treatment, the maintenance of a satisfactory bleed rate, the maintenance of the tower in a clean condition, and the draining of this equipment in winter and subsequent refilling in the spring.

The cooling effect of the mechanical refrigerating equipment may be transmitted directly to the air being circulated to the rooms or it may be transmitted through a secondary refrigerant (usually water or brine) circulated through additional coils that cool the air being circulated to the rooms.

The first and most commonly used method of absorbing heat from the conditioned air is to use direct evaporation of the refrigerant in a coil with the air to be conditioned passing over the outside of the coil surface. The heat is transferred directly from the air into the refrigerant for removal. This requires the use of an air distribution system and, although generally most economical in new construction, may present costly problems in modernization work where ductwork is not installed.

In a chilled-water system, water is circulated through a closed circuit containing two coils. In one coil the water removes heat and moisture from the air in the conditioned space. In the other coil (water chiller) the heat is removed from the water by mechanical refrigeration. This type of system is called a duplex system in that the heat is picked up by chilled water and later removed from the water by means of a refrigeration system.

It should also be noted that in some areas, cold water, at 52 F or lower, is available from city water mains or wells. Such water can be circulated directly through cooling coils of either the central type or individual room type, to provide summer air conditioning.

TYPES OF SYSTEMS

The present generally accepted method of cooling residences is to employ a central system. The main components of the central plant for year-round air-conditioning systems may be obtained in factory-made assemblies providing matched components for both winter and summer conditioning functions or they may be obtained in one or more separate parts and combined on the job into an integrated system. Summer conditioning equipment may be obtained separately and added to existing heating systems or may be installed independently of any heating system. Cooling coils may be used in conjunction with warm air furnaces and duct systems, or chillers may be combined with boilers to provide hot and cold water for circulation to room units as required. Refer to other Chapters 15, 16, 19, 42, and 43 for information on specific system components.

Self-contained room coolers, which are discussed in Chapter 16, are used for room or spot cooling and are not generally used to cool an entire residence. Their application and use are not to be considered further in this chapter, but it may be noted that when only a portion of a residence is cooled the load calculation methods currently used in the industry for central residential systems are not applicable. Refer to Chapter 13 when calculating the load for such applications.

In some areas there is little or no need for heating but there is a distinct need for summer cooling. Both air- and water-cooled package cooling units are available for such areas and range in size from one ton to at least 15 tons capacity. To install these units it is only necessary to make plumbing (for water-cooled units) and electrical connections and add the ductwork required to convey air to and from the conditioned space. These units can also be used to provide central air conditioning for residences having heating systems which do not contain provision for attaching summer cooling equipment.

Year-round air conditioners require less space than a separate heating plant plus a separate summer conditioner. Usually the heating and cooling portions of a year-round air conditioner operate independently of each other. The air circulated by the fan passes through the cooling and heating portion of the equipment, only one of which is in operation at any one time. Some systems are designed to shift the air path alternately through the cooling or the heating surfaces, but many systems use the simpler method of passing the air over both surfaces at all times. Both systems are normally equipped with interlocking control arrangements so that only cooling or only heating will occur at any one time.

Air conditioning can be installed in homes having a hot-water heating system by use of either of the following means:

1. *Room units* resembling convectors and containing both heating and cooling coils. These units are used in place of the conventional radiator or convector. They can be installed in all rooms of the house to provide complete summer cooling, or they can be used in only one or two rooms. This arrangement is shown in Fig. 1.

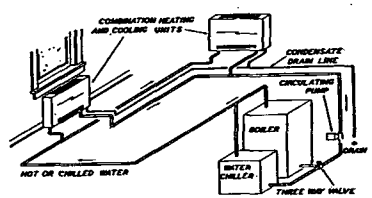

Fig. 1 .... Combination Summer Air-Conditioning and Hot Water Heating System

2. A *split system*. The cooling coil is located in a duct through which air from the rooms is circulated, cooled, and returned to the rooms. Another coil in the same duct can be used for winter heating, or conventional radiators, convectors, or panels can be used to bring heat to the rooms.

When cooling equipment producing chilled water is to be used in a house equipped with a forced-circulation hot water heating system the chiller may be located in the basement or utility room near the boiler. In most of such systems it is then possible, with the addition of suitable valves, to use the same piping system for circulation of heated water in winter and chilled water in summer. The piping must be insulated to prevent sweating when circulating chilled water.

GAS YEAR-ROUND AIR CONDITIONERS

Gas-fired year-round air conditioners based on the absorption cycle are available in sizes suitable for residential use and for small commercial applications.

The conditioners are built in 3½ ton and 5 ton sizes with heating capacities appropriate for various climates. The 3½ ton and one model of the 5 ton units have heating inputs of 120,000 Btuh. This makes them suitable for homes having design heat losses up to 76,800 Btuh. The other 5 ton model has an input of 180,000 Btuh making it suitable for homes having design heat losses up to 115,200 Btuh.

General Description

The principal components of the gas-fired year-round air conditioner are an absorption unit, a gas burner, a centrifugal fan for air circulation, a filter section, and controls. The gas flame supplies the heat to actuate the absorption unit which provides heating in winter and cooling in summer.

The entire unit operates under a vacuum at all times. The absolute pressure within the generator and condenser on cooling cycle is of the order of 2 to 2½ in. Hg (50 to 60 mm) absolute pressure. The pressure within the cooling coil and absorber is between 0.25 to 0.3 in. Hg (6 to 9 mm) pressure. On the heating cycle, since the same coil is used for both heating and cooling, the absolute pressure is on the order of 14 in. Hg (350 mm) or about ½ atmosphere.

Heating Cycle

The gas flame, when applied to the generator of the absorption unit in winter, boils the solution. The water vapor which is thus produced goes directly (bypasses the condenser) to the single coil over which air is passed by the blower. The heat is taken from the water vapor, and the water is returned to the generator by gravity to be used again.

Cooling Cycle

The gas flame, when applied to the generator of the absorption unit, boils the solution. The water vapor which is thus produced goes to the condenser where this vapor is condensed. It then flows into the single coil (which is the evaporator on the cooling cycle). The air being cooled and dehumidified is blown over this coil. The water vapor (through the process of absorption) is returned to the liquid state and flows by gravity to the generator to be used again. The refrigeration unit is factory-sealed and contains a solution of lithium bromide and water which acts as the absorbent, water vapor being the refrigerant. Circulation of these fluids in the system is accomplished by differences in temperature and height of liquid columns, without moving parts.

Control System

Manual switches permit the owner to select heating or cooling, constant or automatic fan operation, and turn the system *on* or *off*. For protection of the unit a generator limit switch and a cooling circuit preventive control switch are provided. The former protects the generator from excessive input and is preset to operate at safe temperature levels both on the heating and cooling cycles. The preventive control switch keeps the unit from serving as a heating plant if the condensing water were cut off. Another protective device used in the year-round gas air conditioner is the low temperature control which prevents the unit from freezing as a result of improper equipment operation.

A fan delay control delays fan operation until the heating coil has reached 140 F so as to prevent cold air circulation when heat is desired.

Gas-Fired Water Chiller

An air-cooled gas-fired water chiller is available featuring an outdoor absorption refrigeration section which circulates chilled water to indoor coils. Application requirements in both new and existing construction are met by optional matching furnace coil, fan coil, and duct coil. These water chillers are currently built in a 3 ton size having an input of 120,000 Btu per hour.

Cooling Cycle. The hermetic absorption refrigeration cycle employs ammonia as the refrigerant and water as the absorbent. The continuous regeneration of the refrigerant follows basic absorption principles. High and low side operating pressures are comparable to those of air-cooled compression cycles.

The only moving parts in the refrigeration cycle are the valves and float of the solution transfer device which circulates solution from the absorber to the generator. Operating energy is derived from the refrigerant vapor generated within the cycle.

Controls. Low-voltage remote thermostatic control for cooling only or for heating and cooling with manual switchover is provided. An attached switch base gives remote on-off control and selection of continuous or automatic fan operation.

Safety controls shut off the gas in the event of excessive pressure or generator temperature.

Heat Pump Year-Round Air Conditioners

Residential heat pumps are either of the unitary or split system type. The usual source of heat is either outdoor air or water. Due to a general lack of adequate water supply, air source equipment is predominant in the residential heat-pump field. The modifications required to add the heating function to an electrically operated cooling system are mainly the addition of a reversing valve to change the flow of refrigerant, automatic defrost means if air is used as a heat source, and additional temperature controls to accomplish year-round operation.

The basic characteristics of the heat pump are discussed in more detail in Chapter 39.

The importance of the heat pump is due to the fact that the heating output always exceeds the electrical input energy. Although the ratio is a function of outdoor air temperature, operating conditions, and equipment design, the heating output is on the order of 2½ times the electrical energy input. The heating capacity decreases with decreasing outdoor temperature. A heat pump for winter heating has its greatest economic advantage in the sections of the country where the cooling and heating requirements are approximately equal.

As the outdoor temperature drops during the heating season the building heat loss increases and the heat output of the heat pump decreases. The point at which the heating requirement matches the capacity of the heat pump is called the *balance point*. For operation at outdoor temperatures below the balance point some form of supplementary heat is required because, for economic reasons, the heat pump in residential applications is usually sized to meet cooling requirements. In addition to supplying heat equivalent to the building heat loss, the heat to be supplied by the system and supplementary equipment includes the requirements for heat during defrost (in the case of air source units) plus the usual piping and pick-up requirements. Supplementary heat is frequently supplied by electric resistance heaters which normally are used only during a small percentage of the total operating time depending on local climatic conditions. It is of interest to note that the operating hours for structures of the same size and design tend to be the same regardless of the geo-