A High-Current Thyratron

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The GL-5855, a new inert-gas-filled thyratron, has massive anode and grid elements sealed directly to a heavy-walled glass envelope. These elements, therefore, are cooled by convection as well as by radiation, permitting full-load operation with low grid current.

INERT - GAS - FILLED thyratrons are being widely used in industrial control applications because of their short warm-up time, ability to operate over a wide ambient temperature range, and freedom from mounting restrictions. A line of gas-filled thyratrons has been described in which some of the restrictions of earlier tubes have been eliminated.[1] The tube to be described here is the *GL-5855* which is an addition, with higher current ratings, to this line, but its structure is quite different from that of its predecessors. It has peak and average current ratings of 150 and 12.5 amperes respectively, a peak forward and inverse anode voltage rating of 1,500 volts, and a 2.5-volt filamentary-type cathode with a 1-minute heating time.

DESIGN

THE *GL-5855* represents a novel approach in the construction of thyratrons; however, the design utilizes certain principles that have been time-tested in transmitting and ignitron tubes.

For many years high-powered transmitting tubes have had one or more of the elements external and integral with the tube envelope. In the case of tubes for extremely high frequency, the design often is dictated by the requirements of minimum lead length and minimum inductance between the tube elements and their respective circuit. In the field of low-frequency tubes, the only reason for external elements is to provide more effective cooling of the elements through convection.

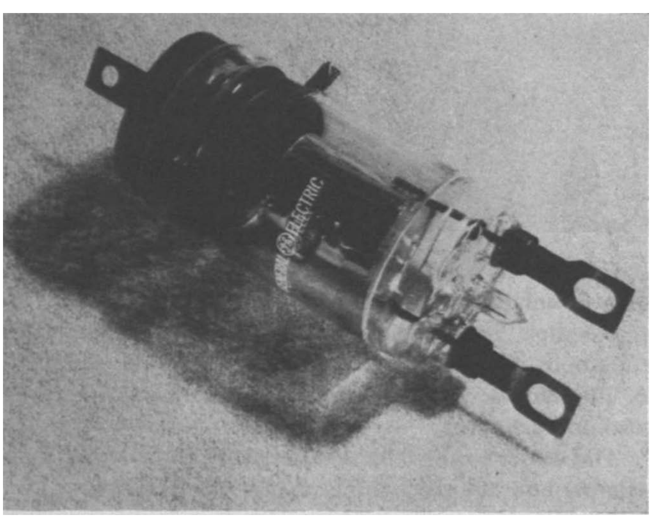

Figure 1. The GL-5855 thyratron is approximately 11 1/16 inches high and has a diameter of 3 3/8 inches

As considerable dissipation takes place at the anode and grid of a thyratron conducting 12.5 amperes average, it was felt that grid emission could be eliminated by designing both the grid and anode as external elements, thereby assuring a minimum operating temperature of the grid.

Ignitron tubes having high current ratings have been designed without bases universally. These tubes are mounted by heavy steel terminals which can be bolted securely to the panel in which they are used.

This type of mounting has proved to be very satisfactory, and the same principle has been carried over to the *GL-5855.* However, the use of a base and socket on a high-current thyratron might lead to the following difficulties in application:

1. Dried-out basing cement causing a loose base.
2. Poor contact in socket causing overheating of and consequent loss of solder in the filament pins.

These types of failure could be very costly to the user, especially if the tube were being used in conjunction with a critical continuous process. By using heavy strap terminals for mounting and electric connection the difficulties are eliminated.

Figures 1 and 2 illustrate a complete tube and a cross section of the *GL-5855.* As is evident, the edges of the anode and grid elements are sealed directly to the glass envelope. Anode and grid seals are fabricated from an iron-nickel-cobalt alloy (Fernico or Kovar) calculated to have a coefficient of expansion sufficiently close to that of the associated glass to allow the seals to be made, annealed, and caused to undergo subsequent temperature cycles during operation without fracture.

The grid consists of two Fernico cups, slotted at the center. These are welded and copper-brazed together back-to-back in such a way that the slots are aligned. A short bracket attached to the outer rim of the cups serves as the grid terminal.

The re-entrant anode is a 3-piece assembly made from a Fernico flange, deep-drawn iron cup, and thick iron disk. The cup is drawn the full height of the anode with flange, at the top, and disk, at the bottom, welded and copper-brazed to the cup. The disk has a twofold purpose. First, it provides good thermal conductivity, thus preventing

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overheating of the center of the anode during operation. Second, the mechanical strength provided by the disk is necessary to prevent the bottom surface from buckling under the atmospheric pressure and thereby contacting the grid surface. An incidental characteristic provided by the thick disk is large thermal capacity.

The anode and cathode terminal straps are welded and copper-brazed to their respective seal assemblies. A hole in the anode terminal permits mounting on a bolt as large as one with a 3/8-inch diameter. The openings in the cathode terminals are elongated and wide enough to allow for variations in the over-all length of the tube and for variations in the positioning of the mounting bolts.

COMMUTATION FACTOR

In addition to those previously discussed, an important rating for an inert-gas-filled thyratron is the commutation factor rating, which is 200 for the *GL-5855*. Commutation factor is defined as the product of the rate of current decay in amperes per microsecond just prior to commutation and the rate of inverse voltage rise in volts per microsecond just after commutation. High commutation factor operation is to be found most widely in multiphase circuits, employing an inductive load where the load current is continuous.

If a tube is operated in excess of its commutation factor rating it is subject to rapid clean up of the gas as a result of excessive ion bombardment of the anode. To prevent clean up of gas in tubes having low commutation factor ratings, it is sometimes necessary to modify the circuit to reduce either the rate of decay of current or the rate of rise of inverse voltage, and consequently the commutation factor, to within the rated value. The rate of decay of current may be reduced by adding reactance in series with the transformer windings, while the rate of rise of inverse voltage may be reduced by adding a series resistor and capacitor connected between the anode and cathode of each thyratron. Additional expense and maintenance are involved in circuits requiring these modifications. In the line of tubes described in the literature, the high commutation factor rating was attained by using a design in which positive ion bombardment of the anode is held to a minimum by:[1]

1. Close spacing between anode and grid resulting in a minimum number of ions being affected by the anode field at the end of conduction.
2. Thorough shielding of the anode leaving only a small portion of its area available for ion bombardment.

From the cross section, Figure 2, it is apparent that these conditions also are fulfilled in the design of the *GL-5855*. Although the anode actually has no shield surrounding it, the effective shielding is complete inasmuch as the top surface of the anode is external to the tube and hence cannot possibly be influenced by mobile ions inside of the tube. As in the previously described line of tubes, the close anode-to-grid spacing also permits loading the tube to the highest possible gas pressure.

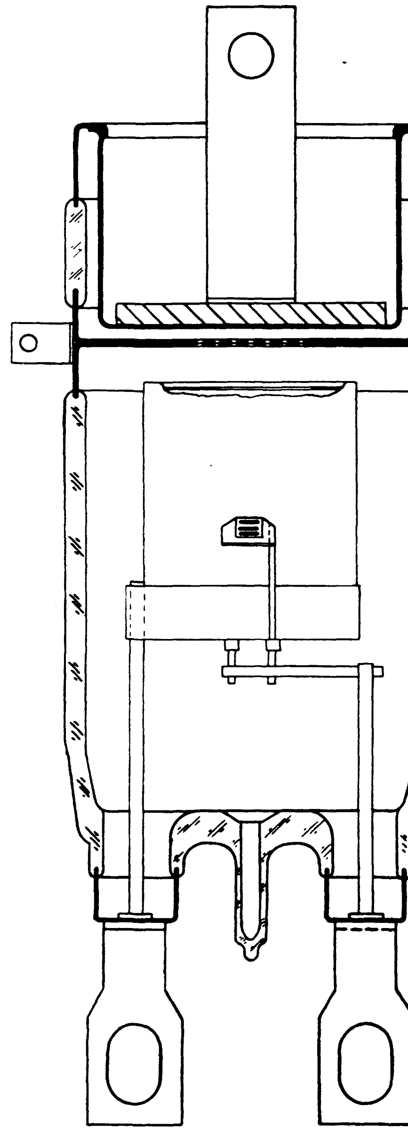

Figure 2. Cross section of the GL-5855

Table I. Test Conditions

	Per Tube Values
1. Average current, amperes	12
2. Peak current, amperes	30
3. Peak inverse voltage, volts	1,175
4. Rate of rise of inverse voltage in volts per microsecond	120
5. Rate of current decay in amperes per microsecond	1.5
6. Commutation factor (product of items 4 and 5)	180

Tubes are being tested under conditions shown in Table I, in a circuit having an inductive load and in which the load current is continuous. In this test the tubes are being commutated under the worst conditions, at the instant when the transformer voltage is maximum.

As is the case with the other tubes in the line, the commutation factor rating for the *GL-5855* is high enough to obviate the need of circuit modifications in most industrial control applications.

REFERENCE

1. **A New Line of Thyratrons, A. W. Coolidge, Jr.** AIEE *Transactions*, volume 67, part II, 1948, pages 723–7.