or not, depending upon the load on the conduit. Drainage is provided by the drainage pockets filled with crushed stone or gravel and may be installed on either or both sides of the conduit. They conduct water from the top of the conduit to the drain below which is connected to the sewer or some other disposal facility. Variations of the concrete-box type have side walls constructed of hollow vitrified tile, concrete blocks, or other suitable materials, and covered with a reinforced concrete slab. The top and sides are sometimes covered with a waterproofing membrane of asphalt or hot pitch and roofing paper.

The solid-pour construction, Conduit B, Fig. 1, is also usually made with common materials and consists of poured structural concrete which is vibrated and tamped around a conventionally insulated steam line. If the insulation has a high compressive strength it can support the pipe, otherwise, the pipe should be supported independently. Reinforcing is sometimes used to prevent settlement. An eccentric space may be left around the pipe by using insulation larger than the outside diameter of the pipe to permit upward movement of the pipe during the warm-up periods. During construction, pipe is suspended by wires. Precautions should be taken to prevent the pipe from floating. The top of the conduit should be coated with asphalt emulsion or tar to help seal shrinkage cracks. Anchor stresses are higher with this type of construction. Variations of this type include enclosure of the pipe and insulation in tile, concrete, steel, or asbestos pipe and then pouring of concrete around outer pipe. This method provides space for pipe supports, if needed. External drainage can be provided by methods similar to the concrete box type construction.

Conduits constructed of common materials are often preferred by the district heating industry because of the conditions imposed in congested street beds, heavy traffic loads, and drainage conditions or because of the ease of opening and closing the conduit, for branch pipe connections.

Prefabricated conduits, C and D, Fig. 1, are commonly constructed in standard lengths. In some, as in C, the insulated pipe or pipes are placed within a corrosion-resistant helically-corrugated metal jacket which is protected with a heavy asphaltic coating. Similar casings are made of steel protected with an anti-corrosive compound. Both are of welded construction and can be tested under air pressure. In conduit D the insulated pipe is placed concentrically within the corrosion-resistant metal jacket and the intervening space between jacket and insulation poured full of high melting-point asphalt or left as an air space. In these conduits, the pipes are supported by precast rings or guides to maintain alignment and to prevent pressure on insulation. Fittings are available for joints, bends, etc. Some of these conduits are also available with cast-iron casings.

Tile conduit E, Fig. 1, is constructed of specially-shaped glazed vitrified bell-and-spigot tile. In the conduit shown, the base drain is made in separate units and is designed to support the main conduit and pipe lines, and to drain the conduit. All joints are cemented. There are several types of tile conduits.

Monolithic conduits F and G, Fig. 1, are similar to the solid-pour type except that the insulation, referred to as insulating concrete, serves also as a conduit and is poured directly around the steam main. The insulation consists of expanded-mica, shredded-rubber or other cellular materials mixed with Portland cement or asphalt; or of a special foaming material mixed with Portland cement. The latter process creates a multitude of minute air cells in the concrete to obtain its insulating qualities. The poured structure is often protected by a water-proofing membrane and strengthened by a concrete duct.

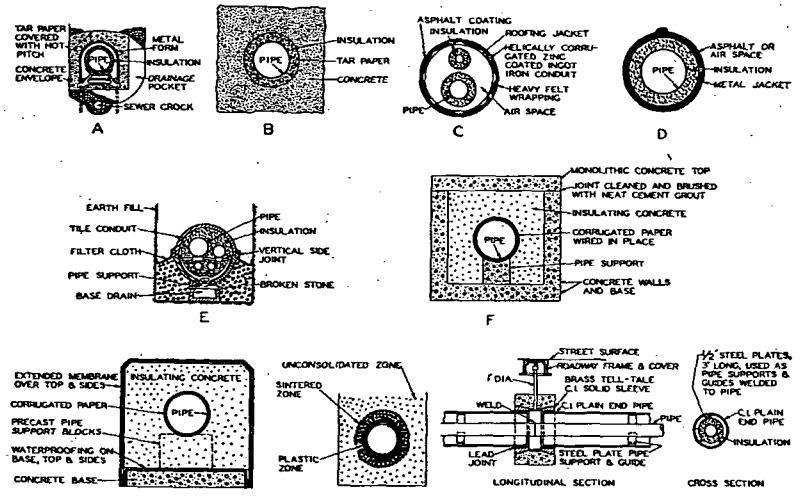


Fig. 1.... A Few Typical Conduits for District Heating Use



Granular-fused type conduits such as H, Fig. 1, consist of a specially sized and selected granular bitumen which is poured in the trench around the pipes. The manufacturers advise that the conduit is formed when heat passing through the pipes forms three distinct concentric zones, all resistant to water penetration. A plastic area surrounds the pipe, outside of which is a sintered zone providing thermal insulation, and finally, an outer layer of unconsolidated particles providing further insulation value. This unconsolidated zone is also the load-bearing portion of the structure.

Waterproof conduits are intended for use where permanency and thoroughly tight joints are required. Some of the prefabricated conduits, C and D, Fig. 1, can be supplied with water-tight cast-iron casings and fittings. The casing shown in I, Fig. 1, consists of cast-iron pipe with lead-caulked joints enclosing the insulated steam main. It is water tight and intended for special applications, where, for instance the duct may be submerged, subject to flooding, or laid in extremely wet soil.

All of the preceding conduits have their application and the choice depends upon local conditions. Any underground conduit is only as good as, among other things, its foundations to prevent settlement, its external and internal drainage, its ability to stand up under the corrosive action of certain ground conditions (see Buried Pipe Lines, Chapter 15 of the 1961 Guide And Data Book), its strength to carry the load imposed on it, its field installation, and its insulating properties.

## Manholes

When conduits are used for underground piping, manholes may be required to house valves and other accessory equipment. They are built of a variety of materials such as reinforced concrete block. They should have adequate volume to permit men to work on equipment. They should be as nearly waterproof as possible and precaution should be taken to prevent entrance of surface water around the covers. Provision should be made for lifting necessary equipment from the pipe line, for drainage, for ventilation, and for automatic water-removal equipment if a sewer is not accessible.

Details of typical manhole construction housing a single expansion joint are shown in the *NDHA District Heating Handbook*, Third Edition, p. 164. If more equipment is installed, the size should be increased accordingly.

Where water removal equipment is required, sumps are installed under the manholes. Water can be removed periodically with portable pumps, or, where water conditions are bad or periodic inspection is not feasible, by installed sump pumps or water ejectors.

The motors for electric pumps should be enclosed in a separate compartment which is ventilated to protect it from heat and vapors. Precautions should be taken against corrosion as mentioned in the Section Piping and Accessory Equipment.

## Piping Tunnels

Because of their relatively high first cost as compared with conduits, walking tunnels are usually not provided for steam mains unless, as in some institutions, they are required to accommodate miscellaneous other utility services or to provide underground passage between buildings.

Tunnels are usually built of reinforced concrete, brick, concrete blocks or other suitable structural materials, and are waterproofed on the outside. Provision for drainage and ventilation is essential.

Since tunnels and conduits are apt to be hot and humid, special precautions should be taken to reduce temperatures and protect equipment. Heat loss from pipes and supports can be reduced by insulating return mains and using more than normal insulation on steam mains. A metal jacket over the pipe covering can permit insulation to carry the weight of the pipe.[8]

The precautions on sizing, design, installation, and protection against corrosion, for accessory equipment, as discussed in the sections Piping and Accessory Equipment, and Conduits for Piping, should be taken for tunnels. Special precautions should be taken to prevent rapid deterioration of enclosed electrical conduit. All electrical boxes, junctions and outlets should be vapor proof. Ventilation of the tunnel can be obtained by installation of suitable fans or by natural means.

## Piping and Accessory Equipment

A district heating distribution system is usually buried in the ground where it is not readily accessible for repairs or replacement. This makes it imperative that the system be carefully designed and installed. The *American Standard Code for Pressure Piping* ASA B-31.1—1955[9] has sections, covering district heating piping systems and fabrication details, from which general specifications and minimum requirements for piping and accessory equipment can be obtained.

Suggestions for selection and installation of materials based on long operating experience of the district heating industry are given in following paragraphs. More detailed information is available in the *District Heating Handbook*, Third Edition.[10]

*Pipe.* Either steel or wrought-iron pipe is satisfactory. Welded construction is most desirable.

*Valves.* Flanged cast-iron valves for pressures under 125 psig are satisfactory. For pressures from 125 to 300 psig flanged-steel and welded-end valves are used. Outside screw and yoke valves are preferred.

*Fittings.* Forged or rolled steel is used for pressures in excess of 125 psig. Where pipe-line apparatus is to be removable, flanged fittings are preferred.

*Expansion Joints.* Pipe bends to absorb expansion are preferable wherever feasible in order to eliminate the inspections, maintenance, and housing required by slip joints. Slip joints should be guided either externally or internally, or both. Corrugated-type joints should have stainless steel or copper corrugations depending upon operating conditions. Spare expansion capacity should be allowed for contingencies such as higher pressures, superheat, and installation tolerances.

*Anchors.* Anchors can be of structural steel, special fittings, or U-shaped steel straps which partially encircle the pipes. Anchors should be firmly bolted or welded to a short length of cast or stainless steel set in concrete. Anchors are often fabricated by welding structural steel to pipe and embedding the ends in manhole walls or concrete poured in connection with conduit. Anchors are subject to humid conditions in conduits and manholes, and can deteriorate rapidly. They should be designed for adequate strength, intended life, and the steam pressure to which they can be subjected, with liberal factors of safety and protection from corrosion. Anchors should be attached to both sides of the pipe. Lugs should be welded to pipe on both sides of loop-type anchors to prevent slippage. The cantilever type of anchor should be avoided. Cast steel is preferred to cast iron for anchor material.

*Alignment Guides.* To assure pipe alignment and proper operation of expansion joints, pipes should be adequately guided. Special precautions should be taken if the pipe deviates from a straight line.