On systems exceeding an equivalent length of 200 ft, it is suggested that the total drop be not over $\frac{1}{4}$ psi. The return piping sizes should correspond with the drop used on the steam side of the system. Thus, where $\frac{1}{24}$ psi drop is being used, the steam main and dripped runouts would be sized from Fig. 22; radiator runouts and undripped riser runouts from Table 6, Column *F*; up-feed risers from Column *D*; the main riser on a down-feed system from Fig. 22 (it will be noted that if Column *E* is used the drop would exceed the limit of $\frac{1}{24}$ psi); the dry-return from Table 7, Column *L*; and the wet-return from Column *K*.

With a $\frac{1}{32}$ psi drop the sizing would be the same for as $\frac{1}{24}$ psi, except that the steam main and dripped runouts would be sized from Fig. 22, the main riser on a down-feed system from Fig. 22, the dry-return from Column *I*, and the wet-return from Column *H*.

Notes on Gravity One-Pipe Air-Vent Systems

1. Pitch of mains should not be less than $\frac{1}{4}$ in. in 10 ft.

2. Pitch of horizontal runouts to risers and radiators should not be less than $\frac{1}{2}$ in. per foot. Where this pitch cannot be obtained, runouts over 8 ft in length should be one size larger than called for in the table.

3. In general, it is not desirable to have a main less than 2 in. The diameter of the far end of the supply main should not be less than half its diameter at its largest part.

4. Supply mains, runouts to risers, or risers, should be dripped where necessary.

5. Where supply mains are decreased in size they should be dripped, or be provided with eccentric couplings, flush on bottom.

Example 3: Size the one-pipe gravity steam system shown in Fig. 27 assuming that this is all there is to the system, or that the riser and main shown involve the longest run on the system.

Solution: The total length of run actually shown is 215 ft. If the equivalent length of run is taken at double this, it will amount to 430 ft, and with a total drop of $\frac{1}{4}$ psi the drop per 100 ft will be slightly less than $\frac{1}{16}$ psi. It would be well in this case to use $\frac{1}{24}$ psi, and this would result in the theoretical sizes indicated in Table 10. These theoretical sizes, however, should be modified by using a wet-return not less than 2 in., while the main supply, *G-H*, if from the uptake of a boiler, should be made the full size of the main, or 3 in. Also the portion of the main *K-M* should be made 2 in. if the wet-return is made 2 in.

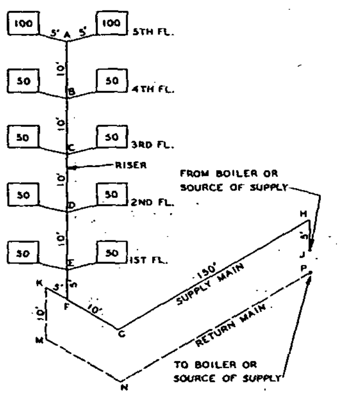

Fig. 27 .... Riser, Supply Main and Return Main of One-Pipe System

Table 10 .... Pipe Sizes for One-Pipe Up-Feed System Shown in Fig. 27

Part of System	Section of Pipe	Radiation Supplied EDR Sq Ft	Theoretical Pipe Size (Inches)	Practical Pipe size (Inches)
Branches to radiators	......	100	2	2
Branches to radiators	......	50	$1\frac{1}{4}$	$1\frac{1}{4}$
Riser	*A* to *B*	200	2	2
Riser	*B* to *C*	300	$2\frac{1}{2}$	$2\frac{1}{2}$
Riser	*C* to *D*	400	$2\frac{1}{2}$	$2\frac{1}{2}$
Riser	*D* to *E*	500	3	3
Riser	*E* to *F*	600	3	3
Runout to riser	*F* to *G*	600	$3\frac{1}{2}$	$3\frac{1}{2}$
Supply main	*G* to *H*	600	3	3
Branch to supply main	*H* to *J*	600	$2\frac{1}{2}$	3
Dry return main	*F* to *K*	600	$1\frac{1}{4}$	2
Wet return main	*K* to *M*	600	1	2
Wet return main	*M* to *N*	600	1	2
Wet return main	*N* to *P*	600	1	2

SIZING PIPING FOR ONE-PIPE VAPOR SYSTEMS

Piping for one-pipe vapor systems is sized so as to permit only a few ounces pressure drop in the system. Otherwise, the method follows that outlined for sizing one-pipe gravity systems.

SIZING PIPING FOR TWO-PIPE HIGH-PRESSURE SYSTEMS

Steam supply piping for two-pipe high pressure can be sized for greater pressure drops than that of the return piping. For a system using steam at 30 psig, the total pressure drop can be 5 to 10 psi, and for 150 psig systems, 25 to 30 psi.

It has been observed that the maximum total pressure in the returns of a 30 psig system is about 5 psig, and that of a 150 psig system is about 20 psig. The pressure in the return mains is caused by the discharge of traps and flashing of condensate into steam because the return-line pressure is below that corresponding to the saturation temperature of the condensate. The usual practice in the sizing of high-pressure returns has been to size on the basis of $\frac{1}{2}$ psi per 100 ft of pipe for 30 psig systems, and 1 psi per 100 ft for 150 psig systems. This is an average figure which corresponds generally to several of the previously published tables for the design of high-pressure return piping.

Notes on Two-Pipe High-Pressure Systems

Pitch of mains should not be less than $\frac{1}{4}$ in. in 10 ft.

Pitch of horizontal runouts to risers and heating units should not be less than $\frac{1}{2}$ in. per ft.

SIZING PIPING FOR TWO-PIPE LOW-PRESSURE SYSTEMS

Piping for two-pipe low-pressure systems is sized in the same manner as for two-pipe vapor systems, except that the

pressure drop throughout the system can be based on $\frac{1}{2}$ psi to 1 psi drop.

SIZING PIPING FOR TWO-PIPE VAPOR SYSTEMS

While many manufacturers of patented vapor heating accessories have their own schedules for pipe sizing, an inspection of these sizing tables indicates that in general as small a drop as possible is recommended. The reasons for this are: (1) to have the condensate return to the boiler by gravity; (2) to obtain a more uniform distribution of steam throughout the system, especially when it is desirable to carry a moderate or low fire; and (3) to prevent large variations in pressure which would nullify the value of graduated valves on radiators.

For small vapor systems when the equivalent length of run does not exceed 200 ft, it is recommended that the main, and any runouts to risers that may be dripped, should be sized for about $\frac{1}{16}$ psi drop per 100 ft, using Fig. 22 or Table 5, while riser runouts not dripped and radiator runouts should be obtained from Column *C*, Table 6. The up-feed steam risers should be taken from Column *B*. For returns use Table 7, Column *O*, the upper portion for mains and the lower portion for risers. It should again be noted that the pressure drop in the steam side of the system is kept the same as on the return side, except where the flow in the riser is concerned.

On a down-feed system, the main vertical riser should be sized from Table 6, Column *B*, but the down-feed risers can be taken from Fig. 22 or Table 5 using a $\frac{1}{16}$ psi drop.

For vapor systems over 200 ft of equivalent length the drop should not exceed $\frac{1}{8}$ to $\frac{1}{4}$ psi if possible. Thus, for a 400-ft equivalent run the drop should be not over $\frac{1}{32}$ psi per 100 ft. In this case the steam mains would be sized from Fig. 22, the radiator and undripped riser runouts from Table 6, Column *C*; and the risers from Fig. 22 because Column *B* gives a drop in excess of $\frac{1}{32}$ psi. On a down-feed system, Fig. 22 would have to be used for both the main riser and the smaller riser feeding the radiators in order not to increase the drop one $\frac{1}{32}$ psi. The return risers would be sized from the upper portion of the same column, while any wet-returns used would be sized from Column *I*. The same pressure drop is applied on both the steam and return sides of the system.

Notes on Vapor Systems

1. Pitch of mains should not be less than $\frac{1}{4}$ in. in 10 ft.

2. Pitch of horizontal runouts to risers and radiators should not be less than $\frac{1}{2}$ in. per ft. Where this pitch cannot be obtained, runouts over 8 ft in length should be one size larger than called for in the table.

3. It is not desirable to have a supply main smaller than 2 in.

4. When necessary, supply main, supply risers, or runouts to supply risers should be dripped separately into a wet-return, or may be connected into the dry-return through a thermostatic drip trap.

SIZING PIPING FOR TWO-PIPE VACUUM SYSTEMS

Vacuum, atmospheric, subatmospheric, and orifice systems are usually employed in large installations and have total drops varying from $\frac{1}{4}$ to 2 psi. Systems in which the maximum equivalent length does not exceed 200 ft preferably employ the smaller pressure drop, while systems over 200-ft equivalent length of run, more frequently are designed for the higher drop, owing to the relatively greater saving in pipe sizes. For example, a system with 2400-ft longest equivalent length of run could be designed for a pressure drop per 100 ft of 1 psi divided by 12, or $\frac{1}{24}$ psi. In this case the steam main would be sized from Fig. 22, and the risers also from Fig. 22 (Column *B*, Table 6, could be used as far as critical velocity is concerned, but the drop would exceed the limit of $\frac{1}{24}$ psi). Riser runouts, if dripped, would also be obtained from Fig. 22 but if undripped, from Column *C*, Table 6. Pipe sizes for other parts would be obtained as follows: radiator runouts from Column *C*; return risers from lower part of Column *S*, Table 7; and return runouts to radiators—one pipe size larger than the radiator trap connections.

Notes on Vacuum Systems

1. Pitch of mains should not be less than $\frac{1}{4}$ in. in 10 ft.

2. Pitch of horizontal runouts to risers and radiators should not be less than $\frac{1}{2}$ in. per ft. Where this pitch cannot be obtained, runouts over 8 ft in length should be one size larger than called for in the table.

3. In general, it is not considered desirable to have a supply main smaller than 2 in.

4. When necessary, the supply main, supply riser, or runout to a supply riser should be dripped separately through a trap into the vacuum return. A connection should not be made between the steam and return sides of a vacuum system without interposing a trap to prevent the steam from entering the return line.

5. Lifts should be avoided if possible, but when they cannot be eliminated they should be made in the manner described in this chapter.

6. No lifts can be used in orifice and atmospheric systems.

SIZING PIPING FOR INDIRECT HEATING UNITS

Pipe connections and mains for indirect heating units are sized according to the quantity of steam condensed by each unit. The condensate per unit depends upon the entering temperature and the air velocity, and may be obtained from manufacturers' rating tables. Where two or more units are placed in series, the entering air temperature for any unit will be the leaving temperature for the preceding unit.

When the amount of condensate has been obtained for each unit, the pipe sizes should be based on the length of run and the pressure drop desired, as in the case of radiators. It is generally desirable to place the indirect heating units on a separate piping system rather than to connect them to the piping which supplies direct radiation. For type of connections see section on Connections to Heating Units.

PRESSURE-REDUCING VALVES

While the illustrations of steam systems in this chapter indicate that they are supplied by separate boiler plants, it is also possible to have steam supplied by a remote boiler plant or by a district heating system at pressures higher than desired for the equipment served. District heating is discussed in Chapter 27.

There are certain fundamental principles that should be followed in the design of a building heating system which is to be supplied from district steam mains. Some of these are peculiar to district heating and some, although they may apply to any building, have been demonstrated to be particularly important when district steam is used. District heating companies have certain regulations regarding the consumer's installation to safeguard the mutual interest of supplier and consumer and to insure satisfactory and economical service. When an installation is designed, local regulations and code requirements should be observed.

Where steam is supplied from a boiler delivering steam at pressures higher than required for the heating system, one or more pressure-reducing valves (pressure regulators) are required. These are used in two classes of service, one