
CHAPTER

7

THE IGNITION SYSTEM

High pressure gun type oil burners depend on a high voltage electric spark to supply the heat required to start the combustion process. This is actually a chain reaction. As the air–oil mixture leaves the burner, the spark vaporizes and ignites a very small portion of the mixture. This initial flame is hot enough to ignite the rest of the mixture. When the system is operating properly, the light off is very smooth. However, a rough light off will cause vibration, smoke, odors, and a guaranteed upset home owner. Service technicians must be aware of the importance of the ignition system and take time to be certain that the system is operating properly every time the burner is serviced. Here are some of the things that can cause problems with the ignition system:

1. The setting of the electrode tips to deliver the spark where it can graze the air–oil mixture as it leaves the burner is absolutely essential to achieve smooth light off (see Figure 7-1). The oil spray must not touch the tips of the electrodes. If that happens, a carbon bridge will form between the tips and short-circuit the spark. The result will be a safety lockout of the burner. There are several diagrams of electrode settings supplied by burner manufacturers found in this chapter. It is always advisable to follow the instructions that are sent with the burner. Some manufacturers have devised electrodes that can fit in only the exact place to ensure smooth light off. This is an attempt to eliminate human error, which has been a serious problem with oil burners in the past. Remember, the spark will take the easiest path to a grounded surface rather than jump between the electrode tips. To prevent this, the setting of the distance between the tips must be smaller than the distance between any metal part of the electrode and a grounded metal part of the burner—like the flame retention head.
2. The air–oil mixture must be balanced to achieve smooth light off. If there is too much air or not enough oil, it will be difficult for the initial vaporization to take place. This will lead to a hard light off. Some things to check are:
 - A. Is the air shutter open too wide?
 - B. Is the retention head set properly?
 - C. Is there too much draft, negative pressure, in the fire box of the boiler?

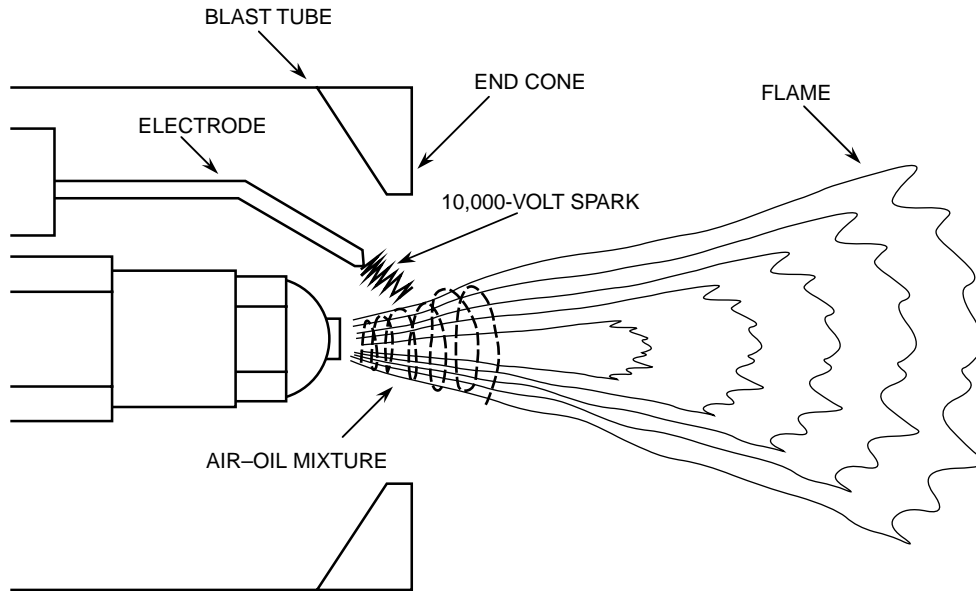


Figure 7-1 The electrode tips are set so that the ignition spark grazes the edge of the air-oil spray as it leaves the end of the oil burner.

- D. Is the entire fuel delivery system (nozzle, filters, pump pressure, etc.) working properly?
- E. Is the oil contaminated with water or is it too cold or heavy to vaporize?
- 3. Are the parts of the ignition system operating properly? Detailed explanations of the operation of the system parts follows in this chapter.

Understand that the smooth ignition of the air-oil mixture depends on all of the oil burner systems. This is where they all come together to create the flame that extracts the energy locked up in the fuel. From this point on you are dealing with fire. Be careful! Be extremely careful!

PUFF BACK

A *puff back* is an explosion caused by an accumulation of the air-oil mixture in the combustion chamber that is ignited by either a “late” spark or the hot refractory material. How serious the explosion is depends on the following:

1. What is the firing rate of the oil burner? How much oil was in the combustion chamber when ignition finally took place?
2. What is the safety timing of the flame safeguard control? How long did the burner run before ignition?

Regardless of the cause, the results are soot all over the house, boiler doors blown open, draft regulator blown out, flue pipe knocked down, or any combination of these. Puff backs can and must be avoided. Careful maintenance and service work are the best defense in preventing puff backs.

IGNITION SYSTEM PARTS

The Ignition System Has Only Four Parts:

1. The ignition transformer or electronic sparking device that provides the 10,000- to 14,000-volt spark.
2. The electrodes that deliver the spark at the exact point required for smooth light off.
3. High tension wires, bus bars, or springs that transport the high voltage electricity from the transformer to the electrodes.
4. The electrode bracket that keeps the electrodes in the proper position for smooth light off. On many older burners the stabilizer was used as the electrode bracket.

THE IGNITION TRANSFORMER

The ignition transformer is a step up transformer, which means that it increases the voltage from 120 to 10,000 volts. The operation of transformers is discussed in detail in Chapter 12, Electrical Equipment.

The Transformer Consists of (see Figure 7-2):

1. A heavy steel *can* that has a mounting plate, an electrical junction box for the primary coil connection, and an opening for the secondary coil connections.
2. A primary coil that has lead wires extending into the junction box.
3. Two secondary coils that have leads connected to the high voltage terminals.
4. A laminated, soft steel core, around which the coils are wrapped. The core provides the magnetic field required to operate the transformer.
5. Coils and core that are inside the can, which is then filled with a tar-like compound for insulation.
6. High voltage terminals surrounded by heavy, glazed porcelain insulators.

THE ELECTRONIC IGNITOR

Electronic ignitor spark generators (see Figure 7-3) supply a 14,000-volt spark to ignite the oil. The increased voltage also increases the temperature, which allows the spark to vaporize and ignite more of the oil in the air–oil mixture as it comes out of the blast tube.

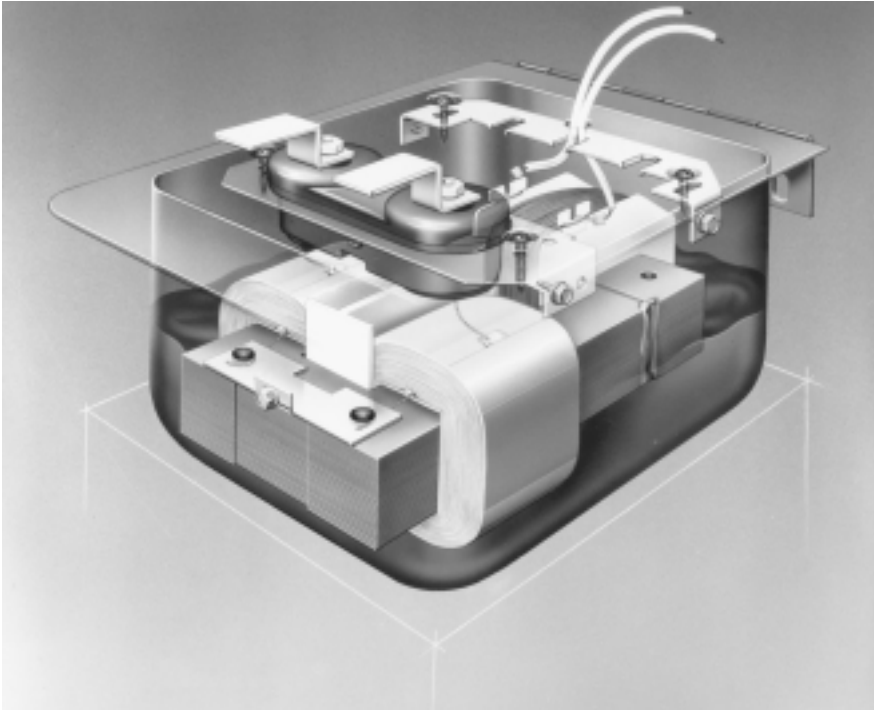


Figure 7-2 Internal view of an ignition transformer. *Courtesy: Webster Heating Products, Inc.*

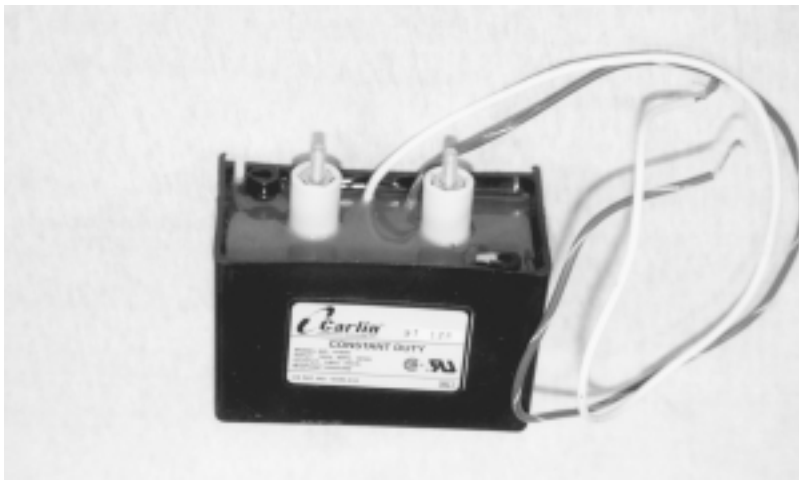


Figure 7-3 The electronic spark generator supplies a 14,000-volt spark for ignition of the air-oil mixture. *Courtesy: Carlin Combustion Technology, Inc.*

This results in a smooth light off even if the oil is cold or contains more of the heavy fractions resulting from the refining process. These units are well sealed are not susceptible to water damage the way transformers are. Another advantage over transformers is that they deliver the same 14,000 volts over a wide range of input voltages, 102 volts to 132 volts. You can be certain that if the motor can run, there will be a spark to ignite the oil.

Electronic Ignitors Are Solid State Units That Operate as Follows:

1. The 120-volt AC current is internally converted to DC.
2. The DC voltage turns power transistors on and off very quickly, sending current through the primary coil of a small internal transformer at a frequency of 15,000 to 30,000 Hz.
3. The secondary coil of the special high frequency transformer produces the high voltage ignitor output that also has a frequency of 15,000 to 30,000 Hz.
4. The high frequency allows the voltage to peak at the output voltage of 14,000 volts. This high voltage current supplies an intense, active spark at the electrode tips.

An electronic ignitor can be used as a direct replacement for an ignition transformer. It is attached to a mounting plate that fits on the oil burner in the exact position as the transformer (see Figure 7-4). There are ignitor kits available (see Figure 7-5) that include the spark generators and an assortment of base plates so the service mechanic can adapt an electronic unit to replace a transformer on any oil burner.

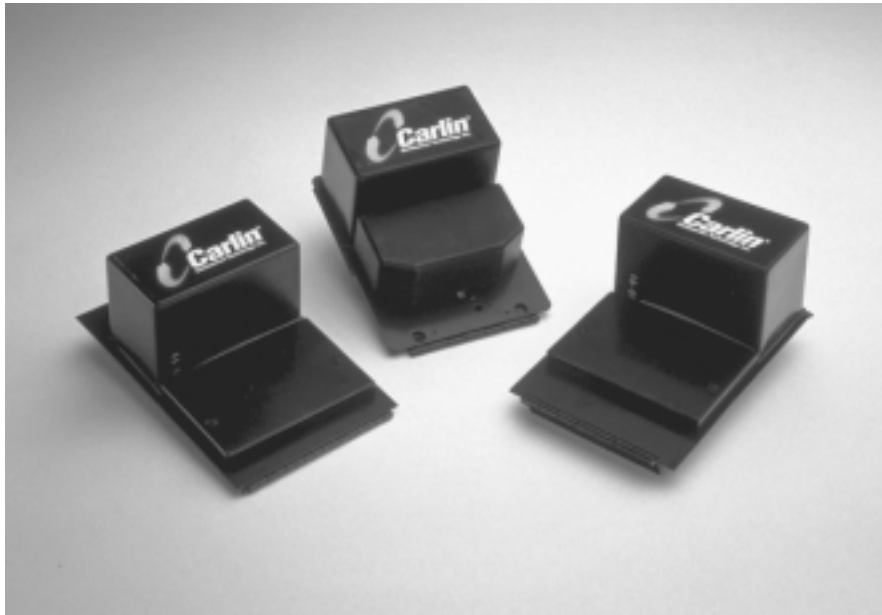


Figure 7-4 Electronic ignitors on mounting plates for various oil burners. *Courtesy: Carlin Combustion Technology, Inc.*



Figure 7-5 Electronic ignitor replacement kit for service van inventory. *Courtesy: Carlin Combustion Technology, Inc.*

The transformer mounting location will vary with the burner manufacturer's design. Figure 7-6 shows a universal replacement transformer kit that can be adapted to a variety of oil burners. Many new oil burners have the transformer mounted on top of the burner on a hinged mounting plate (see Figure 7-7). Access to the drawer assembly is achieved by unbolting the end of the transformer and swinging it open. On this type of burner, the secondary or high voltage terminals are readily available for inspection and testing. The spark generated by the transformer or sparking device must be transported to the electrodes. This is accomplished by using bus bars, springs, or high tension wire.

HIGH TENSION WIRE AND BUS BARS

Oil burners that use bus bars or springs are designed so that when the transformer is in the closed position the secondary terminals (high voltage) are in contact with the bus bars or springs. Bus bars are either metal rods or flat strips that are attached firmly to the end of the electrode (see Figure 7-8). The bars extend toward the rear of the burner where they come into contact with the secondary terminals of the transformer. Bus bars are not insulated, and special attention must be paid to not allowing them to get too close to any metal part of the oil burner. Electricity will always take the easiest path to ground. If the



Figure 7-6 Universal replacement ignition transformer can be adapted to fit a variety of oil burners and reduces the stock inventory of the service vehicle. Courtesy: Webster Heating Products, Inc.



Figure 7-7 Ignition transformer with hinged mounting plate for the Beckett AF oil burner. Courtesy: Webster Heating Products, Inc.

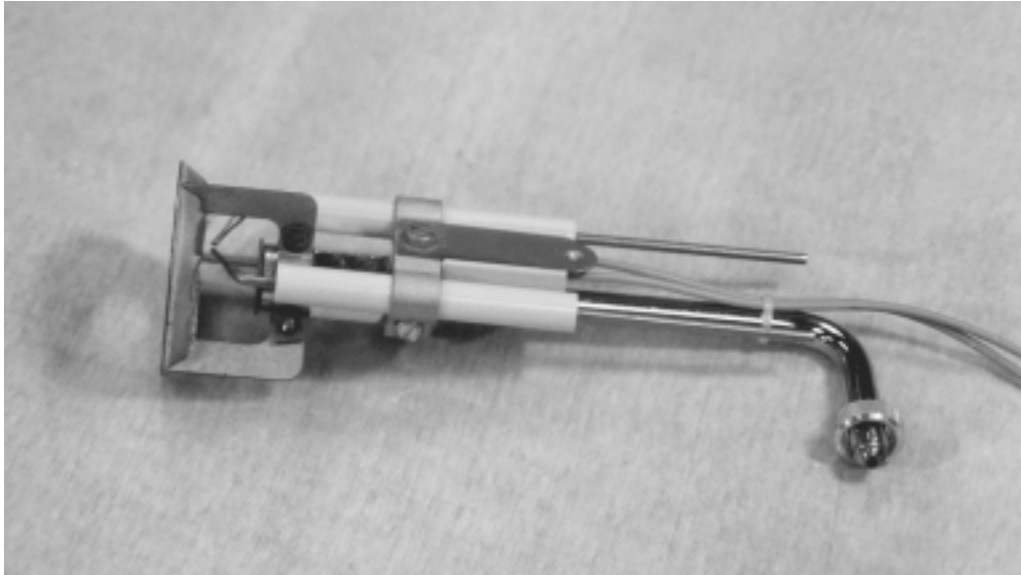


Figure 7-8 The Carlin EZ-1 oil burner drawer assembly shows the positioning of the electrodes and bus bars. *Courtesy: Carlin Combustion Technology, Inc.*

spacing between the electrode tips is larger than the space between the bus bar and a part of the burner, the spark will be inside the burner and not out at the electrode tips. Springs used for this purpose resemble the old screen door closing springs. They are not insulated and must not come into contact with each other or any parts of the burner. An additional problem with springs is that if they are too tight, they may pull the electrodes back into the burner. This will result in either delayed or nonignition and can be avoided by merely stretching the spring a little.

High tension ignition wire is #14 stranded copper wire covered with heavy plastic insulation. A variety of terminal ends are available for use in connecting high tension wire to both the transformer and the electrodes. The best of these is the type that has a metal sleeve that slips onto the outside of the high tension wire.

High Tension Wires Should Be Assembled as Follows (see Figure 7-9):

1. Strip approximately 3/4" of the insulation off the end of the high tension wire.
2. Separate the strands of the exposed wire and bend them back along the insulation. Use a star pattern so there are strands of wire all around the exterior insulation.
3. Slide the terminal end sleeve over the strands of wire. Push the terminal all the way onto the wire and crimp the sleeve to keep it from coming loose.

This method ensures a solid connection between the high tension wire and both the transformer and the electrodes.

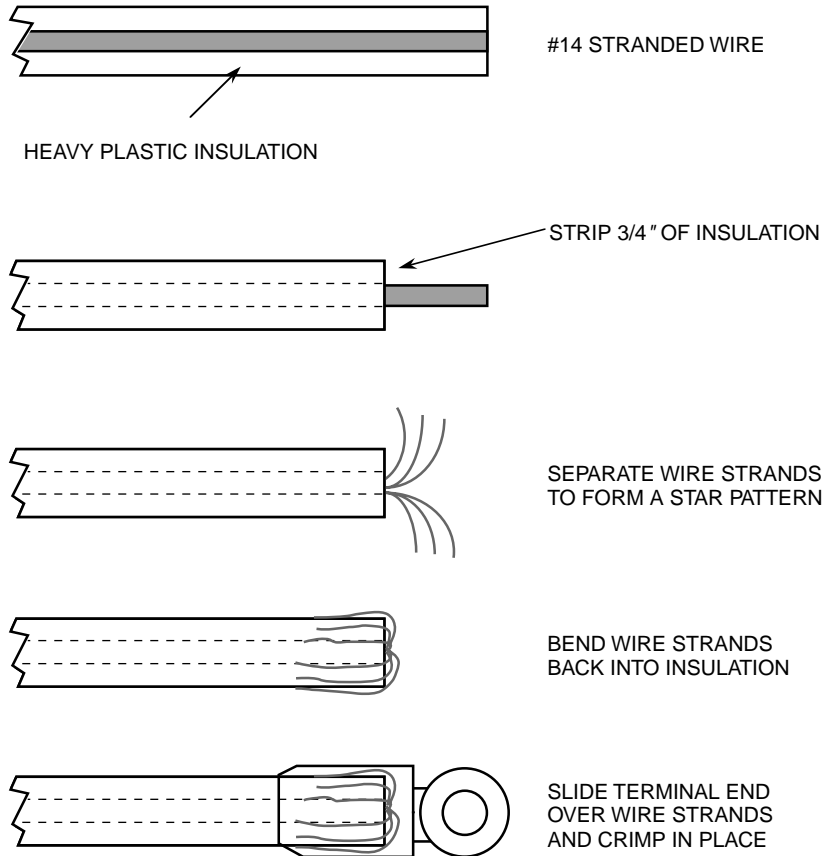
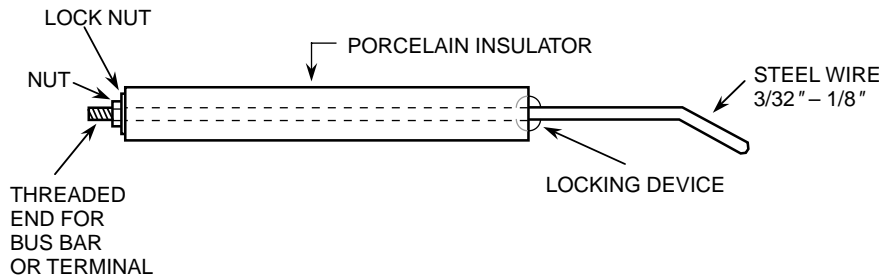
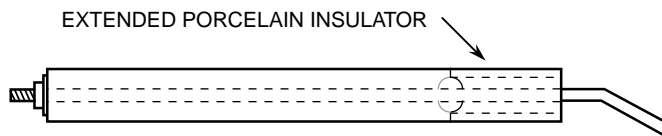


Figure 7-9 Procedure for attaching the terminal end to high tension wire for the ignition system.

ELECTRODES

The electrodes are the oil burner's spark plugs. They are made of heavy steel wire that fits securely into a porcelain insulator (see Figure 7-10). Individual burner manufacturers design their own electrode so there are a variety of these in use. Regardless of their size or shape they all perform the same function. They deliver the spark to the exact position for smooth light off of the air-oil mixture as it leaves the blast tube. There are two types of porcelain, a ceramic material that is an excellent insulator used for electrodes, the glazed and the unglazed. Glazed porcelain has a shiny surface that is easy to clean while the unglazed is dull and hard to clean. The carbon that collects on the surface of the electrode porcelain is a conductor of electricity. It is possible for the high voltage electricity to track across the surface of the electrode and short out if there is enough carbon present.

**STANDARD ELECTRODE****FEMALE ELECTRODE**

EXTENSION CAN BE AT EITHER OR BOTH ENDS FOR
ADDITIONAL PROTECTION

Figure 7-10 Typical oil burner electrode construction.

When servicing the ignition system, if you cannot get the porcelain white, change the electrodes!

The positioning of the electrodes is crucial to the proper operation of any oil burner (see Figure 7-11). Whenever possible, the burner manufacturer's instructions should be followed (see Figures 7-12, 7-13, and 7-14). If they are not available these general rules can be followed.

Proper Positioning of Electrodes:

1. The tips must be at least 1/2" above the center of the nozzle. We do not want the oil spray to hit the tips. This will cause carbon to build up on the tips, which will affect the size of the spark. If the carbon buildup continues, it will actually bridge the gap and short-circuit the ignition system.
2. The tips should always be in front of the nozzle. How far in front depends on the angle of the nozzle spray pattern. Hold the burner assembly up in front of your eyes and try to visualize the spray of oil coming out of the nozzle. The tips should be 1/8–1/4" behind the spray to ensure no carbon buildup on the tips. The air coming through the blast tube will blow the spark into the edge of the spray and no oil will come into contact with the electrode tips.
3. The tips must be 1/8–3/16" apart to get a spark large enough to ignite the air–oil mixture.

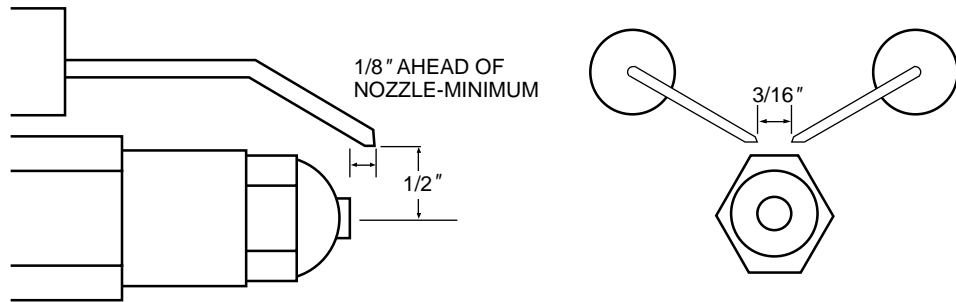


Figure 7-11 Standard oil burner electrode setting.

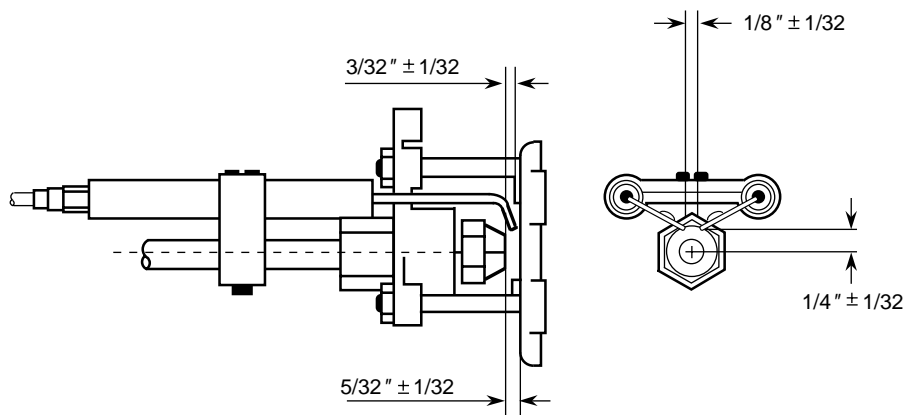


Figure 7-12 Electrode setting for the Beckett AF II oil burner. *Courtesy: R. W. Beckett Corp.*

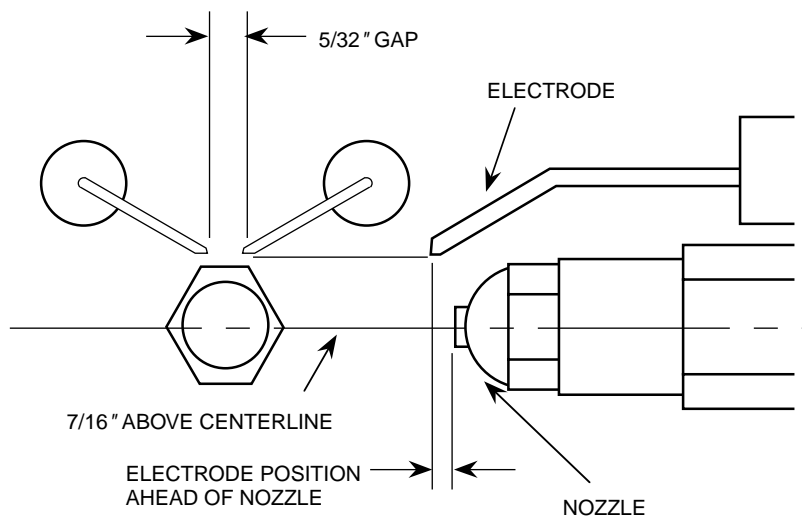


Figure 7-13 Electrode setting for the Beckett AF oil burner. *Courtesy: R. W. Beckett Corp.*

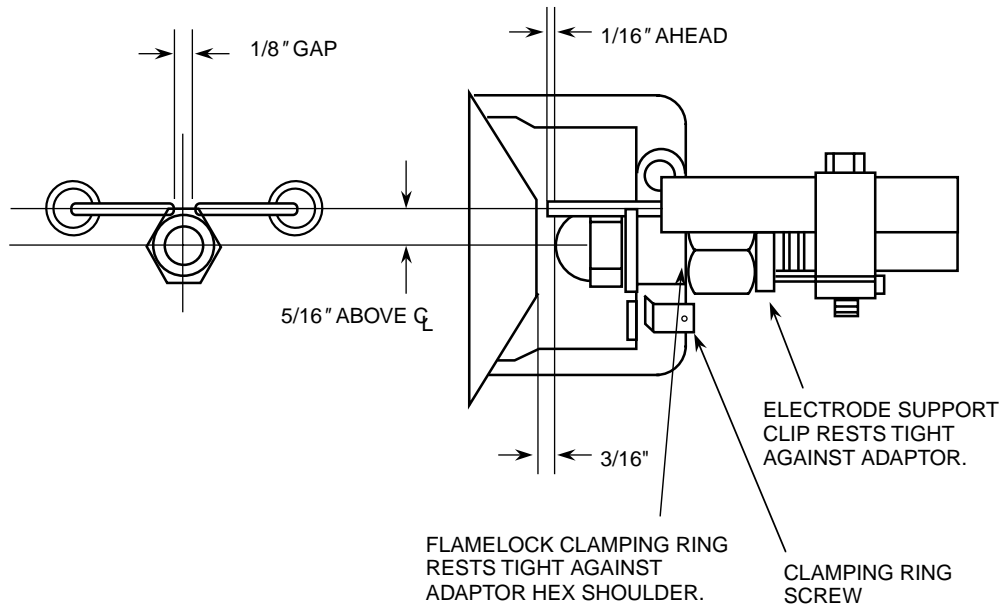


Figure 7-14 Electrode setting for the Wayne Blue Angel oil burner. *Courtesy: Wayne Home Equipment.*

4. If the burner is equipped with a flame retention head, the tips must be farther from the head than the spacing between them.
5. Check the air shutter adjustment to see how much air is going through the burner. A large quantity of air will blow the air-oil mixture away from the spark which means that the tips will have to be set farther in front of the nozzle.

SERVICING THE IGNITION SYSTEM

The ignition system must be serviced during the annual tune-up or any time that the burner locks out on safety. A safety lockout indicates that the burner attempted to start but there was no flame. At this point, you cannot assume that the ignition is functioning properly and that something else caused the lockout. The drawer assembly must be removed and the entire ignition system, electrodes, bus bars or high tension wire, and the transformer must be checked.

To Test the Ignition Transformer:

1. Disconnect the power to the oil burner.
2. Open the transformer or take it off the burner chassis so that you can see the high voltage terminals.

3. Clean the porcelain insulators around the high voltage terminals. Check for signs of cracking or crazing, which is a series of fine cracks in the porcelain.
4. Disconnect the power to the motor so that no oil will spray into the combustion chamber while you are checking the transformer.
5. Turn the burner power on and energize the primary control. Be careful. The transformer is alive and can give you a nasty sting if you touch one of the high voltage terminals!
6. Check the power at the transformer primary leads in the junction box. Use a volt meter. There must be 120 volts, or close to it, going to the primary to get the desired high voltage from the secondary. This must be done quickly because the primary control will lock out on safety, hopefully, in 15–30 seconds. If there is a safety lockout, wait a few minutes before resetting the control so that you can continue the test.
7. Test the secondary voltage with a high voltage tester (see Figure 7-15). Attach the alligator clip of the tester to the transformer case. Turn on the power to the transformer and touch the high voltage terminal with the tester probe. The neon bulb on the tester will glow. Turn the tester dial until the bulb goes out. Read the high voltage output of the transformer by multiplying the dial setting by 100. Each high voltage terminal should deliver 5,000 volts. This can also be done by touching a well-insulated screwdriver blade to the two terminals and gradually increasing the gap between the screwdriver and one of the terminals while still in contact with the other terminal. A good transformer can produce an active spark $\frac{3}{4}$ " long. Be sure to use a dry screwdriver that has a solid plastic handle (see Figure 7-16). Do not use a screwdriver that has a shank that extends through the handle and sticks out of the end.
8. Do not hesitate to replace the transformer if you feel that it is weak. Do not hesitate to replace a transformer that has been under water. They cannot be dried out and used again.



Figure 7-15 Using a high voltage tester to check an ignition transformer. Each terminal should read 5,000 volts.

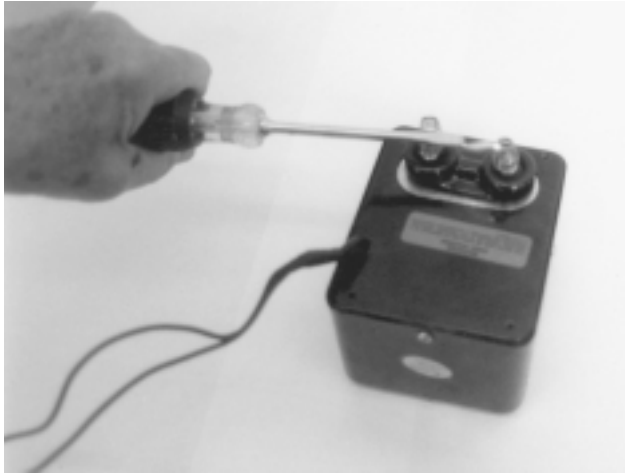


Figure 7-16 Using a well-insulated screwdriver to test an ignition transformer. There should be an active spark across the terminals at least 3/4" long if the transformer is good. Be extremely careful not to touch the terminals and use a screwdriver with a heavy plastic handle!

9. If the transformer is good, reconnect the wiring to the motor, reattach or close the transformer, and run the burner.

To Test the Electronic Spark Generator:

1. Disconnect the power to the oil burner.
2. Take the spark generator off the burner chassis so you can see the high voltage terminals.
3. Clean the porcelain insulators around the high voltage terminals. Check for signs of cracking or crazing, which is a series of fine cracks in the porcelain.
4. Disconnect the power to the motor so that no oil will spray into the combustion chamber while you are checking the spark generator.
5. Turn the power on and energize the primary control. You may have to disconnect one of the cad cell leads to get the primary control to start. Be careful The spark generator is alive with the power on and can give you a nasty sting if you touch one of the high voltage terminals.
5. Using a well-insulated, dry screwdriver blade, touch one of the high voltage terminals and then extend the blade across to the other high voltage terminal. A strong, active spark should appear as you get close to the second terminal. Stretch the spark by moving the screwdriver away from the second terminal. The spark has to be at least 3/4" long.
7. Another method of testing an electronic spark generator is with an Ohmmeter. Disconnect the wiring to the spark generator and test each high voltage terminal to the

burner chassis. You should get a reading of less than 2,000 ohms. The other terminal should give you the same, or close to the same, reading. The terminal-to-terminal resistance should be twice the individual terminal resistance. If the terminal to chassis resistances differ by more than 20%, the spark generator should be replaced.

Any time there is a safety lockout, or during the annual tune-up, the electrodes must be checked.

To Service the Electrodes Follow These Steps:

1. Disconnect the power to the oil burner.
2. Remove the drawer assembly.
3. Check the electrode tips for signs of carbon buildup, spacing, and their position in relation to the nozzle.
4. Remove the electrodes from their bracket. This must be done to ensure that the porcelain is not cracked inside the bracket. Clean the porcelain. Fuel oil can be used as a solvent to remove carbon from the surface of the porcelain.
5. Check for cracks in the porcelain. They will appear to be black lines that cannot be cleaned off.
6. Check for crazing of the porcelain. Crazing is a series of fine lines that resemble fingerprints on the surface of the porcelain. Cracks or crazing will allow the high voltage electricity to leak to ground and will short-circuit the ignition system.
7. Lock the electrodes back into their bracket. Set the tips as explained above or as required by the burner manufacturer (see Figure 7-17). Some electrode brackets have

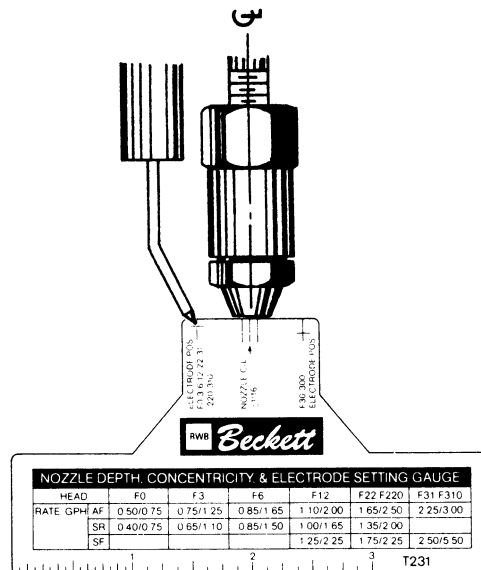


Figure 7-17 Using the Beckett T-gauge to set electrodes. Courtesy: R. W. Beckett Corp.

a split clamp with a screw that pulls the clamp tight around the porcelain. Do not over-tighten this screw because you don't want to strip the bracket. You would then have to contend with a nut and bolt to hold the electrode in place. Some electrode brackets have a set screw that directly holds the porcelain. Most of these require a metal bushing between the set screw and the porcelain. If the electrodes do not fit tight in the bracket, they may have to be shimmed. Aluminum pipe covering straps make an excellent shim stock for this purpose.

8. Clean the surface of the bus bars to ensure solid contact with the high voltage terminals of the transformer. Check the springs' tension and clean them. Check high tension wire for signs of insulation failure; check for loose terminals, then clean them.
9. Replace the nozzle while the drawer assembly is out of the burner.
10. Reassemble the burner. Pay particular attention to the position of the high tension leads from the transformer to the electrodes.
11. Run the burner and check for smooth light off. Use a flame mirror to check the setting of the electrode tips. You can see the oil spray graze the spark if the tips are set correctly. Run the burner through several starting cycles to test the ignition system. Check for oil leaks and clean up around the burner before you leave. Remove any waste from the building when you leave.

To Briefly Summarize

1. The ignition system supplies a high voltage spark that ignites the air-oil mixture as it leaves the end of the blast tube.
2. The setting of the electrode tips is crucial to the proper operation of the oil burner.
3. The burner manufacturer's instructions must be followed when setting the electrodes.
4. The entire ignition system must be checked during the annual tune-up and anytime the burner locks out on safety.

Please Answer These Questions

1. What is the secondary voltage of an ignition transformer?
2. Why does a weak transformer have to be replaced?
3. What is the material used for high voltage insulators?
4. What does the term *crazing* mean?
5. Why are cracks and crazing a serious ignition problem?
6. Explain how you would attach terminal ends to high tension wire.
7. What effect would oil hitting the electrode tips have on the ignition system?
8. What are the factors that determine the position of the electrode tips in relation to the nozzle to ensure smooth light off?
9. What is a *puff back*?
10. When should the ignition system be serviced?