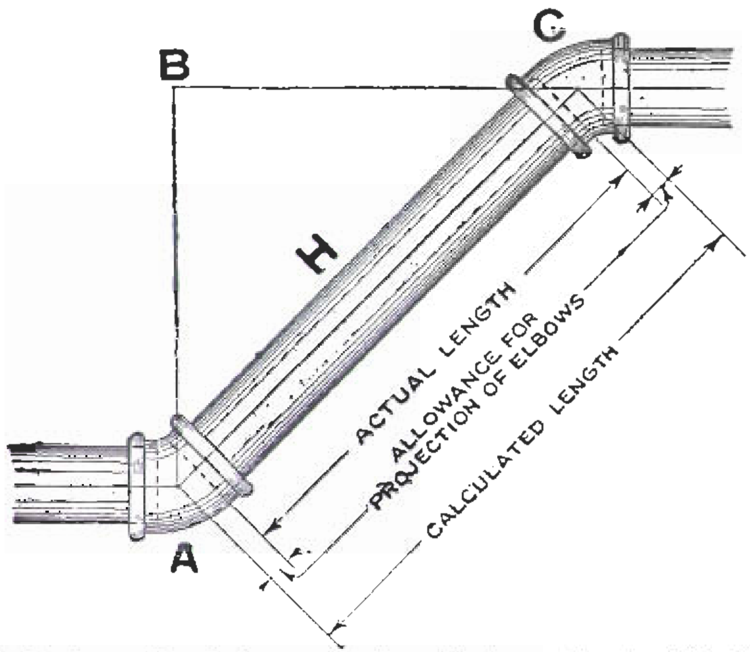
CALCULATION OF OFFSETS



Calculated and actual length of connecting pipe with elbows other than 90°. Note carefully the allowances or deduction from calculated length for projections of elbows.

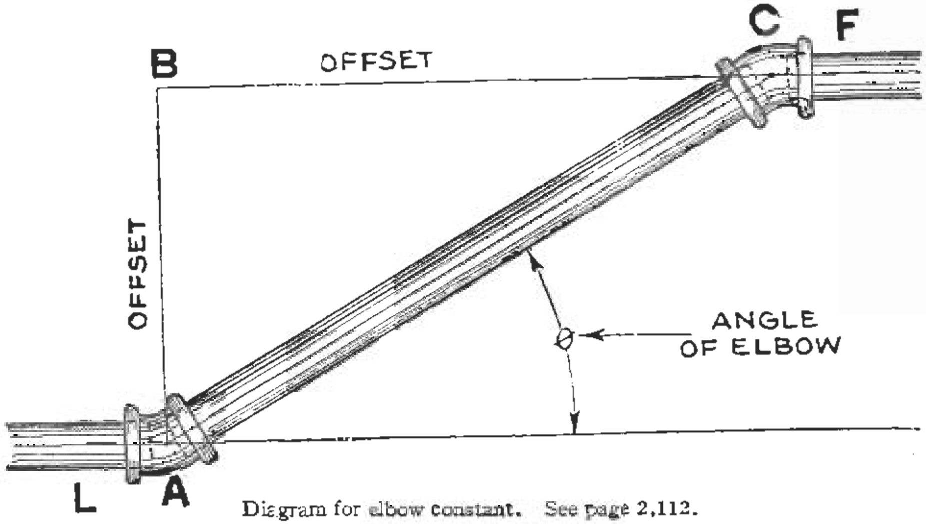


Diagram for elbow constant. See page 2,112.

NOTE.—Methods of calculating offsets, 1. by the aid of geometry will be found on page 3,110, and 2. by aid of trigonometry on pages 1,128 and 1,129 (in Guide No. 1).

"BY HAMMER AND HAND ALL THINGS DO STAND"

AUDELS PLUMBERS AND STEAM FITTERS GUIDE #3

A PRACTICAL ILLUSTRATED TRADE ASSISTANT AND READY REFERENCE

FOR

MASTER PLUMBERS, JOURNEYMEN AND APPRENTICES
STEAM FITTERS, GAS FITTERS AND HELPERS,
SHEET METAL WORKERS AND DRAUGHTSMEN
MASTER BUILDERS AND ENGINEERS

EXPLAINING IN PRACTICAL CONCISE LANGUAGE
AND BY WELL DONE ILLUSTRATIONS, DIAGRAMS,
CHARTS GRAPHS AND PICTURES THE PRINCIPLES
OF MODERN PLUMBING PRACTICE

BY

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THEO. AUDEL & Co. - PUBLISHERS
4[illegible] W. 23RD ST., NEW YORK, U. S. A.

Reprinted 1953

AUDELS PLUMBERS AND STEAM FITTERS GUIDE 3

Printed in the United States

Foreword

These Guides give first hand reliable practical information in clear and concise form. They illustrate ***Plumbing*** in its many practical applications in the clearest and plainest manner and in a way not to discourage the searcher for practical plumbing knowledge, but to make an interesting, instructive and useful reference for all interested in any branch of plumbing.

In the prepartion of these Guides, the aim of the author has been to present the subject in ***the simplest possible manner***, because no matter how well informed the reader may be, he absorbs the desired information much more readily when presented in simple, brief language, than he would when confronted with an unnecessary display of technicalities.

The aim throughout has been to simplify and give information on ***every phase of plumbing***.

Frank D. Graham.

CHAPTER 124A

Radiant Heating

Ques. What is radiant heating?

Ans. Radiant heating is a method of maintaining comfort conditions in enclosed spaces by limiting the heat loss from the human body by radiation and convection.

This is accomplished by warming relatively large areas of the floor, ceiling or walls of rooms to low temperatures, as contrasted with the common practices of heating small surfaces to high temperatures.

Ques. What are the various methods of heating used in a radiant heating system?

Ans. The most common method of supplying heat in a radiant heating system is by embedding hot water or vapor steam pipes in the structure of the building. Other methods of radiant heating are:

1. By the warming of plaster on interior walls and ceiling surfaces.
2. By circulating warm air through shallow ducts beneath the floor or in spaces formed by the side walls.
3. By the use of electrically heated metal plates or glazed fire clay panels.
4. By the use of electrically heated tapestry formed into portable screens or hung on the walls of a room.
5. By attaching fabricated metal plates circulated by hot water or low pressure steam to walls or ceiling.

Ques. What is the method used in the installation of a radiant heating system?

Ans. Essentially, the principle adopted in heating floors, walls or ceilings, is to embed specially constructed pipe coils in the floor, walls or ceiling. These coils are generally constructed of small bore wrought iron, steel, brass or copper pipe, usually ⅜ in. to 1 in. inside diameter.

Ques. Should extra heavy insulation be applied on buildings heated by means of radiant heating?

Ans. No. No more insulation is required for radiant heating than for any other heating system. In fact, an improperly insulated home, which will be considered frequently as uncomfortable because of its prevailing low wall surface temperatures, will result in greater comfort when radiant heating is installed. This system, will to a greater degree, heat the inner surface of the outside wall. However, two factors should be considered:

1. Install ceiling systems only, in homes with fair insulation in order to avoid excessive floor outputs and overheated floors.
2. Consider that insulation always pays for itself by considerable fuel savings.

Ques. Is air venting and draining necessary in panel heating systems?

Ans. Air venting is an essential feature of the control of any panel heating system, because any small amount of air collecting in either of the circuit pipes or pipe coils will cause continued trouble and invariably result in a shortage of heat.

An arrangement similar to fig. 1 will greatly facilitate uniform venting. Due to the continuous slope of the coil connections it may prove sufficient to install automatic vents at the top of the return riser only, and omit such vents on the supply riser.

The fill and drain line according to this scheme are connected at the boiler. The difference of elevation H, should not be less than 3 in. or sufficient to provide for a continuous slope in the coil connection. It should be observed however, that this slope should not be of too great a magnitude in order to utilize fully the gravitational forces acting upon the system when heated.

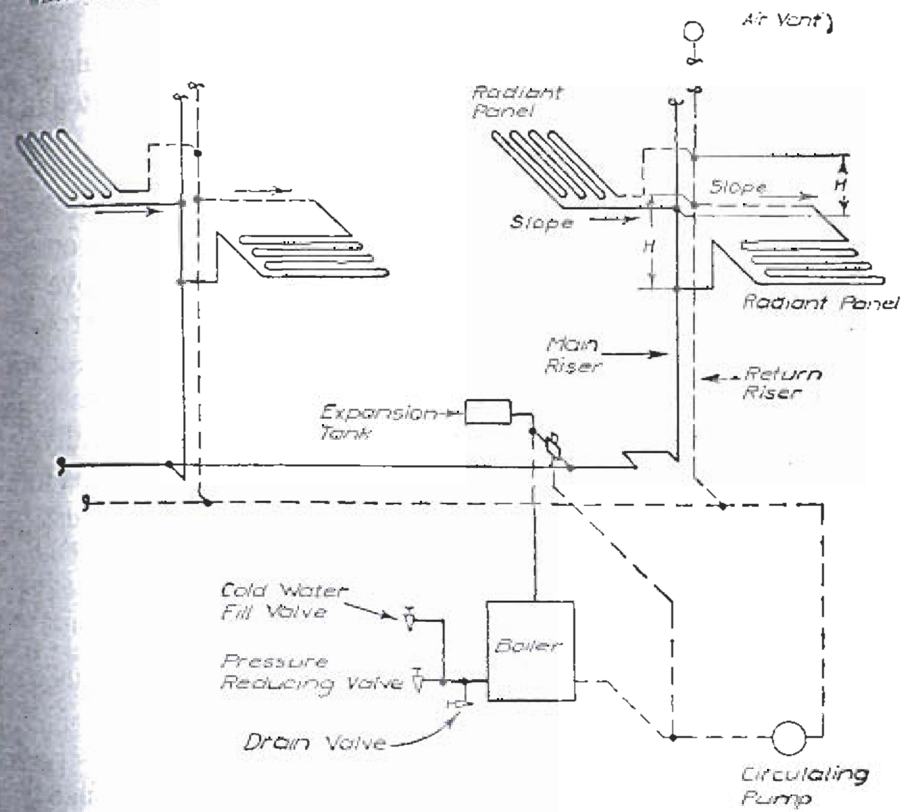


Fig. 1.—Schematic diagram of radiant panel heating system showing draining and venting of circuit pipe and coils.

Ques. Does radiant heating systems have a tendency to leak?

Ans. Not if properly installed and tested. After completion of the installation a hydraulic coil pressure test as recommended by the tube or pipe manufacturer is applied to the system.

Generally the material surrounding the coil protects it from corrosion. An additional safety measure is to connect the coils to the water supply source during the installation period. Thus if the piping become damaged it will be immediately noticed.

Ques. In a radiant heating system, must heating coils be in direct contact with plaster or cement or will a coil located in a dead air space deliver heat satisfactorily?

Ans. A coil hung in air space delivers heat in both directions, up and down. The amount of heat delivered depends on the insulating properties of the ceiling below and floor above the air space, and in some cases, may be sufficient to heat the rooms. Since the air layer surrounding the tube and pipe represents a considerable thermal resistance, all systems with suspended coils operate on higher water temperatures and generally on closer pipe spacings or larger pipe diameters than systems with embedded coils. Copper tubes used in air spaces must be painted dull.

With embedded coils, the pipe diameter is of small influence upon the heat output; with suspended coils, this output increases considerably with the diameter. In general, suspended coil installations are more costly than those using coils embedded in building materials.

Ques. In a radiant heating system is it possible to use the ceiling panel of the first floor to heat a room on the second floor?

Ans. Since heat flows in two directions, that is, both up and down, it is obvious that the second floor room will be heated as well; even with the most effective insulation. This heat flow in the opposite direction is designated as *panel heat loss* and may or may not be usefully applied.

Under certain conditions, such as with coils embedded in concrete slabs, the heat loss upward may equal the ceiling panel output.

Although such conditions influence favorably the erection cost, the temperature of the second floor room will be greatly influenced by regulation of the coil below, which must be considered in the design of the system.

Ques. What are the highest allowable panel surface temperatures in a radiant heating system?

Ans. Temperature conditions satisfactory for comfort by the occupant are the highest allowable. With floors, the maximum allowable temperature changes with the type of occupancy.

Continuously occupied spaces should operate with floor temperatures of 85° F. or less. On ceilings the maximum allowable temperature changes with the ceiling height. Generally 100° F. is considered maximum for 7 ft. ceilings and 10° F. are added for each additional foot. Thus, the maximum allowable temperature of a 9 ft. ceiling is 120° F. With coils embedded in plaster, 130° F. is considered as maximum ceiling surface temperature.

Ques. What method is used to reduce the pressure drop in radiant heating coils?

Ans. One method of reducing the pressure drop is to increase the temperature drop of the water in the coils. Theoretically this drop could be as high as 50° F. and more, but practically it is restricted. The maximum water temperature for floor panels is set, and rather low, by the allowable maximum floor temperature.

Also, for ceiling panels the water temperature is restricted if such panels be installed in rooms with low ceilings. With 8.5 ft. ceiling height for instance, the panel surface temperature should not exceed 115° F. and the maximum water temperature must be selected accordingly.

The minimum or return water temperature also is restricted by the panel efficiency. For obvious reasons a tube conveying water of a mean temperature of 80° F. will result in small panel heat output. For practical purpose, and with the presently used panel structures, temperature drops of from 15 to 30° F. in the floor panels, and from 20 to 35° F. in the ceiling panels are used. In most cases, it is possible to assume the mean water temperature as mean of the maximum (coil inlet) and minimum water (coil outlet) temperature.

Ques. Is damage caused by difference of expansion of copper in concrete or iron in plaster?

Ans. No. Not with systems installed according to the several well-known installation practices. These practices should be adhered to, and care should be taken that proper concrete and plaster mixtures are applied. Actually, differences in expansion are met with any two materials used in conjunction. However, these differences are slight and result in stresses in masonry and tube materials of such small magnitude that they are readily absorbed by the materials in question.

Ques. Can ventilation be applied to radiantly heated rooms?

Ans. Yes. In fact, radiant heating and particularly ceiling heating, is of great advantage where high rates of ventilation are called for. The reason for this is that comfort may be found not only in rooms of 70° F. ambient and 70° F. mean effective temperature, but also in rooms of 55° F. ambient and 85° F. mean effective temperature. Hence, in a radiant heating system, properly designed to take into account a large air change, rooms can be operated with low air temperature, and its inherent higher relative humidity.

Considering a mean outside temperature of 40° F. throughout the heating season, a system thus designed will save half of the fuel required for ventilating purposes. Expressed in other words, when replacing conventional heating by radiant heating, for the condition described, the rate of air change may be doubled without causing an increase of the annual fuel bill. Because of the extra favorable atmospheric conditions met with in such systems, they should be applied where possible to hospitals, and particularly to tuberculosis institutions.

Ques. Can radiant hot water panels be installed in small or low cost homes?

Ans. Yes. Hot water panels are being used increasingly in small, basementless homes where compact boiler burner package units, that fit into closets or small utility rooms provide ample hot water.

Ques. Does hot water panel heating require special boiler equipment or special fuel?

Ans. No. Conventional forced hot water heating plants are used and any one of the popular or available fuels may be used.

Ques. Can additions be made to a hot water panel system or installations made in remodeling an existing house?

Ans. Yes. The installation of additions will be facilitated if the original design allows extra capacity for the addition in the mains, pump and boiler, to the same extent as with any other heating system.

Ques. Are repairs to hot water panels frequently necessary or expensive?

Ans. No. A well designed panel system should require no maintenance. The boiler, pump, controls, etc. are maintained in conventional manner.

Ques. How much heat can be obtained per lineal foot of pipe?

Ans. No one answer can be given. The heat output depends on the pipe or tubing size, the temperature of the circulating water and the spacing of the pipes as well as their location in the panel. Also account must be taken of the construction and location of the panel and the temperature of surrounding air and surfaces. Any output up to about 75 B.t.u. per lineal foot can be obtained.

Ques. How many feet of tube or pipe can be used in one continuous coil?

Ans. Various factors determine the maximum length of coils so that no all inclusive figure applies. In the usual designs, 200 feet is the limit for ceilings and walls using ⅜ in. tube. Floor coil lengths up to 180, 280 and 450 feet may be used for ½ in. ¾ in. and 1 in. respectively.

Ques. Are radiant panel piping installations designed for steam as the heating medium?

Ans. No. The use of steam introduces too many complications.

Ques. What controls are necessary or desirable?

Ans. Panel heating may be installed with no more than what might be used on a conventional radiator installation. However, the somewhat slower response of the majority of panels to changes in heating demand makes it desirable to use a "continuous" type of control system. For typical control system see page 3,840-40.

Ques. Should domestic hot water be taken from the panel system, also should the water in the panel system be replaced frequently?

Ans. No. Addition of fresh water should be kept to a minimum to avoid accumulation of the impurities present in the water.

Ques. What precautions are necessary when closing up a home equipped with radiant heating during the winter months?

Ans. To meet this contingency, the heating system may either be drained out completely, or a good permanent non-alcoholic anti-freeze may be used to prevent the water in the system from freezing. A well designed heating system should drain itself completely and generally from one location without resort to compressed air.

If the closing up of the house be of a relatively short duration, provisions may be made for a continuous operation of the system and the thermostat set at its lowest setting which is usually 40 to 50° F.

Ques. Should provision be made for draining the panel system?

Ans. Yes. The system should be laid out with a vent at the high point, a drain at the low point, and without traps in it, so that it can easily be drained by conventional methods.

Ques. Should cold water be circulated through the piping as a means of summer cooling?

Ans. No. Sweating of the panel may result unless certain precautions are taken. Unless the prevailing humidity is low, this means of cooling is generally impractical.

Ques. Can a hot water panel be satisfactorily designed to operate without a pump or circulator?

Ans. No. Extremely large pipes would be necessary and control would be difficult.

PANEL LOCATION

Ques. Why is radiant panel heating recommended for ceiling installation when the logical place for the panel would seem to be in the floor?

Ans. Ceiling installations provide a greater percentage of radiant heat transmission than either floor or walls. Only about 50% of heat emitted from a floor panel is by radiant rays while about 65% of heat emitted from ceiling panels is in radiant form.

Ques. Why are wall panels not used more frequently?

Ans. If outside walls be used, heavy insulation is needed to minimize heat loss to the outside. If inside walls be used, room

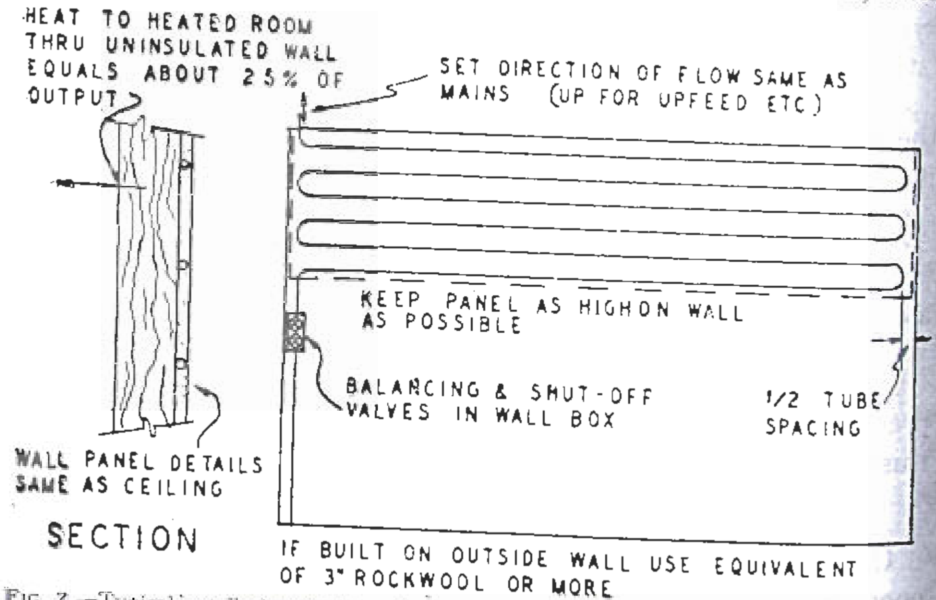


FIG. 2.—Typical installation of wall radiant panel. Installation of wall panels generally follow the same steps as ceiling coils. This typical diagram indicates the desirability of having wall panels high on the wall to prevent screening effect on heat output by placement of furniture. In certain cases of wall installation such as under windows to supplement floor panel installation placement of piping high on wall is not practicable.

tends to be cool near outside walls, warm near the inside. Wall installation is usually used to supplement floor or ceiling panels.

Ques. Does a hot water panel heating system respond to rapid changes in the heating demand such as may be caused by sudden changes in the weather or the incidence of sunlight.

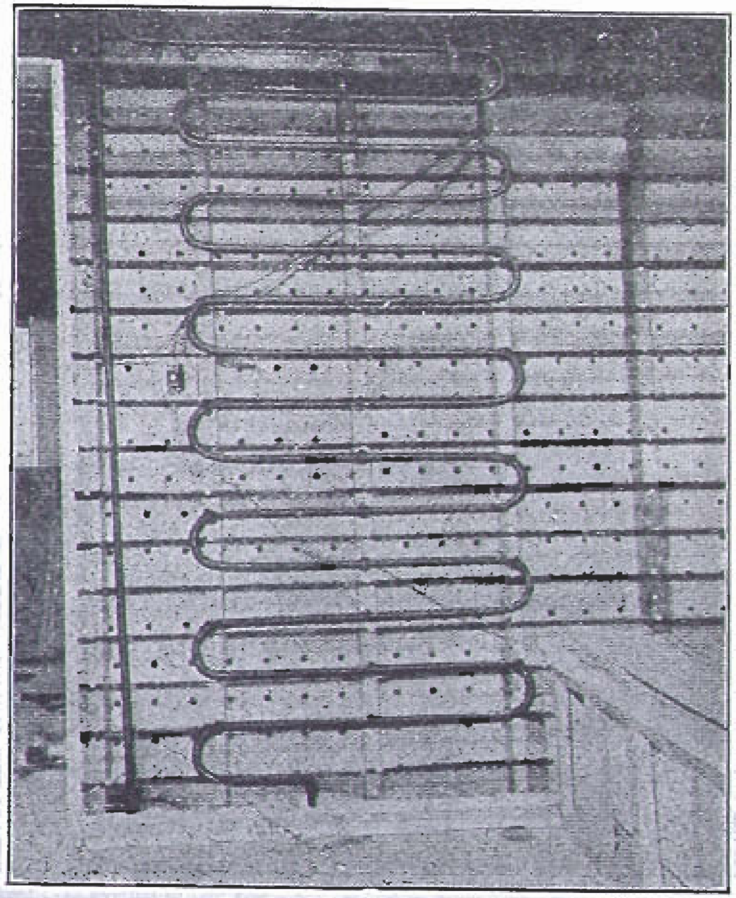
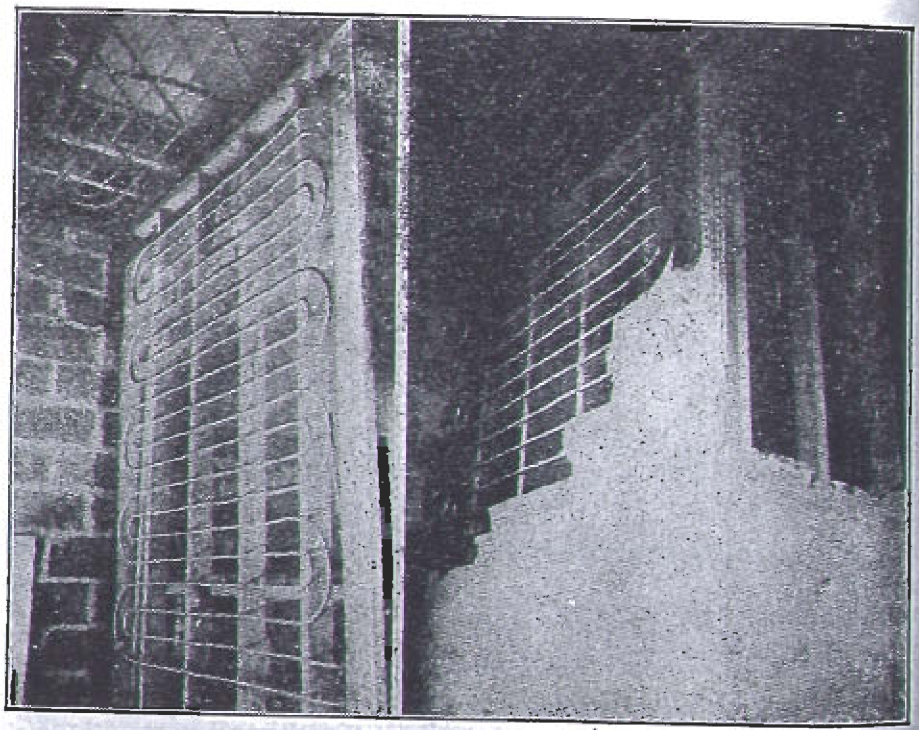


FIG. 3.—Showing typical installation of wall panel in radiant heating system. Although wall panels are usually confined to the upper parts of the walls, bathroom and certain kitchen installations can be run to the floor for concentrated heating. *Courtesy Chase Brass & Copper Co.*

Ans. Speed of response to changes in heating demand vary widely according to panel construction and location and type of control system. Generally panels with less mass respond faster. Control systems of the *continuous* type respond better than those of the *on-off* type.

Ques. Are different sizes of pipes or tubes used in ceilings than are used in floor panels?

Ans. Floor coils are ordinarily of ½ in. ¾ in. or 1 in. inside diameter. Ceiling coils are usually ⅜ in.



FIGS. 4 and 5.—Illustrating method of installing copper tube coil on wall panel with coil attached on room side of metal lath. Here the bottom of the coil is being located approximately 4 ft. 6 in. from the floor. Fig. 5 shows scratch coat of plaster being applied to wall after installation and test of radiant heating coils.

CEILING PANELS

Ques. Do hot water panel coils, when properly installed, have any tendency to crack the plaster in ceilings?

Ans. No. Usual type of hairline cracks from shrinking may appear in the best built homes, but properly designed and installed panel coils in themselves will not cause cracking.

Ques. How does a ceiling panel heat a room since heat is known to rise?

Ans. Hot air rises, heat does not. Heat transmitted by radiant rays flows downward as well as in any other direction. Direction of heat flow depends primarily on panel location.

Ques. Should the heating system be used to dry out the plaster in ceilings?

Ans. No. Uneven drying, cracking and marking may result. Allow plaster to cure and dry thoroughly just as though no coils were present.

Ques. Why should insulation be placed above ceiling panels which are below an unheated space?

Ans. Heat losses to the space above will be excessive unless insulation be used.

Ques. Can panel heated ceilings be decorated with wall-paper or paint?

Ans. Yes. With wallpaper, be sure plaster has cured before application. Let paper paste dry thoroughly before gradual heating of panel. Allow paint to become hardened before heat is applied. Certain oil and varnish base paints may be unsatisfactory for use.

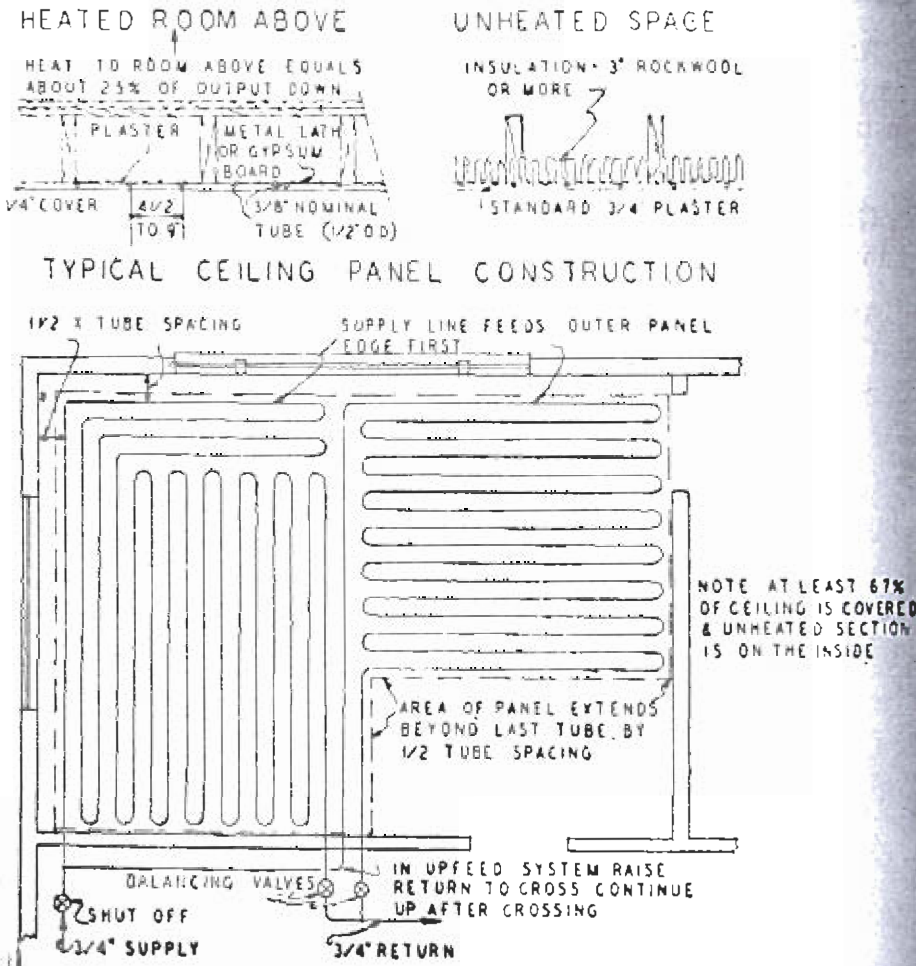


FIG. 6.—Typical piping diagram for ceiling panel. As indicated in the diagram hot water enters the circuit near the exposed wall and leaves the panel from the inside. The water control valves may be located in either the return or supply line to suit the convenience of the particular installation. Surface of the lath should be reasonably level. Coils may be preformed and lifted into place or may be formed on the ceiling itself depending upon what type of piping is used and method of joining.

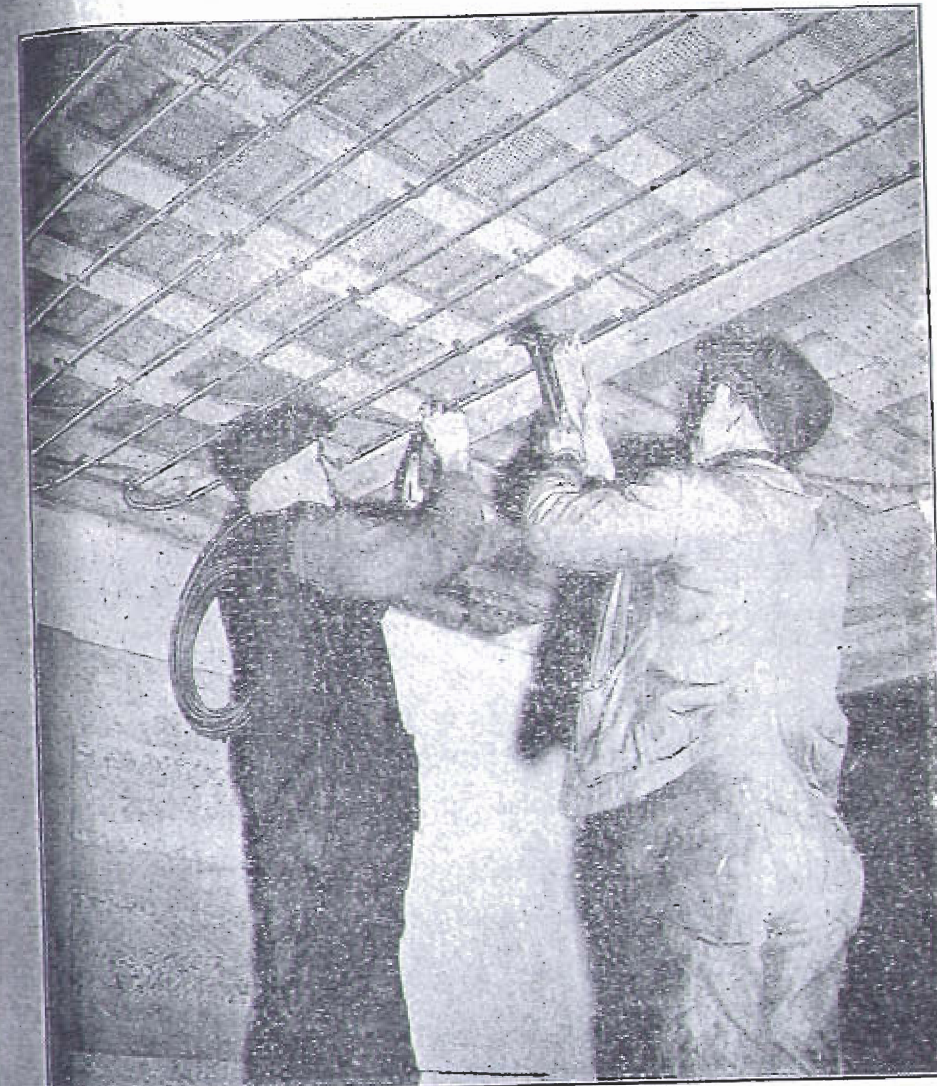


FIG. 7.—Showing method of installing copper tubing on ceiling. The copper tubing because of its great flexibility is easy to install on the ceiling while it is being uncoiled. Note how a board is being used to space the tubing evenly. *Courtesy Chase Brass & Copper Co.*

Ques. Can ceiling pipes or tubes be installed above the metal lath?

Ans. Only when plaster is applied so that it pushes through the lath and practically surrounds the tube.

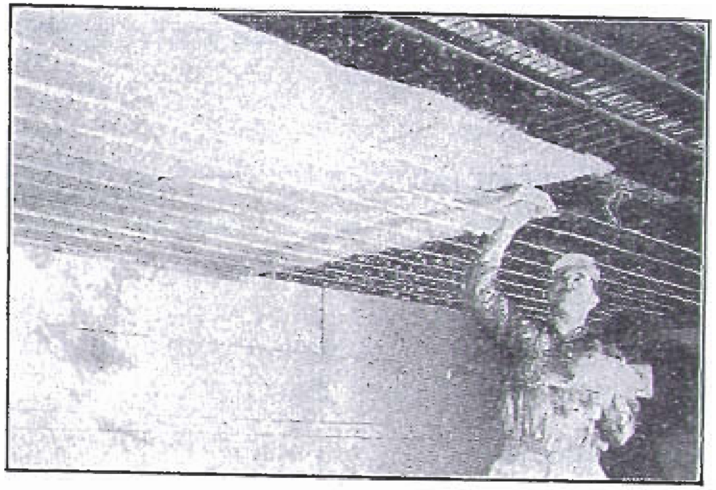


FIG. 8.—Showing application of first coat of gypsum plaster to ceiling. Other coats will give final cover of ¼ inch over copper tube. *Courtesy Chase Brass & Copper Co.*

Ques. Should ceiling panels be installed above plywood or composition board surfaced ceilings?

Ans. Such surfaces have an insulating effect which is undesirable. Full heat output of the ceiling panel is thereby diminished.

FLOOR PANELS

Ques. Will rugs on a floor panel interfere with heat radiation? Will the rug be damaged?

Ans. No. Radiation will be slower until the room warms up; then there will be little difference. The insulation effect of carpeting or rugs can be balanced by maintaining slightly higher water temperature. No damage or "drying" of rugs is apt to occur with floor surface temperature of 85° F. or less.

Ques. Does floor panel installation affect floor varnish or wax polish, and are the coils apt to cause buckling of floor boards tile, or damage linoleum?

Ans. No. If floor surface temperature be held to 85° F. or less the heat will not exceed that of summer sunlight falling on surface of the floor.

Ques. What is to be done if the total floor output with floor surface at maximum temperature be less than room heat losses?

Ans. Use ceiling panels or supplement floor panels with auxiliary ceiling or wall coils.

Ques. What are the recommended floor constructions for panel heating in floors?

Ans. Tubes or pipes buried in concrete at least 3½ ins. thick and a floor covering of tile, terrazzo, asphalt tile, linoleum or carpeting. Wood flooring of the thin type laid in mastic is also suitable. If floor be built on ground, provision should be made for ground water drainage and the slab edges should be insulated.

Ques. At what depth should piping be placed in concrete floor?

Ans. At least 2 ins. but more if loads on floor be heavy. Depth of bury usually varies between 2 and 4 inches.

Ques. How long should concrete floor set before applying heat?

Ans. At least 2 weeks is recommended and then heat may gradually be applied.

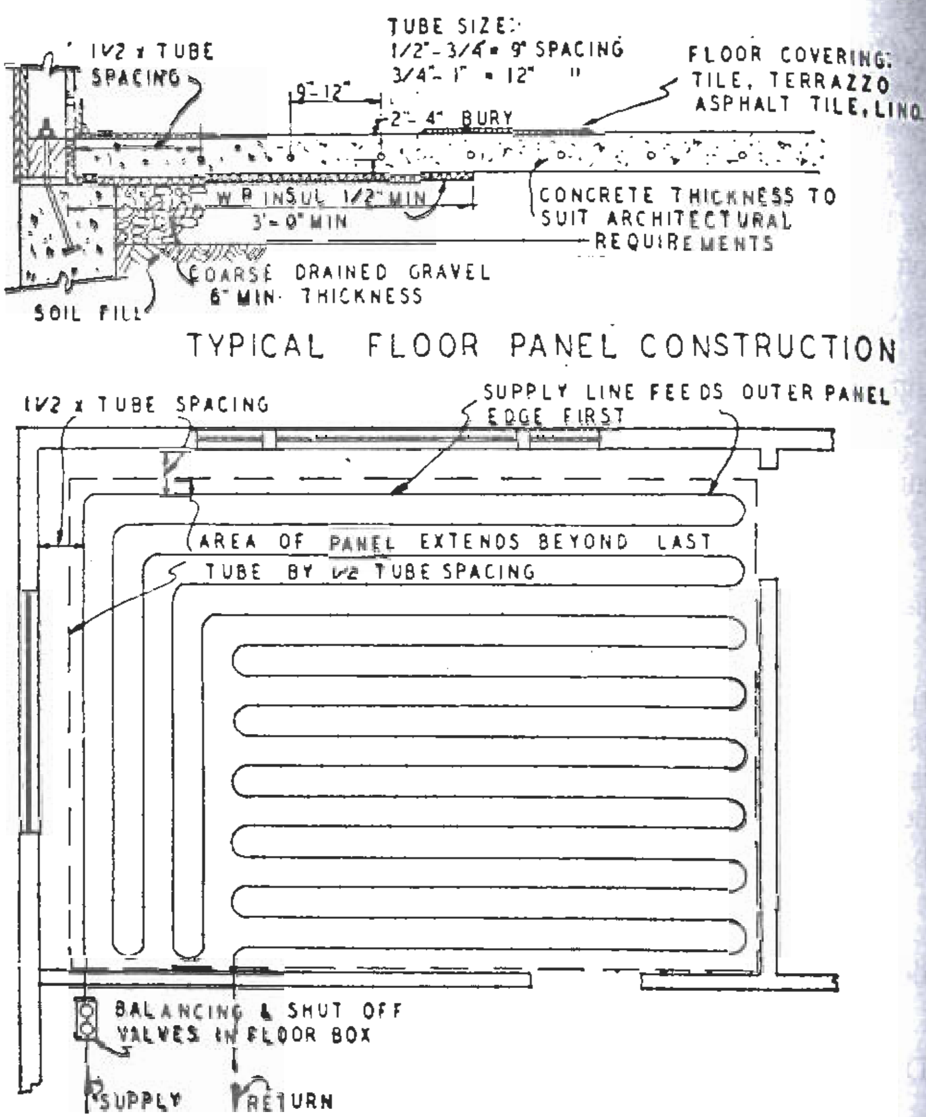


FIG. 9.—Typical piping diagram for floor radiant panel. Installation of hot water coils in floor slabs usually vary little from this typical layout. There is a latitude regarding the depth of burying the coils, but the important thing is to observe that the tubing be all on one level to prevent air pockets and to facilitate drainage. No provision need to be made for different coefficient of expansion of materials as long as tubing be contained in one solid slab. Where slabs are separated by expansion joints and tubing runs from one to the other, a ½ inch felt wrapping extending one inch from face of each slab will ordinarily absorb movements due to expansion.

Ques. How much heat will flow to the ground from a floor panel built on the ground?

Ans. This will vary with the type of construction, fill, etc. If the ground be dry, average floor is estimated to lose 10% to 20% of the amount of heat given to the room.

Ques. Will heat be lost from the slab edges when floor is built on the ground?

Ans. Yes. Heat losses to the outside through the slab edges will probably be greater than amount lost straight down to the ground. Waterproof insulation ½ to 2 ins. thick should be installed continuously along the edges.

RADIANT HEATING PANEL INSTALLATION

Ques. What coil shapes are used in radiant heating systems?

Ans. The coil geometry depends upon such factors as pressure drop, required shape of space to be heated, material employed, whether steel, wrought iron or copper.

For economical reasons it is important to lay out pipe lines with long straight runs. With soft copper tubing a minimum of soldered joints should be provided. For this reason it is desirable in general, to build coils figs. 10 and 11 in such a manner that the length L, is larger than the depth D. Also when using soft copper tubing it is preferable to design coils using not more than two to four lengths of tubing.

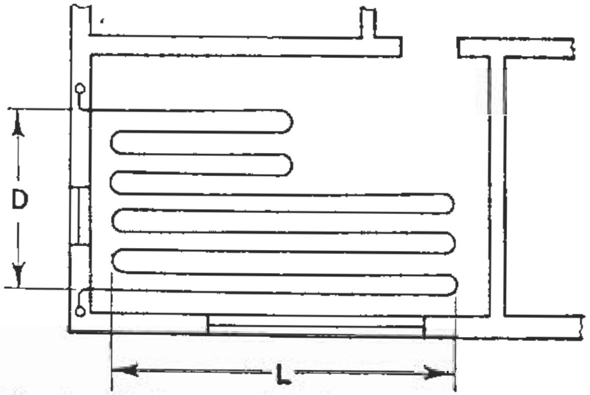
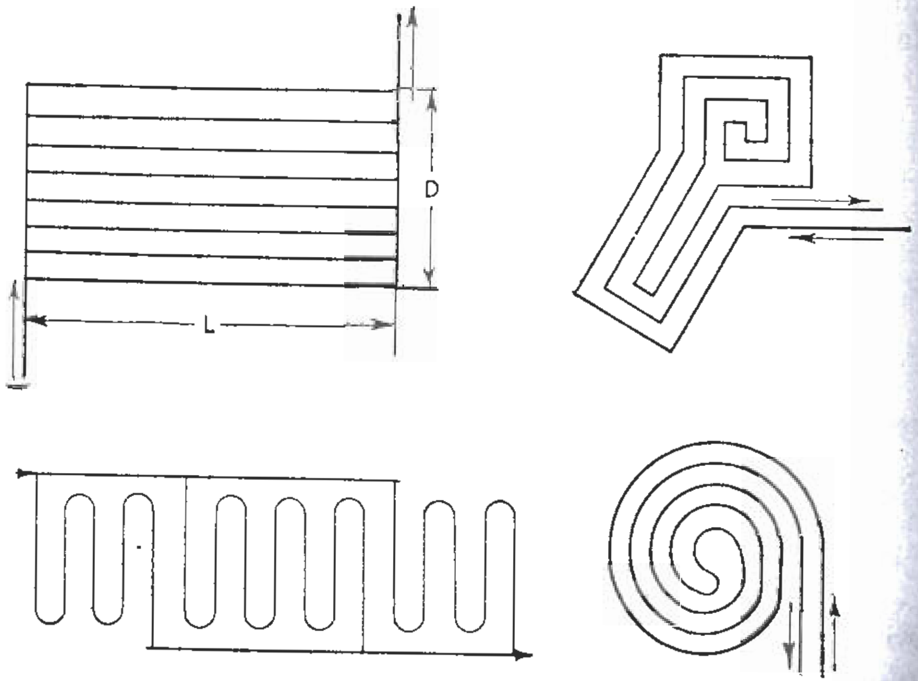


FIG. 10.—Illustrating shape of the conventional sinusoidal coil.



FIGS. 11 to 14.—Fig. 11 illustrates a grid type coil employed only where low pressure drop or possibly constant panel surface temperature is required. Fig. 12 illustrates a coil suitable for a room with irregular shape. Fig. 13 shows a combination grid and continuous coil which is used in large installations where heat requirements necessitates the use of several coils. In a coil system hook-up of this type common supply and return headers are connected to the mains, just as in an elementary grid system. Fig. 14 illustrates a coil fitting into round spaces.

When laying out a heating system it is necessary to select the panel arrangements which will result in the best room comfort conditions. In most cases it will be advisable to locate the panel close to the outside enclosures. Generally in rooms having the greatest heat loss and smallest available panel area, it may be necessary to spread the coil over the entire ceiling or floor surface. In all other rooms the heating coil may not cover more than one half to three quarters of the ceiling or floor surface.

Ques. What size and weight should the heating panel have for stable heat control?

Ans. From the standpoint of design as the limiting factor for effective and stable heat control, the size and weight of the heating panel should always be kept as small as possible; this being particularly important in a light structure.

For heavy masonary structures the weight of the panel is of no great control importance, since in such cases, the ratio of the thermal capacity of the panel to that of the structure, is in any event, favorably small.

Ques. What tube dimensions and distance between centers are commonly used in radiant heating?

Ans. When laying out radiant heating panels a number of combinations of water temperature, tube spacing, and tube diameter may be computed, all of which result in the desired heat output.

Floor Panels.—When considering floor panels the surface temperature is generally restricted to 85° F. In a great number of such panels, the tubes are covered by layers of material having low heat conductivity such as linoleum, wood flooring, etc. which results in small temperature gradient between the parts of the surface located directly above the tubes and the parts of the surface between the centers. For this reason, it is possible to use the more economical larger tube spacings with slightly larger tube diameters.

In high conductivity panels, such as plain concrete slabs, and where the depth of tube cover is small, it is advisable to restrict the pipe spacing to 12 ins. or less in order to avoid great temperature variations between the various points of the floor surface.

Ceiling Panels.—In most ceiling panels, the dimension governing the coil layout is the plaster thickness. Prevailing building practice calls for ⅜ in. nominal round or ½ in. oval tubes, or otherwise to increase the depth of plaster to provide for proper tube cover for ½ in. or ¾ in. nominal tube or piping.

As with floor panels the selection of larger tube spacings in connection with higher water temperatures will prove economical although with the tube spacings of approximately 12 in. or over the efficiency of the panel decreases slightly. The heat flow conditions of wall panels are essentially like those of the ceiling panels.

FABRICATION AND INSTALLATION OF HEATING COILS

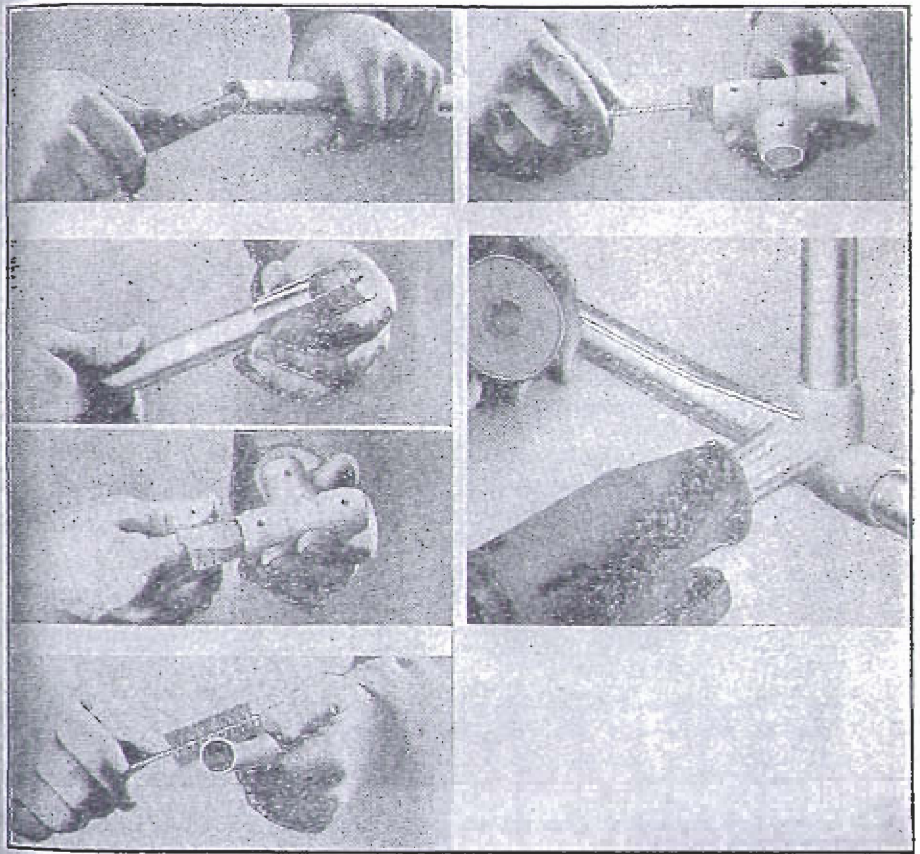
In planning a radiant heating installation full consideration should be given to the methods of fabrication of coils to be installed. If a free choice be given with respect to the materials to be used in the piping system, the selection should be made on the basis of high thermal conductivity of the piping material, its workability, ease of handling, weight of piping, lengths available in addition to the cost of making the necessary joints and connections.

In planning the size of the coils as to length of run, the pressure drop through each coil should be determined and held to a proper amount. This will depend in general, on the flow rate through the coil, the length of the mains, the size of the tube used for the coils and the pump capacity.

Ques. What is the method of tube connections in a radiant heating system?

Ans. Most ferrous pipes are joined by welding, whereas copper tubing is joined by soldering. The solder used in copper

tubing connections usually consists of a 95-5 combination (95 per cent tin and 5 per cent antimony), although in the future the use of silver solder may become popular in jointing both ferrous pipe and copper tubing.



FIGS. 15 to 20.—Showing typical procedure when making solder joints in copper tubing.

When soft soldering copper tube, the tube and inside of the sweat fitting should be thoroughly cleaned and a thin coat of flux applied to the cleaned parts. The fitting is slipped over the tube and the excess flux removed. The joint must be heated evenly and when the flow point of solder is attained, the solder is fed to the gap between the sweat fitting and the tube, and is drawn up into the space between the tube and fitting by capillary attraction.

When a line of solder shows completely around the edge of the fitting, the connection is complete. Finally, all surplus solder is removed by a brush. This operation will show whether or not solder has filled the joint. The joint must be allowed to cool before placing any strain upon it.

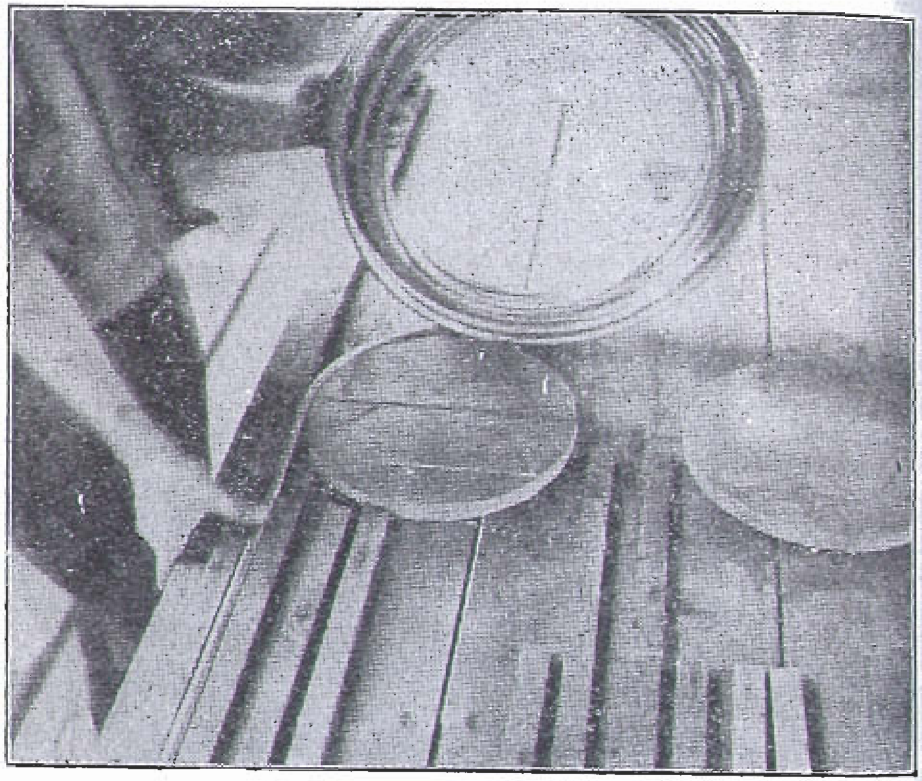


FIG. 21.—Illustrating method of forming bends when fabricating heating coils. Note guide strips in bench to assist in keeping the tube straight during coil forming operation.

Coil Forming and Assembly.—Field fabrication of sinusoidal coils is a comparatively simple matter, and since the installation procedure for copper tube and ferrous pipe is similar, this discussion will concern itself with the forming and assembly of copper coils.

Copper tubing is supplied in lengths of 60 to 100 ft. To assist in making uniform coil shapes a special jig as shown in fig. 21 is commonly used. Wherever one tube coil has to be jointed to another, the tube bends of both rolls are lifted to an easily accessible position, cleaned and connected.

Floor Panels.—A typical layout of a sinusoidal floor coil is shown in fig. 22. No special attachment is required if the concrete covering the coil be poured immediately after the coil is formed and tested.

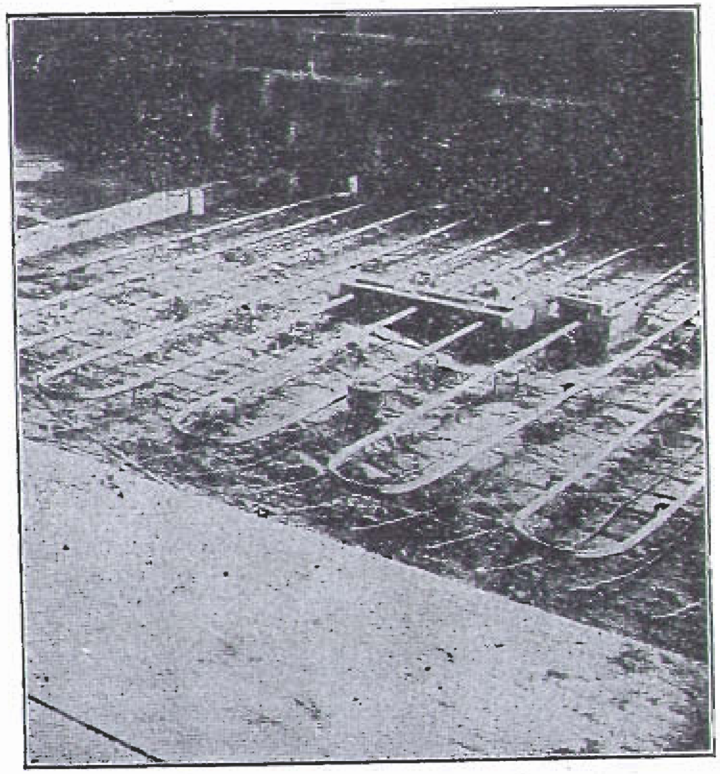


FIG. 22.—Showing method of supporting floor coil by means of specially constructed coil saddles. This method of supporting coils will assure extreme accuracy in depth of bury.

The tube coils should be supported at points where the tube may sag and generally with coils where the concrete slab is not finished immediately after completion of the coil. It is important that the coil be not disturbed during the pouring operation, since this will change the tube spacings and may cause the tube to sag.

Ceiling Panels.—The procedure in installing ceiling coils depends generally upon the size of the coils and the number of coils to be installed.

Coils with few bends and with long straight runs may be laid out directly on the ceiling similar to the floor coil. With large coils it is advisable to

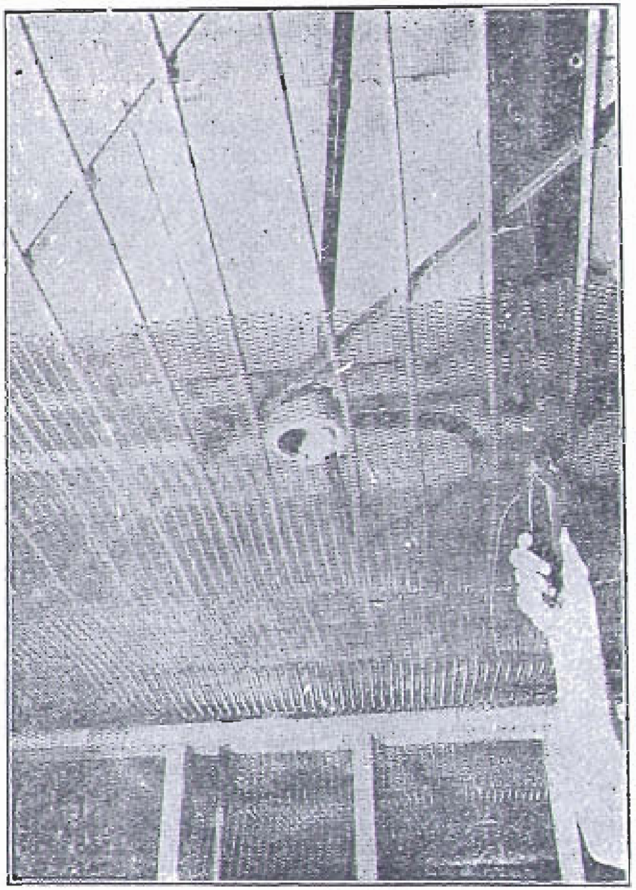


FIG. 23.—Showing method of wiring metal lath to supporting channel when heating coils are installed in ceiling.

pre-assembly the coils to the required size on the floor or assembly bench after which the coils are lifted or hoisted in place. In residental work, the coils are attached to supporting members by means of specially made pipe straps or staples.

Wall Panels.—These coils are mostly small enough to be laid out on the floor and lifted by hand to its location. Only when large wall coils are installed is it necessary to string together the parallel straight runs before the coil is lifted into position.

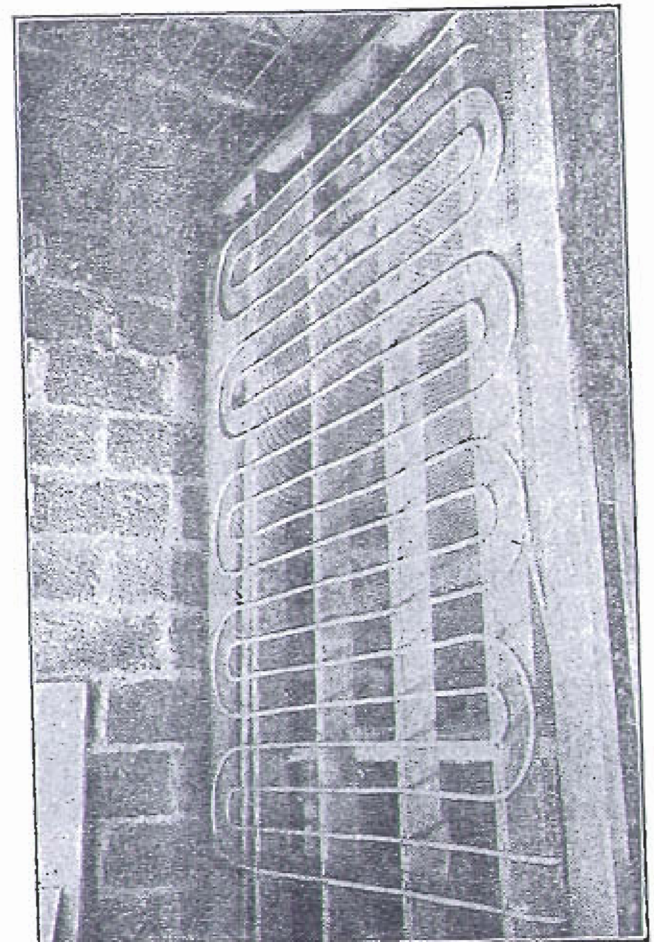


FIG. 24.—Wall coil installed in front of metal lath.

After the coil has been properly located, it is attached to the wall by pipe straps or staples.

Panel Testing.—After the heating coils have been wired in place and the system has been completed in every respect a pressure test is applied shortly before the concrete is poured or before the plaster is applied.

For level coils, it is most important to make certain that the coil inlet and outlet are of the same elevation, and that no point of the coil sags more than half of the inner diameter of the tube. With sloping coils the pitch should be carefully checked. In all cases sagging points must be straightened and supported. The inspection must show that at no point has the tubing been seriously deformed and the tube cross-section decreased. If a damaged section of the tube be found it must be replaced by an approriate length of tube and joined to the coil by the usual method.

There are two testing methods usually applied to radiant heating coils. They are:

1. Air test, and
2. Hydraulic test.

Air Pressure Test.—The air commonly supplied by the conventional air compressor is made at a pressure of at least 100 p.s.i. An ordinary dial type pressure gauge is installed in the line with a cut-off valve on the inlet side of the gauge. If there be any leaks on the system it will be immediately noticed by a pressure drop on the gauge. The location of the leak in absence of the sound usually accompanied by escaping air, may be found by soaping the joint or tube.

Hydraulic Pressure Test.—After a satisfactory air test each coil should undergo a hydraulic pressure test before it is finally covered. When filling the tube care should be taken that all air has been allowed to escape from the system. Coils should be subjected to a testing pressure of approximately 300 p.s.i. and thoroughly checked for leaks. In high buildings the testing pressure should exceed the combined static and pump pressure by at least 100 p.s.i.

After two to three hours the coils are again drained but not before the test gauge has been carefully checked for pressure drop.

BOILER INSTALLATIONS

Ques. What boiler size is used with radiant heating?

Ans. The boiler size may be found in the same manner as that employed with the conventional convection system of heating, by adding the sum of all panel heating requirements, the piping losses and extra capacity required for domestic hot water generation.

Ques. What type of circulators are employed in radiant heating systems?

Ans. In the case of circulating pumps with small capacity such as are used in residential radiant heating systems, it has been found advantageous to select pumps with a somewhat higher head, particularly where these are available within the same price range and horsepower requirement as are standard circulators.

Ques. What are the advantages of high head pumps?

Ans. Greater heads are required with radiant heating than with conventional systems, because the coil pressure drop of the radiant heating system is considerably higher than the drop in a radiator or convector.

With both ferrous and copper piping it is desirable to increase the coil area to a maximum. This relieves the design restrictions and results in an equally good and often less costly, coils.

Grid systems in connection with low head pumps has the disadvantage of being difficult to control causing uneven temperatures.

Ques. May a radiant heating system be combined with domestic hot water generation?

Ans. Only when means of a by-pass or other equipment is used mixing some of the hot boiler water with the heating return. This method will supply the heating coil with water temperatures as required by the outdoor conditions. The by-pass is frequently regulated by an outside thermostat.

Boiler Connections (Small Buildings).—In small buildings it is customary to use the conventional boiler layout as shown in fig. 25. In the flow control or by-pass valve, the return is mixed with hot water, generated in the boiler. This mixing valve is regulated by outdoor and indoor thermostat and if the boiler circulation is fully stopped by this valve the pump is turned off.

The boiler water temperature is kept at constant level, so as to provide for a constant temperature of the domestic hot water. A 100 lb. per sq. in. air tested expansion tank is used in combination with a relief valve, to prevent excessive system pressures. Any conventional domestic water heater may be installed.

In small buildings, the rooms may be grouped according to exposure, and all panels of same exposure connected to a common distribution line, the circulating water of which is regulated by individual mixing valves.

In cases where panels of small heat capacity (lag or inertia) are used, such as ceiling panels in a 4 in. slab and with ¼ in. tube cover and 4½ in. tube spacing, the by-pass valve at the boiler or the convertor may be regulated by aquastat, keeping the hot water temperature constant. The pump is governed by room thermostat. However, in general and particularly with panels of great inertia, this system is not recommended and the water temperature should vary inversely with the outside temperature.

With such panels the time lag between start of panel heating period and start of room heating period is great and if the hot water temperature be kept constant, and is relatively high on warmer days, the panel stores a great amount of heat before the room thermostat is affected, and supplies this heat to the room after the thermostat has cut the hot water supply, thereby causing an excessive rise of room temperature. For this reason, a regulation of the water temperature by outside bulb and inside bulb combined is preferable.

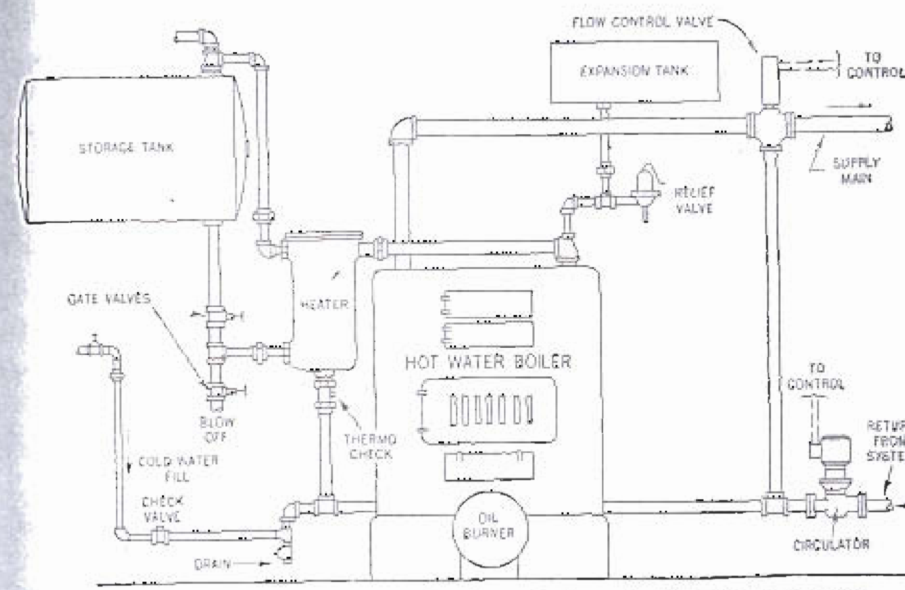


Fig. 25.—Schematic diagram of boiler piping for typical small radiant heating system.

Panel Connections and Balancing of Radiant Heating System.—Although radiant heating coils quite frequently receive individual control valves, it is by no means necessary to install plug cocks or orifices in each system. Such cocks are not essential where the pressure drop in the individual branches of the hot water piping has been carefully computed. If this was not the case, plug cocks or orifices must be installed in each coil connection in order to enable the contractor to properly balance the circulation. Orifices or valves may preferably be located in closets at an elevation above finished floor of about 2 feet or more for floor panels and 6 feet or less for ceiling panels.

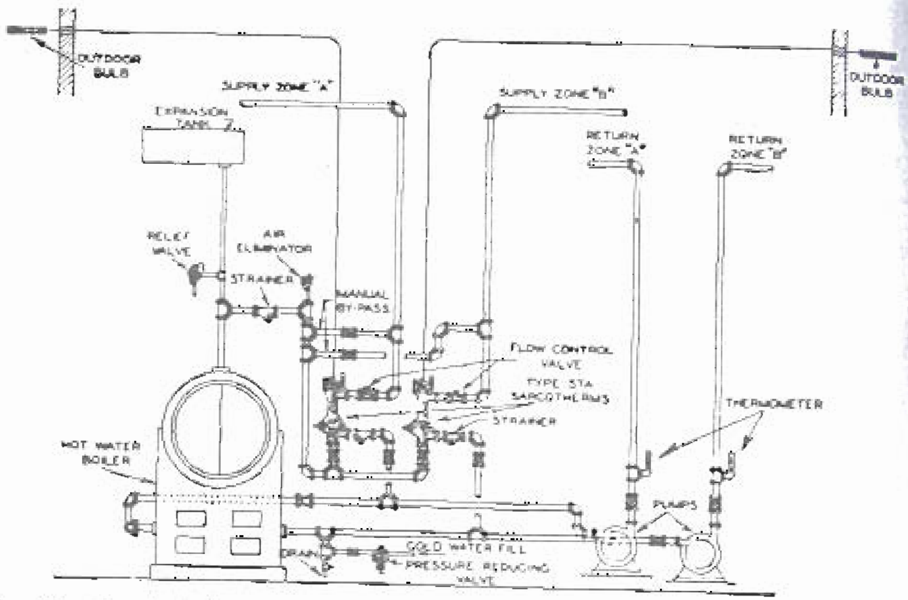


FIG. 26.—Showing boiler piping and control hook-up for large radiant heating system involving zoning. *Courtesy Sarcotherm Controls Inc.*

Where valves cannot be located in closets, they may be installed in wall boxes at convenient height covered by flush wall plates. In order to provide for continuous slope of coil and connections, it is imperative to install the orifice or valves in the panel return line of floor panels and in the supply line of ceiling panels.

A number of radiant heating systems have been built in small houses, having individual supply lines to each panel, with control valves and regulating cocks near the boiler. It was found that such installations proved unduly costly and also that the valves were not actually used for regulation even in cases where thermometer readings proved that balancing of the system was required.

Where cocks are used to provide the proper circulation, and it is found that one room is overheated, the plug is appropriately regulated in order to reduce the rate of flow through the coil and therewith the panel's mean surface temperature. This process does not alter the water supply temperature of the regulated coil or any other coil.

CONTROLS FOR RADIANT HEATING

In the design of any heating system, the first consideration must be perfect comfort for the occupants regardless of outside weather conditions. To preserve and make use of the outstanding advantages of hot water heat, it is necessary to maintain moderate radiator, convector, or coil temperature *modulated gradually* without violent fluctuations. To achieve this it is obviously inconsistent to rely on intermittent operation alone.

The method of controlling the heat by starting and stopping the circulation may be simple but has many serious disadvantages.

In the first place, even the best room thermostats have a definite lag (much depends on their location) so that rooms often become quite uncomfortable before the recirculation of heat restores the desired comfort condition.

A second factor is of even greater importance. When the room thermostat stops circulation, radiators, convectors, or coils cool off rapidly resulting in discomfort which can be aggravated by a drop in outside temperature.

Automatic Controls.—Automatic controls used in connection with most radiant heating systems are essentially similar to those used with conventional systems. A few control systems designed especially for radiant heating are presently available and it is to be expected that additional schemes will be developed which not only take into consideration the radiant component of the room heat transfer, but also the *heat* capacity (inertia) of the panel.

Of the various control systems available, the on-and-off system used in connection with this type of heating has some very serious disadvantages: They are:

1. Starting and stopping the circulating pump necessarily means a cycling operation, i.e. the system has to reverse itself many times as called for by changing room conditions. As pointed out before, this is poor control at best even in conventional hot water heating. However, it becomes much worse when applied to radiant heating. The heavy mass of concrete, or even the lighter mass of plaster, will not be able to reverse itself quickly and a considerable lag will follow which may result in periodic cycles of discomfort.

2. In a radiant heating system with several circuits, it is difficult to obtain a perfect balance of circuit resistance and heat reserve for all rooms. Therefore, when circulation stops, some rooms cool much more rapidly than others. For the same reason, when circulation is restored, some rooms heat up more rapidly than others, with resultant lack of overall comfort conditions.

3. However, the most fundamental objection to the on-and-off principle of control with radiant heat is that it allows the surface of the panel to cool and thereby defects, intermittently, the whole purpose of radiant heat. As the panel surfaces are allowed to become cold at intervals, the whole system ceases to function as radiant heating, and the human body then becomes exposed to cold surfaces with a falling air temperature.

Fig. 27 gives the actual recorded air temperatures and surface temperatures of a concrete floor in which pipes were embedded and controlled by an on-and-off switch operating the pump according to room temperature. The control was set to start the pump when the air temperature dropped to 68° F. In this case the bottom of the pipes was 2 inches below the top surface of the concrete floor. The lag and the amount of variation, will however, vary according to the depth of the pipes below the surface and the type of floor covering used.

4. It has been proved by many years experience that a well controlled continuous flow system is much more economical than an on-and-off system.

Obviously then, the proper way of controlling radiant panels is to allow continuous circulation of water in the coils at all times. The water temperature should be modulated according to outside temperature changes and an indoor thermostat sensitive to radiant heat act as a limit control to prevent over-heating, without stopping circulation.

For these reasons, the continuous outdoor and indoor weather control system, with continuous circulation and anticipation of temperature changes provides utmost comfort in radiant heating.

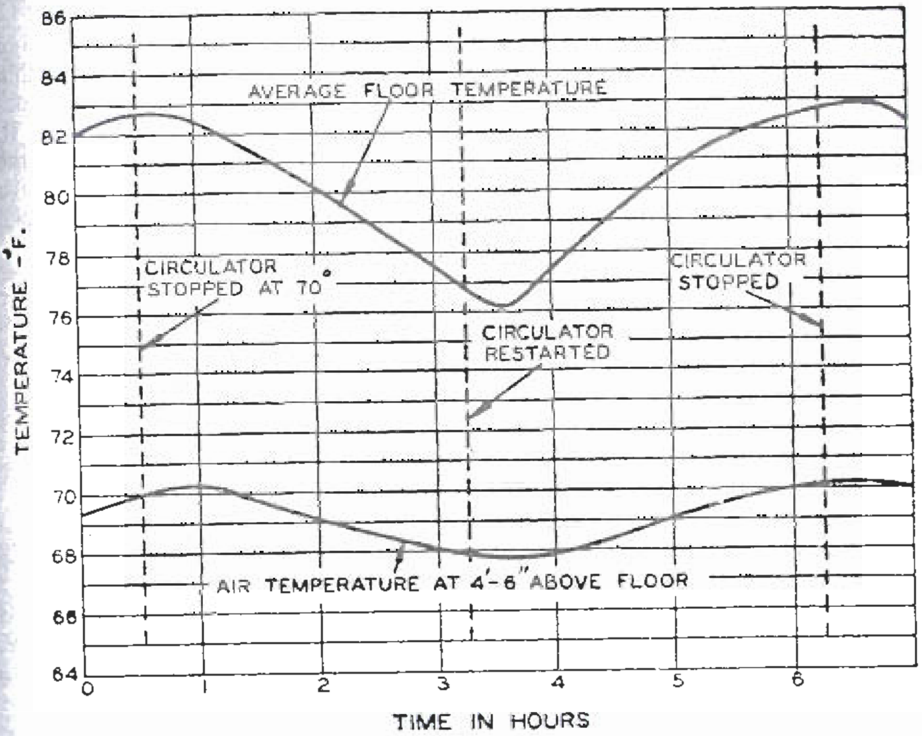


FIG. 27.—Chart showing variation of air and surface temperature with on and off control.

General Characteristics of a Continuous Control System.—An automatic water blender controlled by the outside air temperature with compensating adjustments is manufactured by *The Sarcotherm Controls Inc.* and is shown in fig. 28. A typical boiler installation piping diagram with method of connection is shown in fig. 30.

Principally the water blender control valve consists of a sturdy thermostatic three-way valve, adapted to recirculate to the system a varying portion of the returned water, adding automatically the right proportion of hot water from the boiler or convector to maintain the correct radiator temperatures.

A simple liquid expansion thermostat is mounted on an outside wall of the building, usually with a northwest exposure. Pressure built up within this thermostat, when it absorbs heat, is transmitted through flexible connecting tubing to the valve, operator A, fig. 28 thus pushing piston B, downward. Hot water enters the valve at 1, and return water from the system through inlet 2, at the lower right. Hot and cold water pass through the mixing valve S, then over valve operator A, and to the system through outlet 3.

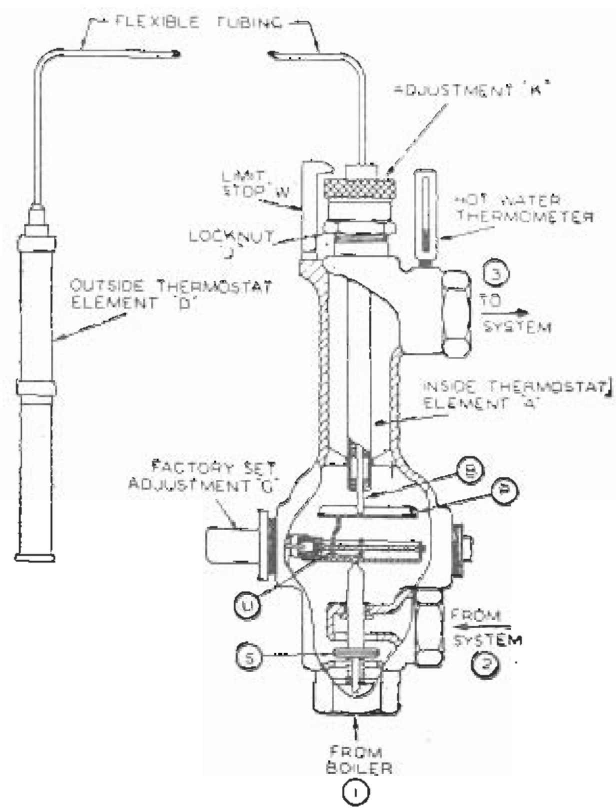


FIG. 28.—Showing construction principles of Sarcotherm automatic water blender valve controlled by outside thermostat element.

The operator A, forms a part of the thermostatic system, so that the position of mixing valve S, is determined by the combined influence of outside temperature at the bulb and that of the mixed water flowing over A. The two members of the thermo-static system are so proportioned as to supply to the radiators water of exactly the temperature needed for the weather conditions existing at any given time.

Curve S, fig. 29 illustrates the result of this action. It is assumed on this chart that at 0° F. outside temperature, the water flowing to the radiators is to have a temperature of 190° F. and that at 65° F. outside, the water temperature is to be 95° F. At all intermediate points, the water blending valve automatically varies the temperature of the water flowing to the system in accordance with this pre-determined gradient. Any other set of base temperatures may be taken care of, depending on the geographical location of the building and the desires of the owners.

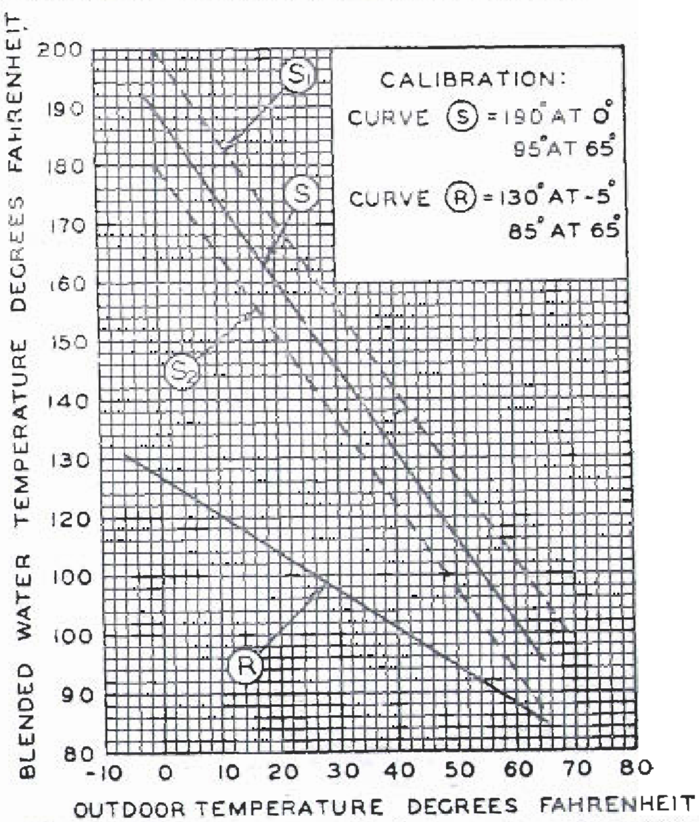


FIG. 29.—Chart showing relation between outside air temperature and temperature of blended water from heating system.

Simple Adjustment.—Should it be necessary to raise or lower the water temperature, the desired adjustment can be made by loosening locknut **J**, and turning knob **K** fig. 28. This will in effect give curve S_1 and S_2 on fig. 29 depending on whether the water temperature is lowered or raised.

All controls are individually calibrated in the factory for the particular needs of the system. Curve S, would be used for a typical hot water system, while **R**, might show the calibration for a typical radiant heating plant.

The water blender control consists of the 3-way mixing valve fig. 28 and outdoor bulb and will proportion the hot water to the system according to outdoor temperature changes. However, for conventional hot water systems, it is recommended that a normally closed switch room thermostat be wired to the circulator.

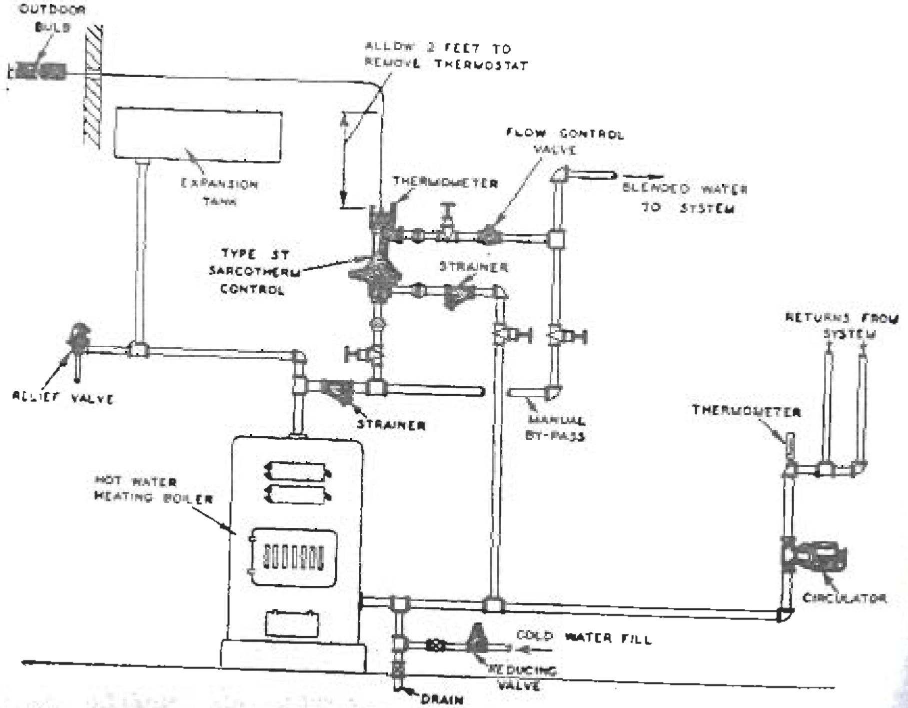


FIG. 30.—Schematic piping diagram showing typical installation of Sarcotherm automatic water blender controlled by outside thermostat.

Compensating Indoor Control.—Heat loss from buildings is subjected to variables, not all of which can be controlled in accordance with fluctuations of outside temperature alone. Exposure, wind velocity and direction, as well as the insulating properties of the building walls, all exert their influence. Because there is a certain lag between changes in atmospheric conditions and the temperature in the rooms, control by outside temperature alone may at times result in rooms becoming too warm. When desired, an automatic check can be provided to guard against such overheating.

With the compensating indoor control it is also possible to arrange for night set-back, without stopping circulation. This method is especially recommended for radiant heating systems where continuous circulation is desired.

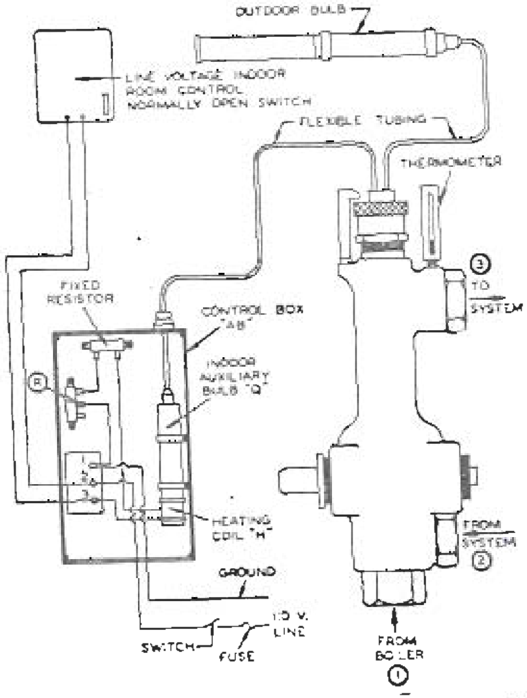


FIG. 31.—Showing automatic water blender valve with compensating indoor control feature.

This control method is similar to that shown in figs. 28 and 30, except that the temperature sensitive system is equipped with an additional bulb **Q**, fig. 31. This bulb is fitted with a small electric heater coil **H**, and a manually adjustable resistance **R**, mounted in a metal box for convenient attachment to a wall in the boiler room as shown in fig. 32.

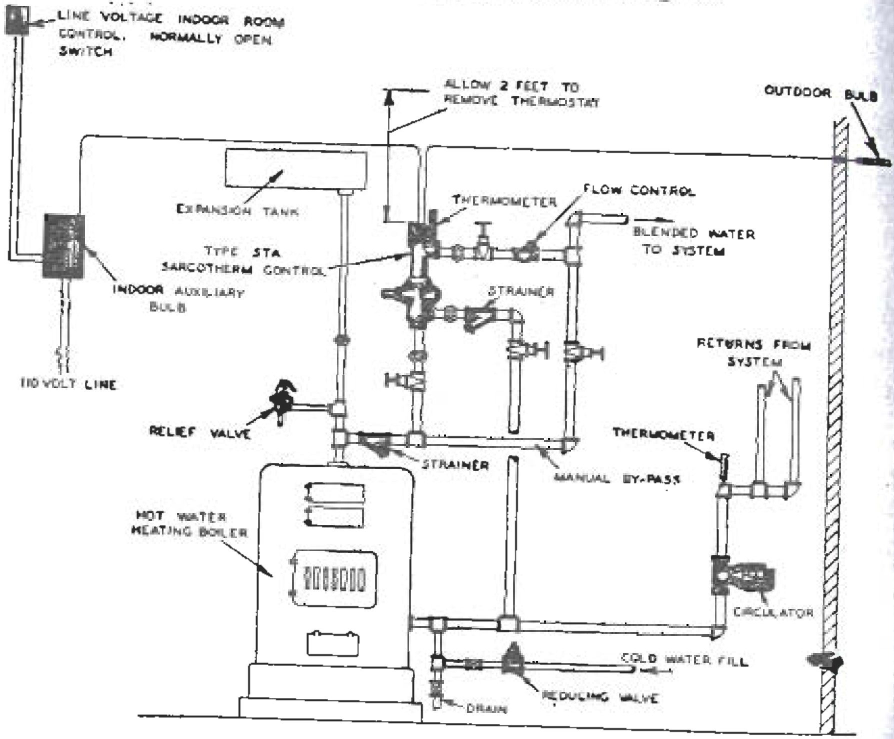


FIG. 32.—Schematic piping diagram of typical installation featuring Sarcotherm automatic water blender controlled by outdoor thermostat in addition to compensating indoor control bulb.

A room thermostat is placed in a key room from which it is desired to check overheating of the system. The thermostat is wired to terminals 1, 2, 3 in the box, fig. 31. It has a normally open switch which acts to close the circuit to the heater **H**, when the desired room temperature is reached. Heat thus applied to bulb **Q**, will cause extra expansion of oil in the thermostatic system, which results in the valve **S**, fig. 28, closing the hot water inlet port, and recirculating the water pumped back through the system. This effectively checks overheating while at the same time preserving the responsiveness of the system to outside temperature changes, because circulation is not interrupted.

Typical Automatic Control Hook-ups for Radiant Heating Installations.—By definition an automatic heating control system is one in which the heat generating apparatus is automatically adjusted and maintained to provide comfortable temperatures indoors during cold weather.

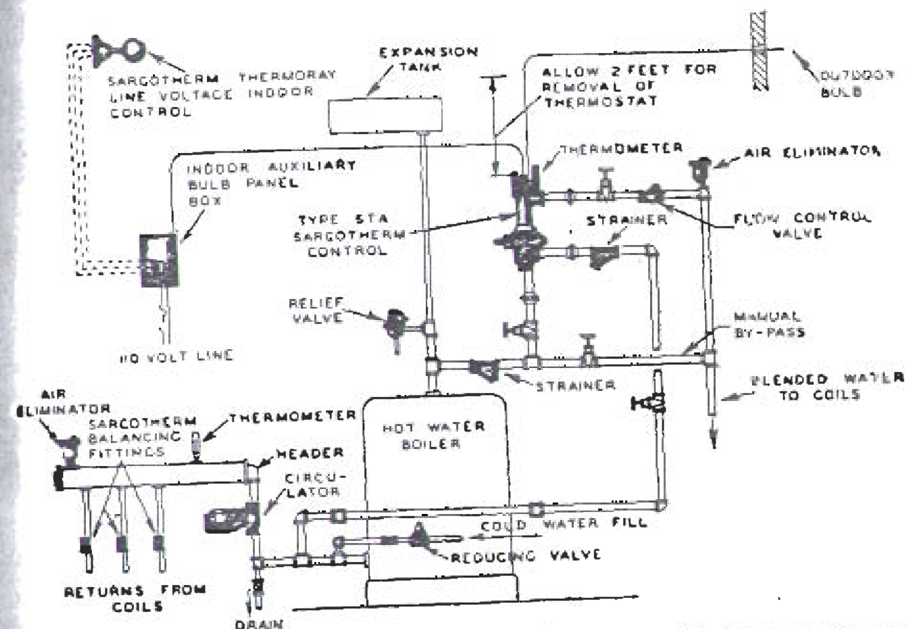


FIG. 33.—Typical control as applied to radiant heating system. Principally a heat control system of this type is operated from an outside thermostat and supplemented with a room heat control instrument. The outside thermostat modulates the temperature of the circulating water in the coils by mixing some of the hot water leaving the boiler with a proportionate amount of return water which is diverted to the three-way valve. *Courtesy Sarcotherm Controls Inc.*

From the practical standpoint in terms of the most common type of installation, the selection of controls may be summarized as follows: *Generally a light panel may be controlled by a room thermostat (with control point reset when necessary); a heavy panel by an outside controller (qualified when necessary by an inside controller).*

Because of the varying conditions under which an effective control system must operate a series of generalized control system diagrams for various types of installations (such as single and multiple-zone) with and without domestic hot water service, etc. has been provided.

It should be clearly understood however, that these diagrams are intended to illustrate the general methods of control rather than to specify

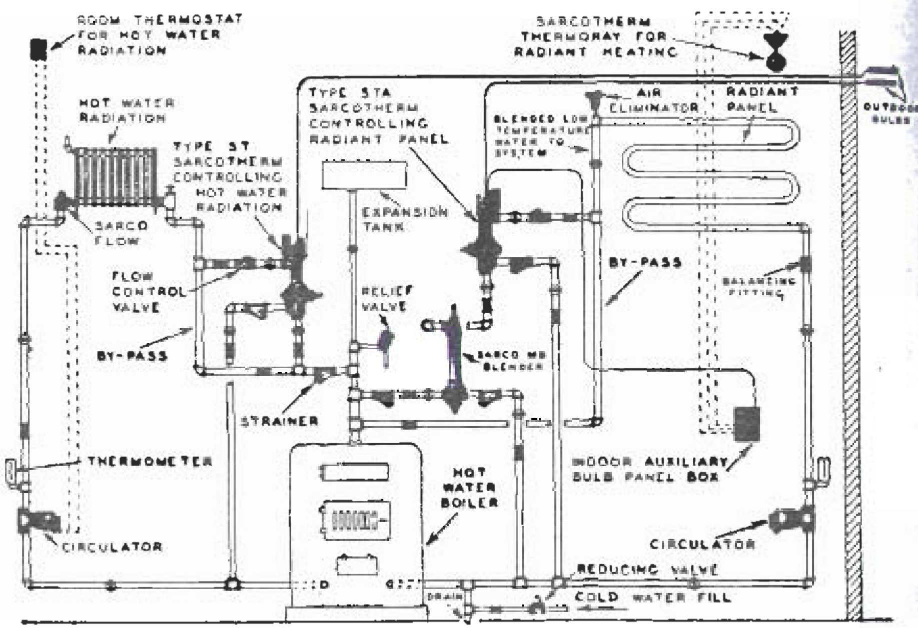


FIG. 34.—Typical split-system heat control. In a system of this type radiant panels are supplemented by conventional hot water heating. The type and size of control valves are largely governed by the size of the installation. *Courtesy Sarcotherm Controls Inc.*

the actual instruments, which should be selected by the heating contractor to fit the requirements of the individual installation.

Also the arrangement of all controls, panels, piping, etc. in the diagrams given is schematic only, and is not intended to represent actual layout for installation purposes.

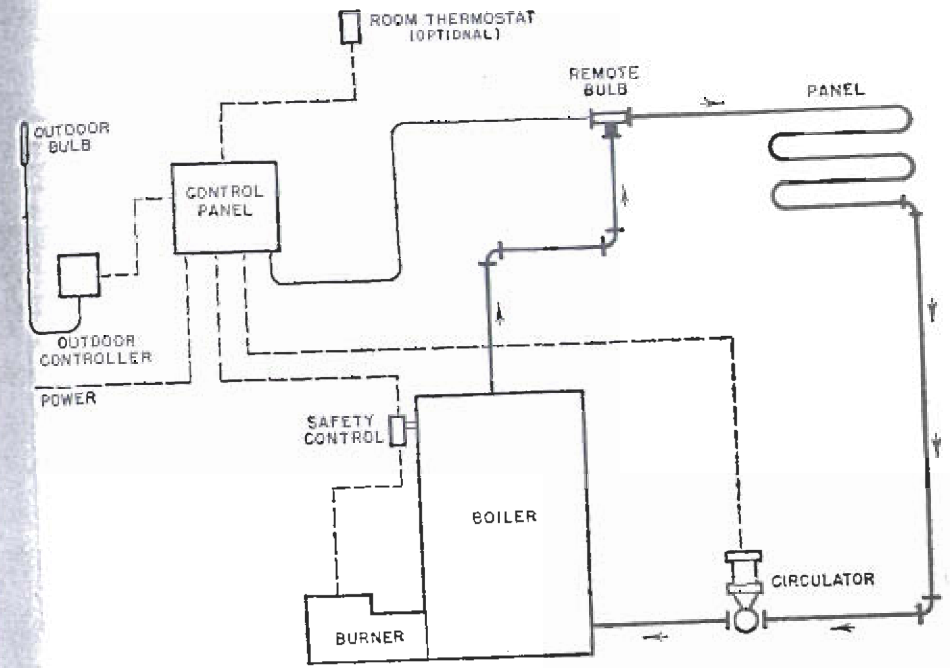


FIG. 35.—Automatic heat control system without indirect heater for heavy radiant heat panel. In a system of this type the outdoor controller measures any change in the heating load as represented by the outdoor temperature. This change in load, transmitted to the control panel, causes a corresponding change in the setting of a temperature controller whose temperature-sensitive bulb is located in the panel supply water (or in the boiler). The temperature controller operates the burner to provide the required water temperature as measured by the temperature-sensitive bulb. The thermostat, if used, senses changes in internal heat loads caused by occupancy, solar gain, etc. and acts as a limit control. The circulator operates continuously except when no heat is required. The safety control prevents excessive boiler water temperature. *Courtesy Minneapolis Honeywell Regulator Company.*

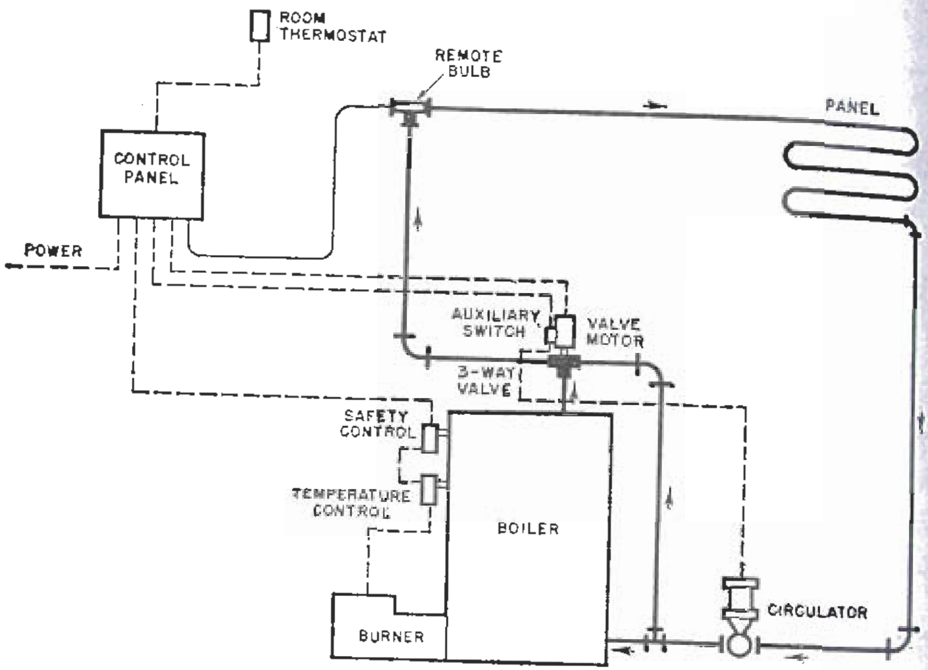


FIG. 36.—Automatic heat control system with indirect heater for light radiant heat panel. Here the room thermostat measures any change in the heating load and transmits the change to the control panel which accordingly adjusts the control point of a temperature controller, whose temperature-sensitive bulb is located in the supply water to the radiant panel. The temperature controller repositions the three-way valve, which mixes hot boiler water and cooler return water from the by-pass to provide a mixture of the proper temperature to satisfy the temperature-controller setting. The burner is controlled by an aquastat (immersion temperature controller) to maintain the necessary temperature in the boiler for the indirect water heater. The circulator is shut down by the auxiliary switch whenever the three-way valve is positioned for zero heating (fully open by-pass). The safety control will shut off the burner if for any reason the boiler water temperature reaches the maximum safe level. *Courtesy Minneapolis Honeywell Regulator Company.*

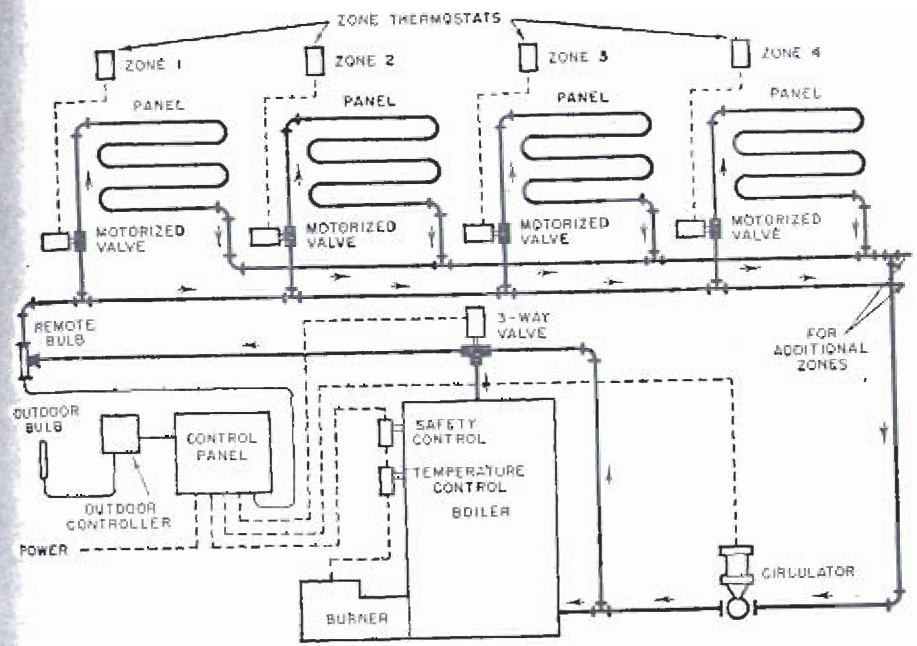


FIG. 37.—Typical multiple zone control radiant heating system with indirect heater. Here the outdoor control measures changes in heating load as represented by outdoor temperatures. These changes transmitted to the control panel, cause corresponding changes in the setting of a temperature controller whose temperature-sensitive bulb is located in the main line to the distribution system, downstream from the three-way valve. The temperature controller positions the three-way valve, which mixes hot boiler water and cooler return water in the proportions required by the setting of the temperature controller, so as to furnish supply water at a temperature commensurate with the heating load. A temperature controller located in the boiler operates the burner so as to maintain the boiler water temperature required by the indirect heater. A thermostat in each zone measures the individual heating requirements of the zone and controls a motorized valve—modulating or two position as the installation may require, in the zone supply line; the zone valve thus regulates the panel temperature in accordance with the individual heating requirements of the zone. The circulator operates continuously so long as any heating is required. The safety control will shut off the burner whenever necessary to prevent excessive temperatures in the boiler. *Courtesy Minneapolis Honeywell Regulator Company.*