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A HIGH POWER PULSE GENERATOR WITH A RESTRICTED
CHANNEL DIAMETER

N. N. Ogurtsova and I. V. Podmoskenskii
Optika i Spektroskopie, 4 (No.4),
(1958), pp 539-541

(From Russian)

DEPARTMENT OF RESEARCH AND DEVELOPMENT SERVICES

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A HIGH POWER PULSE GENERATOR WITH
A RESTRICTED CHANNEL DIAMETER

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For a whole range of tasks (high speed cinematography high temperature pyrometry, etc.) a high temperature continuous spectrum pulse source with constant pulse brightness, is necessary.

In the present investigation, discharge from a network of condensers and ^{inductances} resistances through an aperture in a textolite plate was used as such a light source (Fig. 1). The thickness of the plate was 10 mm, aperture diameter 2 mm. Radiation diverged from the aperture according to the direction of the axes of the impulse. The supply line consisted of four units with the following parameters, $S = 100$ microfarad, $L = 1.5$ microhenry. The discharge voltage was 3000 volts. The characteristic impedance of the line was 0.12 ohm. Oscillographs of the electrical characteristics of the discharge showed that the pulse length was equal to 1×10^{-4} sec, the discharge current amplitude was 13000 amps, and the voltage across the gap was 1000 volts. The current density was 4×10^5 amp/cm., a probe method^[1] was used to obtain the voltage oscillographs. The probe was introduced into the beam emerging from the aperture. The current and voltage oscillograms shown in Fig. 2, indicate that the current and voltage oscillograms are similar in form, i.e., the discharge possesses a rising current-voltage characteristic.

The presence of such a characteristic makes it possible to obtain good matching between the load resistance and the characteristic impedance and was composed of the gap resistance (0.08 ohm) and the resistance of the discharge circuit (0.04 ohm). The unusually high voltage observed under these conditions at the discharge column is explained, as the following experiments show, by the extremely high pressures existing in the channel. The constancy of the discharge current and voltage values indicates that the pressure in the channel does not change appreciably with time.

The maximum pressure in the chamber was determined by the crushing-gauge method, widely employed in internal ballistics. A specially prepared crushing-gauge of small dimensions was located at the centre of the lateral wall of the discharge channel, and did not substantially change the discharge conditions. The pressure was determined from the deformation of the conical copper crushing-gauge and was equal to 500 atmos.

The absence of a rise in voltage and the brightness of the illumination in the early stage of the discharge shows the great importance of the pressure in preventing the initial heating of the air in the chamber. Pressure increase resulted in marked evaporation of the material of the aperture walls. This resulted in marked burning away of the aperture material and led to the observation of the C line in the spectrum. Rapid vaporisation of the wall is to be expected. Approximately two thirds of the energy of the discharge line (1300 joules) is realised in the discharge channel. The channel is almost entirely covered with textolite, and this energy is dispersed mainly through evaporation, excitation and ionization of the elements entering into its composition.

Figure 3 shows the discharge spectrum from which it is evident that in the axial discharge direction, a continuous spectrum is emitted interspersed with absorption and emission lines. The emission lines correspond to ions, and the absorption lines to atoms of the elements entering into the composition of the electrodes and the wall material. The line spectrum on both sides of the continuous spectrum corresponds to the radiation of the beam emerging from the aperture. A comparison of the channel and beam spectra shows that line reversals are general. This indicates that absorption of the continuous radiation of the channel takes place in the beam.

Experiments have shown that the spectrum does not change with a decrease of pressure down to 1 mm Hg. This again confirms the earlier assumption that the high pressure in the channel is caused by gases formed by evaporation of the wall material. A reduction of the length of the column from 10 to 5 mm also had no effect on the character of the spectrum. With further reduction the intensity of the continuous spectrum decreases and the comparative intensity of the line spectrum increases. A similar condition arises with increase in the diameter of the aperture above 3 mm.

Direct absorption measurements showed that with an aperture diameter of 2 mm, a discharge column length of 10 mm completely absorbed the incident radiation. Thus in this case, in consequence of the marked

reabsorption in the discharge, radiation saturation takes place, and it should be expected that it will approximate to absolute black body radiation.

The emission line spectrum is excited at the ends of the discharge channel where the pressure is appreciably less. With a stable current density, reduction in pressure leads to an increase in temperature and consequently, the intensity of the lines with high excitation potentials. Experiments have shown that with a slight rise in pressure at the end of the channel, the intensity of the line spectrum decreases noticeably.

The oscillograph of the monochromatic radiation in the wavelength region 2500-5500 Å showed that the pulse form does not vary with wavelength and corresponds to the form of the current and voltage pulses, i.e., under these conditions, the brightness variation with time corresponds to the current form. Reproducibility of the amplitude and length of the light pulses was achieved to within 2-4%.

The spectral density of the energy brightness was measured in the region 4100-5700 Å. Measurement was carried out by a photoelectric method, i.e., by comparing the source brightness with a calibrated source.

The brightness temperature was calculated according to Planck's formula. The dependence of the brightness temperature on wavelength is illustrated in Fig. 4. Within the limits of measurement error the brightness temperature does not vary with wavelength and is equal to 32 000 K., and the radiation of the source in this region corresponding to the radiation of an absolute black body at this temperature.

Approach of the discharge radiation to black body radiation in the given example is due to the considerable increase of pressure and efficiency in the chamber in comparison with impulse tubes. Deviations from the distribution of an absolute black body are due to absorption and radiation at the edge of the aperture. Using spectrally pure carbon electrodes it is possible to obtain a continuous spectrum almost free from linear absorption (Fig. 5.). Conditions approaching the investigated case exist in the first stage of the spark discharge with a very steep current rise.

The brightness achieved makes the source suitable for investigation of absorption spectra and high speed cinematography.

In addition, the type of discharge described can be used as a continuous spectrum calibrated pulse source with known energy distribution and temperature of the order of 30 000 K., suitable for the investigation of high temperature and pressure plasmas. The current density, pressure,

temperature, chemical composition of the gas and potential gradient of the discharge are known. The transitional processes constitute only a small fraction of the pulse duration and in a number of cases, it is possible to use the integral characteristics. By varying the circuit parameters, it is possible to change the form and brightness of the pulse. Thus, using a line of 4 units, rectangular pulses with a pulse length of 400 μ sec are obtained, in which only 6% of the total light relates to the pulse front. Attention is drawn to the possibility of discharge across the channel. Such discharges are caused by intense ionization due to radiation from the aperture. The photo-ionization is so great as to cause discharge across a gap of up to 100 mm with voltages of the order of 1000 volts.

REFERENCES

- [1] I. V. PODMOSHENSKI & G. N. LAPINA: "Tenth Conference on Spectroscopy (in print).
- [2] M. P. VANUKOV et al.: *Optika i Spektroskopiya*, **1**, (No.5), (1956).

LEGENDS TO FIGURES

- FIGURE 1. Schematic representation of the source.
(1) Spectrograph slit; (2) Condenser; (3) Ignition pulse;
(4) Textolite plate with aperture;
(5) Electrodes.
 $L_1, L_2, L_3, L_4 = 1.5$
 $C_1, C_2, C_3, C_4 = 100$ microfarad.
- FIGURE 2. Oscillographs of current (a); Voltage (b); and radiation of a pulse discharge with restricted channel diameter (c)..
- FIGURE 3. Pulse spectrum.
- FIGURE 4. Dependence of brightness temperature on wavelength.
- FIGURE 5. Pulse spectrum with electrodes of spectrally pure carbon.

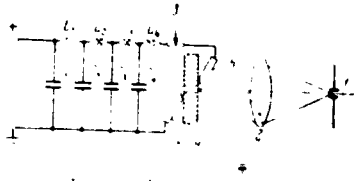


Рис. 1. Схема источника

1 - переключатель, 2 - трансформатор, 3 - подмагничивающий элемент, 4 - пластина, расстояние между линзами $L_1 = L_2 = L$, $L = 1,5$ мкм, $C_1 = C_2 = C_3 = C_4 = 100$ мкФ.

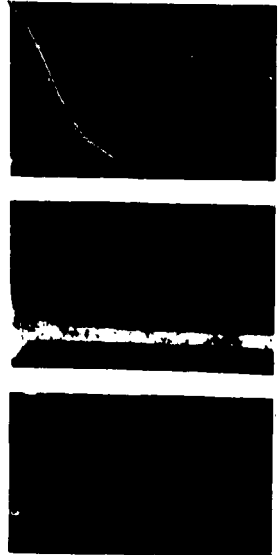


Рис. 2. Осциллограммы тока (а), напряжения (б) и импульса (в) импульсного ряда с ограниченным диаметром канала

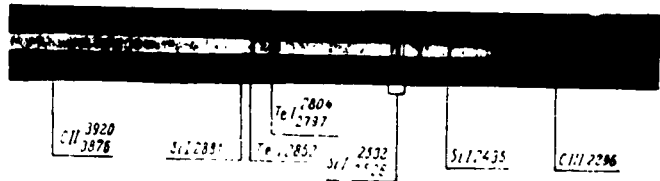


Рис. 3. Спектр импульсного ряда

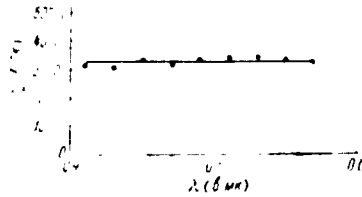


Рис. 4. Зависимость яркостной температуры от длины волны

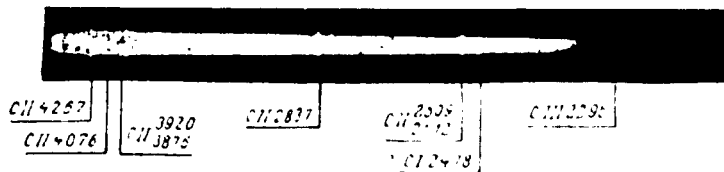


Рис. 5. Спектр импульсного ряда при элентрах из спектральных чистого угля