Raker

Appliance Repair Professionals, Inc.

Electricity Made Simple

Manual 5

WARNING

SAFETY PRECAUTIONS

Safety is very important when working on any appliance.

Disconnect power before servicing any appliance.
Always keep the work area and your shoes dry.
All appliances have sharp edges and should be handled carefully.

Before working on any gas appliance extinguish all open flames and before attempting any gas associated repair, cut off the gas feed.

Always sniff for gas leaks and soap bubble test any parts that may have been disturbed by repair work.

To minimize any potential buildup of gas in case there is a leak, always have the room open to the outside.

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ELECTRICITY MADE SIMPLE:

Introduction

This lesson is going to teach you the practical electrical knowledge that you need in order to properly service all electrical appliances. Most books on electricity deal with the flow of electrons, deep theory, and a great amount of detail on Ohm's Law.

Theoretical knowledge is not necessary to properly diagnose and repair electrical appliances. *Uncle Harry* going to teach you electricity in a way that will cause my old teachers in Electrical Engineering Department at The Johns Hopkins University to roll over in their graves.

For our purposes the theory doesn't matter. The things that do matter are the following:

1. The concepts must be easy to understand.
2. They must be easy to remember.
3. They must provide a fast reliable method of diagnosis.

Uncle Harry's
Story Time

Stephen Hawking chairs the Theoretical Physics Department at Oxford University. He is reputed to be one of the most intelligent people alive today. Incidentally, he is so physically disabled that he can only speak through a voice synthesizer and is totally confined to a wheelchair. A few years ago he wrote a book, "On Space and Time", for layman like you and me. It is a great book intended to help people understand the concepts of "Black Holes" and the "Big Bang" theory.

His editor advised him that for each equation that he presented in his book, sales would drop by one half. He included only one, in the last chapter, $E=mc^2$. It is very doubtful that Uncle Harry is smarter than Hawking's, but you will find no formulas in this book.

Unfortunately electricity can be a bit dry, but *Uncle Harry* will do his best to liven it up. First, why do we spend a whole lesson on electricity? A very high percentage of appliances can be repaired with little or no knowledge of electricity. Probably 90%! But that is not nearly good enough for *Uncle Harry*.

You can't afford to be caught on 10% of your jobs. It is critical to be able to diagnose and repair **every job.** If you get stuck, one job can completely foul up a day, or even a week. One job in 10 comes along pretty often. *Uncle Harry* wants you to be ready for it.

Many mechanics manage to get by with only the smallest amount of electrical knowledge. Recently, I was amazed to see a sign up list a local parts supply house. It was for a free course in basic electricity, and **most of the veteran mechanics I knew had signed up**.

Obviously, even after years of experience, they still felt uncomfortable with electrical problems.

Incidentally, yours truly, *Uncle Harry*, was teaching summer school in electricity in 1961. You are in good hands.

The problem seems to be that most mechanics don't understand the basic concepts and get confused with the simplest problems.

Being capable of electrical diagnosis really separates the men from the boys. When I had a number of mechanics on the road, I could usually get them out of trouble over the phone. Except for one area; if they were stuck on an electrical problem, I too, was in trouble.

Usually, I had to go to the house to diagnose the problems. All too often, they were unable to perform the tests I suggested. They could not supply me with accurate facts that I needed to help them.

Not being able to perform proper electrical diagnosis leads to guessing and a lot of errors and callbacks. You will avoid that situation and learn correctly from the beginning.

There are a number of basic concepts that must be mastered in order to understand how electricity works in appliances.

They are the following:

1. Current Flow

2. The Language of Switches

3. Using your Multimeter

4. Circuit Diagnosis

In this lesson we will cover these concepts, along with a great deal of practical information.

Current flow

Electricity is often compared to water flow in the pipe. I have never really liked the analogy. To some extent it's true, however, electrons don't fall out of the end of the wire onto the floor and pile up like water does out of the end of an open hose. If electrons did that, we'd have a big pile of them underneath all the receptacles in our house, wouldn't we?

There are other problems with the water analogy. Electricity follows it's own set of very specific laws. Those laws are very different from the flow of water and will be covered in this lesson.

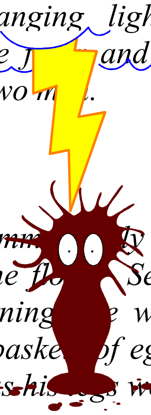
For our purposes, electricity only flows through a good conductor, mostly copper wires. Air is a very poor conductor, and that is why electrons don't pile up on the rug. It take a very high voltage to create a current flow through a poor conductor. Lightning for instance has a high enough voltage, millions of volts, in fact. Lightning will jump right out of an outlet and burn a path across a rug.

Uncle Harry's

Story Time

A "good ole boy" told me a story of his farming childhood. A storm was brewing and he decided to come in from the field. While walking down the road, he found a big black snake also getting out of the rain. He picked it up and wrapped it around his arm. As the rain began he rushed into the family's large chicken coop, black snake still wrapped happily around his arm.

One of the farm hands had just finished loading up two large baskets of eggs and was getting ready to leave. At that moment, lightning hit the coop and came down the hanging light fixture. It jumped to the floor and seared a path between the two men.



The snake immediately uncurled and dropped to the floor. Seeing the snake and the lightning the worker instantly dropped the basket of eggs and headed west, as fast as his legs would go.

It takes about 10,000 volts to jump an inch of dry air. Standard household voltages is a maximum of 240 volts. This is too small to jump at all.

Only in TV's and microwaves do we find high voltages. In microwaves, the high voltage section is clearly marked for danger. The high voltage in the microwave is between 10,000 and 15,000 volts. BE CAREFUL, IT CAN JUMP!

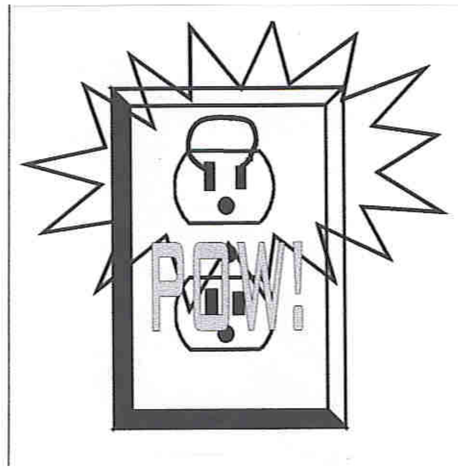
Ohm's Law

In order for electricity or "current to flow", it must complete a loop or circuit. Lightning is special, it flows from the clouds to the ground. In appliance work, we only concern ourselves with normal circuits or loops that are controlled by copper wire.

Copper has a very "low resistance" to the flow of electricity. Copper carries very large amounts of electricity or "current" with ease. For instance, if you took a piece of copper wire and stuck one end into each side of a normal 110 VAC socket, current would flow. In fact, a lot of current would flow. It would probably kick the breaker, and maybe, blow up the receptacle, and you.

The amount of the current flow is determined by the resistance in the loop or circuit.

Short Circuit



If the resistance in the loop is low, the current is high. If the resistance is high the current is low.

This inverse relationship is known as Ohm's Law. Pretty simple really, wouldn't you say. The typical analogy, often used, is a pinch in a water pipe. A restriction acts the same as a resistance in an electric circuit.

In the experiment above, when you blew up the receptacle, there was no resistance and a "short circuit" occurred. In order for a controlled amount of current to flow we need to introduce the correct amount of resistance. On most household circuits we need to keep the current at less than 20 amperes. Otherwise we will pop the circuit breaker.

Loads

The component or resistance that determines the amount of current is called a load. Loads include devices that actually do work. Examples of loads are:

1. Motors (fan motors, drive motors, compressors, timer motors)

2. Heating elements (bake elements, dryer elements, defrost heaters)

3. Copper Coils (water valve solenoids, dump valve solenoids)

4. Light Bulbs

Switches, timers, controls, and thermostats are not loads.

They are merely breaks in the circuit. They only serve to connect and disconnect the loads.

Power Sources

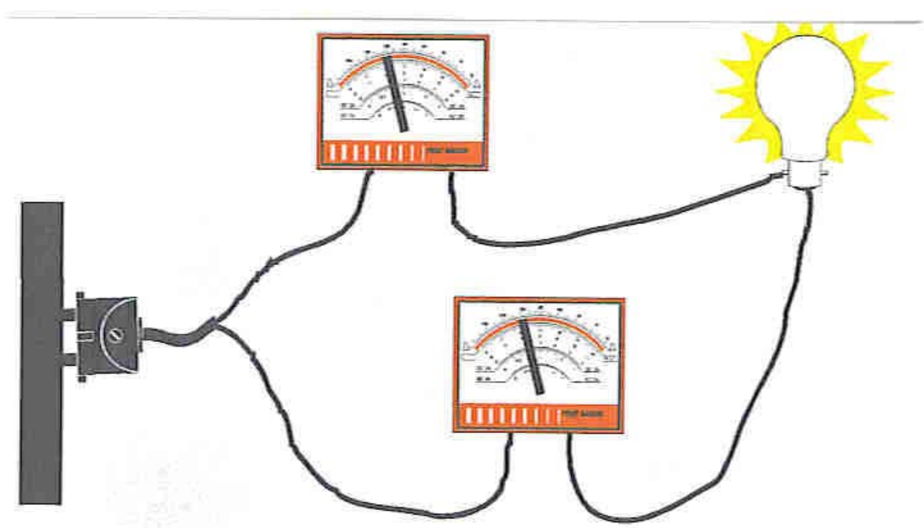
For our purposes, the power source is the utility and the power in either 110 or 220 VAC (volts alternating current). There is no need for us to study direct current and compare it to alternating current. It is too complicated and will accomplish little. All of the logic in this lesson works equally well on direct and alternating current. Today, direct current is only found in portable devices, toys, and cars. Most of the world operates on AC.

For the moment, we assume that we have a stable power supply provided by the local utility. House power problems and breaker panel circuitry will come later.

Current Loops

Look carefully at a simple circuit.

Measuring Current



TWO AMPMETERS IN A LIGHT BULB CIRCUIT

The current flow in any one loop is uniform throughout that loop.

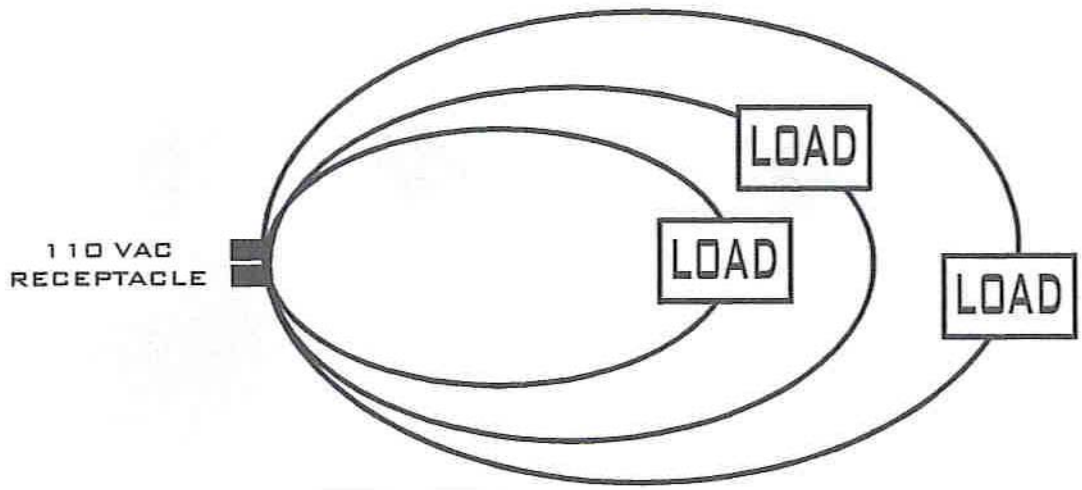
For instance, in the above circuit we connected a light bulb with a line cord to a 110 VAC outlet. The two meters measure the same current flow in either wire. The light bulb **does not use up the electricity** as it passes through.

Whatever enters a load must also exit that load.

The tungsten filament within the light bulb is the only resistance in the circuit. The resistance drops the current flow down to a fraction of an ampere, about 0.5 amps, enough to light the bulb.

Each load device must be provided with its own loop. In symbolic terms, all appliances or even a house are wired in the following way.

Circuit Loops



The loops may be numerous and look complicated but the logic doesn't change

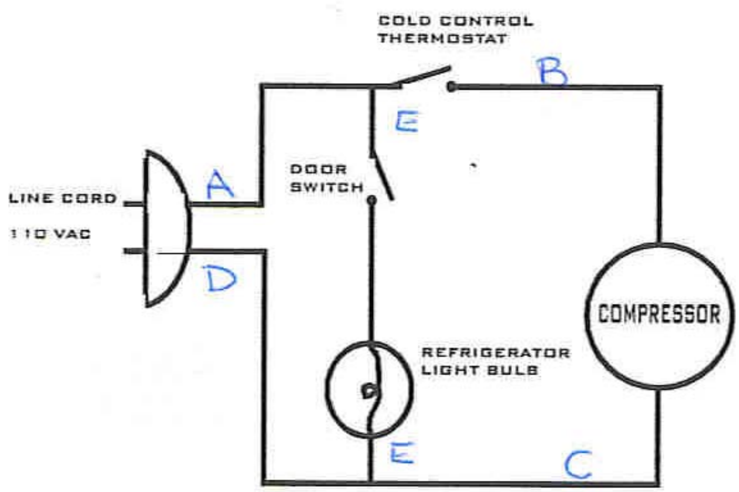
Now you may be wondering why all this talk about loops. The reason is simple. Loops are circuits.

Diagnosis of electrical circuits involves "breaks or failures" in circuits.

Once you understand a circuit , it is not hard to find breaks.

Look at a more complicated circuit:

Simple Manual Defrost Refrigerator Circuit



Making Current Tests

In the second example there are two circuits, one to the bulb and one to the compressor.

Simple symbols are used for the line plug, switches, the bulb, and the compressor. Wires A and D are the line cord wires. The current in both of them is always the same.

Current A = Current D

When the light and the compressor are both on, the current in circuit A will be:

Current A = Current B + Current E

Likewise

Current D = Current E + Current C

In practical terms, the currents might be:

Both A & D = 5.2 amps

Both B & C = 5.0 amps

E = 0.2 amps

The logic is simple. No current disappears. It merely divides into the various circuits and neatly adds back up at the second line cord wire. Circuits can get very complicated with many loops carrying currents simultaneously. During diagnosis, only one circuit is checked at a time.

For instance, while checking a frost-free refrigerator defrost heater, the compressor circuit is of no concern. Even in the previous, simple example, a problem in the door switch, completely eliminates the cold control and compressor circuit from consideration.

Technicians often get confused because they are not sticking to one circuit at a time. They get lost, by unknowingly, testing other parts of the circuit.

Unfortunately, it is usually impractical, and often not very informative, to make current tests. Most of the time the basic problem is "lack of current flow".

Common examples are:

1. A dead bake or broil element

2. A cold dryer heating element

3. An inoperative defrost heater

4. A dead dryer

5. No water to a dishwasher

Testing for current flow with an ammeter wouldn't tell you very much.

You already know there is no current flow!

Uncle Harry's

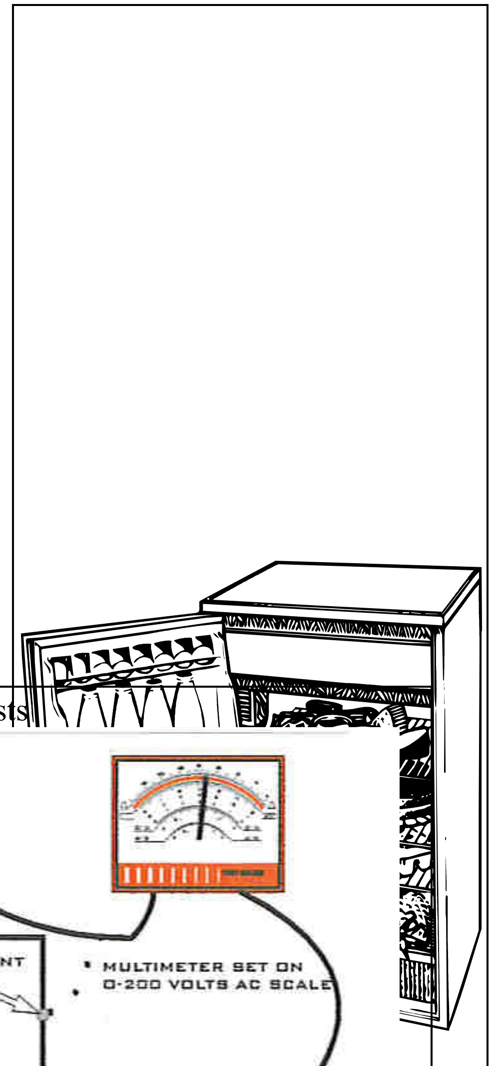
Trick of the Trade # 80

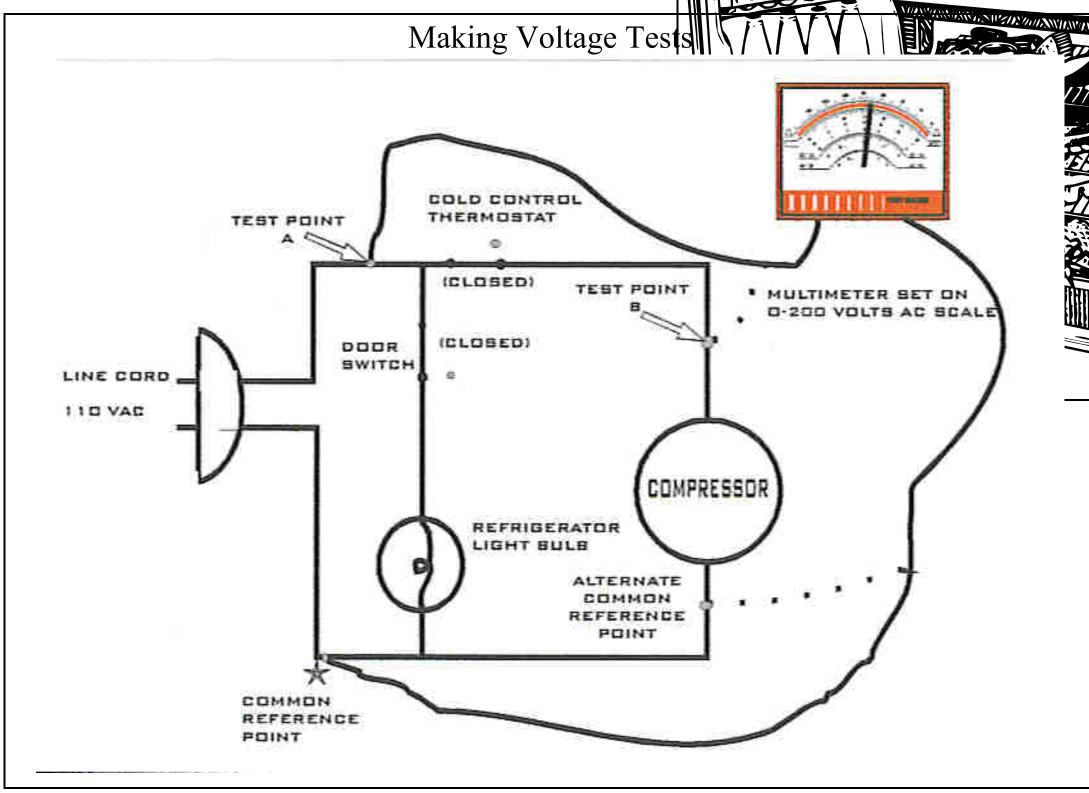
Uncle Harry owns a nice Amprobe ammeter, but it gets used less than twice a year in 1000 service calls. Learn to use a voltmeter properly for the surest diagnosis.

Making Voltage Tests

Voltage tests are a lot harder to understand than current tests. However, if properly performed, they provide essential information.

Go back to the simple refrigerator circuit and turn on the light and the compressor. This is the equivalent of standing in front of the frig with the door open, deciding on dinner.





Using test leads that terminate in small alligator clips, imagine connecting them as shown. The star indicates the "common side of the line" a concept we will cover momentarily.

Test point "A" will read the line voltage, if the power supply and line cord are intact. If the reading is zero, the solution is simple.

You will be surprised at how simple much of electrical diagnosis really is.

Uncle Harry's
Story Time

Until you really are into this business, it is hard for you to imagine how incapable many people are of using the simplest logic to repair their own appliances. ***My secretary*** *fixes a great number of appliances right over the phone.*

She doesn't even tell me about most of them anymore. She simply asks logical questions. For instance:

1. If an appliance is dead she asks , "Is it plugged in?" "Have you checked the circuit breaker?"

2. If a refrigerator is thawing out and dead she asks, "Is the light on when you open the door?" "Was it on before you starting having the problem?"

3. If a disposer is dead she asks, "Have you checked the reset button underneath?"

4. On a cold gas stove, "Does it have a pilot light? Have you checked it?"

5. No water coming into a washer, "Have you checked the water cutoffs?"

Yes, it all really happens!

Overall, it is not good for business to charge "service charges" for stupid information. It is best to eliminate all the obvious things before going on a call. In doing so, a better relationship is established and more referrals result.

Next, connect the meter between "B" and the common. It should measure 110 VAC. There are now two possibilities. These possibilities lead us to a series of very important electrical laws. These laws must be memorized.

1. Law #1. If line voltage is measured across a load, the load should be operating. If it is not operating the load is bad or the internal load wiring is broken.

2. If no voltage is present at the load there is a break somewhere else in the circuit.

Connect the meter between Test Point "A" and "B"

There are again two possibilities.

1. If line voltage appears across a closed switch the switch is faulty. It is not closed, it is open.

2. If no voltage appears the switch **may** be closed and operating properly**.**

No voltage will ever appear across a closed switch.

Law #2. An open circuit will measure full voltage.

Law #3. A short circuit will measure zero voltage.

Unfortunately, there are other reasons for no voltage. No voltage is only a clue and requires further testing.

By testing and using these three simple laws, you can analyze any circuit, no matter how complex.

As you can see, it is important to understand the difference between loads and switches. The laws apply to each one in different ways.

We will leave the heavy theory for a while and come back later.

Understanding "Common," "Ground," and Home Wiring

For your own safety and overall understanding we are now going to study house wiring. Improperly installed house wiring, and problems with ground systems are common and important to understand. Appliance service calls are frequently the result of house wiring problems.

Fortunately for us, over the years, electrical engineers have developed standard ways of wiring homes and appliances. We will review the development of these conventions.

Back in history, early in this century, homes were first wired with electricity. Originally, only two wires were brought into the house and the voltage between them was 110 VAC.

Actually Thomas Edison, in New Jersey about 1900, believed direct current was the best method and built a large utility distributing it. But that's real history and we don't need to go back that far.

Following is a sketch of the early type of house wiring.

Early Electrical House Wiring