

MAJOR APPLIANCES

Installing, Troubleshooting, & Servicing



Jim Johnson

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This text covers the fundamentals of electricity, refrigeration, and mechanical systems related to refrigerator, freezer, room air conditioner, laundry, and cooking equipment servicing, troubleshooting, and repair.

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Preview

Preface

There has been a need for a text like *Major Appliances: Installing, Troubleshooting, and Servicing* ever since the business outgrew its infancy and progressed into an industry requiring thousands of trained technicians. Now, due to technological advances in the past decade, coupled with the regulations on refrigerant reclaim, the need for such a text has intensified. The Association of Home Appliance Manufacturers (AHAM) and the National Appliance Retail Dealers Association (NARDA) are predicting a serious shortage of qualified service technicians. The key word is *qualified*. As in any trade, there will be people who will be “working at it,” but their performance will be below industry standards.

In addition, many cities and states already have or are considering a certification process for major appliance service technicians. Local or state certifications such as these would be apart from the certifications required by the EPA in regard to the handling of refrigerants. Responsible associations and regulatory agencies consider certification a necessity to ensure industry growth and to prevent serious problems that lead to customer dissatisfaction. Focusing on the challenges facing the appliance service industry, the text offers an overview of the business through a “practical, applied approach, to provide the learner with the necessary information to properly service and install major appliances.

The philosophy behind the text is based on the idea that one cannot be an effective service technician if basic concepts are not fully understood. Everyone understands that electricity makes a refrigerator or washing machine work. But unless you understand where electricity comes from and how it does its job, you cannot fol-

low a schematic diagram and effectively troubleshoot an electrical circuit. If, as a service technician, you have not reconciled that fundamental laws of thermodynamics govern the operation of a refrigeration system, your understanding of the heat transfer concept will be forever shrouded in mystery.

Vocational instructors have long recognized that eliminating the mysteries behind basic concepts is the foundation of technical education and that a confident, able technician can only emerge after this has been accomplished. For this reason, the text provides complete information in regard to the basics of electricity and refrigeration before attempting to apply these principles to the operating functions of refrigerators, washing machines and clothes dryers, dishwashers, gas and electric ranges, and microwave ovens.

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Jim Johnson

Electrical Fundamentals

LEARNING OBJECTIVES After studying this Chapter, you will be able to:

1. Describe the process through which a generating plant converts a raw material into electrical energy.
2. Relate the process of generating electricity from magnetism.
3. Understand why some materials allow electricity to flow easily and why other materials are fair or poor conductors of electricity.



Electricity. Ask the average person to explain electricity, and you are likely to hear a brief description of a generating plant and a network of wires leading to homes and offices. For those not employed as a technician in the major appliance service field, a general explanation of an electrical generating station and distribution system would be sufficient. To function as a service technician, however, you'll need a complete understanding of how electrical energy is generated, how it is transported to the desired location, and how it is made to perform useful work.

As a service technician, you will be required to troubleshoot electrical circuits and diagnose system malfunctions through the use of schematic diagrams. To perform these tasks effectively, you must be able to reconcile any questions that may exist in the back of your mind, such as "How is electricity really produced?" or "Why does copper conduct electricity but rubber does not allow electrical energy to flow?"

Once you have answered questions like these and have eliminated any doubts about electricity, its fundamentals, and its relationship to the operation of major appliances, you will be able to function confidently as a service technician. You will not necessarily need to

review all the principles discussed in this section every time you're called to solve an electrical problem. But, after studying and understanding the material that follows and filing it away mentally, you will eliminate any mysteries that would otherwise muddle the thought processes required for logical, step-by-step analysis of a malfunctioning piece of equipment.

1.1 PRODUCING ELECTRICITY

Electrical energy begins at a generating station and, in simple terms, is defined as a form of energy that performs useful work when converted to light, heat, or mechanical energy. This definition should be easy for us to accept because we see it in action every day when we turn on a light, use a toaster, operate an automatic washer, cook with an electric range or allow electricity to make our lives easier in many different ways.

The first question is, "How is it produced?" It's common knowledge that the electricity we use to operate appliances comes from a power plant and that a generator is used to produce the energy, but the answer involves a bit more than saying, "It comes from a generating station." It will help you to view the electrical generating station as nothing more than a factory that takes a raw material, such as coal or oil, and changes the chemical energy in these materials into a another form of energy: electricity.

Figure 1-1 illustrates, in its simplest form, the process of converting chemical energy into electrical energy. You'll note that, as you trace the process from its beginning (a mine supplying coal, for example) to its end, the energy takes six different forms.

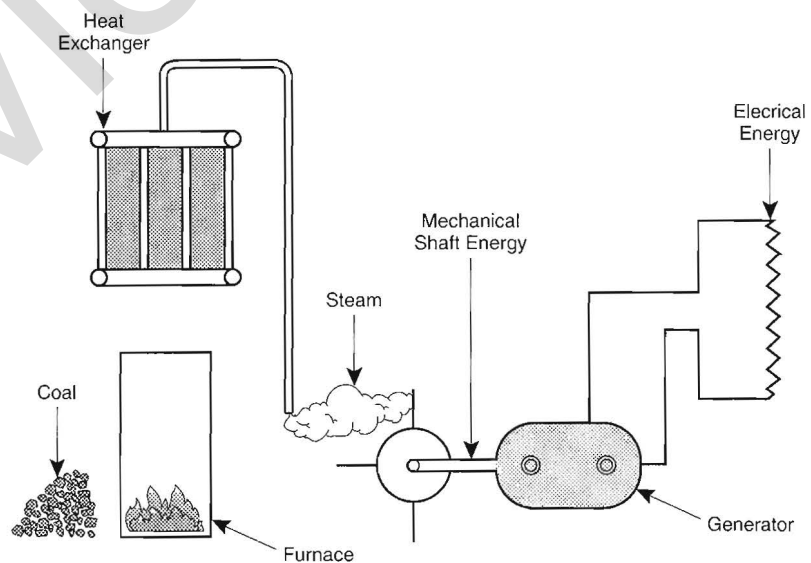


Figure 1-1. Converting chemical energy into heat energy, which creates steam. The high-pressure steam spins the turbine and mechanical shaft energy turns the generator.

Alternating Current Fundamentals, Terms and Definitions

LEARNING OBJECTIVES

After studying this Chapter, you will be able to:

1. Define the method through which alternating current is generated.
2. Define the terms *volt*, *ampere*, *resistance*, and *watt*.
3. Understand how Ohm's law is used to solve electrical problems and illustrate the relationship between the three basic electrical units: current, voltage, and resistance.
4. Understand how the cost of electrical power is calculated and use a step-by-step method to calculate the cost of operating an appliance.



2.1 ALTERNATING CURRENT

When working as an appliance service technician, you should develop the habit of looking for the manufacturer's equipment information tag as you begin servicing the refrigerator, washing machine, or whatever it is you happen to be repairing. Experienced techs consult the tag for the model and serial numbers (especially if the appliance is under warranty) and look for the operating data of the item. One piece of information you'll encounter on the model tag relates specifically to the type of energy used to power the appliance.

Terms such as *120 VAC* or *240 VAC* tell you the proper level and type of energy that must be applied for the appliance to operate properly. *VAC* is an abbreviation for *volts alternating current*, and the numbers preceding the abbreviation tell you the proper voltage necessary for various pieces of equipment.

A refrigerator, for example, operates through a power cord that is plugged into a standard wall outlet, the same receptacle into which you could plug a table lamp or an electric drill. A standard outlet of

this type delivers 120 VAC to the item when it is plugged in. An electric range or standard size electric dryer, however, requires a higher level of energy to operate. When consulting the equipment tag on items such as these, you'll find that 240 VAC is required. You'll also notice a big difference in the type of power cord (usually referred to as a *pigtail*) used on the higher voltage appliances.

The source of all alternating current is the AC generator. As you'll recall from Chapter One, we said that electrical energy is generated when a conductor is passed through the lines of force of a magnetic field. It is more correct to say that the conductor is *rotated* as it passes through the magnetic field. The problem with this description is that, for some, it brings to mind an image of a rotating wire—and then a question: “If the wire is rotating, why doesn't it get twisted?” This question is raised because it's common knowledge that the conductor is fastened tight to a connection that allows electrical energy to flow along the distribution system. The initial reaction to this description of a conductor rotating just doesn't fit with this knowledge.

In practice, one way to apply the rotating conductor definition is to provide some type of slip ring connection that would allow contact of the rotating portion of the conductor to the stationary portion. Another more commonly used method is to let the conductor remain stationary and attach the magnets to the rotating portion of the generator. Figure 2-1 illustrates this concept which eliminates the need for a slip ring method. Cutting the lines of force of the magnetic field is still accomplished when the magnets are connected to a shaft that is rotated through mechanical means.

Once you have accepted the fact that electrical energy is generated through the electromagnetic principle, understanding alternating current is easy. All alternating current generated in the United States is delivered to homes and offices at a rate (or frequency) of 60 cycles

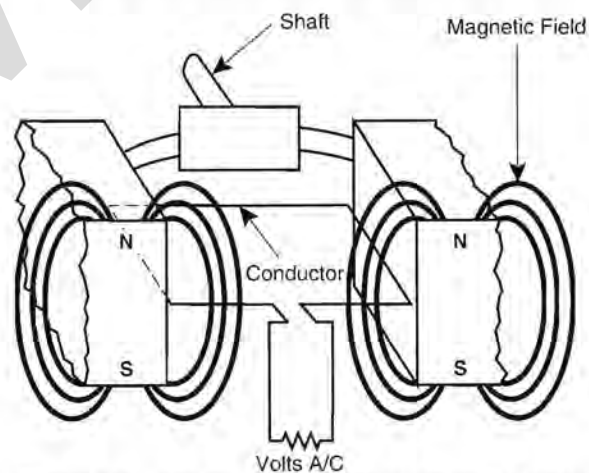


Figure 2-1. An elementary AC generator in which the conductor is fixed and the magnets are allowed to spin around the conductor.

Electrical Distribution Systems

LEARNING OBJECTIVES After studying this Chapter, you will be able to:

1. Understand why the electric company generates power at an extremely high level of energy when the level of power required by the consumer is much lower.
2. Describe the method of construction of a step-up and step-down transformer.
3. Identify the four basic current/voltage systems supplied to customers by the electric company.
4. Understand how an electrical distribution system within a residence delivers power to various types of equipment.



3.1 ELECTRIC COMPANY POWER DISTRIBUTION

Although we've discussed the theory behind the generation of electrical energy, you can't see the electricity. It would be easy to harbor some doubt as to whether or not the things we've talked about are, in fact, real. Despite any doubts about the generation of electrical energy because it can't be seen, we all accept the fact that electricity is something that can be felt, especially when we consider the high-voltage lines that connect our homes to the utility that supplies us with power. To grasp how the alternating current is transported from its point of origin to our homes, where it performs the useful work of operating major appliances, you need only recall the concepts discussed in prior chapters.

Figure 3-1 shows a typical generator you might see on a visit to an electrical generating plant, most of which have several such generators. This one is approximately 5 feet high at its highest point, 8 feet

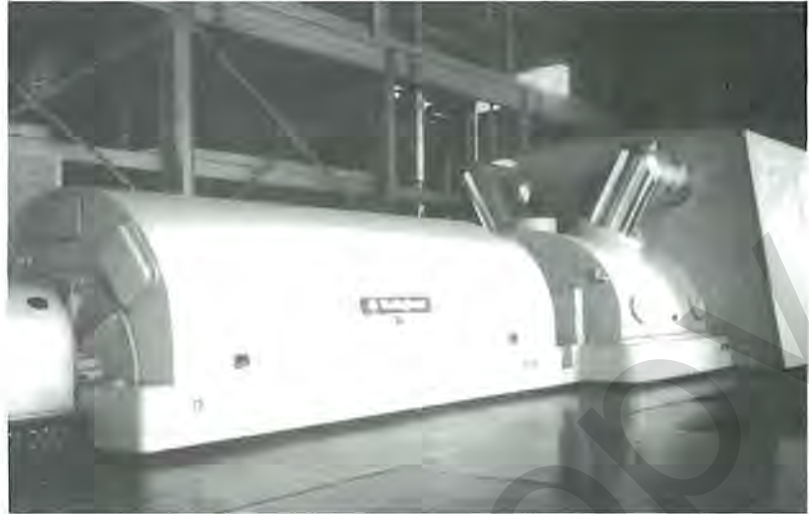


Figure 3-1. A typical generator found in an electric plant. Most electrical generating stations use several such generators to supply power to a service area.

wide, and 15 feet long. As you can imagine, a generator of this size, containing large magnets capable of a very strong magnetic field and accommodating many conductors, is capable of delivering a great amount of energy.

In addition to using generators of large capacity, the electric company also uses another component, the transformer, to achieve the high level of energy (in many cases from 120,000 to 220,000 volts) that is necessary to service a surrounding community. A *transformer* is a device that receives a certain voltage at its primary winding and, depending on whether it is a step-up or step-down transformer, delivers either a higher or a lower level of energy from its secondary winding.

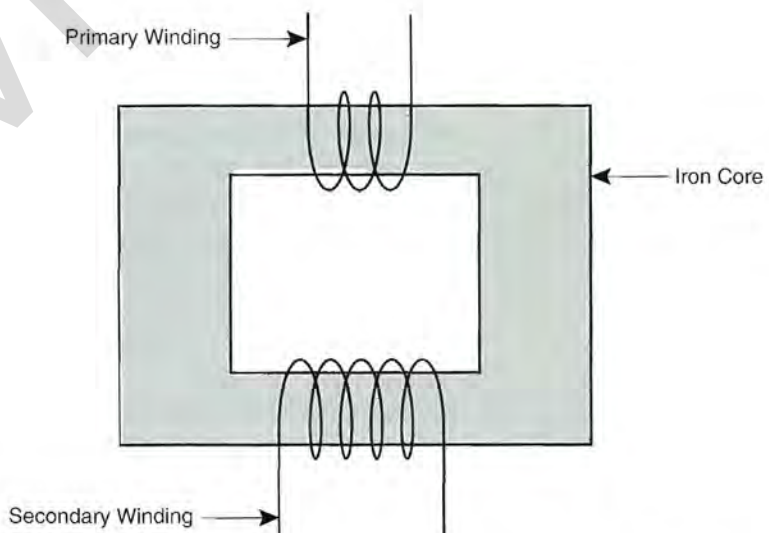


Figure 3-2. A simplified version of a transformer. Note the difference in the number of turns of wire in each winding.

Electrical Components for Major Appliances

LEARNING OBJECTIVES

After studying this Chapter, you will be able to:

1. Identify the different types of components used in refrigerators and freezers, laundry equipment, and cooking appliances.
2. Differentiate between different types of heating elements used in various appliances.
3. Identify a component as a switch or a load.

■ ■ ■

Now that you understand where electricity *really* comes from, as well as how it is transported from the point of generation and distributed throughout a residence, it's time to start applying this fundamental knowledge to the components used in major appliances. To benefit most from this unit, stay focused on the basic definition of electricity: a form of energy that performs useful work when converted to light, heat, or mechanical energy.

When it comes to refrigerators, laundry, or cooking equipment, this basic definition applies on all counts. We use mechanical energy (motors) in several ways, and light for customer viewing of the product or as cycle indicators. We apply electrical power to a wide range of heating elements used in cooking equipment, dishwashing equipment, refrigerators, and electric clothes dryers.

4.1 MOTORS

As an appliance service technician, you'll be replacing motors of many different sizes and styles, used in a wide range of applications. Some motors will be small enough to fit in the palm of your hand,

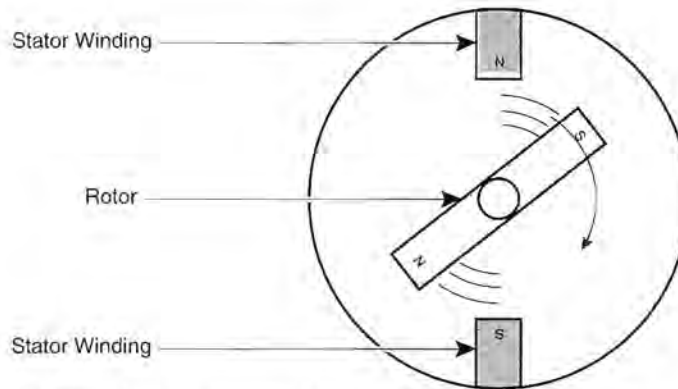


Figure 4-1. An elementary electric motor. The magnetic field set up by the stator winding causes the rotor to spin.

and some will be so heavy and large that it will be a chore to hold them in place while you install them. Regardless of the size, style, or application, the first step in learning to troubleshoot and diagnose motor problems is to understand the elementary electric motor.

Figure 4-1 shows the basic components of an electric motor and illustrates the basic concept (magnetism) behind its operation.

As you can see, the two parts of our elementary motor are the *stator* (the section that *stays* in place) and the *rotor* (the section that *rotates*). Our rotor is really nothing more than a magnet and our stator is the section that contains electrical windings. The law of electrical charges (like charges repel and unlike charges attract) is what makes a motor operate. When electrical energy is applied to the stator windings, a field of energy is set up, specifically an *electromagnetic* field.

Electromagnetic is a key word for you if you fully understood our explanation of the generation of electrical energy in Chapter One. You'll recall we said that, when a conductor is rotated through a magnetic field, a form of energy is set up in the conductor. To understand electric motors, the theory you have to buy into is this: There is a direct correlation between the theory of electromagnetism creating a form of energy in a conductor and the conductor then creating its own magnetic field.

This is illustrated in Figure 4-2. Drawing A shows a conductor positioned in a magnetic field in which rotation cuts the lines of force and sets up a form of energy that can pass along the conductor. Drawing B shows the energy passing along the length of the conductor and, as a result, creating a magnetic field that surrounds the conductor.

To understand how the rotor section of a motor is made to spin, apply the theory of a magnetic field surrounding a conductor in the following manner: The *stator* of the motor is made up of an iron core around which is wound the conductor of a given diameter and length (quite long when you consider the number of turns in a motor winding). This conductor is energized with electricity because it has electrical current flowing through it. A very thin, very tough insulation surrounds the wire and prevents any electrical short that would occur when an

Using Electrical Meters in Appliance Servicing

LEARNING OBJECTIVES After studying this Chapter, you will be able to:

1. Identify the different types of meters used in testing major appliance components and in troubleshooting circuits.
2. Use various meters to measure voltage, amperage, and resistance.
3. Identify specialty meters used in major appliance servicing.



An appliance service technician can comfortably run eight calls a day. In the course of that day, the chances of finding the same problem twice are slim. On one call, you may have to determine whether the voltage applied to the unit is correct. On the next call, you will have to test a control on a dead unit to find out if it is allowing current to pass, and you'll have to use an ohmmeter. Next, you may have to test a motor on an automatic washer to make sure it is drawing the correct amount of amperage. And, to round out your day, you may have to test an oven for the correct cooking temperature or troubleshoot the high-voltage section on a microwave oven.

To accomplish these tasks, you'll have to be familiar with the various types of meters used by technicians, and you'll also need a basic understanding of their method of operation. There are more different brands, types, and combinations of meters on the market than there are different brands of major appliances, and selecting the meters you prefer to use is a matter of personal preference and individual experience.

5.1 MEASURING VOLTAGE

Technicians frequently have to use a voltmeter (or the voltage section



Figure 5-1. A typical analog-type meter used by appliance technicians. Often referred to as a VOM (volt/ohmmeter), it is used for measuring voltage and resistance. (Courtesy of Simpson Electric Co.)

on a multimeter) to test for proper voltage in a wall receptacle. Standard wall receptacles, such as the type you would plug a 120-volt lamp into or a 240-volt receptacle used for electric range and electric dryers, can be checked with a voltmeter. A voltmeter is also used when troubleshooting an appliance for improper operation. On a dishwasher, for example, that is not filling properly, a voltmeter can be used to find out whether or not power is being delivered to the solenoid of the water inlet valve.

A meter like the one shown in Figure 5-1 can be used for either purpose. A meter of this type is known as an *analog multimeter*. It is *analog* because it has a printed scale and because it uses a pointer that moves in response to the electrical input being measured. It is called a *multimeter* because, in addition to measuring voltage, it is capable of measuring other types of electrical inputs (values) such as resistance.

Your inclination might be to be intimidated by a multimeter when seeing it for the first time. There *are* several different scales printed on the meter face, a selector switch that determines the function being used, and, in many cases, several different input jacks into which your test leads may be placed, depending on which electrical function you are using. Don't be intimidated. All reputable manufacturers provide clear descriptions of a meter's features and a concise manual that explains how it operates.

Refrigeration Fundamentals

LEARNING OBJECTIVES After studying this Chapter, you will be able to:

1. Describe the method by which the refrigeration process takes place in a refrigerator.
2. Identify the components in a refrigeration system.
3. Trace the direction of refrigerant flow through a system.



There are those who argue that an appliance technician's job is to repair a refrigerator, not design one. That being the case, it's not necessary to study the methods of heat transfer (often referred to as the *laws of thermodynamics*) to be able to repair a refrigerator that's not functioning properly. While we're in agreement that extensive study in math and engineering is not necessary to become a competent technician, a firm understanding of the basics of how we move heat out of a refrigerator cabinet is essential. Without this understanding, technicians can function to a certain degree. With it they can function with far more confidence and, as a result, be not just competent, but excellent.

Heat is a form of energy that cannot be destroyed, but it can be transferred from place to place. The fundamental definition of *refrigeration* is the transfer of heat from a place where it's not wanted to a place where it's not objectionable. From your point of view as an appliance technician, the place where the heat is not wanted is inside the refrigerator; the place where it's not objectionable is outside the cabinet. As we go through this unit, keep one fundamental idea in mind: *We don't put the cold into a refrigerator, we take the heat out.*

6.1 HEAT TRANSFER

Some basic laws of nature govern the transfer of heat. The first one to be aware of is that heat always moves from a warmer surface to a cooler surface. You could use some complex physics terms to describe this process if your aim was to impress someone, but since our goal is simply to make you understand how a refrigerator works, we'll take the simple approach. If you were to park a black automobile in the Arizona desert in the month of August, the temperature of the hood of that car would probably rise to about 125° Fahrenheit. If you were to then place your hand on the hood of that car, you would definitely experience the transfer of heat from a warmer surface to a cooler surface. Why? Your body temperature is normally 98.6°, and, since you are cooler than the hood of the car, the heat would begin to transfer from the warmer hood to your cooler hand.

To further illustrate this concept of heat transfer, imagine that the same automobile is parked in Minnesota in the month of January. If you were to place your hand on the hood of the car in this location, you would again experience the transfer of heat from a warmer surface to a cooler surface, except this time the heat would be moving from your body to the car.

Another law of nature that governs the transfer of heat is that heat may move in three ways: radiation, convection, and conduction. Understanding each of these will make it easier for you to eliminate the “mystery” behind the process of refrigeration.

Radiation Formally defined, *radiation* is the movement of heat through the air, which doesn't heat the air, but instead heats solid objects. The heating of these solid objects will, in turn, heat the surrounding area. The simplest illustration of radiation is heat energy from the sun. This heat energy passes through the atmosphere without warming it up. But, as the heat energy comes into contact with the earth, it warms its surface. This is, then, one method by which the heat we need to take out of the refrigerator gets there in the first place. It *radiates* in when the cabinet door is opened.

Convection The movement of heat through a fluid is called *convection*. This term is important in the explanation of refrigeration fundamentals for two reasons: First, it explains another method of heat movement into the refrigerator cabinet (moisture in the air carries some of the heat). Second, it explains why a liquid, such as a pitcher of juice, is chilled when it is placed warm into the refrigerator and is cooled by the surrounding air. Convection is also at work when heat is transferred into or out of the fluid that we use inside the coils of the refrigeration system in the refrigeration process.

Conduction The movement of heat through a solid material is known as *conduction*. This is best illustrated by putting one end of a

Refrigerator/Freezer Servicing

LEARNING OBJECTIVES After studying this Chapter, you will be able to:

1. Identify the different types of compressors, condensers, and evaporators used in various types of refrigerator/freezers.
2. Use a wiring diagram to identify components and trace the electrical circuit of a refrigerator/freezer.
3. Describe the different methods that manufacturers use in the construction of various styles of refrigerator/freezers to accomplish air flow and food preservation.

■ ■ ■

If an appliance service technician makes ten calls in one day and works on nothing but refrigerator/freezers, the chance that they would all be the same in construction, specific method of operation, and style would be, to say the least, slim. As a technician, you have to contend with the fact that several different manufacturers of appliances are in competition with each other. As a result, not only do differences exist from one company to another, but manufacturers also have to change their style of construction from one year to the next to maintain their position in the industry. What this means to you is that the 1982 Admiral side-by-side you repaired at 9 o'clock in the morning doesn't look the same as the one you'll be troubleshooting at 4 in the afternoon.

There are some basics that manufacturers can't change. But, to keep the new models coming year after year, a panel may be removed in a different way, a fan motor might be mounted differently, or a feature that appeared last year won't appear on this year's model. Put this all together with the fact that all manufacturers have a product line that ranges from a "bottom-of-the-line" apartment-style

refrigerator/freezer to a 28-cubic-foot side-by-side with an automatic ice maker and a chilled water dispenser, and you've presented a challenge to the person who services appliances. Not only must you become familiar with what is already out there, but you must also keep up with the new developments that are bound to occur.

Studying a textbook or attending a trade school or college training program will give you the background you need to begin working with refrigerator/freezers. The thing to realize, however is that, for you to deal with the various situations as they arise, there's no substitute for field experience.

7.1 TYPES OF REFRIGERATOR/FREEZERS

Whether it's built by Whirlpool, Amana, WCI, or General Electric, there are three basic refrigerator/freezer categories of construction: conventional, cycle defrost (sometimes referred to as automatic and therefore confused with frost-free units), and frost-free. In addition to the three basic categories, there are also variations in cabinet styles, such as single-door, top-mount (a manufacturer's way of saying that the freezer is on the top and fresh food compartment on the bottom), bottom freezer, and side-by-side. For these different types of units to operate, variations of sealed system components and electrical systems are used.

7.2 CONVENTIONAL REFRIGERATOR/FREEZER

The *conventional unit*, so named because it is the simplest of all refrigerator/freezers, contains the sealed system components—the compressor, condenser, and evaporator—in their simplest form without any forced air or defrost systems. Its cabinet is known as *single-door construction* because there is no separate freezer section door outside the cabinet, only an inner freezer door. This type of unit is often found in apartments and may also be supplied with mobile homes. They can be as small as 9 cubic feet in storage capacity and may range in size up to 12 cubic feet. As a general rule, anything from 13 cubic feet on up will be a two-door model unit.

The Basic Refrigeration Unit

An illustration of the conventional refrigerator sealed system is shown in Figure 7-1. The picture shown is actually a page out of an Admiral service manual from a 1976 model unit. Before you jump to the conclusion that we're avoiding using state-of-the-art information, consider what we said at the beginning of this chapter: you need to be familiar not only with the new items that are coming out, but also with what is already out there. In addition, we chose this illustration

Chest and Upright Freezers

LEARNING OBJECTIVES

After studying this Chapter, you will be able to:

1. Identify the different styles of sealed systems used in food freezers.
2. Trace a simplified wiring diagram for a manual defrost and frost-free food freezer.
3. Differentiate between the air flow patterns in a manual defrost and frost-free food freezer.
4. Explain the door lock system used on domestic freezers.
5. Identify the method used to create a counterbalance system on chest freezer lids.

■ ■ ■

Up to this point, we've discussed sealed refrigeration systems as they apply to refrigerator/freezer combination units. While the same basic principles of heat transfer apply in domestic chest and upright freezers, some methods of design are not commonly found in refrigerator/freezer units, but are more widely used on food freezers. The average appliance technician will, in all probability, not work on freezers as often as refrigerator/freezers.

8.1 TYPES OF FREEZERS

Food freezers and their design are easily understood when categorized like refrigerator/freezers. A *food freezer* is defined as being either a manual defrost model or a frost-free model. *Chest-type freezers*, with the rare exception of one or two models equipped with a supplemental heating element system that is energized by manually

setting the cold control in the proper position, are classified as manual defrost units. An *upright freezer* may be either a manual defrost unit or a frost-free unit.

8.2 MANUAL DEFROST SEALED SYSTEMS

Some freezers may come equipped with a refrigeration system design similar to those already discussed, such as a static condenser mounted on the rear of the cabinet or a fan-cooled condenser. In some cases, however, the sealed system design of the manual defrost freezer may appear as the system shown in Figure 8-1. In this case, the condenser is not mounted to the rear of the cabinet, but instead is spot-welded directly to the inner surface of the freezer cabinet.

With this style of design, the entire cabinet surface serves to dissipate heat picked up by the refrigerant as it travels through the evaporator. Another differing feature on this style of sealed system design is the *yoder loop*. As you can see from the drawing, the yoder loop is

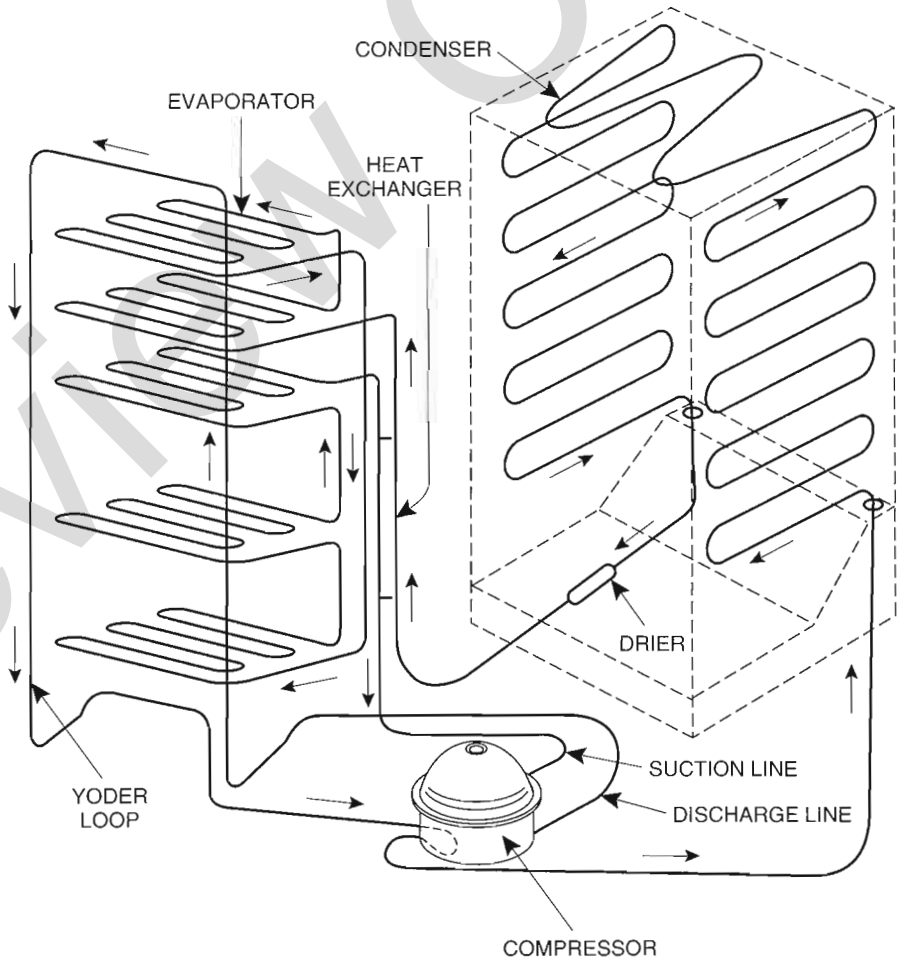


Figure 8-1. Sealed system on a manual defrost upright freezer. The condenser is attached to the inner surface of the cabinet, and the evaporator serves as shelves.

Window Air Conditioners

LEARNING OBJECTIVES

After studying this Chapter, you will be able to:

1. Apply the fundamental principles of refrigeration to a comfort cooling system.
2. Differentiate between the different types of compressors used in window A/C units.
3. Explain the purpose of an accumulator, a desuperheater, and a liquid injection circuit on the refrigeration system of a window A/C.
4. Explain the air handling methods used in the operation of a window A/C.
5. Identify the electrical components used in a window A/C.
6. Trace a simple electrical circuit from a window A/C unit.



In this unit we will again be discussing heat transfer methods used in a refrigeration system, but our focus will be on comfort cooling systems, specifically window air conditioning units. As an appliance service technician, you'll be expected to be able to troubleshoot and repair window A/C units. Some will be small enough for one person to handle, while others will require a helper to gain access to the system's components.

Window air conditioners, also sometimes referred to as *room air conditioners*, will usually be found in sizes ranging from 4,000 BTUs up to 15,000 BTUs. Some manufacturers may offer units slightly smaller or larger than this, but most of the appliance service technician's work with window A/Cs will be confined within these limits. Your customers will have (or at least should have) purchased a unit of the correct size to match their needs, that is, to cool the room they want to cool. You may find this type of unit installed in a window or in a wall opening.

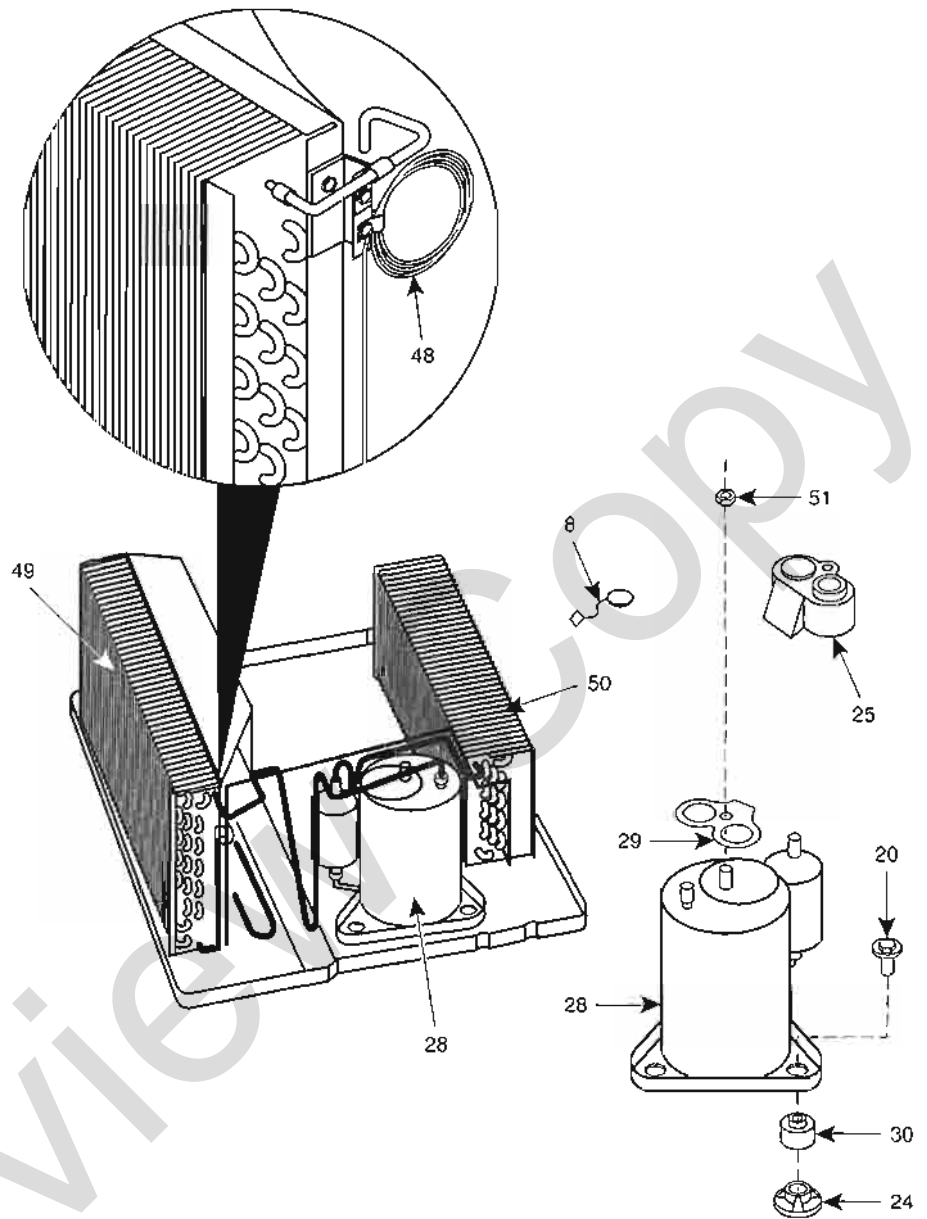


Figure 9-1. The sealed system components of window A/C unit. As in refrigerators, the capillary tube is used as a metering device. Some larger units may use multiple capillary tubes. (Courtesy Fedders Corporation).

9.1 WINDOW AIR CONDITIONER SEALED SYSTEMS

As already discussed, any refrigeration system contains four basic components: compressor, condenser, evaporator, and metering device. Figure 9-1 shows a simplified illustration of a window A/C unit sealed system. In this drawing from a Crosley service manual, the components are easily identified. Component #28 is the compressor, while component #50 is the system's condenser. Component #49 is the evaporator section of the system, and the metering device,

Automatic Washers

LEARNING OBJECTIVES After studying this Chapter, you will be able to:

1. Identify the components that make up the water system of an automatic washer.
2. Differentiate between the various mechanical systems used by manufacturers of automatic washers.
3. Identify the electrical components used in an automatic washer.
4. Trace a simple electrical circuit on an automatic washer schematic.



When it comes to servicing laundry equipment, the appliance service technician has to take a somewhat different approach to troubleshooting and repair. When servicing refrigerators, for example, the differences in design are subtle from manufacturer to manufacturer. Once a technician learns the basic skills required, servicing many different makes and models is easily accomplished. But, when you switch from one manufacturer to another when repairing automatic washers, the differences in design of the mechanical and water systems are dramatic, and learning to repair a wide range of models requires a great deal of field experience.

Certain constants can be applied to laundry equipment. Some electrical components, such as water valves and motors, are fairly simple. Once you learn about them while working on one machine, you can apply that knowledge to repairing another type of machine. But there are a lot of different methods of operation employed when it comes to pumps, transmissions, lint filter systems, and even some electrical components such as timers and lid switches.

To help you understand about automatic washers, we'll first offer an overview of the overall method of operation and discuss some of the general differences between one manufacturer and



Figure 10-1. Pumps. A representation of different pumps used by two manufacturers, Whirlpool and Speed Queen. (Courtesy Gem Products, Inc.).

Clothes Dryers

LEARNING OBJECTIVES

After studying this Chapter, you will be able to:

1. Identify the electrical and mechanical components of a clothes dryer.
2. Explain the air flow system in a clothes dryer.
3. Identify the components in the ignition and burner system in a clothes dryer.
4. Trace a simple electrical circuit in a clothes dryer.



Clothes dryers are simple in their design and construction, and they do not require service as often as other major appliances. Just as automatic washers have different systems that join together and perform a function, the clothes dryer has four different systems: electrical, mechanical, air flow, and heat source. The heat source may be electric heating elements or gas. In the event of gas, today's dryers can be converted from natural gas to LP with a few simple steps. Regardless of the heat source, the mechanical, basic electrical, and air flow systems will be the same.

11.1 ELECTRIC DRYERS

Standard-sized electric dryers operate on 240 volts, and gas dryers require only a 120-volt circuit, plugging into a standard wall outlet. Figure 11-1 shows a typical power cord (often referred to as a *pigtail* in manufacturer's service manuals) and the standard wall receptacle you'll see on a standard size electric dryer. You may see a small apartment-sized electric clothes dryer that operates on a standard 120-volt circuit, but standard-sized dryers that are expected to

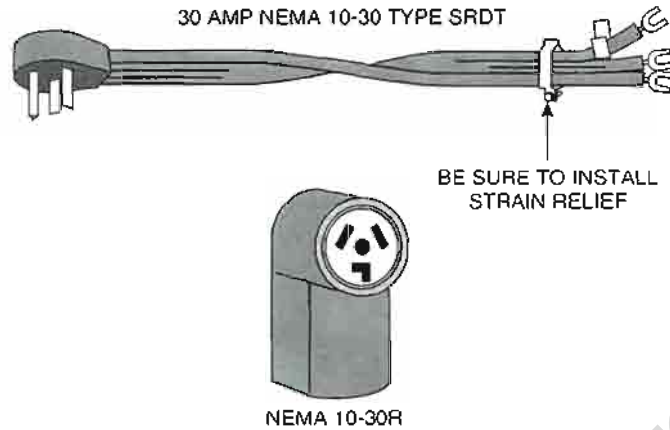


Figure 11-1. An electric dryer requires a 230-volt 30-amp circuit. The power cord of an electric dryer is known as a pigtail, and the receptacle is much different from a standard 115-volt receptacle.

handle a full load from an automatic washer will require the higher-voltage circuit.

In newer homes, the 240-volt circuit will be protected by a two-pole circuit breaker while in older homes, you may find two plug-type fuses used as protection on the electrical circuit. A standard 240-volt electrical circuit for an electric dryer will be rated at 30 amps. This higher-amperage circuit is necessary because of the high current draw of the resistance-type element used in electric dryers. The resistance-type element is the nichrome wire type, often referred to as a *ribbon-type heater*, and is similar in appearance to a heating element in a toaster.

Figures 11-2 and 11-3 show two typical methods of mounting a heating element in a clothes dryer. As you can see, some manufacturers such as General Electric and Maytag, mount the heating element in a plenum located at the rear of the dryer cabinet, while others, such as WCI (Frigidaire, Westinghouse, and Gibson) will mount the heating element in a housing assembly on the base of the dryer cabinet. In other cases, such as Whirlpool (Sears), you may find the heating element in a heater box located behind a cover at the rear of the dryer cabinet. As mentioned, when it comes to laundry equipment, manufacturer's designs differ radically, but the basic performance of the system is the same. In the case of a dryer, air is drawn over a heat source, a motor turns a belt-driven drum to tumble the clothes and operate the blower, and other electrical components control the timing of the cycle and the operating temperature of the unit.

On older dryers, a pulley-to-pulley V-belt drive system was used to accomplish the turning of the drum. Newer units, however, use a much thinner belt that is routed around the entire circumference of the drum. Figure 11-4 shows how the belt is used to tumble the drum. An idler pulley is used to maintain tension on the belt.

Electric Ranges

LEARNING OBJECTIVES **After studying this Chapter, you will be able to:**

1. Identify the electrical components of an electric range.
2. Identify the different styles of electric cooking equipment and differentiate between methods of construction.
3. Explain the method of operation of a self-cleaning oven.
4. Trace a simple electrical circuit in an electric range.



Beginning in the fall and throughout the winter, the appliance technician will find the number of calls on cooking equipment at higher levels than in the summer months. The electric range, wall oven, or cook top are among the types of cooking equipment that will require service. While the positioning of switches and thermostats and some differences in cabinet design may vary from one manufacturer to another, the basic operation remains the same: We use electrical energy and resistance elements to create heat. Controlling the operation of that heating element may be accomplished with variations in the control switching through the use of different types of relays and sensors. Or, in the case of surface units, they may be controlled by a voltage-sensitive switch in one case, by a current-sensitive switch in another. All electric ranges, regardless of design and manufacture, require a 240-volt circuit for operation of the resistance heating elements. A 120-volt circuit is rarely used for operation of a resistance-type heating element. One exception may be on some manufacturer's smooth top units when applying power to the small surface elements.

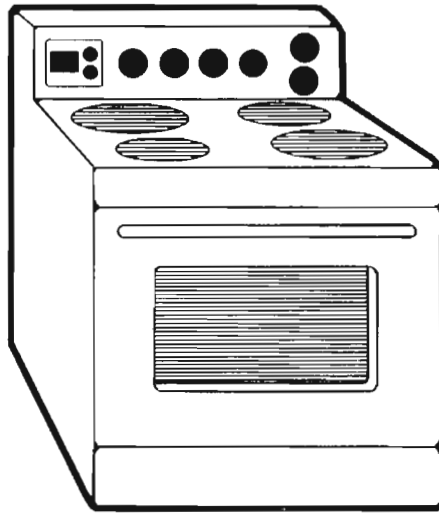


Figure 12-1. The free-standing 30-inch range is the most popular electric cooking appliance. Other sizes are available. Smaller units for apartments and larger units for the customer who wishes to have them.

12.1 THE FREE-STANDING ELECTRIC RANGE

The *free-standing range* is the most common style of electrical cooking equipment you'll encounter as a service technician. The most popular size is the 30-inch, model such as the one shown in Figure 12-1. This shows a standard oven that has four surface units and one oven cavity, in which both the baking and broiling processes are accomplished. With this type of unit, the bake element is located at the bottom of the oven cavity, and the broil element is located at the top.

Like an electric clothes dryer, the electric range requires a different receptacle, and a power cord known as a *pigtail* is used to supply power to the unit. The range pigtail is similar in appearance to the dryer power cord but must carry a higher level of energy since the dryer operates on a 30-amp circuit and the electric range requires a 50-amp circuit.

Figure 12-2 shows a typical electric range pigtail as it is connected to the main terminal block of the equipment. As you can see at the top of the drawing, a reading of 240 VAC will be shown by a voltmeter between points A and C. Correspondingly, points A and C at the bottom of the drawing show where the power cord would plug into the appropriate sections of the wall receptacle. You'll also notice that a reading of 120 VAC will be accomplished from the neutral leg to any of the two hot legs, identified as L1 and L2.

The higher voltage is required for operation of the surface units and bake and broil elements. The lower voltage is used to power convenience lights, clock motor, and, in some cases, the signal lights (sometimes referred to as *pilot lights*). The door locking motor or locking solenoid on a unit equipped with a self-cleaning system may

Gas Ranges

LEARNING OBJECTIVES

After studying this Chapter, you will be able to:

1. Identify the different types of gas ranges used in residences.
2. Explain the difference between standing pilot and electric ignition systems on gas ranges.
3. Identify the fundamental components in a gas range.
4. Trace a simple gas range wiring diagram.



At a distance of 50 paces it's difficult to differentiate between a gas range and an electric range. The cabinet styles offered by gas range manufacturers are the same as those offered in electric ranges.

As an appliance technician, you can expect to find gas range repairs a relatively small part of your responsibilities. This is not due only to the fact that fewer gas ranges are built, but also because many gas ranges are simple in design and breakdowns don't occur as frequently. Older gas ranges are standing pilot systems, while newer, more modern units will be equipped with an electric ignition system for both the surface units and the oven burners. The most common combinations—although not the only ones—consists of surface unit burners ignited by a spark device and the oven burner ignited by a glo-bar device such as the one you will find on a gas dryer.

The actual method of getting the unit into operation varies from one manufacturer to another. Gas valves may be electrically operated in some units (operating voltage varies); in other cases, the gas valve may operate strictly on a pilot/heater pilot system and no electricity is required for main burner ignition.

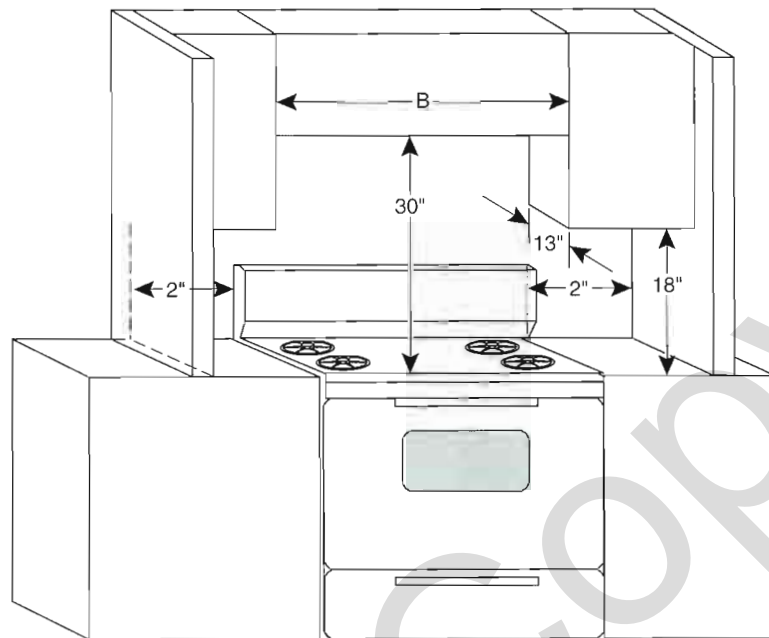


Figure 13-1. The 30-inch gas range is the size found most often in homes using a free-standing unit.

13.1 FREE-STANDING OVENS

The free-standing gas range, like the electric range, is most popularly purchased in the 30-inch size, such as the unit shown in Figure 13-1. Gas ranges may be fit into the cabinet work without worry that they will do damage to the nearby wood materials due to the fact that they are insulated and properly designed for their application.

What serves as a storage drawer on an electric range usually houses the broiling tray on a gas range. The main oven gas burners will, in most cases, be mounted under the panel that makes up the bottom of the oven cavity. While in the bake mode, items placed on the oven racks are heated by warm air circulating around the oven cavity. In the broil mode, items mounted on the broiling tray are heated by a direct flame that is in close proximity. Some manufacturers don't follow this pattern. In those cases, the broiling burner is mounted to the roof of the oven cavity in the same fashion as the broiling element in an electric range. When a unit of this type (both gas and electric) is used for broiling, the manufacturer will usually specify that the oven door must be left partially open.

Figures 13-2 and 13-3 show the typical construction methods used in the gas range designed with two separate burners, one below the oven cavity bottom for baking and the other burner mounted in a position at the roof of the oven cavity for broiling.

In Figure 13-2, the bake burner is shown. The broil assembly is shown in Figure 13-3. You'll note that this particular bake unit uses a flame switch assembly. This means that this range utilizes a *standing*

Microwave Ovens

LEARNING OBJECTIVES After studying this Chapter, you will be able to:

1. Explain how food is cooked by microwaves.
2. Identify the basic components in a microwave oven.

■ ■ ■

Since the development of the microwave oven, one of the major responsibilities of the appliance technician has been to explain the operation of the appliance to the customer to convince them that the unit is not a threat to their personal safety. The reason this situation exists is due mainly to misinformation and false assumptions that microwave signals generated by a microwave oven compares to those signals used in military and powerful radar equipment.

In addition, signs posted in restaurants warning pace maker wearers that a microwave oven is in use have contributed to the customer's unwarranted concerns about the safety of the appliance. In theory, the signal generated by a microwave oven could disrupt the electrical impulses that control a pacemaker, but the wearer would have to be extremely close to the unit and there would have to be a defect in the door seal.

Couple this information with the facts that pacemakers use a frequency far from the the microwave oven signal and that pacemakers are also shielded to prevent any outside interference from outside sources, and you can shatter one of the myths surrounding the mysterious microwave oven.

14.1 MICROWAVE OVEN THEORY

Microwaves are electromagnetic waves of radiant energy. To understand how they accomplish the cooking process, you first have to accept the fact that they exist. One common comparison to microwave energy used in domestic ovens is the broadcast system used in TV and radio systems. There are some similarities. Both systems use electrical energy to send out a signal in a radiant pattern from its source, and both systems generate this signal on a given frequency.

The difference in the two systems is that the broadcast signal is received by a device, such as your radio or TV set, and it converts the signal into sound or a picture. The signal in a microwave oven is used to create friction, which in turn creates heat. The other thing to consider, of course, is that the power level of the TV or radio broadcast station is many thousands of watts, while the power level of a microwave oven is only somewhere in the neighborhood of 400 to 1,200 watts depending on the model and the manufacturer.

The term *hertz* is important (discussed in the chapter on electrical fundamentals). *Hertz* means cycles per second. When we talk about broadcast systems and microwave ovens, we modify the term: *kilohertz*, meaning thousands of cycles per second, and *megahertz*, meaning millions of cycles per second. An AM radio station may generate a signal that operates at 50,000 kilohertz, 50,000 cycles per second. A TV signal may be emitted at a frequency of 204 megahertz, or in simple terms, 204 million cycles per second. This concept can be a difficult one to comprehend—to think that equipment can generate a

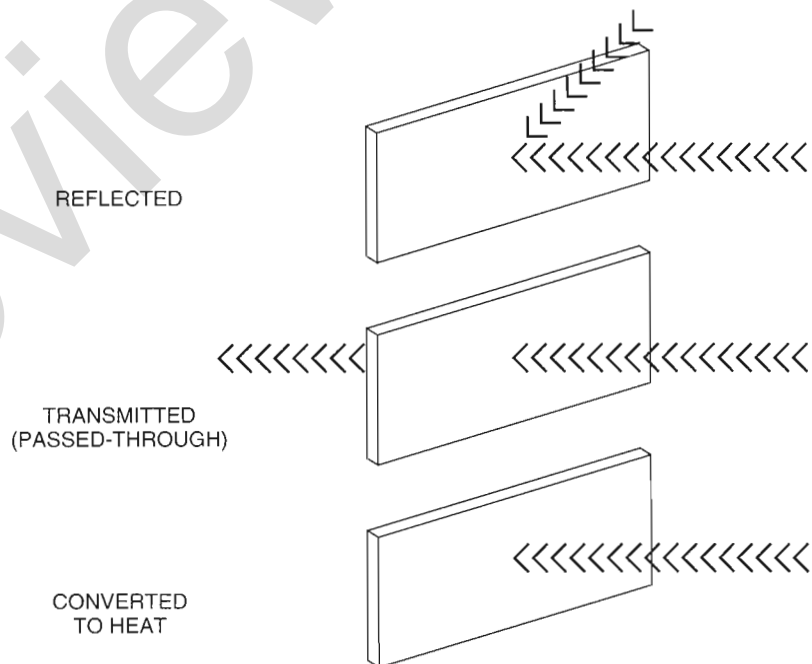


Figure 14-1. A microwave can be reflected by a shiny surface, passed through glass, plastic, or paper and absorbed by other materials such as food and water.

Dishwashers

LEARNING OBJECTIVES **After studying this Chapter, you will be able to:**

1. Describe the basic method of construction of a dishwasher.
2. Identify the electrical components in a dishwasher.
3. Describe the basic method of operation of different brands of dishwashers.
4. Trace a simple electrical circuit in a dishwasher.



Appliance technicians will often be required to install as well as service automatic dishwashers. The dishwasher *change-out*, replacing an old unit with a new one, is the most frequent type of installation. During a change-out, you'll be required to disconnect the power, water line, and drain line from the old machine, unfasten it from the underside of the countertop, then reconnect the water, drain, and electrical supply lines to the new unit, and fasten it to the countertop. Procedures in servicing specific models of dishwashers can vary as widely as those in regard to servicing laundry equipment. The first step in servicing them effectively is to establish an understanding of basic components and apply your basic troubleshooting skills, using common sense to solve the problems you find.

Construction methods vary. The most common method of motor mounting is center-mounted with the shaft pointing up into the tub. Seal assemblies are used to protect the motor. Some manufacturers use a side-mounted motor, and one manufacturer (Maytag) has in past years mounted the motor off to the side underneath the dishwasher tub and used a belt-driven system.

While some things are different, things such as water valves, timers, float switches, and door seals are the same in their basic function from one manufacturer to another. And that's true whether

it's DM (Design and Manufacturing) Company who builds units under several different brand names such as Magic Chef, Admiral, some Sears units and others, Kitchen Aid, Maytag or Whirlpool. The basic method of operation—a wash cycle, a drain cycle, a rinse cycle, and another drain cycle—is the same.

15.1 UNDERCOUNTER DISHWASHERS

The *undercounter*, or *built-in*, dishwasher is the most common unit found in the home. Unlike the portable units, the construction of a built-in is accomplished without an outer cabinet. The tub assembly, which may be plastic or porcelain-on-steel construction, is mounted to a frame that supports it along with the door and electrical components. You may find a thin sheet of insulation around the outer surface of the tub. The purpose of this is to absorb sound. Some manufacturers accomplish sound absorption by spraying a foam insulation on the outer surface of the tub. Figure 15-1 shows a dishwasher tub as it is mounted to its support frame.

Leveling feet on the bottom of the support legs of the unit allow you to slide the unit under the counter, then raise the unit by adjusting them. Some models come with small plastic wheels built onto the back leg section. These allow you to wheel the dishwasher under the counter by lifting up on the front of the unit. Once you have the unit in place, adjusting the leveling legs will raise the unit up off the wheels.

All built-in dishwashers, regardless of manufacturer, are designed to fit into a standard cabinet opening. You'll find that some type of angle bracket is used to fasten the dishwasher cabinet to the underside of the countertop. Standard wood screws, short enough to prevent damage to the counter surface, are used to join the cabinet to

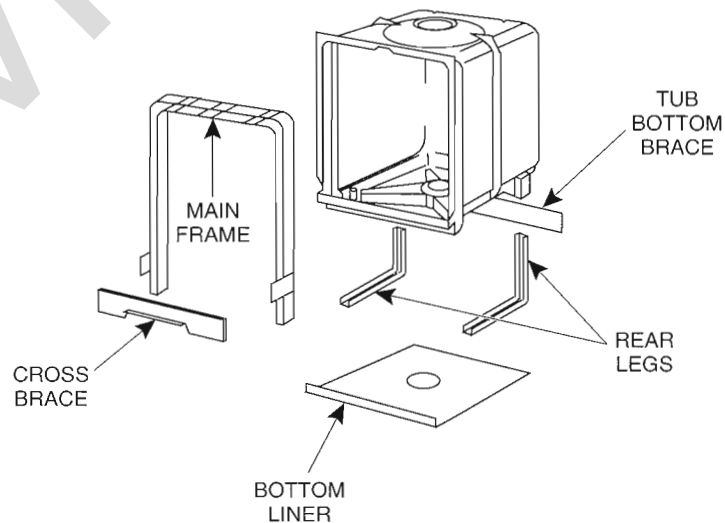


Figure 15-1. Dishwasher construction methods for both an undercounter and a portable dishwasher are fundamentally the same.

Sealed System Servicing

As an appliance technician, you will spend a relatively small percentage of your time servicing the sealed system on refrigerators and freezers. While most of your time will be spent solving electrical problems on various types of appliances and performing mechanical procedures such as replacing pumps and motors, understanding refrigeration systems and knowing proper service procedures is a critical part of your job. It's common for inexperienced technicians to rush into working with the sealed system on a unit that is reported as "running but not cooling" when in fact such a symptom could be indicative of an electrical or air circulation problem. With that thought in mind, we'll go through a short review of the fundamentals of refrigeration as covered in Chapter Six, while at the same time laying the foundation for the development of your troubleshooting skills in regard to refrigeration systems. Refer to Figure A-1.

Compressor. This is a vapor pump that accepts a low-pressure vapor and discharges it as a high-pressure vapor. A compressor may be of the reciprocating (piston) design or a rotary type. Horsepower ranges from a low of $\frac{1}{12}$ for smaller units to a high of $\frac{1}{3}$ for larger units such as side-by-sides or top mount refrigerators above 16 cubic feet. (A bottom freezer of 16 cubic feet and above would also use a $\frac{1}{3}$ HP compressor.)

A hermetically sealed compressor contains an electric motor assembly, as well as the components that accomplish the compression of the refrigerant vapor. Other than an electrical failure, a compressor can fail mechanically by seizing up, in which case it would hum but not start, or there may be a valve failure. In this case, the

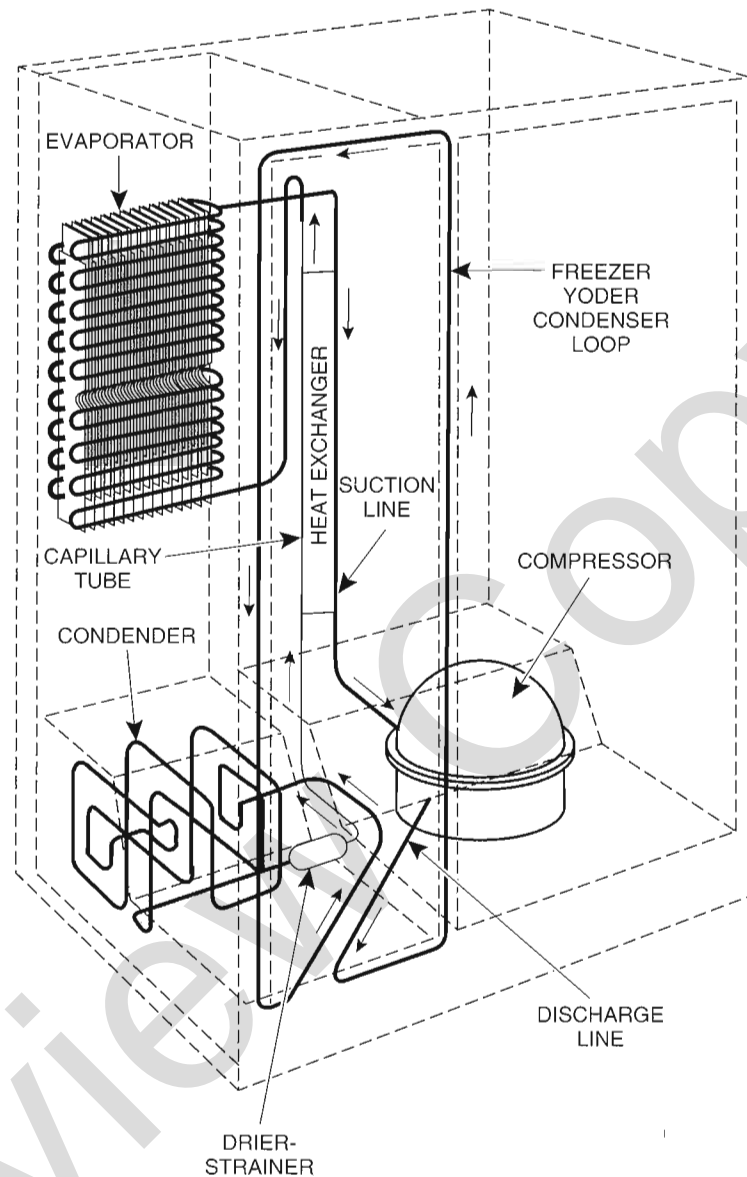


Figure A-3. An illustration of the sealed system of one model of a Maytag refrigerator. (Courtesy Maycor Corp.).

the pressure goes down, the low-side pressure reading on a normally operating refrigerator that is already cooling and has cycled on and off several times is fundamentally not affected by the ambient temperature.

For our discussion on sealed system troubleshooting, we'll be covering the following specific problems:

System overcharge

Undercharge (no leaks, incorrect factory or field charge)

Undercharge (leak on the low side)

Undercharge (leak on the high side)

Partial restriction (high side)

Refrigerator/Freezer Electrical Components

B.1 TEMPERATURE CONTROL

To maintain design temperature, all refrigerators and freezers must have a method of initiating and terminating the refrigeration system. The answer is a control that senses temperature, and then either makes or breaks the circuit to the compressor and other refrigeration components. Your customer may refer to it as the thermostat, some technicians refer to it as the cold control, but most manufacturers prefer to use the term *temperature control*.

The control itself is nothing more than a set of contacts that are controlled by a sensing bulb charged with refrigerant. The sensing bulb (sometimes referred to as a *feeler tube* or *capillary tube*) may be fastened to the evaporator, as in the case of a conventional or cycle defrost unit. Or it may be an air-sensing control, which is the common method of operation in a frost-free refrigerator. From the customer's point of view, the control consists of a knob with numbers. From the technician's point of view, it's a component with two wiring connections, one for power into the switch and the other to allow for power out to the cooling system components. A cutaway view of a temperature control is shown in Figure B-1.

The sensing tube is charged with refrigerant. You'll recall that there is a temperature/pressure relationship between refrigerants, meaning that, if the temperature rises, the pressure rises and, when the temperature drops, the pressure drops. This fundamental idea applies to the temperature control. When the temperature of the evaporator or the interior cabinet air temperature rises, the pressure in the sensing tube rises, overcoming the spring pressure inside the control body and allowing the contacts inside the control to make.

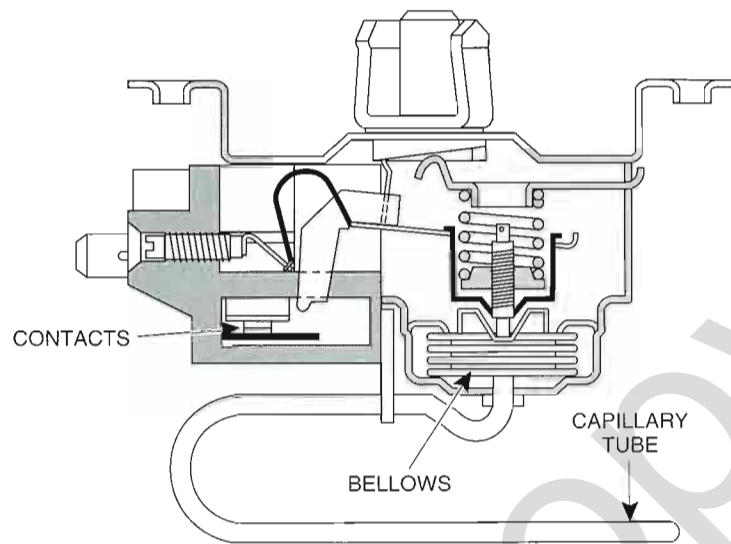


Figure B-1. A temperature control is a switch that is activated by pressure in its sensing tube.

When the temperature drops due to the work being done by the cooling system components, the pressure in the feeler tube drops, allowing the contacts inside the control body to break the circuit to the cooling system components.

A temperature control can fail in one of two ways: Either it will fail in the open position and fail to complete the circuit to the cooling components, or it will fail in the closed position and fail to break the circuit to the cooling components, even though the desired temperature has been reached. Failing in the open position, due either to loss of charge in the sensing tube or to corroded contact points inside the control, is the more common kind of failure. This failure results in a customer complaint of “not cooling, not making any noise.”

When responding to this type of complaint, diagnosing the problem and testing the control can be accomplished as follows:

Step 1: Unplug the service cord from the receptacle. Failing to do this could result in electric shock or tripping a circuit breaker when you allow a hot wire to come in contact with the inner liner of the refrigerator if it happens to be of porcelain on steel construction.

Step 2: Remove the knob from the control. Most simply pull straight off; some older models may require the removal of a screw through the center of the knob.

Step 3: Remove the mounting screws that secure the control to the inner liner, and pull the control out through the access opening or remove the housing that surrounds the control.

Caution! Careful if you're working with a model that requires removal through an opening in the inner liner. The opening may be small, and it may require some twisting and turning to get the control out through the opening. Take care not to damage the control or the liner.

Ice Makers, Ice Dispensers, and Chilled Water Dispensers

The automatic ice maker has been a popular accessory in frost free refrigerator/freezers for many years. Fundamentally, there are two distinct styles of ice makers, the flex tray ice maker and the mold style ice maker. In either case, they can be field installed by technicians but in many cases they are installed at the factory. One exception to the field installed ice maker would be the flex tray type that is designed not only to make ice but also to act as a timing device to initiate the defrost cycle. Whirlpool and Sears refrigerators may sometimes be found to use this type of ice maker control system.

In addition to the automatic ice maker, chilled water dispensers consisting of a water tank for storage in the fresh food compartment, a solenoid valve and connecting tubing are added features commonly found on side by side refrigerators and some top mount models.

C.1 MOLD STYLE ICE MAKERS

The mold style ice maker, sometimes referred to as the Whirlpool or Servel style of ice maker is mounted in the freezer section in such a way that it is directly in the air stream from the evaporator fan. In most cases, the wiring necessary to operate the unit is already built into the refrigerator cabinet but with some models a field installable ice maker kit comes complete with the wiring harness that you'll have to install according to manufacturer's instructions. A mold style ice maker is shown in Figure C-1.

The component that works in conjunction with the ice maker is the solenoid valve. Switches inside the ice maker assembly govern

Refrigerator/Freezer Cabinet Servicing

D.1 REFRIGERATOR INSULATION

Most refrigerators manufactured today utilize urethane foam cabinet insulation to prevent heat gain in the freezer and fresh food sections. The insulation in the door panels is traditionally a fiberglass material, although there may be exceptions. Using a fiberglass instead of foam insulation in the door assemblies allows for easier replacement of the inner door liners, should that become necessary. Styrofoam is also used, usually as a divider between the fresh food and freezer compartments of a top mount refrigerator/freezer. Figure D-1 shows a side view of a typical refrigerator/freezer cabinet that uses a foam insulation between the inner liner and outer cabinet assembly.

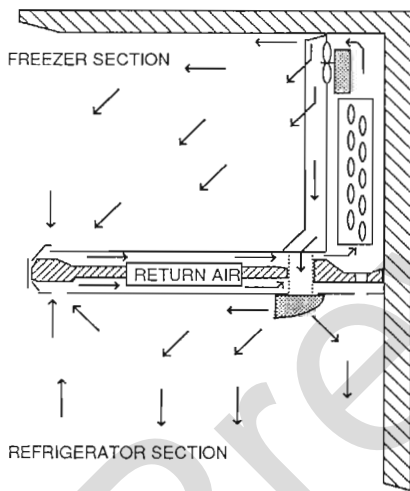


Figure D-1. Urethane foam insulation (represented by the diagonal lines) is used to prevent heat migration into the refrigerator cabinet.

One thing you should remember about servicing a unit with a urethane blown-foam cabinet insulation is that the propellant used to accomplish the insulation process is a CFC, containing the same chemicals used in the refrigerant found in the refrigerator sealed system. When using an electronic leak detector to find a refrigerant leak in this type of unit, the leak detector can be “fooled” into reacting, especially if you’re tracing a possible leak on tubing that runs up into the insulated cabinet.

The styrofoam insulation, such as that found as a divider between refrigerator cabinet sections (shown in Figure D-2), does not cause the leak detector to render a false reading.

Installation Considerations for Major Appliances

E.1 DISHWASHERS

The dishwasher changeout is the most common appliance installation you'll have to accomplish as an appliance technician. The term changeout means that an undercounter dishwasher is already in place and cabinet work will not be necessary. The three things to be considered in a changeout are the water supply line, drain line, and electrical supply.

The minimum requirement for a water supply line is $\frac{3}{8}$ inch, in most cases a soft copper rather than hard drawn copper is used. The soft copper tubing allows for some flexibility in rerouting the water supply line in the event that the water valve on the replacement dishwasher is in a different location (on the right instead of the left side of the machine, for example) or in a slightly different position.

In cases where the dishwasher was installed at the time the home was built, the water line may be routed through the floor or may come directly out of the wall. In cases where the dishwasher was added later, the water line will most likely be teed off the hot water line under the kitchen sink. Figure E-1 shows the three methods of routing water supply lines.

In either case, a separate shutoff valve should be used. In the event that a water inlet valve sticks in the open position or must be replaced due to solenoid coil failure, a separate shutoff valve on the dishwasher supply line will eliminate the necessity to shut down an entire area or the main water supply.

The dishwasher water inlet valve itself accepts a $\frac{1}{2}$ " male pipe thread fitting. The final connection could be a sweat fitting, a flared connection, or a compression fitting that uses a nut and ferrule.

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