Westinghouse

Ignitron Tube

(Sealed-off Type)

Fig. 1 - Westinghouse Ignitron Tube (Sealed-off Type), With Anode Connection Cut Away

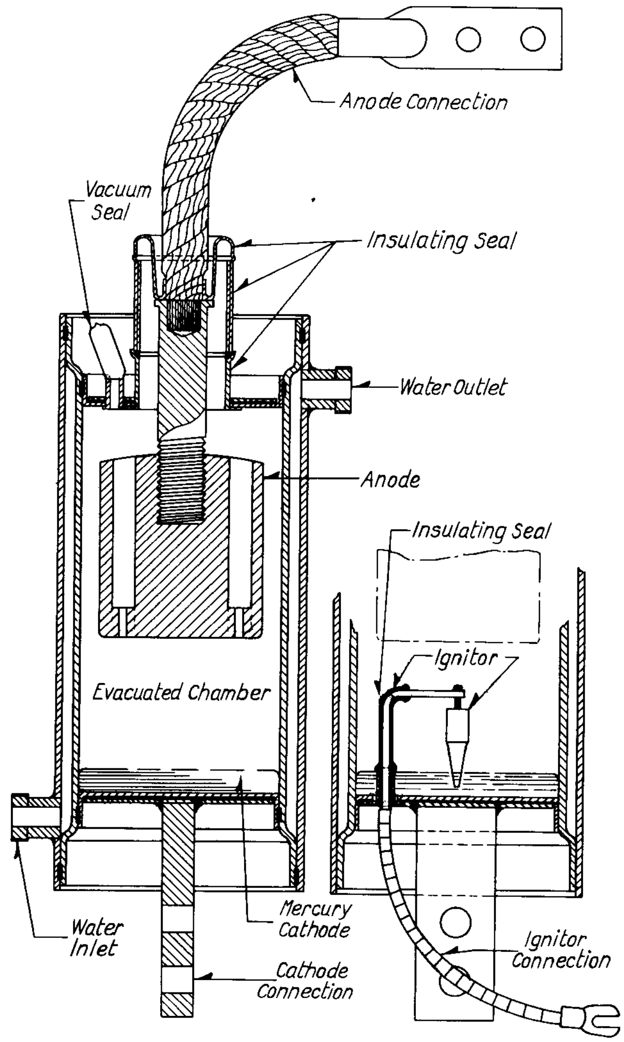


Fig. 2 - Cross Sectional Views of Typical Ignitron Tube Showing General Features of Construction

Description

The Ignitron is a heavy duty electronic tube which conducts uni-directional current through the controlled ionization of mercury vapor. Because of its mercury pool type cathode, which provides practically unlimited electron emission, the Ignitron is ideally suited for such high surge current industrial service as the control of spot and seam welders. For its control, the Ignitron contains an ignitor which functions in the tube as a spark plug does in an automobile cylinder. This ignitor energizes the tube at the beginning of each desired half-cycle of power current.

The tube consists of a permanently evacuated, water-cooled, metallic vessel with the mercury pool cathode in the bottom and a graphite anode supported by an insulating bushing at the top. The auxiliary control electrode, or ignitor, dips into the mercury pool and is also supported in the tube by an insulating bushing. See Fig. 1 and cross sectional view Fig. 2.

Theory of Operation

The Ignitron conducts current in the form of an arc discharge in mercury vapor from graphite anode to mercury pool, as does the conventional mercury arc rectifier. However, the usual keep-alive arc, with its associated cathode spot, is absent in the Ignitron tube. Instead, the ignitor causes formation of a cathode spot for each desired half-cycle of current, or, if desired, for

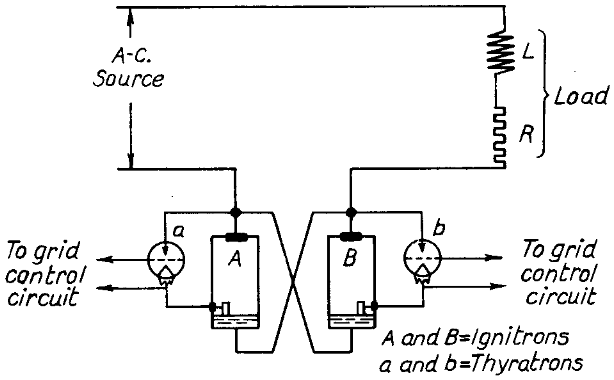
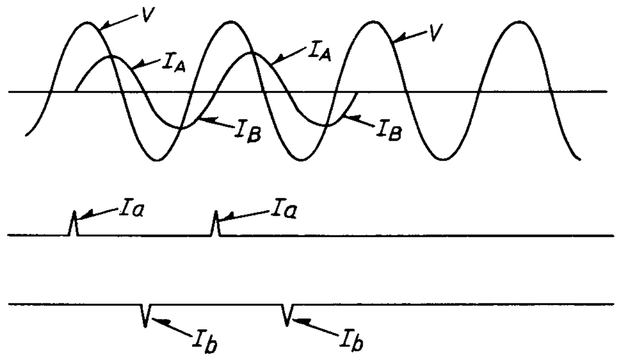


Fig. 3 - Connection Diagram for Controlling Ignitrons



V = Line Voltage
I_A = Power Current of Ignitron A
I_B = Power Current of Ignitron B
I_a = Ignition Current of Ignitron A
I_b = Ignition Current of Ignitron B

Fig. 4 - Typical Wave Forms of Both Power and Ignition Current for Two Cycles of Current Conduction as Applied to an Inductive Load

the latter portion only of the normal half-cycle. Once energized by the ignitor, the tube will conduct current to the end of the particular half-cycle, at which time reverse line voltage reduces the current to zero, extinguishing the arc discharge as well as the cathode spot. The tube must then be again ignited for any further current conduction.

The ignitor operates not from high potential, but from a current impulse conducted through it into the mercury pool. When a relatively small current impulse is passed into the ignitor, a spark first forms at the junction of ignitor and mercury. This small spark functions as a source of electrons. If a positive potential of 50 volts or more be applied to the anode, these electrons are attracted toward the anode. In passing at high velocity through the mercury vapor, these electrons collide with, and ionize, certain of the mercury vapor atoms which, in turn, furnish additional electrons as well as positive mercury ions. These positive ions are attracted to the cathode where they cause rapid expansion of the cathode spot, and more or less complete ionization of the vapor content of the tube results. This entire process occurs in a few micro-seconds after the initiating spark appears, or in an exceedingly small fraction of one half-cycle of line voltage.

The arc voltage drop of Ignitrons is normally between 10 and 20 volts, depending somewhat on the current conducted. Even this low drop, however, entails some tube losses which must be removed by water cooling adequate for the current being conducted.

The ignition circuit most commonly employed is of the type shown in Fig. 3, which, incidentally, shows two Ignitrons in reverse parallel connection for conducting a-c. power to the load, which may be a welding machine. The two grid-controlled Thyratron tubes contained in each ignition circuit, conduct ignition current from the power circuit itself for energizing the two respective Ignitrons. When either power tube has been ignited, the low arc drop of this power tube cuts off further flow of ignition current through the shunt-connected Thyratron tube and ignitor. Fig. 4 shows typical wave forms of both power current and ignition current for two cycles of current conduction as applied to an inductive type load such as a spot welder.

Operating Requirements

Handling

Some care should be exercised in handling Ignitron tubes to avoid injury of the ignitor and other internal parts by movement of the heavy mercury content. Also, dropping the tube or bumping against hard objects may break the glass bushings supporting the anode head and the ignitor.

Mounting and Connections

Normally, the tube is mounted by bolting in an upright position, by means of the heavy copper cathode connection lug, to a well supported bus bar. Obviously, the support should not impart sufficient vibration to the tube as to risk mechanical injury, or, excessive disturbance to the mercury pool.

The heavy flexible anode lead at top of the tube is also bolted to a suitable copper conductor but this lead should never pull excessively on the tube so as to furnish partial support. The small flexible connection at the bottom of the tube is the ignitor lead which connects externally to the ignition-controlling circuit.

Cooling

Most of the heat generated within the tube is removed through the metal container within which the pool cathode rests. Anode heat radiates, in part, to the container wall while the remainder flows out of the tube through the heavy flexible anode lead. For this reason, i.e. to aid in removing heat, the anode bus bar, as well as the cathode bus bar, are preferably of substantial section and surface area.

Principally, however, water cooling is depended upon to keep the tube temperature within safe limits. Therefore, some care and attention in regard to the water supply is essential to safeguard the tube.

Since the tubes normally operate at a few hundred volts potential to ground, insulating hose lengths conducting cooling water to and from the cooling jackets of each tube are necessary. The lengths of this hose must be adequate for the voltage applied, otherwise excessive currents will flow in the contained water column and tend to corrode the water jacket hose fittings.

A water flow switch should be installed at the point of water outlet from the tubes, so connected into the control circuit and its operating point so adjusted that the tubes cannot be operated without adequate water cooling. To properly cool the tubes a flow of from 1/2 to 3 gallons per minute is necessary, depending upon the type of tube and the particular current duty of the tube. Incoming water temperature should never exceed 30°Centigrade. In any event, the temperature of outgoing water must never exceed 40°Centigrade. Whenever outgoing water feels cool to the hand, the tube is provided with adequate water cooling.

The outlet hose connection should be to an open drain, must be unrestricted, and preferably at no higher elevation than the bottoms of the tubes themselves.

Select the most reliable available source of clean cooling water from the standpoint of continuity. If scale or collodial material is present in the water main, install a strainer between the main and the inlet to the tube cooling jacket. The water must be free from sediment or scale forming compounds.

The Anode-Cathode Circuit

Never operate the Ignitron beyond its rating in either maximum or average current values. Also, never operate at voltages in excess of rating. Excessive duty imposed upon the tube may cause complete loss in control and severe injury to the tube when the overload is sufficiently severe. On the other hand, although lesser overloads may appear to be giving normal operation, particularly if the water flow is increased, occasional backfire or reverse conduction of current may result. These backfires eventually will loosen sufficient graphite dust from the anode to render the tube inoperative.

If the anode-cathode potential applied to the tube is extremely low at the instant of ignition, the tube will not operate reliably. Normally at least 50 volts, instantaneous value, is necessary to insure prompt anode "pick-up". Low voltages, in addition, involve difficulties in operating the shunt type ignition circuit as described under the following heading.

The Ignitor Circuit

The ignitors require as high as 100 volts and 15 amperes to start the arc discharge in the Ignitron. This involves an instantaneous wattage input to the ignitor of 1.5 Kw. It is at once evident that this input cannot be allowed to continue for more than an instant at the beginning of each power half-cycle; otherwise the ignitor and also the ignitor controlling tube will be injured. It is therefore necessary that the line voltage be sufficiently high and the load impedance sufficiently low as to insure prompt ignition. In operating welding machines, the transformer should never be energized with the welding electrodes out of contact, nor should very low capacity machines be operated. It has been found that welding currents of at least 50 amperes and line voltages of 200 volts rms. or more, allow sufficiently prompt ignition.

Maintenance

Water connections and cooling jackets of the Ignitrons should be flushed out periodically with high pressure water. To maintain proper cooling efficiency, the interval between flushing operations will depend upon the quality of water used, but with the usual grades, flushing is advisable at 6-month intervals. If the water shows a tendency to deposit scale, it will be necessary to use a cleaning compound. "Oakite" has been found excellent for this purpose.

Water should never be allowed to drip on top of the tube.

When a tube appears to operate improperly, first make sure that its ignition circuit is operating to deliver proper ignition. Replace the ignition controlling tube. Next replace the Ignitron with a spare tube or exchange the tube with one from a different circuit location to determine whether proper operation is then secured. This will indicate whether the tube or the associated circuit is at fault.

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