SUPPLEMENTARY INSTRUCTIONAL MATERIAL
to
INSTRUCTION MANUAL FOR
STEAMFITTER-PIPEFITTER JOURNEYMEN AND APPRENTICES.

SUPPLEMENT No. 6

HYDRONIC
PANEL HEATING

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HYDRONIC PANEL HEATING

The material in this pamphlet has been prepared and approved by the National Joint Steamfitter-Pipefitter Apprenticeship Committee composed of representatives of the Mechanical Contractors Association of America, Inc., and the United Association of Journeymen and Apprentices of the Plumbing and Pipe Fitting Industry of the United States and Canada.

PANEL HEATING LESSONS

Lesson 1.

Aims of this lesson:

(1) To provide the learner with information on early and recent developments of panel heating.

(2) To acquaint the learner with present methods of providing panel heating for buildings.

PROCEDURE:

The student should carefully study the information and the illustrations, then answer the questions in the spaces provided at the end of this lesson.

INFORMATION:

Of the currently used systems of heating of buildings for human occupancy, the so-called "panel heating" or "radiant heating" systems have grown in popularity during the past ten years. While the modern development and use of this method of heating for buildings is rather recent, the mechanism employed is not new, in fact, goes back to the ancients of history. The modern and the ancient methods have one major feature in common—the heating system is employed to heat (or warm) a portion or "Panel" of the room floor, wall or ceiling to, in turn, heat the space, rather than employing a convector, radiator, or air heating system to add heat directly to the occupied areas of the building.

PANEL HEATING

Ancient Methods

The Romans, Koreans, and others, more than 2000 years ago, utilized passages to convey hot flue gases beneath their tile and marble floor surfaces of buildings and baths. The warmed floor surfaces, in turn, provided comfort for the occupants of the buildings. This same method of heating is still in use in the Far East.

More Recent Developments

The early development of central heating systems in the 19th Century ignored these methods of the ancients, and stressed development of fluid distribution methods wherein steam or hot water was distributed by means of piping systems to pipe coils, radiators, convectors, etc., located directly in the space to be heated, or warm air was conveyed by means of ducts to supply heated air to the space, to offset the heat loss of the space.

The early years of the 20th Century witnessed the development of a different mechanism for adding heat to the space. At first (around 1908-1912) warm water pipes (water at 100 F to 120 F) were used to warm plaster wall and ceiling surfaces to, in turn, heat the building. Though this method of heating became extremely popular in England and in Europe during the period of 1919 to 1935, its development and acceptance (in competition with systems employing radiators, convectors, and warm air) in this country were rather slow. While the records show that there were several individual panel heating installations (of sorts) made in this country prior to 1929,—the engineered development in this country began with the installation in 1929 of a large ceiling heating system for the British Embassy Building in Washington, D. C.

During the period 1930-1940, some ceiling and floor installations were made (perhaps less than 150) which used, in the main, piping imbedded in concrete floor slabs and in suspended plaster ceilings.

The current rapid development of panel (or imbedded) heating systems parallels the expanding housing and building program since 1945, so that, as of now, tens of thousands of such installations are made each year.

Current Methods

At the present time the more popular methods of creating warmed building surfaces (or panels) to provide a building with what is commonly called either **Radiant Heating—Panel Heating—** or—**Imbedded Heating**—include methods utilizing piping, such as:

Imbedding warm water tubing or piping in plaster of ceilings or walls.

Imbedding warm water tubing or piping in concrete floors, that rest on earth or in concrete structural slabs (above grade).

Installing tubing or piping under wood floors. Attaching metal ceiling pans to warm water piping.

Piping or Tubing in Plaster

This method involves the use of copper tubing, steel or wrought iron pipe coils, so installed that plaster finish will imbed the coils to thus provide a warmed surface to heat the room.

Copper Tubing may be used, either below wire or rigid lath or above open mesh wire lath. Figure 1 shows such an installation with open

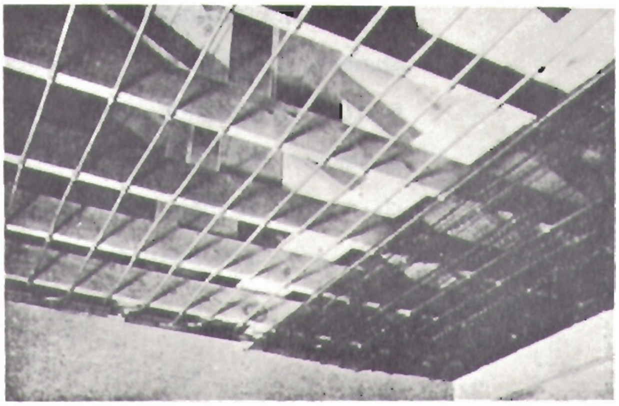

Fig. 1—Tubing For Ceiling Panel

Tubes attached to joists, wire lath also attached to joists, and wire-tied to tubes. Lath will eventually receive plaster finish.

mesh lath below the tubes. Tubing (above lath) may be 3/8", 1/2" or 3/4" nominal (Type K or Type L), either hard or soft tubing. Below the lath, tubing should be 3/8" nominal to limit the plaster thickness. Plaster finish should provide 3/8" cover below tubes. Tubing is fabricated into coils, on 4½" to 12" centers, with the closer spacings of 4½" and 6" more commonly used.

Steel or wrought iron pipe (IPS) may also be used to construct plaster heated ceilings. Such piping is installed above open mesh lath. Figure 2 shows pipe coils, suspended from building

Fig. 2—Pipe Coils for Ceiling Panels

Coils are preassembled and erected. Will receive lath and plaster to form heated suspended ceiling.

structure, ready to receive lath and plaster (to form suspended heated ceilings). Pipe diameters used are ½", ¾" and 1" depending on length of circuits. Coil spacing is generally 6", 9" and 12".

Piping or Tubing in Concrete Floors on Earth

This method is now extremely popular because of the increasing use of the basementless building. Either copper tubing, steel or wrought iron pipe may be used. Figure 3 shows pipe coils for a church building, ready to receive the floor finishing materials. (Note the level coils and the level sub floor). Piping or tubing sizes used are generally ½", ¾" and 1" (IPS or nominal) spaced 9" to 18" on centers.

Piping or Tubing in Structural Slabs

The use of coils in structural concrete slabs of multi-story buildings is not as popular as some

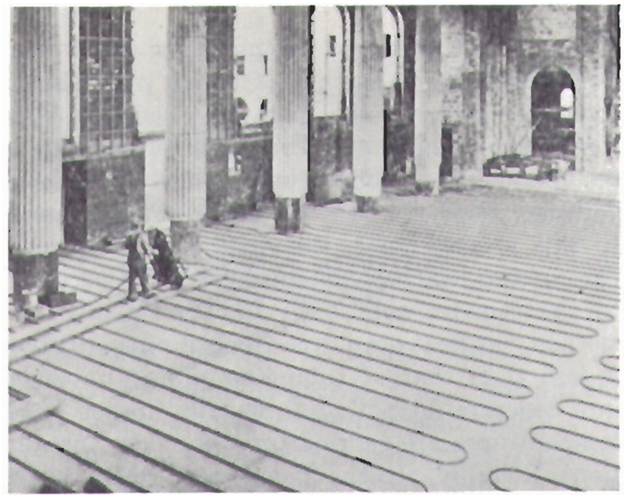

Fig. 3—Pipe Coils in Floor Slab

Welded pipe coils are set on sub-floor ready to receive floor finish materials.

of the other methods described. Very often, this arrangement may be in conflict with local building codes that prohibit piping in load supporting structural slabs if such piping conveys fluids at temperatures and pressures above atmospheric. However, many such installations have been made after receiving the necessary permission of the supervising authorities. Figure 4 shows coils

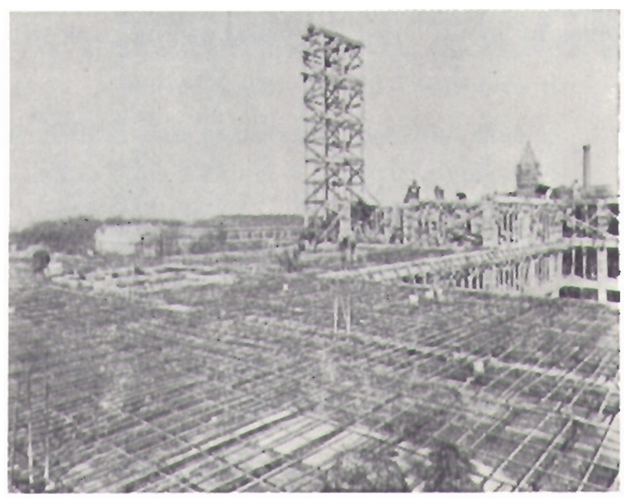

Fig. 4—Pipe Coils in Multi-Story Structural Slab

Welded pipe coils on forms (below reinforcing rods).

and reinforcing rods of such floor slab construction in a multi-story building prior to the pouring of concrete. Again, pipe sizes are ½", ¾", or 1" IPS spaced 6" to 18" on centers. Soft copper tubing should not be used on such installations because of the possible danger of damage to tubing.

Piping or Tubing Below Wood Floors

The use of piping or tubing below wood floors is not as common as that of piping or tubing in concrete floors, though many successful installations have been made. Piping or tubing can be installed between joists (under wood flooring) or between wood sleepers on which flooring rests. In this arrangement, the wood floor becomes a part of the heating system, hence, the necessity for extremely well dried lumber. Using this method, the heat output per foot of pipe or tubing is less than that of tubing or piping imbedded in a concrete floor, though usually higher water temperatures are carried for wood floor installations. Roughly, for the same water temperature, about twice as much piping is generally required for a wood floor installation, as compared with a concrete floor job.

Metal Pans Attached to Piping

Modern design improvements in recent years have brought forward several schemes of creating metal pan ceilings heated by warm water circulated through piping or tubing attached to the ceiling pans. Three such methods in use today include (1) metal ceiling pans supported from pipes by metal clips, (2) metal ceiling pans with coils attached directly to the back side of the pans by welding or brazing, and (3) metal ceiling pans with coils attached to the back side of ceiling pans by a mechanical bond. These systems have future possibilities in the panel cooling field (for combined ceiling heating or cooling) because of the low temperature difference required for heat flow between the pan and the piping, due to the very high thermal conductivity of metal as compared with the rather poor conductivity of plaster. While this factor is not important for the usual panel heating work, it is of extreme importance when such systems are planned for panel cooling.

Other Methods of Construction

While the above methods, described heretofore, are those to which this discussion of the present state of the Panel Heating art will devote itself —there are other methods in use to create warmed panel surfaces. These methods include construction arrangements such as imbedding electric elements in plaster or concrete; locating warm air ducts behind plaster ceilings or walls, and locating warm air ducts below or in concrete floors.

REVIEW SHEET

Lesson 1.

1. Describe the principal difference between panel heating and other types of heat distribution.

2. When and who used the earliest methods of panel heating?

3. Name the principal heating methods employed during the 19th century.

4. Briefly describe the progress of panel heating in the United States since 1900.
   (a) 1900 to 1930
   (b) 1930 to 1940
   (c) 1940 to present

5. Give three common names for panel heating. ________, ________, and ________.

6. If copper tubing is used for heating panels in plaster walls or ceilings
   (a) The tubing should be installed________ the wire lath.
   (b) The tubing should be installed________ the open mesh lath.
   (c) The size of the tubing installed with wire lath may be ______", ______", or ______".
   (d) The largest size of tubing below lath is ______".
   (e) The common thickness of plaster walls and ceilings is ______".
   (f) Coil spacings of tubings may vary from ______" to ______".
   (g) The most common spacings of tubing is usually ______" or ______".

7. If steel or wrought iron pipe is used for heating panels in a plaster ceiling—
   (a) The pipe should be installed ______ the open mesh lath.
   (b) Usual pipe diameters are ______", ______", or ______".
   (c) Coil spacings may be ______", ______", or ______".

8. Heating panels in concrete floors on earth.
   (a) This method is increasing in use because of buildings ______ ______ ________.
   (b) Coils may be of ________, ______ ______, or ________ ________.
   (c) Usual pipe sizes are ______", ______", or ______".
   (d) Spacings may vary from ______", to ______" on centers.

9. Heating panels in structural slabs.
   (a) All building codes ______ permit the use of coils in load bearing slabs.
   (b) Pipe sizes for coils may be ______", ______", or ______".
   (c) Spacing may vary from ______", to ______", on centers.
   (d) Soft copper tubing should not be used because of ____________ to tubing.

10. Heating panels below wood floors.
   (a) This method is used ________ than in concrete floors.
   (b) The tubing may be installed ________ the ________ or ________.
   (c) Nearly ________ the heat results from a concrete floor as compared to a wood floor installation having the same water temperatures and pipe capacity.

11. Metal pan systems of heating panels.
   (a) This method is comparatively ________.
   (b) The metal ceiling pans may be secured to the pipe coils with ________.
   (c) Or they may be secured by ________ joints.
   (d) Or by a ________ ________.
   (e) This heating system may also be with modifications used as a ______ ______ system.
   (f) The heat conductivity of metals is ________ than for plaster.

12. Other methods of providing warmed panel surfaces.
   (a) Imbedded ______ ________ in plaster or concrete.
   (b) ______ ______ ______ behind plaster walls or ceilings.
   (c) ______ ______ ________ below or in concrete floors.

PANEL HEATING LESSONS

Lesson 2.

Aims of this lesson

(1) To study the effects of proper room heating with relationship to the human body.

(2) To study the amount and methods of heat exchange from heating systems to the occupied spaces.

(3) To investigate various types of heating for maximum comfort.

PROCEDURE:

The student should carefully study the information and the illustrations, then answer the questions in the spaces provided at the end of this lesson.

COMFORT FUNDAMENTALS

In any discussion that concerns the operation of panel heating systems, or, for that matter, any heating system, certain fundamentals as to the workings and comfort relationships of heating systems should be reviewed.

The human body at all times releases heat to the surrounding environment. The three main heat exchange mechanisms that come into play are heat exchange by convection, heat exchange by radiation, and heat exchange by evaporation.

The average adult, under normal conditions, must release approximately 400 Btu per hour to the surrounding environment. This heat release, which goes on all the time, divides approximately as follows into the three heat exchange mechanisms—

By evaporation—about 100 Btu per hour, which leaves about 300 Btu per hour to be released by convection and radiation, so that

By convection—about 140 Btu per hour to 160 Btu per hour, and

By radiation—about 160 Btu per hour to 140 Btu per hour.

The subdivision of about 300 Btu per hour into convection vs. radiation release depends on the temperature of the surrounding air and the temperature of the surrounding surfaces.

A room occupant with normal clothes has an outer clothing surface temperature of about 82 F (average). With surrounding air at 72 F and the surrounding average surface temperature of walls, floor and ceiling at 68 F, then the split of 140 Btu per hour released by convection against 160 Btu per hour by radiation will be approximately correct.

However, should the average temperature of the surrounding surfaces drop to, say, 62° (as might occur in a room with a sufficiently large glass area exposed to low outdoor temperatures), then the air temperature of the room must be raised to about 78° or higher to achieve comfort. It is this comfort phenomenon that explains the expression of cold 70°, i. e.—a room controlled at 70 F air temperature, but uncomfortably cool because of the low surrounding surface temperatures resulting from large cold glass areas.

To carry this explanation in the opposite direction, should the surrounding surfaces of the room be held at, say, 82 F (equal to the 82 F outer temperature of the clothed human body)—then no heat can be released from the body by radiation—i.e., no radiant heat exchange between surfaces at the same temperature. In this case, the air temperature of the room **must** be reduced to about 58° to 60°, in order to provide for releasing the entire 300 Btu per hour by convection. The body heat must be released or the body functions will break down.

It is this relationship that comes into play in the working of Panel heating systems, or so called Radiant Heating systems,—utilizing large areas of the room warmed above room air temperature, resulting in raising of the average surface temperature of the room.

One point should be emphasized—heating systems are **not** installed to supply heat to the occupants. The heating system—any system—using convectors, radiators, heated air, or panels—supplies heat to the occupied spaces—at a rate that balances the heat loss from the space, and thus provides a surrounding room environment of about 70° that **permits** the human body to release its heat to the surroundings in a **comfortable** manner. Generally, the slightly higher mean radiant temperature that exists in a panel heated room, with the correspondingly slightly lower air temperature, will provide for better comfort than, say, a reverse condition of low surface temperatures and the corresponding higher air temperature.

Heat Release to Room

Generally, panel heated floors operate at a surface temperature of about 75 F to 85 F, while panel heated ceilings operate at about 95 F to 120 F surface temperature, depending on load, weather requirements, available areas for heating, etc.

Each square foot of heated surface releases heat to the room in two ways—by **radiation** exchange with the cooler surfaces, and by **convection** to the cooler air of the room. To compare this with other forms of heating, for the **average** room under **average** conditions—

1 sq ft of ceiling panel at 120° releases **about** 60 to 70 Btu per hour to the room (approximately 70% by radiation and 30% by convection).

1 sq ft of floor panel at 85° releases **about** 30 to 40 Btu per hour to the room (approximately 55% by radiation and 45% by convection).

1 sq ft of steam cast iron radiation at 215° releases 240 Btu per hour to the room (approximately 25% by radiation and 75% by convection).

1 sq ft of a concealed radiator or convector at 215° releases approximately 240 Btu per hour (almost entirely by convection).

The heat release values and their division into radiation and convection components are very approximate only, as these values and this relationship depends on many factors, such as surrounding surface temperatures, position of surface, height of room, etc. These values are provided only to illustrate the relationships.

The operation of a panel system involves the same basic principles as those of any other heating system. The required number of Btu's per hour are calculated for the maximum (or design) heating demand. Radiation, or convectors, or panel surface is installed so that the number of Btu's per hour supplied by the heating surface are in balance with the calculated heating requirement of the room. For example, for a room requiring 8000 Btu per hour, the heating demand could be satisfied in any of the following ways—

Using 215° C.I. steam radiators—By installing 33 sq ft of radiation, operating at 240 Btu per hour per sq ft. Total output—8000 Btu per hour.

Using 180° C.I. hot water radiation—By installing 48 sq ft of radiation, operating at 167 Btu per hour per sq ft. Total output—8000 Btu per hour.

Using ceiling panels (110°-120°)—By installing 133 sq ft of panel area, operating at 60 Btu per hour per sq ft. Total output—8000 Btu per hour.

Using floor panels (80°-85°)—By installing 227 sq ft of panel area, operating at 35 Btu per hour per sq ft. Total output—8000 Btu per hour.

Again, do not use the ceiling and floor output values for design. They are approximate and indicated only to illustrate this relationship.

Temperature Gradients

One of the important operating factors that affects comfort is that of the **temperature gradient**, or the floor to ceiling temperature difference for a heated room. The smaller the temperature gradient, the better the comfort, i.e., less chance of having cold feet and a warm head. The **temperature gradient** or difference in temperature between floor and ceiling depends on many factors but mainly on the temperature and position of the colder walls and floor surfaces, and the temperature, size and location of the heating medium.

For example, it is not unusual to have the following conditions in a 9 ft. high room even though the 5 ft. level temperature (thermostat location) is maintained at 70° for each heating system:

	Temp. at floor	Temp. at 5'0"	Temp. at ceiling
Hot water radiators (180°)	69°	70°	72°
Steam radiators (215°)	67	70	76
Steam Convectors	65	70	78
Warm air	62	70	80

The temperature gradients for floor and ceiling panel systems are much improved over the above. Usually, only a two or three degree spread exists for the well designed and well installed panel system.

This improvement in temperature gradient provides for more comfortable living and working conditions, and also tends to reduce dust streaking and convection currents.

REVIEW SHEET

Lesson 2.

1. The human body releases heat by three heat exchange methods, namely __________, __________, and __________

2. Under normal conditions, the average adult should release approximately __________ Btu per hour.

3. The Btu (British Thermal Unit) is the amount of heat required to raise __________ of water __________ degree temperature fahrenheit.

4. The human body gives up approximately —
   (a) __________ Btu per hour by __________.
   (b) __________ Btu per hour by __________.
   (c) __________ Btu per hour by __________.

5. The temperature of surrounding air and surfaces effects the heat release of the body by __________ or __________.

6. Favorable comfort heating conditions for an adult in normal clothing requires ______°F surrounding air temperature and ______°F surface temperature of walls, ceilings and floors. These conditions result in the proper heat release by __________ **and** __________.

7. If the temperature of the surrounding surfaces drops due to large cool areas it is necessary to __________ the air temperature to have proper comfort.

8. If the temperature of the surrounding surfaces is increased to the temperature of the persons clothing, then the __________ must be __________ in order to effect a __________ from the __________.

9. The principal function of all heating systems is to supply heat to occupied spaces at a sufficient rate to make up for any heat losses. The ideal air temperature for the human body is about ______° which allows for proper and comfortable __________.

10. The surface temperature of floor panel heating is ideal at ______°F. to ______°F. and at______°**F. to**______°F. for ceiling panels.

11. Heated surfaces release heat by __________ exchange to __________ surfaces and by __________ to the __________ air.

12. Approximate heat releases for 1 sq ft of heating surface —

Type	Surface temperature	Btu/hr.	% by radiation	% by convection
Ceiling panel				
Floor panel				
Steam C. I. radiation				
Concealed radiation				

Find the number of sq ft radiation required in the following problems. In Nos. 15 and 16 use average figure from No. 12

	Type	Surface temperature	Heat loss Btu/hr.	Sq. ft. radiation required
13.	Concealed radiation	215°	12000	
14.	Steam C. I. radiation	215°	9600	
15.	Floor panel heating	85°	13500	
16.	Ceiling panel heating	120°	9100	

17. The temperature difference between the floor and ceiling is termed the __________ __________.

18. The greatest comfort in heated spaces occurs when the temperature difference between floor and ceiling is the __________.

19. In a well designed and installed panel system the temperature difference between floor and ceiling may be as low as __________ or __________ degrees.

PANEL HEATING LESSONS

Lesson 3.

Aim of this lesson:

(1) To study the advantages and disadvantages of floor and ceiling systems of panel heating.

PROCEDURE:

The student should carefully study the information and the illustrations, then answer the questions in the spaces provided at the end of this lesson.

Comparison of Ceiling and Floor Systems

Properly designed satisfactory heating may be provided through use of either a floor system or a ceiling system. The choice of floor or ceiling installation is generally one of practicability and cost. No set rules can be established for all installations as the peculiarities of a particular building may dictate particular advantages or disadvantages for either of these two panel arrangements.

In general, the advantages and disadvantages of floor and ceiling panel systems may be summed up as follows:

Floor Panels

Usually are cheaper to install.

Very satisfactory for high ceiling spaces such as churches, banks and factories.

Very satisfactory for schools serving small children who would spend most of their time close to the floor.

Usually more difficult to control because of the lag resulting from thermal storage.

Usually have a higher reverse loss to the ground though this is generally not serious.

Ceiling Panels

Have the advantage that their output cannot be obstructed by furniture or shifting of office partitions.

Operate with a lesser lag and therefore are easier to control.

Must be careful not to permit too high a ceiling temperature in a low ceiling room.

WHY PANEL HEATING?

Panel Heating does not provide a cure-all for all heating system troubles. When properly designed and properly installed, panel heating does permit taking advantage of the many good features of this form of heating.

The **advantages** of panel heating may be grouped as follows:

Architectural

Panel systems are installed as a part of the building and therefore are completely out of sight. The apparatus cannot interfere with the location of furniture, drapes, etc.

Cleanliness

Panel systems eliminate the streaking and dust patterns created by convection or radiator systems.

Comfort

Panel systems operate with smaller temperature gradients. They provide warm floors in the basementless house. Panel systems provide the means of supplying satisfactory heating to offset large cold glass areas. Air within a panel heated room often feels more "fresh" and more comfortable to the occupants because of the lower temperature and the elimination of the baking effect of the air and dust.

The **disadvantages** of panel heating may be grouped as follows:

Temperature Control

Generally, panel systems are more difficult to properly control, particularly floor systems because of the high thermal storage and resulting lag. This difficulty shows up as a serious disadvantage in floor heating systems serving buildings having light walls and large glass areas.

Costs

Though panel systems for the basementless house are often installed at equal or lower costs as compared with other satisfactory forms of heating, in general panel systems cost more than other equally satisfactory heating systems. The increased cost is usually caused by the construction problems encountered in installing panel heating and the many installation precautions which must be taken to assure a tight system.

REVIEW SHEET

Lesson 3.

1. Satisfactory panel heating may be either ____________ or ____________ systems.
2. ____________ are usually less expensive to install.
3. ________ ________ are exceptionally desirable where there are high ceilings.
4. ________ ________ are desirable where small children occupy the space.
5. ________ ________ are more difficult to control than ____________.
6. ________ ________ are likely to have a large amount of heat loss to the ________.
7. ________ ________ is usually installed completely ________.
8. ________ ________ eliminates ________ ________ on walls.
9. ____________ usually offsets the discomfort caused by large cold glass openings.
10. ________ ________ has a fresher and more comfortable heating effect than systems having a higher operating temperature.
11. ________ ________ ________ are more difficult to control than other conventional types of heating systems.
12. ________ ________ usually cost a little more than other conventional types of heating because of construction problems.

PANEL HEATING LESSONS

Lesson 4.

Aims of this lesson:

(1) To study the method of properly installing and protecting various types of panel heating coils.

(2) To study the effects of corrosion on panel heating systems.

(3) To study the advantages of proper insulation of panel heating.

PROCEDURE:

The student should carefully study the information and the illustrations, then answer the questions in the spaces provided at the end of this lesson.

INSTALLATION METHODS

Floor or ceiling panel systems employ a hot water circulating system for distribution of water at temperatures ranging from 100° to 140° to permit the coils, in turn, to heat the building construction. The circulating arrangement is very similar to any good forced hot water circulating system and incorporates the usual components of a hot water boiler, or convertor, circulating pumps, supply and return hot water mains, branches to individual coils, closed or open expansion tanks, some form of automatic control, including thermostats, mixing valves, safety regulators; and such accessories as air vents, balancing fittings, etc. The following discusses some of the more pertinent installation and construction details which apply specifically to panel heating systems.

Panel Construction (Imbedment)

In order to assure panel effectiveness, it is extremely important that the plaster or concrete be properly applied to the panel piping. For plaster ceiling installations, proper application of plaster is of extreme importance in the construction of the panel, for without such satisfactory imbedment the overall system cannot function properly.

Wire lath should be wire tied to the pipes or tubing at frequent intervals whether the pipes or tubing are installed above the lath or tubing used below the lath. If the tubing or piping is installed above the lath, it is important that the first coat of plaster should be well worked up through the wire lath to insure proper contact with the tubing or piping. Plastering techniques for ceiling panels are no different than those required for any **good three-coat gypsum plastering installation** other than the necessity for insuring complete contact between the plaster and the tubing or piping.

Figure 5 shows first coat of plaster being applied while Figure 6 shows the back side of the panel with the first coat up and around the

Fig. 5—Application of Plaster to Lath and Tubes

Tubes attached to joists. Lath below tubes, also attached to joists. First coat of plaster applied to lath and tubes.

Fig. 6—Plaster in Contact with Tubes
Back side of plaster panel showing first coat of plaster forced through lath to contact tubes.

tubes. If there is insufficient contact between plaster and the tubes, — say, less than one-third of tubing circumference — an uneven temperature spread will result with unsatisfactory operation. Insufficient contact between tubes and plaster requires higher water temperatures to be used in order to provide for proper heat flow to the room.

If tubes are below wire or rigid lath, first coat of plaster must always be worked hard against the tubes to be sure that no voids are created between the tubes and the lath.

This complete imbedment is also important for pipes in concrete. In addition to providing for maximum thermal conductivity between the piping and the concrete, complete imbedment also provides corrosion protection.

The importance of good contact between pipes or tubes and the adjacent lath and plaster in the case of plaster ceilings and the imbedment of piping or tubes in concrete cannot be stressed too strongly. It is this formation of an integral working assembly that dictates the future satisfactory operation of the heating panel.

Coils — Serpentine or Grid

Coils for panel systems are constructed either as grid assemblies or serpentine assemblies. The center to center spacing of the tubes or piping is the same whether the coils are assembled in grid formation or in serpentine formation.

Grid coils have the advantage of lower circulating resistance, which means that lower head pumps can be used. Serpentine coils must be limited in length in order to keep pumping heads down. In general, copper tubing is formed into serpentine coils while steel or wrought iron pipe may be formed into either serpentine or grid assemblies. One disadvantage of grid coils is that it is sometimes difficult to obtain proper circulation through all branches of the grid.

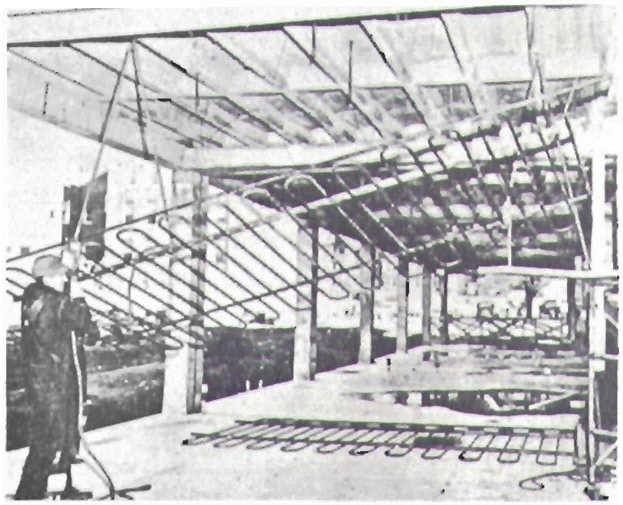

Fig. 7—Prefabricated Pipe Coils (Serpentine)
Preassembled coil attached to back angle.

Steel or wrought iron coils are generally prefabricated and installed as an assembled unit, while copper tubing coils are often formed directly on the ceiling. Figure 7 shows prefabricated serpentine pipe coils being readied

Fig. 8—Copper Tubing Coil (Serpentine) Fabricated in Field
Tubes below lath. Straps attach tubes to joists. Tubes will also be wire-tied to lath.

for attachment to building. Figure 8 shows formation of copper serpentine coils below wire lath, while Figure 9 shows a pipe grid assembly ready to receive concrete floor slab.

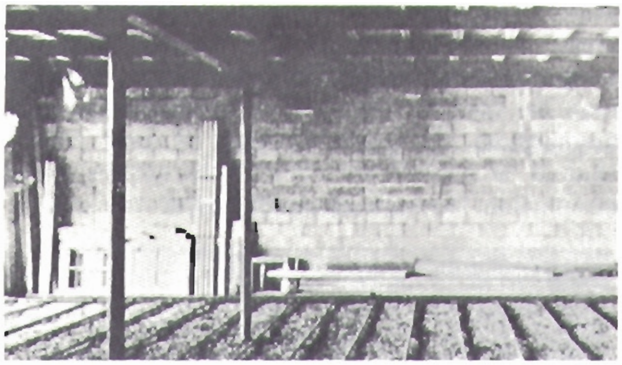

Fig. 9—Grid Type Coil

One further word about prefabrication — in order to permit panel systems to be cost-competitive with other forms of heating, every effort should be made to have coils for large installations installed in standard sizes. This will permit standardization of the coil assembly and even standardization of bending of sub-assemblies. Figure 10 is a view of standardization of such

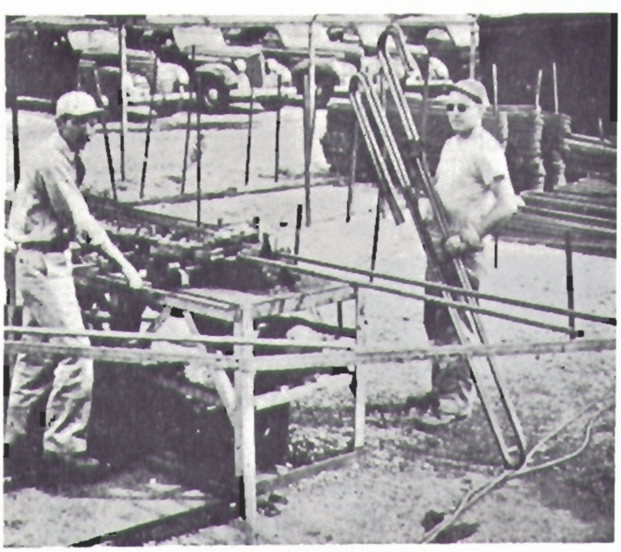

Fig. 10—Prefabrication of Sub-Assemblies
20 ft lengths of pipe bent into standard sub-assemblies.
To be welded into "standardized" sinuous pipe coils.

sub-assemblies, while Figure 11 shows final assembly into coils.

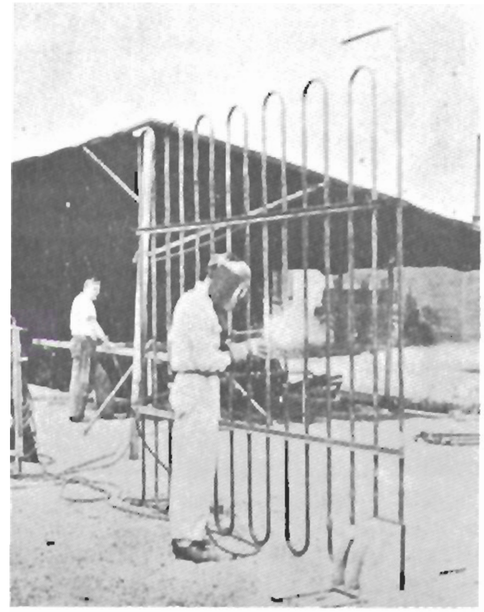

Fig. 11—Assembly of Pipe Coils
Welding sub-assemblies into full sized coil.

Coil Materials

The materials most commonly used today for panel heating installations include copper, steel and wrought iron. Type K or Type L copper tubing should be used for both mains and coils, preferably soft tubing for coils. Hard temper copper tubing is used often for grid type coils.

When steel or wrought iron pipe is used in the fabrication of pipe coils, this material is standard IPS. Some of the steel pipe manufacturers provide standard weight steel pipe of higher ductility when such material is to be used for coils.

If copper tubing is used for coils on imbedded piping, all joints in such tubing must be soldered. While 95-5 tin-antimony solder is much preferred because of its higher structural strength with higher water temperatures and pressures, some panel heating installations have used a 50-50 tin-lead solder. If steel or wrought iron pipe is used to form pipe coils, all joints in such piping must be of welded construction.

Copper tubing is selected for such reasons as: easier bending, better corrosion resistance, lower friction losses, and solder joints more readily constructed than welded joints. Further, if tubing is to be placed below lath, then 3/8" nominal size copper is the most logical material to be used.

Steel or wrought iron pipe is selected for such reasons as: lower material costs, coefficient of expansion more nearly that of concrete, more capable of resisting construction damage in field, and, though welded joints are more costly to fabricate than soldered joints, welded joints have a better chance for absolute tightness, with long life.

Coil Supports

Pipe coils to form panels should always be well supported and should be set as nearly dead level as possible. Pockets or loops that would interfere with proper draining of coils and proper venting of system must be avoided.

In the supporting of steel or wrought iron floor coils, pieces of pipe, angle iron, reinforcing rods, mounds of Portland cement concrete, or pieces of stone concrete block may be used. Such coils should **never be supported on pieces** of wood or cinder blocks because of corrosion difficulties (discussed later). Figure 12 shows

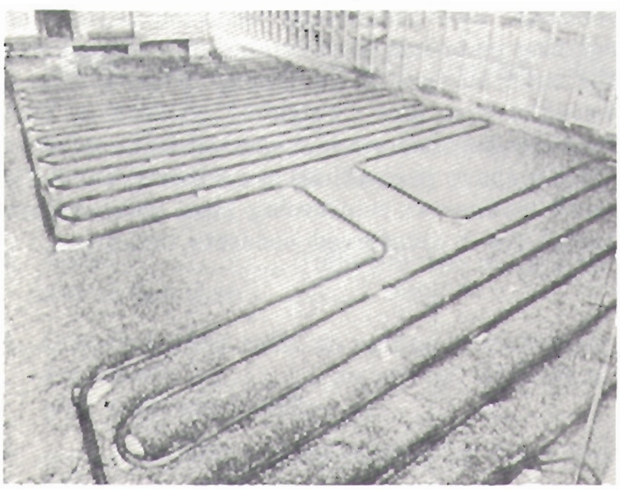

Fig. 12—Coil Supports

Pieces of concrete block are used to support pipe coil prior to pour of concrete.

serpentine coils supported on pieces of concrete block wherein the coils are set level ready for pouring of floor slab.

When steel or wrought iron pipe coils are used for ceiling panels to form suspended plaster ceilings, supports are run across the coil pipes. These supports may be 1¼" pipe or 1½" angles located on three to four foot centers. The individual coil branches must be wire-tied to each pipe or angle at each point of intersection. The hanger pipes or angles, in turn, are supported from the structure. When ceiling coils, either copper, steel or wrought iron, are set below wood joists (above lath), the coil pipes, themselves, should be kept slightly clear of the underside of the wood joists to prevent "creaking" which often occurs as the result of thermal expansion.

Wire lath located below pipe or tubes should be wire-tied every 6" along the tube. If lath can be attached directly to the structure, then the wire ties between the lath and the piping need only be on 18" centers.

When copper tubes (3/8" nominal) are installed below rigid or wire lath, the tubes, themselves, should be attached to the lath on at least 18" centers. However, the tubes should also be directly attached to joists or building structure in order to limit the weight of water and tubes to be carried by the wire lath. Figure 13 shows

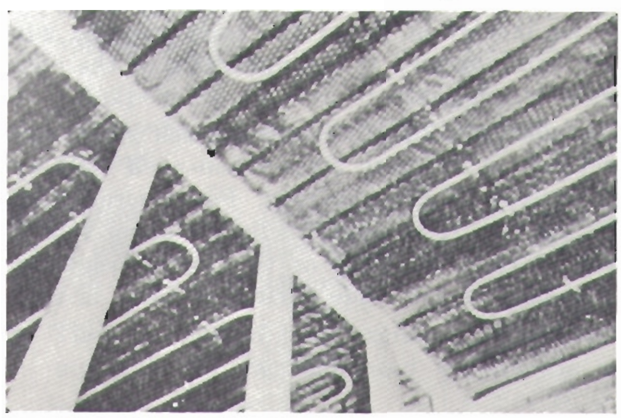

Fig. 13—Coil Support

Tubing attached to joist above, independently of wire lath.

such tubing installed below the lath with independent attachment to the wood joist above the lath.

Insulation

All plaster panel coil installations should have insulation installed above the coils unless it is intended to have some heat flow upward, with a resulting reduction in heat flow downward. If the spaces above the coils are unheated, insulation equal to 4″ rock wool should be installed above the coils. If the spaces above the coils are heated, insulation equivalent to 2″ rock wool is sufficient. The performance of a plaster panel in supplying heat downward is materially affected if such insulation is omitted. Figure 14

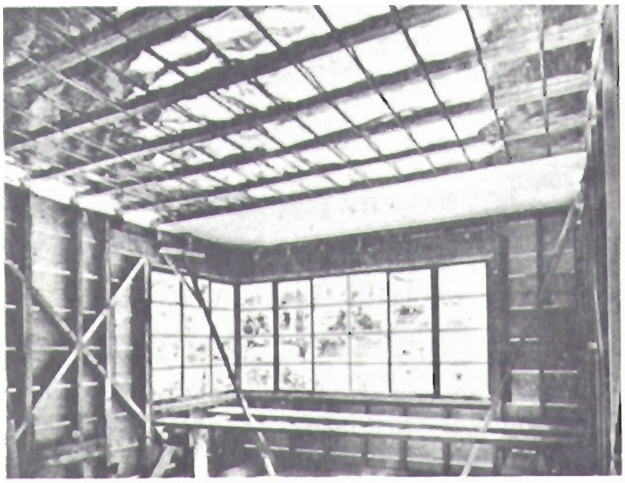

Fig. 14—Insulation Above Tubing

Insulation between joists. Note notches in joists for tubing. Lath will be attached to joists, and tied to tubing.

shows insulation above the coils prior to wire lath being applied to the underside of the coils.

Insulation is equally important below pipe coils installed in concrete slabs when such coils are to be used for floor heating. For concrete slabs resting on grade, edge insulation along footing wall at least 24″ deep or to a point below the frost line, or a 5′ wide perimeter band, is sufficient to provide effective insulation against reverse loss.

Corrosion

The problem of corrosion is important in the overall operation of panel systems. Any of the piping or tubing materials that must be imbedded in building construction, of necessity, must be relatively good as to corrosion resistance.

Generally, internal corrosion in a panel heating system is not serious. The water in the system is recirculated. Entrained air, introduced by makeup water, is relieved at either an open expansion tank or at a closed expansion tank. Copper tubing, steel pipe and wrought iron pipe are all commonly used and are satisfactory for a recirculating water system.

The outside of such piping or tubing can become involved in corrosion difficulties because of the presence of ground water, the presence of cinder concrete or the presence of some organic matter, such as wood. Because of these hazards, all necessary precautions must be taken to safeguard against this difficulty, such as a water proofing membrane to protect against ground water, completely avoiding use of cinder concrete, and preventing wood or organic insulating materials from coming into contact with the outer surface of the piping. Normal steel or wrought iron pipe completely encased in Portland cement concrete is protected from corrosion (if the above precautions are adhered to) in the same manner as reinforcing steel rods are protected for a reinforced concrete building.

REVIEW SHEET

Lesson 4.

1. Floor and ceiling panels usually circulate water at temperatures ranging from ____° to ____°.

2. The component parts of a panel system may include (a) ______ ______ ______; (b) ______ ______; (c) ______ ______ ______; (d) ______ ______ ______; (e) ______ ______; (f) ______; (g) ______ ______; (h) ______ ______; (i) ______ ______; (j) ______ ______.

3. Panel heating in plaster and ceilings should have ______ ______ with plaster.

4. Wire lath used with ceiling panels should in all cases be securely ______ ______ to heating coils.

5. Poor heat distribution in ceiling panels is usually the result of ______ ______.

6. The more complete the imbedment of panel heating pipes in surrounding materials, the more ______ ______ system will operate.

7. Complete imbedment of pipes in concrete ______ ______.

8. Two types of coils for panel systems are ______ ______ ______.

9. Copper tubing is usually formed into ______ ______.

10. Where lower pump pressure and lower circulating resistance is desired, ______ coils should be used.

11. Usually, ______ coils provide more even circulation than ______ coils.

12. Copper tubing coils on ceiling installations are usually ______ as erected while steel pipe coils are usually ______ ______.

13. ______ tubing is usually used for main and coils.

14. Steel pipe having ______ ______ is desirable for coils.

15. Copper tubing joints should be soldered with ______ ______ solder, although some installations can be made with ______ tin lead solder.

16. Steel or iron pipe joints must be ______.

17. Give three advantages for using copper tubing for coils: (a) ______; (b) ______ ______ ______, and (c) ______ ______ ______.

18. Give three advantages of using steel or wrought iron pipe for coils: (a) ______ ______; (b) ______ ______ ______, and (c) ______ ______ ______.

19. Pipe coils should be installed ______ to avoid ______.

20. Floor coils supported on wood or cinder blocks will ______ more rapidly than on less absorbent materials.

21. Steel or wrought iron pipe coils used for ceiling panels may be supported with ______ or ______ on three or four foot centers.

22. All steel or wrought iron pipe coils for ceiling panels should be ______ ______ to supports.

23. All pipe coils attached to under side of wood joists should have a slight clearance to prevent ______.

24. Copper tubing installed below lath should be directly attached to ______ and to the lath ______ on centers.

25. The direction of heat exchange from heating coils can be influenced by the use of ______.

26. Reverse heat loss in floor panel heating over unexcavated areas will result unless coils are ______.

27. If ground water, cinder concrete or organic materials come in contact with panel heating coils ______ is likely to result.

28. The effects of ground water on coils may be overcome by the use of a ______ ______.

PANEL HEATING LESSONS

Lesson 5.

Aims of this lesson:

(1) To study the function of the various components of a panel heating system.

(2) To study the methods of installing components other than the heating coils.

PROCEDURE:

The student should carefully study the information and the illustrations, then answer the questions in the spaces provided at the end of this lesson.

Mains and Risers

The rules for good workmanship and proper installation, applying to the installation of hot water mains and risers for hot water radiator circulating systems, apply equally to panel heating systems. Except for the use of coils to form panels in lieu of use of cast iron radiators or convectors for hot water heating systems, the circulating and distributing systems are alike. If the distribution system involves long runs, reversed return systems are suggested to equalize flow resistances.

Mains should pitch up in the direction of flow to more readily assure venting of air to high points. Self venting of a system is of extreme importance as a small amount of air lodged at strategic points in the distribution system or in a coil may block proper circulation for the entire system or for parts of the system. Similarly, the drainability of the system is important. If possible, the piping system should be run so that the entire installation may be drained at one low point. If this is not readily achieved, then individual drain valves should be located at remote points to permit draining of the system.

Boilers and Pumps

Hot water boilers serving panel systems are selected in the same manner as hot water boilers serving radiator systems. The total net load is arrived at in the same manner, i. e., the sum of the heat outputs from the effective panel areas, plus the sum of the reverse losses, plus the sum of the piping losses.

Pumps and circulators used in panel systems are also similar to those used in hot water radiator systems. In larger installations, with long coil circuits, centrifugal circulating pumps with circulating heads up to 30 to 40 feet may be used. However, most small systems can be designed so that standard hot water circulators, providing an 8 to 10 foot circulating head, are sufficient. The pressure drop that must be overcome by the circulator is the sum of the pressure drop for the length of the **least favored** coil circuit, the pressure drop for the run of main, and the pressure drop for the flow control valve.

Air Vents

One of the most troublesome problems encountered in the installation and operation of panel systems is that of clearing the system of air that tends to prevent circulation in parts of the system. High points of the system must be vented either through an expansion tank or through automatic vent valves. If possible, a self venting arrangement should be used. This involves locating supply mains in the basement and return mains at the top of the building above the highest coils. Supply risers and return risers then feed up. All piping pitches up in the direction of water flow, which thus permits air to be pushed ahead of water, and thus provides a self venting system. The high point of the system should be the end of the return main before dropping back to the basement, and a vent to an open expansion tank can be taken from this high point. If this arrangement is not possible, then individual automatic vent valves should be installed at the top of the several high points of the system.

Expansion Tanks

Each system should be provided with either an open or closed expansion tank. The size of the expansion tank is arrived at in a manner similar to method used for selecting an expansion tank for any hot water heating system. The storage capacity for the expansion tank must be large enough to take care of the increase in volume that will result from the highest water temperature in the system. The total quantity of water stored in the piping, coils and boiler of the system must be determined, and an expansion tank equal to about 4% of this volume is roughly the correct size for a panel system, since such systems generally operate with a top water temperature of 150°. The volume increase of water heated to 150° represents about a 2% change, and selecting an expansion tank of double this capacity is approximately correct. This doubling of capacity provides for some reserve before automatic water feeder adds water to system and also some reserve before overflow takes place. These reserves prevent alternate spilling and makeup of fresh water, which would result from an undersized expansion tank. Keeping fresh water makeup to a minimum is a good safeguard against corrosion and water treatment difficulties.

Balancing Cocks

Balancing cocks are very important in that they permit adjusting water flow to assure proper system operation. Water flow to individual coils often must be adjusted to take care of improper load calculations, changes in desires of occupants, but primarily to assure correct water supply to each coil in accordance with load requirements for each room. Balancing cocks or valves should be installed in each individual coil branch, either on the supply side or on the return side — whichever is the more practical location. Balancing valves are usually square headed or T-handled plug cocks. These plug cocks may be located in floor recesses when serving floor coils, in the branches from supply mains in the basement to upper floor coils, or in the branches on returns. Balancing valves may be placed anywhere in the system that is easy to reach as long as their throttling action is effective. In smaller systems, all balancing cocks for the entire system can be located in the boiler room by using "home runs" from each individual coil to the plug cock. Figures 15, 16 and 17 illustrate three arrangements for location of balancing valves. Figure 15 locates three separ-

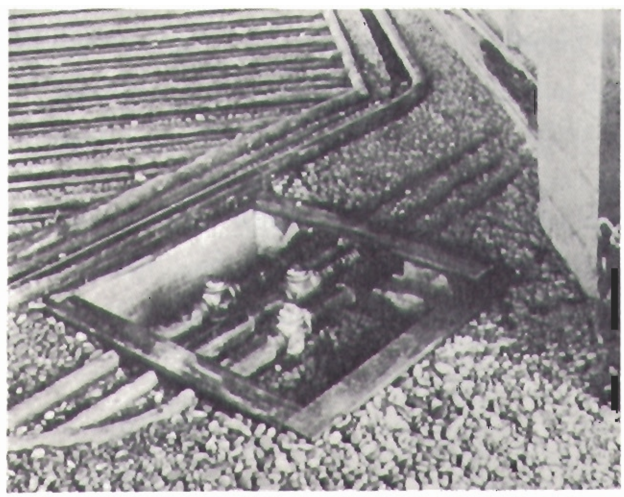

Fig. 15—Balancing Cocks

Three balancing cocks located in floor pit. Controls separate circuits. Joined to form common branch.

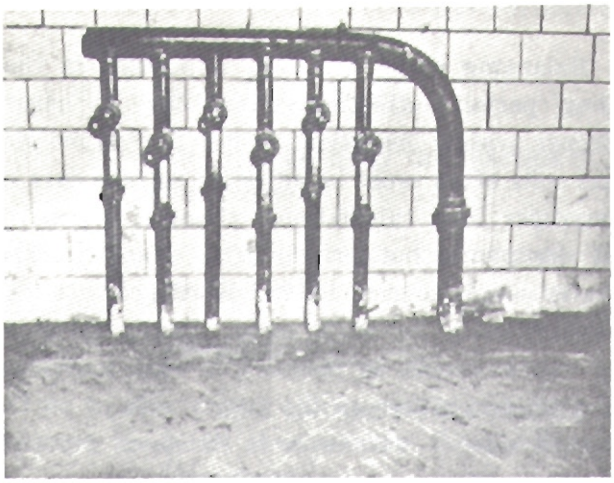

Fig. 16—Balancing Valves

Valves to control six separate circuits combined into common header.

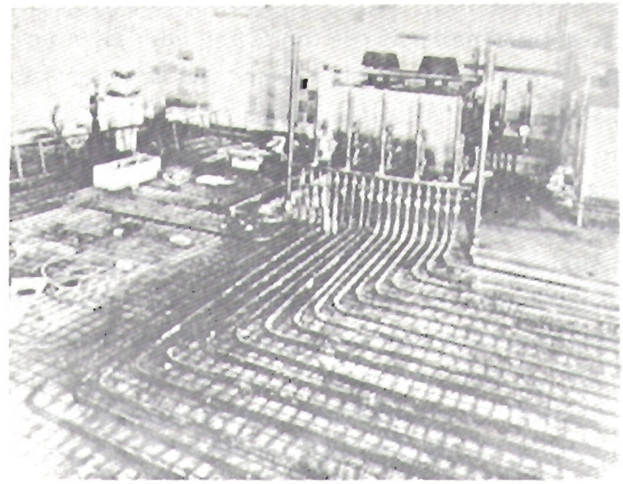

Fig. 17—Balancing Cocks

Balancing cocks serving 18 separate circuits. Each circuit arranged with "home-run" to boiler room. (All balancing done in boiler room).

ate controls in a floor box. Figure 16 shows six coil branches exposed above the floor, forming a return header. (Also note the tapping in the top of the return header for vent.) Figure 17 shows the "home run" arrangement with all returns brought back individually from the coils to the boiler room and an individual balancing valve provided for each separate circuit.

REVIEW SHEET

Lesson 5.

1. The same care and workmanship should be observed in the installation of main and risers for a panel heating job as for a ____ ______ ________ system.

2. Risers are installed __________.

3. Mains are installed nearly __________.

4. Horizontal hot water lines are usually pitched upward in the direction of the flow to permit ____ ________ . . ___ ___ __________.

5. Proper water circulation in horizontal pipes may be effected by not providing ________ ________ of the system.

6. In the installation of mains and risers it is desirable that they be installed so as to ____ . to one point.

7. Hot water boilers for panel systems are similar to boilers for ________ ________.

8. Small panel systems may only require ____ to ____ foot circulating head, while large systems may require ____ to ____ foot.

9. A serious problem to overcome in a panel heating system is the elimination of ____ from the system and unless it is accomplished satisfactorily it will _____ the operation of the system.

10. The function of the vent valves is to ________ ____ ____ from the system and should be located at the ____ ________ of the system.

11. When the temperature of water is raised, the volume is increased and usually ____ ________ _____ is required.

12. Water heated to 150° increases approximately ____ in volume.

13. ________ ___ . . ________ are set to add water to the system as needed to replace any water lost through the over flow.

14. A proper size ________ _____ should be installed to reduce the amount of new water the system may require.

15. The water flow in the coils or circuits may require certain adjustments to meet operating conditions. To provide for these adjustments ________ ________ should be installed in a readily accessible location for each coil.

16. Installations where all circuit returns are brought back to boiler room and are provided with individual controls are termed ______ ____.

PANEL HEATING LESSONS

Lesson 6.

Aims of this lesson:

(1) To acquaint the students with the meaning of the trade terms used in the design of panel heating systems.

(2) To study means of panel heating controls to provide proper space temperatures.

PROCEDURE:

The student should carefully study the information and the illustrations, then answer the questions in the spaces provided at the end of this lesson.

DESIGN CONSIDERATIONS

It is not intended in this discussion of design considerations to provide complete information for design calculations. There are available many satisfactory design manuals for panel heating systems. These manuals are published by such associations as the Heating, Piping and Air Conditioning Contractors National Association, The Institute of Boiler and Radiator Manufacturers, the Copper and Brass Research Association, The American Iron and Steel Institute, as well as most of the manufacturers of steel and wrought iron pipe, copper tubing, hot water pumps and specialties, etc. The data provided by these manuals is very complete and no attempt will be made in this discussion to provide total design information other than a brief discussion as to the general principles.

Definitions

There are a few terms and expressions used in discussing panel heating output data that should be defined.

Panel surface temperature — average operating surface temperature of the heated panel surfaces.

Unheated surface temperature — area average of surface temperatures of all **unheated** room surfaces. This is sometimes called UMRT (unheated mean radiant temperature). As used, this term involves only average of surface temperatures and does not include the radiant effect of emissivity. The **unheated surface temperature** very markedly affects panel output by influencing radiant exchange between heated and unheated surfaces.

Mean radiant temperature (MRT) — weighted average of radiant temperature of all surfaces, both heated and unheated. This term takes into consideration not only the surface temperatures but also their surface emissivities.

Panel Outputs and Water Temperatures

Resolving the many factors that influence the output of a floor or ceiling panel is rather complicated. A panel releases part of its heat by convection and part by radiation exchange with the cooler surrounding surfaces. For a given surface temperature of a heated panel, the important factors that would tend to increase output are: (1) lower unheated room surface temperatures — which increase radiant exchange by reason of increased temperature differences; (2) lower room air temperature — which increases convection exchange; (3) higher rate of outdoor air infiltration — which increases convection exchange; (4) larger areas of vertical glass adjacent to heated panels — which tend to increase the downdraft across heated panel and thus also increase convection effect.

For the average room of average construction, heated to 70° with zero outdoor temperature, the panel output values of ceiling and floor panels are about:

With ceiling surface of 120° —
about 60 to 70 Btu per hour per sq ft

With ceiling surface of 110° —
about 45 to 55 Btu per hour per sq ft

With ceiling surface of 100° —
about 35 to 42 Btu per hour per sq ft

With ceiling surface of 90° —
about 25 to 30 Btu per hour per sq ft

With floor surface of 85° —
about 35 to 45 Btu per hour per sq ft

With floor surface of 80° —
about 25 to 40 Btu per hour per sq ft

The **water temperatures** required to provide the above **panel outputs** vary with the panel construction, depth of bury, tube or pipe spacing, amount of back insulation, and many other important factors. Water temperatures and water flow rates are usually calculated for about a 15° to 20° temperature difference between inlet water temperature and outlet water temperature. For ceiling plaster panels with tube or pipe spacing of 4½″ to 9″ centers, the average water temperature usually encountered in the panel at maximum output conditions is in the order of 105° to 140°. With floor panels using pipe or tube spacing of 6″ to 18″ centers, the average water temperature encountered at maximum output conditions is in the order of 100° to 140°.

It is extremely important to recognize that the above values for **design outputs** and **water temperatures** are given only to portray an order of magnitude and should not be used for any design calculations.

Automatic Controls

Selecting the correct and proper automatic control apparatus for a panel heating system is perhaps one of the most difficult problems encountered in the installation of such systems. The automatic controls are intended to regulate heat output of panels to provide comfortable room temperatures, while offsetting changes in outdoor weather conditions, influence of sun and wind, opening and closing of doors, etc. Because panel systems are built into the building, they involve to a greater or lesser degree the serious problem of thermal lag or inertia. Heating panels wherein pipes are imbedded in concrete have considerable thermal inertia and therefore a resistance to ready change. Plaster panels have the same effect to a lesser degree. As opposed to the system inertia, the building, itself, may have differences in thermal inertia. For example, a building may be constructed of light weight materials with thermal storage at a minimum and also include large glass areas. Such a building is subject to rapid load change with sudden changes in outdoor weather. Conversely, the building may be of heavy masonry construction and also have small glass areas. Such a building reacts in a relatively slow manner to sudden changes in outdoor weather.

It is this relationship of lag or inertia, with sudden changes in weather conditions, that dictates the importance of selecting the proper automatic controls.

Some small buildings may be adequately served with nothing more than a room thermostat intermittently operating a circulator. More complicated buildings require zoning (separation of the piping circuits) to permit offsetting wind and sun influences on the several sides of a building, or zoning to separate bedrooms from living rooms.

A few of the more basic arrangements of controls for panel heating include:

Room thermostat directly controlling circulator;

Room thermostat varying temperature of water supplied to system, with circulator operating continuously;

Outdoor thermostat varying water temperature supplied to system in accordance with a fixed schedule, and circulator operated continuously;

Outdoor thermostat varying water temperature supplied to system (with a room thermostat acting as an overriding correcting device), in accordance with schedule, and circulator operating continuously;

Separation of piping system into several zones with individual room thermostats controlling flow valves for the separate circuits, or controlling separate circulators intermittently.

These control devices may be electrically operated, pneumatically operated, or may be self-contained.

REVIEW SHEET

Lesson 6.

1. The average operating surface temperature of heated panel surfaces is termed the ____ ____ ____.

2. The average surface temperature of all unheated room surfaces is termed ____ ____ ____ ____ ____.

3. The radiant heat exchange between heated and unheated surfaces is affected by the ____ ____ ____.

4. The weighted average of radiant temperature of all surfaces, both heated and unheated is termed the ____ ____ ____, abbreviated ____.

5. The amount of output by panel heating may be influenced by —
   (a) Lower unheated room surface temperatures which may increase ____ ____ because of increased temperature differences.
   (b) Lower room air temperature may increase ____ ____.
   (c) Higher rate of air leakage from outside may increase ____ ____.
   (d) Large areas of **vertical glass** may increase ____ ____.

6. For average conditions with inside desired temperature at 70° and outside at zero, panel outputs may be as follows:
   (a) With ceiling surfaces at 120°, output may be from ____ to ____ Btu/hr/sq ft
   (b) With ceiling surface of 110°, output may be from ____ to ____ Btu/hr/sq ft
   (c) With ceiling surface of 100°, output may be from ____ to ____ Btu/hr/sq ft
   (d) With ceiling surface of 90°, output may be from ____ to ____ Btu/hr/sq ft
   (e) With floor surface of 85°, output may be from ____ to ____ Btu/hr/sq ft
   (f) With floor surface of 80°, output may be from ____ to ____ Btu/hr/sq ft

7. The water temperature of the panel outputs above will vary with (a) ____ ____ ____; (b) ____ ____ ____; (c) ____ ____ ____, and (d) ____ ____ ____.

8. The temperature difference of the water between the uncirculated and the circulated water is usually from ____ to ____ degrees.

9. The water temperature in ceiling panels with $4\frac{1}{2}''$ to $9''$ spacing of tubes may vary from ____ to ____ degrees.

10. The water temperature in floor panels with $6''$ to $18''$ spacing may vary from ____ to ____ degrees.

11. The heat exchange from concrete panel is ____ than from plaster panels.

12. Panel heating is ____ to overcome temperature differences than other forms of heating.

13. The inability of a panel system to quickly overcome temperature differences is termed ____ ____.

14. Panel heating may be any of the following:
    (a) Room thermostat directly controlling ____;
    (b) Room thermostat directly controlling ____ ____ with continuous circulator.
    (c) Outdoor thermostat controlling ____ ____ with continuous circulator.
    (d) A combination of outdoor thermostat and a room thermostat to correct any ____ difference.
    (e) A combination of outdoor thermostat and room thermostat in combination with a unit heater or blower system to correct any ____ ____.

PANEL HEATING LESSONS

Lesson 7.

Aims of this lesson:

(1) To acquaint the learner with proper methods of testing new installations.

(2) To acquire a knowledge of proper procedures for the operation of a new installation.

(3) To review the important items to check in the proper maintenanoe of a panel heating installation.

PROCEDURE:

The student should carefully study the information and the illustrations, then answer the questions in the spaces provided at the end of this lesson.

OPERATING ADVICE

Testing

Testing procedures are of extreme importance in the construction of an imbedded piping system. The concealed portion of a panel system should be pressure tested to 150 psig to assure tightness of welds and soldered joints. (In a tall building, the piping should be tested to at least two times the operating pressure, but at least 150 psig.). If it is possible, when testing a copper tubing installation, it is strongly recommended that heated water be used and the circulator operated to make certain that temperature stresses and vibration will show up all possible defective soldered joints. This may not always be possible. Pressure test on any system should be held for at least four hours.

Filling and Venting

When filling a system, it is recommended that the water be introduced at the low point, and the system should be filled very slowly. By introducing the water into the bottom of the system and filling very slowly, the tendency for air pockets to form is considerably reduced. It is the air pockets trapped within the piping system that later create circulating difficulties.

It is suggested that the entire system be flushed out several times. One method is to close all coil valves but one, and then circulate full pump capacity through a single coil, and repeating the operation for the other coils. This may not always be possible but, in general, a good flushing of the system is desired. It is recommended that a strainer be used at the pump suction, and this should be checked and cleaned frequently.

Drying Out

In plaster ceiling work, it is extremely important that panels be dried out thoroughly before hot water is circulated. It is suggested that plaster be air dried for two to three weeks. After that, water at about 80° should be circulated for two days. Then, the water temperature may be increased to 130°, raising the water temperature about 5° per day, so that the drying out, using warm water, takes about two weeks. With this slow drying period, a satisfactory plaster panel will be created, which will later permit rapid changes of water temperature without danger of thermal stresses or cracks.

Start Up and Balancing of System

After proper filling and venting the system and proper drying out of system, the automatic controls should be checked to assure that they operate in accordance with the intended control requirements, both as to automatic temperature regulation and as to fulfilling safety cutoff requirements. When starting the system for the first time, all balancing valves on individual coils should be wide open. Proper balancing can only be done in cold weather for there must be a load to create a water temperature difference.

It is generally recommended that the **least favored** circuit be checked first to determine whether that room is obtaining adequate heating. The **least favored** circuit is usually the longest coil, farthest from the boiler, involving the greatest flow resistance. Generally, the other rooms may require that their balancing cocks be throttled to prevent overheating. The most important single problem during the startup and balancing period is to make certain that every coil circuit operates properly and that there are no inoperative serpentine coils or dead portions of grid coils. Air pockets are usually the most serious offender and very often the circuit in difficulty can only be cleared by valving off all other circuits and using full pump capacity on the troublesome circuit.

Maintenance

Important items to be checked during maintenance of a panel system are:

Clean strainers;

Check automatic and safety controls for proper operation;

If open expansion tank is used, check water level in tank and operation of automatic water feeder (if used);

If closed expansion tank is used, check air cushion in tank and operation of water pressure regulating valve and water relief valve;

Check operation of all air vents;

Make certain that the system is not air bound and that all coil circuits operate properly. In order to clear coil circuits in difficulty and eliminate air pockets, it may be necessary to completely drain the system and refill slowly, following suggested "filling and venting" procedure given on page 26.

REVIEW SHEET

Lesson 7.

1. The concealed portion of a panel system should be tested before it is ________.

2. Panel systems should be tested to withstand a pressure of at least ________.

3. Pressure tests should be held for at least ____ ________.

4. Copper tubing installations should, when possible, be tested under operating conditions in order to ______ ________ ______.

5. Filling the system from the low point at a ______ _____ aids in reducing the number of ____ ________.

6. Circulating difficulties in a system are usually the result of ____ ________.

7. A new system should be flushed ________ times.

8. A strainer which can be checked and cleaned should be installed at the ______ ________.

9. The plastering surrounding an imbedded system should be _____ ______ for ____ to ______ weeks.

10. In a plastered ceiling with imbedded piping the temperature of the circulating water should be __________ gradually.

11. In a new installation, all balancing valves should be ______ ______ on the initial starting.

12. The system, in order to insure proper balancing, should be balanced in _____ ______.

13. In checking the circuits of an installation the ______ ______ ________ should be checked first.

14. The circuit with the greatest flow resistance is usually the ______ ________ ________.

During operation of panel heating the following should be checked for proper performance:

15. ________________

16. ____________ ____________

17. ____________ ________, and

18. ____ ________.

PANEL HEATING LESSONS

Lesson 8.

Aims of this lesson:

(1) To study the possibilities of using panel heating installation as a cooling system.

(2) To learn the extent that panel heating systems may be used as a cooling system.

PROCEDURE:

The student should carefully study the information and the illustrations, then answer the questions in the spaces provided at the end of this lesson.

PANEL COOLING

Panel systems have been used to some limited extent to provide for cooling in the summer. Complete air conditioning requires control of at least the room temperature, relative humidity, air motion and the freshness of air; along with control of such other factors as purity of air and cleanliness. A panel cooling system operating alone cannot provide these important services in order to act as a complete air conditioning system. It cannot lower surface temperatures sufficiently to provide comfort if room air temperature and relative humidity are not controlled.

Panel cooling can be used to supplement other air conditioning apparatus so that, jointly, they will provide a comfortable environment and, under certain operating and installation conditions, can do so economically. However, there are certain operating considerations and limitations that should be recognized when thinking about panel cooling systems.

The surface temperature of cooling panels and the water temperature of the distribution piping system must be operated above the dewpoint temperature of the space. For example, if the room conditions are 75° to 80° dry bulb with a relative humidity of not over 50%, then the dewpoint temperature of these spaces varies between 55° and 60°. This means that the water temperature in the system should not be cooled below 60°, or there will be sweating of piping and ceilings.

Some metal panel cooling systems now in use operate with a very small temperature difference between the circulating water temperature and the panel surface temperature, in the order of 4° to 6°, or, say, a 68° panel temperature when using an average of 63° water. This is not possible with plaster ceiling panels or concrete panels as the thermal resistance of plaster and concrete is too great. Instead of the 4° to 6° temperature spread possible with metal panels, this spread is more in the order of 10° to 15° for plaster or concrete. This higher temperature differential results in higher panel surface temperatures, and therefore a reduction in possible heat pickup by panel.

Metal panels can be operated so that a heat pickup rate of 15 to 20 Btu per hour per sq ft is possible. Such pickup rate may account for as much as 40% to 60% of the calculated sensible heat gain in the room. Use of metal panels in this fashion permits reducing the amount of cooling work which must be performed by an air cooling system, and, therefore, can reduce such air cooling system requirements about 50%. This, in turn, provides for comparable reduction of ducts, space for ducts, fan equipment rooms, etc. Even so, the reduced quantity of air is still sufficient to provide for the ventilation, fresh air, and dehumidification requirements of the conditioned spaces.

Refrigeration apparatus or a water-to-water heat exchanger should be used to cool the panel system water. City water or well water should not be directly supplied to any panel system even though such water is cold enough to do the cooling. The water of any panel system, for either winter or summer operation, should always be recirculated to minimize corrosion, scaling, fouling and air pockets.

REVIEW SHEET

Lesson 8.

1. Complete air conditioning requires regulation of ____ ________, ______ ________, ____ ________, and ________ ____.

2. Panel cooling can only be used to supplement the air conditioning system with respect to ____ ________.

3. Panel cooling in some cases may ______ operating costs of the air conditioning system.

4. If the water temperature of the cooling system is below the dewpoint temperature, ________ of surrounding areas may result.

5. Metal panel cooling systems are more effective than ______ ____ _____ ______ because of the quicker exchange of heat.

6. Metal panels may pick up as much as ____ Btu/hr/sq ft

7. A satisfactory metal panel system may perform as much as ____% of the cooling work required.

8. City water or well water is ____ suitable for panel cooling if supplied directly.

9. Water in any panel system, should be ____________ to reduce corrosion, scaling and air pockets.

PANEL HEATING LESSONS

Lesson 9.

Aims of this lesson:

(1) To study the uses of panel heating for snow melting.

(2) To learn the proper methods of installing panel systems for snow melting.

(3) To acquaint the learner with proper operating procedure for panel systems used for snow melting.

PROCEDURE:

The student should carefully study the information and the illustrations, then answer the questions in the spaces provided at the end of this lesson.

SNOW MELTING

The techniques required for the construction and installation of snow melting systems are the same as those used in the construction and installation of panel heating systems. Snow melting systems are now being provided for the controlled melting of snow for sidewalks, ramps, roadways, bridge approaches, airport runways, filling stations, etc., to list but a few applications wherein the cost of snow melting installation can be more than offset by savings in the cost of removal of snow, reduction in maintenance, eliminating the need for special snow removal equipment, reduction of hazards and increase of operating efficiency.

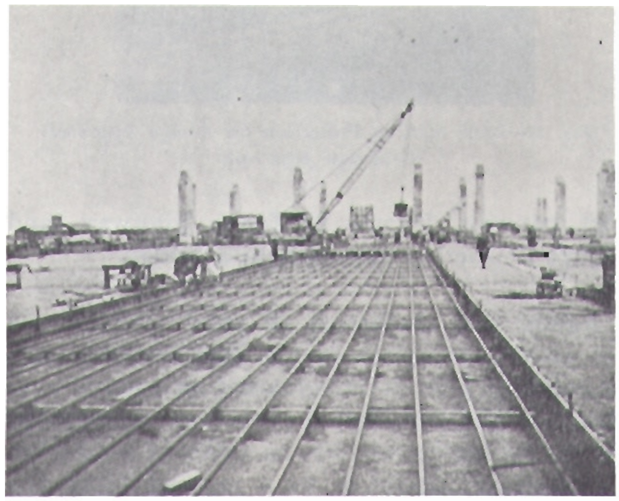

Fig. 19—Runway Snow Melting Coil
Grid type pipe coil — all welded. Supported on steel frame. Pipes to be completely imbedded in concrete runway slab.

Figure 18 shows construction of snow melting installation for a sidewalk, Figure 19 for an air-

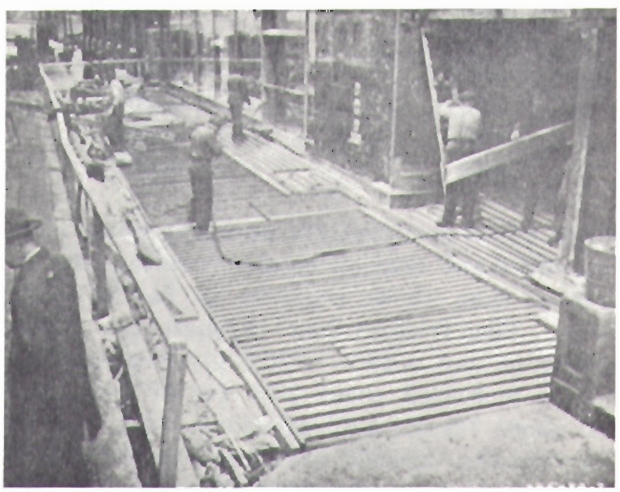

Fig. 18—Sidewalk Snow Melting Coil
Grid type pipe coil — all welded construction.

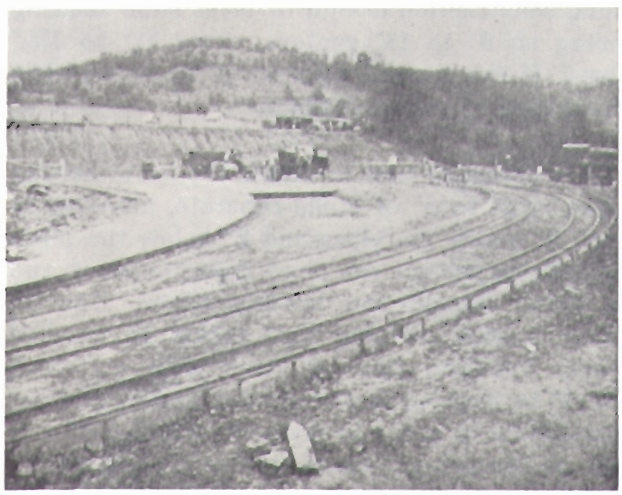

Fig. 20—Roadway Snow Melting Coil
Grid type coil under wheel tracks.

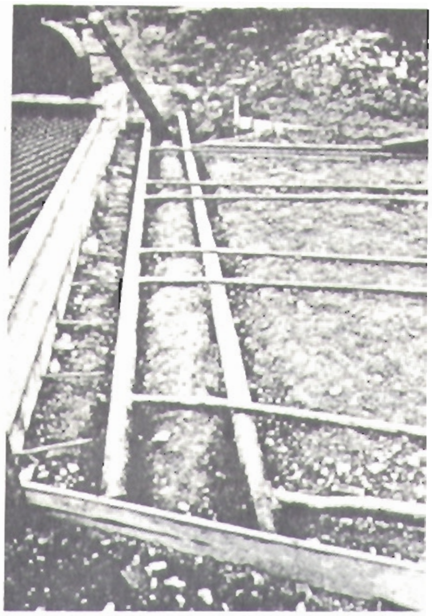

Fig. 21—Snow Melting Protection for Bridge Approach Grid type pipe coil.

port runway, Figure 20 for a highway, and Figure 21 for the approach to a bridge.

Again, this discussion of snow melting will not provide complete design data for it is only intended to provide information on general construction and installation problems. Snow melting piping can be installed as a part of a concrete slab surface, under or as a part of black top finish, or as a part of a sidewalk. Coils may be either grid or sinuous type, and piping materials may be either steel, wrought iron or copper. The usual construction design involves snow melting piping on 9" to 18" centers, using ¾" to 1¼" pipes. If the spacing between pipes is too wide, channeling of snow will result.

It is generally best to encase the snow melting pipes in 5" to 6" of stone concrete, allowing at least 2" above the pipes and 2" below the pipes in order to protect the pipes from corrosion and to better spread the heating effect. The fill under a snow melting slab should be crushed stone. Cinders, slag or other acid materials should be avoided in and around a snow melting installation in order to prevent corrosion of piping. If the ground water level is high, a waterproof membrane is recommended for installation below the piping.

Coil Spacing

Coils used in concrete slabs are usually spaced as follows:

Pipe or Tubing Size	Spacing
¾"	9" to 12"
1"	12" to 15"
1¼"	15" to 18"

Snow Melting Rate

The amount of heat required to melt snow depends on such factors as the rate of snowfall, wind velocity, outdoor temperature, relative humidity, startup requirements, etc. Generally, these systems require about 100 to 250 Btu per hour per sq ft of surface area for maximum load conditions.

Circulating Solution

Obviously, the solution to be circulated in a snow melting system must withstand freeze-up. The solution most commonly used is a water-glycol antifreeze or a light hydrocarbon. Alcohol should never be used in a snow melting system. Commercial antifreeze solutions have inhibitors added to reduce the corrosion effect of the glycol.

The freezing points for several water-ethylene glycol solutions are:

Per Cent Glycol by Volume	Freeze Point
25%	10°
32%	0°
38%	—10°
44%	—20°
49%	—30°
52%	—40°

When glycol solutions are used, the pump characteristics and heat exchanger requirements are greater than those required to handle water alone. The friction loss through the piping system of, say, a 40% — 60% glycol-water solution is increased about 20% for 80° solutions, and about 7% for 120° solutions. Also, because the viscosity, specific heat and specific gravity of the solution are not that of water, the heat exchangers require more heating surface.

Operating Precautions

Do not heat glycol antifreeze solutions in a direct heater such as a boiler. Do not heat glycol solutions in a steam heat exchanger, using steam over 40 psig. Glycol solutions should not come in contact with surfaces over 300°, or the inhibitors added to the solution break down and the solution becomes more corrosive.

Do not make a direct city water connection to the system. If antifreeze solution backs up, the domestic water system will become contaminated.

Open expansion tank systems are recommended. If closed pressure tank must be used, then do not use automatic water makeup. Water makeup to any snow melting system using antifreeze must be measured so that quantity of water and quantity of antifreeze added to system are always known. This information is required in order to prevent losing the freezeup protection.

REVIEW SHEET

Lesson 9.

1. Snow melting systems may be used on ______________, __________, __________, __________ __________, and ________ ________.

2. Snow melting installations result in a ________ ____ on snow removal and eliminate the necessity for having and maintaining ________ __________ __________.

3. Snow melting panels are usually installed as a part of a __________ ________ or ________ ________.

4. The panel coils may be either ________ or ________.

5. Snow melting coils may be spaced from ____" to ____" on centers, using ____" to ____".

6. Channels in the melting snow is the result ______ ______ ____ of coils.

7. Snow melting pipes in concrete should have at least ____" above and ____" below the pipe.

8. Cinders, slag and acid materials should not be used around the pipes, as ____________ ____________ may result.

9. Snow melting systems require for maximum load conditions from ________ to ________ Btu/hr/sq ft of surface area.

10. Most anti-freeze solutions except ________ are suitable to use in a snow melting system.

11. Anti-freeze solutions may cause ________ friction in the piping than regular water.

12. Over heating of auto freeze solutions may cause the __________ to break down and result in damage to the system by ________.

13. Snow melting systems should not be connected directly to city water supply, because of possible contamination from the ______ __________ __________.

14. It is recommended that ________ __________ tanks be used.

15. The water and the auto freeze solutions should always be measured when put into the system otherwise ________ may result.

PANEL HEATING LESSONS

Lesson 10.

Aims of this lesson:

(1) To familiarize the learner with working drawings and layouts for panel heating systems.

(2) To recognize the nomenclature for various parts and units of a panel heating system.

PROCEDURE:

The student should carefully study the information and the illustrations, then answer the questions in the spaces provided at the end of this lesson.

INFORMATION:

Fig. 22 on following page shows the working plan for the coil layout and a schematic sketch for the connection around the boiler. Study fig. 22 and then answer the questions.

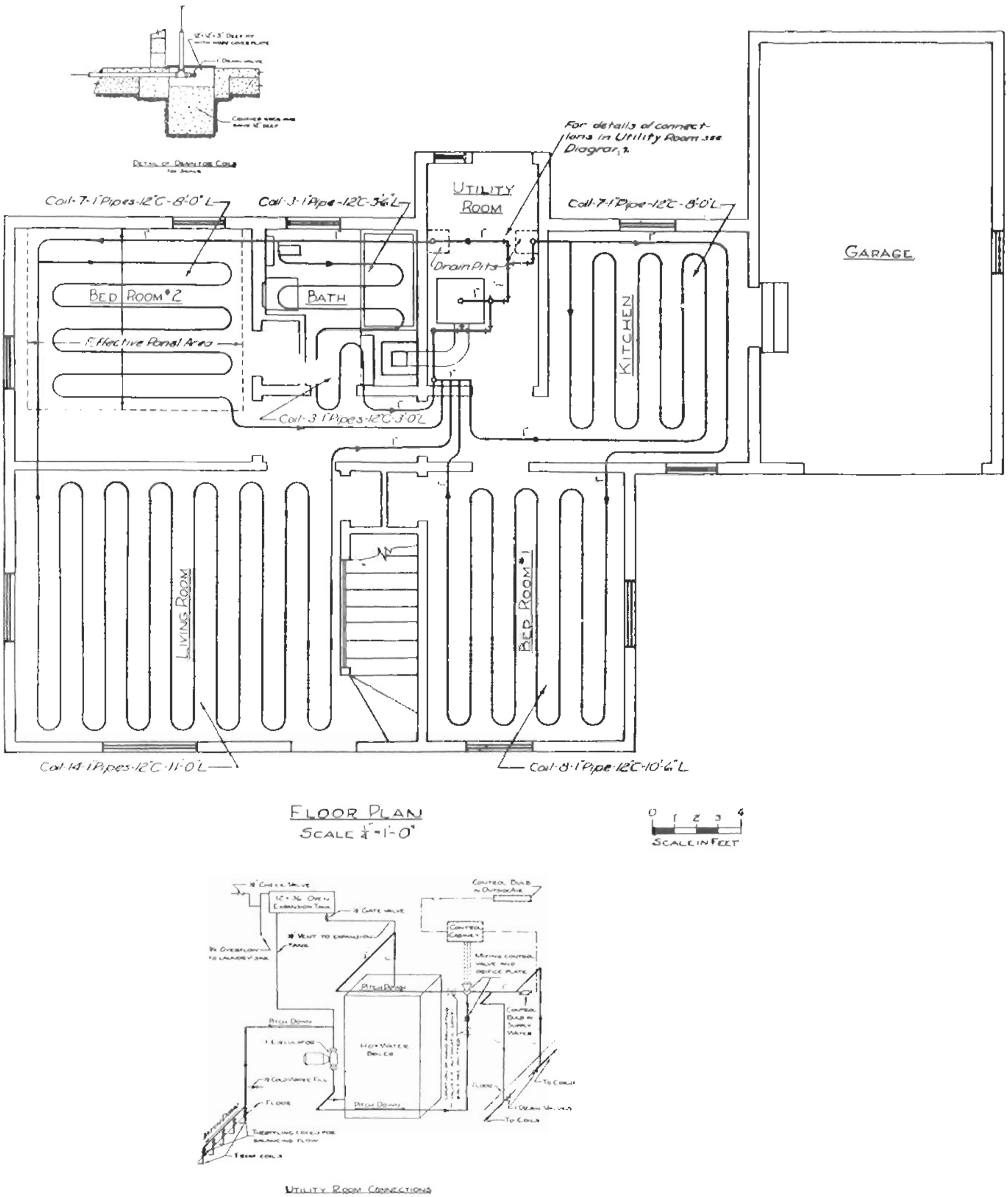

Fig. 22—Floor Slab Panel Heating System

Typical working plan for installation of heating coils in a floor slab. Drawing provides location plan for coils, coil details, boiler and pump connections.

REVIEW SHEET

Lesson 10.

1. The coils are of the ________ ________.

2. The direction of the flow of the hot water is from the ______ to the ______.

3. The pipe size for the coils is ____________ and all coils shown on plan are spaced ________" on centers.

4. The balancing cocks are shown in the __________ ______ ____.

5. The expansion tank is the ______ type.

6. The circulating pump should be installed between the ________ and the ________ ________.

7. All piping should pitch ______ in direction of coils to insure proper ________.

8. The mixing control valve permits ________ ________ to enter into the circulating system as needed.

9. Control bulb in outside air helps adjust system to ________ ________ in outside temperature.