Dust in Relation to Heating

BY KONRAD MEIER

Readers of THE HEATING AND VENTILATING MAGAZINE Will recall the thoughtful and practical discussion by Konrad Meier of present heating methods, published in the issue for January, 1911, under the title of "What is the Matter with Modern Heating Practice?"

Mr. Meier has further amplified his views in a paper presented at the recent meeting of the heating engineers' society. Some of the more important points in addition to those contained in his previous article, are given herewith :

It is a popular notion that steam and hot water systems give a differ ent sort of heat. Engineers would define this more correctly by stating that various methods of heating will produce different air conditions. The old-fashioned devices are still considered by many people to be more wholesome, even though less efficient than the modern apparatus, of which it is often said that it does not ventilate, the dead air and stuffiness being attributed generally to the lack of air supply incidental to heating. Partly out of this idea has grown the popularity of the indirect system, but .now complaints are heard, that through heating, and even tempering, by stacks, the air will lose its natural sweetness and refreshing qualities.

The recent tendency to oppose plenum ventilation on the part of the medical profession appears to be the result of such observations.

Engineers themselves will have observed, especially in public buildings and schools, that even a generous plenum supply will not always make the occupants forget the desire to open the windows. Heated but unoccupied rooms are often found stuffy, even after long vacancy, when a slight amount of natural ventilation should suffice to keep them sweet. Everybody has noticed the stifling air of ill-kept empty railroad coaches which is not altogether caused by overheating, nor by previous occupancy. In such cases the foulness of the air cannot be due to lack of ventilation alone.

These circumstances would indicate a cause of vitiation aside from the well-known sources and explains in a measure the demand for purer air which has really arisen and become general only with the introduction of the modern ways of heating.

None of this evidence is proof that the heating apparatus itself is at fault, but it should certainly raise the

question whether the quality of room air is altered in any material way by the process of heating. Changes in temperature and relative humidity even though they bear on comfort to an extent would not account for it, since we know they do not in themselves affect the sweetness of the air at least within the wide range between a brisk, dry, cold, northwest, and the moist, warm, ocean breezes in summer.

If it be found that the air is undergoing chemical, physical, biological or only purely thermal changes through any of the prevailing methods of heating, we will then have to answer the next question, whether such changes may be considered as deterioration and are of any consequence, in general, or only in particular cases. When the causes and effect are determined, we will be able to prescribe the remedy.

CAUSES OF VITIATION

As proof of certain chemical changes we have the investigations of Professors v. Esmarch and Nussbaum. The former authority has demonstrated the following points:

Dust, especially when of organic nature, will decompose on heating surfaces from a temperature of about 16o° F. upwards. Of the gases produced, ammonia is shown by chemical reaction, not only over the radiator, but in the room air at large. The quantities are too small to be called a poison to the average person, but are quite often noticeable by odor. Under extreme conditions, when steam is turned into a dusty radiator or stack, the ammonia may become very disagreeable. Analysis was made for CO, but none could be found.

When heating surfaces were carefully cleaned before the test, the effect on the air was still present and demonstrable by analysis, but less intense, thus showing that the dust suspended in the air will also decompose when passing over the heating surfaces, and that there is a constant vitiation going on beside the periodical effect taking place while reheat ing. No traces of any foreign gases could be detected until steam was turned on, hence we are safe in saying that heating is the cause. We may conclude also, that if heating were accomplished by clean surfaces and without causing air circulation, decomposition could not take place.

Prof. Nussbaum, investigating independently, has arrived at the same general conclusions, but has gone further into certain details. He found that moist organic dust will begin to decompose even at 140° F. while dry dust, or dust in dry air, must be heated to about 200° F. before gases become noticeable. The same applies to dust lying on surfaces or passing by them.

Various kinds of dust were subjected to the tests. Inorganic matter was found to produce the least odor and practically no gas, while ordinary house dust, as it enters into rooms from the streets, with the air or by way of shoes and clothing, produces most of the ammonia. This is explained by the large percentage of animal excreta which ordinary street and house dust contains particularly in cities with non-absorbent pavements.

OZONE WILL NOT GET PAST RADIATOR OR STACK

Another indication of chemical reaction was furnished unwittingly, incidental to certain tests of ozonizing apparatus. It appeared, that the output of ozone was always reduced when the air was allowed to pass the electrodes slowly and to become heated thereby. The tendency of the ozone to combine with organic matter increases with temperature. Hence a good portion of the output was always absorbed even while the air to be ozonized was passing the generator. When slowing down the air current and raising its temperature, a point was reached at which no more ozone could be found in the air issuing from the apparatus. The temperature rise in such devices is much smaller than is usually the case with heating. Furthermore the surfaces for heating are much larger and less apt to be

clean. We are safe in assuming that no ozone will ever get past a radiator or stack. It is most probable, that a certain amount of oxygen is also sacrificed by the process of heating, but the extent of this has not been established. In any event, the absorption of ozone, which may be said to be the sweeping, purifying element would account in a measure for the lifeless quality of air issuing from a register or ascending from a radiator.

To prove certain physical changes in room air, it is only necessary to recall the long established facts, that fog and cloudiness are largely caused by dust and soot and that the relative humidity, at which condensation becomes visible, is much dependent on the purity of the air. This shows that moisture has a distinct tendency to cling to dust and weight it down, more or less, according to atmospheric conditions.

There is no doubt, however, that this moisture ig evaporated when dust is being heated. It is lightened thereby and all the more easily joins the current of warm air rising from a heater. The continuous air circulation incidental to heating keeps a certain amount of dust in motion, which would otherwise settle down, and will therefore add certain elements to the air we breathe.

As proof of this we need to call attention only to the visible tracks left by the dust, on walls above radiators which are sometimes deflected by shields, but should be prevented in other ways. It is by no means likely that live organisms are destroyed to any extent by the ordinary forms of heating apparatus. This depends on higher air temperatures or on steam itself. Furnaces, except in red-hot condition, which is undesirable in other ways, and radiators, therefore, cannot be considered as sterilizers. They merely dry the dust, stir it up and keep it in motion while the heat is on. Considering this, we are forced to admit, that heating increases the bacterial contents of the air.

EFFECT OF VITIATION BY HEATING

The elimination of the ozone and whatever loss of oxygen may occur, probably have no distinct and traceable effect on health. They represent the general drawback of indoor life, not serious in itself, probably because we have long since become inured to it. The situation is different in regard to the contamination of the air by fine, dried dust, which has become general more recently, through prevailing methods of heating. This may be clear if we remember, that the old-fashioned tile oven, the ordinary free standing, well-polished iron stove, or the open fireplace depend on their effect largely on radiation, and that the heating surfaces are readily accessible and apt to be clean. This cannot be said of the hot-air furnace, nor of indirect stacks, nor of certain styles of radiators, and least of all of the screened direct surfaces.

While the public may have become indifferent to the immediate sensible effect of dust contamination, because it is so general, it is nevertheless a real nuisance. The prevalence of chronic ailments of nose and throat would indicate that we are not immune to it. It is one of those elements which have eluded the ordinary air tests made with the idea of determining the need of ventilation, and did not exist to any extent at Pettenkofer's time, when the carbonic acid test was recommended. Naturally. it would not show in this sort of test. Nor would a bacterial test be fair, since the dried particles are not so apt to settle down on the surfaces prepared for them as ordinary, unheated dust would do.

If the lessons to be drawn from the campaign against tuberculosis and modern hygiene in general are of any value. we must admit that this flying dust is most undesirable.

As to the bearing of the purely thermal quality of the air, we can only judge by general experience. It is true, overheating has been shown by Fluegge to cause a. distinct lowering· of vitality. The question is

not really one of overheating in this case, but whether radiant heat with comparatively low air temperature, or higher air temperature without heat rays, are more conducive to comfort and health, and whether the latter tendency produces effects similar to overheating.

Aside from the direct bearing of the hot-air currents on the dust, we have to consider the lower relative humidity of hotter air and its greater drying effect on persons as well as on dust and other objects, caused partly by the air in transit, and in the neighborhood of the register. All things considered, there would seem to be no question that the excessive dryness which is often complained of in heated rooms is materially increased by those methods of heating depending on air as the heat carrier, and is made more irritating by the attendant increase of dustiness.

There is also the general observation that cool air is breathed in more freely. This may be partly due_ to the feeling that it is more inviting, or the subconsciousness that it is more refreshing. We are certainly more apt to take a deep breath of fresh, sweet air than of tainted, stuffy air. Again, there is also the purely physical condition of its smaller volume for the same amount of oxygen, causing less labor in respiration, even though its final temperature may be the same. Most persons have more difficulty in getting their breath in hot air than they do in cold air.

If there is anything in the theory that free air circulation around each person is a most desirable element in creating comfort, regulating the thermal formations of the body and conserving health, cooler air surrounding a body would seem to be more likely to induce this in the natural way by temperature difference, than warmer air would do. The currents created by a hot-air heating system generally do not take place where such circulation might be wanted. Hot-air heating therefore would tend to reduce the convection of heat from the body which Fluegge claims to be a necessary function.

MEANS TO PREVENT VITIATION OF AIR BY HEATING

Naturally, the foremost remedy that suggests itself is to exclude the dust, as the main source of vitiation. We all agree this would be desirable, but unfortunately it cannot always be done. Even where artificial devices for this purpose are used in connection with warm air heating and air supply systems more or less dust will enter into a building in other ways. Vacuum cleaners and general vigilance will help, but the fact remains, that in a great majority of cases we will have to contend with more or less dust, and must proceed on this assumption.

FAVORS MODERATE TEMPERATURE OF HEATING SURFACES

The safest way to prevent the chemical adulteration of air through decomposing of organic matter would appear to be a moderate temperature of heating surfaces. With clean surfaces and dry air, according to V. Esmarch and Nussbaum, there will be no vitiation with temperatures up. to 160° F., and none to speak of until the surfaces are near the boiling point. Under less ideal conditions, where more or less dust is to be expected, the temperature should be kept down to about 160° F. or lower, as a rule, excepting an occasional rise to 18o° F. during a cold spell as unavoidable and of minor importance.

Moderate temperature of heating surface seems also advantageous in view of the devitalizing of the air by the absorption of all the ozone and probably of part of the oxygen.

To avoid the contamination of room air by dust, whether in dried, decomposed, or normal condition, it would seem advisable again to heat at low tension, which means liberal surfaces at relatively low temperature. Low and shallow styles of radiation depending the least upon convection, are also indicated. Even with equal air volumes in circular

tion, the movement will be less concentrated, less intense, and less apt to pick up dust. It may be well to distinguish and repeat that air circulation created by heating is not the kind which is useful from a ventilating point of view. No matter what may be our final judgment in regard to secondary circulation, or the desirability of a certain movement of air around the bodies, it should still be our endeavor to prevent or distribute as far as possible, all sensible air currents by heating. They are likely to be either too hot or too cold for comfort and not apt to occur where they might be needed.

ADVANTAGES OF HOT-WATER HEATING

Hot-water heating would seem to meet the situation best in respect to temperature and liberal surfaces, but whichever system is used, it is advantageous to reduce the tendency to create air currents and to give preference to the kind of surface that is yielding a greater ratio of its heat by radiance. Low and flat radiation which is recommended is generally no more expensive considering its higher total efficiency.

The next important rule should be to insist on clean heating surfaces. It will not do to rely for this on the good intentions of any one concerned. Engineers must take the first step to induce or compel clean surfaces by selection of the most easily cleanable styles and by proper disposition to keep the greatest possible part of it in view. As it happens, the styles which are giving the best radiant heat and the least air current are also the easiest to clean. Radiators should have fair spacing between loops to show the dirt and to make it likely that it will be removed. They should not be tucked away in corners. Better means are always at hand to make them inconspicuous or presentable, as the case may require. Enamel finish in some neutral color, black or white, is only one of those means, which, by the way, will help appreciably in the radiating efficiency. This sort of finish, it is sometimes complained, would show the dust. It is all the more desirable then, in order to induce clean surfaces.

OTHER UNSANITARY PRACTICES

There are a number of other practices, which in the light of the foregoing should be classed as unsanitary.

It is unsanitary to place heating surfaces overhead, where the dust is not seen and rarely removed, except by air currents.

It is unsanitary to run pipe connections to radiators in a roundabout, fussy way that will make dirt corners.

It is unsanitary to use floor registers for heating under any circumstances.

Similar features and practices that may appear questionable from these viewpoints may be tolerable under some conditions, but objectionable in other places. One should use judgment and discretion in this respect. In hospitals, for instance, a stricter standard should prevail, also in public buildings where the service and maintenance are not of the best.

ENAMELED RADIATORS ADVOCATED

For years we have enjoyed clean plumbing fixtures, designed on hygienic lines, and we have insisted on cleanliness in many other ways, if only on general principles. There is every reason why we should insist on the same qualities in heating equipment, which is now nearly always on a decidedly lower plane in this respect than other apparatus in one and the same building. Enameled radiation would be produced, if there were a serious demand, while the better styles of radiation are true and good in design, they are usually false and cheap-looking as to finish. The best finish enamel is the most sanitary, and in its turn would encourage proper self-assertive disposition in place of the unfortunate habit of hiding. Substantial appearance and neatness in details will also help in this direction.

If it be conceded, that cooler air, combined with mild radiant heat is

the desirable, pleasant atmospheric condition to be reproduced indoors by artificial heating, we come again to the same conclusion in regard to the methods. Flat, low, widely- spaced direct radiation at moderate temperatures would evidently give the nearest approach to it, when combined with whatever ventilation that may be desired, by direct leakage by windows, or by a clean, evenly and low tempered air supply system. In direct or hot-air heating should be used only where the heat requirement is comparatively small, that is, in substantial buildings and in rooms with moderate exposure, for which the incoming air for heating need not be much above room temperature. In exposed buildings of light or permeable construction hot-air heating in any form is not only uncertain, inefficient and undesirable on account of the dust pollution, but it will involve high air temperature with colder walls, lower relative humidity, especially as a structure becomes dry under the active ventilation. Again, in massive structures, with little exposure, there may be good reasons for some artificial air supply, while natural leakage is often all that is necessary in buildings requiring much heat.

Considering, that the requirements for heat and for ventilation generally are not all coincident, and that a purer, more effective and wholesome air supply can be secured by windows or other rational means, when and where required, and without affecting the heat supply, and considering that direct heating induces direct leakage from outdoors while the indirect system admits the air through musty passages and spoils its freshness, it would seem that the idea of better sanitary conditions through heating by air is largely a delusion. The indirect method should be restricted to cases where it is really indicated, or, if no other system will do, the conditions might be made more favorable for it by extra- protection. In any event, such apparatus should be designed to avoid excessive air temperature, equipped with filters to keep the dust out of air passages and heating stacks, and with all provisions to induce proper maintenance.

In so far as excessive dryness in itself, as caused by heating, may be undesirable and unwholesome, it is pertinent to consider also the best means to overcome these extremes. As previously pointed out the method of heating in itself makes an appreciable difference and would seem to be the natural remedy, under ordinary conditions and for new apparatus. To relieve an old plant it may be necessary, sometimes to use artificial moistening, but when doing so it should be borne in mind, that moistening without taking care of the dust is liable to increase discomfort through the increased decomposition of organic matter. The rule should be to moisten only when the air supply can be filtered or washed.

The excessive dryness complained of sometimes with direct steam heat is often nothing but irritation of the respiratory tract through dust. It should be relieved in such cases by cleaner radiation and cleaner surroundings, and by lower temperature of heating surfaces. Moistening pans will raise humidity, but generally do not improve the air while dust and dirt are present, owing to the increased tendency for decomposition.

The tempering surfaces should be arranged to secure a swift passage for the air and designed also with the idea of making them self-cleaning, and to reduce the chance of drying and decomposing dust in transit. Present styles of tempering stacks and coils are by no means ideal in this respect. They could be improved considerably in the direction of higher velocities and heating efficiency without necessarily increasing resistance.

These would seem to be sufficient reasons for reform, and the lines on which to improve heating apparatus from the sanitary point of view do not seem difficult to follow and would lead, if anything toward greater effi-

ciency in other directions. Nor should there be much difference in cost, when taken as a whole. Hot water heating, for instance, can be brought down in most cases very nearly to the cost of steam, if scientifically planned, and the practical possibilities of its adaptation to all sorts of conditions are by no means exhausted. It is very well suited for utilizing waste heat from all sorts of motors. The ways and means for reform to go more into detail would raise too many questions, but in general, all those suggested may therefore be said to be within our reach.

Briefly resuming we may put down the following rules, which may serve also as a guide in the event of a discussion:

i. To prevent chemical vitiation of room air by heating it is desirable to have surfaces at moderate temperature, if possible not exceeding 180° F. at any time and to use easily accessible and clean radiation. Air supply should be filtered where necessary.

2. To prevent the physical admixturn of dust and its drying, caused by the air currents due to heating, it is desirable again to use heating surfaces at moderate temperature, well distributed, spread out and inducing salubrity in general.

3. To reduce the pollution of the air by the bacteria the same means are indicated as those recommended to keep down the dust.

4. To produce thermal conditions most agreeable and wholesome to a majority, it seems desirable to favor the application of radiant heat which warms the surroundings and occupants directly and produces comfort at lower air temperature. It should be used in a mild form and be well distributed. Ventilation should be treated separately. Each problem can be solved by itself to the best advantage.

5. To prevent excessive dryness, the same idea of keeping down air temperature by utilizing heat rays seems indicated.

6. Ventilating apparatus should be made self-cleaning throughout.