FOR OFFICIAL USE.

K.3.

P.W.—K.3.

Post Office Engineering Department

TECHNICAL PAMPHLETS FOR WORKMEN

Subject:

Heating Systems.

ENGINEER-IN-CHIEF'S OFFICE,
1919.

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FOR OFFICIAL USE.

HEATING SYSTEMS.

(K.3).

The following paper is of kindred interest:

I.P.O.E.E. Paper, No. 50.
"Low Pressure Hot Water Heating."
By T. J. Monaghan, B.Sc.

HEATING SYSTEMS.

TABLE OF CONTENTS.

HEATING SYSTEMS.

1. THE PRINCIPLES OF THE HEATING OF BUILDINGS.

The warming of a room is not perfectly satisfactory unless the following conditions are fulfilled :—(*a*) It must be possible to keep the temperature at any desired level no matter what the weather conditions may be. (*b*) The temperature should be approximately uniform throughout the room. (*c*) No harmful or unpleasant effects must be introduced by the heating arrangements. In heating, as in other things, perfection is seldom attainable. Nor can the question of cost be overlooked. Except for very small buildings some form of heating other than by individual units such as coal or gas fires best meets the requirements. The principal systems used are low pressure hot water, low pressure steam, and medium high pressure hot water, and these only will be dealt with in this pamphlet.

A room at a temperature higher than that of the outside air is losing heat all the time through the outside walls and windows; through the inner walls, ceiling and floor if the neighbouring rooms are at a lower temperature than it, and also in the air used for ventilation, for heat is spent in raising the temperature of incoming air to that of the room and is carried away by the air removed from the room. To keep the temperature of the room constant, heat must be supplied at the same rate as it is being lost. In the heating systems dealt with in this pamphlet the heat supply is derived from surfaces, in the form of radiators and pipes, at a higher temperature than the room. The source of the heat supply is fuel burning in the grate of a boiler, the heat being transmitted through the plates of the boiler to water or steam therein by which it is carried to the heating surfaces where it gives up part of its heat, cools in doing so, and is returned to the boiler to be reheated and again distributed. Lack of space prevents detailed descriptions being given, but it is hoped that the following notes read in conjunction with careful inspection of actual apparatus will render the use and action of the various items clear.

2. LOW PRESSURE HOT WATER SYSTEM.

This system is safe and easily maintained and is in very common use. It gets its name from the fact that it is open to the

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atmosphere at one or more points, therefore the greatest pressure in it is simply that due to the height of water in the installation, and the maximum possible temperature of the water is but little above 212deg. F., the boiling point of water at atmospheric pressure. Water heated in the boiler leaves through the flow pipe at the top of the boiler, circulates through the radiators where it cools, and returns to the lower part of the boiler through the return pipe. For equal volumes, cold water is heavier than warmer water, and it is the excess of pressure at the foot of the cool column over that at the foot of the warm column that causes the circulation of the water in this system. The force tending to cause circulation is small and is greater the greater the height of the columns and their difference in temperature. In large installations it is sometimes necessary to use a pump to assist the circulation. Two connections to each radiator

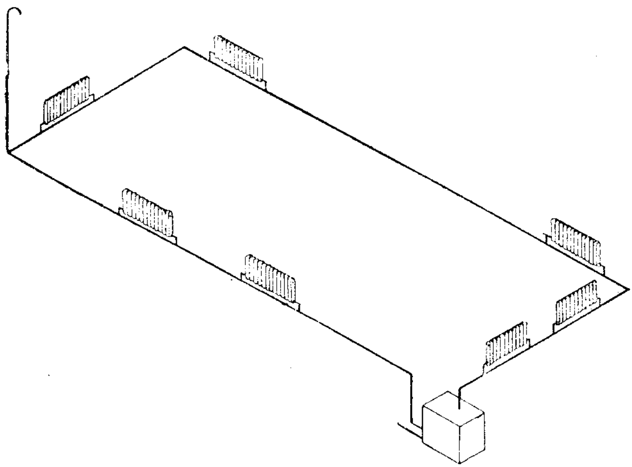

Fig. 1.

are made, an inlet and an outlet. Both may be made to the bottom of the radiator, one at each end, or the inlet may be taken to the top. The circulation through the radiator is caused by the cooling of the water therein due to its giving up heat to the room. The inlet and outlet may be joined to a single pipe passing the radiator, see Fig. 1, or there may be one pipe feeding the inlets of a number of radiators, the outlets being connected to a common return pipe, see Fig. 2. Some details of the more important parts of an installation are given below.

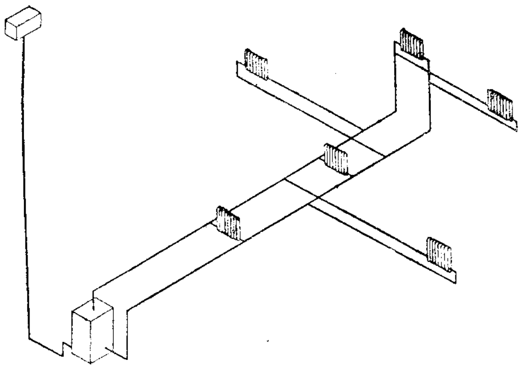

Fig. 2.

Boiler.—The boiler in this system is of course full of water, and as it is necessary that the heat from the fire should pass to the water with as little waste as possible the heat receiving surfaces of the boiler should be kept clear of soot. Scale is apt to form inside the boiler, more especially when what is known as hard water is used. No hot water for cleaning purposes should be drawn from the boiler, for the cold water admitted to take its place brings more scale-forming material with it. To enable the fire to burn properly and to prevent damage to the fire bars by the formation of slag upon them the openings in the grate must be kept free. This allows to pass through the fire a current of air which provides the oxygen necessary for the combustion of the fuel and keeps the fire bars relatively cool. The ashpit below the grate should be kept clean.

Chimney and Damper.—The flow of air carrying oxygen to the fire is caused by the draught produced by the chimney, and to regulate this flow at will the damper is used. The chimney draught is caused in a manner very similar to the circulation of the water in the system. The gases in the chimney are lighter than a similar column of the colder air outside and the heavier column forces up the lighter one, air thus passing to the fire where the oxygen is absorbed, the gaseous products of combustion leaving via the chimney. Heat passing up the chimney is a loss and the damper, which is simply a variable obstruction in the path of the hot gases, should be so adjusted that the draught is sufficient to keep the fire burning as vigorously as weather conditions require and no more.

The Thermometer indicates the temperature of the water in the boiler. This temperature should vary with the outside temperature, for the colder the weather the greater the heat supply required to keep the building at a given warmth. A little experience should enable the attendant to know at what temperature he should keep the water in the boiler for various weather conditions. In order that the thermometer may register the temperature of the water and yet be easily renewed, if necessary, it is usually placed in a metal pocket in the boiler, the pocket being partly filled with mercury to convey the heat to the thermometer bulb.

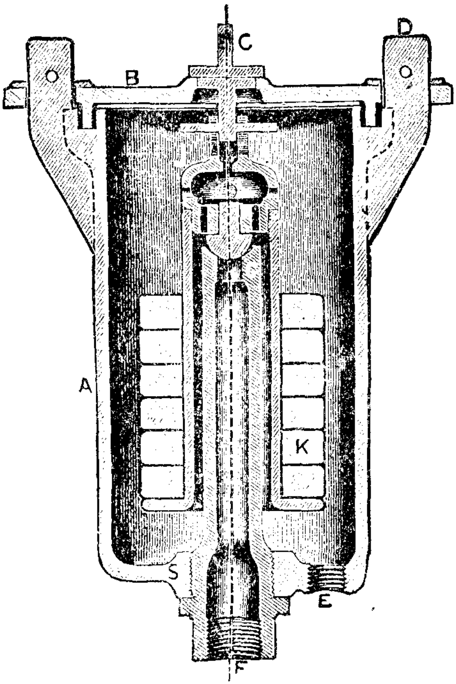

Fig. 3.

A safety valve—see Fig. 3—is used to prevent excessive pressure coming on to the boiler. It consists of an outlet from the boiler with a movable stopper which can be loaded by weights or a spring to any desired extent; the greater the load the greater the pressure necessary to lift it. Should the pressure in the boiler rise above that due to the load on the opening, the stopper rises, allows water to escape and relieves the pressure on the boiler. It is most important that the loading of the valve be not altered without instructions. Care should also be taken that the movable portion does not corrode on the seat and in those valves where it is possible to twist the lifting portion on the seat without altering the adjustment of the valve, full use should be made of the facility.

An open air-pipe of 1 in. to 2 in. diameter, carried to a point above the level of the supply tank is sometimes fitted on the boilers as an additional safeguard against excess pressure.

The Altitude Gauge enables the attendant, without leaving the boiler house, to see that the water supply to the installation is in order. It also indicates undue rise of pressure in the boiler. It consists of a pressure gauge with a movable hand in addition to the pressure hand. When everything is known to be in order the movable hand is set to coincide with the pressure hand. Any fall of water level is indicated by the pressure hand falling back from the position occupied by the movable hand; any rise of pressure by the pressure hand moving beyond the position occupied by the movable hand.

Supply and Expansion Tank.—The supply of water to the installation is obtained from an open tank, which must, of course, be higher than the highest radiator or pipe in the installation proper. Flow of water into the tank is generally from the public supply controlled by a ball cock in the usual way, and a pipe is taken from the lower portion of the tank to the boiler. It is better to let the cold water enter a return pipe near the boiler rather than direct, and it is of great importance that there should be at all times a free passage from the supply tank to the boiler. There should, therefore, be no valve in the pipe connecting them, and the supply pipe should enter the boiler in such a position that it cannot be cut off from the boiler by the operation of any of the main valves in the circulations. Water expands on heating, and if an installation be filled with cold water this water will occupy a larger volume when heated. The supply tank is usually arranged with the ball cock low down so that sufficient space is left in the tank for the expansion of the water in the installation. An overflow pipe from the tank should be provided.

Radiators are merely arrangements for getting a large amount of heating surface into a relatively small space. They consist of a number of hollow columns opening into each other at the top and bottom. They are usually placed on outside walls; below windows or near doors. The incoming air for ventilation is frequently passed over them to be warmed before going to the room, and in such cases adjustable air inlets are placed behind the radiators and baffle plates in front of them. The function of the baffle plates is to cause the air to pass over as much of the heated surface as possible and not straight through the radiator.

Air Cocks and Pipes. Air Locks.—A certain amount of air is dissolved in water and is liberated when the water is heated. Air is lighter than water and the released air ascends; as air is a poor conductor of heat and is also liable to impede or stop the circulation by forming air locks, arrangements are made for the escape of the air from the installation. An air cock, which for this system is simply a small valve, or an air pipe which must, of course, rise to a point above the supply tank, should be provided at all points where air is likely to collect. All pipes should rise from the boiler, a slope of about 1 in. in 10-20 feet being suitable for nominally horizontal pipes. An air cock should be fitted at the top of all radiators. The air cocks should be opened periodically, especially at the beginning of the heating season, and left open until water begins to come, when they should be closed. Air locks formed in accidental sets in the pipe line—see Fig. 4—sometimes give trouble.

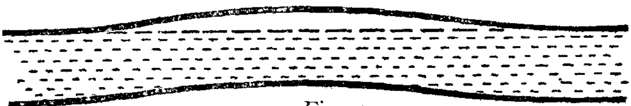

Fig. 4.

Lagging is material which conducts heat badly and is applied to the boiler and to any pipe surfaces where it is not required to give up heat. It prevents waste of heat and thus saves fuel.

Valves are used to vary the resistance to flow in the pipes in which they are fixed. Those which, when closed, completely prevent the passage of water, are best, as they enable parts of the system to be isolated for repairs. It is usual to fit two valves on each radiator, an inlet and an outlet; one is operated by a hand wheel at the discretion of the occupants of the room, the other is operated by a key kept by the attendant. With this arrangement all the radiators on a particular circulation can be arranged to heat equally. First open fully all the valves on all the radiators, then close gradually the key operated valves on the hotter radiators (usually those nearer the boiler), and continue until all the radiators are equally hot. On a large system with several circulations, valves are fitted in the flow and return of each circulation, and these valves also should be adjusted until all the circulations heat equally. Drain cocks are fitted on each circulation on the side of the valve remote from the boiler, and a drain cock is fitted on the boiler also. Pipes connect the drain cocks to the drainage system of the building. This arrangement enables any part of the system to be emptied for repairs with a minimum of inconvenience especially during the heating season, for it is not necessary to cut off the heat from the whole building to attend to a fault on one

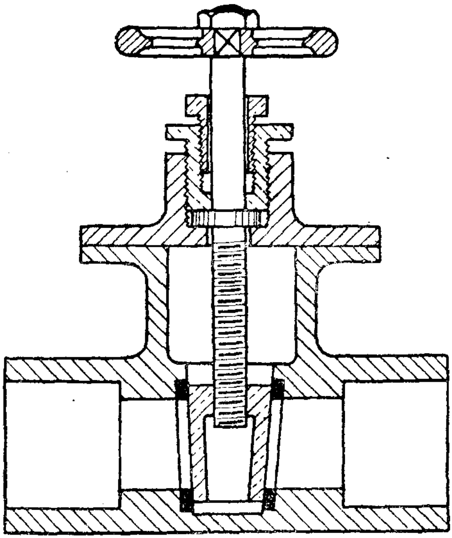

Fig. 5.

circulation. Figs. 5 and 6 show two types of valve, the "gate" valve and the "globe" valve respectively.

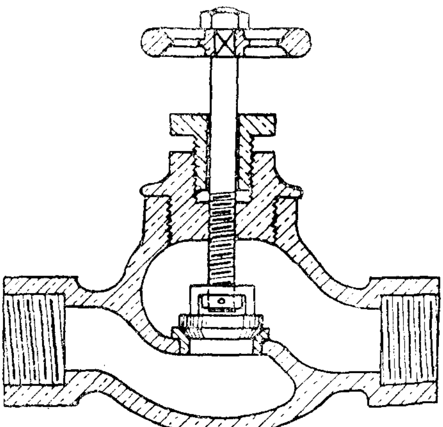

Fig. 6.

Pipes.—The joints in the pipe lines may be spigot and socket or screwed. Arrangements should be made to allow the pipes to expand freely when heated. The changes in direction of the arrangements may be necessary such as a loop in the pipe line, pipes due to the lay-out of the installation are sufficient to allow for this in most installations, but in long straight runs special Expansion joints which enable the pipes to slide in and out according to the temperature are used on some installations, but are rather troublesome.

A copy of "Instructions for working Low Pressure Water Heating Apparatus" (Card T.E. 479) should be hung up in the Heating Chamber of each low pressure hot water heating installation, and the instructions should be closely followed. Similar cards of instruction are usually furnished by firms installing other special types of apparatus (High Pressure, Medium Pressure, etc.), and should be followed in each case.

3. LOW PRESSURE STEAM SYSTEM.

In this system the heat carrier is steam at atmospheric pressure or a few pounds per square inch above it. There is very little advantage from the heat carrying point of view in using high pressures, which also introduce increased liability to leakage. Further, the higher the pressure the higher the temperature of the steam, and unduly high temperatures make the neighbourhood of the radiators too hot for comfort, and the baking of the dust on the radiator surfaces is apt to cause unpleasant odours. The steam required may be generated in an independent boiler, or, in buildings where high pressure boilers exist for other purposes, the steam required for heating may be taken from the high pressure main, being reduced to any desired pressure by a reducing valve. The circulation of steam in the system is due to the cooling of the steam in the radiators lowering the pressure there, the pressure in the boiler being thus greater than that in the radiators. A certain amount of the steam, when cooled, condenses into water, and arrangements must be made for this condensed water to be returned to the boiler.

The main points of difference between the steam system and the low pressure hot water system are given below.

Boiler.—There must be a space above the water in the boiler to permit steam to be given off, but the water level must not be allowed to fall too low. A gauge glass, with cocks top and bottom to enable it to be replaced when necessary, is fitted to indicate the actual water level at any time, and the water supply arrangements should be such that the level is kept approximately constant.

Piping Systems.—The steam main rises from the highest point in the boiler to some feet above it, and is then given a downward slope so that water of condensation from the steam in the main will not flow back through the steam main. In the one pipe system the main makes a circuit falling all the time, and re-enters the boiler below the water level. From the steam containing portion, single pipes are taken to the radiators, the water of condensation returning through the same pipe to the main, where it flows down the gradient provided to the boiler. In the two pipe system two connections are made to each radiator, one from the steam main as above, the other to the return main, the whole of which is below the water level in the boiler. The steam condensed in the steam main is drained into the water main.

Radiators.—The radiators are similar to those used on the hot water system, but there is not the same flexibility of control by the valve, which should be fully open or closed. To regulate the heat the radiator may be cut off for varying intervals—an unsatisfactory method.

Air Cocks.—The air contained in the system before starting up, as well as that in the water from which the steam is generated, must be got rid of, for air is a bad conductor of heat. Air is heavier than steam, and thus falls in this system so that it would appear that the air cock should go at the bottom of the radiator. As, however, that is where the water of condensation collects, a compromise is made, and the air cock is put about half-way up. A very common form of air cock consists of a cylinder of metal, which, when expanded by contact with the steam, closes the outlet, but when in contact with cooler air, contracts and allows the air to escape. The setting of the air cock can be adjusted to suit varying pressures. Similarly, arrangements must be made to liberate the air on the return main at a point above, but as close as practicable to, the water level in that main.

Water Hammer.—Air locks impede the circulation in this system also, and another serious trouble is caused if the pipe line is so fixed as to allow condensed water to lie in it anywhere. This water is set into motion by the flowing steam, and causes very loud rattling noises, as well as introducing a certain amount of risk of fracture of the pipes.

4. MEDIUM AND HIGH PRESSURE HOT WATER SYSTEM.

The temperature at which water boils increases with the pressure, so that if the pressure be increased above atmospheric, it is possible to get water at a temperature considerably above the normal boiling point of 212° F. without the production of steam; this fact is utilised in the medium and high pressure systems.

The terms "**high pressure**" and "**medium pressure**" are used in a relative sense only, and it does not necessarily follow that the working pressure in the one will be greater than in the other.

Coil boilers and small-bore piping of approximately ⅞ in. internal diameter are used in both medium pressure and high pressure systems, but in the case of the latter the boiler and piping form a closed hermetically sealed circuit, provision being made for the expansion of the water as its temperature rises, by means of an "expansion tube" partly filled with air, at the highest point in the piping, while in the case of the medium pressure system this expansion tube is replaced by a combined deadweight pressure and vacuum valve fitted to a section of the pipework system which terminates in an expansion tank open to atmosphere. The valve thus relieves excess pressure, or allows water to enter the system when a vacuum is formed, as the case may be.

As an additional safeguard, it is customary in Post Office medium and high pressure installations to fit Hall's valves on the piping. This safety valve consists of two separate valves: (a) a thin disc of copper always exposed to the pressure in the piping, and which is ruptured at a pressure of 1,200lbs. per sq. in., and (b) a spring-loaded valve which comes into operation after rupture of the disc, and blows off so long as a pressure exceeding 500 lbs. per sq. in. exists in the system.

The circulation is caused exactly as in the low pressure water system, but due to the higher temperature used is much more vigorous. This enables smaller pipes to be used, but they must be of great mechanical strength. The disadvantages of high temperature heating surface have been mentioned above in connection with the low pressure steam system.

The piping is continuous throughout, a coil of pipe in a brickwork chamber forming the boiler, loops and coils being formed as required to give the necessary heating surface in the space being warmed. In large installations the pipe, after passing through portions of the building, is taken back to the heating chamber, where a second coil is formed to re-heat the water before carrying the pipe to the rest of the building. The high pressure used renders this system somewhat dangerous; no obstacles can be put in the path of the water, so that no valves are fitted. The system requires very careful maintenance, and is more satisfactory than the safer installations, only where heat has to be got up quickly, as in buildings occupied only at intervals.

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