return piping usually follows the same grade as the steam piping. Return of condensate by gravity is desirable, but usually, the condensate is pumped back under pressure.

In a heating system the pipes carrying condensate are more subject to corrosion than other parts of the system. Care must be taken to give proper pitch to the pipes and to provide proper venting of noncondensable gases. (See Chapter 43, Corrosion.)

PIPE TUNNELS

Because of their relatively high first cost as compared with smaller conduits, *walking tunnels* are usually not provided for steam mains in the district-heating industry unless they are required to accommodate miscellaneous other services or to provide underground passage between buildings. However, in institutions a different approach may be justified. Many institutional buildings are expected to last several times longer than the life of underground conduit.

Adequate maintenance programs are frequently harder to initiate and keep up in institutions than in industry. As an underground steam line approaches the end of its reasonable life, traps, threaded connections, valve bonnets, gaskets, and expansion joints may require nearly continuous maintenance. Without walking tunnels it might be impossible to maintain steam service. When institutional appropriations for steam-main replacement are involved, some institutions try to postpone construction of new buildings until sufficient funds for walking tunnel extensions are available.

Tunnels are usually built of reinforced concrete or brick and are waterproofed on the outside. Provision for drainage is essential. Repair work along main lines may be seriously hampered if tunnels are less than 4 ft wide by 6 ft high. Tunnels with sidewalks running over the top are effective in melting snow. Special precautions to reduce corrosion from ceiling condensation is in order where ceilings are close to grade.

Tunnel piping is generally supported on racks at the side or sides of the tunnel or by ceiling hangers. Roller frames and insulation saddles may be used, or the lines may be placed directly on horizontal pipe supports. The latter construction may cause appreciable heat loss, due to bare pipe at the supports. Special attention should be paid to the corrosive effect of moisture in tunnels. Steel pipe supports and anchors in contact with the floor are especially vulnerable. Pipe supports made of steel pipe may be welded (using proper welding rods) to short lengths of cast-iron pipe embedded in the tunnel floor. Dipping the lower portion of supports in a protective coating before installation is helpful. Concrete mounds around the pipe supports at the floor help to divert water from the support. Pockets for supports should not extend through floors, walls, or ceilings, as entry of ground water will reduce the life of the support.

Fewer expansion loops and more expansion joints are expected in tunnels. Possibility of superheat as well as the steam pressure must be considered in providing for pipe expansion. Extraction steam from a turbine may be supplemented at night by steam direct from high-pressure boilers, and consequently the steam may be superheated as it passes through reducing valves at the power plant. Unanticipated superheat may cause excessive expansion which may damage anchors and the distribution piping system. Desuperheaters may be required ahead of the distribution piping. Thermometers at critical points will be helpful.

Spare expansion capacity in expansion joints may be desirable due to the following:

1. Workmen may allow unexpected tolerances in cutting and welding of lines.
2. Due to seasonal conditions, the temperature of the line at time of welding may not be at the lower design temperature or the temperature of the line may not be uniform at time of welding.
3. Partial failure of reducing valves may cause line pressures to exceed the design pressure.

Pipe anchors should be designed for line thrusts occurring with valves both open and closed. Liberal factors of safety for corrosion are desirable in sizing anchors. The tendency of anchors to slip along a pipe may be reduced by welding steel lugs to the pipe on either side of the anchor. The lugs will bear against the anchor in case slippage of U-straps or U-bolts occurs.

Branch lines will exert side thrusts on mains and produce distortion of the main and misalignment of expansion joints near the branch. Good design can be achieved by locating anchors exactly at tees and at Y-branches. Unless anchor designs are specifically detailed, workmen tend to install anchors on one side of branch tees, thereby causing distortions that the anchor was supposed to avoid. Where branches do not coincide conveniently with fixed anchors, sliding anchors may be used to prevent distortion of the main and yet allow movement of the branch with movement of the main. Special pipe guides may be necessary to prevent distortion of expansion joints. Expansion joints with both an anchor base and a branch service connection can be effectively used to eliminate troubles caused by branch line thrusts.

Where excessive tunnel temperatures will reduce efficiency of maintenance personnel, extra thick insulation may be desirable. For the same reason return lines in tunnels are insulated. For further comments on insulation in tunnels see Chapter 28.

Electric conduit for tunnel lighting may not last beyond the early life of the tunnel whether exposed or embedded in the concrete. Knob and tube wiring and bare lamps may be more satisfactory. Extensive tunnel systems effectively use 220 volt lamps to offset line loss.

Tunnel heat and high humidity may make tunnels uninhabitable for workmen when steam leaks must be serviced. Portable fans to blow air into one manhole and to pull it out of another may be essential. In addition, general ventilation obtained by a permanent fan, continuously operating, may be necessary. Perforated manhole covers located at ends of runs allow air to enter and sweep the tunnels. Doors across tunnels may be opened or closed to force extra ventilation air through that portion of a tunnel system where repair work is being done.

BUILDING PIPING AND EQUIPMENT

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. Although some of these apply to any building, they have been demonstrated to be particularly important when district steam is used.

Most district heating companies enforce certain regulations regarding the consumer's installation, partly to safeguard their own interests, but principally to insure satisfactory and economical service to the consumer. When an installation is designed, local regulations should be observed.