Refrigeration Service Engineers Society
1666 Rand Road
Des Plaines, Illinois 60016

DUCT SYSTEM DESIGN CONSIDERATIONS
Part 2

by Roger M Hensley, CMS

INTRODUCTION

One of the most important components of any HVAC system is the duct system. The layout and sizing of the ductwork and the selection and location the terminal devices (grilles, registers, and diffusers) are critical to the overall system performance. The best equipment manufactured will produce unsatisfactory comfort control if it is installed with a faulty or poorly designed duct system. In some cases, HVAC equipment failure can result from a poorly designed or installed duct system. The duct system is made up of both the *supply* system and the *return* system. Each of these duct system components is equally important in ensuring that the installed HVAC system will provide the proper control of temperature and humidity to fulfill the comfort needs of the building's occupants.

It must be the first priority of the duct system designer to make sure that his or her design is capable of delivering the proper amount of air (cfm), at the proper velocity (ft/min), through a properly selected terminal device (grille, register, or diffuser) to condition each room or zone of the structure properly for the occupant's comfort. The only valid method of determining the room cfm requirements is to complete a room-by-room heat gain and heat loss calculation, such as an ACCA *Manual J* load calculation. The conditioned air also must be delivered to the room or zone in such a manner that the primary airstream does not come in contact with the room occupants. The primary airstream should be delivered into the unoccupied zone of each room (see Figure 1). On the surface this may sound like a tall order, but it can be accomplished by paying close attention to the details and following a few simple rules of good duct system layout and design.

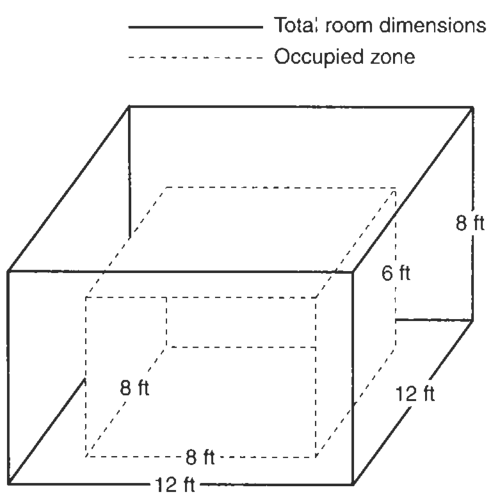

Figure 1. "Occupied zone" of a room

DUCT SYSTEM LAYOUT CONSIDERATIONS

You must take into account the physical layout and characteristics of the structure's floor plan when deciding on the type and location of the duct system to best condition the space. The possibility of using multiple systems (two or more), or an individually controlled, zoned system within the structure may need to be considered.

Small single-floor structures

Structures with less than 1,500 to 1,800 ft^2 and relatively simple floor plans lend themselves well to the utilization of one system, as long as the indoor air handler or furnace is located as close as possible to the geographic center of the structure. However, if the floor plan is complicated or if the indoor air handler or furnace location necessitates extremely long duct runs, either zoning or the use of two or more systems may be desirable. Figure 2 on page 3 shows a small single-floor residence. The indoor section of the system (H/A) is located near the geographic center of the structure. Note also the location of the thermostat (T).

Large single-floor structures

Even a structure with more than 1,800 to 2,500 ft^2 may be served by a single system if the indoor unit can be located near the geographic center of the structure and the floor plan is relatively simple. Figure 3 on page 4 shows a roughly 2,500-ft^2 structure with a single ceiling distribution system. Note the locations of the indoor unit, the thermostat, and the supply and return ducts. Structures like this one also lend themselves very successfully to systems that employ individual zone controls and zone dampers. Figure 4 on page 5 shows the same floor plan as Figure 3, but with the addition of zone controls and zone dampers.

Large, rambling floor plans present challenges for the system designer. The physical layout of such a structure—even if the indoor air handler or furnace can be located near the geographic center of the structure—often necessitates long duct runs. Figure 5 on page 6 shows a large residence (approximately 2,800 ft^2) with a single floor distribution system. The long duct runs mean that other factors, such as increased resistance to air flow and increased heat gain and heat loss within the duct system, must be taken into account. Longer running cycles will be required to satisfy the desired comfort conditions in the parts of the structure served by long supply and return duct runs.

Comfort conditions in the rooms that are the farthest away from the indoor unit can suffer. In a typical scenario (depending on the location of the control thermostat), the rooms closer to the indoor unit and the thermostat will achieve the desired comfort temperature before the rooms that are supplied by longer duct runs. Look at Figure 6 on page 7, for example. It shows the same floor plan as Figures 3 and 4. Again there is a single system, this time with floor distribution and ceiling returns. But note that the indoor unit has been moved to the garage. The result is a variety of long and short duct runs. Customer complaints in these situations include rooms that are cooler than the thermostat setpoint during the heating season and warmer than the thermostat setpoint during the cooling season. Large temperature gradients from room to room within a structure should be avoided. In comfort conditioning, it is desirable to maintain the temperature across the various rooms and zones within 3°F.

With the type of structure and floor plan shown in Figure 6, consideration should be given to zoning the structure with individual zone controls (as in Figure 4) or utilizing multiple systems (see Figure 7 on page 8). The use of a zoned system with individual zone controls allows the proper amount of supply air to be directed into each zone based on the zone's individual heating and cooling requirements. The use of multiple systems results in shorter duct runs and provides for better comfort control within the individual rooms of the structure.

Multistory structures

Using two or more systems in multistory structures is often a wise decision. Due to the natural effect of warm air rising and cool air falling, trying to utilize one system to condition a multistory structure can result in unsatisfactory performance and lead to customer dissatisfaction and complaints. During the heating season, the upper floor will tend to overheat because the warm air that is being delivered to the lower floor will migrate to the upper floor by natural convection currents within the structure. The lower floor will tend to be cooler for the same reason—the warm air is rising to the upper level of the structure. During the cooling season, too, the upper floor will be warmer and the lower floor will be cooler. Proper temperature control of both upper and lower floors can be extremely hard to achieve. The use of a design that employs two or more systems can help overcome this problem. Systems that utilize individual zone controls and either multispeed or variable-speed fans, blowers, and compressors (or a combination of these components) can be used very successfully in multistory applications.

SUMMARY

The problem of designing an air distribution system for a particular structure can lead to a variety of different solutions. There is rarely a single "right" system for any given structure—although there may be many "wrong" ones! The challenge for the designer is to select the best system type for each application. It must be the goal of the installer to install the system as designed. A properly designed and installed air distribution system for the structure will significantly reduce customer complaints and callbacks.

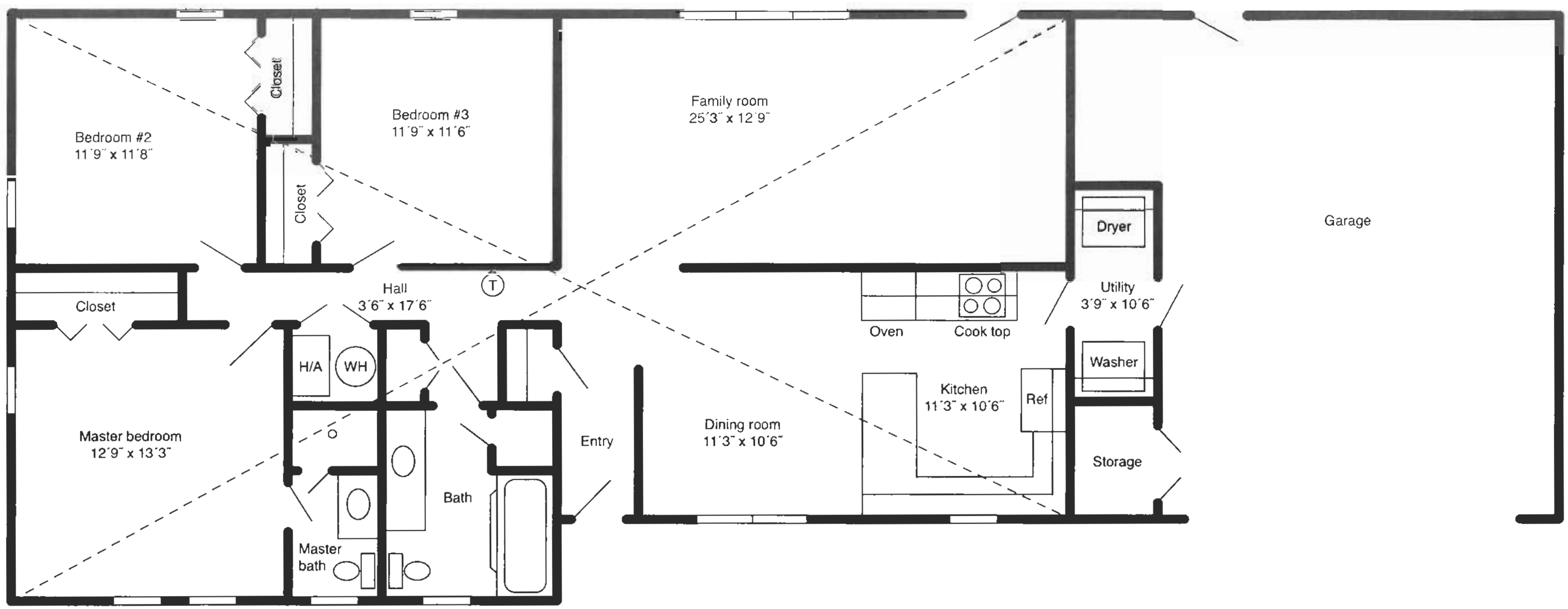

Figure 2. Small single-floor residence with indoor unit near center of structure

Figure 3. Large single-floor residence with overhead distribution system and indoor unit near center of structure

Figure 4. Large single-floor residence with zoned overhead distribution system

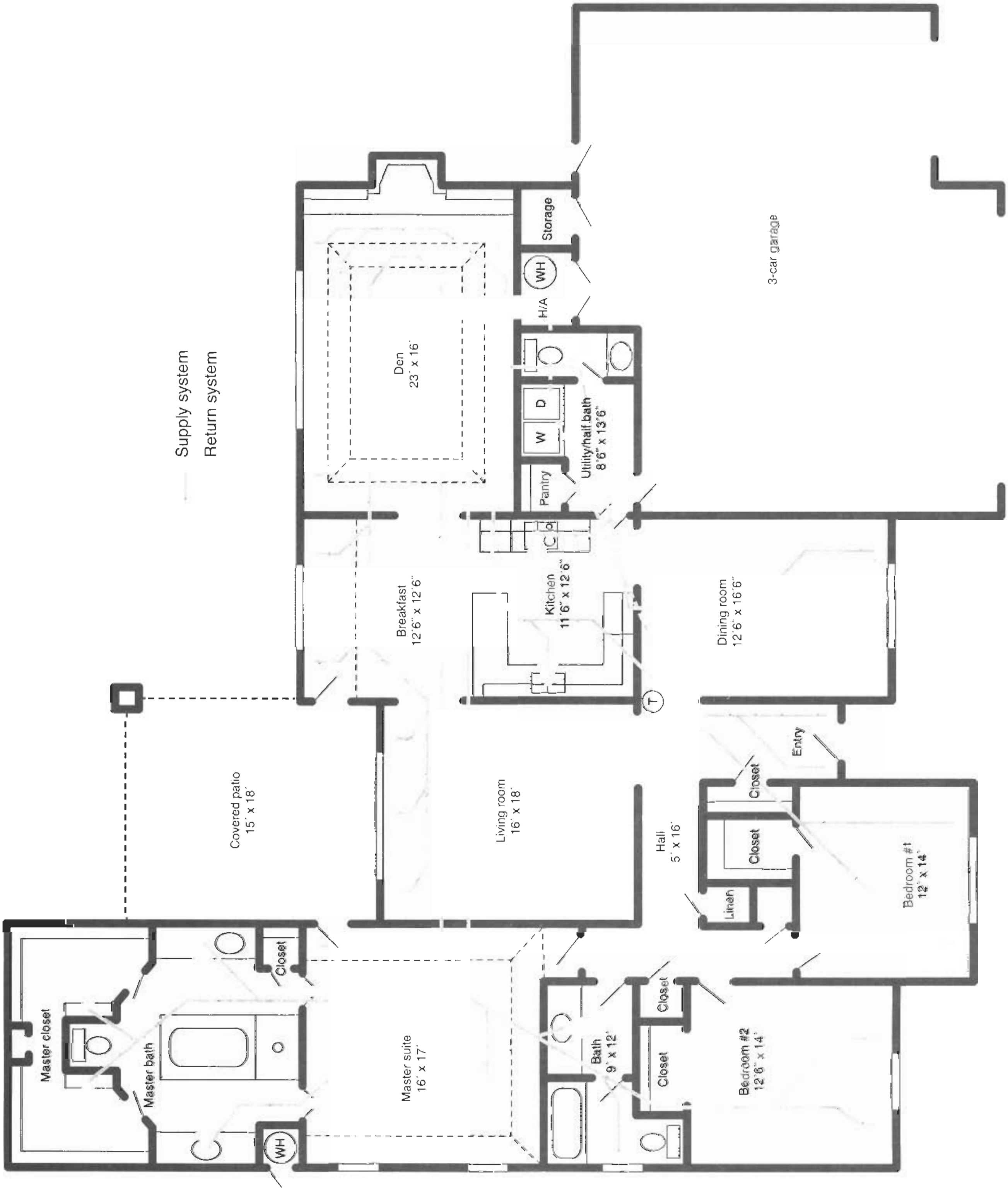

Figure 5. Large single-floor residence with rambling floor plan

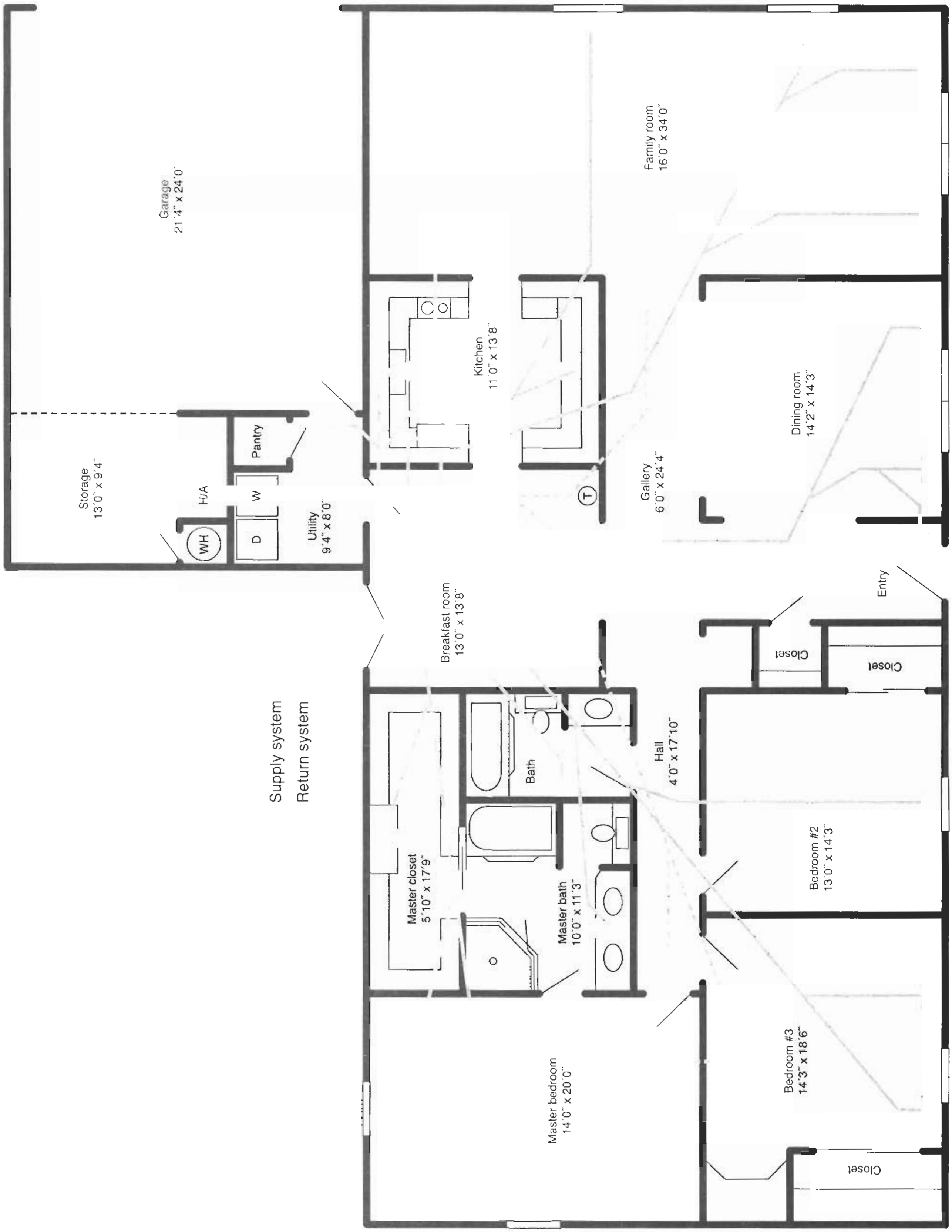

Figure 6. Large single-floor residence with floor distribution system and indoor unit in garage

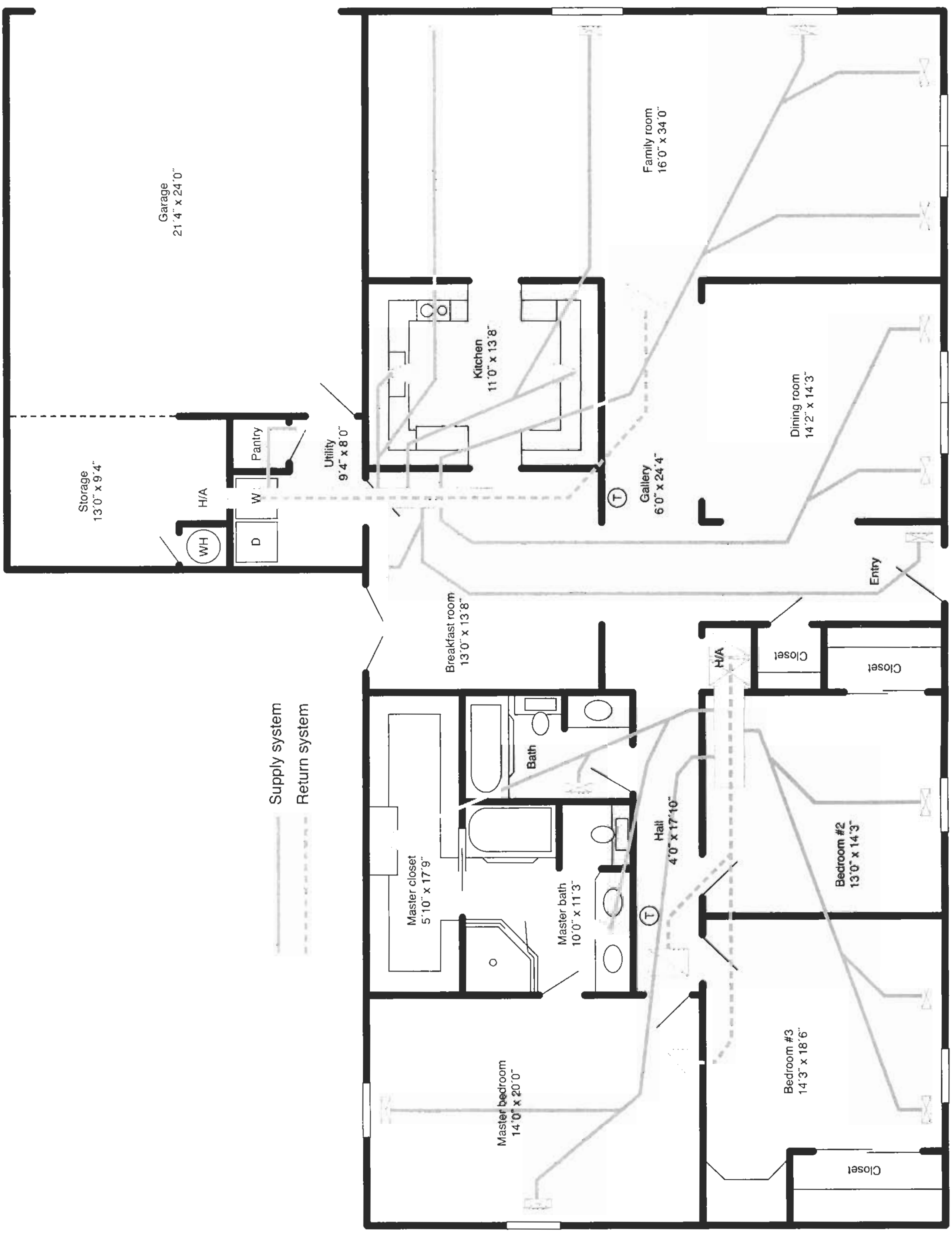

Figure 7. Large single-floor residence with two floor distribution systems