How Should the House Be Heated?

V. Heating by Hot Water

BY ARTHUR E. NORTON

HEATING houses by hot water is not nearly so modern as steam heating. Thomas Tredgold, in a book published in 1836, credits the idea of employing steam as a heating medium to Colonel William Cook in the year 1745, while the use of hot water goes back to Roman days, even, perhaps, to a period before the Christian era began.

Coming to more recent history, it may be said fairly, I think, that before the development of the so-called vapor system (a special form of steam heating described last month), there was in this country a strong trend toward hot water heating for residences. But at present there is a very close competition between these two methods, with increasing popularity of the vapor system in many localities. In fact, the arguments for the one or the other seem so evenly balanced that many an owner is perplexed in making a choice. And he certainly has a right to be perplexed because each has its own peculiar merits, and not all the good points are inherent in either.

If it is fair to present steam heating in its more perfected form, *i.e.* as a vapor system, so is it required to present hot water heating not only as the system is installed in its simplest form, but with such improvements as have been added to offset some of its inherent disadvantages. To do this we must first go back to fundamentals and study the simple 'gravity' hot water system.

As in the case of heating by air, there must be in the hot water plant a 'loop' of the heating fluid somewhat like *Fig. 1*. Of course this diagram is crude and omits many features, yet it is designed to show a working principle. The heater warms the water to say 180°. In the radiator the water cools to about 160°. Now the cooler column of water weighs slightly more than the hot column, so that it will fall and push the lighter side up, thus promoting a *very slight circulation* in the directions indicated. Thus the name of 'gravity system' is applied to distinguish it from 'forced' circulation when pumps are used, as in large buildings.

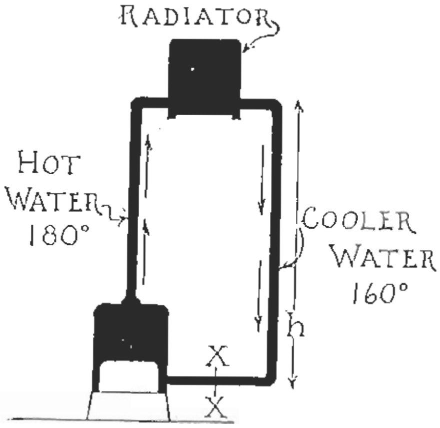

FIGURE 1

There are several observations to be made about the conditions arising in the 'gravity system.' First, if the radiator were entirely blanketed so that it could give off no heat, there would be no circulation. Second, the velocity of the water in the pipe at the point XX in *Fig. 1* is dependent not only upon the difference in temperature but also upon the height of water above that point.

A third fact to be noted is that the hot water system, including boiler pipes and radiators, is completely filled with water at all times, in this respect being unlike a steam system. Provision must of course be made for the expansion of the water when heated. This is done in the regular old-fashioned system by providing an open 'expansion tank' at the top of the house in which the water may rise if the fire becomes too hot. The expansion tank is shown in *Fig. 2* together with two schemes for arranging the basement piping. On the right is shown the 'two-pipe' arrangement; that is, each radiator receiving its hot water from one pipe (supply main) and returning its cooler water to another pipe (return main). On the other side of the same diagram is the 'one-pipe' or 'shunt' method, each radiator returning its cool water to the same pipe from which the hot water came. The second method has the advantage of less cost but is not generally considered as good as the two pipe method for house heating, one reason being that the radiators at the end farthest from the heater receive water of relatively low temperature, and must therefore be of larger size for the same heating effect. Yet sometimes the particular layout of the house plan makes the latter a necessary choice.

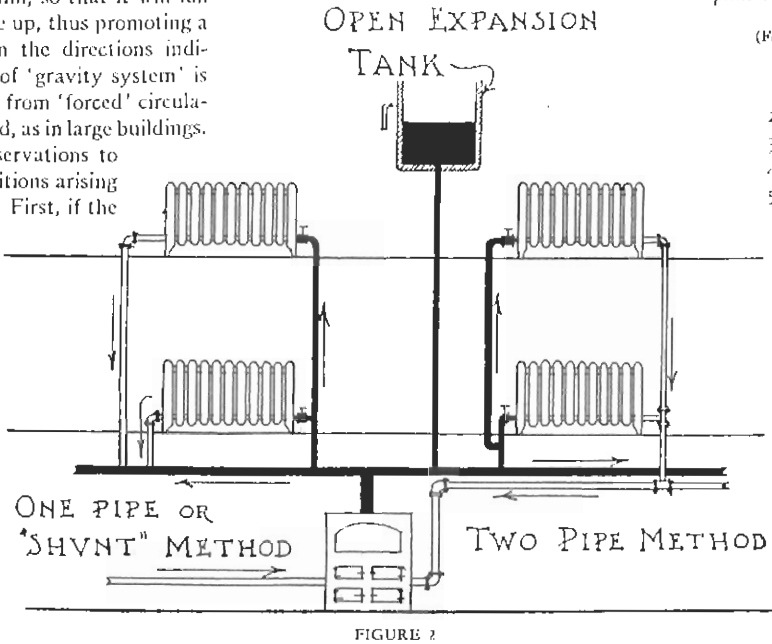

FIGURE 2

There is one physical condition in a hot water system which must always be fulfilled — that the water shall not become heated in the boiler above its boiling point so as to make any steam. The reason is obvious from what was noted above about the system being completely full of water and not having sufficient space for steam. Of course there are times when by careless operation too hot a fire will start to cause trouble in this respect, but the water will simply be forced higher in the expansion tank and run out at the top through an overflow pipe which must be carried down to some sink or drain where a spouting of hot water will do no harm.

The limitation of temperature to some point below the boiling point brings out the fact that the boiling point is higher than 212 degrees because the pressure in all but the highest points of the house is higher than atmospheric pressure. The higher the water stands above any point, the higher the temperature at which the water will boil. Hence if we can put the expansion tank high enough or devise a scheme for creating sufficient pressure we can have water at any temperature we please.

The exact relation of height to pressure and temperature is shown in the following table.

TABLE OF HEIGHTS, PRESSURE, AND TEMPERATURES

Height of Expansion Tank (Feet)	*Pressure Produced* (Lbs. per sq. in. by gage)	*Boiling Point Corresponding to Pressure* (Degrees Fahr.)
5	2.2	219
10	4.3	225
20	8.7	236
30	13.0	246
40	17.4	254
50	21.7	262

It should be clearly understood that, while the above temperatures are the *maximum* that can be allowed, the *operating* temperatures at the heater must be kept quite a little below the boiling point because we are limited by the conditions affecting the highest radiators.

For example, a two-story house would ordinarily have about 30 feet of height from heater to expansion tank which gives a limiting temperature according to the table of 246 degrees. Yet even in coldest weather it is best to avoid heating the water at the heater higher than say 195 or 200 degrees.

This limitation of temperatures to a lower amount than is allowable in a steam system is the reason for the necessity of larger radiators. But with the increased number or size of radiators the honse can be kept just as warm as with steam. The size of radiators, however, is a real disadvantage of hot water heating and one which appeals strongly to the owner who desires wall space for other things.

To overcome this disadvantage, a scheme was devised a few years ago — a good example of Yankee ingenuity. In effect, the idea is to have the column of water running to the expansion tank partly replaced by a slng of mercury. Since this substance is about thirteen times as heavy as water, it makes it possible, without raising the expansion tank, to get greater pressure at the heater and therefore to allow hotter water in the system without boiling.

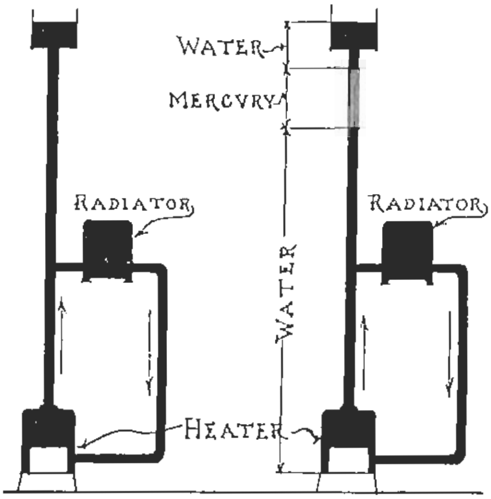

FIGURE 3 FIGURE 4

Fig. 3 shows the ordinary open expansion tank, while *Fig. 4* suggests the effect of the mercnry. Actually the arrangement is more involved and you have to buy a patented accessory, but the effect is just the same as if the mercury were inserted as shown. Note that the use of a column of mercury 20 inches high would be equivalent to lifting the expansion tank about 20 feet higher and would allow the water to be about 20 degrees hotter. The device which is inserted for this purpose is called a 'mercury seal' or 'generator.' I wish they would not use the latter name, for the only *generator* is the fuel.

Just as the mercury seal was devised to overcome the well-known disadvantage of low temperatures and large radiators, so another improvement has been devised to offset another disadvantage. I refer to the fact that a hot water heating is ordinarily very 'lazy.' It is slow to get the heat up and slow to cool off if the day turns out to be warmer than usual.

This makes the problem of close regulation very important and has brought out in recent years an interesting development called the 'tank in basement' or 'pressure tank' method.

In *Fig. 5* are shown the essentials of this plan. Under the first floor is a sealed tank. The water entering the system from the city mains contains a certain amount of air which will rise to the top of this tank, leaving the tank filled with water only up to a certain level, called the 'water line.' Above this we have a cushion of air nnder pressure which will increase as the water in the system gets hotter and expands under the action of the heat.

The simple idea is to use this air cushion as a regulator by connection through a pipe with a diaphragm and lever which are attached to the dampers. Another point claimed by the originators of this plan is that smaller pipe sizes can be used with consequent higher velocity of the water flowing in the pipes.

There are other methods of regulation by a temperature control at the heater or by a thermostat in the centre of the house, the latter being used with any kind of heating system.

In this matter of regulation lies a very fundamental fact about hot water as a heating medium — perhaps the most fundamental fact. Steam must exist at about the same temperature while effective; hence steam temperature is practically kept *constant at the boiler*, but *regulated at the radiator*. On the other hand, water may be heated to any temperature (within limits) and thus have *temperature regulated at the boiler* with conditions kept *constant at the radiator*. This essential difference touches upon a very practical phase of the household problem, namely, that in so far as the household requirements demand the same temperature at all times, with but little or no manipulation at the radiator, hot water has a certain convenience due to regulation at the *source*. But in so far as the different rooms have diverse requirements as to temperature in different parts of the day or for different people in various rooms, the possibility of regulation by a quick opening radiator valve and the immediate delivery of heat makes the steam or vapor system superior.

This necessity for regulating hot water *at the source* is so important that some people omit valves from the radiators, as they are so inconvenient to use, being down close to the floor and requiring several turns.

The sleeping room problem with hot water systems is very important. It takes quite a while for the radiator to cool down even though the valve is shut off, because the radiator valve probably has a small hole drilled through it to let a little warm water circulate at all times. This is done to avoid a freeze-up on very cold nights. A procedure which I would recommend is to make a close fitting bag of felt or quilting material which can be slipped over the radiators at night, something like the old-fashioned covering for a teapot. During the day the cover can be folded up and kept in a closet.

The proper installation of a hot water system is generally regarded as requiring greater skill on the part of the contractor and workman than steam or vapor, because the circulation is caused by such slight differences in temperature that care must be taken to favor the flow at all points. The cost is necessarily greater than the one-pipe steam system due to the larger size of radiators and to double piping, but is about the same as the improved steam or vapor heating.

A final summary of the advantages and disadvantages of hot water should be made, I believe, with vapor heating in mind as the close competitor. If this be done the score would stand, I think, as follows:

Advantages of hot water

(1) *Simple regulation at the source rather than at the radiator.*
(2) *Possibility of running at a very low temperature during spring and fall.*

Disadvantages of hot water

(1) *Too slow in responding to sudden demand for heat and too slow in cooling off when demand ceases, as in case of sleeping rooms.*
(2) *Radiators larger than required for steam.*
(3) *Possibility of freeze-ups.*
(4) *Heating of domestic hot water not so convenient as with steam.*

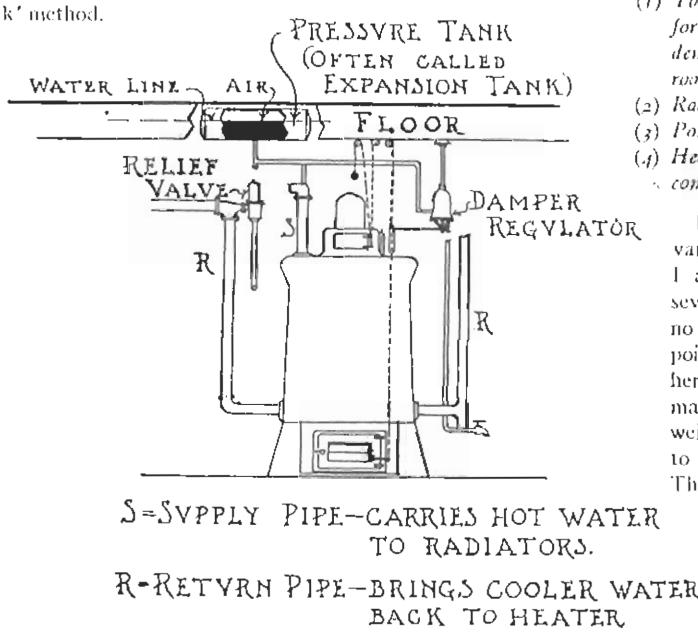

FIGURE 5

In closing this first series of studies of various methods of house heating, may I again emphasize what I have said several times — namely, that there is no one best system with all the good points. The owner must see what inherent conditions go with each plan and make his own decision as to the relative weights in his own case to be assigned to each advantage or disadvantage. The purpose of these papers has been to make it a bit easier to discern these facts, and to make the owner somewhat more certain how to handle the system which he wants. A later series of articles will cover special features.