

Ductwork

Objectives

After studying this chapter, you will be able to:

- Explain operation of the supply and return air duct systems.
- Assemble, join, install, and repair all types of duct.
- Install registers, diffusers, and grilles.
- Insulate and properly support piping.
- Explain why and how to use mastic and fiberglass membrane.
- Name and describe the use of many types of fittings.

Important Terms

A-coil	perimeter system
bonnet	plenum
branch lines	radial system
cfm	register boot
conventional system	registers
diffusers	return air
downflow furnace	scrim
drive cleats	S-hooks
ductboard	starting collar
extended plenum	supply air
fiberglass membrane	takeoff
forced air	trunk line
horizontal furnace	U-channels
insulated flexible duct	upflow furnace
mastic	vapor barrier

The information contained in this chapter provides the knowledge needed to working with heating and air conditioning ductwork. Some sizing information is presented as simplified "rules of thumb," consistent with practices in the field, rather than becoming involved with complex formulas. While the illustrations in this

chapter show typical situations, keep in mind that adaptation to conform with state and local codes may be necessary.

28.1 Forced Air Systems

The majority of heating and cooling systems are classified as "forced air" types. Central heating and cooling involves the use of one furnace, centrally located in the structure, that is equipped with a motor driven fan to blow treated air through a ductwork system to the living spaces. Basic components of a *forced air* system are a furnace unit, a remote air conditioner (compressor/condenser unit), ductwork, **Figure 28-1**, and *registers* (outlet devices that direct and usually control the volume of the airflow). The ductwork consists of separate "supply air" and "return air" sections. The *supply air* section is used to distribute treated air to living spaces, while the *return air* section brings air from the living spaces back to the furnace unit to be heated or cooled again.

28.1.1 Conventional System

Before the development of forced-air systems, gravity furnaces were used. These furnaces had to be located centrally, with short runs of ductwork from the furnace to the air outlets. All supply air outlets were located in or near inside walls of rooms. Return air inlets were generally located in or near the baseboards of outer walls. For a period of time after they were introduced, forced-air systems were similarly designed, and many existing houses have this type of system. Such an arrangement, with inner wall-located outlets and outer wall-located inlets, is called a *conventional system*.

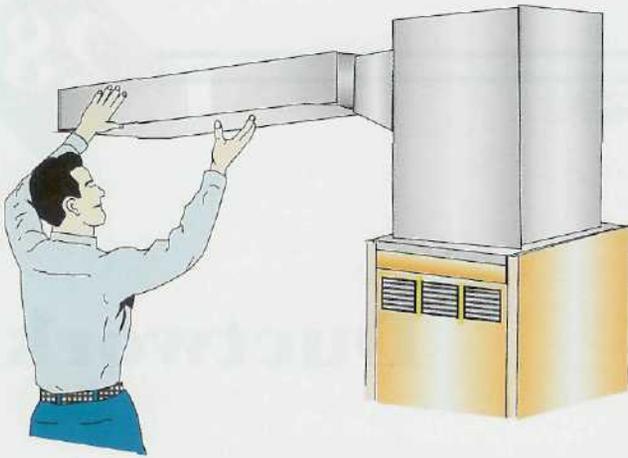


Figure 28-1. Installing an air duct system may be a part of your job in either new construction or remodeling work.

28.1.2 Perimeter System

The *perimeter system* uses forced air and locates the supply air outlets in the baseboard along outside walls, or in floors or ceilings near outer walls **Figure 28-2**. The supply air "blankets" the wall against drafts (heating mode), or radiant heat during the cooling mode. This air circulates inward to a return air grille located in an inside wall where it is drawn off and returned to the furnace for **retreatment**. The perimeter system provides

sufficient and uniform air circulation for maximum comfort.

28.2 Furnace Classifications

All forced air furnaces are classified according to the direction of the airflow for the supply air. The upflow and downflow furnaces are most common, but horizontal-flow models are necessary for some applications.

28.2.1 Upflow Furnace

The *upflow furnace* is normally located in a basement or closet, **Figure 28-3**. The supply air duct system is attached to the furnace *plenum* (sometimes called the *bonnet*), a sheet metal chamber anchored to the top of the furnace with sheet metal screws. The air conditioning evaporator coil is mounted on top of the furnace, but inside the plenum. The supply air duct is often insulated to help maintain the temperature of the treated air. Return air enters the bottom of the furnace. The blower serves for both heating and air conditioning mode, but airflow direction remains the same.

28.2.2 Downflow Furnace

A *downflow furnace* is usually used in a building having a crawl space under the first floor, or in a mobile

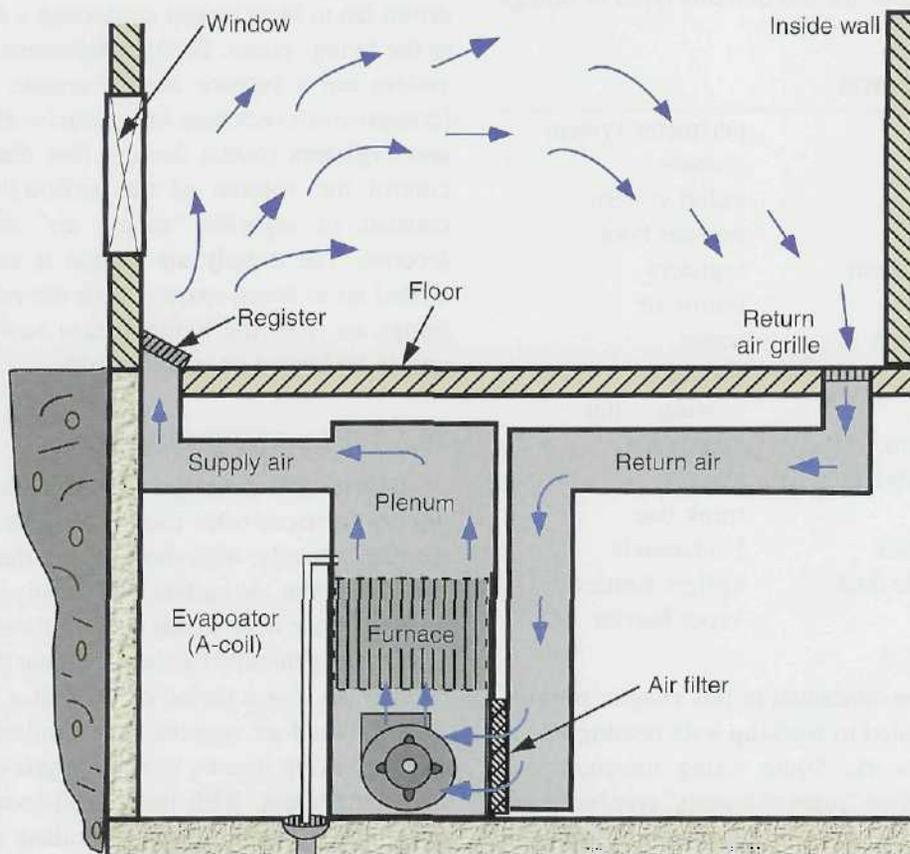


Figure 28-2. The perimeter system uses outlets located along outside walls.

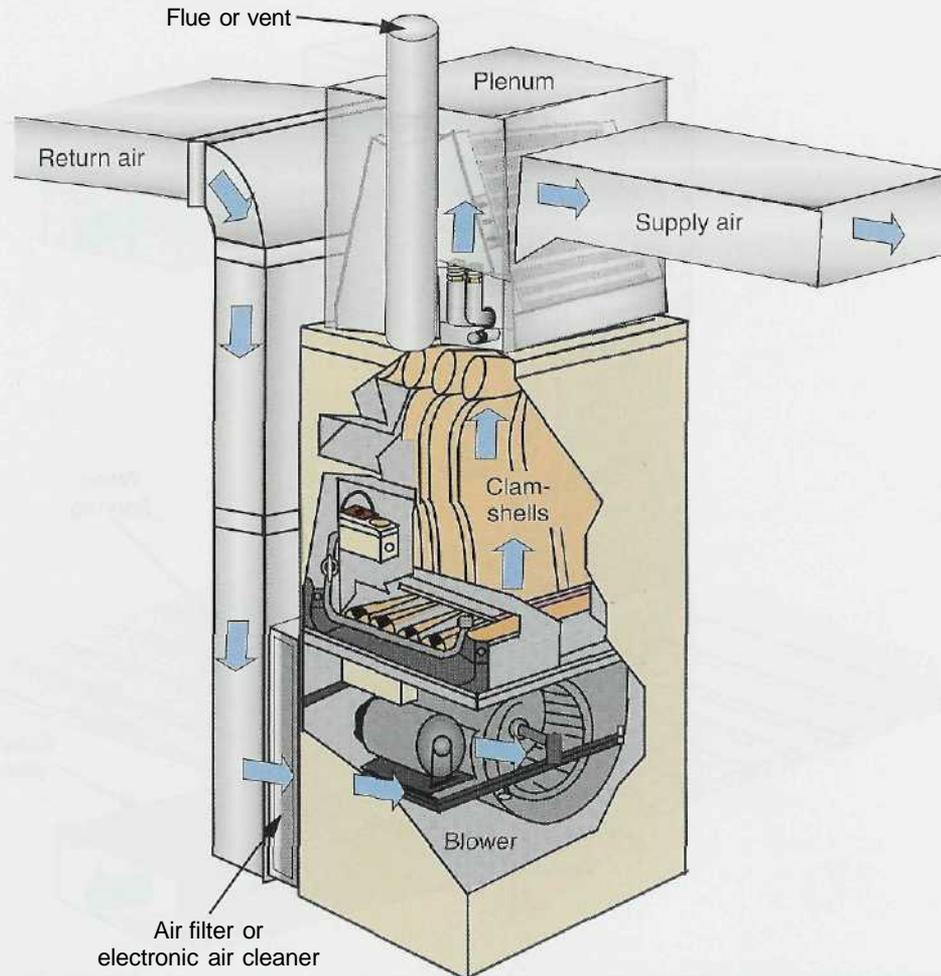


Figure 28-3. An upflow furnace has a top-mounted plenum to distribute supply air. Upflow units are typically located in a basement.

home, **Figure 28-4.** The air conditioning evaporator coil is mounted on the bottom of the furnace, inside the plenum. Supply air travels from the plenum through ductwork to the living spaces. Return air enters the top of the furnace. The blower serves for both heating and air conditioning.

28.2.3 Horizontal Furnace

This *horizontal furnace* is designed for use in a crawl space or attic, **Figure 28-5.** Supply air exits at one end and return air enters through the other end. This means the ductwork is located in the crawl space or in the attic, along with the furnace. These horizontal furnaces are usually electric, but gas, oil, or heat pump can be used.

Air Conditioning Evaporators

The *A-coil* is the most popular type of air conditioning evaporator for residential systems. The slant-coil and upright-coil types are primarily used for commercial and industrial systems. Commercial and many industrial air conditioning systems operate the

same as residential types. The components are simply bigger (and easier to repair). See **Figure 28-6.**

28.3 Distribution Systems

There are two types of duct systems commonly used for supply air distribution. They are the radial system, which uses strictly round pipe, and the extended plenum system, which combines round pipes with rectangular ducts.

28.3.1 Radial Piping System

A *radial system* is one that uses round pipe running directly from the plenum to the *register boot* (component that is used to connect the pipe to the outlet registers). There is a separate run from the furnace plenum to each register boot. These piping runs radiate from the furnace plenum, **Figure 28-7.** This system is practical where the piping runs are located in an attic or crawl space. The radial system is most economical and easiest to install, but is not practical if the furnace cannot be centrally located. Any

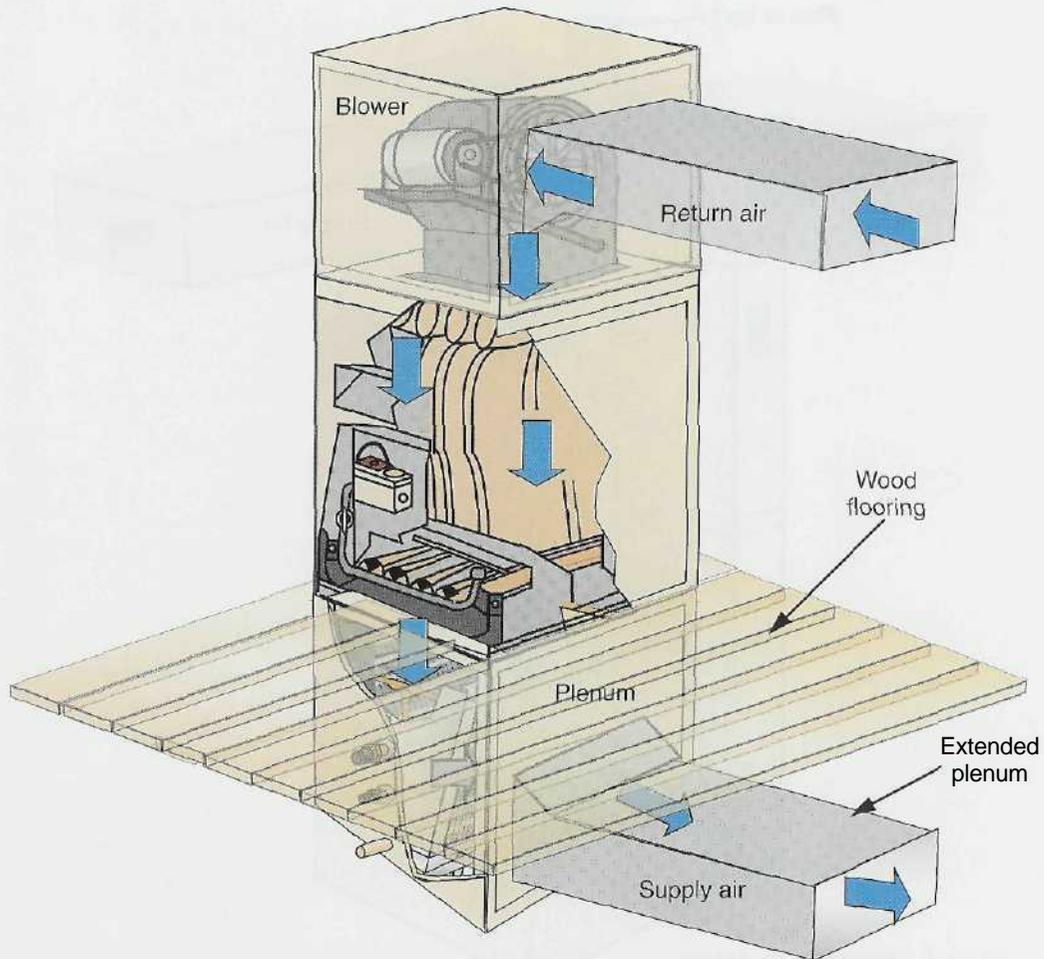


Figure 28-4. In a mobile home, or a building with a crawl space instead of a basement the downflow furnace is commonly installed. The plenum is below the unit.

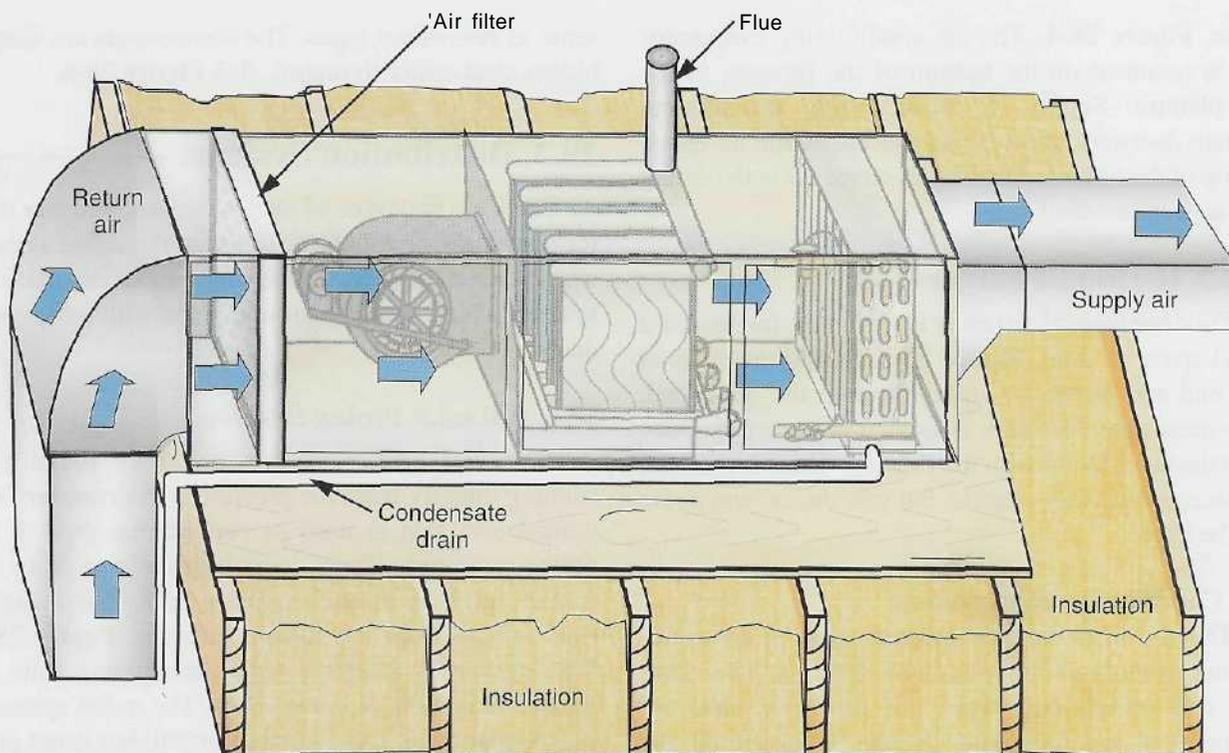


Figure 28-5. A horizontal furnace is usually located in an attic or a crawl space.

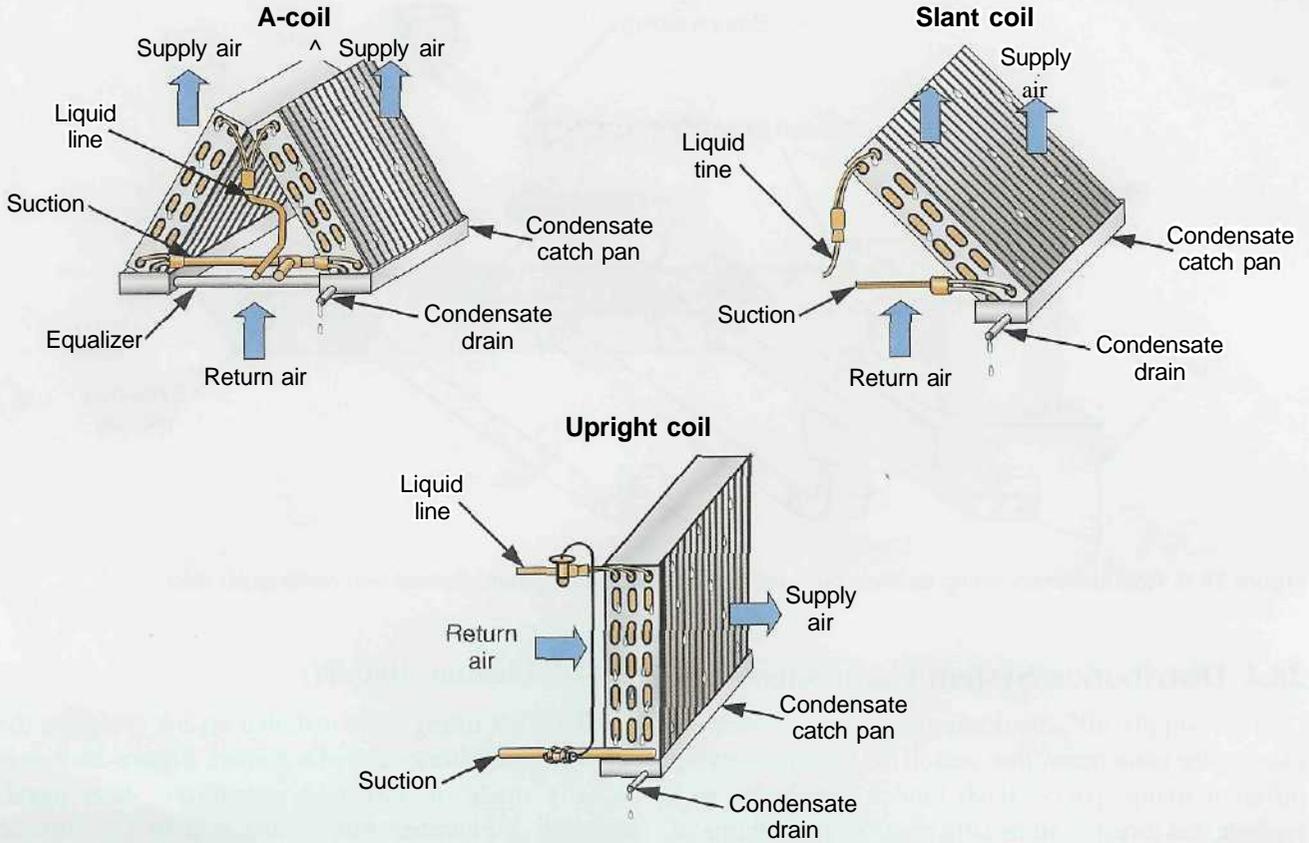


Figure 28-6. The three types of air conditioning evaporators. In residential installations, the A-coil type is most commonly used.

building that is odd-shaped or long cannot use the radial system.

28.3.2 Extended Plenum System

An *extended plenum* system, **Figure 28-8**, combines rectangular duct with round pipes. The furnace

plenum is extended with rectangular duct, and all round pipes branch out at right angles from the extended plenum. This permits short lengths of round pipe to reach the registers. For a neat appearance, the round pipes are normally installed in the spaces between the flooring joists. It is necessary to cut a hole and add a register boot at the end of each run.

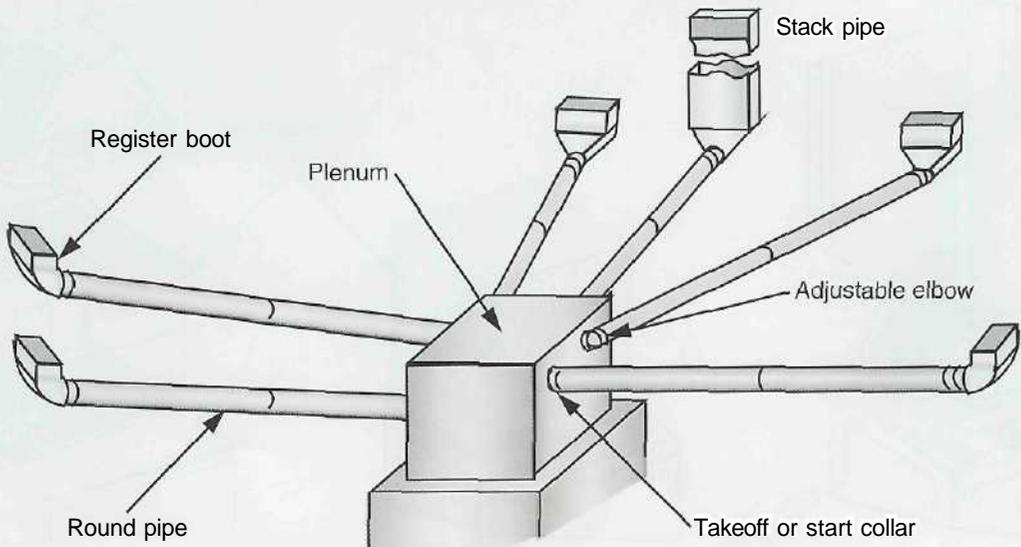


Figure 28-7. The radial piping system uses round pipes running straight to the register boots. In this example, the stack pipe will connect to the furnace for distribution.

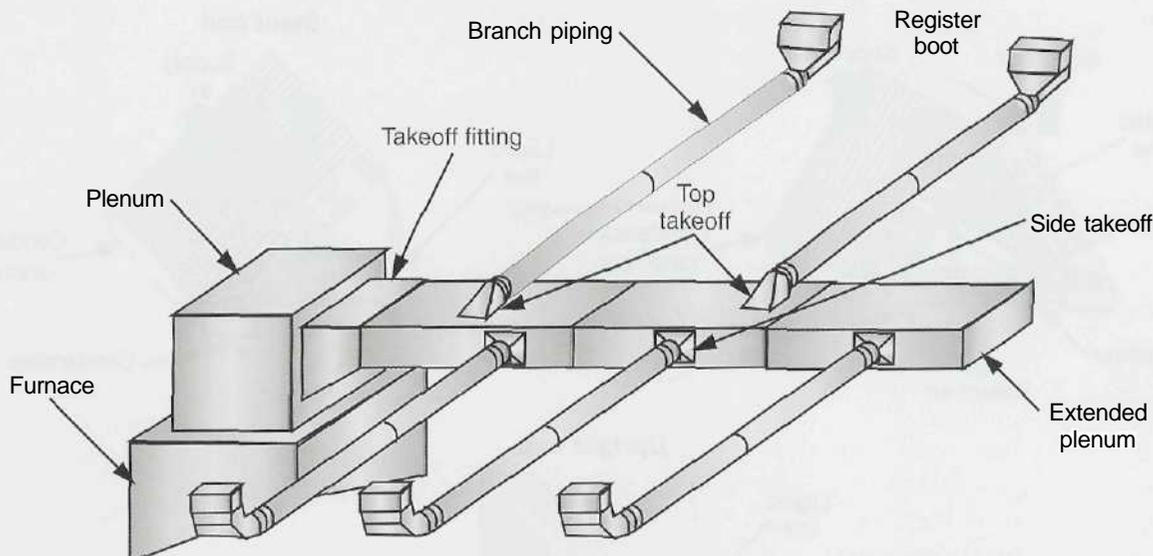


Figure 28-8. Round branch piping extends outward from an extended plenum formed with rectangular duct.

28.4 Distribution System Components-^

The "supply air" distribution system includes the plenum, the main *trunk line*, and all the branches serving different living spaces. Each branch terminates in a register that directs and usually controls the volume of the airflow. Another system of air duct serves to return air from the living spaces for heating or cooling. This system is called "return air," and includes another main trunk line and all its branches.

28.4.1 Plenum (Bonnet)

The first fitting to be installed on any system is the **plenum**, sometimes called a *bonnet*. **Figure 28-9.** It is usually made of 30-gauge, galvanized sheet metal, forming a chamber that is attached to the furnace outlet, **Figure 28-9A.** The plenum functions as an air-mixing chamber before sending the air to the living spaces. It also provides the necessary surface for attaching takeoffs and starting collars. The cooling

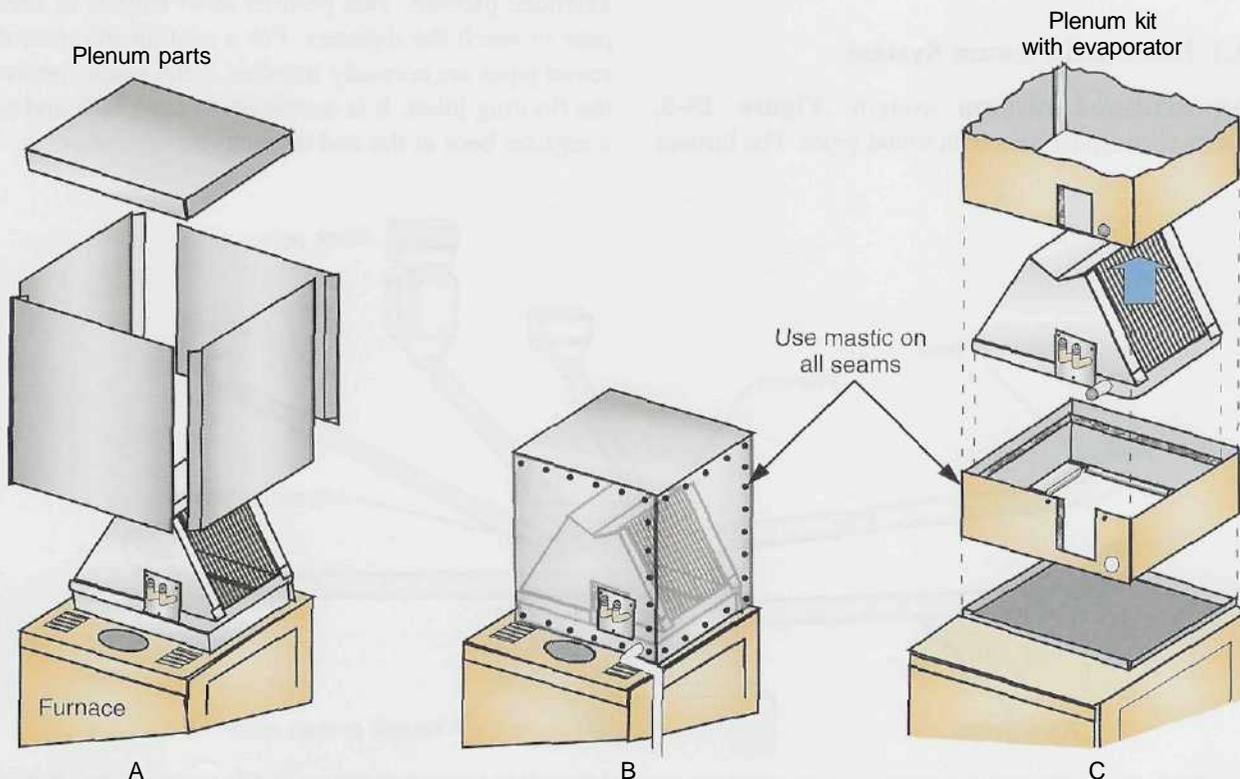


Figure 28-9. A plenum can be fabricated in the field (A, B) or it may be assembled from a factory kit (C).

evaporator is located inside the plenum, Figure 28-9B, and the supply air duct attaches to the plenum. The furnace manufacturer offers a plenum kit along with the necessary evaporator. For adding air conditioning to a previously installed furnace, some sheet metal work may be required. After all parts are assembled and screwed together, the seams must be anchored with sheet metal screws and sealed with *mastic* (a nontoxic adhesive material used for permanently sealing joints and seams). See Figure 28-9C.

Ductboard made from compressed fiberglass is becoming increasingly popular for plenums and rectangular duct. Ductboard is inexpensive, easy to work with, cuts with a knife, and is already insulated. Applying insulation by hand to metal ducts is often necessary, but is time-consuming and costly. See Figure 28-10.

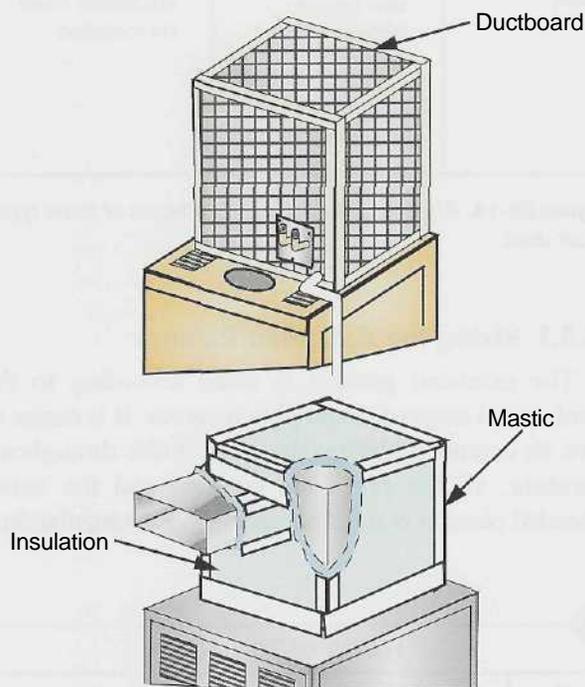


Figure 28-10. A plenum can be fabricated from ductboard, which is less expensive than installing insulation by hand on a metal plenum.

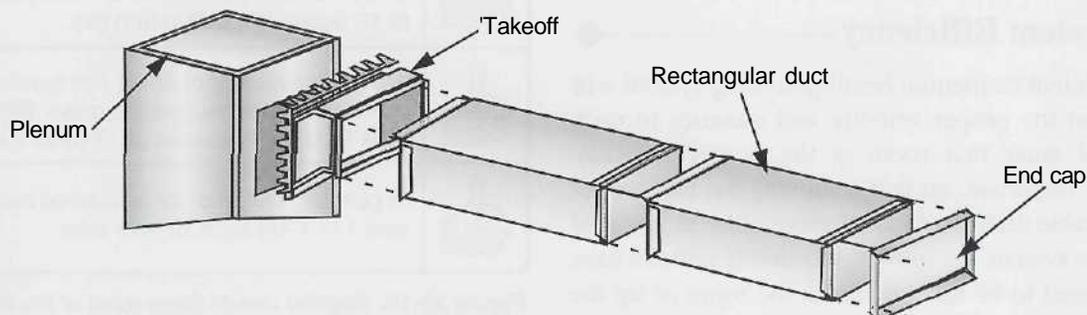


Figure 28-12. An extended plenum, formed from rectangular duct, has a takeoff fitting at one end and a cap at the other.

28.4.2 Round Metal Pipe

Round pipe can be used as a main trunk line or a branch line, in both supply air and return air situations. Round metal pipe has the most efficient characteristics, and is commonly used. For heating only, the round pipe supplying air to a register outlet need only be 6" in diameter. For air conditioning, or combined heating and cooling, the pipe should be 8" in diameter. Additional 6"- runs are often used to obtain required capacity. Standard round pipe comes in 30-gauge, 3"-14" in diameter, and in 2', 3', 5', and 10' lengths. All round pipe is factory crimped on one end for easy insertion into another length of pipe, See **Figure 28-11**.

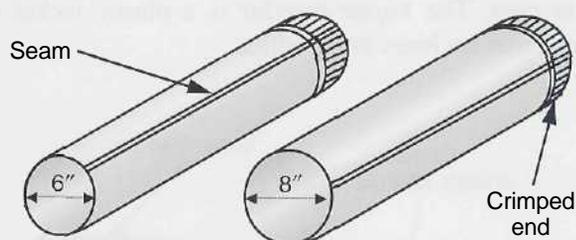


Figure 28-11. Round pipe for branch lines can easily be snapped together at the seam. The crimped area at one end allows the pipe to be slipped inside the next section of pipe, forming a joint.

28.4.3 Rectangular Duct

Rectangular duct is 30-gauge, galvanized sheet metal, and mainly used as a trunk line, or "extended plenum." Rectangular duct is widely used in the northeastern and northwestern parts of the United States. It is used as a spacesaver and can be easily routed in overhead space between floor joists, or in an attic. **Branch lines** consisting of round pipe come off the extended plenum to transport air to a register. A branch line begins with a starting collar or takeoff installed on the extended plenum, (main trunk line). The end of the extended plenum must be blocked with an end cap that is anchored with sheet metal screws and sealed with mastic. See **Figure 28-12**.

28.4.4 Insulated Flexible Duct

As shown in **Figure 28-13**, *insulated flexible duct* consists of several layers, each with a specific function. The *core* is usually two plies of polyester film used to encapsulate the galvanized steel wire helix. The purpose of the *wire helix* is to help flexible duct keep its shape. The *insulation* is a fiberglass blanket, varying in thickness, depending on the R-value. Many states have adopted energy codes for flexible duct that require certain R-values for code approval. A basic requirement is an R-value of 4.3, but Florida requires an R-6, and Washington and Oregon require R-8. *Scrim* is a high-tensile-strength, fiberglass mesh that provides more protection protect the insulation and inner core. The *vapor barrier* is a plastic jacket or sleeve that encloses the product.

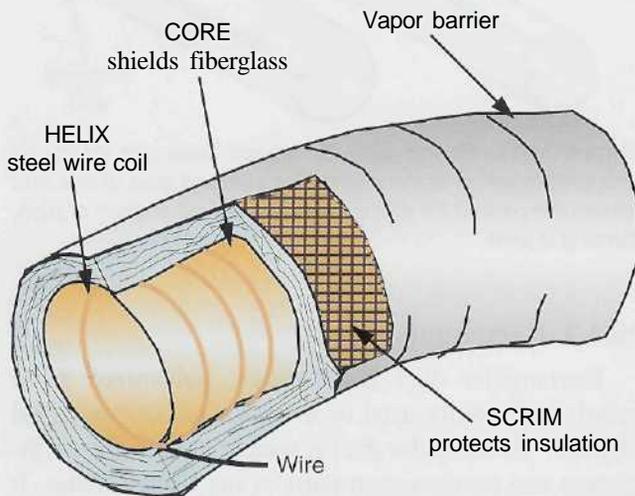


Figure 28-13. This cutaway view shows the construction of a typical insulated flexible duct.

Comparison of ductwork types

Various types of ductwork are available for use in a heating and air conditioning system. Because they were all designed for a particular application, they have different strengths and weaknesses. **Figure 28-14** is a list of some pros and cons of the major duct types.

28.5 System Efficiency

An efficient residential heating/cooling system will move air at the proper velocity and quantity to each room, and enter that room at the proper location. Velocity is important: air that is moving too **fast** creates uncomfortable drafts and makes more noise as it comes through the system. Air moving too slowly will not have enough speed to be thrown across the room or up the wall. See **Figure 28-15**.

Major Duct Types

	Pros	Cons
Round metal pipe	<ol style="list-style-type: none"> 1. Excellent airflow characteristics 2. Longer-lasting than flexible duct 	<ol style="list-style-type: none"> 1. If required, insulation must be installed
Insulated flexible duct	<ol style="list-style-type: none"> 1. Pre-insulated 2. Ease of installation 3. Reduced labor costs 4. Eliminates some fittings 	<ol style="list-style-type: none"> 1. Not as long-lasting as metal duct 2. Some reduction in airflow 3. Must be fully extended (cannot make sharp bends)
Rectangular duct	<ol style="list-style-type: none"> 1. Spacesaver; can use space between floor studs 2. Longer-lasting than flexible duct 	<ol style="list-style-type: none"> 1. If required, insulation must be installed

Figure 28-14. Advantages and disadvantages of three types of air duct.

28.5.1 Sizing the Extended Plenum

The extended plenum is sized according to the number and sizes of round pipe it serves. It is easier to have an extended plenum the same width throughout, therefore, all the pipes are counted and the entire extended plenum is sized accordingly. Rectangular duct

Rules of Thumb

	Air should travel from the furnace/air conditioner throughout the system at an average velocity of about 700 ft./min.
	On average, most system resistance to airflow is approximately 0.08 (0.075) static pressure (0.10 Supply air, 0.05 return air).
	With an air velocity of about 700 ft/min., air conditioners are designed to move 400 CFM PER TON, and furnaces at 12 CFM/1000Btu.
	In general, 1 CFM of air is required to heat or cool 1 or 1-1/4 sq. ft. of floor area.

Figure 28-15. Regular use of these rules of thumb will help you solve forced-air system problems.

used for extended plenums is 30-gauge, galvanized sheet metal, 8" deep, 60" long, and comes in standard widths of 10", 14", 18", 24" and 28". One of these standard sizes should provide the needed capacity, but any length of duct can be cut to a shorter length.

28.5.2 Rule of Thumb for Determining Plenum Size

To determine the width required for an extended plenum, count the number of round pipes it will serve, **Figure 28-16**. For 6" round pipes, multiply this number by 2, then add 2 — the total is the required duct width in inches. For 8" round pipes, multiply by 3, then add 2. If the desired size is not available, choose the next larger size. See

EXAMPLES:

A duct serving four 6" round pipes will have a width of $4 \times 2 = 8 + 2 = 10$.

A duct serving five 8" round pipes should have a width of $5 \times 3 = 15 + 2 = 17$. Since rectangular duct is not available in a 17" width, use the next larger standard size, which is 18".

28.5.3 Rule of Thumb for Determining Size of Branch Lines

1. Determine square footage of the room.
Length of room, times width of room, equals square footage.

$$10' \times 12' = 120 \text{ sq.ft.}$$

2. Determine cfm of air needed to supply the room, cfm means "Cubic Feet per Minute" and defines the amount of air flowing.

One cfm of air is required to heat or cool 1.00-1.25 sq. ft. of floor area.

EXAMPLE:

A 120 sq. ft. room will require between 96 and 120 cfm.

$$120 \div 1.00 = 120$$

$$120 \div 1.25 = 96$$

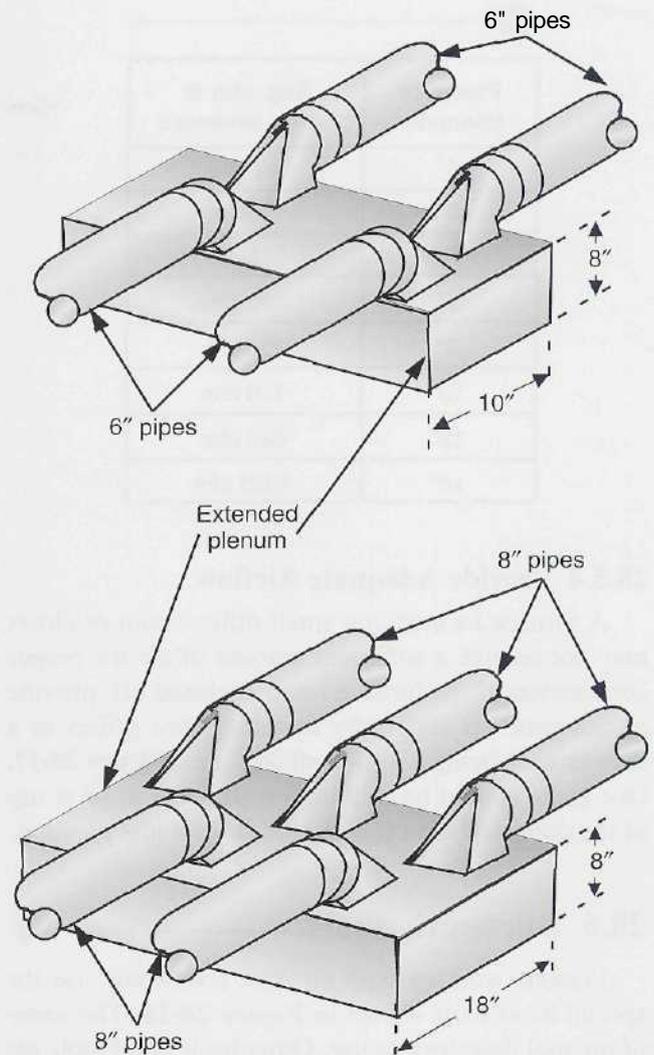


Figure 28-16. The number and size of round pipe branch lines determines the width of the extended plenum.

3. Select pipe(s) size according to cfm needed.
How much air can a given diameter of pipe carry?
A 120 sq. ft. room requiring 96-120 cfm will need one 6" pipe (110 cfm), or use a combination to total about 96-120 cfm.

Square footage	64	80	100	120	150	200	256
Room size	(8X8)	(8X10)	(10 X 10)	(10 X 12)	(10 X 15)	(12.5 X 16)	(16X 16)
cfm required	51-64	64-80	80-100	96-120	120-150	160-200	205-256



Pipe size (diameter)	Avg. cfm @ Static pressure
4"	30 cfm
5"	65 cfm
6"	110 cfm
7"	160 cfm
8"	230 cfm
10"	410 cfm
12"	680 cfm
14"	1000 cfm

28.5.4 Provide Adequate Airflow

A furnace located in a small utility room or closet may not receive a sufficient amount of air for proper combustion. If the furnace room is closed off, provide an adequate air supply by installing two grilles in a door or wall facing a well-ventilated area, **Figure 28-17**. One grille should be in a high-wall position or at top of the door, and the other should be in a low position.

28.6 Ductwork Tools

Persons working with air duct commonly use the special hand tools shown in **Figure 28-18**. The name of the tool describes its use. Other basic hand tools are also needed. These might include a trouble light,

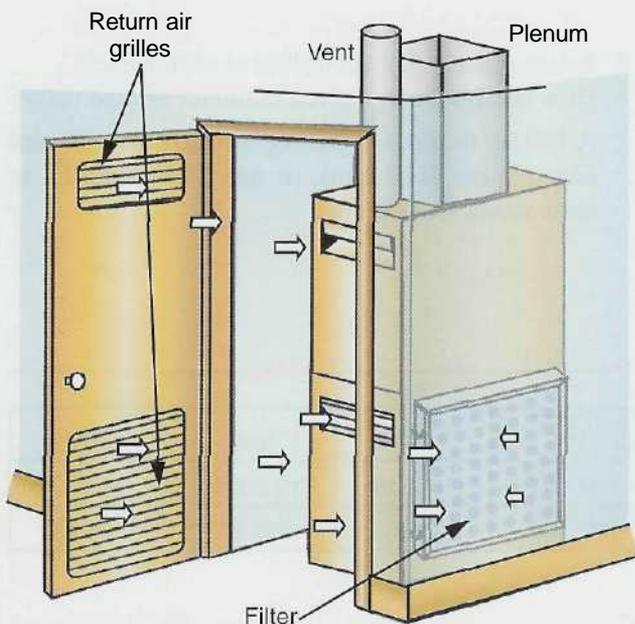
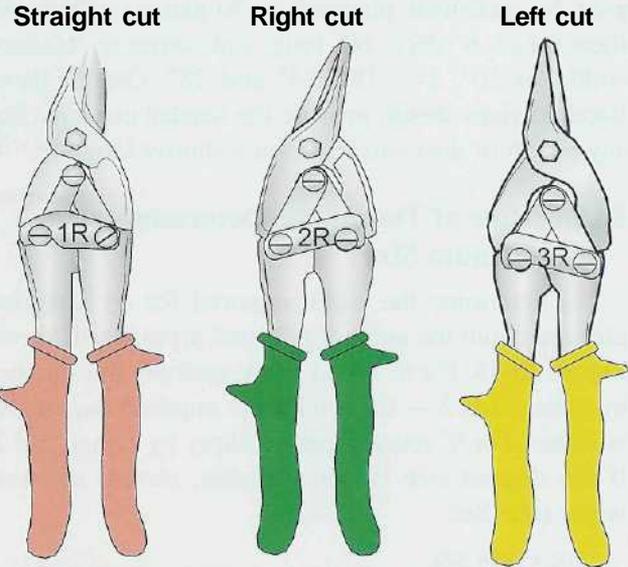


Figure 28-17. Two grilles in a closet door provide sufficient airflow for furnace operation and return air.



Note: Aviation snips are used for cutting holes in sheet metal. Never use them to cut wire.

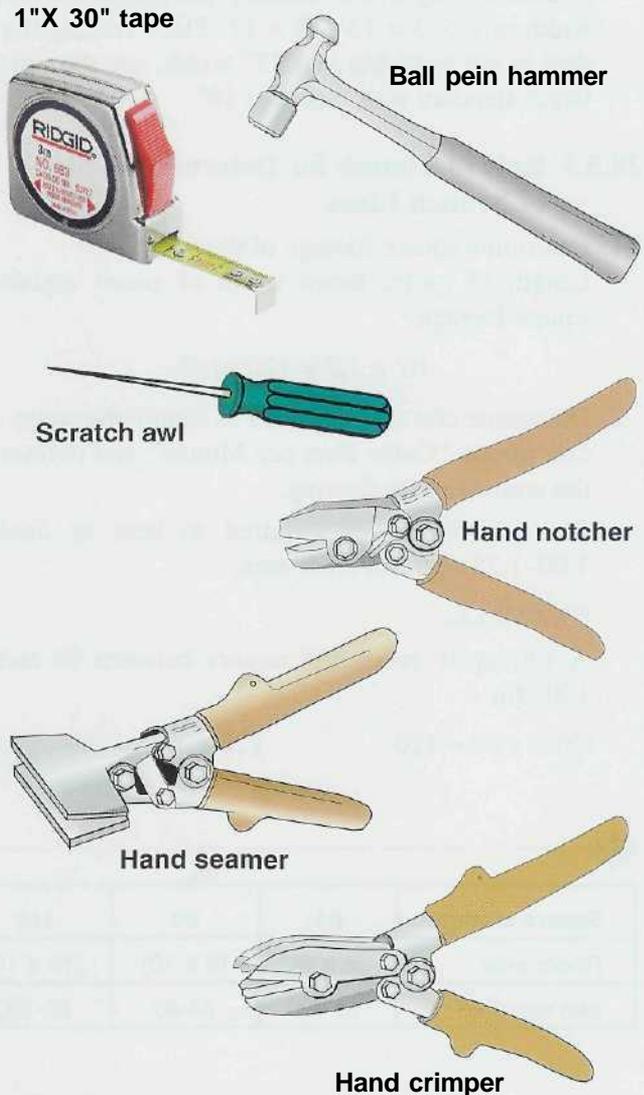


Figure 28-18. Hand tools often are named according to the job they perform.

battery operated **drill**, chisel, gloves, lineman's pliers, diagonal cutters, and **longnose** pliers. **NOTE:** *Aviation snips are used for cutting openings in sheet metal. Never use them to cut wire.*

28.7 How to Lay out a Duct System —#

The heating and cooling units should be matched to the square footage of the building's floor space. In addition, they should be able to distribute a set quantity of air (measured in cubic feet per minute, or *cfm*) to the living area through the duct system, **Figure 28-19**. A living space of 1200 sq. ft. is matched up with a 100,000 Btu furnace and a 3-ton air conditioner, **Figure 28-19A**. Come off the plenum with one or two main trunk lines having a total capacity of 1200 cfm, running toward the living areas. **Figure 28-19B**.

EXAMPLES:

Two 12" round duct main trunks @ 620 cfm each = 1200 cfm

Three 10" round duct main trunks @ 400 cfm each = 1200 cfm

With the main trunk lines installed, begin branching from the mains with smaller lines running to the various rooms. Always keep a constant rate of airflow (cfm) to the various rooms. A branch line must properly reduce in size to maintain a constant airflow from the trunk line. A velocimeter or anemometer, **Figure 28-20**, is often used to check and correct airflow problems. Such meters can read velocity (speed), cfm (flow), and temperature.

28.8 Installing Starting Collars and Takeoffs

Starting collars and takeoffs are installed on the plenum to begin a "run." A **starting collar** is used with round duct, while a **takeoff** is used with rectangular duct.

28.8.1 Starting Collars for Round Duct

It is best to mount the starting collar on the side of the plenum, 6" below the top, to ensure proper mixing of the air. Never install a collar on top of the plenum. To install a starting collar, first mark the proper size opening with a pencil or metal scribe, **Figure 28-21**. Next, pierce the metal surface with a sharp tool and use snips to cut the opening. Then, insert the collar into the opening and fold the tabs down inside the plenum. Finally, secure the collar with three sheet metal screws and seal it with mastic.

Sq. Ft. of Floor Area	Furnace BTU's	Air Conditioner Tonnage	CFM of Air Movement
400	33,000	1 Ton	400
800	67,000	2 Ton	800
1,200	100,000	3 Ton	1,200
1,600	133,000	4 Ton	1,600
2,000	167,000	5 Ton	2,000

A

Dimensions	Approx. CFM	Sq. In.
4" Round	30	12.57"
5" Round	60	19.64"
6" Round	100	28.27"
2 ¹ / ₄ " X 10"	60	23.00"
2¹/₄" X 12"	70	27.00"
3 ¹ / ₄ " X 10"	100	33.00"
3 ³ / ₄ " X 12"	120	39.00"
7" Round	150	38.48"
3 ¹ / ₄ " X 14"	140	46.00"
8" Round	200	50.27"
8" X 8"	260	64.00"
9" Round	290	63.62"
10" Round	400	78.54"
12" X 8"	440	96.00"
12" Round	620	113.09"
16" X 8"	660	128.00"
14" Round	930	153.93"
16" Round	1300	201.06"

B

Figure 28-19. A—Heating and cooling units matched to floor area. B—Approximate cfm of airflow (at a velocity of 700 ft./min.) for different-size ducts.

28.8.2 Takeoff for Rectangular Duct

Manufactured takeoffs are available in many sizes, such as 8"x 8", 12"x 8", 14"x 8", or 16"x 8", and mount easily on any side of the plenum. It is best to mount the takeoff 6" below the top of the plenum to ensure proper mixing of the air, **Figure 28-22**. When the furnace is located at one end of the house, the extended plenum may run to the opposite end. When the furnace is located at the center of the house, two takeoffs are used to provide an extended plenum on each side of the furnace.



Figure 28-20. Anemometer is used to obtain airspeed, cfm, and temperature. (Courtesy of Sperry Instruments, Inc.)

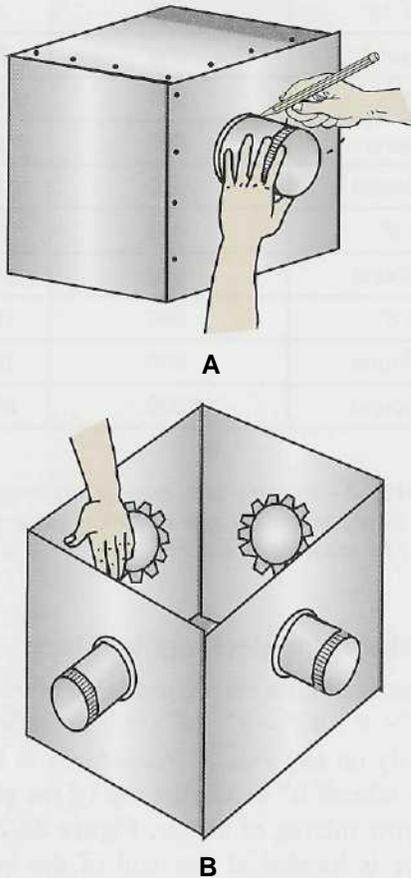


Figure 28-21. A—Mark and cut the opening for the starting collar on plenum. B—Insert the collar and bend tabs over. Secure the collar with three metal screws and seal with mastic.

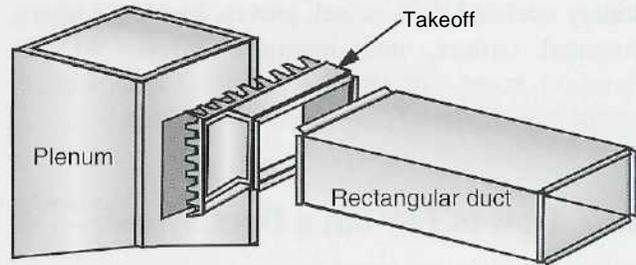


Figure 28-22. Top of the takeoff should be located 6" below the top of the plenum.

To install the takeoff, first mark off the proper size opening. Next, pierce the metal surface using a drill or sharp tool and cut the opening with snips. Then, insert the takeoff into the opening, and fold the tabs down inside. **Finally**, secure the takeoff with three sheet metal screws and seal it with mastic.

28.9 Working with Round Metal Pipe - *

Standard round pipe is made of 30-gauge, galvanized metal. **Figure 28-23.** Round pipe is usually shipped nested, with the seams open, **Figure 28-23A.** Fittings are usually shipped preformed and ready to install. Each pipe length has an easily connected snap-lock seam. Round the pipe with your hands until the **two** seam edges meet. Insert the tongue on one seam edge into the groove on the other seam edge. Start at one end of the pipe and work down the seam toward the other end until the entire seam is snapped **shut**, **Figure 28-23B.**

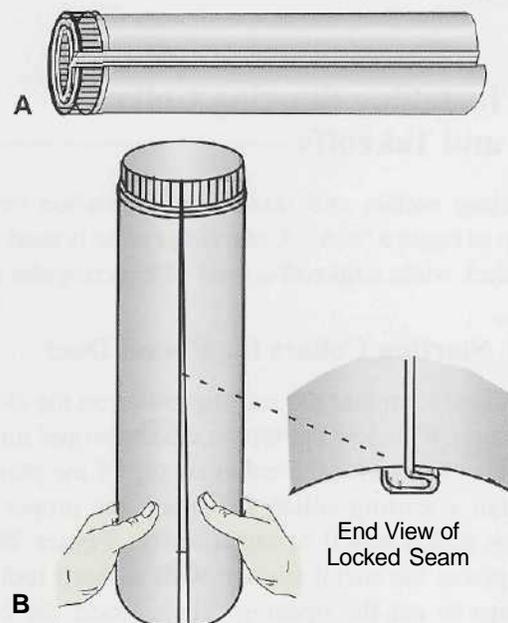


Figure 28-23. Round metal pipe. A—Nested pipe lengths with open seams. B—Self-locking seam snaps together when compressed or squeezed with normal hand pressure.

28.9.1 Joining Pipe Lengths

Each pipe length has a plain end and a crimped end. Lengths are joined by sliding the plain end of one length over the crimped end of another length. Line up seams for best appearance and push lengths together for a tight joint. Fittings are made similarly. The crimped ends always point in the direction of airflow. Secure each joint with three drive screws evenly spaced around the joint and seal with mastic. See Figure 28-24.

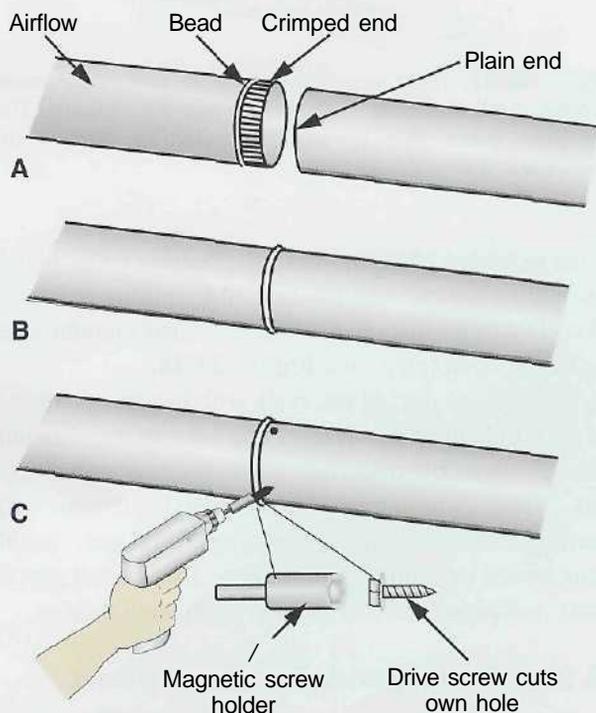


Figure 28-24. Joining pipe lengths. Making connections with round pipe should be step-by-step. A—Each length has a crimped end and a plain end. B—The crimped end slides into the plain end of the next pipe until seated against the bead. C—Three drive screws should be used to secure each joint. Temporary wire supports are often used to hold pipe steady while connections are being made.

28.9.2 Cutting Round Pipe

The last length of duct in a run usually must be cut, Figure 28-25. Do not snap the seam together until after the cut is made. Hold the last piece of unformed pipe in place and mark where it is to be cut. Your cutting mark should be on the plain (not crimped) end. Be sure to allow enough extra length for the cut end to slip over the crimped end of the preceding piece, up to the bead. Draw a straight cutting line across the pipe, then make the cut with tin snips. When you make the cut, the tin snips will squeeze the snap-lock seam edge closed. Before you can form the pipe, you will have to pry the seam open again, using a screwdriver.

If you need to cut a piece of pipe that is already formed, use a hacksaw. Make a continuous line around the pipe to follow while cutting. Support the round pipe between two wood blocks or other flat pieces, then saw with smooth, even strokes, beginning at the seam. Because of the hacksaw frame, you will only be able to saw part way through the pipe. You will need to rotate pipe and start again with saw on top. Continue in this manner until the cut is complete.

28.9.3 Adjustable Elbows

Adjustable elbows can be conformed to the desired angle. A 90° adjustable elbow can be twisted to form any angle from 0°-90°, Figure 28-26. A 45° adjustable elbow is also available. Insert the crimped end to move with the direction of airflow. Install the elbow and secure the joint with sheet metal screws, then seal it with fiberglass tape and mastic. Do not use ordinary duct tape.

28.9.4 Sealing Collars

Fiberglass reinforcing membrane will wrinkle when it is wrapped around a joint between round and rectangular ducts. To make the membrane material lie

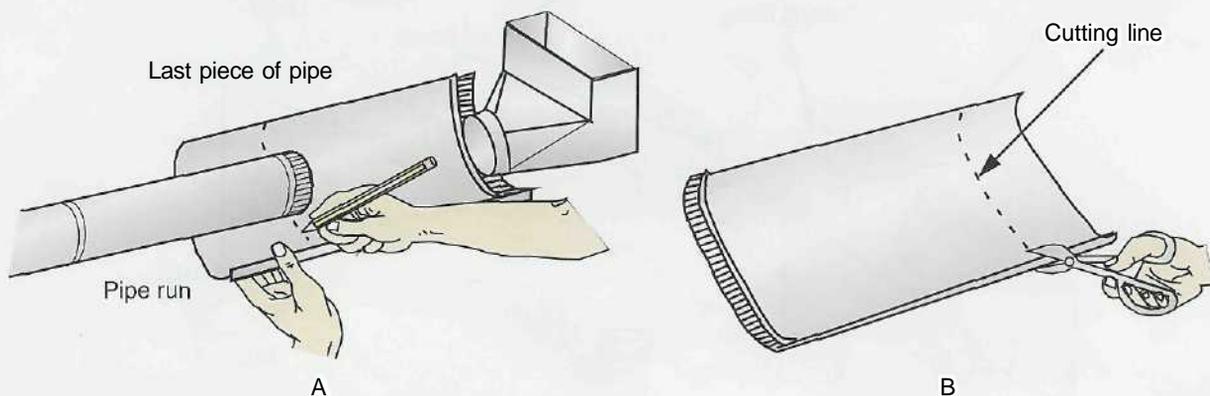


Figure 28-25. In a branch run, the last piece must usually be cut to size. A—Mark the cut with a pencil or scratch awl on the plain end. B—Make the cut with tin snips or aviator snips.

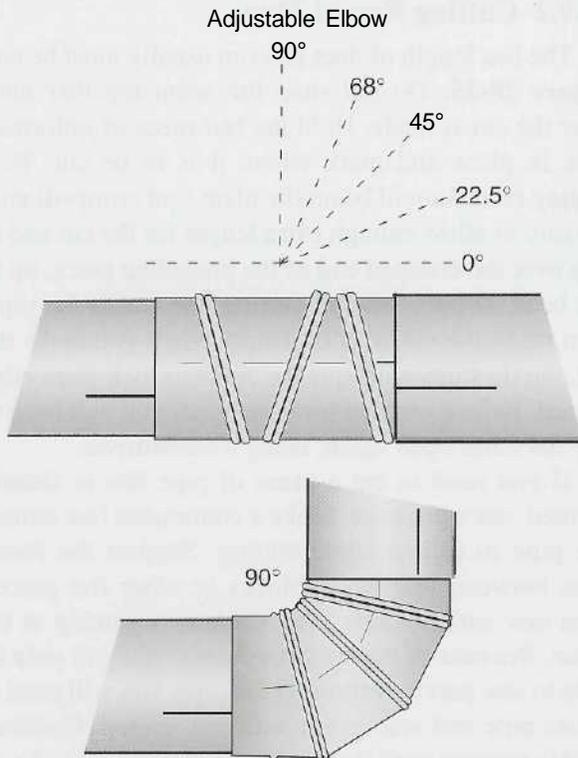


Figure 28-26. Adjustable elbows are convenient for making all types of turns. They are available in all round duct sizes.

flat, use a utility knife, to make a series of slices about every two inches along its edge. When the material is wrapped around the round duct, the tabs will fan out and lie flat against the rectangular duct, **Figure 28-27**.

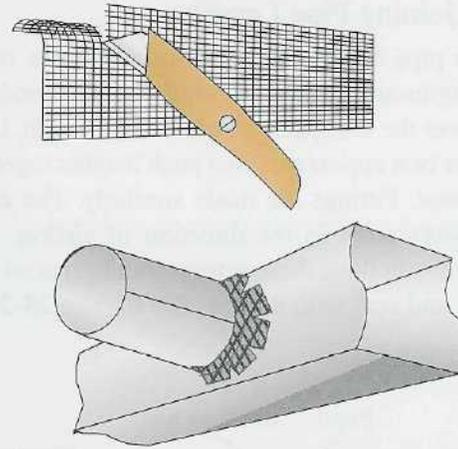


Figure 28-27. After securing the collar with sheet metal screws, seal the collar with membrane and mastic. This prevents leaks due to vibration. Cutting slits in the membrane will help it lie flat.

of the extended plenum, install the starting collar before assembling the rectangular duct. Side starting collars or takeoffs can be installed in the extended plenum after the run is completed. See **Figure 28-28**.

Support the duct at intervals with hangers or straps. Be sure to keep ducts at least one inch from joists and other combustible materials. Close the end with an end cap. After completing the extended plenum with starting collars or takeoff fittings attached, install branch runs to connect with outlets, insulate all supply ducts and pipes that are located in unheated areas.

28.10 Extended Plenum System —

Begin with the takeoff fitting in the plenum, and work outward. When a branch pipe comes off the top

28.10.1 Working with Rectangular Duct

Most rectangular duct is made of 28-gauge galvanized sheet metal in 4' lengths. Each duct length is made up of two half sections, as shown in **Figure 28-29**.

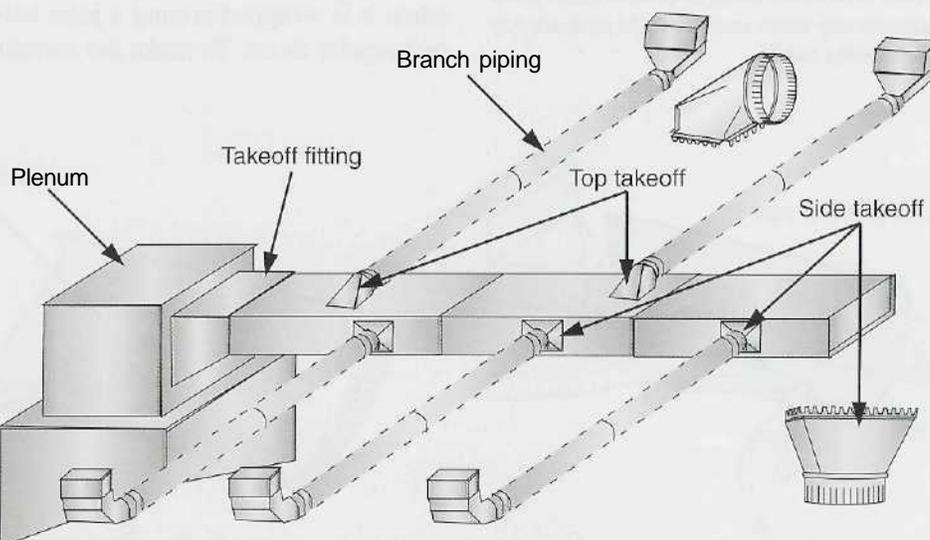


Figure 28-28. An extended plenum system uses side takeoff fittings to connect branch lines. A centrally located furnace may have two extended plenums, one on each side.

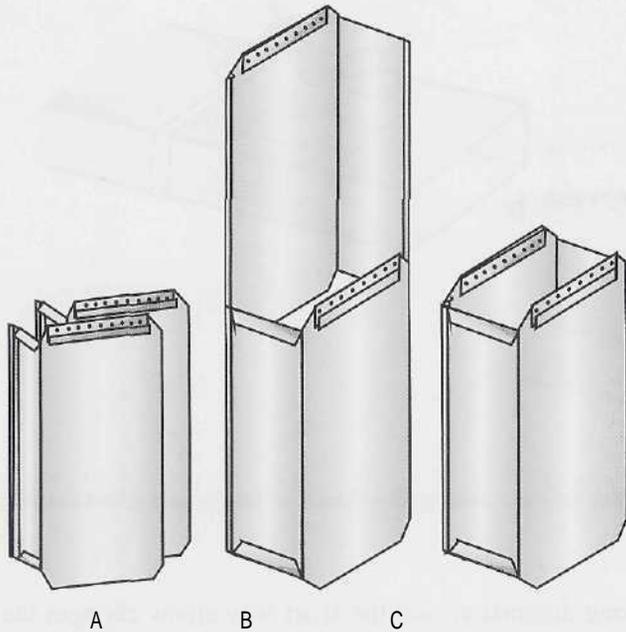


Figure 28-29. How to assemble rectangular duct. A—Match the ends of the two half sections. B—Start the edge channels. C—Slide the two sections together.

To form a length, place the two half sections on the floor with the "S-hook" ends up. Pick up one piece and engage its edge channels with the channels on the other piece, then slide the two together.

After assembling a section of duct, hammer each channel snug for a tight fit. This can be done as shown in **Figure 28-30**. Hang the assembled duct over a sturdy board suspended between two sawhorses so the seam lies flat on the board edge. Use a ball pcin hammer to tighten the seam.

Rectangular duct is joined with "S-hooks" and drive cleats, **Figure 28-31**. One end of each section has formed *S-hooks* on the long edges and "U" channels for the *drive cleats* on the short edges. The other end has plain long edges, with *U-channels* on the short edges. Join pieces by inserting a plain end into the S-hooks of the next piece, as shown in **Figure 28-31B**. Slide drive cleats through the U-channels to lock the pieces together, **Figure 28-31C**. Drive cleats are 10" long and used on 8" rectangular duct. When the drive cleats are in place, bend ends down over duct to complete and secure the joint. Seal the joint with mastic.

Where a shorter length is required, cut the **two** pieces before forming the duct. Always cut the plain end, not the end with the S-hook connection. Measure carefully, then cut both pieces to the same length with tin snips, **Figure 28-32**. After cutting, use a sturdy screwdriver to pry the edge channels to their original form. Cut back the corners of the new end and use a hand scamer to form a new U-channel on the short edge of each piece.

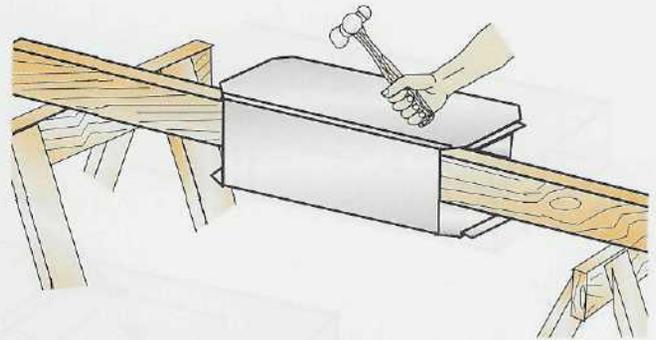


Figure 28-30. Use a ball pcin hammer on each seam for a tight fit.

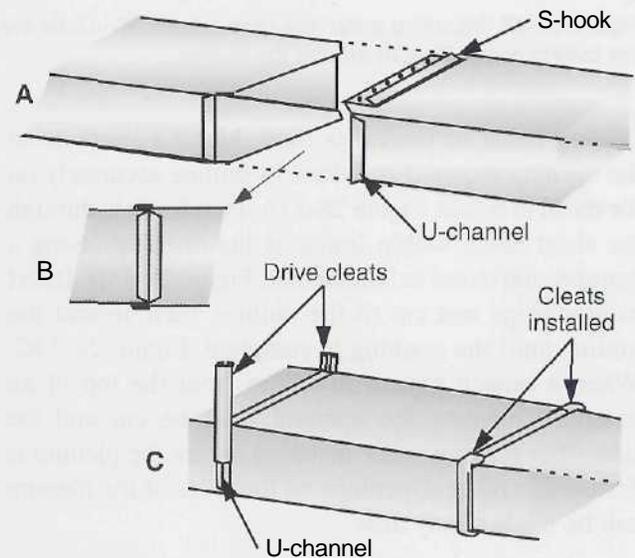


Figure 28-31. Joining rectangular duct, using S-hooks and drive cleats.

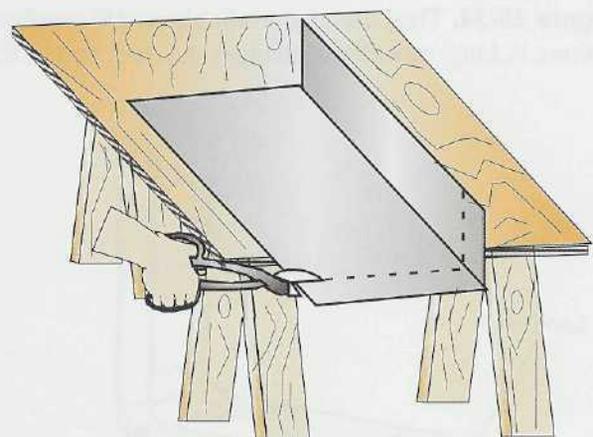


Figure 28-32. Measure carefully, then use snips to cut duct pieces to size.

28.10.2 Cutting Openings

To begin branch pipe runs, openings must be cut in the plenum. **Figure 28-33**. These openings may be rectangular or round, depending upon whether a

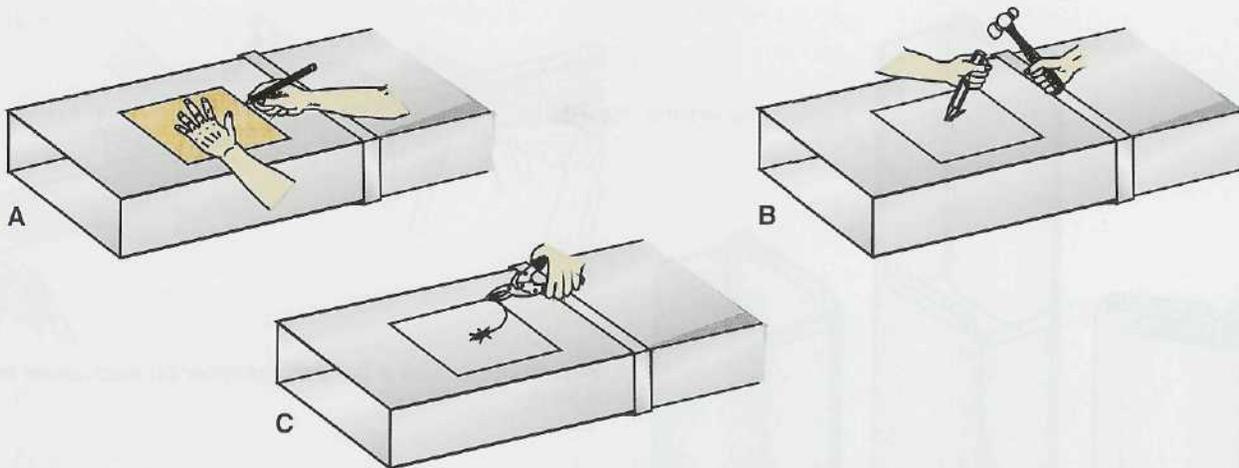


Figure 28-33. Installing a top-mounted takeoff. A—Draw the outline for the opening. B—Punch a hole to use when starting the cutting snips. C—Cut around the outline.

starting collar or takeoff is used. Make a template of the opening required and draw its outline accurately on the metal to be cut, Figure 28-33A. Punch a hole through the sheet metal within limits of the opening, using a hammer and chisel or similar tool, Figure 28-33B. Insert aviator snips and cut to the outline, then around the outline until the opening is complete, Figure 28-33C. When a branch pipe will be run from the top of an extended plenum, the opening must be cut and the takeoff or starting collar installed before the plenum is fastened in place. Openings on the sides of the plenum can be made at any time.

28.10.3 Rectangular 90° Elbows

Rectangular elbows are not adjustable, but are available in 90° "long-way" or 90° "short-way" forms, **Figure 28-34**. They are also available in 45° configurations. A long-way elbow changes the direction of the

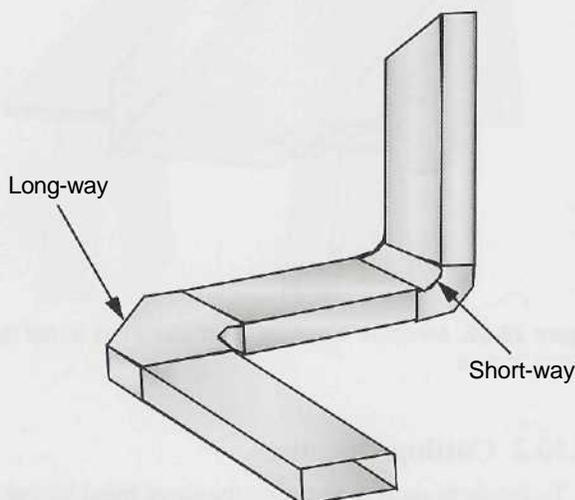


Figure 28-34. Rectangular elbows are made in two varieties: long-way and short-way. They are not adjustable.

long dimension, and the short-way elbow changes the direction of the short dimension. To form any smaller angle needed, 45° and 90° rectangular elbows can be cut.

28.11 Duct Support

All duct should be run in a straight line and supported at regular intervals — typically, 2'-5' — to prevent any sags. The best support material is woven polypropylene strap that comes in various widths. It is sometimes called "webbing strap" and is wide enough so it won't bite into flex duct. Perforated metal strap is a second choice, with steel wire being least desirable. Steel wire is still often used to support round pipe for branch runs. The wire should be wrapped once around the pipe before anchoring to a joist. See Figure 28-35.

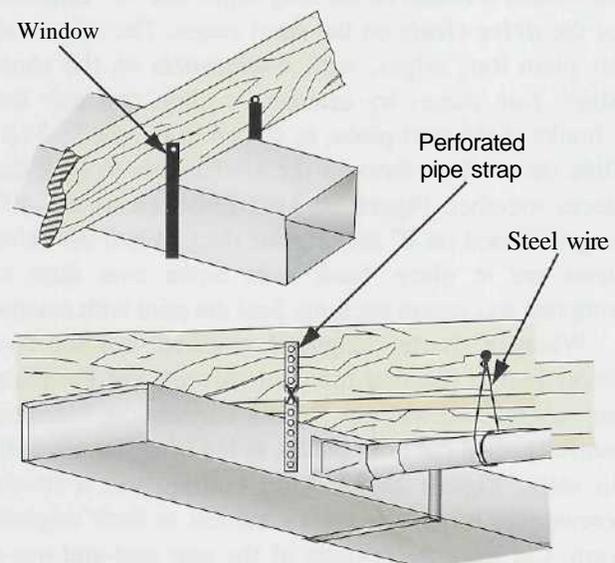


Figure 28-35. Three methods of duct support include woven polypropylene strapping, perforated pipe strap, and wire.

Keep pipes at least one inch from joists and other combustible material. To prevent heat loss, metal duct is often wrapped with insulation, **Figure 28-36**. If insulating material is applied after the duct is already in place, the insulation will have to be slit or stripped to get around the supporting strap or wire. This opening must be rescaled to maintain **insulating** effectiveness.

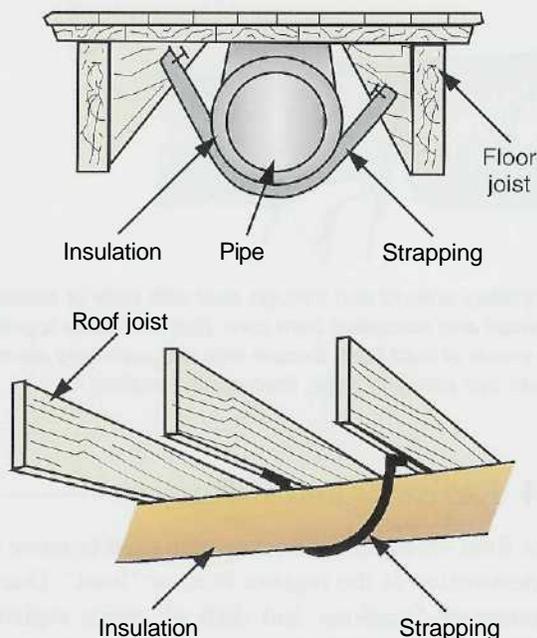


Figure 28-36. Duct is often located in the basement and hidden between floor joists. When located in the attic, it is hung with strapping attached to roof joists. Insulation is often wrapped around the duct to prevent heat loss.

28.12 Working with Insulated Flexible Duct

Insulated flexible duct can be used for main trunk line runs; it also can be used as branching duct, **Figure 28-37**. This type of duct is available in a variety of sizes, insulation thickness, and specifications, **Figure 28-38**. Check local building codes for the exact R-value required in your area. To prevent reduced airflow, insulated flexible duct must be fully extended when installed. Avoid any abrupt turns. When a sharp turn is necessary, cut the flex duct at the turn and install a 90-degree elbow of the same diameter. Do not use wire to support flexible duct. Instead, use a wide fabric strapping material and anchor it to wood framing with staples.

28.12.1 Making Connections

Making connections with insulated flexible pipe is not difficult, but must be performed properly to obtain

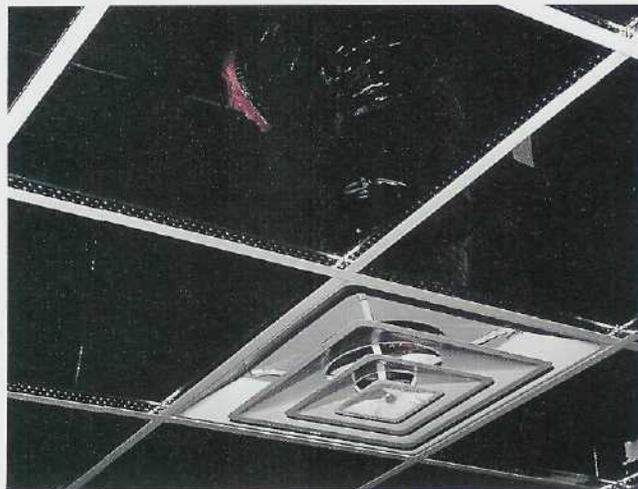


Figure 28-37. Insulated flexible duct used for a branch line in a commercial application. The diffuser is sized to drop into the suspended ceiling grid.



Figure 28-38. Different sizes and insulation thicknesses are available in insulated flexible duct.

correct airflow and prevent leaks. **Figure 28-39** shows the connection procedure step-by-step.

28.13 Wall Stack

Wall stacks, **Figure 28-40**, transport air vertically, from floor to floor. In residential applications, stacks carry air to high-wall or second-floor registers from a basement or crawl space. They can also be used to carry air to baseboard or low-wall registers from attic piping.

28.13.1 Installing Wall Stack

If possible, work from the basement. As each section is attached, push the stack up into the stud space and attach the next section, **Figure 28-41**. Continue until the top of the stack reaches the register box or fitting to which it will connect. Reduce the

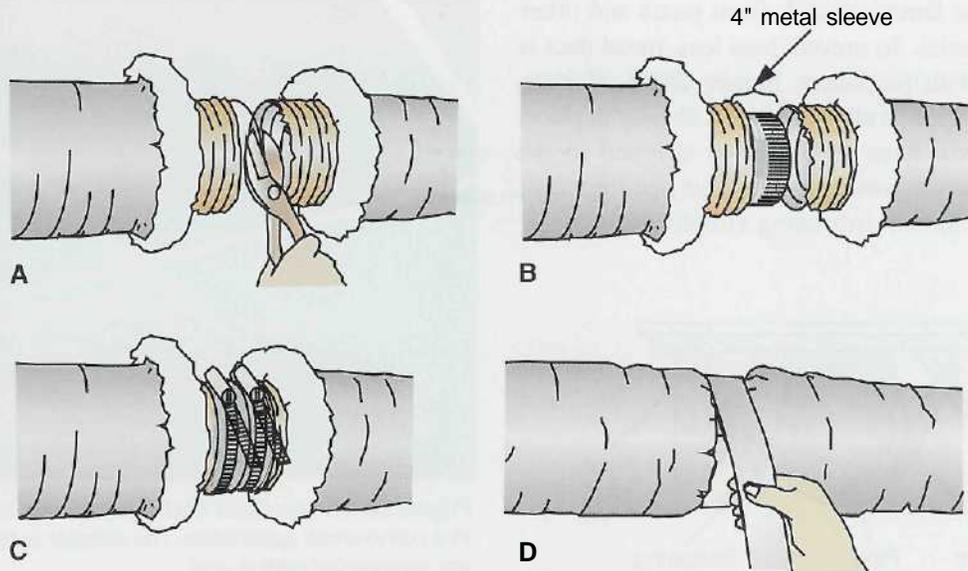


Figure 28-39. Connecting lengths of insulated flexible duct. A—Cut completely around and through duct with knife or scissors. Cut wire helix with heavy-duty snips or side cutters. B—Peel back the jacket and insulation from core. Butt two cores together on a standard 4" metal sleeve. C—Tape core together with at least two wraps of duct tape. Secure with two approved clamps. D—Pull jacket and insulation back over cores. Tape jackets together with two wraps of tape, then mastic sealant.

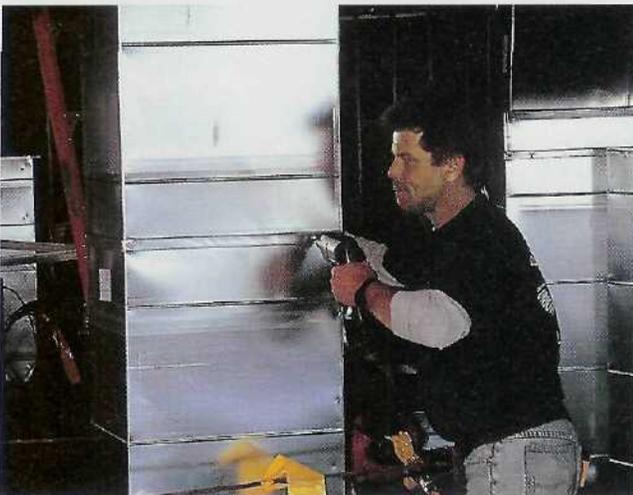


Figure 28-40. Rectangular duct is used to provide vertical passages (wall stacks) that carry treated air from floor-to-floor of a building. This stack is being fabricated for use in an office building. Note: The worker should be wearing safety glasses.

length of last section as required. When stack must be lowered from above, enlarge openings as necessary and lower stack into the stud space as it is assembled section by section.

To join two sections of stack (or "riser") duct together, "S" cleats can be used to secure the long sides of the duct. Sheet metal screws should be applied on the shorter sides of the ducting, and if needed, can be used on the longer dimension. The seams are then sealed with mastic. The same care should be taken when connecting with the stack heads or boots, Figure 28-42.

28.14 Registers and Diffusers

The final fitting in the duct system used to move air to its destination is the register box, or "boot." Due to the numerous locations and difficult areas registers must fit, boots are available in a variety of shapes and sizes, Figure 28-43. Supply air is released into a room

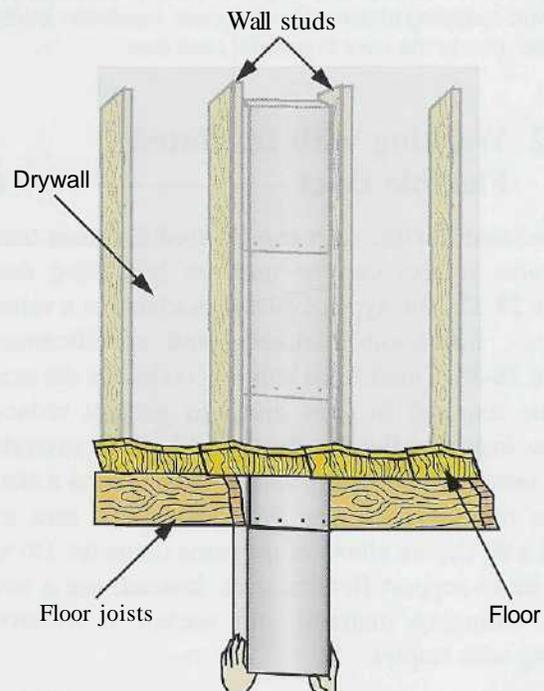


Figure 28-41. In residential installations, wall stack is generally pushed up into the wall from the basement. When cutting openings for a stack, use a flashlight and mirror to check for obstructions between studs.

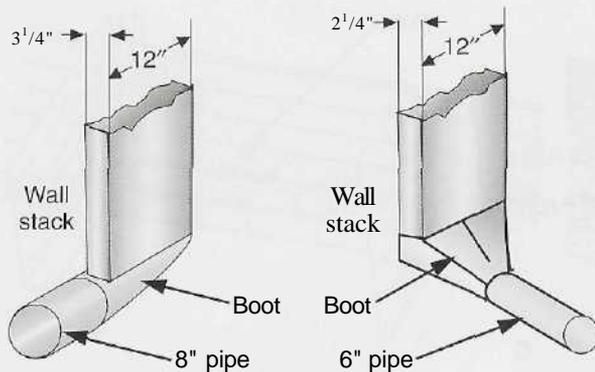


Figure 28-42. Wall stack duct is designed to fit between the studs inside a wall. Different sizes include 2-1/4" or 3-1/4" deep by 10", 12" or 14" wide. Standard length of a stack section is 24".

through registers or diffusers. Both have dampers or vanes for controlling the amount of air, but *diffusers* also have adjustable vanes for controlling the direction of discharged air. For most effective air movement, registers and diffusers are located in the baseboard on an outside wall, or in the floor near the baseboard.

28.14.1 Locating a Floor Diffuser

Locate the diffuser near an outside wall, but at sufficient distance from the wall to clear draperies or other obstructions. Draw an outline of the opening required, then drill a hole in the center of the planned opening. Measure from the hole to the sides of the opening, then go into the basement or crawl space and find the hole position from below. Measure the same distance from the hole to be sure it will clear floor joists or other obstructions. If not, the opening must be shifted. See **Figure 28-44**.

28.14.2 Installing a Floor Diffuser

A typical one-piece diffuser fits into a 12" x 4" rectangular opening in a register boot. After locating the proper position, cut a hole in the floor just large enough for the boot to fit snugly. The metal edges of the boot should be level with the floor. Secure the boot in position by nailing it to the floorboards. Insert the diffuser into the boot and anchor it with screws at each end. See **Figure 28-45**.

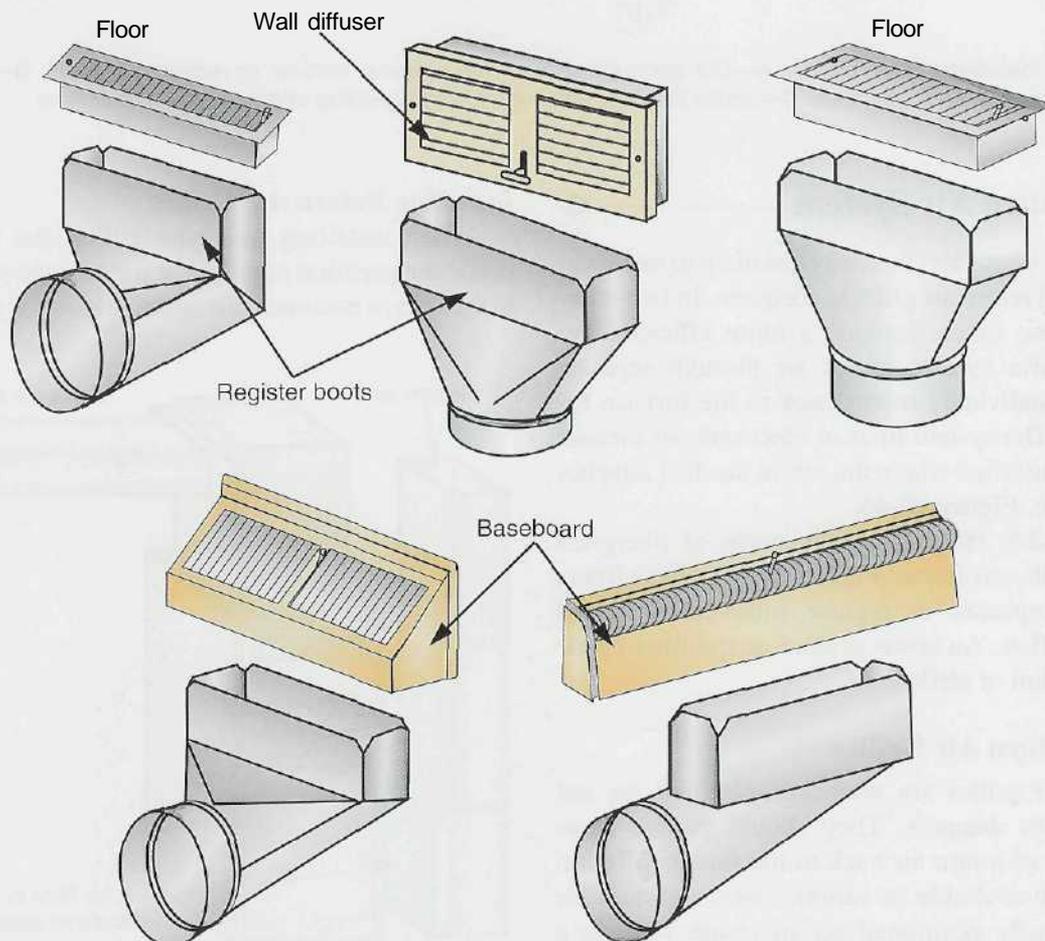


Figure 28-43. Placement of supply registers or diffusers is important to ensure a pleasant room temperature. A variety of shapes and sizes are available to meet varying requirements.

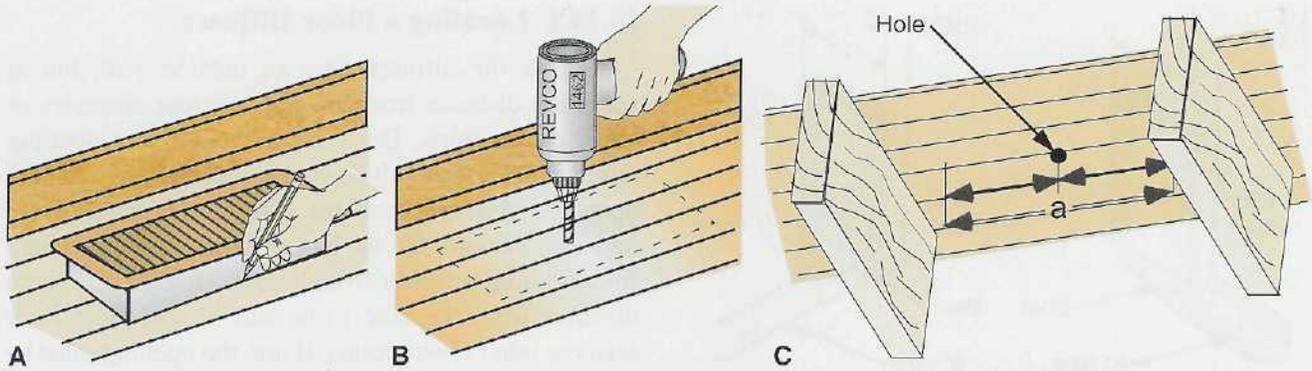


Figure 28-44. Preparing to cut a floor diffuser opening. A—Measure and trace the opening for the diffuser. B—Drill a centered hole through floor. C—Check clearances from below.

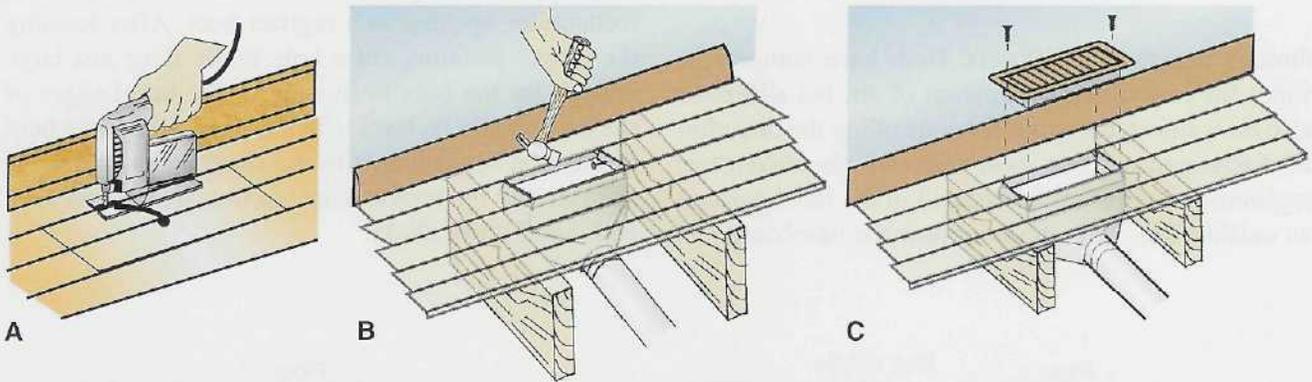


Figure 28-45. installing a floor diffuser. A—Cut along the outline with a jigsaw, circular, or reciprocating saw. B—Secure the register box (boot) to floor with nails. C—Install the floor diffuser into boot opening and secure it with screws.

28.15 Return Air System - — — — —

In houses where air can easily circulate to one location, a central return air grille is adequate. In two-story homes or long ranch designs, a more efficient, yet more expensive system routes air through separate piping from individual rooms back to the furnace for retreatment. The system filter or electronic air cleaner is normally installed where the return air duct attaches to the furnace, **Figure 28-46**.

A disposable filter is usually made of fiberglass within a cardboard frame, **Figure 28-47**. These filters should be replaced at regular intervals to avoid restricted airflow. An arrow printed on the filter frame shows direction of airflow.

28.15.1 Return Air Grilles

Return air grilles are nonadjustable, and are not equipped with dampers. They should permit unrestricted flow of return air back to the furnace. Return air grilles are available in various sizes. A return air grille is normally positioned on an inside wall, in a baseboard on an inside wall, or in the floor next to an inside wall, **Figure 28-48**.

Installing Return Air Grilles

When installing wall-type grilles, the floor plate inside the partition must be cut for passage of return air to the duct or enclosed joist space below. It is easier if the

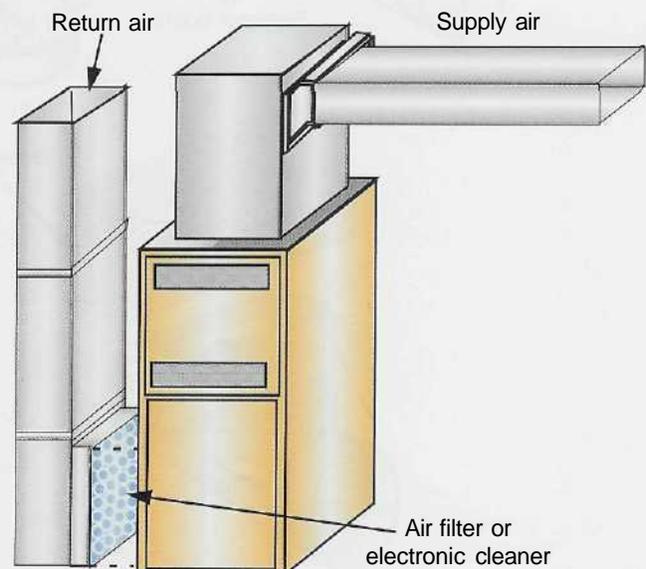


Figure 28-46. For proper circulation, return air is just as important as supply air.

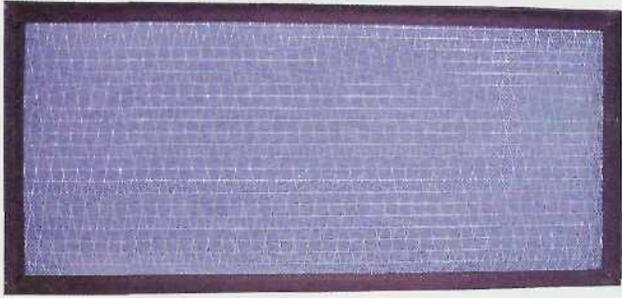


Figure 28-47. A disposable air filter can be positioned within a centrally located return air grille.

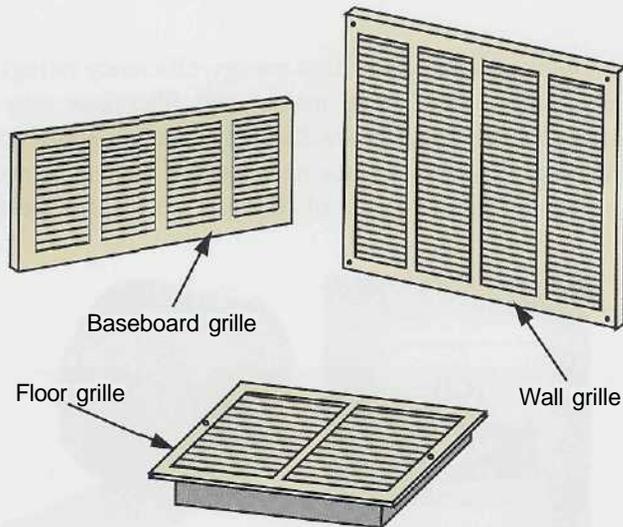


Figure 28-48. Return air grilles may be located in floor, ceiling, wall, or baseboard.

floor plate can be cut from below the floor. Using the stud space as a return-air duct requires sealing off the stud space just above the grille opening with a 2" x 4" wood block as shown in **Figure 28-49**.

Installing floor type or baseboard type grilles is much the same as installing supply air registers in those surfaces, **Figure 28-50**. Floor type and baseboard grilles require larger holes than diffusers.

28.15.2 Basement Return-Air System

With the return-air grilles installed and the return takeoff fittings attached to the return-air plenum, it is only necessary to complete the runs from the grilles to the furnace. This may be done through sheathed joist and stud spaces, direct ducts, or a combination of the two, **Figure 28-51**.

28.16 Insulation

Insulate all supply ducts and pipes installed in an attic, crawl space, or other unheated areas. Carefully wrap the insulating material around each pipe and secure with proper glue or by applying tape along the seam, **Figure 28-52**.

WARNING: To avoid a fire hazard, the warm-air plenum and branch ducts must be separated from wood joists, floors, and other structural elements by at least 1" of clear space or insulation.

28.16.1 Leaks in Air Ducts

Over time, fabric-based duct tape grows brittle and the glue dries out. This permits sections of duct to

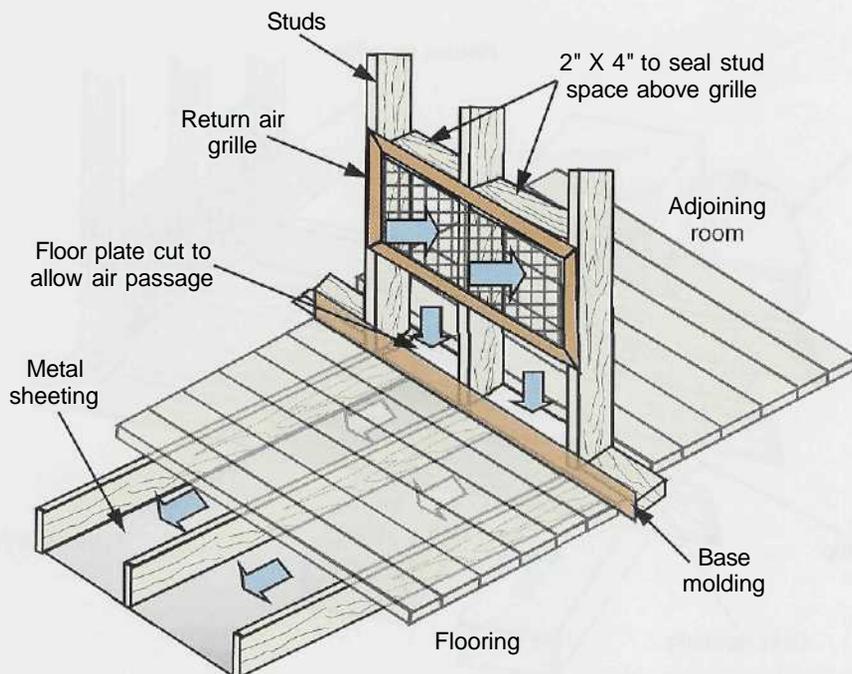


Figure 28-49. With wall-type grille openings, air is returned to the furnace through stud spaces, sheathed joist spaces, or ducts.

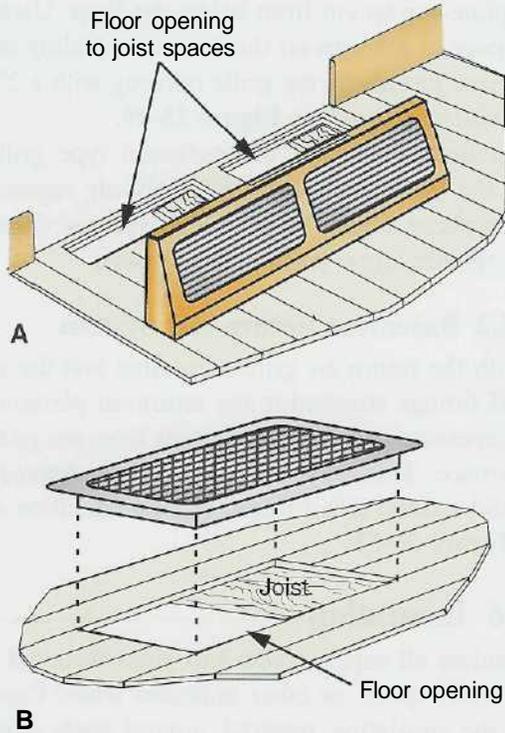


Figure 28-50. A—If a large baseboard grille is used, double stud and joist spaces should be prepared. B—Floor type grilles are commonly used when the furnace is located in the basement.

come loose and leak air. Air leaks from poorly sealed ducts can be one of the biggest energy and money losers in a home. The California Energy Commission has ruled that fabric-based duct tape can no longer be used for sealing ductwork, and other states are considering a similar ban.

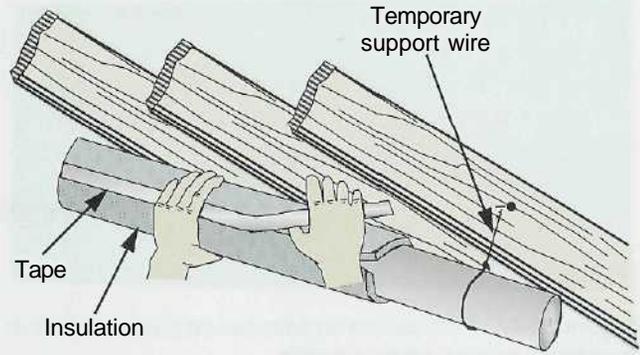


Figure 28-52. Use tape or sealant to close insulation on round pipe. Remove temporary support wires and replace them with strapping.

Ducts in homes with high energy-efficiency ratings are usually sealed with mastic and fiberglass reinforcing membrane, **Figure 28-53**. Mastic is a nontoxic adhesive-material used for permanently sealing joints and seams for **all** types of air duct materials. Most



Figure 28-53. A—Mastic is available in 1, 2, and 5 gallon recyclable plastic pails. B—Fiberglass reinforcing membrane is designed for use with mastic. A roll is 3" x 50' or 3" x 150'. (Courtesy of RCD Corporation)

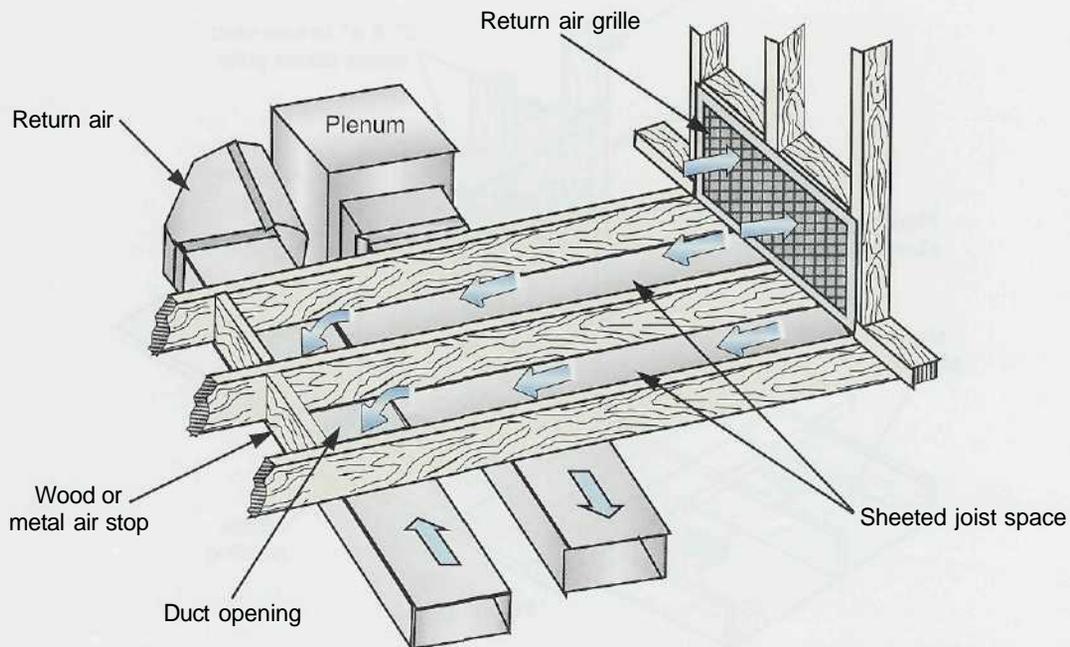


Figure 28-51. Sheeting, or panning, is easier to install than duct and just as efficient.

mastic is water-based, nonflammable, fiber-reinforced, fast drying, and waterproof. Easy application, and clean-up with soap and water are attractive features of the material. Mastic can be applied by brush, trowel, caulking gun, or with a gloved hand. It typically dries to touch in 1 or 2 hours, but unusually wet conditions may require 4-5 hours drying time. Insulation can be installed over mastic that is **still** wet, but care is needed to prevent excessive movement and loss of seal.

28.16.2 Fiberglass Reinforcing Membrane

Fiberglass reinforcing membrane is used with mastic for sealing air leaks in insulation, air ducts, plenums, and fittings. This inorganic woven **fiberglass membrane**, **Figure 28-5313**, will not rot, is lightweight and conforms to irregular surfaces. A typical roll is 3" wide x 50' long, or 3" wide x 150' long, **Figure 28-54**. This product is designed to be used with mastic as a reinforcement when there is a gap of 1/4" or more. If the membrane has a sticky side, apply it over the clean metal surface before applying the mastic. If the membrane does not have a sticky side, apply a thin layer of mastic and place the membrane in this layer. Add another layer of mastic until the membrane is completely covered.

28.17 How to Use Mastic

Before applying mastic or fiberglass reinforcing membrane, the duct surface must be clean and dry. Use a cloth to wipe dust from the surface of the duct, **Figure 28-54**. If an oily film or grease is present, wipe the duct clean with a damp cloth. If necessary, use a grease-cutting cleaner on the cloth, then wipe thoroughly dry.

28.17.1 Sealing Joints with Less Than 1/4" Gaps

Load the brush with mastic, and coat the entire joint with a continuous strip of the adhesive. Use the end of the brush to work mastic into joint. Spread mastic at least 1" on each side of the joint. **Figure 28-55**. The mastic should be thick enough to hide the metal surface of the duct (about 1/16" thick).

28.17.2 Sealing Joints with Gaps Greater Than 1/4"

If the gap in the duct connection is wider than 1/4", use fiberglass reinforcing membrane in addition to mastic. Cut enough membrane to cover the joint, and press the membrane over the joint, **Figure 28-56**. If necessary, first brush a thin layer of mastic on the joint to hold the membrane in place. Finally, cover the membrane with mastic in a layer about 1/16" thick, overlapping the membrane on each side.

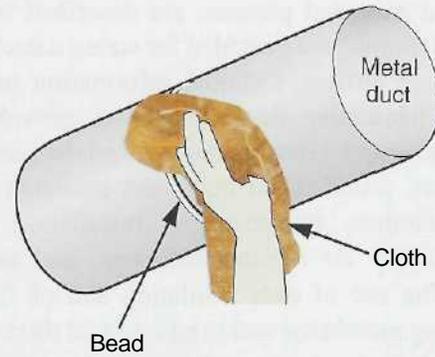


Figure 28-54. Mastic will not stick to a dirty surface. Wipe dust off the surface, and clean any greasy residue.

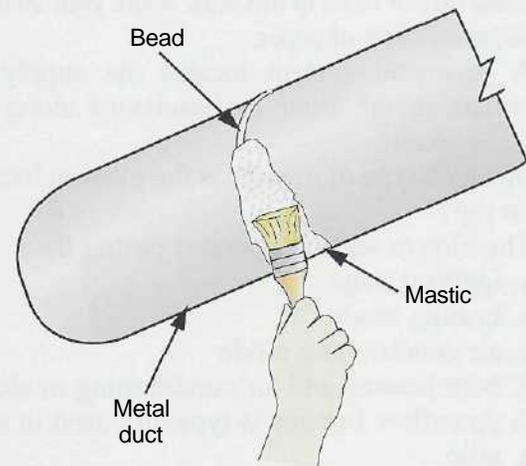


Figure 28-55. Joints with a gap of less than 1/4" can be sealed with mastic only.

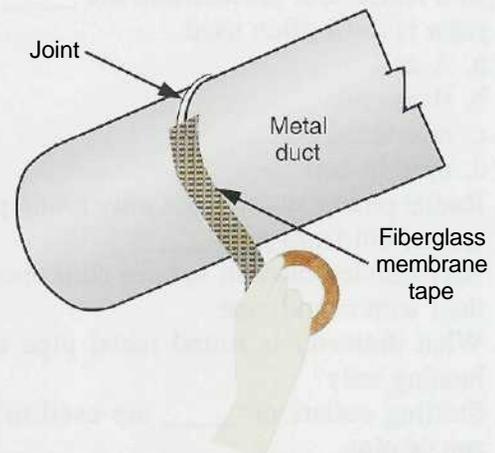


Figure 28-56. Gaps of more than 1/4" require use of reinforcing membrane.

Summary

This chapter introduced the classifications of forced-air furnaces, based on direction of airflow, and described the difference between conventional and perimeter systems. The major air distribution systems,

radial and extended plenum, are described in detail. "Rules of thumb" are provided for sizing a duct system for efficient airflow. Detailed information on laying out and fabricating duct systems is provided, and covers the major types of duct materials: rectangular metal duct, round metal duct, and insulated flexible duct. Directions are given for installation of wall stacks, supply air registers/diffusers, and return air grilles. The use of duct insulation and of fiberglass reinforcing membrane and mastic to seal duct air leaks is covered.



12. Which of the following materials is the preferred support for ducting?
 - a. perforated metal strapping
 - b. wire
 - c. woven polypropylene webbing
 - d. wooden brackets
13. What type of duct cannot be used to make sharp turns?
14. To end a run of pipe, a _____ or diffuser is used.
15. All ductwork running through _____ areas (such as attics or crawl spaces) should be insulated.