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THE POSSIBILITY OF THE USE OF LIQUID DISCHARGERS IN HIGH-VOLTAG--ETC(U)
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FOREIGN TECHNOLOGY DIVISION

AIR FORCE SYSTEMS COMMAND

THE POSSIBILITY OF THE USE OF LIQUID DISCHARGERS IN HIGH-VOLTAGE NANOSECOND PULSE CIRCUITS

by

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FOREIGN TECHNOLOGY DIVISION

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U. S. BOARD ON GEOGRAPHIC NAMES TRANSLITERATION SYSTEM

Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

*ye initially, after vowels, and after ъ, ь; e elsewhere.
When written as ё in Russian, transliterate as yё or ё.

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

Russian	English	Russian	English	Russian	English
sin	sin	sh	sinh	arc sh	$\sinh^{-1}$
cos	cos	ch	cosh	arc ch	$\cosh^{-1}$
tg	tan	th	tanh	arc th	$\tanh^{-1}$
ctg	cot	cth	coth	arc cth	$\coth^{-1}$
sec	sec	sch	sech	arc sch	sech^{-1}
cosec	csc	csch	csch	arc csch	csch^{-1}

Russian	English
rot	curl
lg	log

THE POSSIBILITY OF THE USE OF LIQUID DISCHARGERS IN HIGH-VOLTAGE NANOSECOND PULSE CIRCUITS

G.A. Mesyats, G.A. Vorob'yev

In the article a comparison of the time of commutation t_k of air and oil dischargers is made, and it is shown that in the latter t_k is less. It is also found that the strength of the oil at short pulses does not depend on its moisture content.

In the use of the spark discharger as a commutator of a high-voltage nanosecond pulse circuit, a fundamental importance is the slope of the characteristic of the commutation, which implies the change in the voltage with time on a spark gap after its breakdown. If we disregard the effect of inductance L of the discharge circuit, then the leading edge of the pulse will repeat the characteristic of commutation. Under this condition the voltage on the leading edge of the pulse is simply expressed in terms of the resistance $R_н$ and resistance of the discharger R(t):

$$u_\Phi = u \frac{1}{1 + \frac{R(t)}{R_н}},$$

where u is the charging voltage.

The resistance of the discharger during the breakdown period varies with time. When the voltage u is unchanged, the magnitude of this resistance will be less, the less the length S of the spark gap of the discharger. Since here

$$S = \frac{u}{E}, \tag{2}$$

where E is the electrical strength of the medium in which the discharger is found, then R(t) and the slope of the characteristic of commutation will depend on the electrical strength of the medium. This conclusion is well confirmed for gases for which it is found [1] that the time of the commutation t_k at a constant pressure is equal to

$$t_{\kappa} = \kappa \frac{1}{E^2}, \tag{3}$$

where k is the coefficient dependent on pressure and the kind of gas.

Proceeding from these considerations, it was interesting to investigate the duration of commutation of the oil dischargers and compare them with the gas dischargers, since the electrical strength of the oil considerably exceeds the strength of the majority of the gases. The duration of the commutation process was investigated with respect to the duration of the leading edge of the pulse, which appears on the load resistance. A diagram of the experimental apparatus is given on Fig. 1. The capacitance C through resistance R is charged up to voltage u necessary for breakdown of the spark gap. The resistance R is selected so that the total charge of the capacitance C occurs in 5-6 seconds. It is easily possible to track the charge process on the scale of a kilovoltmeter and reliably record the magnitude of the breakdown voltage.

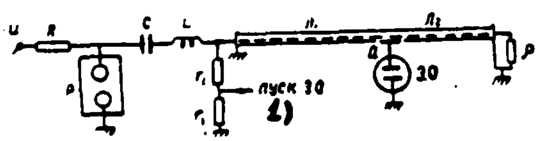

Fig. 1. Schematic diagram of the apparatus. Key: 1) trigger.

After the breakdown P along line $Л_1$ (15 m of cable RK-162 with wave resistance of 75 ohms), a pulse goes to the divider Д. The capacity divider Д, built into the cable, reproduces the high--voltage pulses with a leading edge of 10^{-9} s without noticeable distortions. The inductance of the discharge circuit of the discharger was $70 \cdot 10^{-9}$ H. The duration of the leading edge of the pulse was determined on the oscillogram at a level of 0.1-0.9 as an average of 10 measurements.

The breakdown of the transformer oil with a strength of 180 kv/cm and the air in uniform and nonuniform fields was investigated, and the ball-ball and point-point electrodes were used for this. Data of the experiment are given in the table.

Table

и, кв 1)	$t_ф$, нсек, 2) воздух 3)	$t_ф$, нсек, 2) масло 4)	Электроды 5)
15	7,5	4,2	6) шар—шар
15	16,4	5,6	7) острие—острие
5	7,5	3	6) шар—шар

Key: 1) kV; 2) ns; 3) air; 4) oil; 5) Electrodes; 6) ball-ball; 7) point-point.

From the table it is clear that the commutation process in the oil occurs faster than it does in air. Actually, the difference in the duration of the commutation is even greater, since the less t_k, the greater the effect of the inductance of the discharge circuit is felt. For example, when $t_k = 0$

$$t_\Phi = 2{,}2 \frac{L}{R_н}. \quad (4)$$

In the investigation it was discovered that for oil t_ϕ there is a certain spread.

The larger t_ϕ is, the less the strength. Since the strength of the oil is greatly affected by the different impurities such as water, gas, products of decomposition due to discharges in the oil, and so on, then the commutation characteristic of the oil with static breakdown with its aging will be elongated.

It was of interest to study the breakdown of the oil with the pulse voltage, since with the pulse breakdown the effect of the impurities is weakened. To do this a special discharger was constructed, in which it was possible to set the gaps at several tens of microns. The length of the gap was measured under a microscope. A voltage pulse with an amplitude of 60 kV and duration of the leading edge of 15 ns was used. The breakdown occurred on the leading edge of the pulse. The apparatus used for obtaining such a pulse is described in [2].

A very interesting fact was revealed here. It was found that the strength of the highly moistened oil with a gap length of more than 100 μ and the strength of the distilled water exceed the electrical strength of the pure transformer oil (Fig. 2). However, with static breakdown the pure oil has a strength of 180 kV/cm, and the moistened oil - 50 kV/cm. This indicates that the delay of discharge in the moistened oil is greater than it is in the pure oil. It also follows to note the small spreads (of the order of 10^{-9} s) in the delay times under the effect of the indicated pulses.

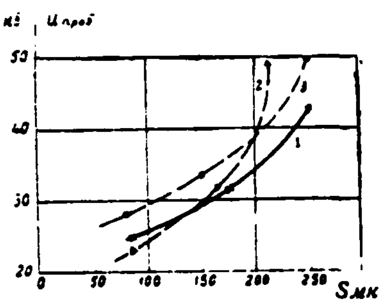

Fig. 2. Dependence of the breakdown voltage on the gap length.
1 - pure transformer oil, E = 180 kV/cm; 2 - moistened transformer oil, E = 50 kV/cm; 3 - distilled water. Key: 1) microns.

The high pulse strength of the contaminated oil and water indicates the possibility of their use as commutators under the effect of pulses with a steep leading edge, for example, as peakers in nanosecond high-voltage circuits. In this case, the commutation time should be greatly decreased, since the strength of the oil increases by more than one order.

Tomsk Polytechnic Institute im. S.M. Kirov - Submitted 10 March 1961

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