections to admit air. There is no mechanical ventilating system. The outside wall is also pierced with ventilators which are  $10\frac{1}{2}$  by  $28\frac{1}{2}$  inches on the outside. The air enters these and comes into a duct at the bottom of a radiator and passes by the heated coils of the radiator and into the room. These ducts are so constructed that they may be closed completely, half open or entirely open. In the opposite wall at the floor is the opening of an exhaust duct which draws the vitiated air out of the room. This duct contains a radiator which heats the air, causing it to ascend and leave the building at the roof.

Each room is provided with a thermometer and each teacher is instructed to watch and regulate the temperature, by means of the ventilators, radiators and windows. Of course the circulation of air is entirely dependent upon the amount of fresh air admitted into the room. In this way the teacher is entirely responsible for the air which her students must breathe. The comfort and welfare of the pupils now becomes dependent upon the training of the teacher in physiology which will keep her alert and intelligently at her best.

The Selma school has the customary mechanical fan system. The air is continually blown into and drawn out of the rooms at a uniform rate through registers in the wall. The temperature is governed by a thermostat and the teacher has no special duty since she is not permitted to open the windows. However, in case the room becomes unbearable she may open the door into the corridor.

The criteria selected to judge the ventilation were temperature, humidity, air currents, absences occasioned by respiratory troubles, and the general comfort of the room.

The fifth grade rooms and a high school class room in each building

were selected to be studied. These rooms were visited from time to time during the months of November, December, January, February and March. At each visit the temperature, relative humidity, air currents and general comfort were noted.

The temperature and humidity were taken by means of a hygro-thermograph. The air currents were registered by means of flags tied to the registers and at Harrison School by means of flags at the outlets and the amount of the openings in the ventilators. The temperature registered by the thermometer in the rooms was in every case checked.

**Results.** It was found impossible to keep an accurate check upon the respiratory illnesses which occurred, since some of the teachers failed to keep records and the visits made to the schools were too infrequent, but the records indicated that when absences occurred they were in the majority of cases due to colds, sore throat or influenza.

The following chart gives the attendance percentage for each group. The average attendance at Harrison is higher than at Selma, but this does not necessarily prove that the percentage of respiratory illness is less, although it appears that such is the case.

|      | SELMA SCHOOL |             | HARRISON SCHOOL |             |
|------|--------------|-------------|-----------------|-------------|
|      | Fifth Grade  | High School | Fifth Grade     | High School |
| Nov. | 96.6%        | 92%         | 96.6%           | 95.9%       |
| Dec. | 94%          | 93%         | 94.8%           | 96.5%       |
| Jan. | 97.5%        | 95%         | 94.5%           | 96%         |
| Feb. | 93.5%        | 93%         | 96.6%           | 97.3%       |

Table I indicates the range of temperature, and humidity of each room as well as the air currents, condition of windows and ventilators and the general comfort.

From these figures it can be seen that the relative humidity of the Harrison building is higher than the Selma building, although neither is too dry for a school room. The temperature in the Selma building is more constant, which is not necessarily desirable, although in the Harrison building it has been allowed to range too high. In Selma there was always a good circulation of air due to the fan while many times at Harrison the circulation was stopped because a teacher failed to open the ventilators and windows.

**Conclusion.** From the results obtained no definite conclusion can be drawn as to the superiority of either system as it is working at present. Each system presents difficulties. The chief difficulty with the system at Harrison seems to be in the teachers. Each teacher has it in her power to control the air and temperature in her room, but the above data show that they are very lax in doing so. Perhaps in their busy class work they fail to realize how much the success and health of their students depend on the air that they breathe and the temperature of the room. If each teacher could be impressed with her responsibility, we believe that the Harrison system would prove most satisfactory because the air need not be over-heated as in a fan system, it circulates readily, and is sufficiently moist and clean to be called fresh air.



TABLE I. Atmospheric and other conditions recorded at the Selma and Harrison Schools.

| SELMA FIFTH GRADE |       |      |         |                 |             | HARRISON FIFTH GRADE |         |       |      |           |                 |             |           |
|-------------------|-------|------|---------|-----------------|-------------|----------------------|---------|-------|------|-----------|-----------------|-------------|-----------|
| Date              | Temp. | Hum. | Current | General Comfort | Ventilators | Windows              | Date    | Temp. | Hum. | Currents  | General Comfort | Ventilators | Windows   |
| Nov. 20           | 72    | 60   | Good    | Comf.           | .....       | Closed               | Nov. 20 | 74    | 78   | Fair      | Too Warm        | Open        | Closed    |
| Nov. 30           | 71    | 69   | Good    | Comf.           | .....       | Closed               | Nov. 30 | 72    | 60   | Fair      | Warm            | Open        | Open      |
| Dec. 10           | 76    | 44   | Fair    | Stuffy          | .....       | Closed               | Dec. 14 | 74    | 50   | Good      | Comf.           | Open        | Closed    |
| Jan. 5            | 72    | 42   | Good    | Hot             | .....       | Door Open            | Jan. 6  | 70    | 55   | Good      | Comf.           | Open        | Closed    |
| Jan. 12           | 74    | 39   | Good    | Comf.           | .....       | Closed               | Jan. 12 | 72    | 45   | Poor      | Stuffy          | Half Open   | Closed    |
| Jan. 31           | 72    | 42   | Poor    | Too Warm        | .....       | Door Open            | Feb. 9  | 72    | 57   | Excellent | Comf.           | Open        | Open      |
| Feb. 18           | 72    | 40   | Good    | Comf.           | .....       | Door Open            | Feb. 18 | 74    | 48   | Fair      | Too Warm        | Half Open   | Door Open |
| Feb. 25           | 72    | 34   | Good    | Comf.           | .....       | Closed               | Feb. 25 | 72    | 42   | None      | Stuffy          | Closed      | Closed    |
| Mar. 2            | 72    | 35   | Good    | Comf.           | .....       | Closed               | Mar. 2  | 72    | 42   | Poor      | Stuffy          | Half Open   | Closed    |
| Mar. 9            | 72    | 32   | Good    | Comf.           | .....       | Closed               | Mar. 9  | 76    | 51   | None      | Hot             | Closed      | Closed    |
| SELMA HIGH SCHOOL |       |      |         |                 |             | HARRISON HIGH SCHOOL |         |       |      |           |                 |             |           |
| Date              | Temp. | Hum. | Current | General Comfort | Ventilators | Windows              | Date    | Temp. | Hum. | Currents  | General Comfort | Ventilators | Windows   |
| Nov. 20           | 72    | 50   | Good    | Comf.           | .....       | Closed               | Nov. 20 | 70    | 77   | Good      | Comf.           | Open        | Closed    |
| Nov. 30           | 74    | 74   | Good    | Stuffy          | .....       | Closed               | Nov. 30 | 74    | 45   | Poor      | Hot             | Closed      | Closed    |
| Dec. 10           | 70    | 55   | Good    | Comf.           | .....       | Closed               | Dec. 14 | 72    | 49   | Fair      | Stuffy          | Half Open   | Closed    |
| Jan. 5            | 74    | 43   | Good    | Hot             | .....       | Closed               | Jan. 6  | 68    | 54   | Good      | Comf.           | Open        | Closed    |
| Jan. 12           | 70    | 35   | Good    | Comf.           | .....       | Closed               | Jan. 12 | 72    | 50   | Fair      | Comf.           | Open        | Closed    |
| Jan. 31           | 74    | 43   | Good    | Too Warm        | .....       | Closed               | Feb. 9  | 70    | 55   | Fair      | Fairly          | Half Open   | Closed    |
| Feb. 18           | 74    | 40   | Good    | Too Warm        | .....       | Closed               | Feb. 18 | 70    | 60   | Good      | Comf.           | Open        | Open      |
| Feb. 25           | 71    | 37   | Good    | Too Warm        | .....       | Closed               | Feb. 25 | 66    | 57   | Good      | Comf.           | Open        | Closed    |
| Mar. 2            | 75    | 35   | Good    | Hot             | .....       | Closed               | Mar. 2  | 72    | 42   | Poor      | Stuffy          | Closed      | Closed    |
| Mar. 9            | 72    | 39   | Good    | Comf.           | .....       | Closed               | Mar. 9  | 68    | 54   | Poor      | Hot             | Closed      | Closed    |

The Selma building is equipped with a fan system which functions as effectively as the average fan system. However, as may be expected, the temperature is too high and too constant for ideal conditions.

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