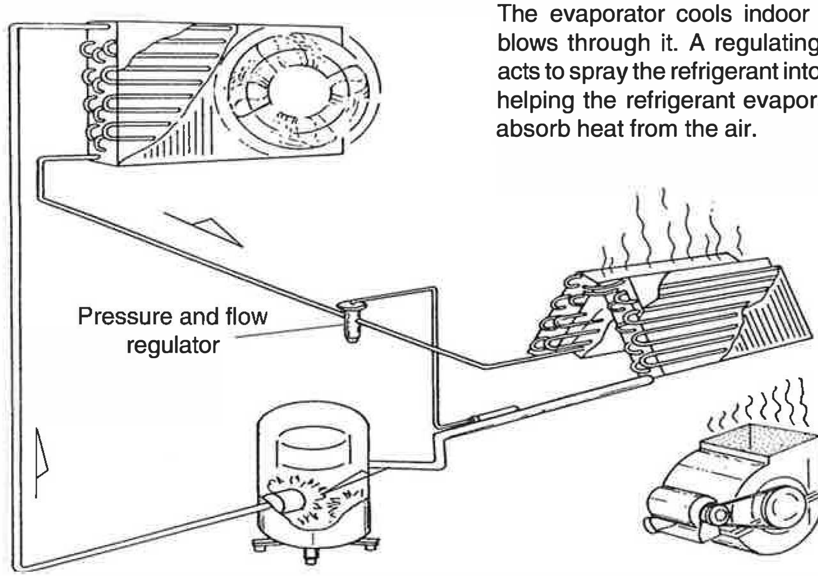
## 4.3 Air Conditioning Systems

Mechanical air conditioning systems are expensive to operate. Therefore, it is important to use all of the low-cost cooling strategies first, to save energy and provide better comfort. The three most effective low-cost cooling strategies are: shading or reflecting solar heat, indoor air circulation, and ventilation. Air conditioning is appropriate only when the less expensive options discussed earlier cannot adequately overcome the heat and humidity.




***4-8 Air Conditioning System Operation** - This illustration shows the major components of a central air conditioning system and explains their operation. The refrigerant collects the heat from indoors, the compressor moves the refrigerant outside, and the heat is then released outdoors.*

Air conditioning system efficiency relies on good maintenance. Good maintenance minimizes cooling costs; neglect maximizes cooling costs. Careful thermostat control by the residents is also a key ingredient to keeping cooling costs to a minimum. **For every degree Fahrenheit that a house thermostat setting is raised, air conditioning costs are reduced 3 to 6 percent.** Keep the thermostat set at 78°F or higher and, when you leave, turn the thermostat up to 84°F or higher. The air conditioner will run longer than usual when you return, but you will save energy and money because the unit ran very little or not at all while you were gone. Automatic setback thermostats work well for residents with consistent schedules.

Room air conditioners can cool a room where occupants spend most of their time. They are usually less expensive to operate than central air conditioning. Always use fans to circulate air when using air conditioning.

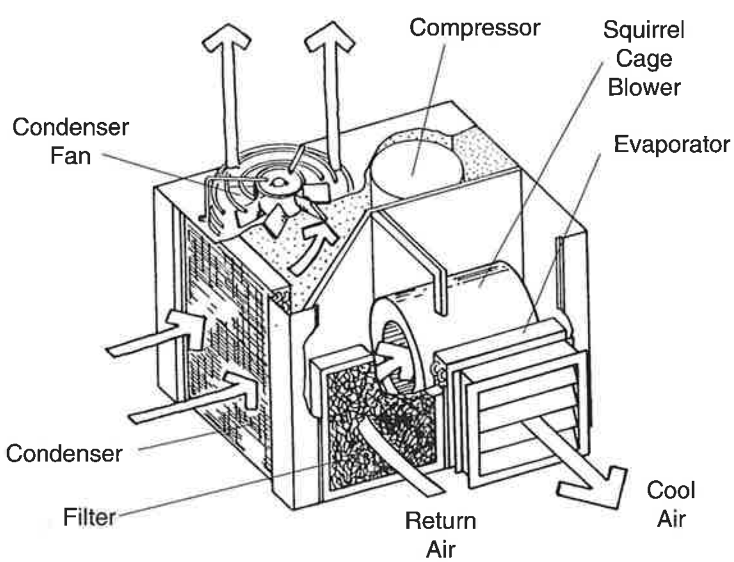
## 4.3.1 Introduction to Air Conditioners

Air conditioners gather heat from the home and move it outdoors. An air conditioner works like a refrigerator. A refrigerator cools one area (inside the refrigerator cabinet) while releasing heat into another area (the kitchen).

**Heat pumps work exactly the same way as air conditioners, but they provide both heating and cooling. All of the measures discussed for air conditioners apply to heat pumps** (*see Section 4.3.8, Heat Pumps*).

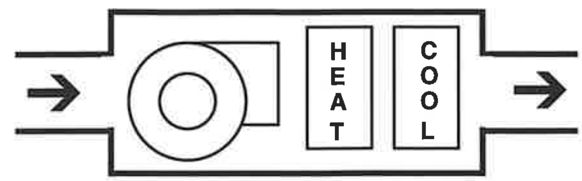
Air conditioners cool the home using a coil called the evaporator. They dump the heat outdoors via a coil called the condenser. A compressor moves the heat-transferring fluid called a refrigerant between the two coils. A heat pump works the same way but the flow of refrigerant is reversed during the winter and the indoor coil becomes a heating coil rather than a cooling coil.

The refrigerant absorbs large amounts of heat from inside air as it changes from a liquid to a gas in the evaporator. You've felt this evaporator effect if your index finger has ever felt numbed with cold while using a spray can. When the liquid evaporates at the spray nozzle, it absorbs heat from the surrounding air and cools your finger. In the same way, the refrigerant in an air conditioner evaporates and removes heat from the indoor air.




***4-9 Packaged Air Conditioner** - The packaged air conditioner contains the evaporator, the condenser, the compressor, and all the other parts in a cabinet located outdoors. Indoor air is circulated through the evaporator and cooled in this horizontal air handling unit. Outdoor air circulates through the condenser which removes the heat collected from the indoor air.*

Indoor moisture condenses on the cold evaporator coil. This dries the air and makes the home more comfortable in humid climates. The amount of water that an evaporator must remove to provide comfort is part of the design and selection of air conditioning systems (*see Section 4.3.5, Sizing Air Conditioners*).




***4-10 Horizontal-Flow Air Handler** - This is the most versatile type of air handler. Horizontal-flow air conditioners and heat pumps are installed on roofs, in crawl spaces and attics, and outdoors on concrete slabs.*

The compressor pumps the hot gaseous (evaporated) refrigerant into the condenser. There the refrigerant condenses from a gas back to a liquid. Outdoor air blown through the condenser coil removes heat from the coil.

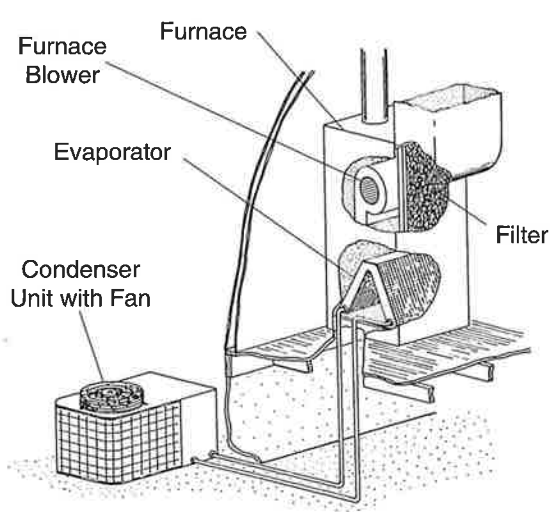
Figure **4-8** gives a graphic explanation of the cooling process utilized by an air conditioning system.

### 4.3.2 Types of Central Air Conditioning Systems

Central air conditioners are either packaged units or split-system units. The difference between these two types is the location of a major component called the air handler. Packaged units have outdoor air handlers and split systems have indoor air handlers.

The air handler is a steel cabinet containing the blower and the evaporator. It is connected to supply and return ducts. The supply ducts carry air from the air handler to the living spaces. The return ducts carry air from the house back to the air handler.

Split-system air conditioners have an indoor air handler that is very often a gas, oil, or electric furnace. The furnace is equipped with a cooling coil. The condenser, fan, and compressor are located outdoors in another cabinet (*see figure* **4-11**). Split-system air conditioners have one of three types of air handlers: upflow, down-flow, or horizontal-flow. The names describe which way the blower moves air. Study figures **4-10, 4-12,** and **4-13** for an explanation of these different types.




***4-11 Split-System Air Conditioner** - This down-flow furnace has a compartment for the cooling coil. Most upflow and horizontal furnaces will have their cooling coils in the supply ductwork adjacent to the furnace.*

Packaged air conditioning systems (also called unitary air conditioners and self-contained air conditioners) have the compressor, condenser, evaporator, and two fans all contained in a single cabinet located outside the home (*see figure* **4-9**).

Packaged air conditioning systems may also contain a gas furnace or some electric resistance heating coils enclosed in the same cabinet with the cooling unit and blower. Packaged air conditioners are usually horizontal-flow units, mounted on the roof or on a concrete slab outside.

### 4.3.3 Ratings for Air Conditioning Systems

Central air conditioners are rated by how much heat they remove for each watt of electric power they draw. Before January 1, 1979, the rating was called the Energy Efficiency Ratio (EER). This rating didn't take into account the energy that the air conditioner wastes getting started.

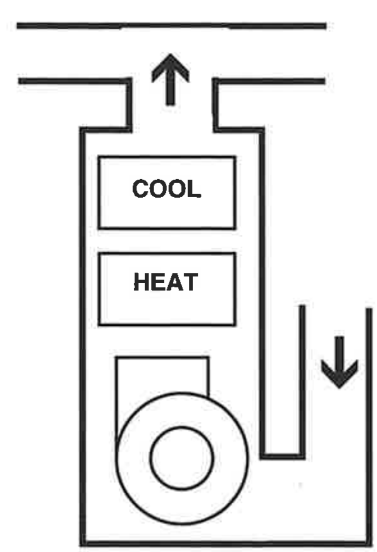
In 1979, all manufacturers of central air conditioners were required to rate central air conditioners by their Seasonal Energy Efficiency Ratio (SEER). The SEER predicts seasonal performance better than the EER because it accounts for the energy that is wasted every time the air conditioner starts up. The SEER ratings of air conditioners are included in the Air Conditioning and Refrigeration Institute directory which is published in April each year (*see Appendix* C).

Room air conditioners are still rated by the EER. The ratings are listed by the Association of Home Appliance Manufacturers (see Appendix C). The American Council for an Energy Efficient Economy lists the most efficient central air conditioners and room air conditioners in their annual guide, *The Consumer Guide to Home Energy Savings* (*see Bibliography*).

The EER and SEER are ratios of cooling capacity. The capacity of the air conditioner in Btus per hour are divided by the watts of electric power it draws (SEER or EER = Btus/hour ÷ watts). The higher the EER or SEER, the more efficient the air conditioner.

The SEERs of central air conditioners sold today range from 7.5 to almost 17. This means that the most efficient air conditioners produce twice as much cooling for a dollar's worth of electricity as the least efficient models.

Room air conditioners are generally less efficient than central air conditioners and the EERs range from 5 to 12.

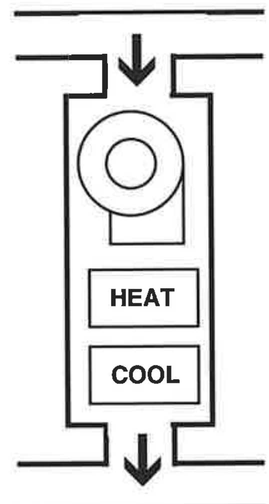



***4-12 Up-Flow Air Handler -*** *Return air enters the bottom and the heated or cooled supply air exits through the top into the supply plenum and ducts. Up-flow air handlers are popular in homes with basements.*

## 4.3.4 High-Efficiency Central Air Conditioners

In a 1983 experiment, the Florida Public Service Commission equipped twelve homes in Miami with two central air conditioners each: an efficient model (SEER - 11.3) and a standard model (SEER - 6.5). The experimenters ran the standard air conditioner for one week and then ran the high efficiency model for a week. The average savings for using the high efficiency air conditioners was 30 percent. The annual savings averaged about $300 per home.

If you buy a new air conditioning system, choose a high efficiency unit with the right characteristics for your cooling requirements and climate. You will save money in the long run.



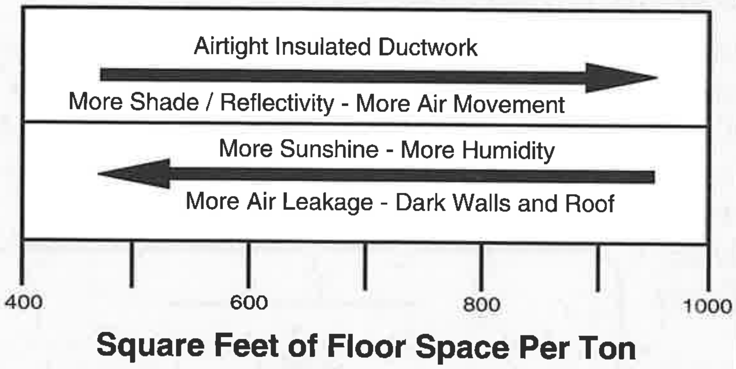
***4-13 Down-Flow Air Handler*** *- Return air enters the top, is heated or cooled, then exits the bottom into supply ducts. These types of air handlers are popular in manufactured homes and in homes with crawl spaces. Supply ducts run under the floor.*

Air conditioner efficiency has improved steadily since the 1970s energy crisis. The improvements include: bigger coils, improved coil design, and more efficient electric motors for the compressor and the fans. Today the most efficient models have compressors and blowers powered by variable speed motors. They rate as high as 16.9 SEER. These new air conditioners run much of the time, eliminating many inefficient start-ups. The older systems make the conditioned air colder than necessary, then shut off so the house doesn't get too cold. The newest systems adjust the speed of the compressor and blower to meet the demand for cooling.

When selecting a high efficiency air conditioning system, the contractor should determine the proper size of the system and select the right condenser and evaporator to attain the rated efficiency. **Replacing your current air conditioning or heat pump system will not give you the rated efficiency unless you replace the indoor coil along with the other components.** Experts still disagree on whether very high efficiency units can remove enough moisture in very humid climates. Air conditioning systems with SEERs more than 12 should be sized and selected carefully to ensure adequate moisture removal. Expect to pay $600 to $1200 more for a very efficient central air conditioner.

## 4.3.5 Sizing Air Conditioners

The most important consideration to achieve comfort and minimize energy cost is to select the correct size air conditioning equipment. Consider cooling, moisture removal, and energy efficiency. The evaporator, condenser, compressor, fan, and fan speed should fit each particular home's cooling requirements, and these parts should be matched to each other.




***4-14 Sizing Air Conditioning Systems** - The above illustration shows how factors such as climate and energy efficiency affect the ideal size of an air conditioner. The size of an air conditioner is rated in tons (12,000 Btus per hour per ton). The chart shows how many square feet of floor space can be cooled by a ton of air conditioning capacity in the hottest weather depending on the factors shown on the chart.*

It's normal for a correctly sized air conditioner to run from 15 to 30 minutes each hour when the outdoor temperature is 85° to 90°F. The unit should run almost constantly when the outdoor temperature is above 95°F.

Cooling comfort is produced by dropping the air temperature and removing the humidity. The air conditioner must run for significant periods of time to remove moisture. It pulls the indoor air through the evaporator coil, where the moisture falls out and is piped away through a drain. An oversized air conditioner cycles frequently, removes less moisture, and wastes energy. If your air conditioner runs all the time, it does not necessarily mean that it is sized correctly. It could be oversized but working extra duty to overcome maintenance, repair, or adjustment problems.

The capacity of air conditioners to remove heat from a home is measured in Btus per hour, or "tons" of cooling capacity. Each ton equals 12,000 Btus per hour (1 ton = 12,000 Btus/hour). The air conditioner should have a ton of capacity for every 400 to 1,000 square feet of floor space, depending on your home's energy efficiency and climate (*see figure* **4-14**).

"One ton per 400 square feet of floor space" is a rule-of-thumb used to estimate the size of central air conditioners in older, less efficient homes. However, sizing the system smaller to provide one ton per 650 square feet of floor space will provide better efficiency and humidity control in most homes built since 1975. Central Power & Light of Texas sizes air conditioners for very energy-efficient homes with features like ceiling fans, radiant barriers, window shading, airtight ducts, and light-colored roofs and walls, at about one ton per 1,000 square feet of floor space. These rule-of-thumb values are presented here for general information only and should not be used to size air conditioners.

It was standard practice in the past to oversize the air conditioner by 10 to 50 percent to ensure that it was big enough to cool the home. However, researchers at Texas A & M and others found that air conditioners that are undersized by 10 to 20 percent are more efficient and more effective at removing moisture.

Reputable contractors size air conditioning systems accurately through careful hand calculations or with computer programs. The Air Conditioning Contractors of America publishes a calculation procedure called Manual J, which is the standard method for sizing central air conditioners. Several air conditioning manufacturers and others have developed computer programs based on Manual J or on other calculation methods. To ensure correct sizing, ask your contractor to show you the hand- or computer-generated calculations for your system. Ask the contractor to install the smallest size air conditioner capable of cooling your home. Also ask about moisture removal capacity of the system and sensible heat factor (SHF).

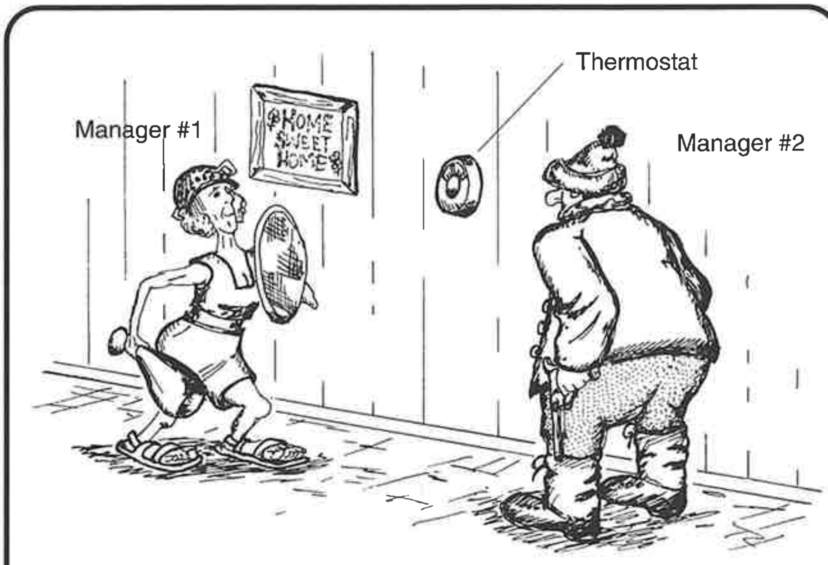
The SHF is a very important sizing consideration that rates the air conditioner on its ability to remove moisture. The SHF is a decimal number between 0.5 and 1.0. The lower the SHF, the more moisture the unit will remove from the air. The SHF depends on the size and construction of the evaporator coil and on the fan speed.

Homeowners in dry and moderate climates should purchase a unit with high SHF, because they need less moisture removal and air conditioners with high SHF are more efficient. However, homeowners in humid climates will probably want an SHF of between 0.67 and 0.77 to reduce humidity and the accompanying mold, mildew, and microscopic pests. Make sure your contractor thinks about moisture removal when sizing your central air conditioning system. A relative humidity of less than 40% will surpress mold, mildew, and other microscopic pests which are linked to respiratory problems.

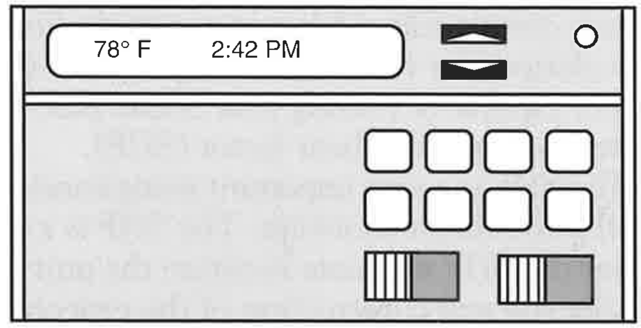
Proper sizing and equipment selection are especially important with new higher efficiency air conditioners. These new energy-efficient units must have a low enough SHF to provide adequate moisture removal. An oversized new air conditioner won't reach its potential high efficiency, nor will it remove enough moisture to provide adequate comfort.

### 4.3.6 Control of Central Air Conditioners

The location of your thermostat can cause problems in controlling cooling systems. Thermostats should be shaded from direct sunlight. A thermostat located on a warm outside wall may cause the air conditioner to operate erratically. In that case, move the thermostat. Turning the thermostat past the desired temperature will not make the air conditioner cool your home any faster and it will waste energy. Pacific Gas and Electric has reported that "dueling managers," (*see figure* **4-15**) who move the thermostat




***4-15 Dueling Managers** - Air conditioning systems operate erratically and inefficiently when residents move the thermostat setpoint between different comfort settings.*




*4-16* ***Automatic Thermostat*** *- These timing devices automatically raise the temperature when occupants leave the house and lower the temperature just before they return. Automatic thermostats can reduce cooling costs 10% or more.*

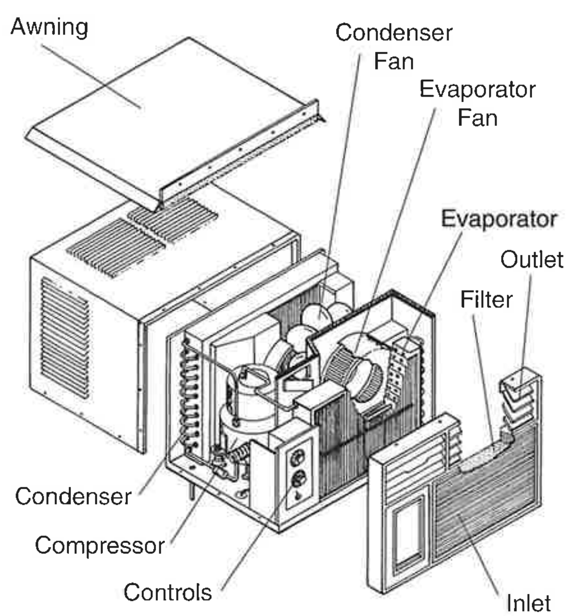
setting back and forth to suit their different comfort demands, cause air conditioning systems to operate erratically and inefficiently.

**Residents who leave and return at regular times every day can save money and increase the comfort and convenience of both cooling and heating by using automatic setback heating/cooling thermostats** (*see figure* **4-16**).

Thermostats often do not provide good comfort control in very humid climates. Manufacturers of automatic controls are developing air conditioning controls that will respond to both temperature and humidity. And manufacturers of air conditioning equipment have developed variable speed equipment that will be more flexible in providing both cooling and humidity control in the future.

### 4.3.7 Room Air Conditioners

Room air conditioners are small packaged air conditioning units installed in windows or in an exterior wall. All room air conditioners manufactured after January 1, 1990, have an energy efficiency rating (EER) of at least 8. The most efficient units have an EER of around 12. However, you can still buy room air conditioners with EERs as low as 5.3 unless you shop carefully.




***4-17 Room Air Conditioner*** *- The evaporator, or cooling coil, faces indoors, and the condenser coil faces outdoors in this type of air conditioner.*

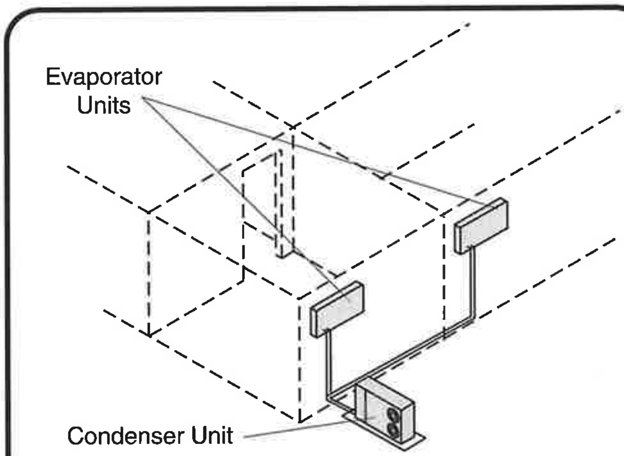
The energy efficiency rating is computed by dividing cooling capacity, measured in Btus per hour by the watts of power used (*see Section 4.3.3, Ratings for Air Conditioning Systems*). The federal government requires all air conditioners to carry a yellow energy label listing cost-of-operation, including the EER. The higher the EER, the more efficient the air conditioner and the lower its operating cost. A model with a high EER may cost more to buy, but will return your investment quickly in energy savings.

The evaporator, condenser, compressor, controls, and all other parts are contained in the cabinet of the room air conditioner (*see figure* **4-17**). The evaporator and its fan face indoors, and the condenser and its fan face outdoors. Warm air from the room enters through a filtered section of grille in the front cover of the unit, moves through the cooling evaporator coil, and comes back into the room through the unfiltered section of the grille. The heat from indoors is released outdoors by the condenser and its fan.

Room air conditioners do not have ducts and don't have the inefficiencies associated with ducts. Circulate air with ceiling fans and portable fans while operating room air conditioners.

**Room air conditioners can save substantial energy and money over central units. They cool a specific comfort area where the occupants spend most of their time instead of cooling the whole house.**

***Caution:*** *The National Electrical Code allows a room air conditioner drawing less than 7.5 amps to be plugged into any 15 amp household circuit. However, you should not have any other major appliance on the same circuit. Room air conditioners should be powered by their own dedicated electric circuit if they draw more than 7.5 amps. A dedicated circuit means that you do not power anything else with that circuit.* Room air conditioners rated at more than 14,000 Btus per hour normally use 230 volt dedicated circuits.




***4-18 Split-System Room Air Conditioner*** *- These cooling systems use an outdoor condenser and one or more indoor evaporators mounted to the wall or ceiling. The advantages are individual room temperature control and no ductwork. There is also no need for a large opening in the wall since the only connection between the outdoor unit and indoors are refrigerant lines.*

The most important maintenance task for the homeowner is to keep the filter and the coils clean. ***Caution:*** *Unplug the room air conditioner before servicing it.* The filter is visible and easily removed from the front of the unit. Most filters are made of foam rubber designed to be cleaned with soap and water.

In some models, the insides of the air conditioner slide out of the cabinet for cleaning and servicing. With others, you must remove the unit and disassemble the cabinet for major cleaning. Surface dirt and lint can be removed from the unit while it's in place. If either of the coils is very dirty, spray it with a household detergent or coil cleaner, then spray again with clean rinse water. Be careful to keep the water away from electrical components. Let the unit dry completely before using it or storing it. At the same time, straighten any damaged fins with a fin comb as described in Section 4.4.2, Cleaning Evaporator Coils.

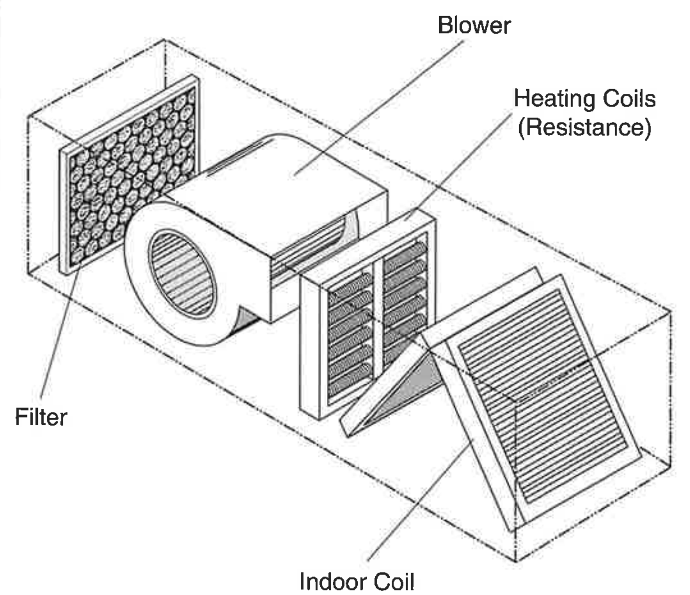
There are three energy conservation measures specifically for room air conditioners, besides the general recommendations discussed above.

1. Seal thoroughly around the perimeter of the room air conditioner's cabinet to prevent warm air leaks in summer and cold air leaks in winter.

2. During the heating season, remove the room air conditioner and close the window, or cover the indoor side with either plastic sheeting or an insulated removable box. Do not cover the unit on the outside, unless you also have an indoor cover, because warm, moist, indoor air leaking into the unit can form condensation.

3. If possible, shade the room air conditioner from direct sunlight. Shading prevents buildup of heat in the cabinet and allows the condenser and its fan to operate more effectively. Allow at least 18 inches of clearance over the room air conditioner so the shade awning does not restrict air flow.

Several manufacturers make split-system room air conditioners with two main parts, like the system illustrated in figure **4-11** on page 41. The evaporator or indoor unit attaches to a wall or ceiling indoors (*see figure* **4-18**). The condenser is located outdoors and is a smaller version of the unit shown in figure **4-25** on page 53. You can connect two or more room units to the same condenser unit, with refrigerant lines running from each indoor unit to the condenser outside. Split-system room heat pumps use the same design (*see Section 4.3.8, Heat Pumps*).




***4-19 Horizontal Unit*** *- This horizontal heat pump or air conditioner shows the location of the major components which need service: the filter, the blower, and the indoor coil.*

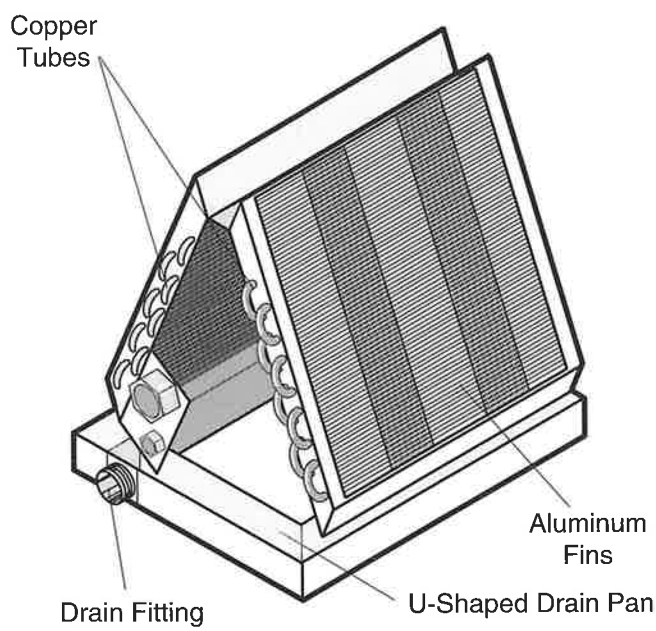
Split-system room air conditioners and heat pumps eliminate duct leakages because they have no ducts, they do not require a large opening through a window or wall, and they allow zone cooling and heating.

Several manufacturers make portable room air conditioners that sit completely inside the room and do not remove heat from the home. Instead, they cool one part of a room while heating another. These models are **not** recommended.

### 4.3.8 Heat Pumps

Electric heat pumps work like the mechanical central air conditioning systems described in Section 4.3.1 (*see figure* **4-19**). The difference between an air conditioner and a heat pump is that a heat pump is reversible. Instead of calling the coils the evaporator and the condenser, they are called the indoor coil and the outdoor coil, because they change functions when the system changes from heating to cooling.

**Heat pumps can provide very efficient electric heating in addition to efficient cooling.** Heat pumps move heat into the home during the heating season, and out of the home during the cooling season. They are almost identical to air conditioners except for a few extra parts that allow the refrigerant to follow two different paths: one for heating and one for cooling.

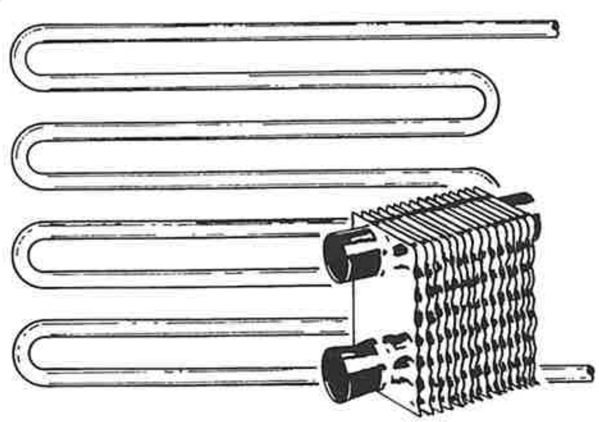



***4-20 A-Coil** - The indoor coil of split-system heat pumps and air conditioners is an A-shaped panel of tubes and fins. A U-shaped pan under the bottom catchs and removes water which condenses on the coil.*

Heat pumps are either packaged units or split systems just like air conditioners. Heat pumps require the same routine maintenance procedures as central air conditioners.

Heat pumps have electric resistance coils that are activated if the indoor coil is not providing sufficient heat. Electric resistance heat is far less efficient than a heat pump so you don't want any electric resistance heat until the heat pump cannot maintain a comfortable temperature. An outdoor thermostat should prevent the coils from operating until the outdoor temperature is below 40°F.

Servicing heat pumps requires special training because of their complicated electric controls and their reversible roles of heating and cooling.

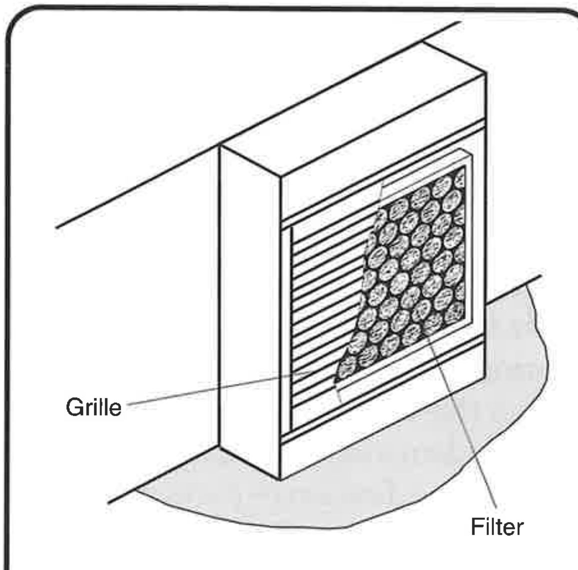


***4-21 Coil Construction** - Evaporator and condenser coils are made from copper tubing and aluminum fins. Air moves through the tiny spaces between the fins. The air is either cooled or heated depending on whether the coil is an evaporator or a condenser. (Courtesy of Lennox Industries)*

## 4.4 Air Conditioning System Maintenance

You can achieve impressive savings through simple maintenance tasks. A recent study funded by Pacific Gas and Electric found that heat pumps (which are just reversible air conditioners) are routinely neglected by homeowners. The maintenance and repair procedures described here saved an average of 27 percent of the electricity consumed in heat pump systems. A study by Gulf States Utilities predicted homeowner savings from $6 to $77 per month, if standard maintenance procedures are carried out.

Many of the maintenance and repair jobs described here can be performed by a person who is moderately handy with tools. Refer to the owner's manual or the service manual for specific information about your cooling equipment. If you lack the skills and confidence to perform routine maintenance, hire a reputable cooling contractor to inspect, repair, and maintain the system as outlined below. As part of this maintenance job, the contractor could show you the location of the components of the system and teach you how to perform routine maintenance.




***4-22 Alternate Filter Location*** *- Filters are often located behind central return air grilles.*

**The four most common problems with central air conditioners are: oversizing, low air flow, improper refrigerant charge, and leaky ducts.**

Properly sized air conditioning equipment is very important for both efficiency and comfort. There isn't much you can do about an existing oversized air conditioner. But, when buying a new one, don't assume that your existing unit is sized properly. Have the cooling contractor calculate the proper size of equipment by considering: average summer temperature and humidity, the size of your home, the solar load, air leakage, and the amount of heat generated indoors (*see Section 4.3.5, Sizing Air Conditioners*).

If the air flow in the system is inadequate, a trained technician should fix the air flow problems to make the system operate efficiently (*see Section 4.5, Air Flow and Ductwork*).

Either a low or high refrigerant charge makes the air conditioning system perform poorly and inefficiently. A trained technician should measure the charge to tell if the refrigerant charge is high or low and then adjust the charge if necessary (*see Section 4.4.5, Checking Refrigerant Charge*).

Leaky ducts are a widespread problem that affect most central air conditioning systems. Seal the leaks to improve efficiency and save energy costs (*see Section 4.5.2, Sealing Leaky Ducts*).

The whole air conditioning system works better if the components are kept clean (*see Sections 4.4.1 through 4.4.4*). **Caution:** *Disconnect electricity from the air conditioning unit* *before any maintenance work is begun*. Clean the coils and clean or replace filters very regularly, and clean the fan blades, grilles, motors, compressors, and controls before excessive dirt accumulates. Oil the motor and fan bearings once a year with a few drops of 20 weight electric motor oil.

### 4.4.1 Keeping Filters Clean

All evaporators in home cooling systems should be protected by air filters. The filters for central air conditioning systems are located: adjacent to the blower in the main return air duct (*see figure* **4-19**); in the cabinet of the air handler; or behind the grille of a central return register (*see figure* **4-22**). **Dirty filters block a significant percentage of air flow and drastically reduce cooling efficiency.**

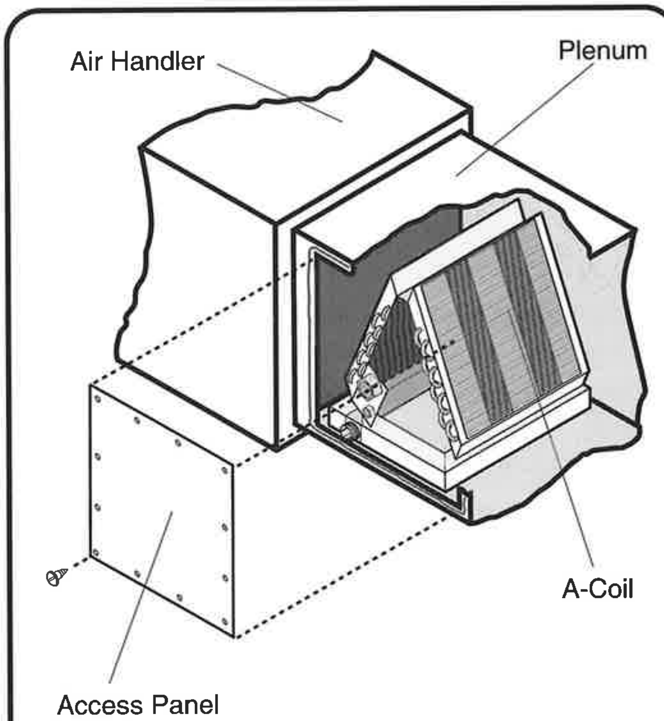
The filter should be changed or cleaned each month that the air conditioner is in use. The average air conditioning system will lose about 1 percent efficiency per week because of decreasing air flow due to dirt on the filter. A clean filter also keeps the evaporator coil clean longer.

### 4.4.2 Cleaning Evaporator Coils

Even with clean filters, the evaporator coil (*see figure* **4-20**) will get dirty and lose more than 5 percent efficiency per year. Clean the evaporator every 3 to 5 years. Neglecting cleaning will shorten the life of the blower and the compressor, and lead to excessive cooling costs.

Cleaning evaporator coils is simple. All coils can be cleaned using similar methods. However, getting to the coil may be difficult.

The evaporators in packaged air conditioners and room air conditioners are usually fairly easy to reach by removing an access panel or part of the cabinet. Evaporators in split-system air conditioning systems are often more difficult to reach. You may have to cut a hole in the main supply duct or remove the blower to get enough room to work. If you have to cut a hole in the duct, use stiff galvanized steel to make an access panel big enough to overlap the hole a couple of inches all the way around (*see figure* **4-23**). Fasten the access panel with sheet metal screws spaced about two inches apart, and caulk the edge of the patch with silicon caulking.

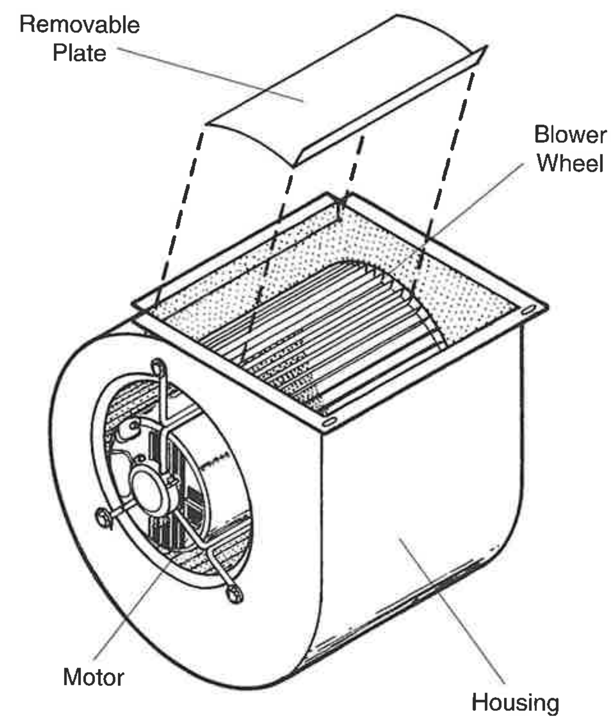



***4-23 Plenum With A-Coil** - Evaporator coils are often located inside the plenum adjacent to the air handler. Sometimes an access opening with a metal cover panel must be installed in the duct in order to clean the evaporator.*

All you need to clean the evaporator coil are a couple of spray bottles, a pair of rubber gloves, and some rags. A small whisk broom or bristle brush is also useful.

Coils have a dirty side facing the air flow coming to the blower, and a clean side facing away. If you can reach the dirty side, brush away the loose dirt and lint. **Caution:** *Be careful not to bend the soft metal fins*. Then spray the cleaner into the coil from both sides, if possible, and give the cleaner some time to loosen the dirt. If necessary, brush the surface of the coil again to remove the more stubborn dirt.

Next, spray the rinse water into the coil. The cleaner and rinse water will drain into the pan or trough beneath the evaporator. If you can reach the pan, clean it too, and remove the dirty water.




***4-24 Squirrel Cage Blower*** *- These fans are used in almost all air handlers and evaporative coolers. Dirt on the blades of the blower reduces the efficiency and the capacity of the cooling system.*

The most important part of cleaning the coil is loosening the dirt. The water which condenses on the coil during operation will rinse the coil if it can't be rinsed thoroughly because of inadequate space.

Select a cleaner for the type of dirt deposits on the evaporator coil. If the dirt deposits are light and dry and do not seem to have penetrated the inner parts of the coil, then a strong household cleaner will probably do the job well. If the dirt is heavier and packed into the coils, use a special foaming cleaner designed to penetrate the coil and push the dirt out. If the dirt is greasy and stuck firmly to the surfaces of the coil, professionals use a caustic or basic cleaner that cuts through the grease and loosens the dirt. Don't use the caustic cleaner unless the coil is greasy. The foaming cleaners and caustic cleaners are available at heating and cooling supply stores. **Caution:** *Use rubber gloves to protect your hands from these strong cleaners*.

While cleaning the evaporator, check the drain in the pan or trough to make sure that it is open. If the drain is plugged, clean it so water from the evaporator will flow out. A plugged drain can hold excess water in the pan and encourage mold growth. Sometimes fins on the coil are damaged by careless shipment or installation or by ice formation on the coil. You can repair bent and flattened fins using a "fin comb." This plastic tool has teeth that fit into the spaces between the fins; it straightens the fins as you pull it through them (*see figure* **4-27**). The fin comb is sized by how closely the fins are spaced apart in "fins per inch."

**A clean evaporator is absolutely necessary to the proper and economical functioning of an air conditioning system.** If you can't clean the evaporator yourself, then pay a professional to do it. It's a "pay me now or pay me later" situation. Pay now for service now, or pay high utility costs, suffer with poor performance, and burn up your compressor later.

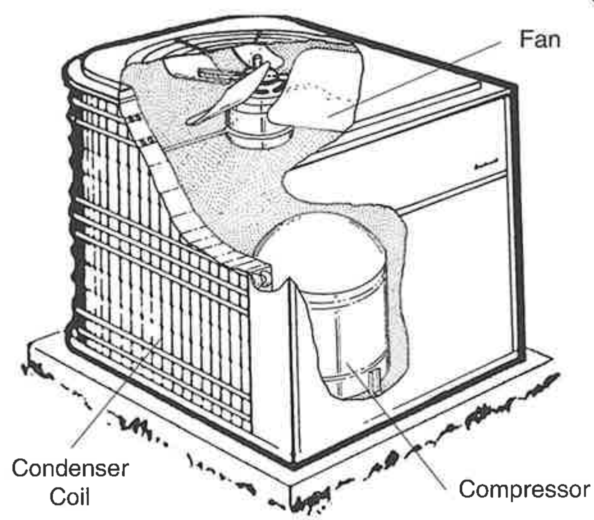
### 4.4.3 Cleaning the Blower

Dirt on the blower blades greatly reduces their ability to move air over the cooling coils. The amount of air flow over the cooling coils directly affects cooling efficiency.

Although the blower can sometimes be cleaned in place, remove it to do a much better job.

***Caution:** Before cleaning the blower, shut off power to the air conditioner at the breaker box or main switch.* Some blower motors are connected to the main control box by a foolproof plug. Other blowers have individual wires connected to terminals in a control box. Label the wires and terminals as you disconnect them so there is no possibility of improper reconnection.

It is not usually necessary to remove the blower wheel from the motor and housing, but you may need to remove a plate in the blower housing (*see figure* **4-24**) to get more space to work on the fins of the blower. Clean the blower wheel with compressed air or with a brush and vacuum cleaner. Cylindrical hair styling brushes work well to clean blowers without removing the blower wheel from the housing.




***4-25 Outdoor Condenser Unit -** The fan in the outdoor unit pulls outdoor air through the condenser coil, cooling the coil and releasing the heat collected from the indoors. The refrigerant charge of the air conditioning system is measured at the compressor.* (Courtesy of Lennox Industries)

### 4.4.4 Maintaining and Cleaning Condenser Coils

Avoid activities that create airborne material which could be sucked into the condenser. Cutting grass or allowing children to play near the condenser stirs up dust and grass that can quickly plug the coils. Dryer lint can also plug the coils—be sure your dryer vent is located at least 10 feet away from and downwind from the condenser.

Dirt collects on the outside of the coils and is easily visible (*see figure* **4-25**). Clean the condenser whenever it appears dirty. If the condenser gets very dirty and you neglect it, the low air flow can burn out the compressor and leave you with a large repair bill.

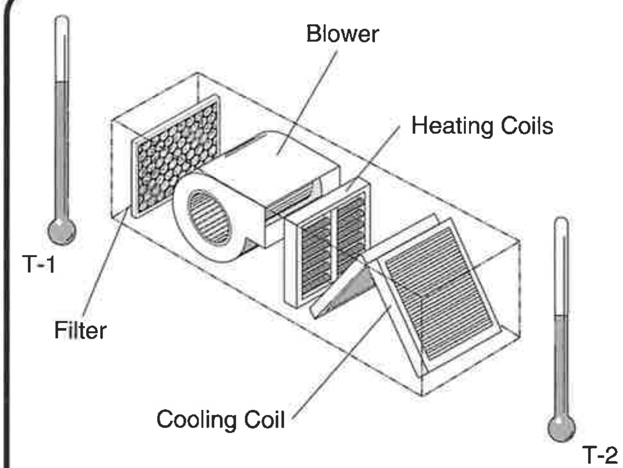
Cleaning condenser coils is similar to the technique for cleaning evaporator coils. First remove the loose dirt and debris carefully with a bristle brush. (You will often have to remove the top or side panels of the condenser unit to get access for cleaning.) Spray the coils with a household cleaner or a coil cleaner if there is stubborn dirt on the coils. Rinse the coils with a garden hose, from the inside out, to force dirt out the way it came in. ***Caution:*** *Be careful not to damage the fins. Keep the water pressure low.* Straighten damaged fins with a fin comb as described in Section 4.4.2, Cleaning Evaporator Coils.

## 4.4.5 Checking Refrigerant Charge

A 1988 research report stated that 70 percent of all air conditioners tested in the Phoenix area had an incorrect refrigerant charge. The ideal amount of refrigerant is specific to each air conditioner and installation. **Either too much or too little refrigerant in the air conditioner reduces its efficiency, lowers its cooling capacity, and shortens the life of the compressor.** A correctly charged system contains refrigerant to within a half ounce of the ideal amount.

Many air conditioning technicians do not regularly check refrigerant charge. Insist that your air conditioning contractor check the refrigerant charge during a maintenance call, and correct an improper charge.

More is not better for refrigerant in an air conditioner. Overcharging is extremely harmful to your air conditioner and it increases your cooling costs. Never add refrigerant or let a service technician add refrigerant without determining if the system needs refrigerant and, if so, exactly how much.




***4-26 Measuring Temperature Difference** - The difference in temperature between the inlet and outlet of the air handler, while either the heating or cooling coils are activated, gives an estimation of air flow. Measuring the temperature rise across the heating coils is the more accurate way to measure air flow.*

Checking refrigerant charge requires measuring indoor temperature, humidity, outdoor temperature, suction pressure, and system head pressure. Only trained air conditioning technicians are qualified to measure refrigerant and to charge an air conditioning system (*see figure* **4-25**). It requires special knowledge, tools, and equipment. The correct charge for a central air conditioning unit (with matched indoor and outdoor coils) or a packaged unit is stamped on the nameplate of the unit. The correct charge can always be achieved by vacuuming the refrigerant out of the lines into a device that recovers the refrigerant. The technician then weighs in the proper amount of refrigerant.

Refrigerants do not wear out and do not need to be replaced, unless the system has a leak or needs major repairs. If your air conditioning system needed refrigerant any time since you installed it, there is probably a leak. Refrigerant leaks should be repaired by a professional because refrigerant is expensive and its release damages our earth's atmosphere. **The Clean Air Act of 1990 forbids the release of refrigerants from home air conditioners into the atmosphere.** Contractors must use special equipment to recover refrigerant after July 1, 1992.

## 4.5 Air Flow and Ductwork

Studies indicate that approximately half of all existing air conditioners have lower air flow than that required for good efficiency. These reports found that 35 to 70 percent of all duct systems attached to central air conditioners have significant leakage. Either of these problems by themselves can waste 10 to 30 percent of the energy a home uses for air conditioning.

### 4.5.1 Air Flow

Most home air conditioning systems are forced air systems. They employ a large blower mounted in a steel cabinet called either a furnace, an air handler, or an air conditioning unit.

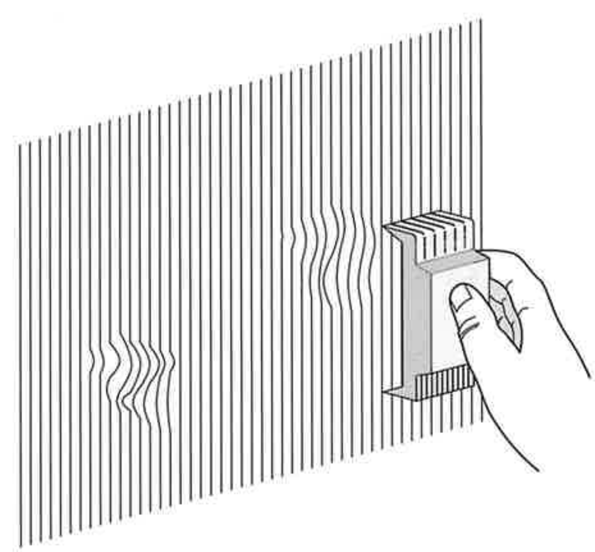
The blower moves the air through a closed loop of ducts. It sucks air from the home (called "return air"), and forces the air through an evaporator coil which cools the air. The cool air flows through the supply ducts and out the registers into the rooms. The warmer room air returns to the air conditioner, where it is cooled.

The cooling capacity and the efficiency of the system depend on adequate air flow. There should be about 400 cubic feet per minute of air flow in the system for each ton of air conditioning capacity. **Experts in air conditioning say there is no way to compensate for low air flow except increase the air flow.**

Service technicians measure the air flow in the air conditioning system in a variety of ways. The most reliable way is measuring the temperature rise across resistance heating coils (if present) which share the same air stream as the cooling coil. Various types of air pressure, velocity, and flow meters are also used. The temperature difference between supply and return air should be 15° to 21°F when the air conditioning system is operating. A reading outside this range could indicate a problem with air flow or refrigerant charge (*see figure* **4-26**).

If the air flow falls short of the manufacturer's recommendations, the technician may increase the air flow by cleaning the evaporator coil, increasing fan speed, enlarging registers, adding more ducts, or enlarging the ducts to increase the air flow. Adding or enlarging ducts may seem drastic but in some cases might be the only remedy for poor cooling efficiency and high cooling costs.

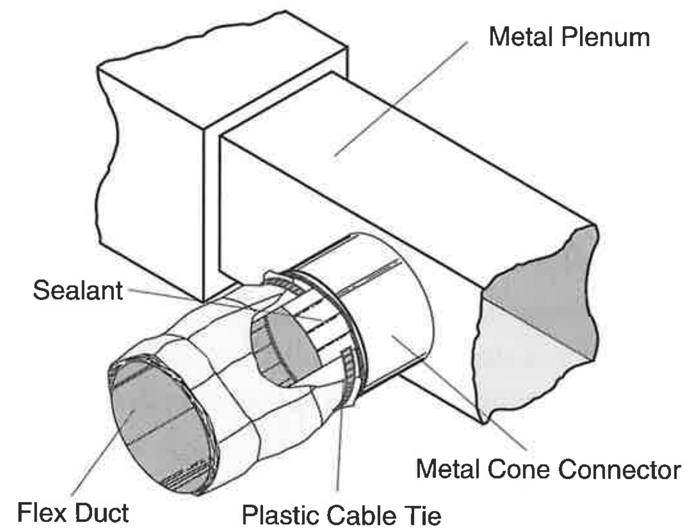
Restrictions to air flow have the greatest impact on the return air side of



***4-27 Fin Comb** - Fins of a coil are often bent by ice forming on them or during installation. Bent fins are a severe air flow problem. Fin combs straighten bent fins.*

the system; so, repairs should start with the return ducts. Every supply register must have an unobstructed airway back to a return register. Blockage of supply or return air ducts and registers can pressurize or depressurize portions of the home, resulting in greatly increased energy use.

Typical ways to improve free air return to a central return air register are cutting off the bottom of doors, or installing louvered grilles in doors. Be sure to maintain an inch or more clearance under interior doors in rooms without return registers.




***4-28 Flex Duct** - Flex duct is used in many modern air conditioning installations. The joints between metal connectors and flex duct should be made as shown here and not with duct tape.*

Obstructions in the supply air duct system include dents in the ducts, debris inside the ducts, and bent and dirty registers. These are major problems in some homes. Insulated flex-duct is used in many modern homes. Flex-duct is often kinked at support brackets, at bends, and where the flex-duct is installed through tight spaces. If you have flex-duct and some supply registers do not provide adequate cooling, check for kinks and depressions in the flexible duct. Make sure that the bends are as gradual as possible. Improper joints in flex-duct can be a leakage problem (*see figure* 4-28).

Supply registers can have severe blockages if the fins have been flattened by foot traffic or if they are dirty. Registers with flattened fins should be replaced, or the fins straightened, to allow adequate air flow. Clean dirty registers.

Inspect ducts with a flashlight, a trouble light, and a mirror. Secure all wall and floor registers with screws so children do not put toys and other objects into the ducts. **Do not block registers with furniture, drapes, or other objects.**

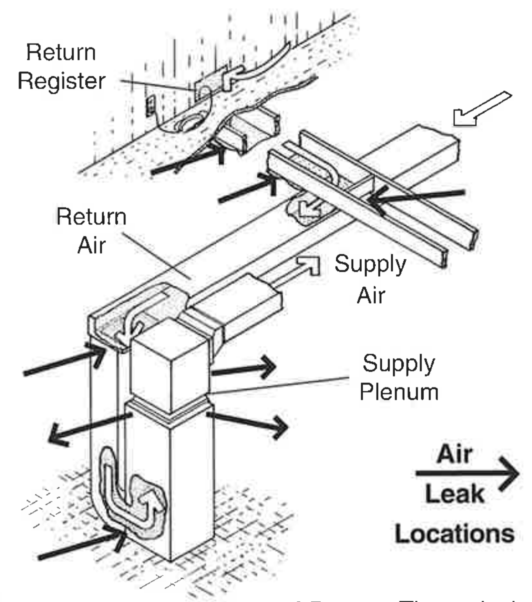
Supply registers closest to the air handler sometimes deliver more cool air to the rooms closest to the furnace. You may be able to change the air flow by moving the adjustable vanes in registers, or by sealing off portions of the registers closest to the air conditioner. It is not usually a good idea to block off registers altogether because this reduces air flow and cooling efficiency.

### 4.5.2 Sealing Leaky Ducts

Florida Solar Energy Center research in 160 homes showed that turning on an air conditioner more than doubled the average air leakage rate. An average of 16 percent of the return air was air from outdoors that had leaked into the return ducts. Supply ducts had significant air leakage, too. Duct repair reduced air conditioner energy use by more than 17 percent.

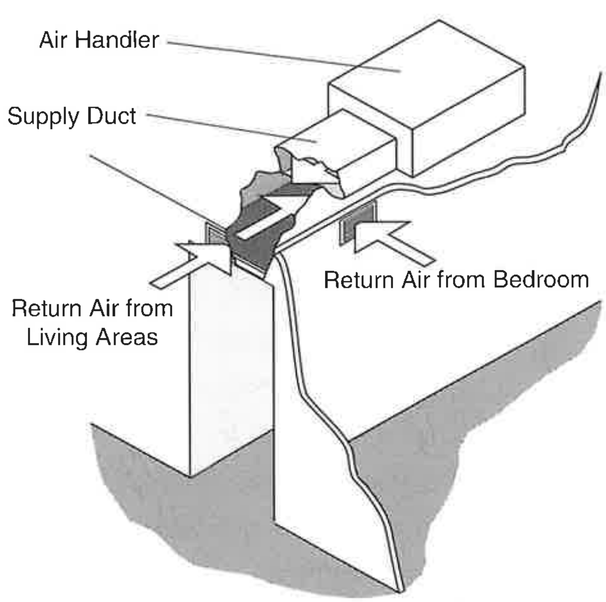
Keep in mind that a forced-air duct system should be a closed system. Airtight ducts from the air handler supply air to the house, and return it to the air handler. There should be no openings besides the registers. And, the registers should seal tightly to wall, floor, and ceiling surfaces.

Some of the worst return air leaks occur in the air handling unit, at the joint between the cabinet and the supply and return air plenum (*see figure* **4-29**). The plenums are sheet metal boxes that connect to the top, bottom, or side of the air handling unit. They serve as the main outlet and inlet to the air handler. Some return plenums use plywood or fiberglass duct board boxes, which are not airtight.




***4-29 Up-Flow Air Handler and Ducts*** *- The typical duct leak locations are marked by arrows that indicate whether air is entering or escaping the duct.*

Joints between the return plenum and the main return air ducts may also be very leaky. Holes in the cabinet of the air handling unit can be major leaks, too.



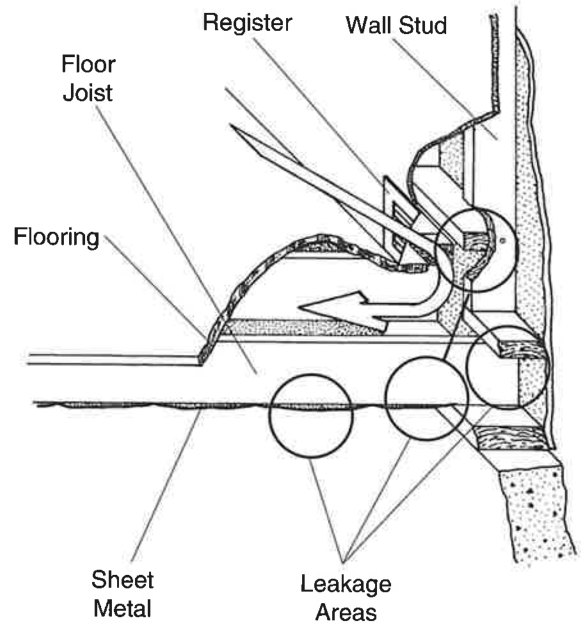

***4-30 Drop-Ceiling Air Return*** *- Hot air from the attic is drawn into the drop-ceiling air return and into the home unless the top of the cavity formed by the drop ceiling was sealed carefully during construction. Be sure to check the joint between the air return and the air handler.*

**Caution:** *Major air leaks near the air handler can be a safety problem if there is a combustion furnace in the air handler. The leaks can cause pressure imbalances that interfere with chimney operation.* Inspect the plenums, ducts, and connections near the air handler and seal these areas carefully and completely.

Air conditioning contractors often use spaces behind walls, below floors, and above ceilings as return ducts. These cavities can be a source of air leaks. If the wall, floor, or ceiling cavity serving as the return air duct has openings to the outside or to an area which is not cooled (like the attic), then hot humid air can enter the duct system (*see figure* **4-30** *and* **4-31**). The heat and humidity in this air will overwork the air conditioner and cost you money. Remove the return register grille and examine the cavity for holes and cracks. A trouble light, flashlight, and mirror will help you locate the leaks.

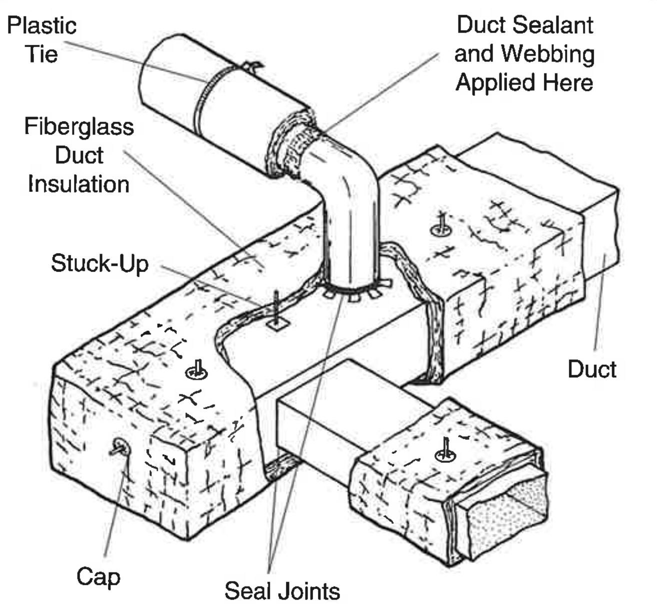
In very damp climates, the cabinets of packaged air conditioners may rust. Rust holes can create large leaks in the supply or return air passageways. If the metal sides, bottom, or divider panel rusts from the water in the evaporator pan, warm outside air mixes with the cool indoor air circulating through the cabinet.

Rust often means that the air conditioner must be replaced. You may be able to salvage it by fastening sheet metal patches to the holes, and sealing them with duct mastic.




***4-31 Return Air Registers** - Air return registers and ducts which use wall, floor, and ceiling cavities sometimes have openings to the outdoors, attic, or basement.*

Rust formation is accelerated if the air conditioner cabinet is placed directly on a concrete slab without spacers providing a dry air space beneath the cabinet. If the air conditioner sits directly on the slab buy rubber spacers to put under the corners of the cabinet, to hold the unit off the slab.



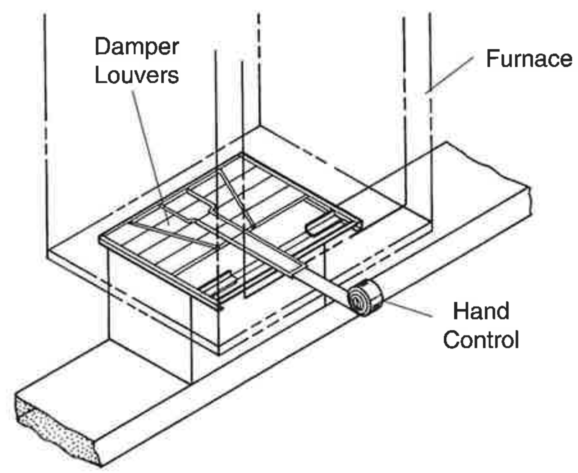

***4-32 Duct Sealing and Insulation** - Air conditioning ducts should be insulated when they are located in hot attics. The joints should be sealed first because the insulation does not stop air leakage.*

## 4.5.3 Insulating Ducts

It pays to seal all the leaks in ducts that run through a warm area like the attic. Pay particular attention to return ducts. It makes good economic sense to both seal and insulate ducts that run through hot attics. First, seal the ducts as described above, then insulate them. Duct insulation by itself does not seal air leaks.

Ducts can be insulated using various methods. Careful installation ensures that the materials are used to their best advantage.

Seams should be as tight as possible. Carefully cut around obstacles to avoid gaps in the insulation. Mechanical fasteners hold insulation in place better than tape. Duct insulation depending entirely on tape to hold it in place will eventually fall off. You can use wire or plastic twine wrapped around the duct and insulation and stapled into nearby wood framing to fasten duct insulation. This method is very effective and requires no special tools or fasteners. Plastic ratcheting ties or wire are effective fasteners for insulation on round ducts (*see figure* **4-32**).




***4-33 Manual Damper** - This damper prevents cooled air from entering a down-flow furnace during the summer. It is used with packaged air conditioners and ground-mounted evaporative coolers.*

A simple and effective way to insulate sheet metal ducts uses foil- or vinyl-faced fiberglass duct insulation fastened to the ducts with pin-type fasteners (*see figure* **4-32**). The pins are either glued or welded into place on the duct. The pin sticks out perpendicular to the plate.

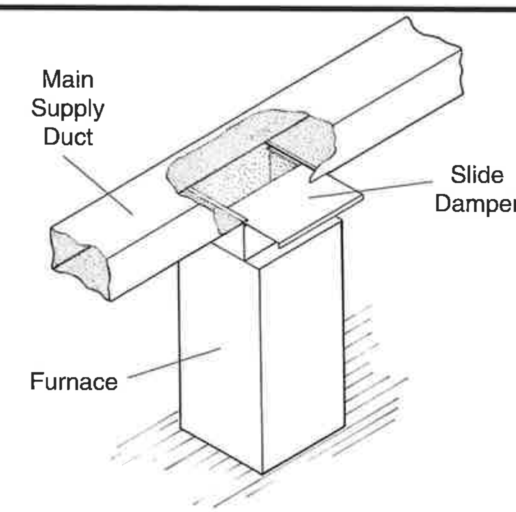
The glue-type pins are called stuck-ups or stick pins. They have a perforated plate covered with construction adhesive that sticks to the duct. The other type of pin is welded to the duct, using a special device called a pin welder. The pin welder plugs into a 110-volt outlet and welds the pin to the duct.

Plan the pin spacing and locations in advance so you'll have a pin wherever you need one. There are no hard and fast rules for pin spacing and location—try to visualize how the pieces of insulation will fit on the duct and then provide plenty of pins to ensure a neat and secure installation.

Fiberglass duct insulation usually has a reinforced foil facing and is 3 to 4 feet wide. Attach the pin type fasteners to the duct, and impale the insulation foil-side-out on the pins. Fit metal washers over the pins to clamp the insulation loosely to the duct. Cut the protruding part of the pin for safety.

The insulation should wrap all the way around the duct. Position a pin at the overlapping edges to keep the lap together. Tape the seams with a high quality tape, like the aluminum foil tape sold by heating wholesalers.

Good quality fiberglass duct insulation and stuck-ups are usually sold by commercial insulation suppliers. Look under "Insulation" in a telephone directory to find a supplier who sells commercial or industrial insulation.

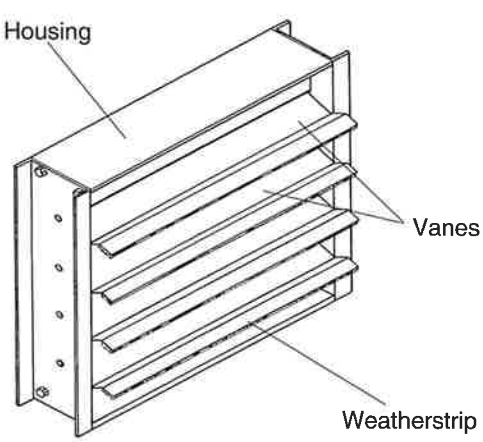



*4-35 Slide Damper - Dampers like this are used when a packaged air conditioner or an evaporative cooler shares ductwork with a furnace. The damper is closed in the summer to keep the cooled air out of the furnace.*

### 4.5.4 Shared Ductwork

Shared-duct systems commonly have problems with dampers, return registers, and duct connections. They can waste large amounts of heating and/or cooling energy. Inspect all ducts and connections for leakage, and be certain the dampers operate properly.

Many packaged air conditioners share ductwork with a standard home furnace. These shared-duct cooling systems require one damper in the furnace and another damper at the supply outlet of the air conditioner. The damper in the furnace prevents air conditioned supply air from entering the furnace during the cooling season (*see figures* 4-33 *and* 4-35). The damper in the packaged air conditioner prevents furnace-warmed air from entering the air conditioner during the heating season (*see figure* 4-34). Evaporative coolers need the same types of dampers when they share ducts with forced air furnaces. Central return registers for packaged air conditioners return indoor air to the outdoor unit and must be completely sealed during winter months.




*4-34 Damper for Outdoor Air Handlers - When a packaged air conditioner or evaporative cooler shares ductwork with an indoor furnace it must have a damper like this one to prevent hot air from flowing into the unit during the winter. The blades of this damper are pushed open by the force of the fan in the evaporative cooler or packaged air conditioner and they fall closed by gravity.*