DEVELOPMENT OF DEVICE FOR SELF-SUSTAINED GAS DISCHARGE USING HIGH VOLTAGE GENERATOR

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РАЗРАБОТКА УСТРОЙСТВА ДЛЯ ПОЛУЧЕНИЯ САМОСТОЯТЕЛЬНОГО ГАЗОВОГО РАЗРЯДА

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Аннотация. *В данной статье рассматривается сборка генератора высокого напряжения из подручных материалов, прототип может быть использован для учебных и исследовательских целей.*

Introduction. Gas discharge is a flow of electrical current through the gas medium under the action of electric field, accompanied by a change in the gas state (ionization, redistribution of carriers, and etc.). Under normal conditions, most gases and air are insulators, since the content of ions is negligibly small. Therefore, if the applied voltages are not too large, the gases do not pass electric current. That is, in order to make gas conductive, it is necessary in some way to create free charge carriers - ions in gas. At that there are two possible cases: either these charged particles are generated by the action of some external factor or they are introduced into the gas from the outside, or they are generated in the gas by the action of electric field existing between electrodes. The first type of discharge is called non-self-sustained discharge, the second one - self sustained discharge [1].

There are two basic ways by which non-self-sustained discharge is created: this is high temperature and various radiations, such as UV radiation, gamma rays, and others. The detachment of electron from atom (ionization of atoms) requires certain energy, called ionization energy. It depends on the structure of the atom and, therefore, it is different for different substances. In parallel we can observe a continuous reverse process of recombination of ions and electrons to neutral atoms, accompanied by the release of energy. Partially it is emitted in the form of light. This so-called glow of recombination is one of the reasons for the glow of many forms of gas discharge. Upon termination of the work of ionizer due to ion recombination the current in the gas stops, so this discharge is called non-self-sustained [1].

Next, let us consider a self-sustained discharge. The emergence and formation of avalanche of charges is not limited to the impact ionization process. When there is a relatively small increase in voltage, on the electrodes of gas-discharge period, the positive ions acquire high energy and striking the cathode, electrons are knocked out of it, and secondary electron emission occurs. The formed free electrons, on their way to anode, produce impact ionization of gas molecules. Positive ions, on their way to cathode at electric fields E=E_k, ionize the gas molecules.

If every electron, knocked from a cathode, can accelerate and produce impact ionization of gas molecules, then discharge will be sustained even after the termination of the external ionizer action. The voltage, at which self-sustained discharge is developing, is called circuit voltage.

When the inter-electrode gap is completely covered by conductive gas plasma, its breakdown starts. The voltage, at which the breakdown of the electrode gap occurs, is called breakdown voltage. Corresponding electric field strength is called break-down voltage strength.

At high voltages between the electrodes of gas gap the current greatly increases. This is due to the fact, that electrons arising under the action of external ionizer action and greatly accelerated by the electric field, collide with the neutral molecules of gas and ionize them. As a result, secondary electrons and positive ions are produced. Positive ions move towards cathode and electrons move towards anode. Secondary electrons again ionize gas molecules, and therefore, the total number of electrons and ions will increase as the electrons move towards anode as avalanche. This causes an increase in electric current. The above process is called impact ionization.

However, impact ionization under the influence of electrons is not sufficient for discharge sustaining when external ionizer is removed. For this purpose it is necessary for electronic avalanche to be reproduced, i.e., so that new electrons occur in the gas under the influence of some processes. These are the following processes:

- positive ions, accelerated by the electric field, striking the cathode, knock out electrons;
- positive ions collide with gas molecules and transfer them to an excited state. Transition of such molecules to the ground state is accompanied by emission of photons;
- photon absorbed by a neutral molecule, ionizes it, the process of photon ionization of molecules occurs;
- ejection of electrons from cathode under the action of photons;
- at significant voltages between electrodes of gas gap there is a moment, when positive ions, having free path length smaller than that of electrons, acquire energy sufficient for ionization of gas molecules, and ion avalanches are approaching to negative plate. When except electronic avalanches, the ion avalanches occur, the current strength grows almost without an increase in voltage [3].

To obtain self-sustained gas discharge one needs a transformer of high voltage, which can be assembled from a transformer of line scanning and electronic control gear.

A line transformer is a component of block of TV line scanning. It serves to generate high voltage at the second anode of the kinescope and secondary voltages: power supply of chains of kinescope glow, accelerating voltage and video amplifier power. It also generates pulses of line retrace for the work of circuit blanking. It may be either a conventional transformer, or it can be made in one body with the rectifier. Also on this transformer there are regulators of focusing and accelerating voltage [2]

Experimental Details. Our interest in the project is the voltage applied to the anode of kinescope. In the simplest approximation, this is galvanic isolation, consisting of two coils - primary and secondary. The power of electronic control gear of the given lamp is 40 watts. The primary winding is supplied with input voltage, received by network voltage transformation by means of fluorescent lamp ballast. Thus, at the primary winding we get voltage of about 700 V (measured empirically). At the secondary winding, the voltage will be 31000-40000V. This voltage range is obtained indirectly on the basis of the Paschen’s curve.

- The removal of the transformer of line scanning from monitor Samsung SyncMaster 15GLe

Fig. 1a,b .The removal of the transformer

- Measurement of the resistance of outputs on the line transformer, based on which the outputs of the primary and secondary windings were found.

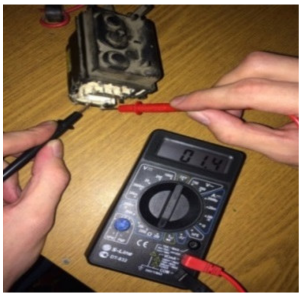

Fig. 2. Searching a primary winding

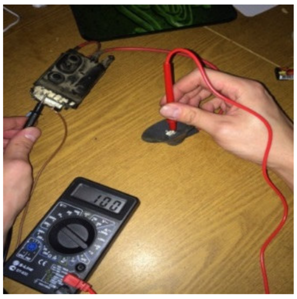

Fig. 3. Searching a secondary winding

- Measurement of the voltage of outputs on the electronic control gear.

Fig. 4. Electronic control gear

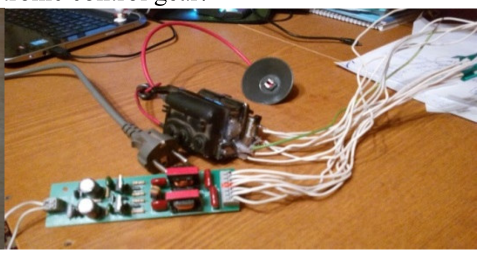

Fig. 5. High voltage generator

- Based on data from a multimeter, we selected the optimal scheme of connecting the line transformer to the electronic control gear. After a few trial runs the system proved to be stable. In the next step the final assembly of the device, i.e. soldering and insulation, was carried out.

Conclusion. Low-power generators of high voltage are widely used in defectoscopy for power supply of portable charged particle accelerators, X-ray and electron beam tubes, photomultiplier tubes, detectors of ionizing radiation. In addition, they are also used for electro-impulse destruction of solids, for producing ultrafine powders, for synthesis of new materials. They are also used as the spark leak detectors, to run the gas-discharge light sources, at a discharge diagnosis of materials and products, and as a demonstrative Materials for school and university students (Jacob's ladder).

REFERENCES

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2. Raizer, YP. (1991), Gas Discharge Physics. New York: Springer.