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Author	岸上, 弘(Kishigami, Hiromu)
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A High Voltage Pulse Generator for Use in the Kerr Cell Shutter

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Hiromu KISHIGAMI*

Abstract

A new type of the high voltage generator for the optical shutter utilizing the Kerr effect has been devised. Its principle lies in superposing two electric circuits, of which the one, the main circuit, generates a high voltage, while the other serves as an auxiliary discharge circuit in which an ignition coil, which is used for automobiles, is employed. It is possible to generate pulses of voltages higher than 10 kV easily by this method.

I. Introduction

Mechanical shutters can not be used as high speed shutters because of an upper limit of the shutter speed, which is of the order of 10^{-3} sec. To obtain shutters with speed higher than this value, electro-optical shutters became to be utilized. There are two kinds of electro-optical shutters. One is the high speed camera shutter for the image-converter tube, which was first proposed by Holt[1] and designed by Jenkins and Chippendale[2]. The other is the Kerr cell shutter, of which the characteristics have been summarized recently in papers by Zarem and others[3].

The use of a thyratron tube as a part of the auxiliary circuit of a pulse generator for the Kerr cell shutter has the following difficulties: the discharge occurs spontaneously even when the switch is off, and moreover the waveform of the pulse is not constant because of the instability of the circuit. It is not easy to eliminate above difficulties. The author constructed a high voltage pulse generator for the Kerr cell shutter. The principle of this pulse generator depends on the main discharge in atmosphere and an auxiliary discharge. The main discharge circuit is constructed mainly by a commercial flyback transformer used in TV apparatus. The auxiliary discharge circuit, which is provoked by an ignition coil

*岸 上 弘 Assistant at Keio University.

1) Holst, G. ; British Patent No. 326, 200.
2) Jenkins, J. A. and Chippendale, R. A.; J. Brit. Inst. Radio Engs.. **11** (1951), 505.
3) Zarem, A. M., Marshall, F. R. and Poole, F. L.; Electrical Engng., **68** (1949), 282.
4) Martin, J and Kenneth, N. O. ; R. S. I. **24** (1953), 52.
5) Saxe, R. F. and Chippendale, R. A. ; Brit. J. Appl. Phys. **6** (1955), 337.

of automobiles and a microswitch, induces the main discharge. The effects of the high frequency in the main discharge circuit and of the instability of the power source and electro-magnetic field of the surroundings and so on are made vanishingly small.

Consequently, the main circuit works very steadily, resulting in a stabilized waveform of the pulses.

II. The electronic circuit and elements

The electronic circuit is constructed from a high frequency oscillator, a flyback transformer and a rectifying circuit of high frequency and voltage, forming the main discharge, and a *DC* current source, a microswitch and an ignition coil, acting as the auxiliary discharge circuit.

Since nitrobenzene is used for the Kerr cell, its specific resistance being extremely high of the order of the 10^{12} ohm-cm, power is not needed for the circuit, so that as the elements for the main circuit, ordinary TV parts can fulfill the purpose of the main discharge circuit. The auxiliary discharge circuit controls the discharge of a *DC* high voltage in the main discharge circuit, which occurs between the electrodes of the discharge gap. It can generate a high voltage for inducement of the main discharge at the outputside of the ignition coil because large current can be passed in a very short time in its input side. In the follwing, a practical circuit is explained. The circuit diagram is shown in Fig. 1. The section enclosed with dotted lines is the power source supplying a fairly ripple-free *DC* of 270 volts from an *AC* line. 6*BQ*6*GT* is an oscillator tube, 6*AX*4*GT* a damper tube to prevent the reverse current, *FT* a flyback transformer for high frequency to charge low to high voltage, 1*X*2*B* a rectifier tube for high frequency and high voltage, *S* a threepoint gap for discharge of the main and auxiliary circuits, *MSW* a microswitch, *IL* an ignition coil, and finally *E* output terminals.

As the oscillator circuit, 6*BQ*6*GT* combined with a flyback-transformer is used, through the latter of which positive feed-back is made. If the variable resistor VR_1 is changed, the frequency of oscillation shifts either to higher or lower value, because the time constant of the input resistance to the grid is changed and the plate voltage of 1*X*2*B* varies accordingly. The high voltage obtained by retifying the plate potential of 1*X*2*B* is supplied to condenser C_1.

On the other hand, the auxiliary circuit rectifies an *AC* of 6.3 volt, and charges C_2, which stays in the charged state until the microswitch is pushed on, when the discharge current passes through the primary winding of *IL* in a short time generating a high voltage pulse in the secondary winding as shown in Fig. 1. The high voltage pulse which is generated in the secondary side is supplied to the electrode gap *S* consisting of a needle and a cap with a hole 1 mm in diameter at its point, and gives rise to the discharge in the gap. Thus the resistance between

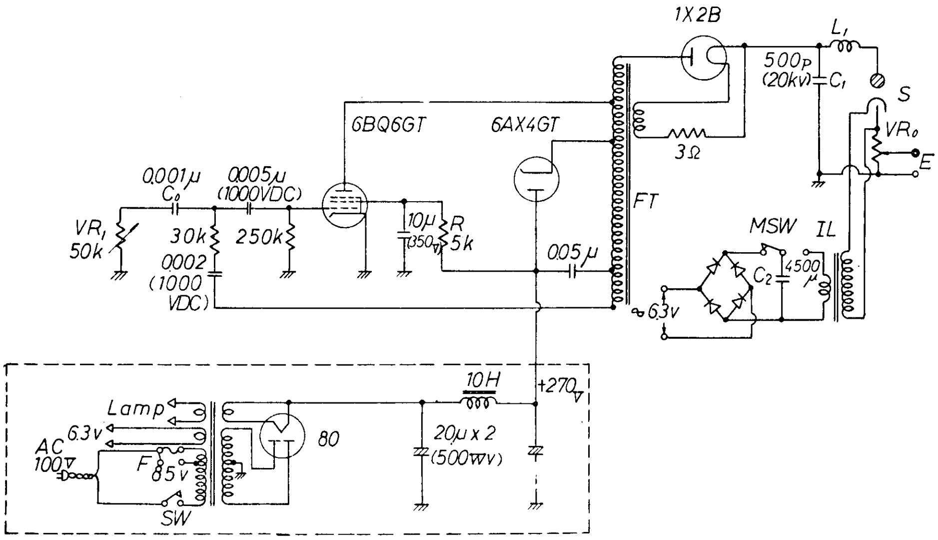

Fig. 1. Pulse generator for Kerr cell shutter.

the gap electrodes decreases extremely due to the ionization of air at that place. Consequently the high voltage is supplied to C_1 in order to discharge between a steel ball plated with chromium and a needle at gap S. The discharge current pulse passing through load resistance generates a high voltage between the ends of VR_0. Pulses of an arbitrary voltage with constant width can be obtained by dividing the load resistance into several sections and taking taps. The distance between the ball and the needle at gap S can be adjusted by a screw to induce the main discharge only when the auxiliary discharge occurs. The reason why the micro-switch is used instead of a snap switch is that the change of the contact resistance is extremely rapid in case of the former. In this way the voltage of the output of ignition coil IL is maintained very high and the constant characteristics can be obtained each time.

III. Experiment

When the charge in the condenser C_1 with the load resistance VR_0 of 5 kΩ is discharged, the waveform of the output voltage has a short rise time and a time width from switching to the time at peak voltage narrower than 20 μsec and the tail of waveform decays exponentially. As this is unsuitable for the pulse to be used for the present purpose, a coil of several turns is inserted in series with respect to VR_0. As the result, the rise time becomes longer than before, being about 20 μsec, and the peak voltage appearing between both ends of VR_0 is lower than before, being about 70 % of the former case, but its waveform was improved.

This is due to that about 30% of the total voltage drops in the coil. The circuit to visualize the pulse on an oscilloscope is shown in Fig. 2. The resistance of 1 kΩ

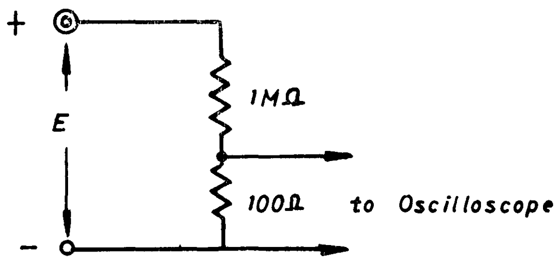

Fig. 2. Output side of circuit.

out of 5 kΩ of VR_0 is connected in parallel with a series resistance made of 1 MΩ plus 100 Ω is observed on the oscilloscope. Therefore, the voltage between both ends of 1 kΩ resistor can be calculated by multiplying by 10^4 the voltage obtained by means of an oscilloscope. The pulse with a 20 μsec width and a 1.5 kV height is generated between the ends of 1 kΩ resistor. Thus waveforms of a constant width with different height of 1.5 kV, 4.5kV, 6.0 kV or 7.5 kV can be obtained arbitrarily. If one wishes to alter the width, the value of VR_0 should be varied from the order of 1 kΩ to zero Ω, then the width will vary from the order of μsec to mμ sec easily.

The resultant waveform is illustrated in Fig. 3.

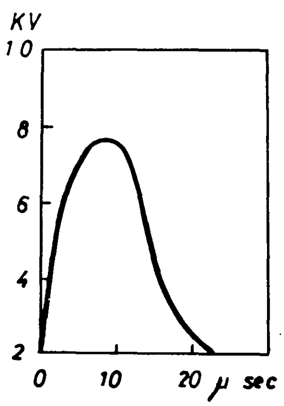

Fig. 3. Weveform of pulse.

IV. Conclusions

Troubles which occur in using a thyratron tube as a part of an auxiliary circuit of the pulse generator for the Kerr cell shutter are removed in the present apparatus by the use of a new auxiliary circuit, and the whole circuit is made simpler and more stabilized than before.

Reduction of the pulse width from the order of μsec to mμ sec can be done easily by a variable resistor. If pulses of higher voltages than in the present case are needed, two flyback transformers should be connected in cascade.

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