and air conditioning systems. The flexible control of heat output secured by this method materially reduces the required size of by-pass around the heaters. Some applications of sub-atmospheric systems are proprietary.

TWO-PIPE ORIFICE SYSTEMS

Orifice steam heating systems may have piping arrangements identical with vacuum systems. Some of these omit the radiator thermostatic traps but use thermostatic or combination float and thermostatic traps on all drip points. A return condensate pump with receiver vented to atmosphere, a return line vacuum pump, or a return trap, is generally used to return the condensate to the boiler or place of similar disposition, such as a feed-water heater or hot well. The heat emission from the radiators is controlled by varying the pressure differential maintained.

The principle on which these systems operate is based on the fact that the steam flow through an orifice will vary when the ratio of the absolute pressures on the two sides of the orifice exceeds 58 per cent. If the absolute pressure on the outlet side is less than 58 per cent of the absolute pressure on the inlet side, no further increase in flow will be obtained as a result of the increased pressure difference. If an orifice is so designed in size as to exactly fill a radiator with 2 psi gage on one side and ¼ psi gage on the other, the absolute pressure relation is:

$$\frac{14.7 + 0.25}{14.7 + 2.0} = 0.90 \text{ or } 90 \text{ per cent.}$$

Should the steam pressure be dropped to ¼ lb on the supply pipe, the pressure on each side of the orifice would be balanced and no steam flow would take place. From this it will be apparent that if an orifice of a given diameter will fill a given radiator with steam when there is a given pressure on the main, reducing this steam main pressure will permit filling various desired portions of the radiator down to the point where the main pressure equals the back pressure in the radiator provided the supply pipe pressures may be controlled sufficiently close. If orifices are designed on a similar basis for a given system and proportioned to the heating capacity of the radiators they serve, all radiators will heat proportionately to the steam pressure. The range of pressure variation is limited by the permissible noise level of the steam flowing under the pressure difference required for maximum heat output. The control of the steam supply is obtained by a valve placed in the steam main, which maintains a determined pressure by varying the vacuum in the return lines, or by varying the pressure in the supply lines and the vacuum in the returns. The valves are frequently manually set from a remote location, guided by temperature indicating stations in the building; or thermostatically controlled from a thermostat on the roof, which automatically measures the differential of outside and inside temperatures. Since the range through which the pressures may be varied is usually from 0 to 4 psi gage, the control should be capable of maintaining close regulation to maintain the desired space temperatures, particularly in mild weather.

A recommended orifice schedule is shown in Table 1. Some systems use orifices not only in radiator inlets but also at different points in the steam supply piping for the purpose of balancing the system to a greater extent. In this manner the difference between the initial and terminal pressure in the steam main may be compensated to a great extent. For example, if the initial pressure was 3 psi gage and the pressure at the end of the main was 2 psi, an orifice could be used in each branch for the purpose

TABLE 1. ORIFICE CAPACITIES FOR LOW PRESSURE STEAM SYSTEMS

This table is based on data from actual tests[a]

Orifice Diameter 64ths of an Inch	6 in. Hg Differential	5 in. Hg Differential	4 in. Hg Differential	2 in. Hg Differential	1 in. Hg Differential
	Capacity Expressed in Square Feet E D R				
7	18–23	16–21	15–19	10–13	
8	23–29	21–27	19–25	13–17	8–11
9	29–36	27–33	25–30	17–21	11–14
10	36–44	33–40	30–37	21–26	14–17
11	44–52	40–48	37–44	26–31	17–20
12	52–62	48–57	44–51	31–37	20–24
13	62–72	57–66	51–59	37–43	24–28
14	72–83	66–76	59–67	43–49	28–32
15	83–94	76–86	67–76	49–56	32–37
16	94–106	86–97	76–86	56–64	37–42
17	106–119	97–109	86–97	64–72	42–47
18	119–133	109–122	97–108	72–80	47–52
19	133–148	122–135	108–120	80–88	52–58
20	148–163	135–149	120–133	88–98	58–64
21	163–179	149–164	133–145	98–107	64–71
	Capacity Expressed in Pounds per Hour				
7	4.5–5.8	4.0–5.3	3.8–4.8	2.5–3.3	
8	5.8–7.3	5.3–6.8	4.8–6.3	3.3–4.3	2.0–2.8
9	7.3–9.0	6.8–8.3	6.3–7.5	4.3–5.3	2.8–3.5
10	9.0–11.0	8.3–10.0	7.5–9.3	5.3–6.5	3.5–4.3
11	11.0–13.0	10.0–12.0	9.3–11.0	6.5–7.8	4.3–5.0
12	13.0–15.5	12.0–14.3	11.0–12.8	7.8–9.3	5.0–6.0
13	15.5–18.0	14.3–16.5	12.8–14.8	9.3–10.8	6.0–7.0
14	18.0–20.8	16.5–19.0	14.8–16.8	10.8–12.3	7.0–8.0
15	20.8–23.5	19.0–21.5	16.8–19.0	12.3–14.0	8.0–9.3
16	23.5–26.5	21.5–24.3	19.0–21.5	14.0–16.0	9.3–10.5
17	26.5–29.8	24.3–27.3	21.5–24.3	16.0–18.0	10.5–11.8
18	29.8–33.3	27.3–30.5	24.3–27.0	18.0–20.0	11.8–13.0
19	33.3–37.0	30.5–33.8	27.0–30.0	20.0–22.0	13.0–14.5
20	37.0–40.8	33.8–37.3	30.0–33.3	22.0–24.5	14.5–16.0
21	40.8–44.8	37.3–41.0	33.3–36.3	24.5–26.8	16.0–17.8

Note.—The radiator orifice plates recommended in this table are made of brass stampings 0.023 in. thick cup-shaped to be inserted in radiator valve unions.

[a]Flow of Steam Through Orifices into Radiators, by S. S. Sanford and C. B. Sprenger (A.S.H.V.E. TRANSACTIONS, Vol. 37, 1931, p. 371).

of obtaining a more uniform pressure throughout the system. Such a provision may be particularly useful in this system for branches close to the boiler where the drop in the main has not yet been produced. Some orifice systems are proprietary.

SIZING PIPING FOR STEAM HEATING SYSTEMS

The functions of the piping system are the distribution of the steam, the return of the condensate and, in systems where no local air vents are provided, the removal of the air. The distribution of the steam should be rapid, uniform and without noise, and the release of air should be facilitated as much as possible, as an air bound system will not heat readily nor properly. In designing the piping arrangement it is desirable to maintain equivalent resistances in the supply and return piping to and from a radiator. Arranging the piping so the total distance from the