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NEW TYPE OF LOW-VOLTAGE MERCURY ARC.

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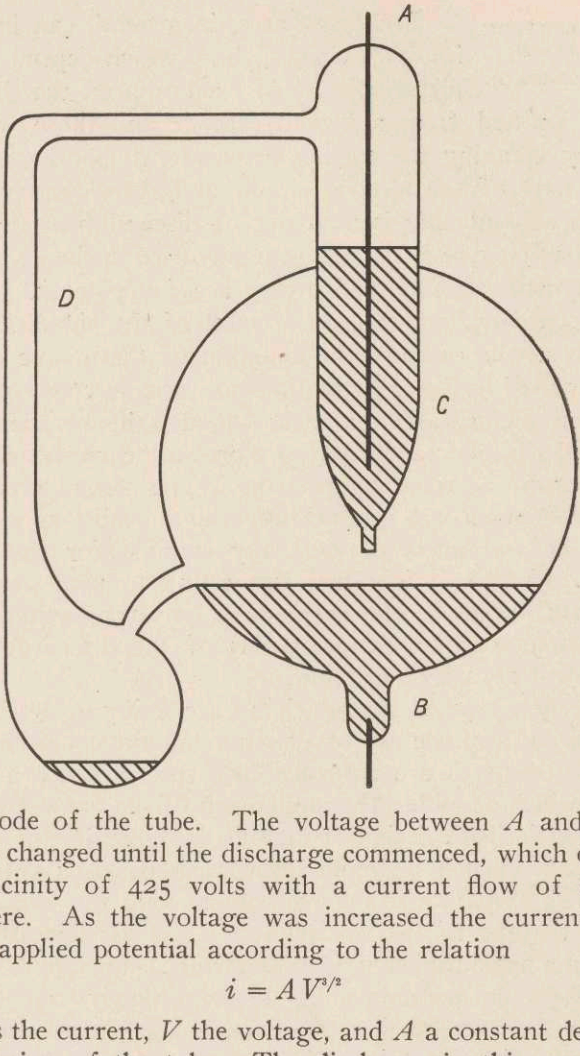
MERCURY arcs, in general, can be divided into two classes, those which depend for their primary cause of excitation on the thermionic electrons emitted from a heated cathode and those which are started by breaking the contact between two pools of mercury forming part of the electric circuit and whose mechanism of excitation subsequently is a matter of discussion at the present time. The first type is the one generally used in the investigation of the characteristics of the mercury arc, *i.e.,* potential gradients, electron concentration, etc., on account of the simplicity of the conditions at the cathode, the emission of thermionic electrons. The tubes used in the investigations are usually constructed with a tungsten filament, and a nickel anode, the evacuated space being filled with mercury vapor at a pressure corresponding to its vapor pressure at room temperature. The second type of discharge tube on account of the complicated conditions existing at the cathode and anode is not very suitable for experimental research, although it is rather interesting to note that in this type of arc the anode can be made of any conducting material without effect on the characteristics of the discharge but the cathode must always be mercury.

In the new type of arc which we are going to describe both the anode and cathode are of mercury but the conditions at the cathode or the anode are controlled by a special device, a mercury dropper, which simplifies the mechanism of the arc. A diagrammatical sketch of the design of the tube is shown in Fig. 1.

The tube, which is highly evacuated, contains two electric terminals A and B, which make contact with the two pools of mercury, the end of the vertical tube C is constricted and terminates in a small capillary tube, diameter .5 mm. approximately, which allows the mercury in C to drop slowly, one drop per second on the average, into the second pool connected with B electrically. The side tube D is used to replenish the supply of mercury in C which gradually runs into B and to keep the mercury in the pool B at a constant level.

In the operation of the tube, the terminals A and B were connected to a battery and the reservoir C filled with mercury which runs through the capillary into B, A being the cathode and

FIG. 1.



B the anode of the tube. The voltage between A and B was gradually changed until the discharge commenced, which occurred in the vicinity of 425 volts with a current flow of one-half milliampere. As the voltage was increased the current varied with the applied potential according to the relation

$$i = AV^{3/2}$$

where i is the current, V the voltage, and A a constant depending on the design of the tube. The discharge in this case was a deep red color, but the mercury drops were surrounded with a green haze which seemed to indicate intense ionization around them as they fell through the entire electric field. By using an oscillograph, arranged to measure the current-voltage characteristic of the discharge, oscillations of the same period as the falling drops were detected.

At sufficiently high voltages, however, the character of the discharge gradually changed at about 500 volts from the type described in the preceding paragraph to one where an intense discharge occurred whenever a drop fell, decaying to zero in the interval between successive drops; moreover, the glow in this case was the same as that associated with the mercury arc.

Using the mercury dropper as the anode, the voltage applied between *A* and *B* was slowly varied until the discharge started, which began at 300 volts, approximately. In operation the discharge showed a brilliant green corona around the tip of *C* but behind the falling drop, the drop itself as it fell through the discharge space showing a bright green haze around it, although the surface of the second pool—the cathode—appeared undisturbed. At a voltage of 320 the average current carried was 55 milliamperes for one design of tube, but the current fluctuated over a wide range due to the changing resistance of the tube. From observations with the oscillograph two types of oscillation were found, first a high-frequency oscillation of several thousand cycles per second, which could be detected by placing a telephone in series with the tube, and second an oscillation of large amplitude with a period corresponding to that of the cycle of the falling drops. Under certain conditions the amplitude of this oscillation varied from zero to a maximum value which depended on the construction of the tube, the high-frequency oscillations occurring in the region of the peak current.

The observations of this type of discharge seem to indicate that the primary mechanism of the discharge may be due to one of the two following types of phenomena or even to both acting simultaneously:

(1) Ionization of the gas in the neighborhood of the falling charged drops as they change their electrical energy by falling through the potential gradient.

(2) Electric discharge between the charged mercury drop and the column as the drop is being severed from the capillary

or just after it has parted and fallen through the cathode or anode potential gradient.

In this paper, a new type of mercury cathode or anode is described which consists essentially of a device for allowing mercury droplets to fall from one mercury reservoir, the cathode or anode as the case may be, to another used as the anode or cathode. When the potential difference between the cathode and anode is sufficient, in the tube described above 300 or 400 volts according to the direction of the applied field, a discharge commences whose current fluctuates with the same period as that of the falling drops, as the resistance of the tube decreases markedly each time a drop falls through the field. The falling drops are also surrounded by a bright mercury glow, showing that intense ionization occurs around the surface of the drop.

In conclusion, the authors wish to express their indebtedness to Prof. K. T. Compton, of Princeton University, for the loan of the oscillograph which was used in this investigation.

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