Allanson
ENVIRONMENTAL ELECTRICS

THE A.B.C's OF IGNITION TRANSFORMERS

www.allanson.com

USA | 99 Adams Blvd. | Farmingdale, New York | 11735
Phone: 631-293-3880 | Fax 1-631-293-3470

CANADA | 33 Cranfield Road | Toronto, Ontario | M4B 3H2
Phone: 416-755-1191 | Toll-Free 1-877-264-8444 | Fax 1-877-278-0907

THE A.B.C.'s OF IGNITION TRANSFORMERS

Art Leary, P. Eng.

PART A — THEORY

Of the many components that go into the assembly of a modern oil burner for house heating, perhaps the least understood is the ignition transformer.

Before any discussion of what to expect from the transformer in performance or what you can or cannot do in service situations it will be helpful to understand some of the basic ideas that make it work.

The battery in your car is a source of direct current with a voltage (or electrical pressure) of 12 volts. The current always flows in the same direction through a load such as headlights or a horn. The lights in your home, T.V., radio or vacuum cleaner however, operate from so called house current and in North America this power is not 12 volts but 120 volts or 10 times the voltage of your car battery. The most important difference however, is that house current is *not* direct current (D.C.) but is alternating current or A.C. Furthermore, the voltage and the current in any load connected to this A.C. in North America reverses 120 times in 1 second. This is usually referred to as 60 cycle power, or more recently 60 "Hertz" power, in honour of one of the pioneers in electrical science. Thus, the power that is used to operate an oil burner is "120 volts 60 HZ". This 120 volt 60 HZ power is used to run all the electrical devices on the oil burner. These include the fan/pump motor, the ignition transformer and the relays and switching devices associated with the primary control.

For this discussion we will consider only the way in which an ignition transformer is designed to use the 120 volts 60 HZ power and how this affects the service problems related to the ignition function.

If suitably sized insulated wire is wound into the form of a coil that surrounds a magnetic material such as steel or iron, it has the capability of inducing an alternating magnetic flux in that iron when AC is applied to the coil terminals. Today we take this phenomenon as a common place process, but for the 19th century experimental scientists it was a major discovery.

Even more important was the associated discovery that the alternating magnetic flux could, in turn, induce a voltage in another coil of wire that was closely coupled to it. It was also evident that if the two coils of wire (the one causing the flux and the other linked to it only my magnetic flux) had an equal number of turns, the voltage in the second or secondary coil produced the *same voltage* as was applied to the first or primary coil. Thus, if the ratio of turns was 1 to 1 then the voltage ratio was 1 to 1. It is now clear that we can create whatever voltage we need by simply varying the ratio of the number of turns in the two coils so that the voltage we need becomes available at the secondary terminals.

It can be truly said that the development of equipment to utilize this phenomenon has been the foundation of the modern electrical age and, indeed our present way of life and standard of living.

For charging a car battery the secondary current must be at a voltage value near the car battery voltage, or about 1/10 the value of the house current voltage of 120. Thus, the transformer secondary winding of a battery charger would have approximately 1/10 the number of turns of the primary. On the other hand an ignition transformer must have sufficient voltage to cause a spark to jump across the electrodes. How much voltage then is needed for this?

Let us go back into the physicist's laboratory — a simple experiment shows that in *still* air it takes about 25,000 volts to cause a spark to jump 1 inch. If we use 10,000 volts, which is the most common value in oil burners, we estimate the spark will jump across about 3/8 of an inch and will hold up to 3/4" and in still air we find that a good ignition transformer will do this. This represents a voltage ratio of 83:1. The turns ratio is actually about 85:1 to allow for losses in the transformer.

But, you say, the gap across the electrodes is much less than 3/4", why so much voltage? This brings us to the question of what really is a spark and what properties does it have?

As used in oil burners, the electrical spark existing in air is an extremely hot "Plasma" or stream of electrons pulsing across the air gap under the pressure of the 10,000 volts from the transformer. This stream of electrons is, in fact, an electrical current, as is any net movement of electrons. Since we are concerned with the heat involved in the plasma or Arc we must make sure that:

A) It is sufficiently hot to ignite the oil.

B) It is stable and dependable and not intermittent.

C) It is safely guarded so as not to become a health hazard by shock or burn.

In order to satisfy the first requirement it has been found necessary to design the transformer so that it can supply enough current to create the required heat. One of the early scientists, named OHM, that prepared the foundation for electrical engineering proposed an equation that relates the factors, of volts, amperes (current) and power (heat or watts) as well as resistance (OHMS), commonly known as "OHM's Law". The equation says that in a circuit to which a given voltage is applied, the current that will flow in that circuit is dependent on the electrical resistance of that circuit.

In electrical terms: $I = \frac{V}{R}$ Where: I = Electrical current in amperes
V = Electrical volts
R = Electrical resistance in OHMS

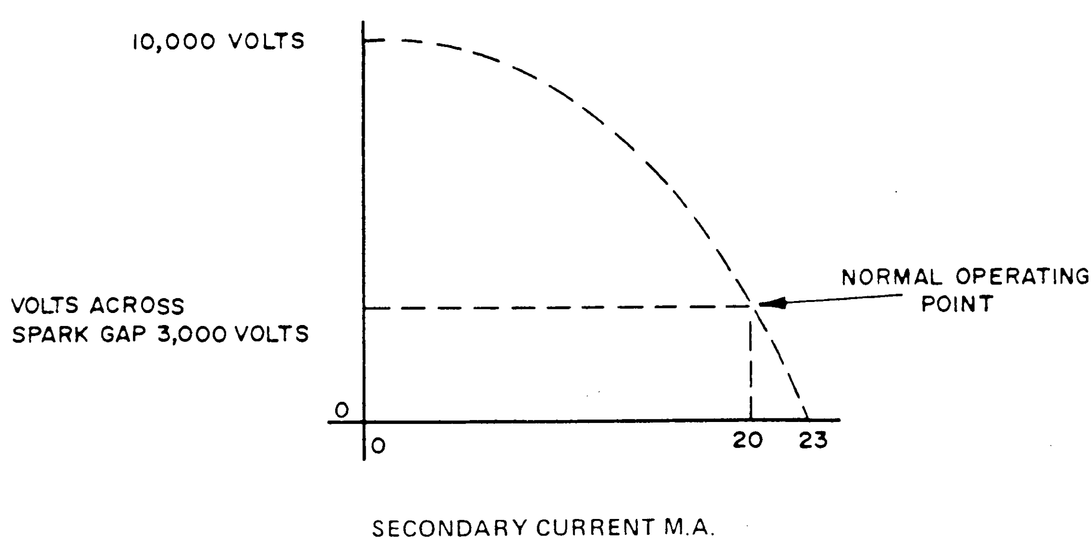
Or by transposing terms we might find it expressed as:

$$\underset{\text{(Volts)}}{V} = \underset{\text{(Amperes)}}{I} \times \underset{\text{(OHMS)}}{R}$$

A further development of OHM's law says that the power consumed by a given load can be expressed in terms of the current through the load in amperes multiplied by the voltage that produces that current (in volts).

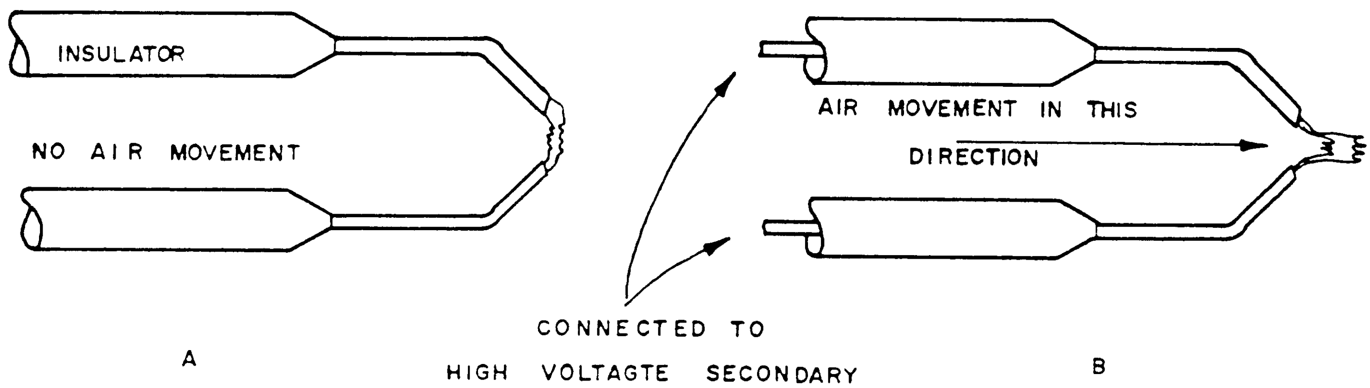
Thus Power (watts) (Heat) = Volts x Amps

Experience over a number of years resulted in the conclusion that to ignite No. 2 fuel oil reliably with a reasonable margin of safety requires a minimum of 50 to 75 watts, created by electrical discharge in the arc. If we start with an open circuit voltage (no current flowing) of 10,000 volts, we design the transformer so that it will deliver the necessary wattage when the arc is established across the electrodes. To understand the values of voltage and current involved, look at the small graph and note how the voltage drops as the current increases to a maximum of 23 M.A. on short circuit.



Note that the voltage across a 1/8" to 3/16" arc is approximately 3,000 volts. The arc resistance and the internal circuitry of the transformer combine to limit the arc current to about 20 M.A. (.020 amps). The arc wattage then = 3,000 x .020 = 60 Watts.

But why 10,000 volts? The gap is only 1/8 to 3/16 of an inch and a smaller voltage will jump this much gap. Here we come to the margin of safety factor. Once a path of electrons has jumped through the atmosphere and created an arc, the path through which the spark has jumped becomes ionized since some of the electrons attached to the gas molecules have been knocked out by the force of the discharge. In 60 HZ power the next 1/2 cycle of voltage causes another arc to jump, but it is easier to follow an ionized path created by the first spark. Now if there is a fast movement of air through the electrodes, (such as is necessary to feed air to the combustion chamber to burn the oil spray), the initial ionized path is stretched out in a curved or horseshoe shape. (Diagram B).



ELECTRODE ASSEMBLY

This demands more voltage to establish the arc and maintain it. To create a reasonable safety margin (to allow for conditions of low line voltage, dirty or leaky insulators on the draught tube electrodes), 10,000 volts is considered to be ideal for most burners in use. There are, of course, industrial and special burners that require higher burning rates and higher blast tube air velocities. For these 12,000 volts transformers and even higher ratings are used.

PART B – CONSTRUCTION

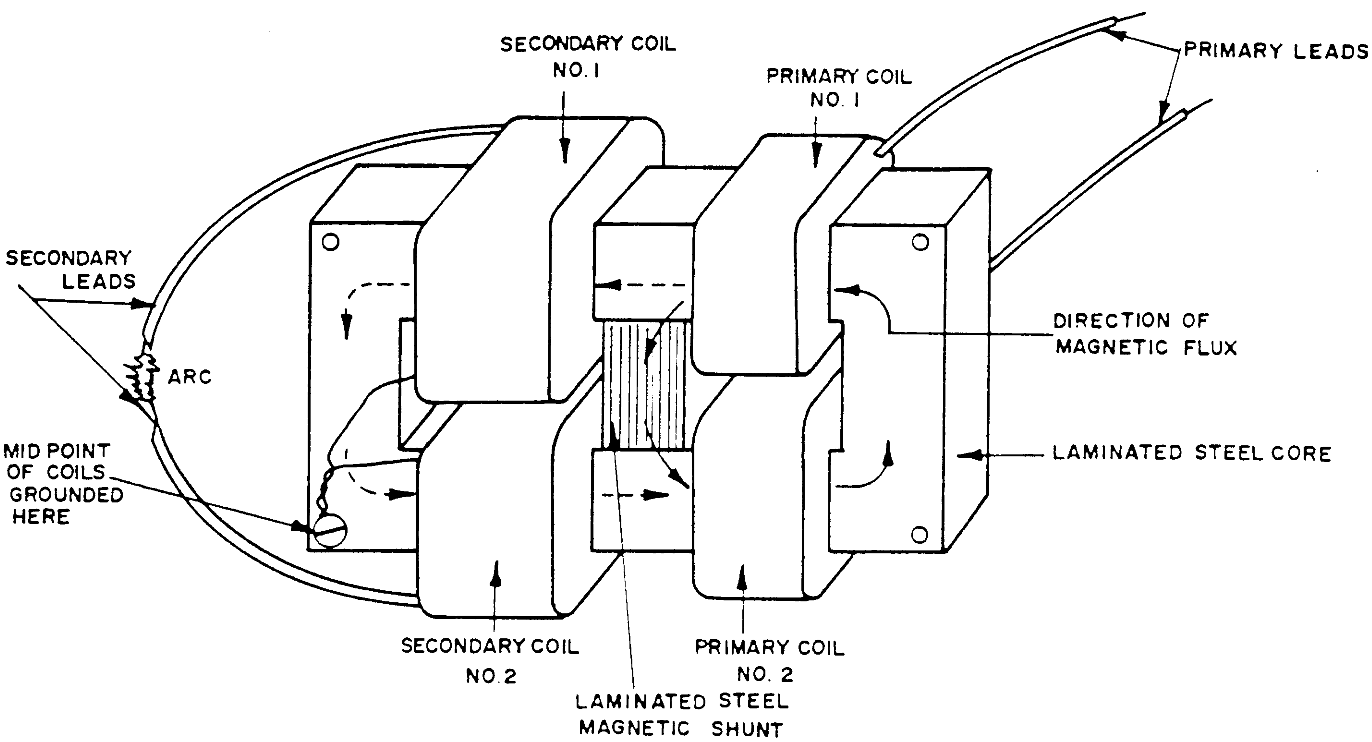
To return for a moment to the basic concept of the turns ratio of a transformer we find we can increase voltage by increasing the turns of the secondary. This seems like getting something for nothing – but, there is usually a price that must be paid for voltage gain. That price is governed by the law of conservation of energy. If we ignore the small losses in the transformer the energy supplied by the transformer primary windings is the same that is drawn by the load from the secondary winding. If the secondary voltage is boosted then the secondary current (amperes) is reduced.

Thus Power (Primary) = Line Volts x current (amps) x (power factor)

= power (Sec.) = Sec. arc volts x load current

There are, of course, unusual or fault conditions that must be considered. If, for example, the secondary of a standard power transformer is short circuited there will be excessive current through the secondary windings. This, in turn, induces an overload or excessive current, in the primary and if circuit protection in the form of fuses or circuit breaker is not provided, the transformer will overheat and burn out.

The ignition transformer is a little different from a standard power transformer. A short arc (1/8 to 3/16") is a very low resistance path and in fact acts very much like a short circuit. Why, then, does the ignition transformer not burn out? This is a good question that can best be answered by a look at the internal construction of the transformer core.



To reduce overall bulk, (size) and for reasons of lower cost manufacturing, the transformer's coils are designed to handle only 1/2 the terminal voltages. This applies to both primary and secondary. For one thing the coils themselves can be built with insulation that need handle only 1/2 the voltage stress – this saves money. Second, the overall bulk of the coil can be shaped to fit into a smaller sized case.

The magnetic flux created by the primary coils and induced into the steel core travels through the laminated steel core in the direction indicated. Notice that the flux makes a complete circuit through the core. (Steel is a much easier path for flux than air). While the arrows all point in one direction keep in mind that the flux changes direction 120 times in a second. Note also that the secondaries surround the flux too.

Now if all the flux created by the primary coils linked all the secondary turns a short circuit on the secondary terminals would indeed cause a heavy current to flow and result in a burn out. Now, by a clever little trick we by-pass some of the flux so that only part of the total flux links with the secondary. (Dotted arrows).

In fact this magnetic shunt is the major factor in controlling exactly how much current the secondary windings can deliver to the arc. By reducing the size of the shunt less flux will pass through it and more flux is available to the secondary. This means the arc current (and therefore arc heat) will be higher. We use this means to produce some industrial burner transformers that are rated at 40 M.A., rather than the normal 23. Of course, if we increase the shunt size secondary current will be reduced.

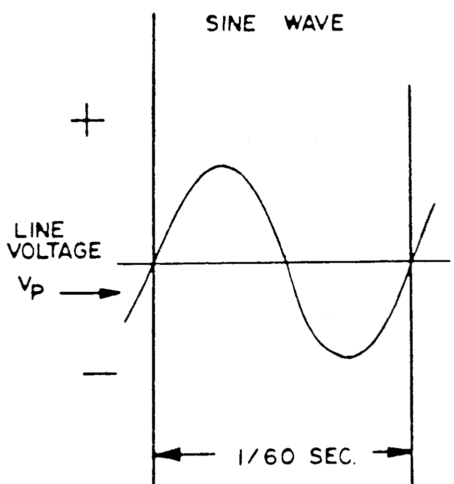
Now we know why it is not only acceptable but very urgently recommended that the secondary terminals be short circuited rather than left open whenever it might be necessary to apply electric power to the transformer during servicing (where it has to be disconnected from the electrodes).

There are two benefits that result from this:

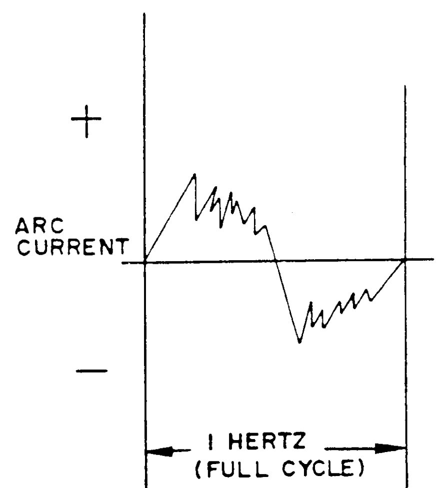
1. You remove the hazard of touching an open circuit terminal that has high voltage — 10,000 volts is lethal!!

2. You remove the high voltage stress on the secondary insulation. Keep in mind insulation deterioration is the most common cause of transformer failure.

The 60 HZ alternating current as it comes from the power lines has a smooth "shape" to illustrate this graphically on a time basis. The "Shape" would appears as a wave. See drawing A — This shape is referred to as a "Sine" wave.



A

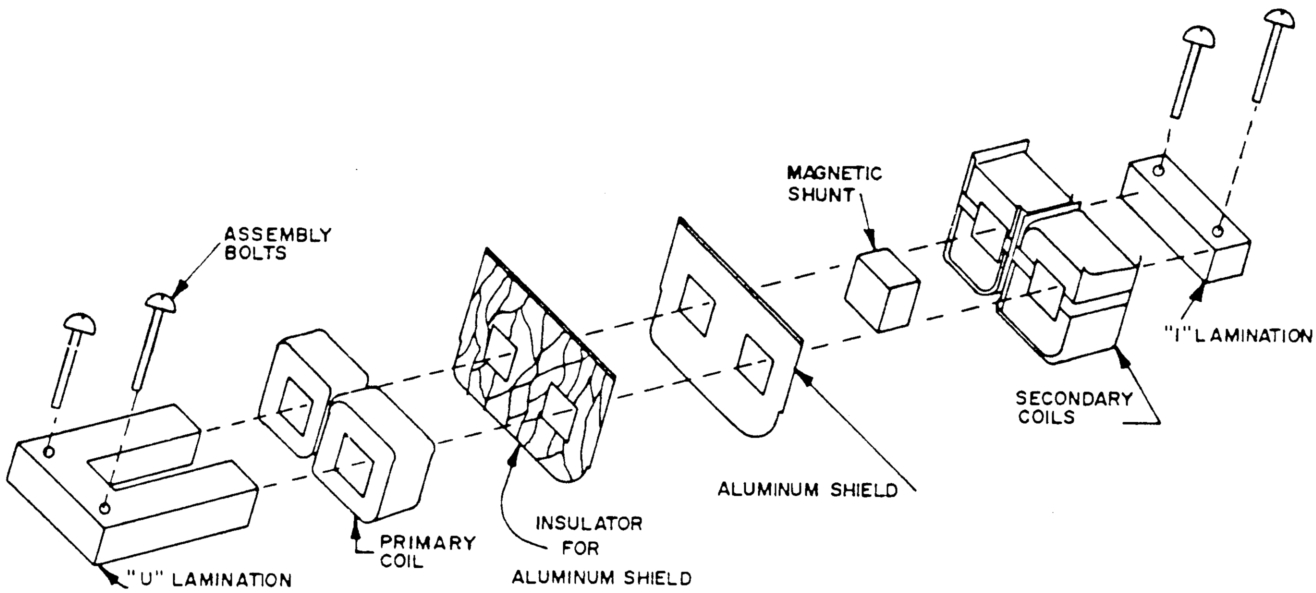


B

When a spark or arc is established across the electrode gap the current through this arc is no longer a smooth sine wave, but is an erratic shape that has a very large quantity of small "Spikes" or harmonics. You can get an idea of this phenomenon by listening to the buzz sound of an electrical arc. (Drawing B above).

The significance of this is that these harmonics can be very high multiples of the original 60 HZ frequency, so high, in fact, that they extend right up into the radio frequency band. (500 KHZ and up). This high frequency is generated by the arc, but the current in the secondary winding is also rich in the same high frequency harmonics. At this frequency these harmonic fluctuations can be induced by capacitive coupling (like a radio tuner) into the primary windings, which, are of course, connected to the house wiring. This wiring can act like an antenna and the signal will cause a noisy interference on nearby radio and

TV sets. To prevent this interfering signal from getting into the house wiring an electrostatic shield of aluminum is inserted into the transformer between the primary and secondary coils. This is quite effective and eliminates the need for line filters such as were used in earlier days of oil burner use. See exploded view:



Most North American ignition transformers have been built to operate continuously. In doing so they will become warm. CSA and UL regulations are such that the outside surface of the transformer case must not exceed 90°C. Most transformers operate well below this temperature.

In order to get the best protection against moisture the core is vacuum-pressure impregnated before it is assembled into the case. By heating in a vacuum all the moisture that may be trapped in the small spaces of the winding is pulled out. During the final phase of this process the core is immersed in hot liquid compound and the vacuum changed to pressure. This fills all the empty spaces and seals against moisture. Bituminous compound may seem a little archaic in this age of epoxy and sophisticated plastic material. It has, however, proved to be the best material to use because it will flex to accommodate changes in dimension that occur during normal heating and cooling cycles. The potting compound also insulates against moisture and electrical breakdowns.

When the core of the transformer has been completed and connected to its electrical leads and contacts inside the case it is filled with a bituminous potting compound which has been heated, for pouring purposes to about 400° F. This compound has a percentage of powdered slate or silica mixed in it. It tends to make the potting material thicker, but its main purpose is to improve the heat conducting properties of the compound. The faster the heat developed in operation can be conducted to the case through the compound, the cooler the transformer will operate.

PART C – TESTING AND CHECKING

Perhaps the most common cause of transformer failure is moisture. Outside of mechanical damage, all transformer failures are due to *insulation* failures. Insulation can fail because of chemical change in the insulation itself (overheating and/or presence of corrosive materials including water.)

Water is a most destructive factor because it provides a relative low resistance path to electrical current particularly if high voltage is involved, as it is here. Traditionally, oil burners are installed in locations often subject to ambient conditions less than ideal. In basements, high humidity and sometimes flooding occurs. In industrial sites, high ambient temperature and dusty, corrosive atmosphere can deteriorate insulation and coat the glazed, high voltage, porcelain bushings. It is good practice to keep the glazed porcelain bushings wiped clean of dust or oil. Both materials tend to attract moisture and make it easier for a leakage arc to occur over the bushing surface.

It has been often asked – "How do you test an ignition transformer?" It is a good question because many servicemen are reluctant to become too adventurous where high voltage is concerned – and rightly so. We know that many experienced men . . . "Old Timers" if you will, (and I'm one too), have removed the high voltage leads and "tested" the transformer by short circuiting it with an insulated screw driver, then slowly lifting it from one terminal to determine how long an arc can be drawn. With experience it is possible to get some idea of whether the transformer is working properly or not. 5/8" to 3/4" of an arc can be drawn from a good transformer if all other variables are "Normal". By this we mean: input line volts, clean, dry bushings, etc. A more meaningful test using the screw driver, is to test each terminal to ground (transformer case.) The spark should give the same "snap" from each side to ground.

It can't be emphasized too much that great care must be taken when working with a live ignition transformer. If you do use the screw driver test make sure the handle is well insulated. Thick plastic is preferable to wood since wood can absorb moisture and sometimes has small cracks. Keep in mind that you may be liable for any problems that can arise as a result of this type of testing. Shock, fire, or even an explosion (which might occur in presence of a gas leak) are possibilities.

With a 2 to 3 month period during summer months, when the oil burner is not used, moisture can accumulate in the high voltage circuitry of the transformer. "Corona" is a type of high voltage discharge that can happen in a high humidity environment. It can be described as a distributed arc, not concentrated in a single spark. In the presence of air, Corona produces Ozone (O_3) and this is a highly corrosive gas that can oxidize and breakdown insulation materials. One possible result is that a turn-to-turn or even a layer-to-layer short circuit can occur in the high voltage winding.

This usually occurs in one winding, not necessarily both at the same time. This localized fault can cause a drop in output voltage in one coil, but it will not prevent the transformer from operating close to its normal performance. This is why it is important to test each high voltage terminal to ground and not just terminal-to-terminal.

With a properly calibrated volt meter, or watt meter it is possible to gain specific information on the transformer's performance, and service persons would be well advised to carry such equipment.

Normal manufacturing tolerance permits $\pm 5\%$ variation in output voltage. However, if you suspect an abnormal condition, first check the input line voltage. There are many areas where line voltage can drop 10% to 12% during certain times of the day. Normally, at 120 volts input you will find 10,000 volts in the secondary. But, if the line voltage drops to 100 volts (and it can) the secondary will be only 8300 volts.

The electrodes are the means by which the energy of the transformer can be used to create a hot electric discharge close to, but not in the oil spray. The gap setting of the electrodes is very important and affects the transformers operation as well as the reliability of ignition. 1/8" minimum to a maximum of 3/16" is still the correct setting and should be checked periodically.

It has been said that an ignition transformer is either good or bad. There is no halfway. If there is any doubt in your mind, replace it. The most annoying and potentially dangerous situation in operation of an oil burner is the result of intermittent or unreliable ignition. Puff-backs and dangerous blow outs can result from an intermittent ignition function, so play it safe!!

"THE SERVICEMAN WHO UNDERSTANDS AND UTILIZES THE ADVANCED TECHNOLOGY AVAILABLE TO-DAY, IS THE MOST IMPORTANT FACTOR IN MAXIMIZING BURNER EFFICIENCY AND CONSERVING ENERGY"

TROUBLE SHOOTING OIL BURNER IGNITION SYSTEMS

This brief guide to trouble shooting oil burner ignition systems is intended to suggest a point-by-point procedure that will permit fast isolation, identification, diagnosis of the problem, and the correct solution.

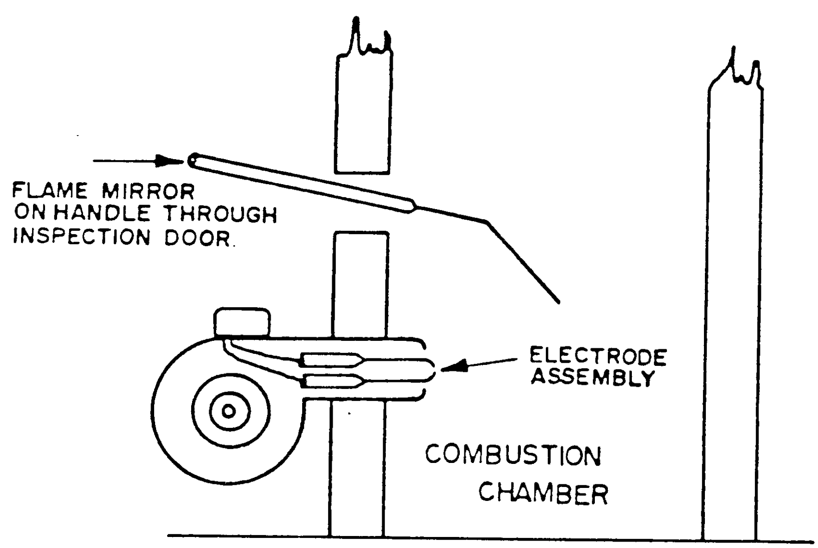
Rather than attempt an educated guess, use the check list below to diagnose the problem quickly and accurately; then apply the prescribed corrective action. Some of the steps will appear obvious but do them anyway. It's surprising to realize how much time can be wasted looking for a complicated problem when only a fuse needed replacing.

Assuming enough examination of the burner malfunction has been made to determine that the problem lies with the ignition system, the following points will help to diagnose and clear the problem.

THE PROBLEM .... THE DIAGNOSIS .... THE CURE

NO IGNITION

Does a spark exist at the electrodes? A flame mirror check will assist visual verification.



If a spark does exist and the nozzle is not plugged, the electrodes can be out of position. Check and adjust, including the correct gap width 1/8" to 5/32". These can most accurately be spaced by using a 1/8" or 5/32" feeler gauge.

If a spark does not exist, try the following steps:

Is there power at the transformer primary? If not, check the following:

A) Household fuse and safety power switch.

B) Primary relay contacts - Clean and adjust or replace the relay if necessary.

C) Wiring connections - Tighten loose terminals and replace broken wires if needed.

D) In some installations, an intermittent duty relay is used which may malfunction. If the motor runs on a thermostat call for heat, determine what primary relay is in use. If an interrupted duty ignition type relay is used, check step "E".

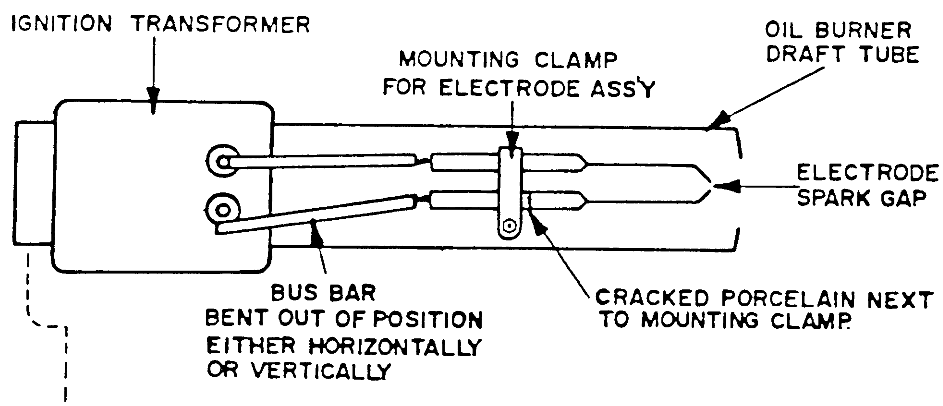
E) The separate transformer relay used on the interrupted duty primary control is activated by either photocell or thermally operated detection circuit. A continuity or Ohmeter check will reveal if the control circuit is the culprit. Zero Ohms indicates a short circuit in a cad cell circuit. Normal operational resistance should be under 1500 Ohms -- but not zero. Infinite resistance indicates an open circuit in either type -- look for a loose or broken wire or a pinched cad cell lead wire. Make sure relay contacts are clean.

INTERMITTENT OR UNRELIABLE IGNITION

1. Spark gap at electrodes may be too large - Check and adjust to 1/8" width gap.

2. Low line voltage - Check with a voltmeter.

3. Transformer becoming defective - Check each high voltage terminal to ground with a calibrated voltmeter (one side may be dead). If there is no more than a 400 volt difference, replace the transformer.



4. Bus bars may be bent out of position or not making good contact with transformer - Clean and adjust.

5. Cracked electrode porcelain causing energy leakage - Replace.

6. Dirty electrode porcelains - causing "tracking" - Clean and re-install. Non-glazed porcelain may be porous and dirty causing a short circuit. Remove and replace.

7. Carbon build-up on electrode gap effectively changing size of the gap - Clean and adjust.

8. Loose wire on primary relay - Tighten all terminals.

9. Pitted contact on primary relay - This is common on continuous duty type relays where the same contacts start motor and energize ignition contact. Motor starting current can exceed contact rating in relay. Sooted relay contacts should be cleaned or, if badly pitted, replace relay.

10. Electrodes not close enough to oil spray - Check and reposition close to, but not in the oil spray.

11. Air tube air velocity may be too high for voltage at gap. Some industrial burners have a high enough velocity and rating to require 12000 volts or more for reliable operation.

RADIO OR TV INTERFERENCE

1. Most common cause is a poor ground on metallic frame of oil burner (and furnace too!). Try tightening all metallic cable fittings (BX) and if necessary run a separate wire from body of the oil burner nearest transformer to the nearest water pipe (copper or galvanized pipe), or to a separate ground rod.

2. A cracked porcelain can cause leakage of high tension in a place where metal shielding of oil burner is not effective (usually caused by excessive tightening of set screw on porcelain).

3. Similarly if the high tension leads are oxidized, they may leak energy to ground.

4. If all else fails and the problem is severe enough to generate complaints, connect a .01 mf capacitor (600 volt rated) across the primary circuit of the transformer, as close to the transformer as possible.

TUNE-UP TIME IGNITION FAILURE

To prevent breakdown of the ignition function during tune-up procedure, it is helpful to know what is the cause. Consider the following:

1. Insulation failure/breakdown is the reason ignition transformers malfunction.

2. Insulation materials such as varnish (on the conductors), paper insulation between layers, compound for encapsulation, and porcelain bushings all are subject to deterioration and failure when subjected to abuse.

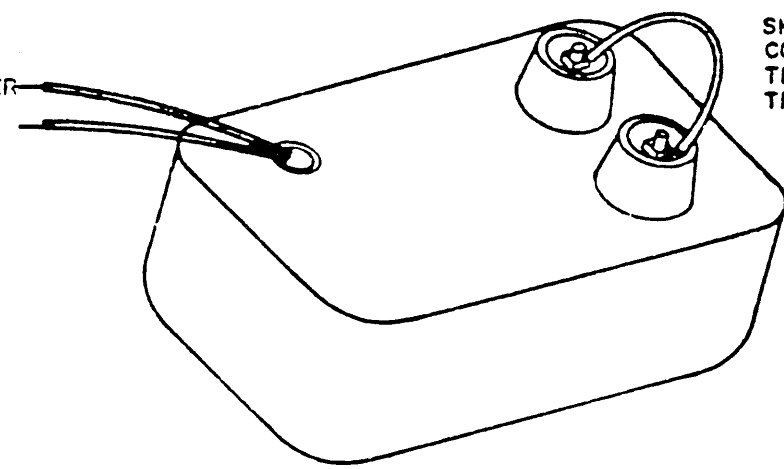
3. Failure occurs when electric current passes through defective insulation, or over a dirty or carbonized path on the porcelain.

4. Once an arc has been established inside the transformer, the resulting heat oxidizes the path through which it passes making it an electrical conductor. It is not a "self-healing" situation.

5. "Abuse" can consist of exposing the windings of the transformer unnecessarily to maximum voltage stress. This happens when the transformer is energized (power applied to the primary) with no secondary load connected - often referred to as "open circuit" operation.

6. When an arc is established at the electrodes, under normal operation, it acts as a load which acts similarly to a short circuit. In supplying electric energy to the arc, the transformer windings do not develop the high voltage that they do when open circuited, thus the insulation is not subjected to a high voltage stress.

7. Therefore, if it becomes necessary to operate the burner with the primary energized, but with the secondary disconnected from the electrodes, always short circuit the transformer secondary terminals with a short piece of wire.



8. Such a short circuit will remove the hazard of shock and will not harm the transformer in any way. It has been designed to have a short circuit current limited to 23 ma which is very close to its normal operating current.

Tune-up often takes place toward the end of summer before the heating season begins. There is a good chance the burner has not operated for several weeks. If located in a damp basement, moisture can gather on the electrodes and under the transformer lid. Under these circumstances it is particularly important that insulation be protected from high voltage stress, at least until a period of normal operation warms the transformer enough to drive off the moisture.

Such preventive measures will greatly extend the life expectancy of the ignition transformer and save service department dollars by eliminating call-backs.

TECHNICAL NOTES

WHY IGNITION TRANSFORMERS FAIL TO PERFORM AND SERVICE RE-CALLS OCCUR

In transformer manufacturing, specifications allow for a tolerance in secondary voltage output. Most manufacturers try to keep this variation to less than plus or minus 5% but UL and CSA regulations permit more than this amount. UL and CSA, for example, allows a 10,000 volt transformer to produce as low as 9200 volts.

In following a policy of reducing production costs, a transformer manufacturer may decide to reduce the number of secondary turns to save material and cost. This will result in a secondary voltage of less than 10,000 and may be as low as 9200 and still meet UL and CSA requirements. With normal primary voltage of 120 volts, the 9200 secondary volts will perform adequately provided the burner is in good adjustment. This means the electrodes must be clean (no leakage), the spark gap no more than 1/8", and the nozzle not partially plugged with carbon.

In many areas of rural New York, Connecticut, Pennsylvania, New Jersey, Delaware and Maryland heavy line loading from both industrial and domestic customers can cause severe voltage drop during the two peak load periods of each working day (6:30 - 9:00 a.m. and 4:00 - 6:30 p.m.). Air conditioning loads and other induction motor loads cause power factor problems to arise that tend to prevent automatic voltage control equipment from functioning effectively in the utility's distribution network. It is not unusual to have a nominal 120 volt service drop to 105 volts or even lower for significant periods of time. The power company is warning of "brown outs", --- periods of low voltage due to energy shortages.

Now let's examine what this can do to a typical oil burner:

Consider the possible case of an ignition transformer that has been manufactured to produce an output voltage on the low tolerance side say 9500 volts instead of 10,000. Further, this burner is operating in an area where the line voltage for part of the day is down to 105 volts. The transformer is intended to work from a 120 volt line, but it happens to be built to produce only 9500 volts with a primary of 120 volts.

Thus at 105 volts the secondary voltage will be $\frac{105}{120} \times 9500 = 8312$ volts. Even at 108 volts primary, we would still obtain only 8550 volts at the secondary terminals.

This provides little or no leeway for any other normal variation in the oil burner operation. If the electrodes have gone out of adjustment due to erosion or thermal stress, a spark gap of up to 1/4" or more can often be found. The electrodes may have shifted slightly out of position relative to the oil spray. If the burner happens to utilize a relatively high draft tube velocity, the reliability of ignition is further jeopardized.

Thus we can see several reasons for ignition trouble recalls. Low line voltage can result in uncertain or delayed ignition and consequent blow-back.

How does one determine if a transformer is not delivering its full output?

The most accurate method is to use a voltmeter designed and calibrated for the purpose. These are available. The so-called testers that employ a neon light and a variable resistor do not measure voltage accurately enough, but may be useful in comparing the voltage to ground from either high voltage terminal. Even here it would be a bit difficult to assess the value of the difference, should one exist.

How can we be sure that reliable ignition will be present in spite of the several adverse conditions outlined above? If, for example, we have checked line volts and found it to be as low as 105 volts for a significant period of time (1/2 hour or more), we can install a 12,000 volt ignition transformer. Now, what performance can be expected?

With 105 volts on the primary, a normal 12,000 volt transformer will develop

$\frac{105}{120} \times 12{,}000 = 10{,}500$ volts.

Now, if the 12,000 volt transformer happens to be manufactured on the low side of the manufacturing tolerance (-5%), we would still get 10,500 x .95 = 9975 volts which is still very good indeed. Thus we have a good margin of performance which is a desirable safety factor to overcome improperly set spark gaps or high draught tube velocity conditions.

It is very unlikely that both transformer and line voltage tolerance will occur together on the high side but if they do, let us examine what would take place using a 12,000 volt transformer:

Transformer output at 120 volts on the high side of manufacturing tolerance

- 12,000 × 1.05 = 12,600 volts.

Now, if this transformer is connected to a primary power line that is say 125 instead of 120, we get $\frac{125}{120} \times 12,600 = 13,020$ volts.

13,000 volts or 6500 volts to ground is well within the stress capability of the transformer insulation and there should be no problem with the oil burner electrodes provided they are not cracked or dirty. Glazed porcelain is much to be preferred as an insulator for the electrodes as it prevents absorption of moisture and oil and is easier to clean.

Keep in mind that the 12,000 volt transformer has characteristics similar to the 10,000 volt model in that as soon as the arc is established, the electrode voltage reduces to approximately 4000 volts.

Art Leary