IGNITRONS

1-1. IGNITRON THEORY.

a. DEFINITION AND DESCRIPTION. The ignitron is a gas-discharge electronic tube with a mercury pool cathode and an ignitor starting electrode. There are five basic parts in an ignitron, namely: The cathode, anode, ignitor, terminals, and envelope. A typical ignitron is illustrated in figure 1. The basic elements and their properties are discussed in subparagraphs b through f following.

b. ELECTRON FLOW.

(1) The flow of electrons in a wire can be compared to the flow of water through a pipe. The current flowing through a wire consists of millions of electrons moving in a group, just as millions of molecules flowing through a pipe produce the water flow.

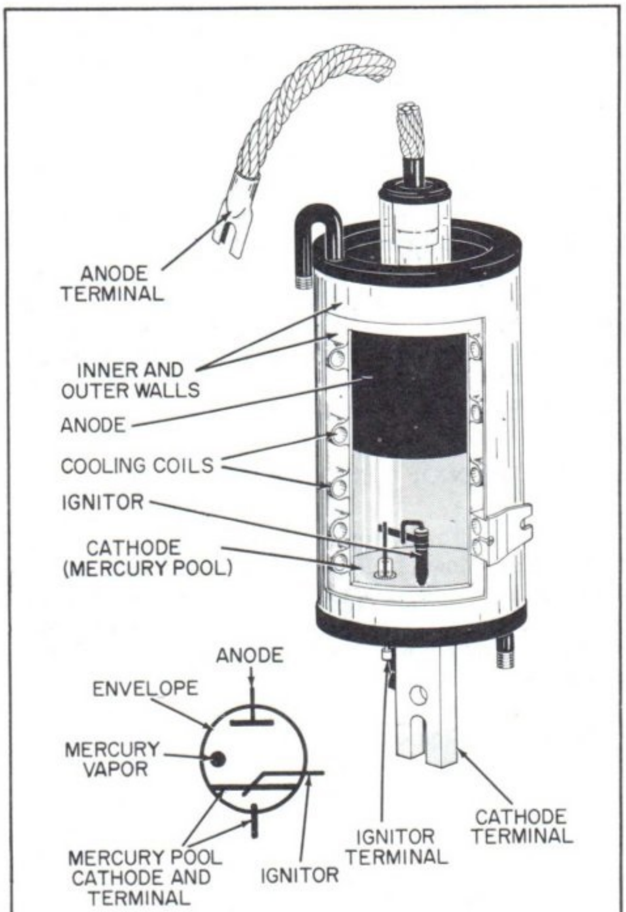


Figure 1. Ignitron Elements and Graphic Representation

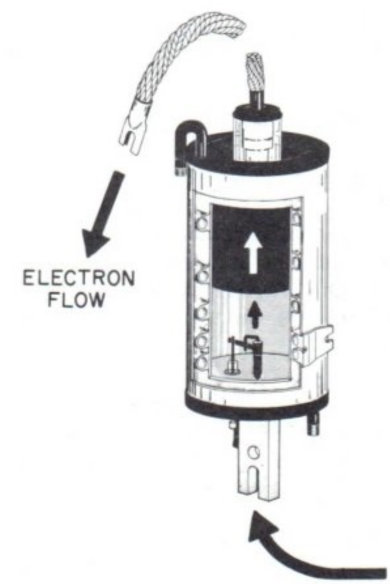


Figure 2. Electron Flow Through an Ignitron

(2) As long as electrons in a wire fail to flow in the desired direction they produce no useful result, similar to the immobility of water in a pipe where there is no flow. An electric generator or battery is comparable to a water pump, and a water valve is comparable to a switch, variable resistance, or an electron tube insofar as the control of electron current is concerned.

(3) The requirements of industrial electronic equipment require that precise control of the flow of electrons be provided. High speed relays could be used to control the starting and stopping of electron flow, however, even the fastest relays are slow compared to the switching action of ignitrons. An ignitron can be turned on and off with precision measured to a few microseconds. In addition to the precise and rapid switching action, the further usefulness of ignitrons lies in the ability to control the magnitude of the current flowing to the load.

Thus, an ignitron not only functions as a switch, but also as a precisely controlled variable resistor and timing device.

(4) The accepted theory of current flow states that electric current flows from the positive terminal. Experiments and developments within recent years have proven that electrons flow toward a point of more positive potential. This current flow is referred to as an electron current, and is the current flow described and illustrated in this book.

(5) The following paragraphs explain how this flow of electrons in an ignitron is accomplished and how the precise control of this electron flow is accomplished.

c. FUNCTION OF THE CATHODE.

(1) Visualize an electrical circuit in which a switch is used to control the flow of electrons. When the switch is closed, electrons flow; when the switch is opened, electron flow ceases. In electronic control equipment, the switch is replaced by an electron tube, and in this discussion the electron tube is an ignitron.

(2) Since the ignitron tube is connected into the electrical circuit and the circuit continuity is broken, electrons must flow thru the ignitron. The electron flow is from the cathode to the anode.

(3) Electrons cannot pass through the gap between the cathode and anode unless some additional influence or element is introduced which will initiate the flow of electrons.

(4) In an ignitron tube, the cathode consists of a pool of mercury, sometimes five or six inches in diameter. This pool of mercury is the source of electrons, which in the case of larger ignitrons, will supply approximately 10^{25} ("1" followed by 25 zeros) electrons per second when the ignitron is firing.

(5) Unlike most other electronic tubes, the cathode of an ignitron is a pool of mercury and is not heated to release electrons.

(6) Instead of a hot cathode a starting electrode, called an ignitor, is used to strike an arc at the surface of the mercury pool, thereby releasing electrons from the cathode. The function of the ignitor will be described in detail later in the discussion. This electric arc liberates an infinite number of electrons which will flow toward the anode, providing it is positive with respect to the cathode.

d. FUNCTION OF THE ANODE.

(1) The anode is the element within the ignitron which attracts the free electrons liberated from the cathode. This attraction exists just as long as the anode is positive with respect to the cathode.

(2) When an ignitron is connected into an alternating current circuit the anode is positive for one-half cycle, and negative for the next half cycle. When the anode is negative, electron flow stops since the anode is incapable of emitting electrons. This is a principle characteristic of an ignitron, and of other electron tubes also. The ignitron acts like a rectifier, except that the time of actual firing during the positive half cycle can be controlled with precise accuracy.

(3) The anode of an ignitron is made of graphite for three principle reasons: Graphite will not emit electrons under the normal operating conditions; graphite has low electrical resistance, actually decreasing with an increase of temperature; and the dull black surface of graphite is an excellent heat radiator. The last item is very important since the dissipation of the internally-generated heat in an ignitron is essential.

(4) Due to the presence of mercury in an ignitron, and consequently mercury vapor, the space between the cathode and anode is filled with millions of mercury vapor molecules. The mercury vapor molecules, which are much larger than the electrons, are bombarded by the electrons flowing toward the anode. This bombardment knocks electrons out of the mercury vapor molecules, thereby producing positive ions.

(5) In addition to the electrons emitted from the mercury pool cathode, the liberated mercury electrons also flow to the anode, thus increasing the total number of electrons attracted by the anode. The ions remain in the tube for a relatively long time and have the affect of neutralizing most of the space charge within the tube. This ionization of the mercury vapor molecules is the reason for the greater current carrying capacity of gas filled tubes as compared with high-vacuum tubes.

e. FUNCTION OF THE IGNITOR.

(1) The ignitor element in the ignitron is used to trigger the flow of electrons from the cathode to the anode by striking an arc at the mercury pool surface. This arc then transfers to the anode and will sustain itself without further assistance from the ignitor.

(2) Once the ignitor has liberated electrons from the cathode, in the manner explained previously, there is no further requirement for its functioning until the next positive cycle occurs at the anode. This being the case, a pulse of positive voltage from a thyratron trigger circuit or equivalent device is used to fire the ignitor. Once electron flow from cathode to anode has been established, the ignitor relinquishes control and only a removal or phase reversal of the anode potential will stop the current flow.

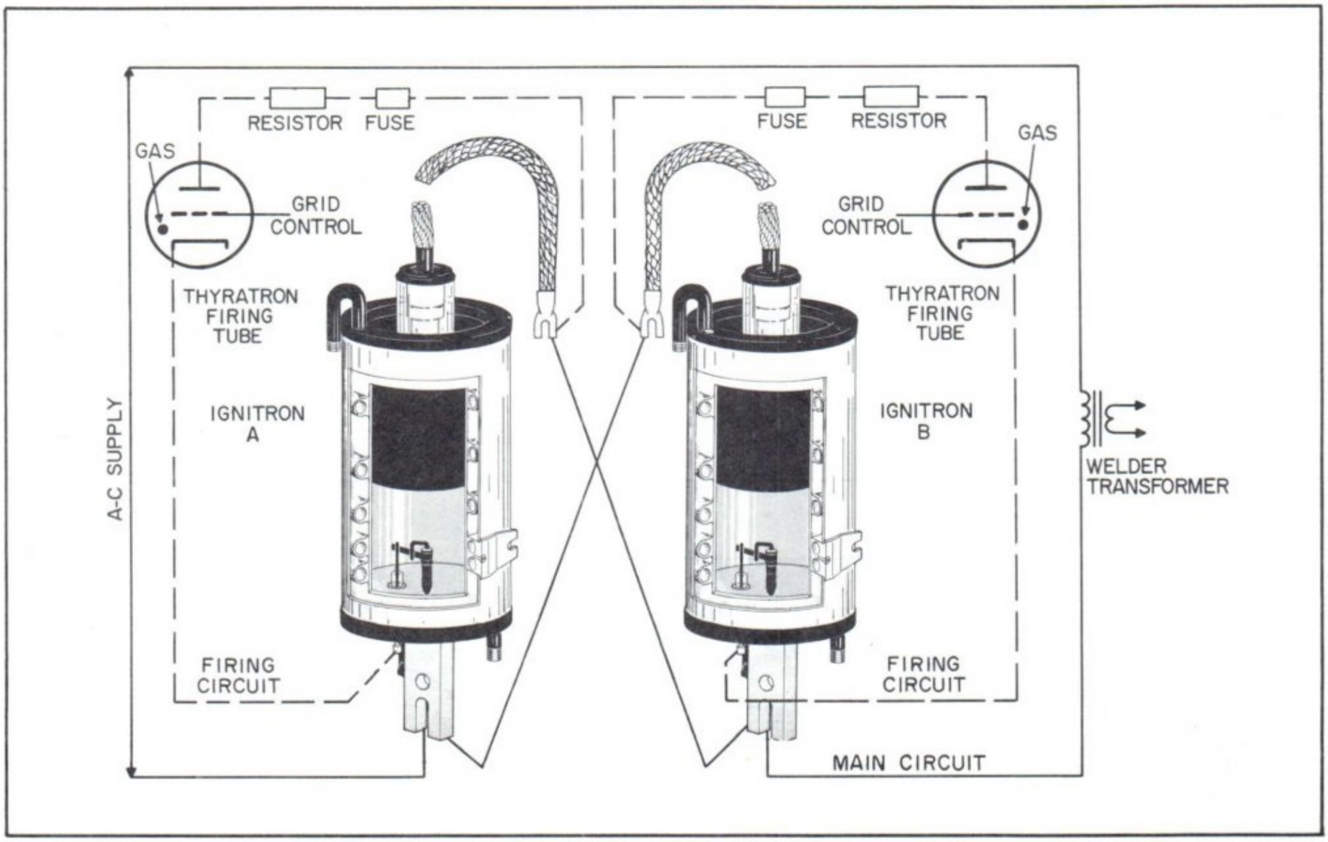


Figure 3. Functional Circuit of an Ignitron Welder

f. FUNCTION OF THE ENVELOPE.

(1) The primary function of the envelope of ignitron tubes is to maintain a vacuum tight enclosure around the operating elements.

(2) In addition to the vacuum tight enclosure, a cooling means is incorporated in the envelope to dissipate the heat developed in the tube.

(3) The most common and efficient method of cooling is accomplished by circulating water thru copper cooling coils brazed to the inner envelope, or by making a double-walled envelope and circulating water thru the double-wall enclosure.

(4) Ignitron tubes using convection cooling or forced air cooling can be designed, however, the use of a liquid coolant provides the highest degree of efficiency, control and longevity.

g. IGNITRON FUNCTIONAL CIRCUIT.

(1) Two circuits are used in an ignitron tube welding control, the main or cathode to anode circuit, and the firing or ignitor circuit. Figure 3 shows how these circuits are used to incorporate an ignitron tube into a welding equipment control circuit.

(2) In power rectification, a third circuit is used called the holding anode circuit. A small auxiliary anode is used to maintain a sufficiently high degree of ionization to maintain the mercury arc even at fractional loads.

h. IGNITRON THEORY ANALYSIS.

(1) As stated previously, the ignitron has five basic parts - cathode, anode, envelope, terminals, and a starting electrode called an ignitor.

(2) The difference in the operation of ignitron tubes as compared with other tubes is in the method of liberating electrons from the cathode and thereby initiating current flow.

(3) The cathode of the ignitron is a pool of mercury, instead of the conventional coated metal found in most other electronic tubes.

(4) The electrons are liberated from the mercury pool by forming or striking an arc between the ignitor and the mercury. This differs from most electronic tubes in which the electrons are liberated by heating the coated-metal cathode to a sufficiently high temperature to free the electrons.

(5) As shown in figure 4, the tip of the ignitor is immersed in a mercury pool. Due to the very

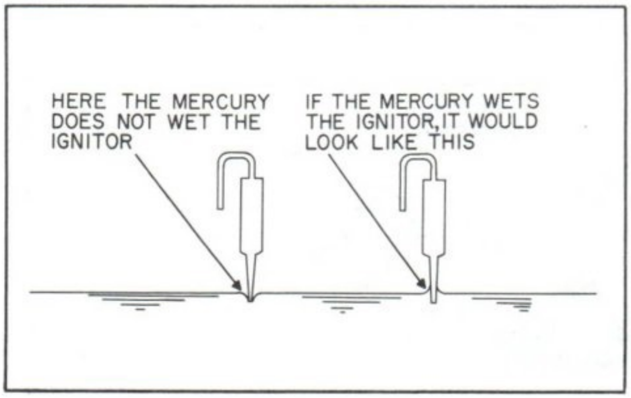


Figure 4. Ignitor in the Mercury Pool

strong surface tension of mercury, a slight pulling-away occurs where the mercury touches the ignitor. This is indicated by the downward dip (called a meniscus) of the mercury at this point. If the mercury "wets" the ignitor, an upward flow (like a fillet) would result.

(6) When a peak current of 10 to 40 amperes is passed through the ignitor-cathode circuit, a high potential (voltage) difference is established between the ignitor and mercury pool. When this potential difference is sufficient to strike an arc, electrons are liberated from the mercury and a cathode spot or arc is formed.

(7) Voltage required to force current through the ignitor prior to firing is on the order of 100-200

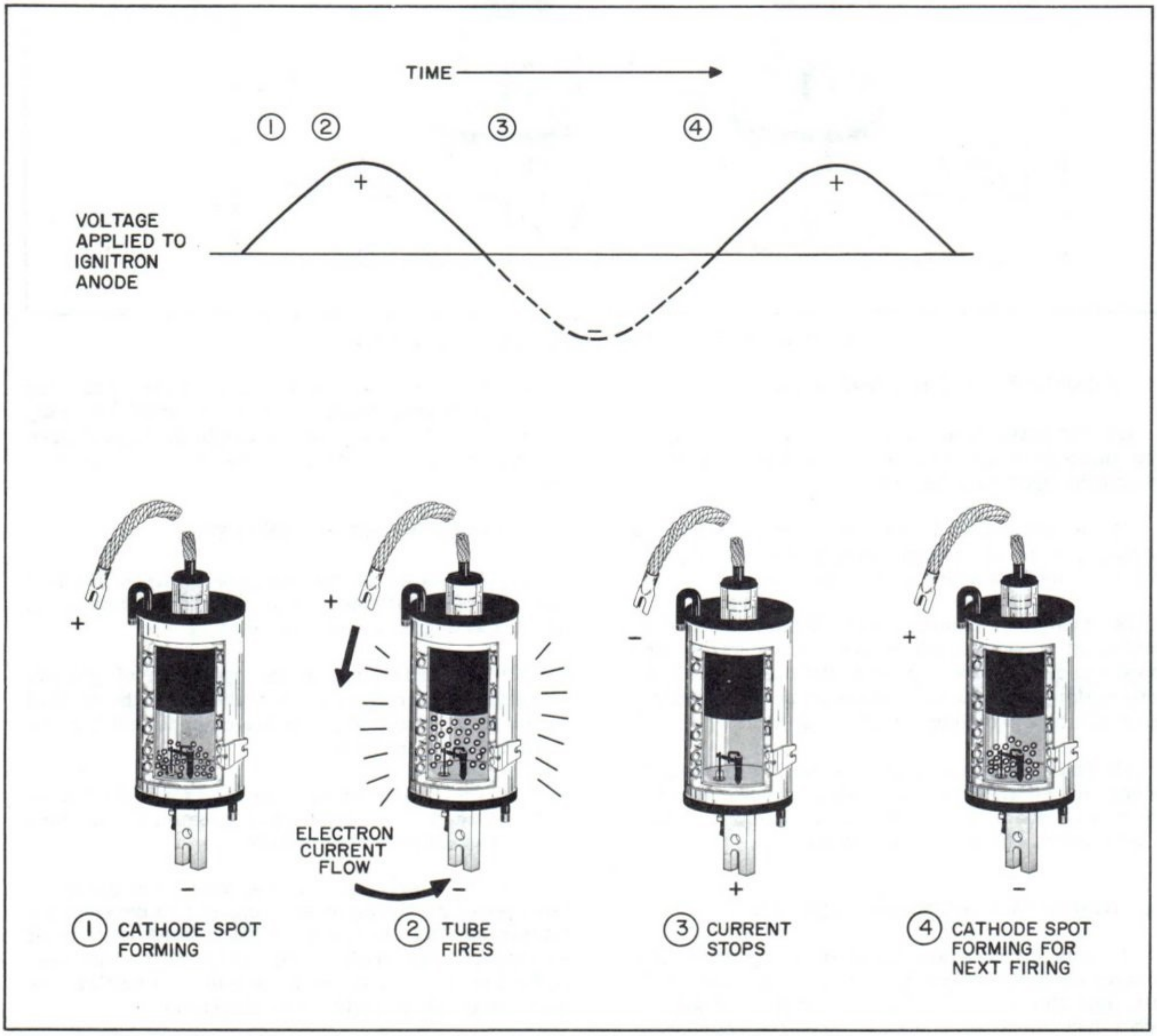


Figure 5. Ignitron Rectification

volts. As soon as the ignitor fires, this voltage drops to about 10 volts.

(8) As the ignitor current increases beyond a critical point, the potential gradient causes tiny sparks to form at the meniscus. These sparks are the beginning of a cathode spot which spreads over the surface of the mercury until a sufficient number exist to supply the current demand. Literally billions of electrons are released from each cathode spot since it takes 6,182 times 10^{18} electrons to conduct one ampere for one second.

(9) During the cycle when the anode becomes positive it attracts the electrons given off by the mercury-pool cathode, thus conducting current through the tube. Obviously, when the anode becomes negative or opened the current flow stops.

(10) It is necessary to re-ignite the cathode spot in order that electrons will be available when the anode is positive again. The ignitron circuit is designed so that the ignitor current flows only for the short period of time necessary to start the electron flow. At the end of this time, and until the next cycle, the ignitor current is essentially zero.

(11) The mercury-pool cathode is repeatedly renewed by condensation of the mercury vapor, therefore it is practically indestructible.

(12) The cathode-to-anode current can be turned off only by reducing the anode potential below the ionization potential of mercury vapor, or by allowing the anode to swing negative, as during the negative half cycle. Once the ignitron fires, the ignitor circuit loses all control of the cathode-to-anode current until the anode current drops to zero.

i. RECTIFICATION WITH AN IGNITRON.

(1) In 60-cycle alternating current, the current changes direction 120 times each second (twice each cycle). A diagram for three half-cycles of alternating current is shown in figure 5. Total time required is 3/120 second.

(2) Electrons flow from the cathode to the anode only while the anode is positive. At the point in the diagram where the broken line begins, the anode has just reached zero potential and is about to become negative, therefore the flow of current stops. The ignitor ceases to function once the current has started, and current will not flow through the tube during the next positive half cycle until the ignitor produces another cathode spot.

(3) In ignitron tubes used for rectifier service, the ignitor may be triggered to start the flow of current again at any time after the anode becomes positive again. The ignitor timing may be delayed thereby controlling the average current conducted by the tube.

j. CURRENT CONTROL WITH AN IGNITRON.

(1) An ignitron tube with the aid of thyratrons and other electronic devices, can provide precision control over the current flowing through a circuit. This type of control is essential where ignitrons are used to feed current into the primary of a welding transformer. (See circuit in figure 3).

(2) In ordinary rectifier service, the ignitor starts current flow at the beginning of each positive half-cycle. The entire cycle of operation repeats continuously thus providing an output of pulsating direct current.

(3) For resistance welding, direct current is unimportant since resistance welding is usually done with alternating current. By connecting two ignitron tubes in inverse parallel (the anode of one tube connected to the cathode of the other, figure 3) each tube will conduct on opposite half-cycles and the output of both tubes together is still alternating current.

(4) Ignitron tubes make it possible to obtain precise control over the average amount of current flowing through a circuit. This is done by controlling the exact point at which the ignitor is fired. The switching accuracy of ignitrons is extremely good and this feature together with no relay contact wear make ignitrons extremely valuable in industrial control equipment.

(5) In most welder circuits, the ignitron tubes are required to conduct in a more complex sequence. The conduction time of the ignitron tubes are illustrated in figure 6. There are actually four phases of operation involved, "squeeze" time, "weld" time, "hold" time, and "off" time. The ignitrons fire only during the "weld" time, each ignitron sharing the load as shown in figure 6. The larger the shaded areas, the larger the average current output will be.

(6) In the same welder circuit, another job might require less heat, therefore less current. If the job requires less current, the ignitrons are controlled to pass current during a smaller fraction of each half-cycle.

(7) The timing diagram (figure 6) shows two complete cycles allocated to "weld" time. This "weld" time, as well as the "squeeze", "hold", and "off" times are usually adjustable in most spot welders.

(8) Therefore, it is obvious that two items control the average current output of the ignitron, first of all, the number of cycles allocated to the "weld" time, and the proportion of each "weld" cycle allocated for firing.

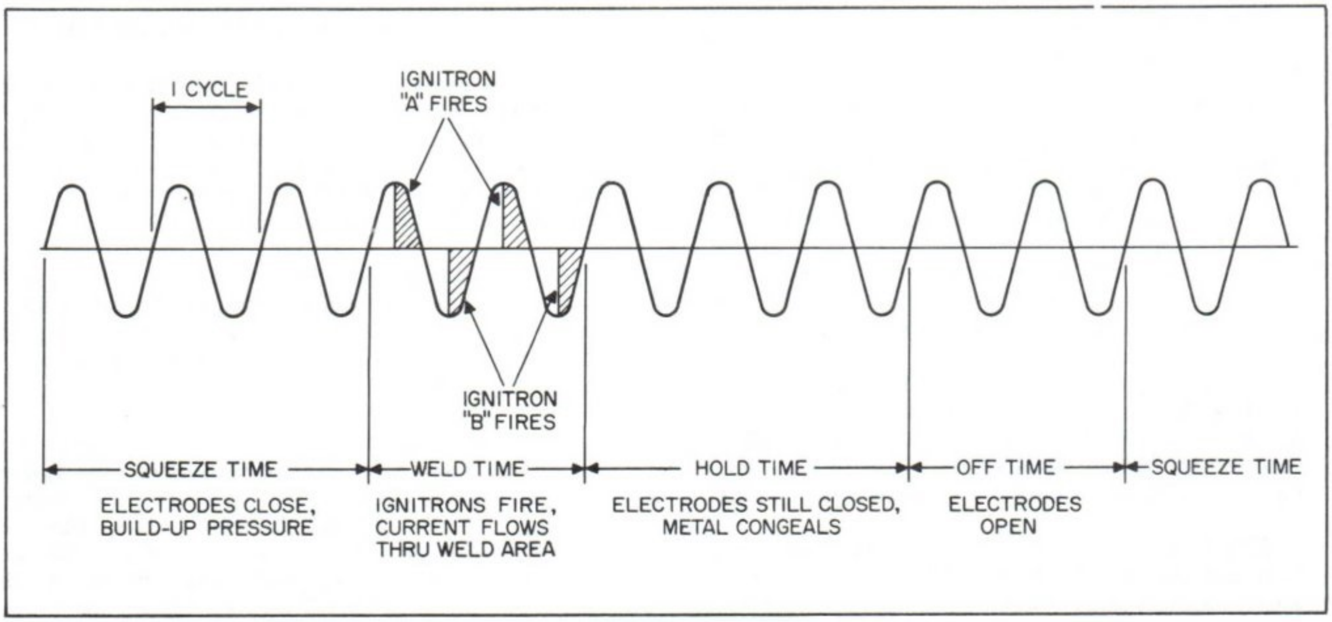


Figure 6. Ignitron Current Control

1-2. OPERATING SUGGESTIONS.

a. GENERAL. There are three basic conditions which usually result in complete ignitron failure or sporadic operation. These are:

(1) Exceeding maximum tube ratings.

(2) Insufficient flow of cooling water.

(3) Ignitor firing tube malfunction.

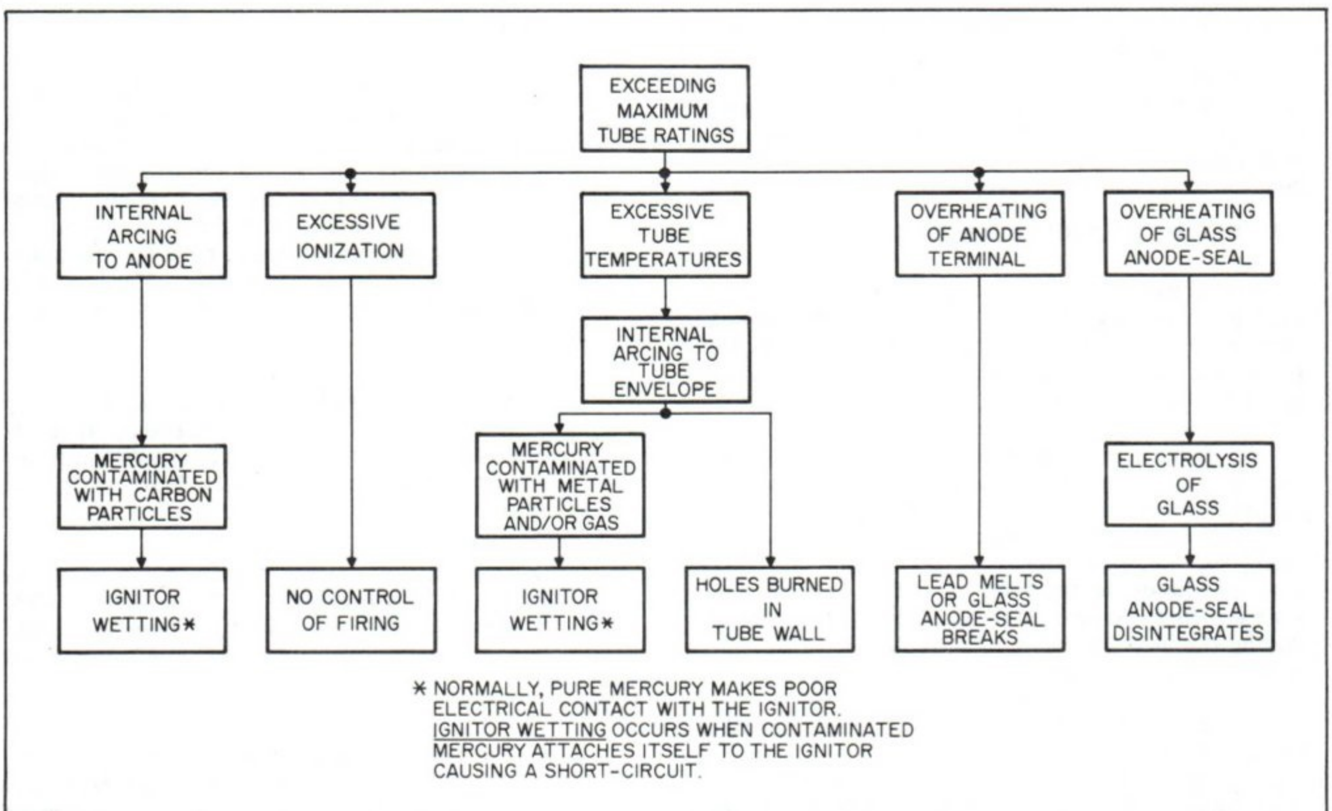


Figure 7. Effects of Exceeding Maximum Tube Ratings

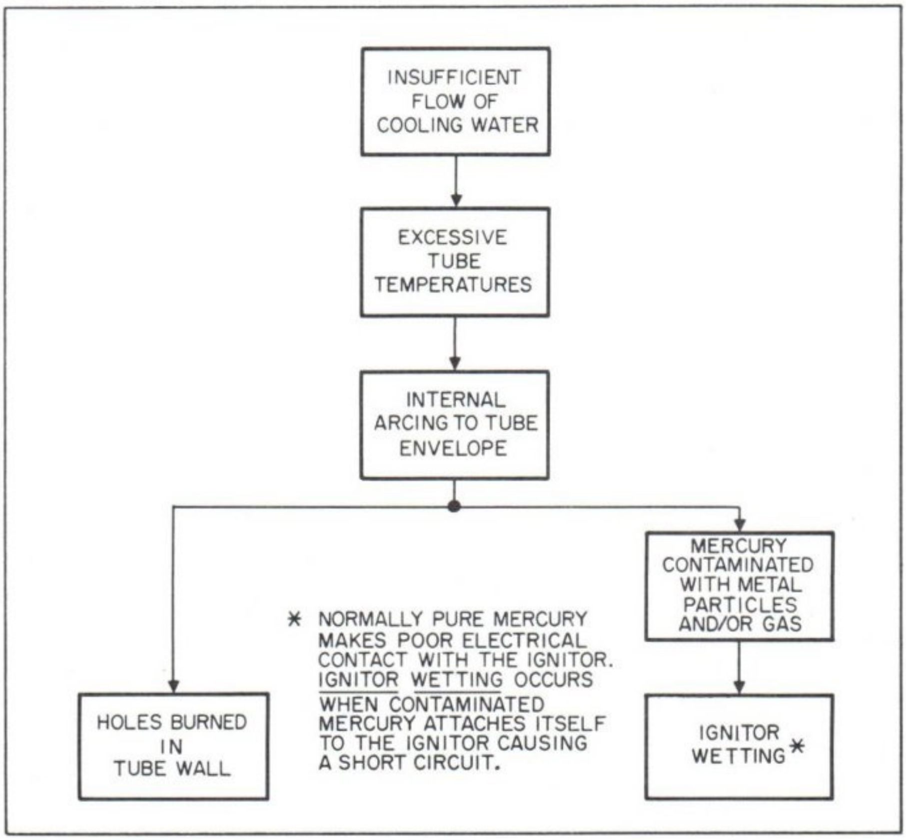


Figure 8. Effects of Insufficient Flow of Cooling Water

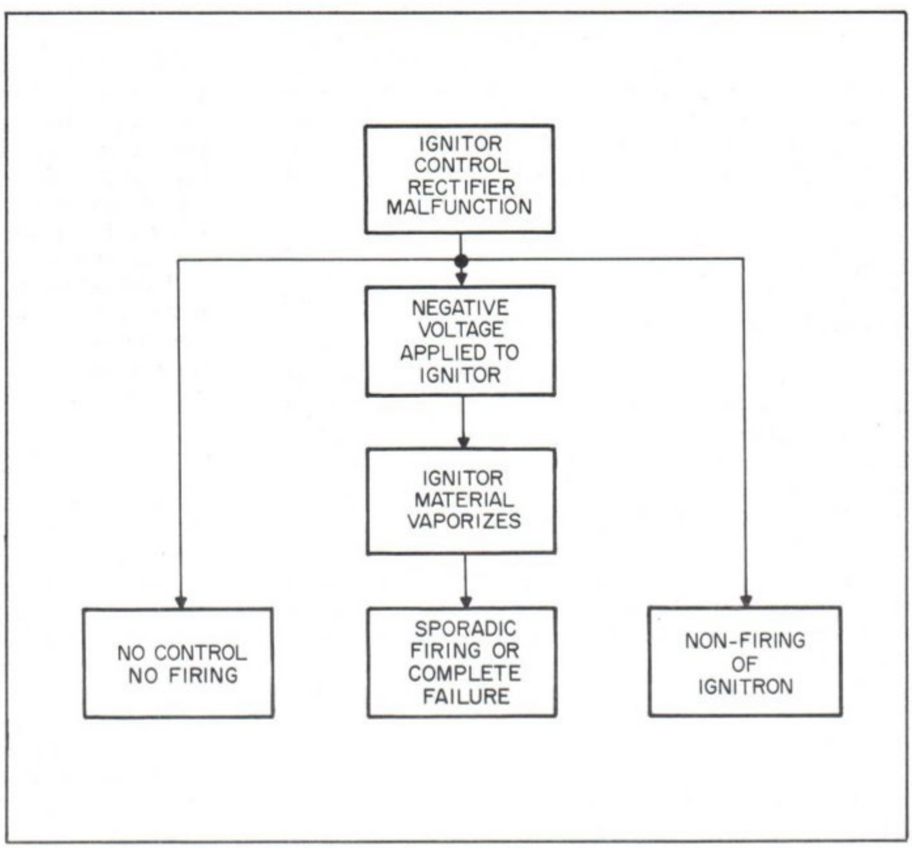


Figure 9. Effects of Malfunction in Ignitor Control Rectifiers

PREVENTIVE MAINTENANCE CHECK

BE SURE THIS IS DONE	BE SURE THIS IS NOT DONE
1. Water supply and controls adequate.	1. Water and thermostat power shut off immediately after shutdown.
2. Allow tubes to cool before shutting off water and power to thermostat controls.	2. Overload tubes.
3. Mount control to avoid excessive vibration.	3. Replace ignitrons without checking rectifiers or firing tubes.
4. Keep terminals clean and tight.	4. Store tubes on side.
5. Check tubes periodically.	5. Rough handling of tubes.
6. Keep records of tests and equipment performance.	
7. Store ignitrons in an upright position.	

Figures 7, 8, and 9 illustrate the actual resultant malfunction or breakdown of the ignitron and the chronological sequence of events which lead up to it. A preventive maintenance program applied through periodic inspection will reveal these conditions as they develop. Immediate correction thereof will tend to eliminate most ignitron failures and untimely equipment breakdown.

b. WATER TEMPERATURE.

(1) The cooling system of an ignitron can be compared to an automobile engine cooling system. Similarly, the cooling coils or water jacket in an ignitron is comparable to the water jacket in a liquid cooled automobile engine, and the flow of water through these coils or water jacket is used to maintain the operating temperature below a maximum limit.

(2) It is obvious that the lower the temperature of the coolant before entry into the coils or water jacket, the lower will be the rate of flow required to maintain a safe operating temperature.

(3) Due to a time lag between the transfer of heat from the ignitron to the water, it is necessary to allow the cooling water to flow through the ignitrons for a period of time after the anode power has been turned off. Non-compliance with this rule can lead to tube overheating immediately after power shut down.

(4) For example, water should be circulated through National NL-1051A and NL-1052A type ignitrons for at least 15 or 20 minutes after anode power has been removed. This period of time should be at least 20 to 30 minutes with type NL-1053A ignitrons.

c. THERMOSTATS.

(1) National ignitrons are equipped with a flange for mounting an over temperature protection thermostat and/or a water-saving thermostat. Figure 10 shows a typical installation where one ignitron is equipped with an automatic overheat shutdown thermostat, and the second ignitron is equipped with a water-saving thermostat.

(2) Water saving on NATIONAL® ignitrons can be accomplished in two ways:

(a) By use of a water-saver thermostat paralleled by relay contacts as shown in figure 10. The contacts of the thermostat should be shorted by a pair of auxiliary contacts closing when the weld initiating switch closes, and held closed during the weld cycle. This mode of operation starts the water flow immediately when the weld initiating switch is closed and provides maximum cooling. The thermostat then functions to provide water flow during part of the non-conducting period to remove the heat stored in the ignitron and cuts off the water when the ignitron is cool. With this type of operation the full rated load of the ignitron is available since the water starts flowing prior to the beginning of the conduction period. It also permits saving of tip and transformer cooling water by controlling this water with the same solenoid water valve.

(b) By using only the protection thermostat, C4391N7-52 or C4391N7-59, and partially closing a hand valve in the cooling water line to give only the flow needed for adequate cooling on the particular job. The hand valve should control water flow to only one pair of ignitrons. Tip and transformer water flow should not be reduced. If water flow is reduced too far the protection thermostat will open and thereby prevent damage to ignitrons.

(3) Such occurrences as fluctuating water pressure, irregular flow, and temperature rise of cooling water no longer cause unnecessary shutdowns and unnecessary loss of production time. The thermostat will shut down the equipment only when the

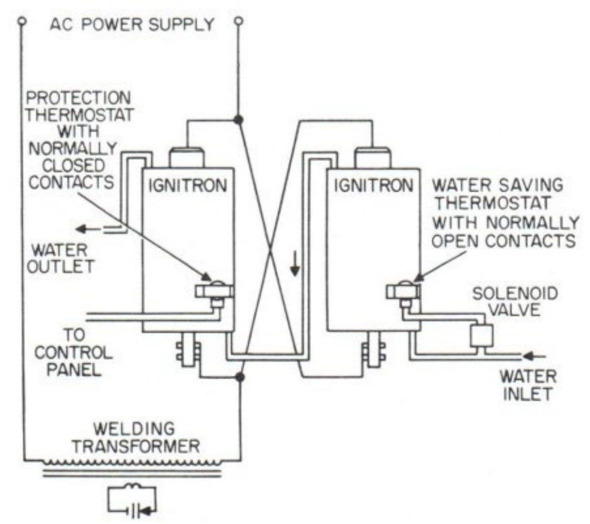


Figure 10. Thermostats

tube temperature rises high enough to endanger the ignitrons. As the cooling water does not come in contact with the outer can there will be no condensation and consequent damaging drip from the ignitron. Nor is it necessary to shut off the water during down time to prevent condensation on the ignitron.

(4) The greater thermal capacity of the NATIONAL® construction permits greater maximum averaging time, for increased welding capacity. On the B and C sizes, it has been increased by 50% and on the D, by 100%.

(5) Spare tube stocks can be reduced to a minimum. Since the thermostats are demountable, tubes are purchased without thermostats and can be used to replace old style tubes or, with the addition of a thermostat can be used for thermal protection. It is necessary to stock only one style tube for each size used.

(6) All sizes use the same thermostats. A small thermostat stock is adequate for proper maintenance of all welders. All thermostats are supplied with the necessary mounting clamps. No delicate adjustment is necessary on the thermostats before mounting.

(7) The high efficiency of the cooling system makes possible maximum water saving. A substantial water saving, in excess of 90%, for many applications, can be obtained by reducing the water flow by means of a manually operated water valve. This is possible because the coil construction maintains turbulent flow at low rates of flow. The protection thermostat protects the ignitrons and shuts down equipment if reduction has been excessive. Additional savings are possible during down time with a water-saver thermostat and solenoid valve.

(8) There are no stagnant spots in the cooling system to build up sediment deposits. The coils are self flushing and all sediment is flushed down the drain. This eliminates loss in cooling efficiency due to such deposits and decreases maintenance costs.

(9) Table I lists the actual cooling requirements of size B, C, and Jumbo C National Electronics ignitrons. The thermostat mounting plate on National Electronics ignitrons is solidly brazed to the inner cylinder or copper cooling coils thereby providing positive temperature sensing with a minimum of thermal lag.

TABLE I. COOLING REQUIREMENTS OF B, C, AND JUMBO C IGNITRONS

SIZE	AMPS (DC)	INLET WATER (TEMP °C)	100% LOAD		50% LOAD	
			WATER FLOW REQ'D (GPM)	PRESSURE DROP PER TUBE (LBS PER SQ IN.)	WATER FLOW REQ'D (GPM)	PRESSURE DROP PER TUBE (LBS PER SQ IN.)
B	56	15	0.25	0.4	0.063	0.1
		30	0.50	0.75	0.125	0.2
		40	1.50	3.00	0.25	0.4
C	140	15	0.375	0.6	0.125	0.2
		30	0.5	0.9	0.25	0.4
		40	1.25	4.0	0.5	0.9
JUMBO C	220	15	0.875	1.5	0.375	0.6
		30	1.375	5.0	0.875	1.5

1-3. MAINTENANCE HINTS.

a. GENERAL. Obviously, the basic conditions which lead to tube failure are those to which preventive maintenance should be applied through periodic inspection. If any of the conditions outlined in the following paragraphs are found to exist, they should be corrected as soon as possible.

b. FOUR COMMON CONDITIONS THAT WILL CAUSE IGNITRONS TO OPERATE IMPROPERLY.

(1) Operating the control when only one of the two ignitrons is conducting. Long weld time or repeated short welds under these conditions will produce high current surges, which may destroy the operating ignitron, and in some cases may cause insulation puncture in welding transformers. This condition is most commonly referred to as half cycling and can result from one or more of the following faults:

(a) Operating welder with open or high resistance secondary circuit. This condition is often caused by broken or badly worn electrodes, low electrode pressure, dirty or scaly stock, poor electrical contact joints in the secondary circuit, or frayed or broken gun cables. Such an open or high resistance secondary may reduce the demand current on the ignitrons to a point so low that one or the other tube will not ignite or may go out during its conducting half cycle. An auxiliary load resistor connected across the primary of the welding transformer will prevent damage to tubes and transformer from this fault.

(b) Operating welder when one of the ignitor firing thyratrons has failed or when one of the dry type rectifiers in the ignitor circuit has failed.

(c) Operating a relay fired welder with burned or broken ignitor firing relay contacts, or when relay is bouncing or chattering.

(d) Operating welder equipped with phase shift heat control (especially on heavy welding job with long weld time) when unbalanced firing is occurring. This is most often due to improper adjustment of power factor correction adjustment, or fault in ignitor circuit to one ignitron such as high resistance contact in socket of one ignitor firing thyratron.

(e) Operating welder when one ignitron has open or shorted ignitor, or when one ignitor fuse has blown.

(2) Operating the control without sufficient water flow or no water flow. Repeated operation of equipment under such conditions can sufficiently overheat the tube to cause its glass-to-metal seals to leak air and make the tube inoperable, In severe cases, the glass may melt or break. These cases are more frequent and generally more destructive where protection is dependent on a flow switch, because the time lag of some flow switches is so great. Thermostat protection has a much more rapid response, thus greatly reducing the possibility of damage.

(3) Mounting of ignitrons in control.

(a) Ignitrons should always be mounted so as to be as nearly vertical within 4-5 degrees as possible. If the tube is tilted in any direction, excessive immersion or insufficient immersion of the ignitor can result. In either case, shorter tube life and erratic operation can result.

(b) Tilting the tubes to match ignitor cold resistance will rarely, if ever, improve tube operation; in fact, in most cases it will shorten tube life or produce erratic operation. Ignitors are positioned in manufacture so as to have the proper immersion depth with the tube in a vertical position.

(c) All connections to the tube should be clean and tight because any looseness can result in high resistance connections which will generate heat and may damage tubes. Lock washers should not be removed or left off because without them tight joints can become loose under vibration.

(4) Statistics show the most frequent cause of ignitron failure is rough handling and accidental destruction from such things as short circuiting by foreign articles in the control panel or tubes being drenched with cold water while they are still hot from recent operation. These statistics show that comparatively few ignitrons die of the normal cause; i.e., gradual eroding away of the ignitor through billions of firings until it becomes thin enough to burn off. Contrary to some opinion, cold resistance of ignitors does not constitute a method of matching tubes. Peak volts and peak amps required to start an arc spot determine the condition of an ignitor and are not necessarily directly related to cold resistance. Seldom, if ever, can balanced firing be achieved by matching ignitor cold resistance. Some ignitors with very low cold resistance such as 5 ohms have been produced that have very satisfactory peak volt ampere requirements for firing. The same is true of some ignitors with resistances much higher than the average. If unbalanced firing exists, it is most frequently traceable to some circuit difficulty.

c. IGNITRON TROUBLE-SHOOTING SYMPTOMS.

(1) Severe electrode spitting, with well dressed electrodes and normal air pressure, suggests a gassy ignitron.

(a) Make certain that water is flowing, disconnect both ignitor leads, and allow points to close. If sparking occurs when points touch work, one of the ignitrons may be gassy. The gassy tube can often be identified by leaving the ignitor leads off and observing the ignitrons for glow in the top glass seal.

If one is glowing under these conditions, that tube is gassy.

(b) In some cases, the glow observation method is not workable because of excessive blackening of top glass seal or glow discharge occurring in tube where it cannot be readily seen through glass seal. To determine which tube is gassy, disconnect both ignitor leads, energize panel, and check for voltage across primary of welding transformer. If any voltage appears, one ignitron is gassy. De-energize panel and disconnect anode lead of one ignitron, re-energize panel and repeat the voltage check. If voltage is gone, the disconnected tube is bad. If voltage is still there, the connected tube is probably bad. De-energize panel and disconnect anode lead of other tube. Re-energize panel and repeat voltage check again. If voltage is still there, the transformer or other circuitry adjacent to welding transformer is grounded or shorted, and probably neither tube is bad.

(2) Repeated line breaker tripping and/or abnormal groaning of welding transformer indicates half cycling. Under these conditions, weld heat will vary from normal.

(a) The non-firing tube can usually be found by observation.

(b) A severe unbalance of control when operating on high current long weld time jobs will cause similar symptoms.

(c) Half cycling is more often due to ignitor circuit rectifier or ignitor firing thyratron failure than ignitron failure. These components should be checked before ignitron is replaced.

(d) When half cycling is occurring, de-energize the panel and disconnect ignitor leads from tubes. Check cold resistance of ignitor to cathode bus. If resistance of either ignitor is below 10 ohms or above 150 ohms, this may be the trouble, and that ignitron should be checked in another panel or sent to the tube manufacturer for testing.

(3) Electrode spitting on welder for short time after overnight or over-weekend shutdown.

(a) Occasionally, welder will show this symptom for a short time, and then operate satisfactorily until the next day, only to do it again. This is usually a gassy ignitron, which after a few conductions cleans itself up. To determine which is the gassy tube, you must proceed as in Item (1) above, but it must be done before welder is put into operation after long shutdown.

(b) This symptom can also result from a moisture ground in welding transformer.

(4) Occasional half cycling and intermittent transformer groaning with fluctuation in weld heat accompanied by occasional cold welds.

(a) This is often the symptom of normal ignitron failure at the end of life. The gradual erosion of the ignitor will become apparent by this occasional malfunction of equipment and will become more frequent. A cold resistance check of the ignitor will show that its resistance has gone above 150 to 200 ohms or below 10 ohms and the tube should be tested or replaced.

(b) This symptom can also indicate failure of one of the ignitor firing thyratrons. Such trouble caused by thyratrons is a result of peak emission slump in the thyratron. An average emission check of the thyratron will not indicate the bad tube. The bad thyratron can often be detected by observation. If one tube is glowing intermittently bright and dim, or glows with a distinctly different color than similar tubes, this is likely the faulty tube and should be replaced.

1-4. TESTING IGNITRONS.

a. GENERAL. The following tests can be used to determine whether the ignitor has become "wet" or whether gas has formed in the tube.

CAUTION

Safety precautions should be taken during these tests.

b. IGNITOR TEST. (See figure 11)

(1) Remove tube from equipment.

(2) Connect ohmmeter to ignitor stud and cathode bus. (Ohmmeter R x 1 scale).

(3) Hold tube vertical with cathode bus down. The reading should be 10-200 ohms.

(4) Slowly tilt tube toward ignitor stud about 15°, then tilt about 15° in opposite direction. The resistance should vary smoothly down and up.

(a) If resistance in step (3) above is below 10 or above 200 ohms, this is probably the tube causing trouble.

(b) If resistance change is erratic (shows sudden changes), the ignitor is broken or wetted (bad tube).

(c) If ohmmeter reading is either 0 or infinity, ignitor has been destroyed.

(5) Several tubes should be tested in a similar manner, including new tubes in order to provide the serviceman with the "feel" exhibited by this test.

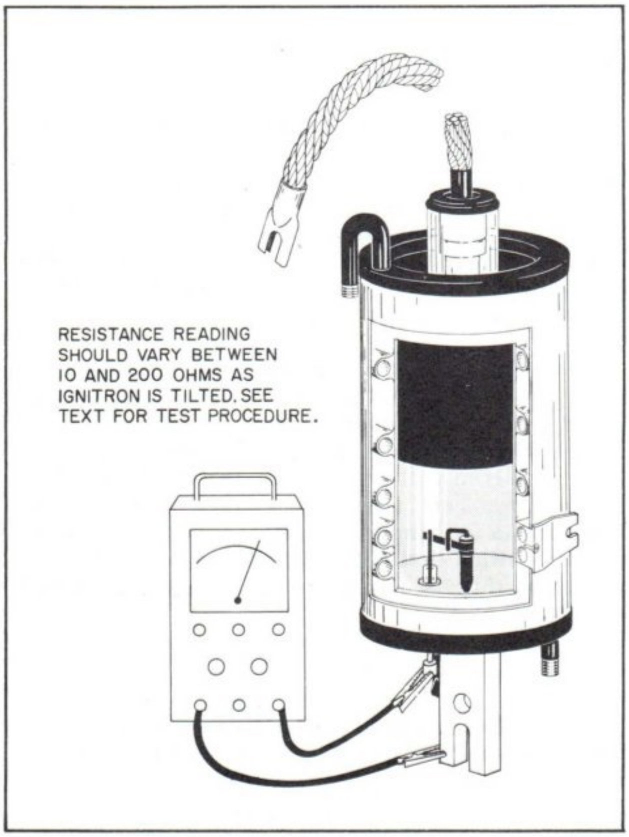


Figure 11. Ignitor Resistance Test

(6) If the test shows that the ignitor is wet, the tube may operate satisfactorily for a while; however complete failure or sporadic operation is inevitable.

(7) Wet ignitors indicate that the tube was probably operated at temperatures in excess of ratings, or that sidewall arcing had occurred. An investigation should be made to correct this condition.

c. VACUUM TEST. (See figure 12)

(1) PRELIMINARY TEST PROCEDURE.

(a) Use a hand-held spark coil capable of generating a 1/2 to 3/4 inch spark. These spark coils are available from Scientific Supply outlets.

(b) After the tube is cool, disconnect the anode cable terminal from the panel.

(c) Connect the cathode (tube envelope) temporarily to ground in order to protect the circuit insulation.

(d) Touch the spark coil tip to the anode cable. During this test, a hazy blue or gray glow that flashes or appears intermittently may be visible through the glass anode seal. This is a normal phenomena.

(e) If sustained sparking is visible in the space between the glass seal and the inner anode lead, the tube may be gassy. Remove it from the panel and perform the high potential test procedure.

(f) If sustained sparking is not visible, the tube may still be gassy, and the test should be continued.

(g) Bend the anode cable so that the terminal is approximately 1 inch from the tube cylinder.

(h) Place the tip of the spark coil against the anode terminal and press it slowly toward the tube cylinder. A spark should jump between the terminal and the tube cylinder before the gap reaches 3/16 inch. If the gap has to be decreased below 3/16 inch to make the spark jump, the tube may be gassy and should be removed from the panel for high potential testing.

(2) HIGH POTENTIAL VACUUM TEST. (See figure 13)

WARNING

Extreme safety precautions must be exercised because of HIGH VOLTAGES involved.

(a) Energize tester with secondary of H.V. transformer open circuited and variable transformer at 0 volts. Increase voltage to maximum and record primary current in H.V. transformer. This current should be very small.

(b) Reduce voltage to 0 volts. DE-ENERGIZE TESTER.

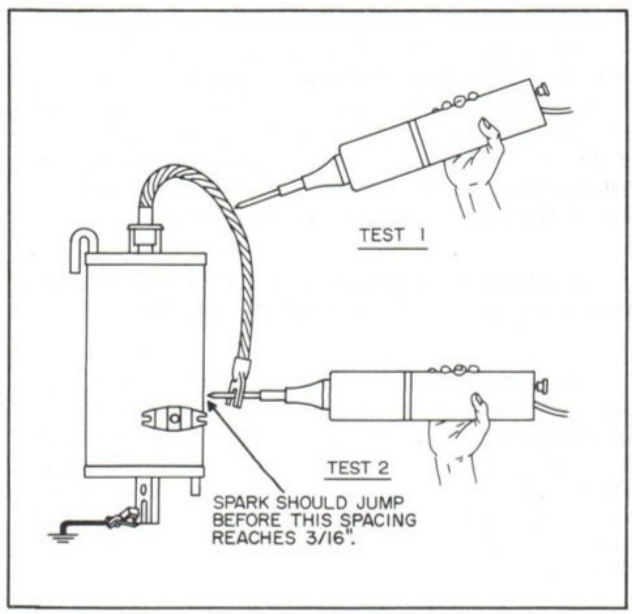
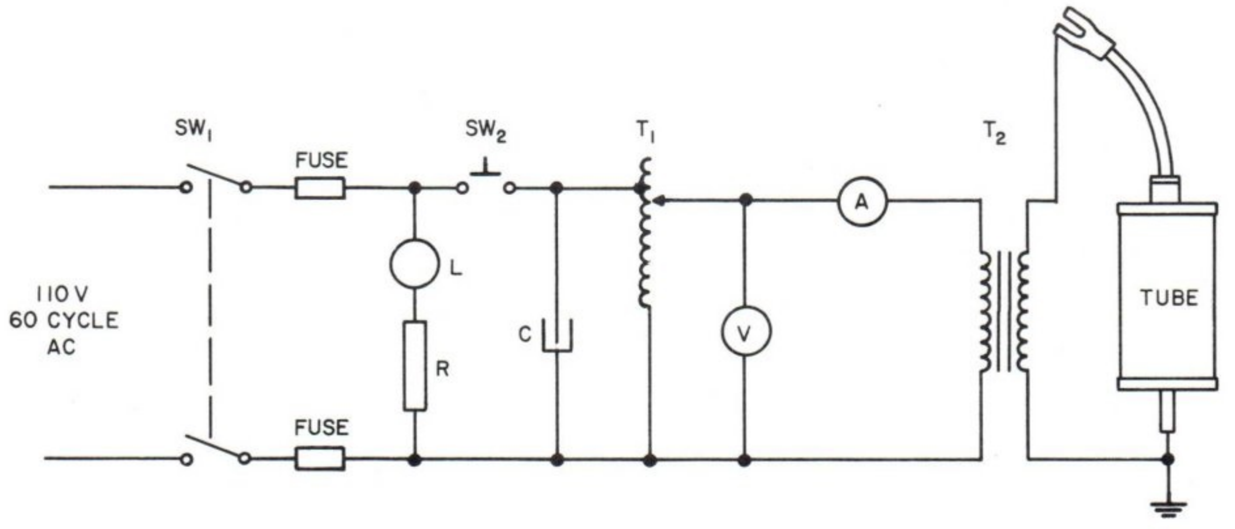


Figure 12. Preliminary High Potential Vacuum Test



A – Ammeter 0-5 Amps. AC

C – Capacitor .25 mfd 400V

F – Fuse 1 Amp. 230V

L – Neon Lamp .25W

R – Resistor 12K .25W

SW_1 – Switch D.P.S.T. 120V 2 Amp.

SW_2 – Switch S. P. Spring Loaded N. O.

T_1 – Variable Transformer 0-135V 1 Amp.

T_2 – High Voltage High Impedance Transformer Pri., 120V; Sec. any voltage between 6,000 and 12,000.

V – Voltmeter 0-150 V AC

A suitable enclosure can be constructed of wood or dielectric material. Care should be exercised so as not to leave any energized wires or parts accessible for accidental contact.

Automotive high voltage ignition cable is recommended for the leads connecting the tube to the H.V. transformer secondary.

Figure 13. Test Setup For High Potential Vacuum Test

(c) Support the ignitron tube in a vertical position with the cathode bus down.

(d) Cathode bus should be grounded so that only the anode lead can be elevated to high potential.

(e) BE SURE TESTER IS DEAD. Connect the high voltage secondary of the H.V. transformer to the anode lead. BE SURE TO CONNECT GROUNDED SIDE of H.V. transformer secondary to cathode bus of tube.

(f) Use variable transformer to gradually increase voltage across tube (always starting at 0 volts), until maximum is reached.

1. If the steady current is not in excess of open circuit current, the tube has good vacuum.

2. If a steady current in excess of the open circuit current is read, the tube has poor or no vacuum. (Tube is bad.)

3. Occasional flicks of the ammeter may be observed while elevating voltage. This is caused by arcs from small droplets of mercury on internal parts and does not indicate poor vacuum.

4. If steady current is allowed to flow for some period, gas can sometimes be cleaned up and tube will appear to pass repeat test. This tube is not operable because gas will reappear after some storage period.

(g) Reduce voltage to zero, de-energize tester, and remove tube.

1-5. COPPER COIL COOLING VERSUS WATER JACKET BATH COOLING.

National Electronics tubes use copper tubing coils for water cooling. The advantages of this construction are listed below.

a. COPPER COOLING COIL. The high conductivity of copper, greater thermal mass of assembly, and turbulent flow of the cooling water through the tubing are utilized to give maximum cooling efficiency.

b. INNER WALL TEMPERATURE CONTROLLED FOR PARTICULAR AREAS. Close spacing of coil is maintained on lower section for cooler wall where mercury condensation is desired. Wide spacing on upper section eliminates danger of arc-backs by preventing mercury condensation near anode.

c. NO SWEATING—NO DRIPPING WATER TO INJURE OTHER COMPONENTS. Cooling coils and outside of inner can are covered with an insulating coating. This coating plus the outer can prevent outside air contact with water cooled parts and eliminate water condensation on tube.

d. POSITIVE TEMPERATURE SENSING. Copper thermal block and thermostat mount are brazed and soldered to inner can. No variations in temperature sensing will result from aging or impurities in cooling water. Even muddy water does not impair the accuracy.

e. NO SEDIMENT DEPOSITS OR FLOW RESTRICTIONS. The sweeping bends of the cooling coil produce free highly turbulent flow, are self-flushing, and maintain high cooling efficiency.

NOTE

These advantages found only in NATIONAL ELECTRONICS' coil construction ignitrons give longer trouble-free service, less down time, and consequently, lower maintenance costs. Because of higher cooling efficiency, National ignitrons can be used with warmer cooling water and less cooling water than other makes.