CHAPTER III.

THE COMBINATION SYSTEM.

HOT WATER AND HOT AIR.

In the combination system of heating, where both air and water serve to convey heat from the furnace to the various rooms, a slight saving in fuel is effected by causing the gases to pass over water heating surface suspended above the fire. Aside from this, whatever gain is made is at the expense of ventilation, since in rooms heated by direct radiation the same air is used over and over. Plans of a residence heated by a combination system are shown in Figs. 20, 21 and 22.

Living rooms should receive a continuous supply of warm fresh air. This may be furnished most conveniently in the ordinary manner through the furnace pipes, adding direct radiation if necessary in exposed corners. To deliver fresh air at points too remote from the furnace to be reached by an ordinary hot air pipe an indirect radiator may be used, suspended just below the register and supplied with air from the furnace or directly from out of doors. Valves should be omitted from such radiators to avoid danger from freezing. The heat may be regulated by the register.

In finely furnished rooms indirect radiation may be used to advantage in place of direct radiation when the appearance of the latter is considered objectionable or when it is difficult to provide space for them. When so used they may be arranged with a return duct and the air in the room rotated as in direct heating. Under such conditions the heating surface is less effective than when placed in the room, hence it must be liberally proportioned.

DIRECT RADIATION.

The usual location for a direct radiator is near an outside wall or below a window, although good results may be obtained in rooms not too greatly exposed when the radiator is located near one of the inner walls. Radiators should be set in as inconspicuous places as possible, provided such location will be effective. Direct radiation may properly be used in rooms where a constant supply of fresh air is not required, as in bedrooms occupied only at night, when air may be admitted through raised windows, or in halls not used as living rooms. Unlike steam, the temperature of the water in the radiators may be gradually reduced by throttling down the supply with the valve. In rooms where heat may not be required for days at a time a small hole should be drilled through the disk of the radiator valve to prevent the heat being

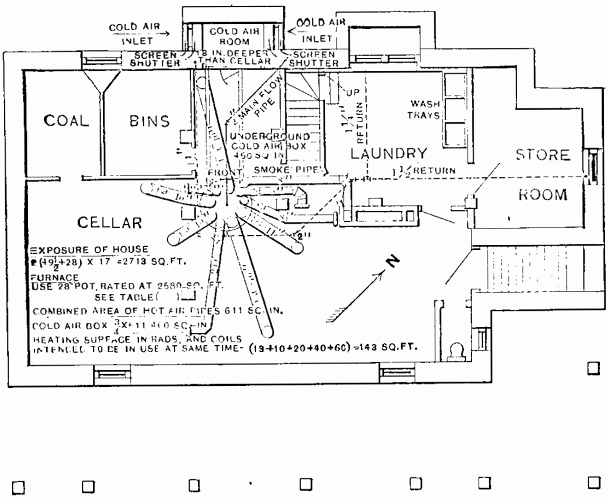

Fig. 20.—Basement Plan (8′ 0″) of a Residence Heated by a Combination System.

entirely shut off. Hot water radiators contain as a rule from 1 to $1\frac{1}{2}$ pints of water per square foot of surface.

HOT WATER VS. HOT AIR.

Owing to the capacity of water to store heat, rooms having radiators are less subject to sudden changes in temperature than those where hot air is used. Ordinarily this is an advantage, but in living rooms which on certain occasions may contain an unusual number of occupants this feature is objectionable. It is seldom noticed that a room has become overheated until the temperature has risen considerably above the normal. Then the radiator valve is closed, but the water continues to give off its stored heat for some time thereafter, which with the heat from the lights and that from the bodies of the occupants makes it difficult to reduce the temperature quickly. The act of closing a register shuts off all the heat at once.

VALVES ON RADIATORS.

One or two radiators should be left without valves to prevent all being shut off at once, which would cause the water in the

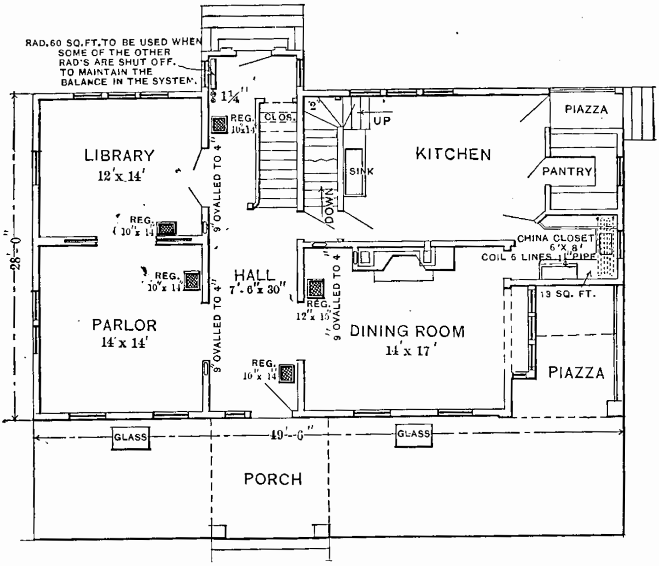

Fig. 21.—First-Floor Plan (9′ 0″) of a Residence Heated by a Combination System.

system to boil. Where the furnace is connected with but one radiator the water must be allowed to circulate through it at all times, whether heat is desired or not.

"BALANCE" OF THE SYSTEM.

One of the difficulties in a hot water combination system is to secure a proper "balance" between the hot water and the warm air, so that they will work harmoniously and one not heat at the expense of the other. It is advisable to place in the hall or other convenient room both a register and a radiator, each of sufficient size to heat the space, so that by using one or the other a proper " balance " may be maintained.

HEATING SURFACE IN FURNACE.

The water heating surface in the furnace may be placed in contact with the fire or suspended above it. In some heaters the water is first brought in contact with the surface in the fire and then ascends through a coil or cast iron section surrounded by the hot gases. The tendency of the water heating surface to deaden the fire with which it is in contact and to greatly diminish the air heating capacity of the furnace limits its use. When the heating

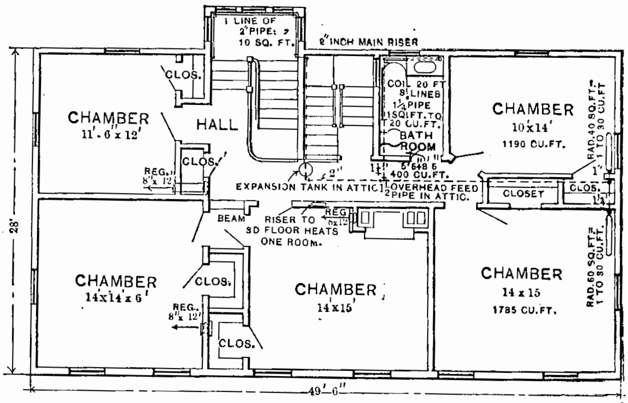

Fig. 22.—Second-Floor Plan (8′ 6″) of a Residence Heated by a Combination System.

surface is in contact with the fire, the water is maintained at a more even temperature than when heated by a coil or section suspended above it. With the latter the heating surface is acted upon chiefly by the radiant heat from the top of the fire, which amounts to little just after firing or until the fresh coal has become ignited. In the meantime the temperature of the water falls. The heating capacity of such surface may be varied to suit conditions. In severe weather by carrying a high fire in contact with the coil or section its capacity may be greatly increased.

When special castings cannot be procured for attaching a hot water combination to a furnace, coils of wrought iron pipe are often used, placed either above or partly in the fire. They are generally made of 1¼ or 1½ inch pipe, according to the radiation supplied. One square foot of heating surface in contact with the fire is capable of supplying 40 to 50 square feet of radiating surface. One square foot of heating surface suspended above the fire may be rated to supply from 15 to 25 square feet of radiating surface. One and one-half inch pipe coils above the fire may be rated to carry about 10 square feet of radiating surface per lineal foot.

DIRECT RADIATING SURFACE.

In estimating the total amount of radiation supplied by the furnace the surface of the supply and return pipes should be added to that in the radiators, unless the pipes are to be covered. In the combination system with open tank sufficient radiating surface should be provided to heat the rooms to 70 degrees in zero weather, with a maximum water temperature not over 190 degrees. This will leave a reasonable margin below the boiling point. If the amount of surface is calculated on the usual basis of cubic space to be warmed the allowances in Table VII will be found safe under ordinary conditions. Of course in determining the amount of surface required for a given room due regard must be had for its exposure, glass surface and the character of its walls.

Table VII.

For rooms with one exposed wall, allow 1 square foot of radiation for 30 to 40 cubic feet of space.

For rooms with two exposed walls, allow 1 square foot of radiation for 25 to 30 cubic feet of space.

For rooms with three exposed walls, allow 1 square foot of radiation for 20 to 25 cubic feet of space.

For bathrooms and small exposed rooms, allow 1 square foot of ratiation for 15 to 25 cubic feet of space.

Use maximum or minimum amount of surface given by above rule according to the degree of exposure. For the closed tank or pressure system use about three-quarters as much surface as with an open tank.

If desired the radiating surface may be based directly on the loss of heat through walls, windows, floors and ceilings. A convenient approximate method is to consider 4 square feet of ordinary wall equivalent in heat transmitting power to 1 square foot of glass; then reduce the exposure of the room to equivalent glass surface by adding to the window area one-quarter the area of the outside walls. Outside doors are to be estimated as equivalent to one-half their area in glass. If the space below or above the room is not heated, add to the equivalent glass surface one-twentieth of the area of floor or ceiling. The total equivalent glass surface thus obtained divided by 1.8 will give the amount of radiation required with the open tank system. For the pressure system divide by 2.4.

To compensate for the increased loss of heat due to winds add the following percentages:

Fifteen to 20 per cent. for rooms having a northerly or westerly exposure.

Ten to 15 per cent. for rooms having an easterly or northeasterly exposure.

For rooms with but one exposure, besides the correction for winds, add 10 to 15 per cent. to the loss of heat by transmission to allow for the effect of the greater cubic contents as compared with the exposure than in rooms having two exposed walls. Otherwise such rooms will be slow in warming.

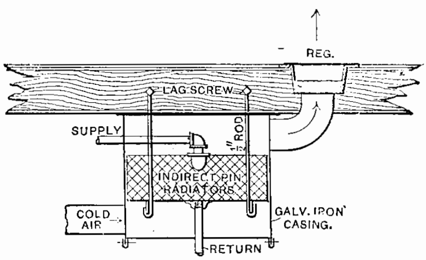

Fig. 23.—Indirect Stack.

INDIRECT RADIATING SURFACE.

For indirect heating with pin radiators the sections should have a depth of 10 to 12 inches to thoroughly warm the air. Fig. 23 shows the arrangement of an indirect stack.

To estimate the amount of indirect radiation when the air supply is taken from the furnace add 25 per cent. to the amount of direct radiating surface that would be required. When the air is admitted to the stack directly from out of doors add 50 per cent. to the amount of direct radiating surface that would be necessary. With indirect radiation for the first floor allow at least 1¼ square inches to each square foot of surface for cold air supply and 1½ square inches per square foot of surface for warm air flue.

HEATING CONSERVATORIES.

For heating conservatories 1¼, 1½ or 2 inch pipes are generally used, run along the wall under the benches. Fig. 24 shows a wall coil. One square foot of radiating surface is, with open tank system, sufficient for 2 square feet of glass. In other words:

1 lineal foot of 1¼-inch pipe will carry 8/10 square foot of glass.
1 lineal foot of 1 -inch pipe will carry 1 square foot of glass.
1 lineal foot of 2-inch pipe will carry 1¼ square feet of glass.

TAPPING OF RADIATORS.

Hot water radiators are commonly tapped:

1 inch for radiators containing 40 square feet and under.
1¼ inches for radiators containing 40 to 72 square feet.
1½ inches for radiators containing 72 square feet and over.

Unless otherwise ordered indirect radiators are usually tapped 2 inches, then bushed to the desired size.

SIZES OF PIPES.

The following sizes of flow pipes for the amount of radiating surface stated will be found sufficient for ordinary runs:

Table VIII.—Capacity of Hot Water Pipes for Direct and Indirect Radiation.

1-inch pipe will supply 40 square feet of direct radiating surface.
1¼-inch pipe will supply 72 square feet of direct radiating surface.
1½-inch pipe will supply 125 square feet of direct radiating surface, or 80 square feet of indirect radiating surface.
2-inch pipe will supply 225 square feet of direct radiating surface, or 150 square feet of indirect radiating surface.
2½-inch pipe will supply 350 square feet of direct radiating surface, or 240 square feet of indirect radiating surface.
3-inch pipe will supply 500 square feet of direct radiating surface, or 350 square feet of indirect radiating surface.

OPEN TANK AND PRESSURE SYSTEMS.

The closed tank or pressure system of hot water heating is often used in combination work. Less radiation is then required than with an open tank, since the water may be carried at a much higher temperature.

On the other hand, in case of any leak, much greater damage is likely to result than with the latter system. The safety valve used with the pressure system must be of such design and materials that it will not stick and fail to open to relieve an overpressure.

The open tank system is most commonly used. Under certain conditions the water may boil and overflow, but if properly arranged this will do no harm and with ample radiating surface will seldom occur. The surging in the pipes will call attention to the fact that the apparatus is not working properly, and that either more radiation must be turned on or the fire must be checked.

EXPANSION TANK AND CONNECTIONS.

The house tank is sometimes used as an expansion tank, but

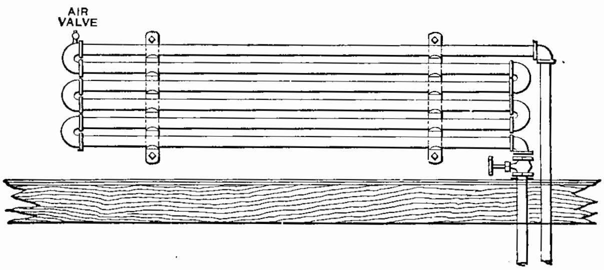

Fig. 24.—Wall Coil.

this is unwise, as in case of boiling rusty water is forced into the tank, rendering the house supply turbid and unfit for use.

A separate tank should be used, which may be provided with a ball cock if desired to insure the proper water level being maintained. The expansion pipe must be so connected that the free expansion of the water cannot be interrupted.

Water expands about one twenty-fourth of its volume at 40 degrees when heated to 210 degrees. The expansion tank should have a capacity equal to about one-twelfth that of the entire system. The radiating surface divided by 40 gives the proper capacity of the expansion tank in gallons.

In the cheapest work no expansion tank whatever is provided, the system being connected directly with the street service, full city pressure of perhaps 80 pounds or more being maintained on the system. In case of leaks from any cause the damage resulting with such a pressure would be much greater than with either the closed or open tank system.

SYSTEM OF PIPING.

Two systems of piping are commonly employed. In one the mains are run through the basement, taking off supply and return connections to the various risers and connecting the expansion pipe to the return near the heater. Fig. 25 shows a radiator on a two-pipe system.

In the other, known as the "overhead feed," the flow pipe rises directly to the expansion tank, the radiators being connected with

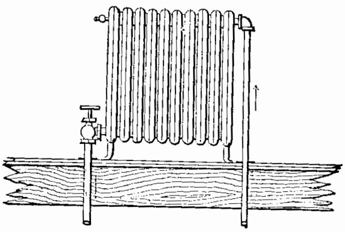

Fig. 25.—Single Valve Radiator Connection.—Two-Pipe System.

the drops or returns, as in Fig. 26, a single pipe serving for both supply and return to radiators on several floors. No air valves are required with this arrangement, since all air escapes from the expansion tank, located at the highest point. Nothing can interrupt the circulation of water through the mains. Fewer pipes and connections are necessary and the circulation is likely to be better than with the two-pipe system.

STEAM COMBINATION.

Some furnaces may be fitted with a steam heating combination. The advantages claimed for this system are quick heating ability and the use of smaller radiators and pipes than in an open tank system, with resulting economy in space and cost.

Among its disadvantages as compared with hot water may be stated its sensitiveness to changes in the condition of the fire owing to the small amount of water in the system, steam going down quickly with a deadening of the fire.

Unless vacuum valves are used there is no range of temperature in the radiators, as with hot water. With steam the boiling point

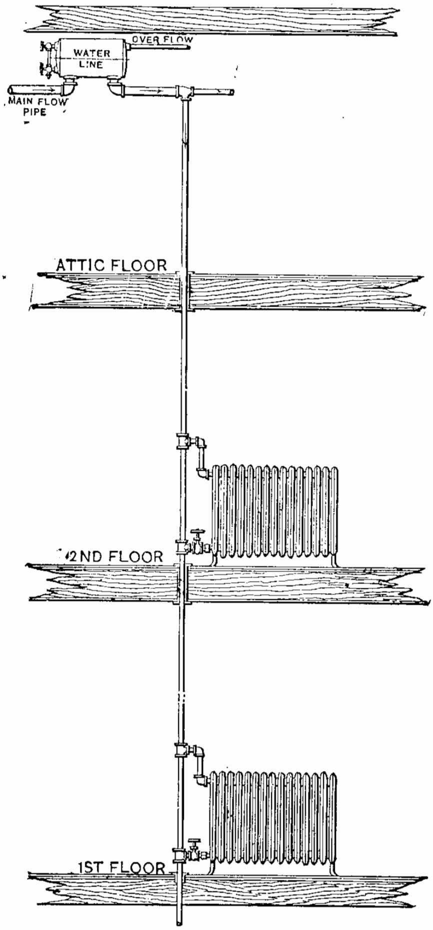

Fig. 26.—Radiator Connections.—Overhead Feed System.

(212 degrees) must be reached before the radiators become hot. The small water capacity involves frequent filling and damage is likely to result from inattention. The apparatus with its additional

valves and fittings is less simple than the hot water combination. In estimating the steam radiating surface allow about six-tenths as much surface as would be required using hot water radiators with the open tank system.

TABLE IX.—Wrought Iron Welded Pipe.

1¼-inch and below, butt welded, proved to 300 pounds per square inch, hydraulic pressure.
1½-inch and above, lap welded, proved to 500 pounds per square inch, hydraulic pressure.

TABLE OF STANDARD SIZES.

Nominal inside diameter.	Actual outside diameter.	Thickness.	External circumference.	Length of pipe per square foot of outside surface.	Actual internal area.	External area.	Length of pipe containing 1 cubic foot. 1 cubic foot = 7½ gallons.	Weight per foot of length.	No. of threads per inch of screw.
Ins.	Ins.	Ins.	Ins.	Ft.	Ins.	Ins.	Ft.	Lbs.	
⅛	0.405	0.068	1.272	9.434	0.057	0.1288	2,500	0.24	27
¼	0.54	0.085	1.696	7.075	0.104	0.229	1,383.28	0.42	18
⅜	0.675	0.091	2.121	5.658	0.191	0.3578	754.322	0.56	18
½	0.84	0.109	2.639	4.547	0.301	0.551	473.84	0.84	14
¾	1.05	0.113	2.299	3.638	0.533	0.866	270.016	1.12	14
1	1.315	0.134	4.131	2.904	0.861	1.358	167.246	1.67	11½
1¼	1.66	0.140	5.215	2.301	1.496	2.164	96.257	2.24	11½
1½	1.9	0.145	5.969	2.01	2.036	2.835	70.727	2.68	11½
2	2.375	0.154	7.461	1.608	3.356	4.430	42.908	3.61	11½
2½	2.875	0.204	9.032	1.329	4.78	6.492	30.337	5.74	8
3	3.5	0.217	10.996	1.091	7.383	9.621	19.504	7.54	8
3½	4	0.226	12.566	0.955	9.887	12.566	14.567	9	8
4	4.5	0.237	14.137	0.849	12.73	15.904	11.312	10.66	8
4½	5	0.246	15.708	0.764	15.961	19.635	9.022	12.34	8
5	5.563	0.259	17.475	0.687	19.986	24.301	7.205	14.5	8
6	6.625	0.28	20.813	0.577	28.89	34.472	4.984	18.76	8
7	7.625	0.301	23.955	0.501	38.738	45.664	3.717	23.27	8
8	8.625	0.322	27.096	0.443	50.027	58.426	2.876	28.18	8
9	9.625	0.344	30.238	0.397	62.73	72.760	2.290	33.7	8
10	10.75	0.366	33.772	0.355	78.823	90.763	1.827	40.06	8

Cast iron radiators with low pressure steam transmit approximately 250 heat units per square foot of surface per hour. Hot water radiators on open tank system transmit about 150 heat units per square foot of surface per hour.