

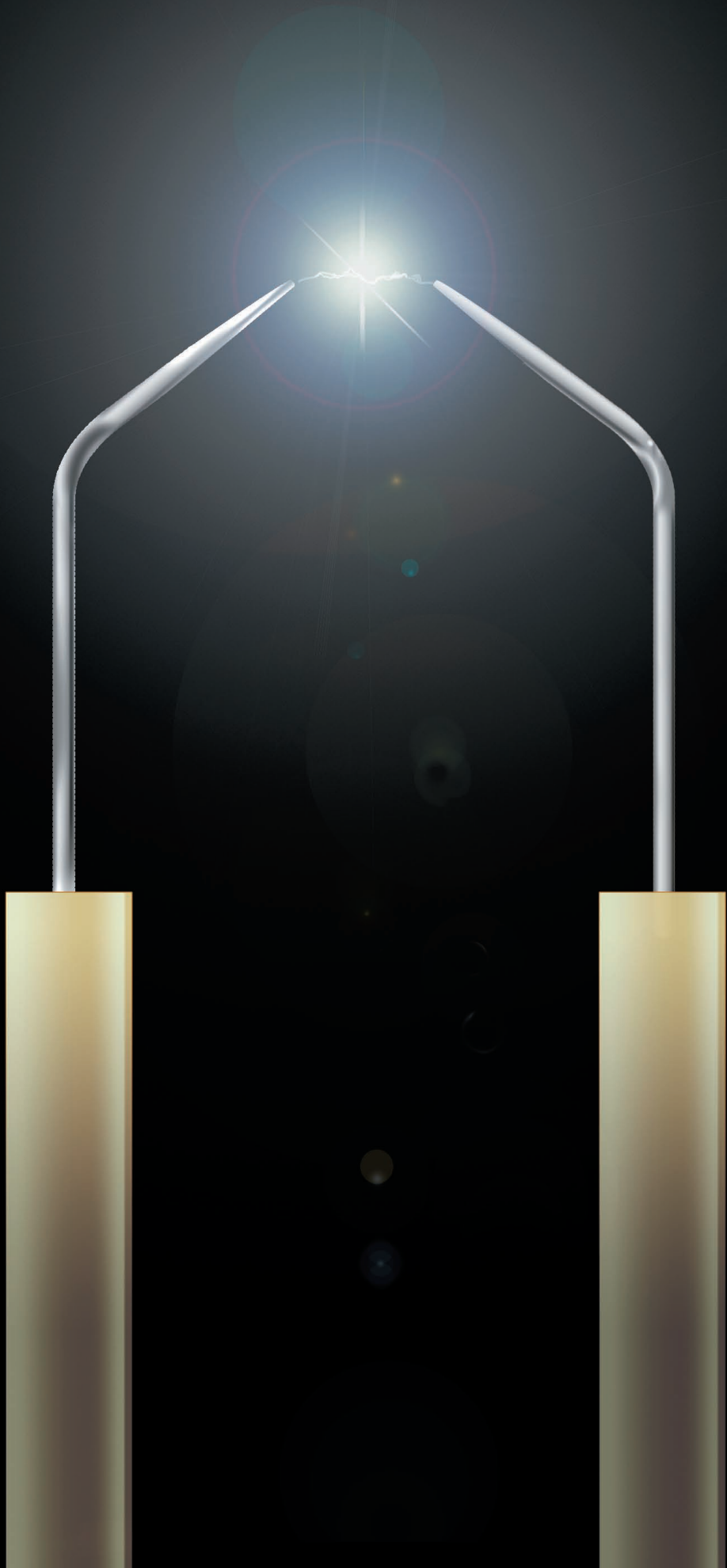
# Chapter 9

## IGNITION SYSTEMS



### IN THIS CHAPTER

- Interrupted and intermittent (constant duty) ignition
- How ignition transformers and ignitors work
- Testing transformers and ignitors
- Servicing and troubleshooting the ignition system



## Chapter 9

# Ignition Systems

## Introduction

The completely automatic electric ignition system is an important part of oilburner technology. There are two different main components used for ignition systems on oilburners: the ignition transformer and the solid state ignitor.

The **ignition transformer** is a step-up transformer using copper windings around an iron core. It steps up the incoming voltage of 120 volts to an output voltage of 10,000 volts. This is accomplished by a 90 to 1 primary to secondary winding ratio around the iron core.

The **solid state ignitor** utilizes electronics to produce an output voltage of any-

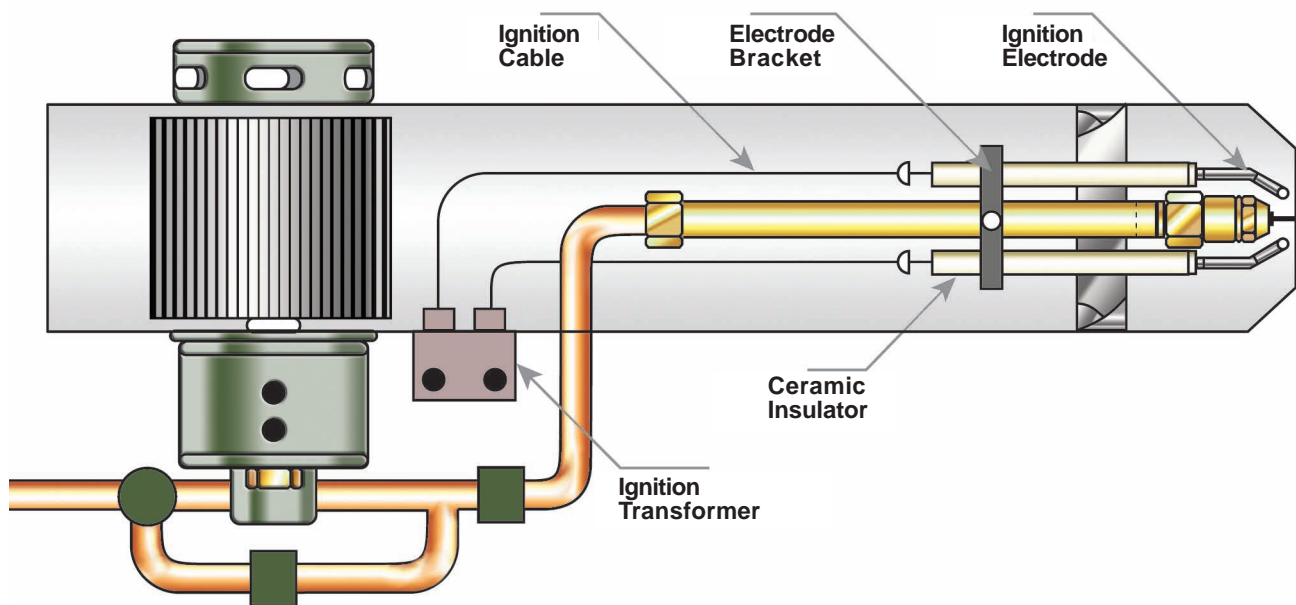
where from 14,000 to 20,000 volts peak.

Both components supply this high voltage electricity to the electrodes. A spark jumps from the tip of one electrode to the tip of the other. The electrical arc then ignites the atomized oil.

Let's examine the various components of the ignition system shown in Figure 9-1.

The voltage travels from the transformer or ignitor through the ignition cables, buss bars, or spring clips to the electrodes which are held in place by the ceramic insulators (porcelains). When it reaches the tips of the electrodes it jumps the gap between them, creating our spark.

**Figure 9-1:**  
Ignition system  
components



Oilburners use one of two types of electric ignition control systems:

**Interrupted ignition:** the ignition spark remains on for only a short time at the beginning of each burner operating cycle, and is turned off once flame is established.

**Intermittent ignition:** the spark that ignites the oil vapors remains on as long as the burner runs. Intermittent ignition used to be called “constant ignition,” and some manufacturers call intermittent ignition “constant duty ignition.”

## Interrupted ignition is better

Over time, the industry has switched between interrupted and intermittent ignition. Interrupted ignition has proven superior because having the spark on during the entire burn cycle *detracts* from performance for several reasons:

- Electrode life is significantly reduced.
- Ignitor or ignition transformer life is significantly reduced.
- Electrical consumption is increased dramatically.
- Operational noise is increased dramatically.
- Intermittent ignition may hide combustion problems that can cause soot-plugged boilers and oil running saturation. The constant arc keeps the flame burning even if it is belching smoke, soot, and unburned oil. With interrupted ignition, a poor flame goes out and the unit would go on safety.
- NOx (nitrogen oxide) emissions are

higher with intermittent ignition because the spark burns nitrogen, creating NOx.

## A strong spark

The spark across the electrode gap at the tips of the electrodes must be strong enough to withstand the velocity of the air being blown through the air tube by the burner fan. The air being blown through the air tube forces the ignition spark to form an arc toward the oil spray. This arc extends into the spray causing the oil vapors to ignite, and the flame to establish. The ignition voltage must be high enough to create a spark that is hot enough to ignite the oil. In some cases, widening the spark will produce better ignition.

## The transformer

The AC transformer is a device that receives electricity at one voltage and delivers it at another voltage, either higher or lower.

Essentially, the transformer consists of two separate coils of wire wound on an iron core. One winding receives the electrical energy from the power source and is called the primary; and the other delivers electrical energy and is called the secondary. If the secondary winding delivers a voltage that is higher than the primary, then it is known as a step-up transformer. On the other hand, if the secondary voltage is lower than the primary voltage, then it is known as a step-down transformer.

The factor that determines whether a transformer is of the step-up or step-down variety is the relative number of turns in the primary and in the secondary windings.

Step-up transformers are used for ignition purposes on oilburners.

Generally, it will be found that ignition transformers are made up of 90 to 100 turns of fine wire in the secondary coil to one turn of stout wire in the primary coil. In the example, you will note there are 60,000 turns in the secondary and 690 turns in the primary coil, a ratio of about 90 to 1. In Figure 9-3 on following page, we can see what the ignition transformer looks like with its outer case removed.

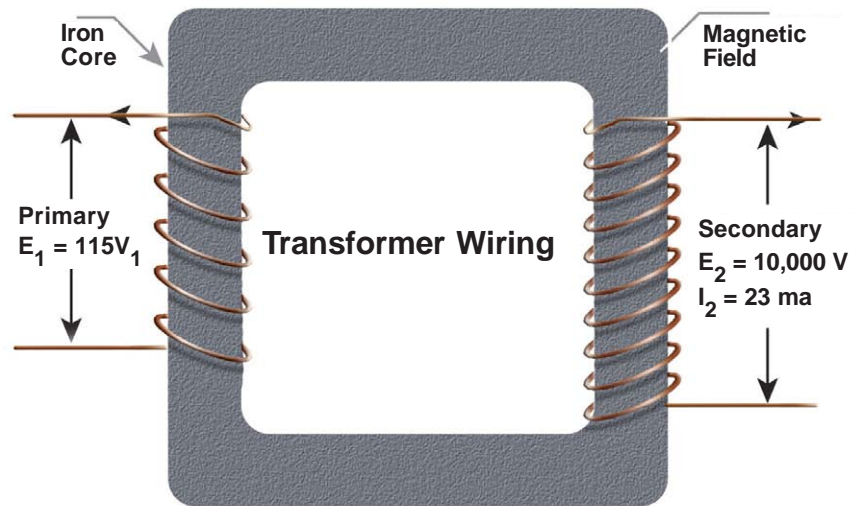
### As voltage increases, amps decrease

This is a good time to explain a most important characteristic of transformers, see Figure 9-2. The rule: If the voltage (E) flowing out of a transformer is increased, the current, or amperage (I), is always decreased proportionately. For instance, if the voltage is doubled, the current will be cut in half. In the case of the transformer in our example, the primary voltage of 115 volts is increased 90 times to 10,000 volts in the secondary coil, where the current flow ( $I_2$ ) is 23 milliamperes, which is 23/1000ths of one ampere. Although not shown in the example, the current flowing in the primary coil can be determined by multiplying .023 x 90, or about 2 amperes, which is average for ignition transformers. This can be proven in the field by checking amperage in the primary circuit with an amperage meter.

### Moisture proofing

It is important that both the primary and secondary coils of the ignition transformer

Figure 9-2:  
Transformer wiring



$$\frac{E_2}{E_1} = \frac{N_2}{N_1}$$

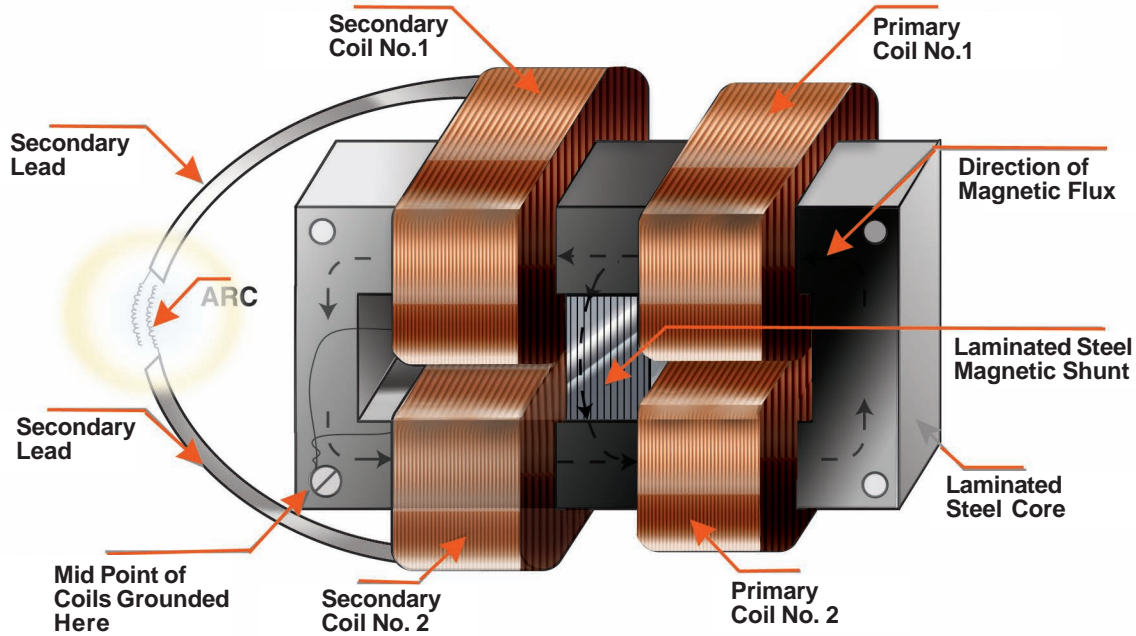
$$\frac{10,000}{115} = \frac{60,000}{N_1}$$

$$10,000 N_1 = (115) (60,000)$$

$$N_1 = \frac{(115) (60,000)}{10,000}$$

$$10,000 N_1 = 690 \text{ TURNS}$$

**Warning!** All high voltage circuits, especially AC circuits, are potentially hazardous. Depending on the size of the person, contact area and time, and voltage characteristics (magnitude, frequency, and path), electric shock can occur and cause bodily damage, burns, or death. Use extreme caution at the input or output end of an ignition transformer!



**Figure 9-3:**  
Construction  
of an ignition  
transformer

are covered with a tar-like compound, whereas solid state ignitors feature epoxies which serve the purpose of moisture proofing the device. Epoxy, by its very nature, is somewhat more resistant to moisture and acts as an excellent corrosion inhibitor and heat conductor.

### If you must replace a transformer

When ordering replacement transformers, several facts must be known:

1. The size of the mounting base and location of mounting holes
2. The position of high tension terminals

3. The style of transformer high tension clips
4. Secondary coil voltage
5. Primary coil voltage
6. Transformer body size

### Wiring ignition transformers

Wire the ignition transformer into the burner circuit as follows:

**For intermittent ignition**, attach a wire from the transformer or ignitor to the neutral wire, and the other wire to the orange motor wire from the primary control. See Figure 9-4 for wiring a



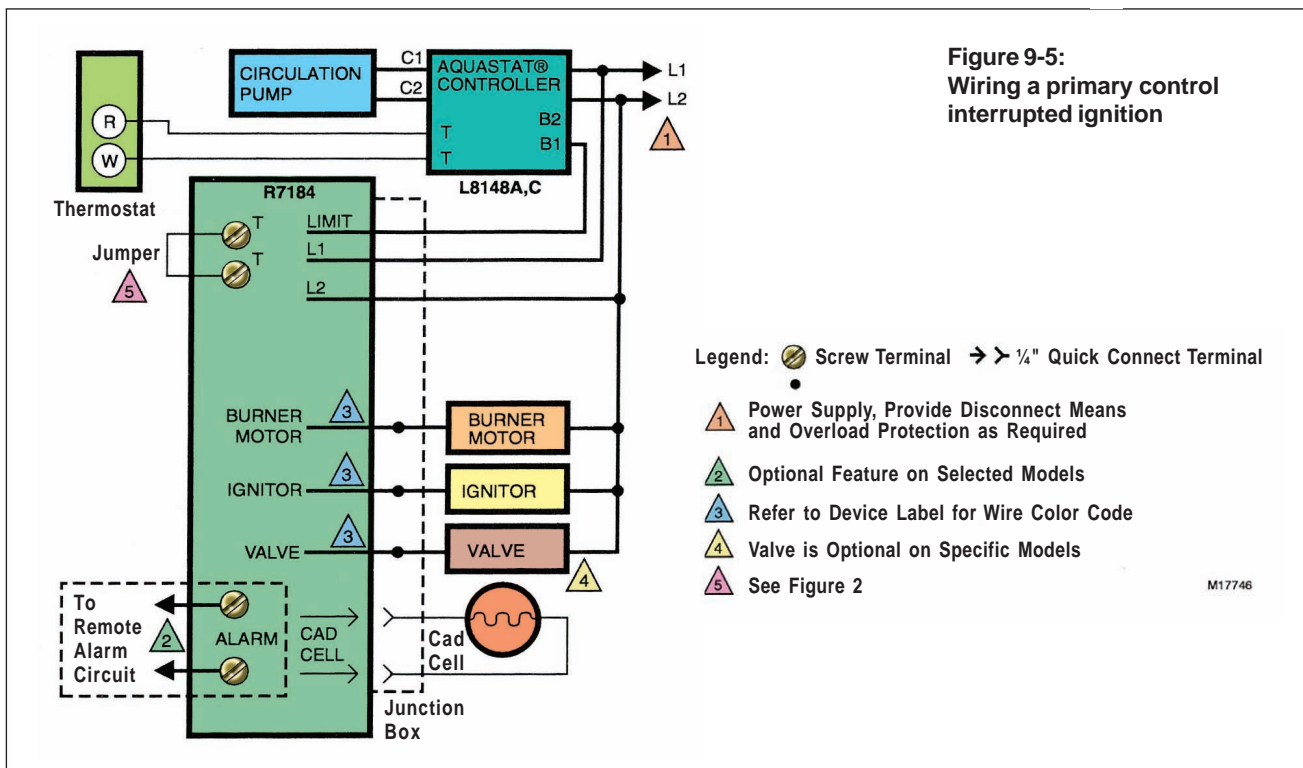
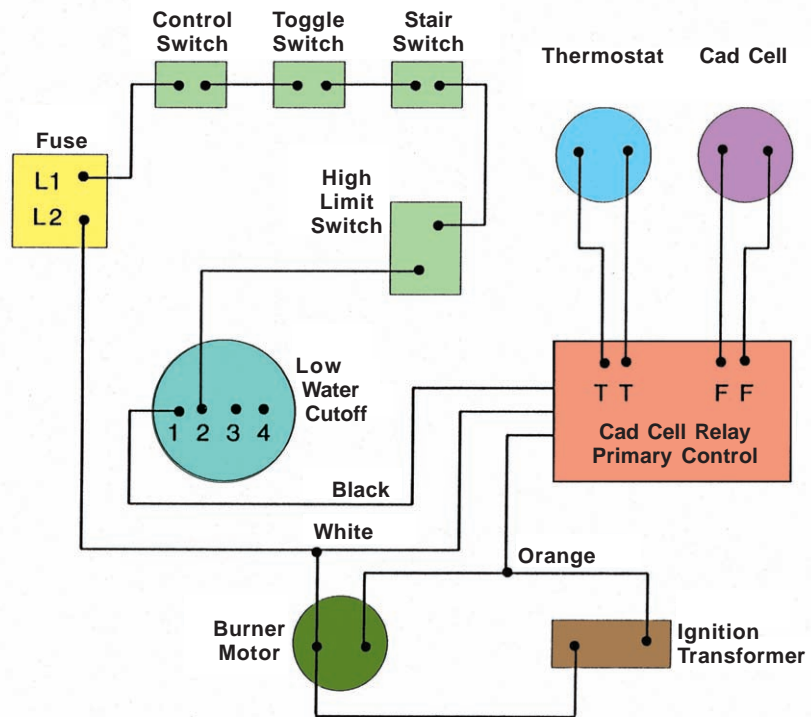
Figure 9-4:  
Wiring a primary  
intermittent  
ignition

primary intermittent ignition (the spark is on whenever the motor is on).

**For interrupted ignition**, you need a primary control built for this purpose.

Attach one wire from the transformer or ignitor to the neutral wire and the other wire to the ignition wire or terminal on the primary control.

See Figure 9-5 for wiring a primary control interrupted ignition (the spark shuts off once flame is established).



## Drawbacks to iron core ignition transformers

An ignition transformer does just what it claims to do—it transforms voltage. There is a single copper winding on the primary side for every 90 to 100 windings on the secondary side and that is how it transforms voltage. This becomes a problem when input voltage drops. For every one volt you remove from the primary side, you remove ninety volts from the secondary side. The ignition of the atomized oil is not a result of the spark, but rather the result of the heat generated from the spark.

Remember, the ability of an ignitor to ignite oil depends on more than just high voltage; it depends on arc output as well! Spark heat energy = voltage times current. You must provide between 600-700° Fahrenheit to ignite atomized No.2 fuel oil.

**Note: 9,000 volts by itself is not what is required to ignite oil; 9,000 volts is considered sufficient to create an arc across the air gaps between the electrode tips normally used in oil-burners. The secondary current flowing through the arc heats the air and lights the oil. The important factor in creating an arc is voltage; the important factor in igniting the oil is current. This is why Underwriters Laboratory (UL) requires 10,000 V ignition transformers to have a short circuit current of at least 19.5 MA (11.6 MA across a 1/8" air gap). Most 10,000 V ignition transformers our industry uses are rated for 23 MA.**

This translates to approximately 9,000 volts and about 19 MA short circuit current. A 10,000 volt 23 MA transformer only has a small margin of error built into it, and can be a problem.

## A few facts

- Ignition transformers are insulated with tar. Tar can melt with heat and the tar oozes from the transformer and typically deposits on the combustion head assembly, making for a nasty clean-up.
- An ignition transformer's tar-covered windings are susceptible to moisture infiltration. Moisture infiltration will cause an immediate shorting of the component.
- Electrical consumption with an ignition transformer is typically 80 to 100 watts of electricity. This is the approximate equivalent to a 100 watt light bulb turned on over the burner when the transformer is running.
- Finally, ignition transformers deteriorate over time. During this deterioration, they cause delayed ignition problems that worsen until, finally, the transformer can no longer light the atomized oil.

## Transformer testing

Over the years, there have been many and various methods of testing transformers. Regardless of the method used, one thing must be kept in mind and that is to be sure the transformer has the correct input voltage to the primary coil. This is very important because the output of the transformer is relative to the input voltage. In other words, if the input is down by 10%, the output will also be 10% lower.





**Figure 9-6: One of several transformer testers available**

Several types of transformer testers are available, Figure 9-6. These testers are dependable and usually come in their own carrying case with all the instructions. The one shown will also act as a backup transformer and can be left on the job as a temporary solution and this can be especially helpful with older obsolete burners. When using any one of these testers, read the instructions for that particular tester because competitive units will operate differently.

## Resistance testing

Another test for iron-core transformers is to check the quality of the windings using an ohmmeter. The following procedure is used:

1. Turn the power to the unit off. Disconnect the primary leads from the circuit.
2. Test the resistance across the primary winding. Attach the test leads from your ohmmeter to the primary leads of the

transformer. You should get a reading of 3 ohms, plus or minus 10% (2.7 through 3.3 ohms). If your reading is higher or lower, you should replace the transformer.

3. Test the secondary side of the transformer. Touch one of your ohmmeter leads to a secondary terminal and the other to a mounting screw or ground. You should get a reading of 12,000 ohms plus or minus 10% (10,800 through 13,200).

Then perform the same test from the other secondary terminal to a mounting screw or ground; you should read approximately the same. If you get a higher or lower reading that varies widely, you should replace the transformer.

The following table is used with this procedure for specific brands:

Trade Brand	Primary Leads	Secondary Posts (each post to ground)
Allanson	2.4 ohms	9,200 ohms
Dongan	3 ohms	12,000 ohms
France	3 ohms	12,000 ohms

## Solid state oilburner ignition systems, electronic ignitors

Manufacturers are now mostly using solid-state electronic ignitors. These units are known for their small size, light weight, and starting power. They may be for dedicated use on a particular type of burner and are also available in generic

versions for retrofit applications, depending on the mounting plate used. Output voltages of between 14,000 volts and 20,000 volts peak with amperages between 16 MA to 45 MA respectively, on the secondary coil, are considered normal, Figure 9-7.

A solid state ignitor is a radical departure from the traditional ignition transformers commonly used on oilburners. Solid state ignitors eliminate transformer design shortcomings. Ignitors utilize a solid state printed circuit board with what is called a ‘tank mechanism.’ This technology allows the ignitor to have a more constant output if the input voltage decreases. Therefore, we have fewer problems with voltage drops.

Ignitors are insulated with epoxy, not tar. Epoxy is virtually resistant to heat and will not melt on the combustion head assembly. This same epoxy makes the ignitor virtually impervious to moisture. Electrical consumption from an ignitor is 30 to 50 watts, much less than the transformer. Ignitors are made from solid state electronic components and are truly ignition control systems.

### Testing electronic ignitor systems

Since these units contain solid-state devices such as transistors, their troubleshooting and servicing should be done to manufacturers’ recommendations. Do not use a transformer tester to test electronic ignitors. Doing so will give you an inaccu-

Figure 9-7:  
Ignitors



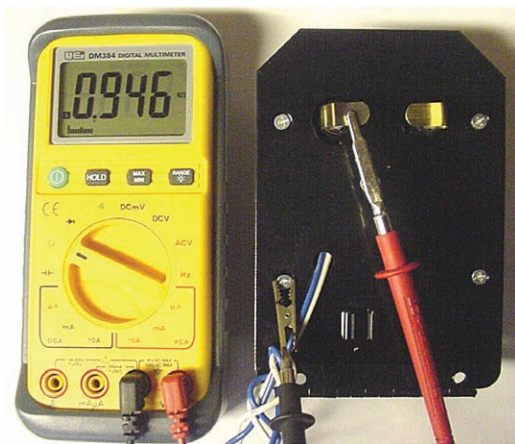
rate measurement and may harm the ignitor and tester. Testing electronic ignitor systems is different from testing ignition transformers because ignitors utilize a high frequency output. The cycling operations of a solid state ignition system are 20,000 times per second. Standard AC transformers cycle at 60 times per second. This is the reason you cannot test a solid state ignitor with a standard ignition transformer tester.

The testing of electronic ignitors is more complicated than testing the iron-core transformer. Before you perform any of these tests, make sure the manufacturer approves of the test, and be extra careful not to directly short the terminals without a spark between them. In many cases, it will short out the ignitor and destroy its internal circuitry. Keep in mind that ignitors are not merely a pair of coils, but rather a complex electronic device made up of several electronic circuits and components.

The first basic test for ignitors is to place an ohmmeter across the ignitor output terminals with the power off and measure

the resistance from each ignitor post to ground, Figure 9-8. Normally, the ignitor is considered good if the resistance from each post to ground has no more than a 10% difference between posts. Each manufacturer is different and they should

**Figure 9-8: Ohmmeter test**



be consulted for the proper output range and differential. It's also important that you verify continuity between the ignitor case ground and true ground.

Another test that is approved by most manufacturers is to bring the ignitor output terminals to within  $\frac{1}{2}$  to  $\frac{3}{4}$  of an inch apart and turn on the power, Figure 9-9. A strong blue spark should be generated. Another trick is to let it spark for a few minutes, five to ten in most cases, and see if the spark changes from blue to orange; if it does change, replace it.

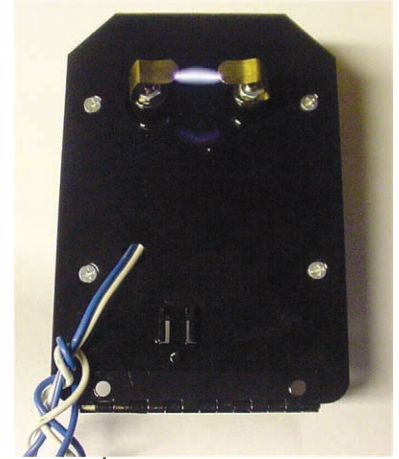
Finally, you can check both electronic ignitors and iron-core transformers with a common test. Bring the ignitor or trans-

former output terminals to within  $\frac{1}{2}$  to  $\frac{3}{4}$  of an inch apart. Place a milliammeter in series with the hot line going to the ignitor and turn it on, Figure 9-10. Again, the reading should stay steady and not vary for at least five minutes with a strong blue spark throughout the test while staying within 10% of the rated amperage draw for the device.

### Cables, buss bars, spring clips

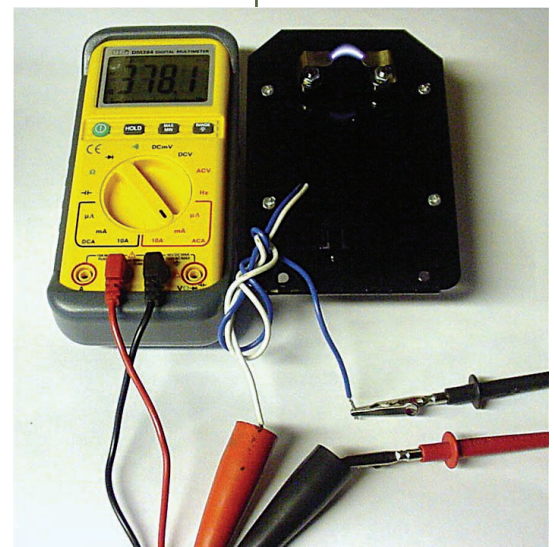
In order to transport the high voltage from the secondary terminals of the ignition transformer, an effective and efficient path must be provided to the ignition electrodes. This path may be an ignition cable, buss bars, or spring type conductors.

**Ignition cables** are normally constructed of heavy stranded copper wire covered with special heavy insulation to insulate against dampness, and ensure transmission around, over, or under any other conducting surface between the transformer location and the electrodes. The outstanding feature of ignition cables is flexibility, permitting easy handling, bending and installation in any burner. Some nozzle assemblies are equipped with clips to hold the flexible cable off the bottom of the burner air



**Figure 9-9: Spark test**

**Figure 9-10: Milliammeter**



tube, especially when the air tube is long; if they are provided, use them.

**Buss bars** are non-insulated heavy gauge strips of metal that are made by the oilburner manufacturer to the length and shape to fit a certain model of burner; they are not interchangeable with other models.

**Spring clips** are similar to buss bars, except that contact with the transformer is maintained by spring tension. After some time, these clips can lose their tension and prevent proper and desired contact. They should be checked whenever the burner is serviced.

## Electrodes

Electrodes are metal rods made of specialized steels, and partially covered with a ceramic (porcelain) insulator, Figure 9-11. These insulators are usually made in two major external diameters (7/16" and 9/16"). As we can see in Figure 9-13, these porcelains come in various lengths. They may be ordered in individual lengths 4" to 30", or they may be sized on the job through the use of a special tool for cutting the porcelain insulator.

Figure 9-11:  
Electrodes



The porcelains serve two purposes: They securely position the electrode rods and they serve as insulators, protecting the metal rod against shorting out to the nozzle assembly. These insulators are center bored to fit the metal electrode rods, either 1/8" or 3/32" in diameter.

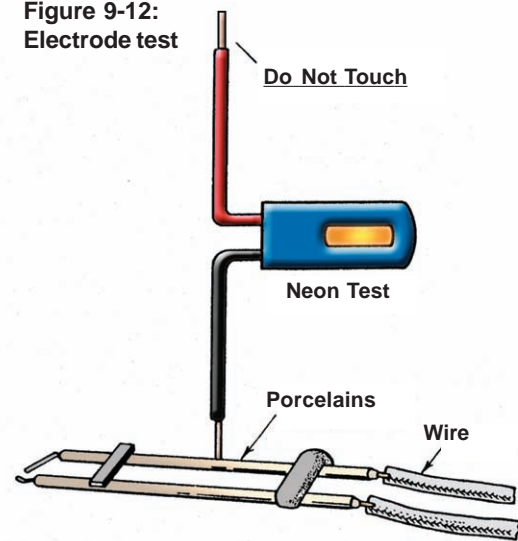
Electrode holders permit secure and correct mounting

of the porcelains and electrodes so that, after adjustment, they cannot shift from vibration or other causes and alter their position. In many cases, the electrode holder is incorporated with the air spinner or turbulator.

## Electrode testing and setting

Figure 9-12 shows one method for testing the porcelain insulator of an electrode for spark leakage. A neon test lamp, with one probe touching the ceramic insulator, the other end of the test lamp free, is shown. By moving the one end of the test lamp over the surface of the porcelain, it can be easily determined whether or not the ceramic insulator is

Figure 9-12:  
Electrode test



cracked. If the insulator is defective, the neon test lamp will glow when the probe reaches the defect.

Figure 9-13 is a setting for electrodes when one is not available from the manu-



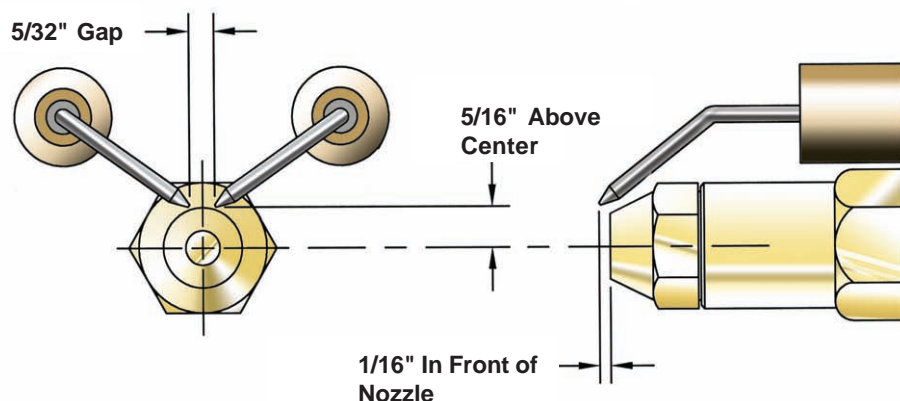
facturer. The recommendations of the burner manufacturer should be followed whenever they are available. Electrode tips should never be permitted to touch or extend into the oil spray, because a carbon bridge will build up between them, ultimately causing ignition failure.

Ceramic insulators should always be treated gently. They should never be dropped or packed loosely in service kits. In field servicing, they should always be wiped clean with a cloth, or cleaned with a solvent. If they show signs of aging or cracking, they should be replaced immediately.

## Ignition service problems

Correcting faulty ignition is important. Delayed or faulty ignition is the prime cause of puffback. Puffback is the most disagreeable of all burner problems. It occurs when ignition is delayed. Due to some fault in the ignition system, the oil vapor does not ignite until after the burner has run for some time. Then the accumulated vapors all ignite at once, creating more combustion products than the venting system can handle. Delayed ignition can cause soot to blow out of the draft regulator, and in severe cases—called puff backs—it can knock down the flue pipe.

Ignition problems are usually the easiest to recognize and solve. In most cases, we find it necessary to merely clean the electrodes and cables, and be certain that all connections are tight and that the spark gap is in proper adjustment. We must make certain that the electrode porcelains and the



transformer terminal porcelain insulators are not crazed (small cracks on surface), cracked, or oil soaked.

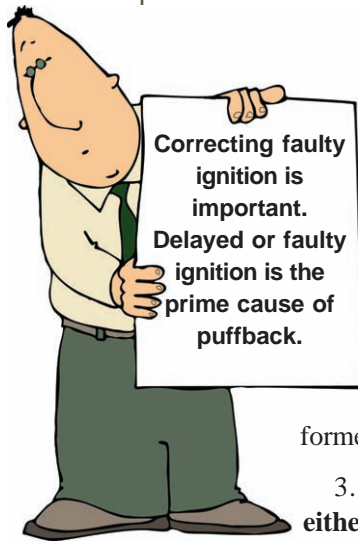
It is important that all exposed metallic components of the ignition system be a safe distance away from any other metallic part of the burner, since it is grounded. The shortest metal-to-metal distance throughout the entire ignition system should be that distance between the two electrode tips. Common sense tells us that any other arrangement would cause the spark to short out before the spark bridges the electrode tips. The best way to avoid this problem is to strictly adhere to the recommended electrode tip settings as shown in the manufacturer's recommendations.

## Troubleshooting ignition problems

1. **Connections at transformer junction box loose.** Always check line voltage connections from the neutral wire of the primary control and the orange wire of the primary control (for intermittent ignition) and the ignition wire of the primary (interrupted ignition) to determine if there are loose connections at this

**Figure 9-13:**  
Typical generic  
setting





**Correcting faulty ignition is important. Delayed or faulty ignition is the prime cause of puffback.**

junction box. If they are loose, tighten them securely. Also check for loose connections at all terminals and make sure that wire nuts are tight.

2. **Test the transformer.** If the transformer is defective, replace it.
3. **Loose connections at either the secondary terminals of the transformer, or loose connections where the high tension leads or buss bars are fastened to the electrodes.** If these connections are found to be loose, attempt to tighten them. If this fails to solve the problem, replace the connectors. Also clean out any dust or dirt that may have accumulated in or around the secondary terminals of the transformer. As previously outlined, check the high voltage leads to determine if the insulation has become defective.

4. **Remove the porcelain insulators from the electrode holder to determine whether they are cracked.** In many cases the porcelains will crack beneath the clamp of the electrode holder. Replace cracked or crazed porcelains, even though they are still functioning properly.

5. **Carbonized insulator.** Carbon accumulations on the ceramic insulators will conduct electricity, thus causing the spark to short out against either the nozzle adapter, nozzle line, or the electrode holder. The carbon must be removed with a solvent or cleaner. Then the insulators must be dried and checked for cracks and/or spark leakage. The procedure for checking for spark leakage has been outlined.

6. **Electrodes in oil spray.** If the

electrode tips are permitted to operate while extending into the oil spray, it will promote a carbon bridge between the electrode tips, thus shorting out the spark and ultimately causing ignition failure. Clean the electrode tips and set them properly.

7. **Electrodes too close to the nozzle.** It has already been outlined that the electrodes set too close to the nozzle will promote spark shorting out from the electrode tip to the nozzle, thus creating a delayed ignition or ignition failure. Set electrode tips according to prescribed procedure.

8. **Spark gap too wide.** If the spark gap is too wide, either there will be no spark at all, or the spark will short out at some other point along the ignition system. Again, set tips as instructed previously. However, we are learning that in many applications today, and due to the changes in fuel oil, a slightly wider than normal gap may result in smoother ignition. Ignition of fuel is not an exact science and so a couple of settings may have to be tried to find the best results.

9. **Insulators not held securely.** In the event the electrode support bracket is loose, or the porcelains do not fit properly in the bracket, it is possible that the electrodes may move out of adjustment because of burner vibrations. Set electrodes and tighten the electrode support bracket securely, but do not overtighten because that may crack the ceramic insulators.

10. **Puffbacks may be caused by lack of draft.** If it is discovered that the ceramic insulators are heavily sooted and/or carbonized and the electrode tips are properly gapped and properly set, then it is

a good possibility that lack of overfire draft is causing the trouble. Refer to Chapter 6—‘Chimneys & Draft.’ Puffbacks and carbon may be caused by a partially clogged nozzle. See Chapter 5 on Nozzles.

**11. Ignition “on” time should be checked.** This, of course, concerns interrupted ignition primary controls. The ignition “on” time is easily checked by connecting one lead of a 40-watt test light to the ignition wire of the primary, and connecting the other lead to neutral or the white wire. Start the burner while watching the bulb time to determine the length of time it remains “on.” With cad cell type controls, it should remain on for the length of time specified by the manufacturer.

## Ignition Control

Most burner manufacturers today use interrupted ignition. On commercial/ industrial burners, ignition “on” times of greater than 10-20 seconds are seldom found. The purpose of interrupted ignition is to ignite the fuel and shut off the system, prolonging ignition system component life. For example, let us say that a residential burner that consumes 1,000 gallons per year is operating with a 1 GPH nozzle. For this example, let us assume the burner will start 3,000 times per year.

### Example 1

*Intermittent ignition* = ignition is on when burner runs. 1000 gallons / 1 GPH = 1000 hours of ignition on time.

### Example 2

*Interrupted ignition* = timed or sequenced ignition.

#### Cad-cell type relays

3000 starts x 45 seconds = 37.5 hours ignition on time

3000 starts x 30 seconds = 25 hours

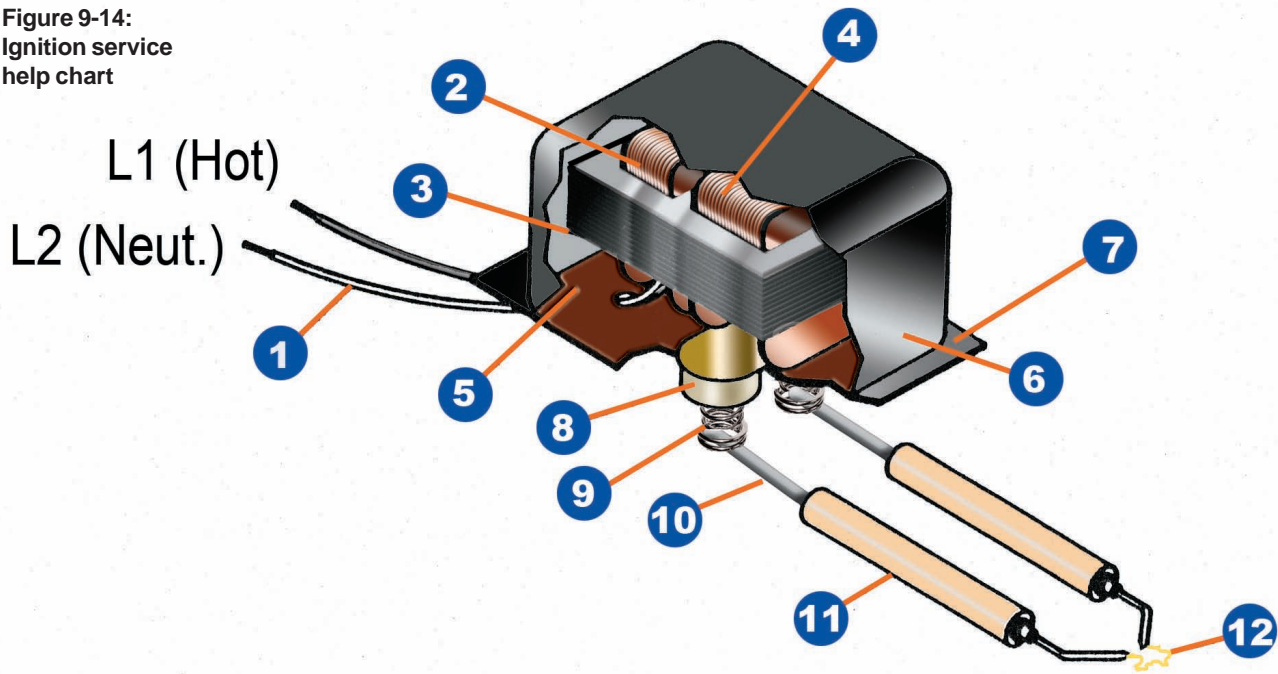
3000 starts x 15 seconds = 12.5 hours

3000 starts x 8/10 seconds = 40 minutes ignition on time

As we can see, we can dramatically lower ignition on-time and prolong the useful life of our ignition systems and reduce service calls.

*Delayed ignition is one of the frustrating ignition problems we encounter. Some solutions are covered in the following charts provided by Beckett Corp., Figure 9-14: Ignition Service Help Chart and Figure 9-15: Delayed Ignition Problem Solving, on following pages.*

Figure 9-14:  
Ignition service  
help chart



Designation	Description	Service Hints
1. 120V ac input wires	Brings 120 volt to primary coil	Wires must not be pinched against housing when transformer is closed
2. Primary coil	Current in this coil generates a magnetic field	
3. Iron core	Transfers magnetic field into secondary coil	
4. Secondary coil	Magnetic field from core induces voltage in this coil	
5. Insulating compound	Keeps moisture out, conducts heat	Should not be leaking out
6. Metal cover	Protects internal of transformer	Should not be punctured or severely dented
7. Mounting base plate	Mounts transformer to burner housing	Must not be bent and cause air to leak from around transformer
8. Transformer output ceramic insulator	Insulates high voltage from ground and opposing terminal. Holds ignition spring dimensions	1. Must not be cracked 2. Must be totally clean
9. Ignition spring terminals	Transmits high voltage to electrode rods	1. Must make good, clean contact to electrode rods
10. Electrode rods	Transfers high voltage to electrode tips	Must be clean
11. Electrode insulators	Mounts electrodes and insulates each electrode from ground	Must be clean and not cracked
12. Arc gap and electrodes	Specified gap (1/8" - 5/32") allows arc to jump to other terminal and ignite	1. Too close causes delayed ignition 2. Too wide results in no ignition and possible damage to secondary 3. Clean and properly adjust

### Delayed Ignition Problem Solving—Electrical

