Heating + Cooling I

ARC 3723 | EBS II
MS State University | CAAD

Heating + Cooling

Hot-Water (Hydronic) Heating

Various fuel types can be used to heat water in a boiler. The hot water can then distribute the heat throughout the building in several ways.

Radiant Floor

A hydronic radiant-floor heating system uses tubing to distribute hot water from a central manifold. The complexity of the system adds to the cost, and air conditioning must be added separately.

When concrete slabs are used, the coils can be cast into the slab. Many systems have also been developed for using radiant heating with wooden floors.

A radiant floor will heat the space by both radiation and natural convection.

Radiant floor heating is a good match for active solar because solar collectors can efficiently produce the relatively low temperatures needed.

(Source: Heating, Cooling, Lighting by Lechner)

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Hot-Water (Hydronic) Heating

Convectors

Most hot-water systems use convectors to transfer the heat from the water to the air of each room. In the past, hot-water of steam systems used cast-iron radiators, which, in fact heated mostly by convection. Today, most convectors consist of fin-tubes or fin-coils to maximize the heat transfer by natural convection.

Baseboard convectors - linear units placed along exterior walls

Cabinet convector - concentrate heating where it is most needed (e.g., under windows to mitigate cold downdraft and low MRT - Mean Radiant Temperature).

(Source: Heating, Cooling, Lighting by Lechner)

Heating + Cooling

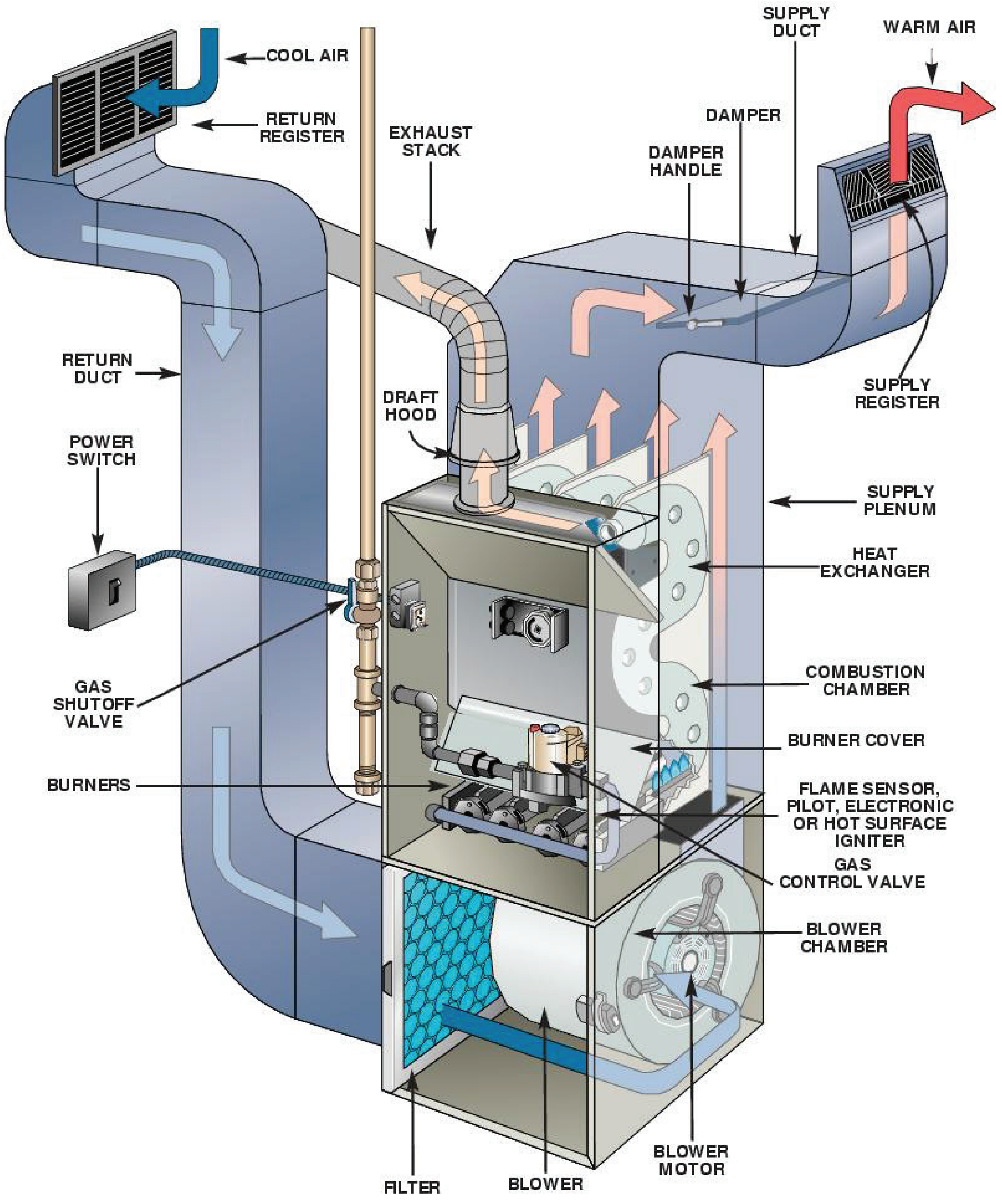
Hot-Air Systems

Hot-air systems can perform the whole range of air-conditioning functions: heating, cooling, humidification/dehumidification, filtering, ventilation, and air movement to eliminate stagnant and stratified air layers.

A hot-air furnace uses a heat exchanger to prevent combustion air from mixing with room air.

(Source: Heating, Cooling, Lighting by Lechner)

A heat exchanger is a system used to transfer heat between two or more fluids. Heat exchangers are used in both cooling and heating processes. (*Source: Wikipedia)*



Source:https://kacexpress.com/

Hot-Air Systems

Loop-perimeter system

Slab-on-grade construction in cold climates. The supply air heats the slab where it is coldest - at the edge. Thus, this system offers the benefits of both hot-air and radiant-slab heating. Main disadvantage is the high initial cost of the system.

(Source: Heating, Cooling, Lighting by Lechner)

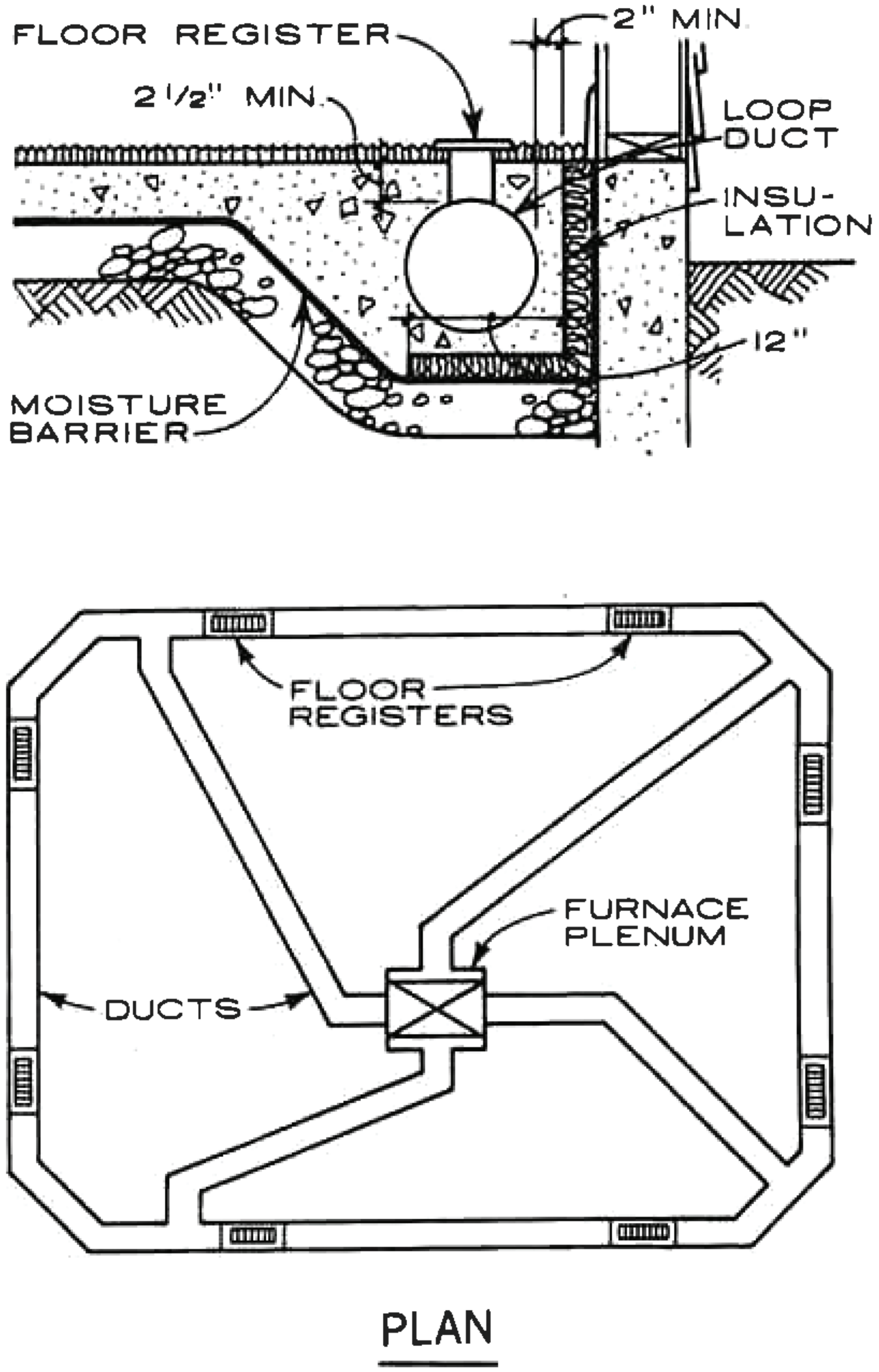


Figure 18.7c A loop-perimeter system for slab-on-grade construction is most appropriate for cold climates. (From *Architectural Graphic Standards*, Ramsey/Sleeper, 8th ed., John R. Hoke, editor, © John Wiley & Sons, Inc., 1988.)

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Hot-Air Systems

Radial-perimeter system

More suitable for crawl space construction. If crawl space is high enough, horizontal furnaces can be used. Same type of furnace can be used in attics.

Note: It is best to keep ducts and equipment within the thermal envelope.

(Source: Heating, Cooling, Lighting by Lechner)

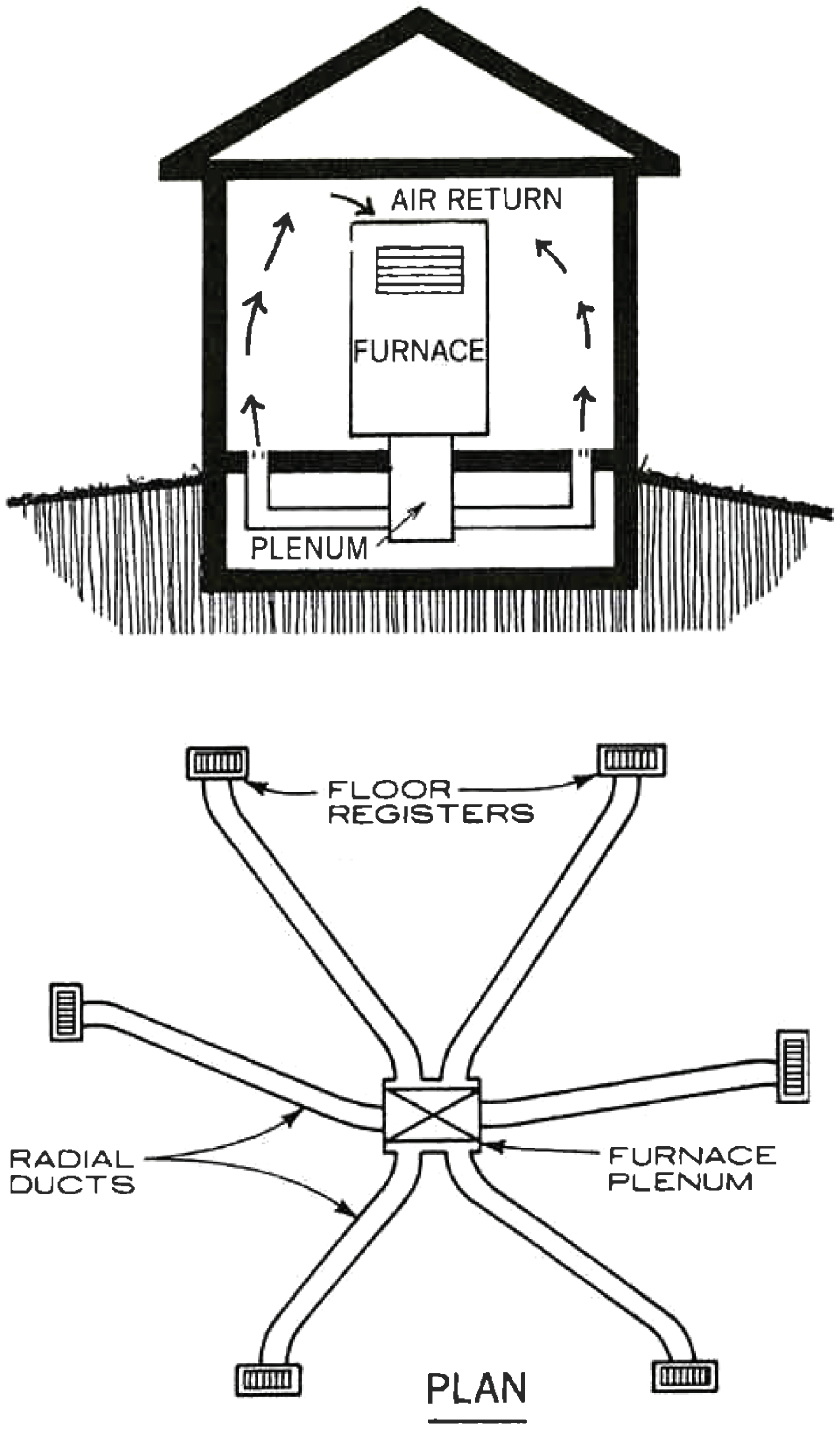

Figure 18.7d A radial-perimeter system is shown for crawl space construction but can also be used in the attic. (From *Architectural Graphic Standards*, Ramsey/Sleeper, 8th ed., John R. Hoke, editor, © John Wiley & Sons, Inc., 1988.)

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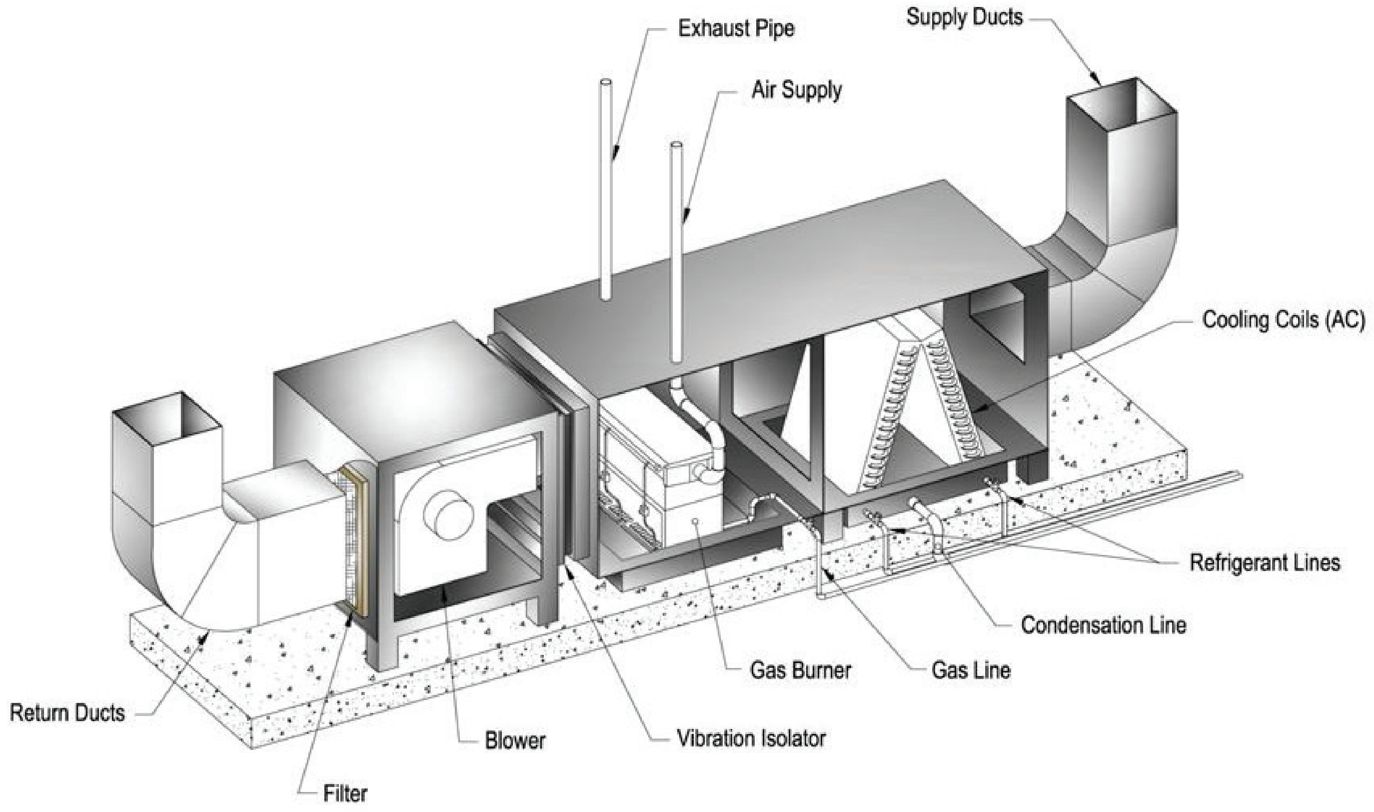
Hot-Air Systems

Horizontal furnaces

(Source: Heating, Cooling, Lighting by Lechner)



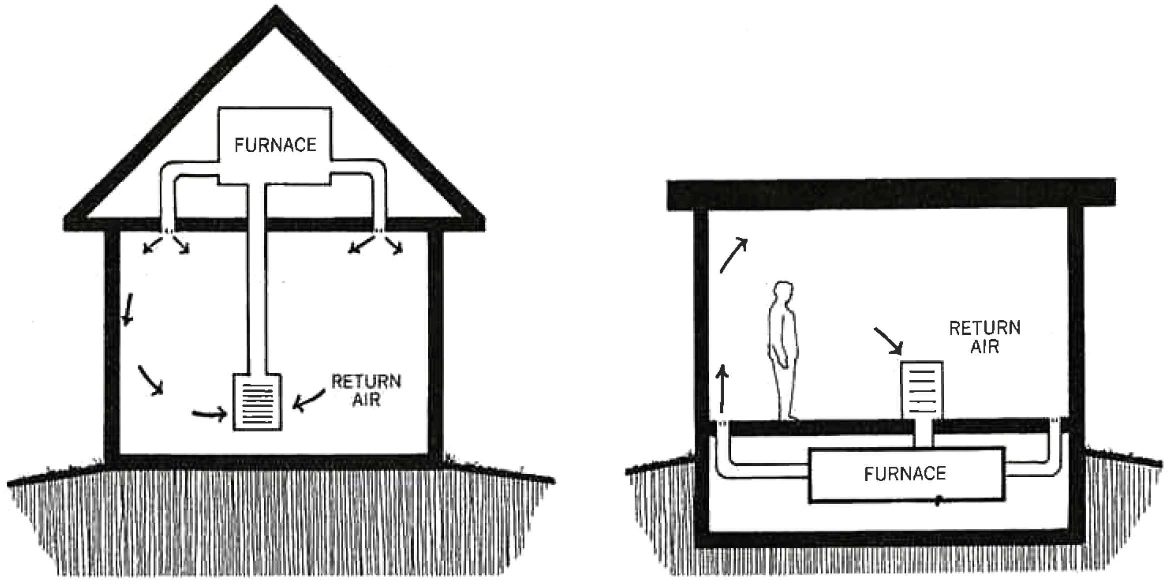


Figure 18.7e Although horizontal furnaces are available for use in crawl spaces or attics, it is much better to have all ducts and equipment within the thermal envelope for both health and efficiency reasons.

Hot-Air Systems

Extended plenum system

Appropriate for many buildings because it enables the supply ducts to run parallel and between the joists, thereby saving space and head room.

(Source: Heating, Cooling, Lighting by Lechner)

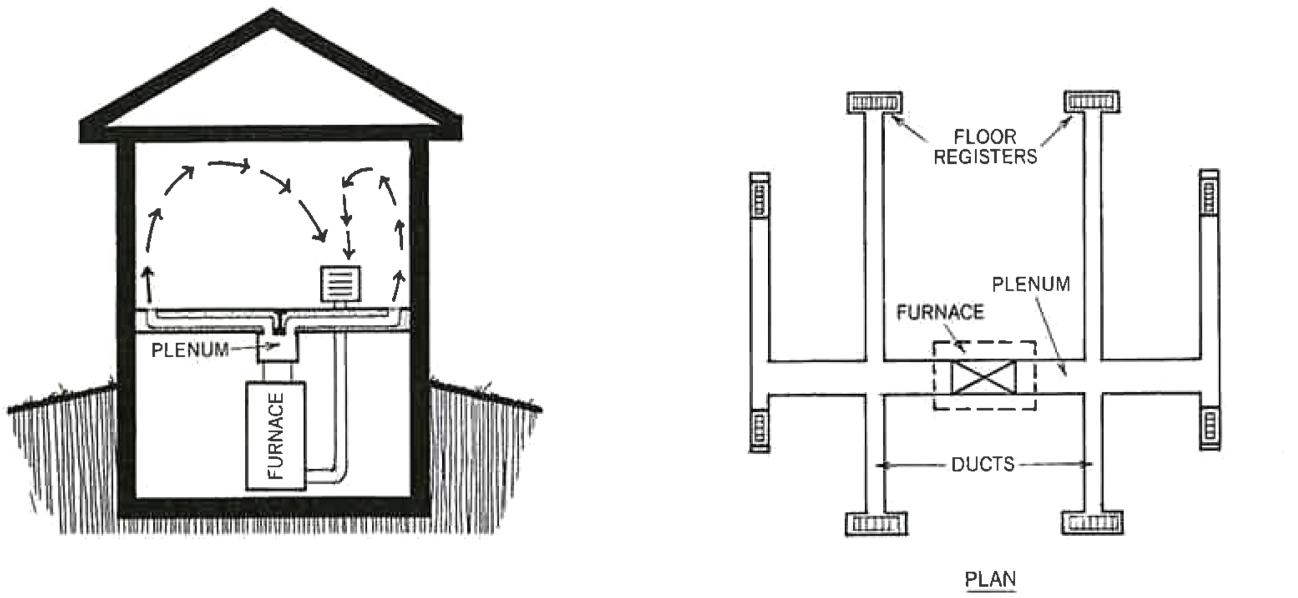


Figure 18.7f The extended-plenum system for basement construction has the supply ducts run between joists to save on headroom.

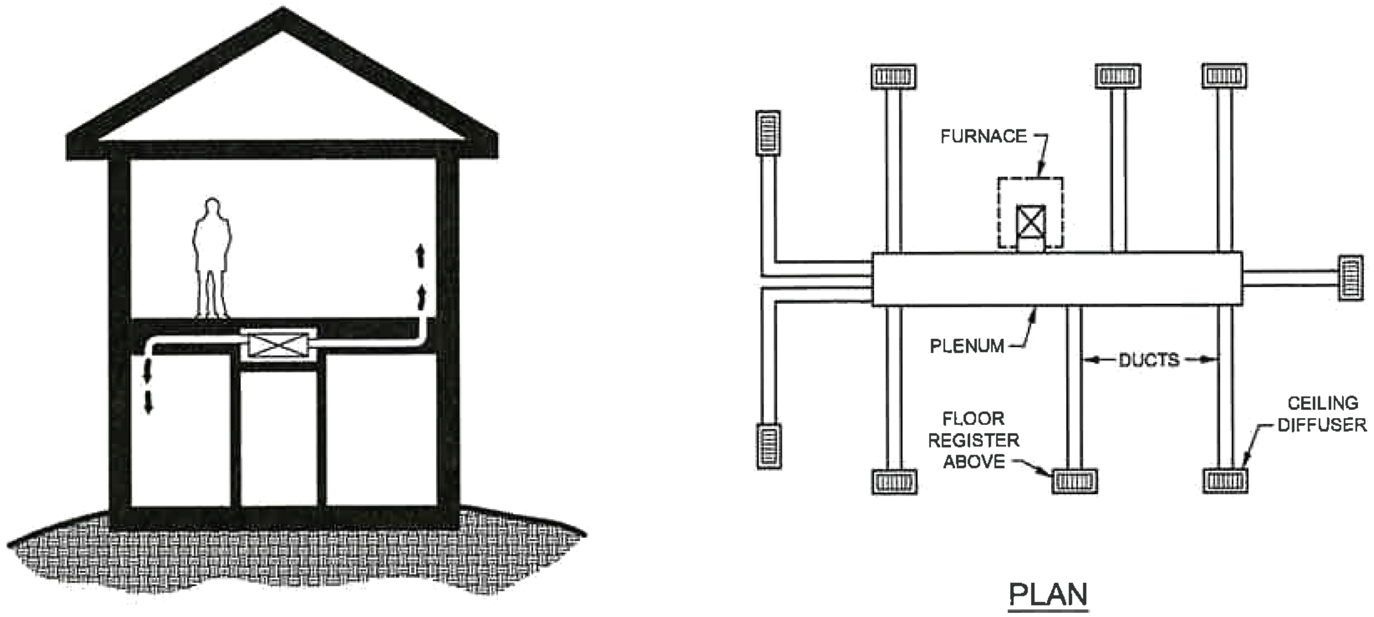


Figure 18.7g The extended plenum above the corridor ceiling system provides both health and energy efficiency benefits by having all ducts within the thermal envelope.

Heating + Cooling

Cooling

Before the invention of refrigeration machines (about 150 years ago), there was no way to actively cool a building.

Until the late 19c the only way to achieve cooling comfort was to use heat-rejection and passive cooling techniques - shading, natural ventilation, evaporative cooling, thermal mass, etc.

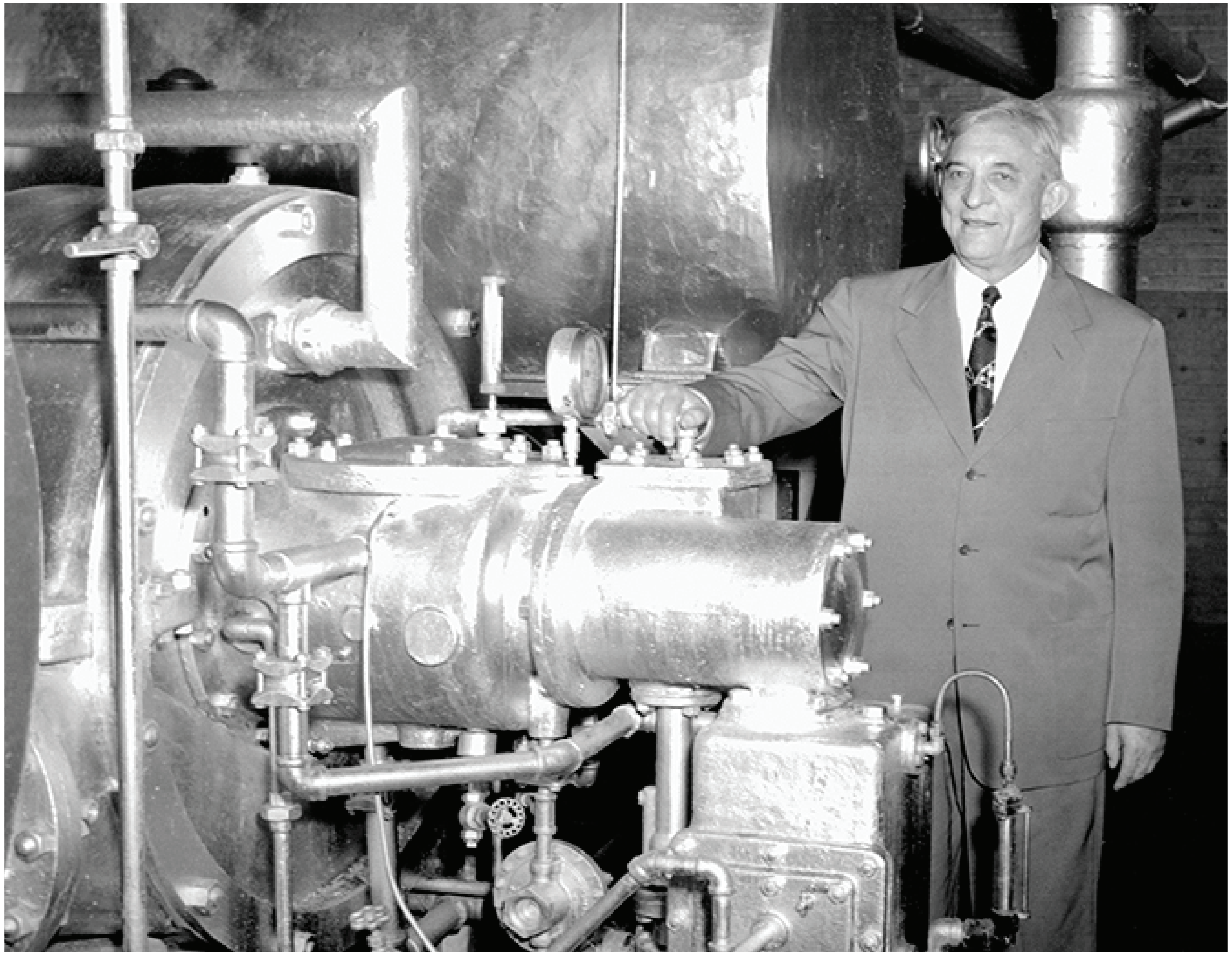
Refrigeration was not used to cool buildings until the 1920s

Fun fact: In 1902, Willis Carrier designed the first modern air-conditioning system, launching an industry that would fundamentally improve the way we live, work and play.

With human comfort the last thing on his mind, a young mechanical engineer completes the schematic drawings for what will be the first successful air-conditioning system. He was tasked with finding a solution for a printing company in Brooklyn that was having problems: Its paper was expanding or contracting in the variable East Coast humidity. That played havoc with the color register for four-color printing, since the ink, applied one color at a time, required pinpoint calibration to avoid badly aligned, muddy illustrations.

The system that Carrier devised still forms the basis of the air conditioner (or, more accurately, humidity controller) today: Air was forced through a filter of a piston-driven compressor, where it was pumped over coils that were chilled using coolant. The cold air was then expelled into a closed space using a fan, cooling the room and stabilizing the humidity.

(Source: Heating, Cooling, Lighting by Lechner and https://www.carrier.com/)



(Source: https://www.carrier.com/)

Cooling

Refrigeration Cycles

Vapor Compression Refrigeration

Vapor-compression refrigeration or vapor-compression refrigeration system (VCRS), in which the refrigerant undergoes phase changes, is one of the many refrigeration cycles and is the most widely used method for air-conditioning of buildings.

Note: The expansion valve removes pressure from the liquid refrigerant to allow expansion or change of state from a liquid to a vapor in the evaporator

(Source: Heating, Cooling, Lighting by Lechner)

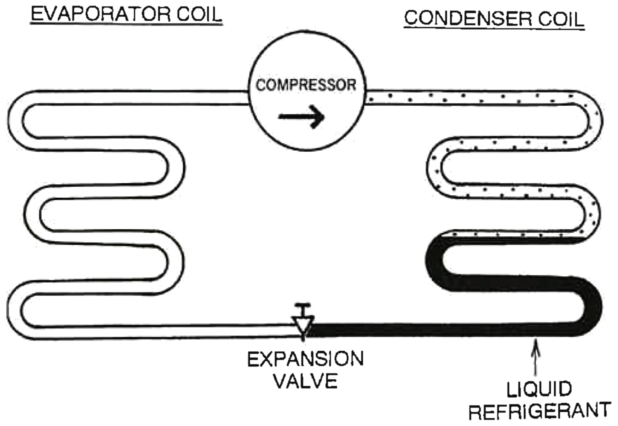


Figure 18.9a The basic components of a compressive refrigeration machine.

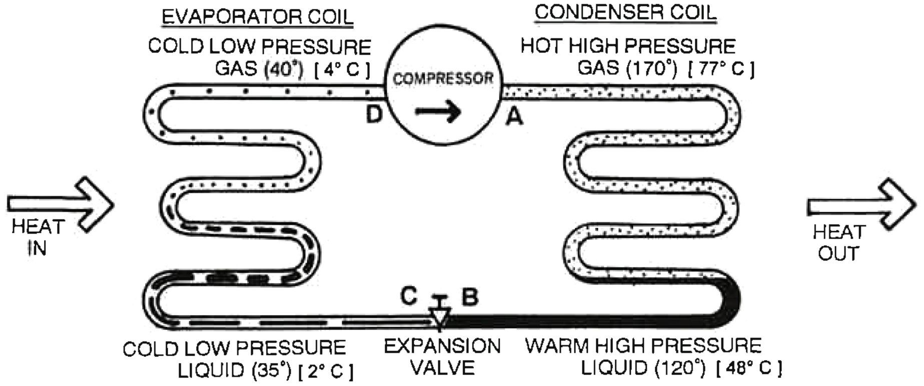
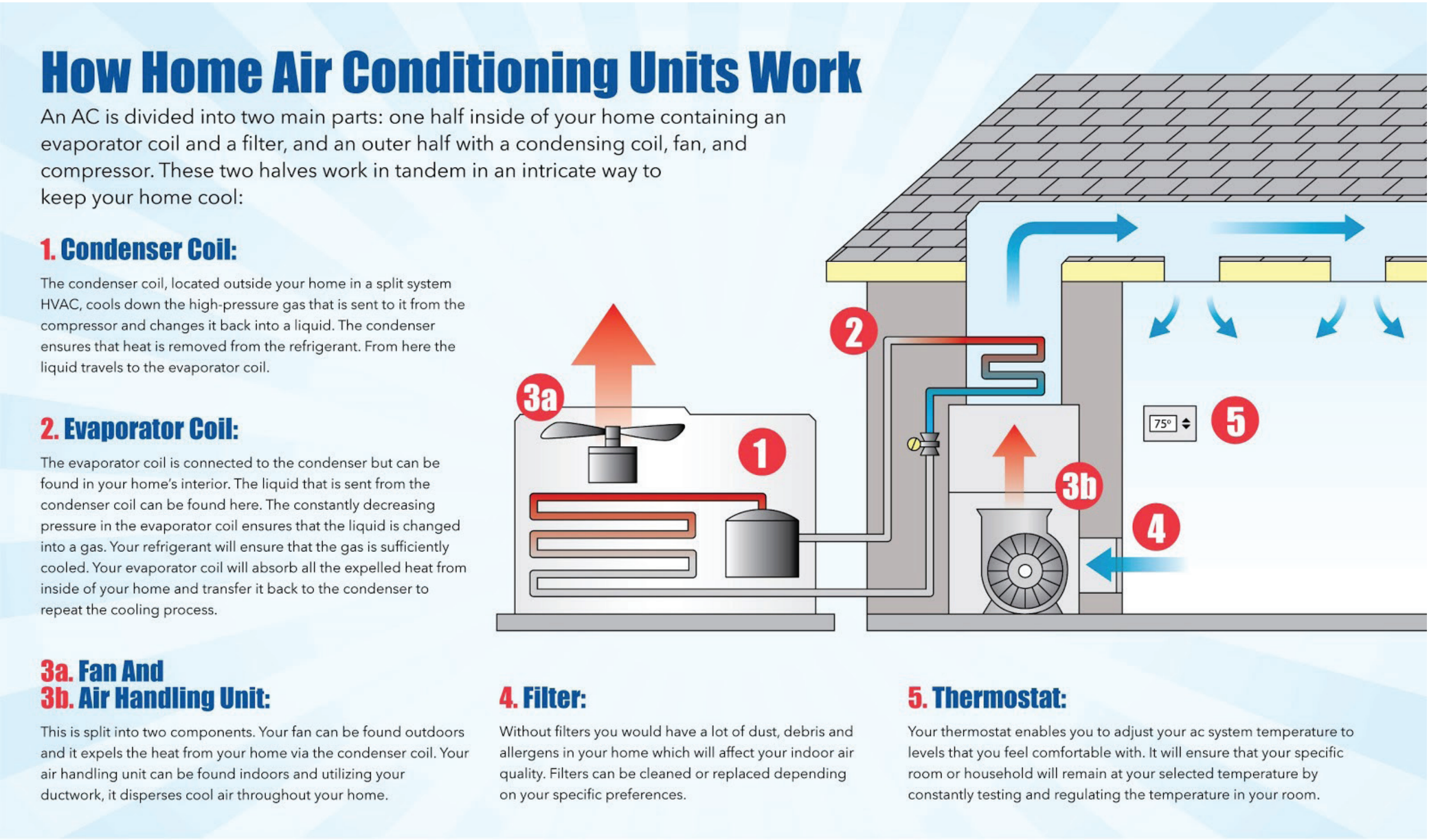


Figure 18.9b Where the refrigerant evaporates, it absorbs heat (cools), and where it condenses, it gives off heat.



How Home Air Conditioning Units Work

An AC is divided into two main parts: one half inside of your home containing an evaporator coil and a filter, and an outer half with a condensing coil, fan, and compressor. These two halves work in tandem in an intricate way to keep your home cool:

1. Condenser Coil:

The condenser coil, located outside your home in a split system HVAC, cools down the high-pressure gas that is sent to it from the compressor and changes it back into a liquid. The condenser ensures that heat is removed from the refrigerant. From here the liquid travels to the evaporator coil.

2. Evaporator Coil:

The evaporator coil is connected to the condenser but can be found in your home's interior. The liquid that is sent from the condenser coil can be found here. The constantly decreasing pressure in the evaporator coil ensures that the liquid is changed into a gas. Your refrigerant will ensure that the gas is sufficiently cooled. Your evaporator coil will absorb all the expelled heat from inside of your home and transfer it back to the condenser to repeat the cooling process.

3a. Fan And 3b. Air Handling Unit:

This is split into two components. Your fan can be found outdoors and it expels the heat from your home via the condenser coil. Your air handling unit can be found indoors and utilizing your ductwork, it disperses cool air throughout your home.

4. Filter:

Without filters you would have a lot of dust, debris and allergens in your home which will affect your indoor air quality. Filters can be cleaned or replaced depending on your specific preferences.

5. Thermostat:

Your thermostat enables you to adjust your ac system temperature to levels that you feel comfortable with. It will ensure that your specific room or household will remain at your selected temperature by constantly testing and regulating the temperature in your room.

https://thesoothingair.com/

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Refrigeration Cycles

Absorption Refrigeration

An absorption chiller, also known as an absorption refrigerator, is a cooling system that uses a heat source, in lieu of electricity and a compressor, to drive the device. The systems are commonly used where excess heat is available and are considered a type of heat recovery device. Using waste heat from a gas turbine makes the turbine very efficient because it first produces electricity, then hot water, and finally, air-conditioning—trigeneration/cogeneration. Absorption chillers use no moving parts and are powered by heat alone.

Diagram: Water evaporates and in the process draws heat from the chilled water coil. The water vapor migrates to the other chamber where it is absorbed. Consequently, the vapor pressure is reduced, and more water can evaporate to continue the cooling process.

(Source: Heating, Cooling, Lighting by Lechner)

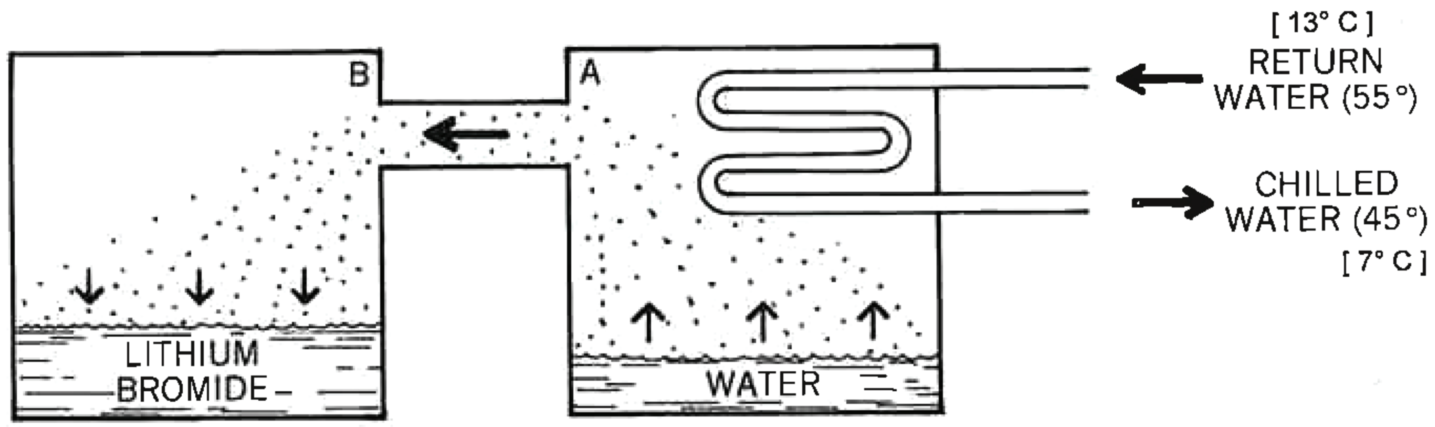

Figure 18.9c The first two chambers of an absorption refrigeration machine.

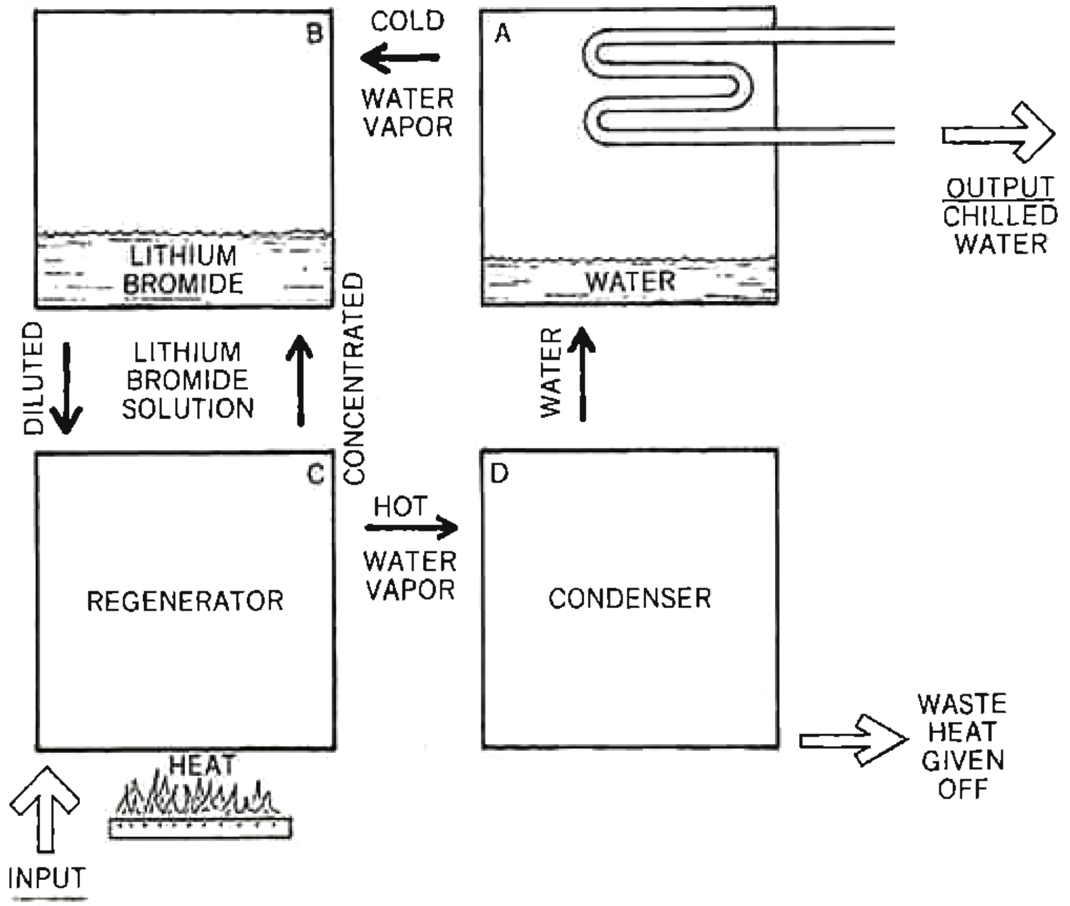

Figure 18.9d The absorption refrigeration cycle has chilled water as an output and a fairly high-temperature heat source as an input. Waste heat is given off in the process.

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Cooling

Cooling Systems

Cooling systems vary mostly by the way heat is transferred from the rooms to the refrigeration machine and from there to the heat sink. The choice of equipment to move heat from each room to the refrigeration machine depends on building type and size.

Cooling systems are often classified by the fluids used to transfer the heat from habitable spaces to the refrigeration machine.

- All-Air System
- All-Water System
- Combination Air-Water Systems

Note: Heat sink - A device or substance for absorbing excessive or unwanted heat.

(Source: Heating, Cooling, Lighting by Lechner)

Manitoba Hydro Place, Winnipeg, MB, Canada, KPMB Architects, 2009 *- Optimizing the orientation to use passive solar gains to condition the interior space; high ceilings to increase natural daylighting: creating envelope buffer zones as winter gardens and double facades for passive solar pre-conditioning of fresh air. Operable windows and solar chimney allow natural ventilation. Thermo-active slab heating and cooling is supported by geothermal heat exchangers. Occupants can control their individual environment according to their own personal preference using operable windows, lighting and shading devices. The building consumes 140 kWh/m²/year of primary energy for building operation, establishing it as the most energy efficient office tower in North America, 60% below a typical office tower. Beyond energy efficiency the building provides a new level of thermal and visual comfort, with all workstations having access to the façade. (Source: https://transsolar.com/projects/manitoba-hydro)*

Cooling

All-Air System

Indoor air is blown over/across the cold evaporator coil and then delivered by ducts to the rooms that require cooling. Air systems can effectively cool, heat, ventilate, filter and dehumidify air.

Main disadvantages are the bulky ductwork and large fan power required.

(Source: Heating, Cooling, Lighting by Lechner)

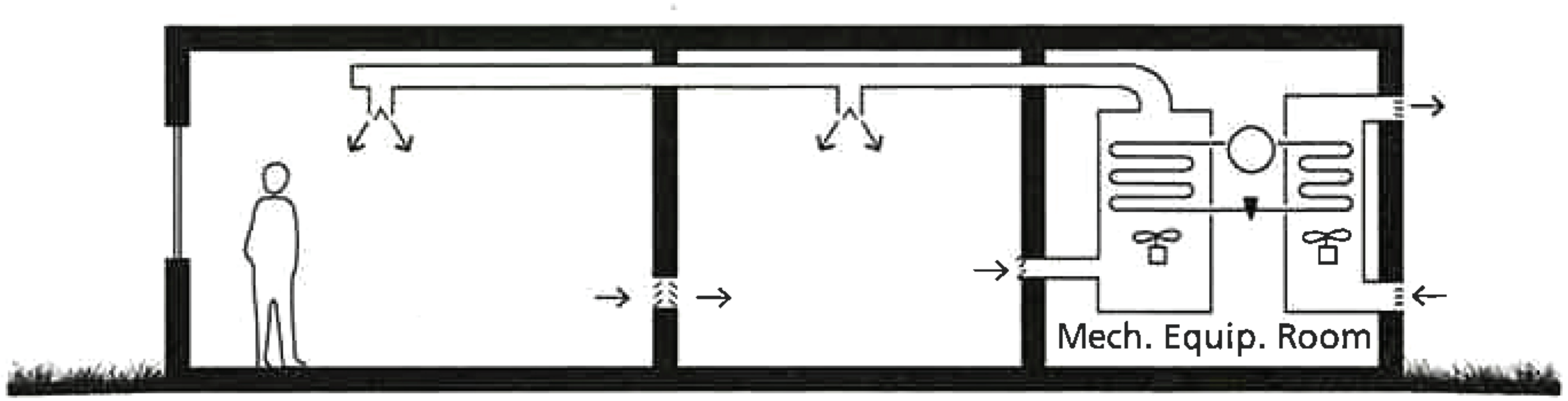

Figure 18.12c A schematic diagram of an all-air system.

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Cooling

All-Water System

Water is chilled by the evaporator coil and then delivered to fan-coil units in each space. Although the piping in the building takes up very little space, the fan-coil units in each room do require some space.

Another advantage is the small amount of energy required by the pumps as compared with fans.

(Source: Heating, Cooling, Lighting by Lechner)

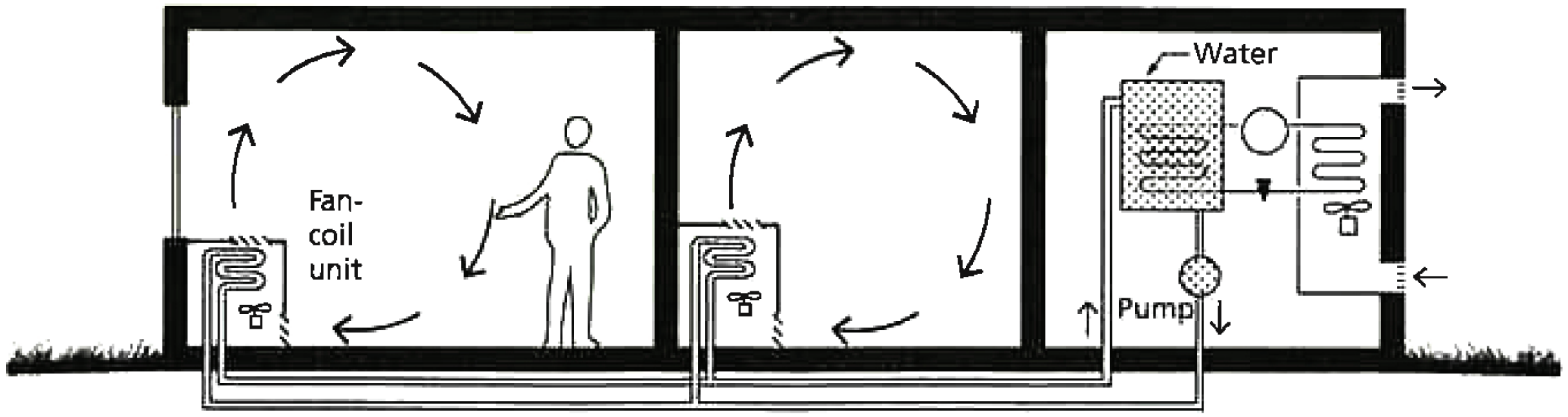

Figure 18.12d A schematic diagram of an all-water system is shown. Because the refrigeration machine in this case chills water, it is called a chiller. Note that with this system the interior room lacks ventilation.

Cooling

Combination Air-Water System

The bulk of the cooling is handled by the water and fan-coil units, while a small air system completes the cooling and also ventilates, dehumidifies, and filters the air. Since most of the cooling is accomplished by the water system, the air ducts can be quite small.

(Source: Heating, Cooling, Lighting by Lechner)

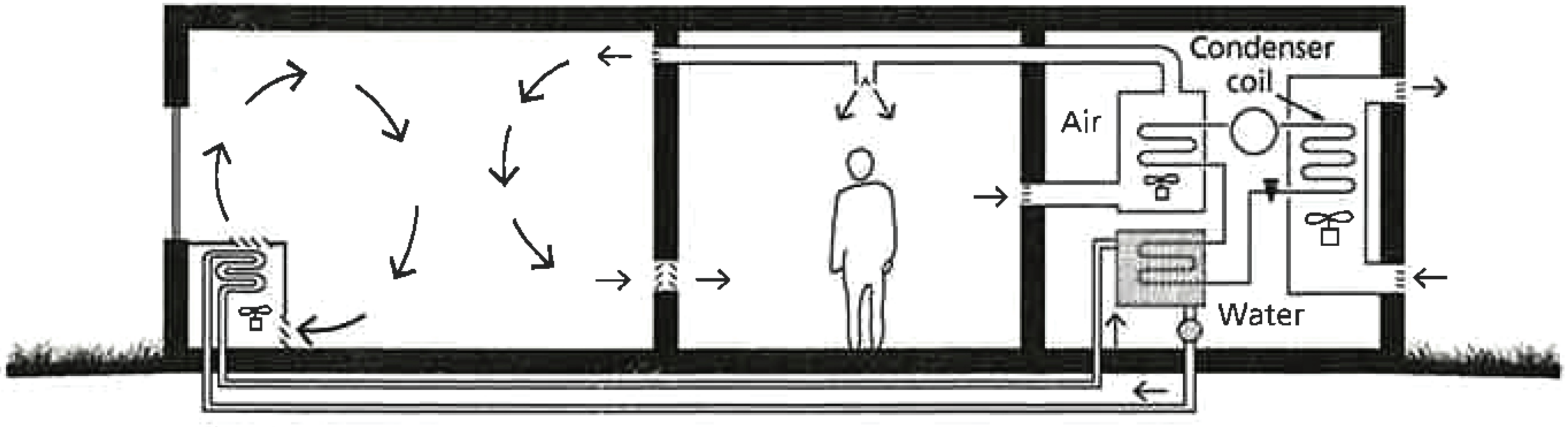

Figure 18.12e A schematic diagram of an air-water system is shown. Note that, unlike all-water systems, this system provides ventilation to all rooms.

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Diagram Assignment - Reference Image

(Source: Heating, Cooling, Lighting by Lechner)

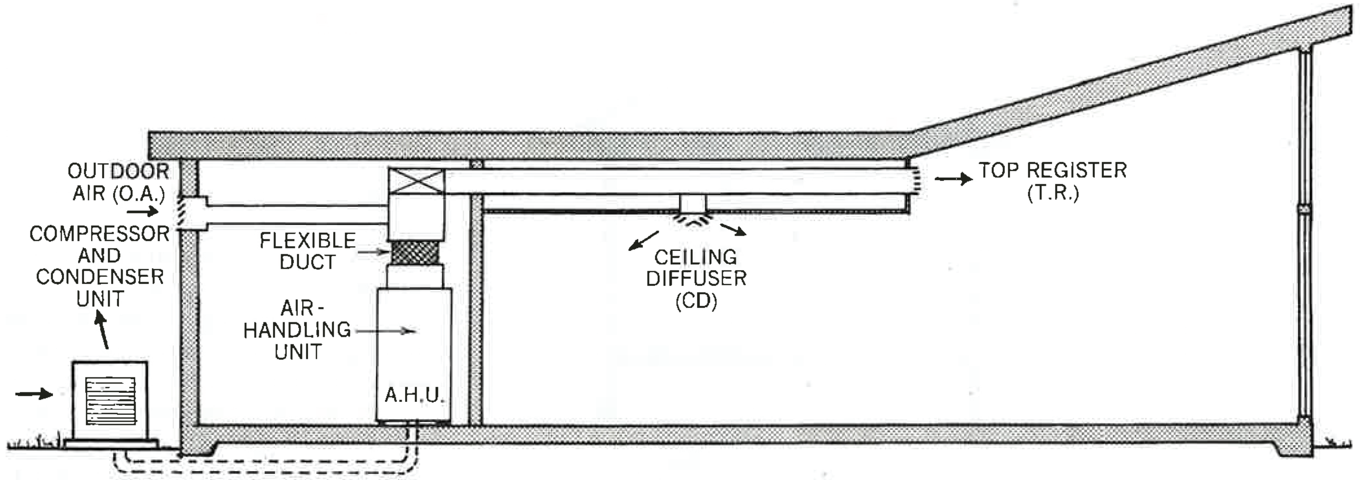

Figure 18.13h See the plan in Figure 18.13g for the location of this section.

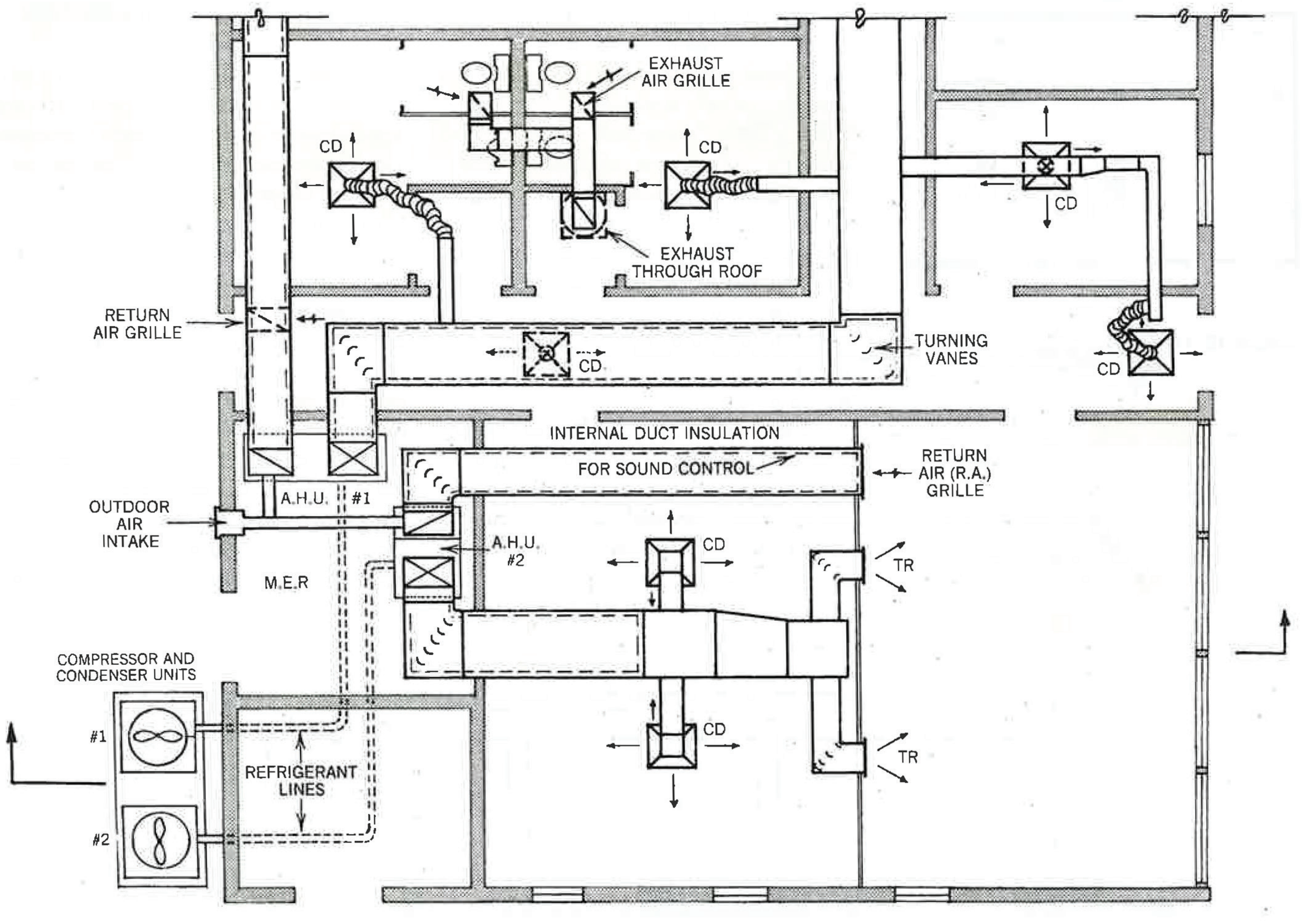

Figure 18.13g This plan shows a small two-zone office building served by two split systems. Double diagonal lines define supply ducts in section, while a single diagonal line across a rectangle defines a return duct. Abbreviations: TR = top register, CD = ceiling diffuser, M.E.R. = mechanical equipment room, A.H.U. = air-handling unit.