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CURRENT PULSE GENERATOR WITH AMPLITUDE OF 1,000,000 A AND STABI--ETC(U)
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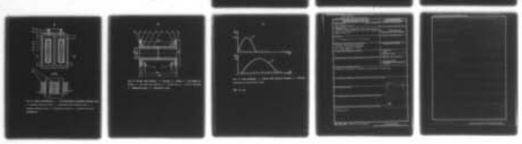

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CURRENT PULSE GENERATOR WITH AMPLITUDE OF 10^6 A AND STABILITY OF $\pm 10^{-3}$ AT A REPETITION RATE OF TWO Hz

by

B. F. Bayanov, A. V. Il'in, et al.

EDITED TRANSLATION

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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 ë in Russian, transliterate as yë or ë. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

GREEK ALPHABET

Alpha	Α α [illegible]		Nu	Ν ν	
Beta	Β β		Xi	Ξ ξ	
Gamma	Γ γ		Omicron	Ο ο	
Delta	Δ δ		Pi	Π π	
Epsilon	Ε ε ϵ		Rho	Ρ ρ ϱ	
Zeta	Ζ ζ		Sigma	Σ σ ς	
Eta	Η η		Tau	Τ τ	
Theta	Θ θ ϑ		Upsilon	Τ υ	
Iota	Ι ι		Phi	Φ φ ϕ	
Kappa	Κ ϰ κ [illegible]		Chi	Χ χ	
Lambda	Λ λ		Psi	Ψ ψ	
Mu	Μ μ		Omega	Ω ω	

RUSSIAN AND ENGLISH TRIGONOMETRIC FUNCTIONS

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

Russian	English
rot	curl
lg	log

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All figures, graphics, tables, equations, etc. merged into this translation were extracted from the best quality copy available.

CURRENT PULSE GENERATOR WITH AMPLITUDE OF 10^6 A AND STABILITY OF $\pm 10^{-3}$ AT A REPETITION RATE OF TWO Hz

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It is often necessary to create powerful generators which operate on an inductive load in order to obtain strong magnetic fields, as well as to use pulsed systems in acceleration equipment. Furthermore, experimental conditions sometimes place limitations on the duration and form of the current pulse and the stability of current amplitude, and also require high operating reliability.

This report examines the generator created at the IYaF of the SO AN USSR which provides a unipolar sinusoidal current pulse with a base length of 1.2 ms and an amplitude of 10^4 amperes. It is stable with precision of ±0.1o/o at a repetition rate of several hertz for an inductive load of 0.1 μH.

In the case in question, the pulsed current in the load circuit cannot be directly switched because there are no gates for this current. Thus, a pulse matching transformer combined with a high-voltage ten kA-current switching gate is used.

The generator (diagram in Fig. 1) consists of cumulative capacitor C_H, which is charged through controlled gate T_1-T_{96} to the primary winding of the pulse transformer ($Tp_И$). The capacitor is recharged through a special recharge choke (Dr_1) and recharge diodes (D_1-D_{40}) in order to recover the energy.

It suffices to regulate the voltage on the cumulative capacitor in order to obtain short-term current amplitude stabilization (as experience has shown). In this case, the voltage is regulated by discharging portions of the charge through a special discharge circuit (3) which is controlled by comparison circuit (4) [1]. Due to the large dynamic and thermal loads in this generator, its parameters in the circuit can be seen to shift slowly through time. Therefore, an automatic current amplitude adjustment circuit (5) is provided to compensate for these shifts by gradually changing the level of the regulated voltage on the capacitor.

The matching transformer (Tp_{k}) is made by the "cable" principle [2]. In order to decrease the transformer's active losses and stray inductance, it is made in the form of secondary bulk winding 3, in the closed grooves of which the wide flat turns 4 of the primary winding are wound (Fig. 2). This design provides the complete connection of the secondary winding current with the primary, whereas the stray currents of the individual primary turns are not connected to each other. This makes the stray inductance proportional to the first order of the number of turns. Here the turns of the primary winding are in dynamic equilibrium. They are isolated from the secondary winding by epoxy-glass insulation four mm thick for a voltage of 20 kV. The transformation coefficient is 40. The stray inductance is $8 \cdot 10^{-9}$ H. The magnetic circuit cross section is 5x600 cm^2, while the peak-to-peak induction in iron at a current of 10^6 A is 15 kGauss.

The main problem in creating the generator was developing a 25 kA switching gate at a voltage of 10 kV and pulse length on the order of one ms.

We decided against the mercury gates ordinarily used in this type of system due to their bulk and complexity of operation.

Two types of gates were developed for this generator. The first version, a thyristor gate, is shown in the diagram in Fig. 1. The small thyristors which make up this gate do not require filament circuits, are not very sensitive to changes in external temperature, and have a long life.

Tests conducted on the thyristors in the short pulse switching mode indicated that UPAKL-150 or VKDU-150 thyristors are capable of switching currents of up to five kA at a sinusoidal pulse length on the order of one ms. Under these conditions, the thyristors can withstand several million pulses without perceptibly changing parameters. Conditions in which on the order of three kA is sent through each thyristor were seleted in the working circuit of the generator in order to provide reliability.

The generator's switching gate consists of eight parallel branches with twelve series-connected VKDU-150-7 thyristors in each branch. A potential-equalizing resistor ($R_{Д1} \div R_{Д96}$) is connected in parallel to each thyristor, and each branch is connected to a common point on the circuit through coupled anode reactors (Re_1-Re_8), which divide the currents according to branches with precision of up to 10o/o. The thyristors are controlled from one starting generator (7) through the pulse transformers (Tr_1-Tr_{96}); the primary winding is a single wire with high-voltage insulation (magneto) which passes consecutively through the magnetic circuits of all the transformers.

One peculiarity of the operation of the thyristors is that individual amplitude overloads above eight kA and a current build-up rate higher than 20 A/μs can render individual thyristors or entire sequential branches completely inoperable. This requires special thyristor protection. A cutoff tube (R_4) with solid insulation was developed for this purpose. When the electronic protection system (6) operates in reaction to the amplitude and the current derivative, explosive breakdown occurs and the cutoff tube shorts the entire switch within a few μs, thereby saving the thyristors from destruction. This circuit also cuts off the generator's power through the UBS [blocking and signalling control] system.

The cumulative capacitor is recharged through the choke (Dr_1) and through four parallel branches of VKDL-200-9 diodes with up to ten series-connected elements (D_1-D_{40}). The recharging pulse length is ten ms at an amplitude of 2.6 kA.

A gas-discharge gate controlled by a pulsed magnetic field was developed as the second version of the switch (Fig. 3).

Cathode 1 and anode 2 are two coaxial stainless steel cylinders which evolve into disks 3 and 4 (which are insulated from each other) at the ends. Supply cables are symmetrically attached to these disks. A helical groove is cut on the outer tube - the cathode. Double-wound $2x10^2$ mm copper bus winding 6 is wound in this groove, forming the magnetic field in the working gap.

The maximum value of the field is near the cathode, and it rapidly declines toward the anode. Both its value and sign vary with the periodicity of the winding pitch in the axial direction along the winding.

The wall of the stainless steel cathode is one mm thick; therefore, the skin effect plays a very small role and the pulse field between the anode and the cathode virtually duplicates the form of the pulse current in the control winding through time in the 100 μs - 2 ms range (see Fig. 4).

The gate operates in the pressure range of $3\cdot10^{-3}$-$6\cdot10^{-3}$ mm hg in air and argon at an anode-cathode gap of one cm and pulse field amplitude on the surface of the cathode of 500 Oe.

This method of control provides effective gating and the uniform distribution of the charge over the entire surface of the electrodes uner the control winding. The gate operates reliably in the 25 kA mode at 10 kV for one ms.

In this mode, the generator has successfully withstood 10^5 pulses and continues to operate reliably.

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2. В.Р. Карасик ПТЭ, 1962, № 6, стр. 5.

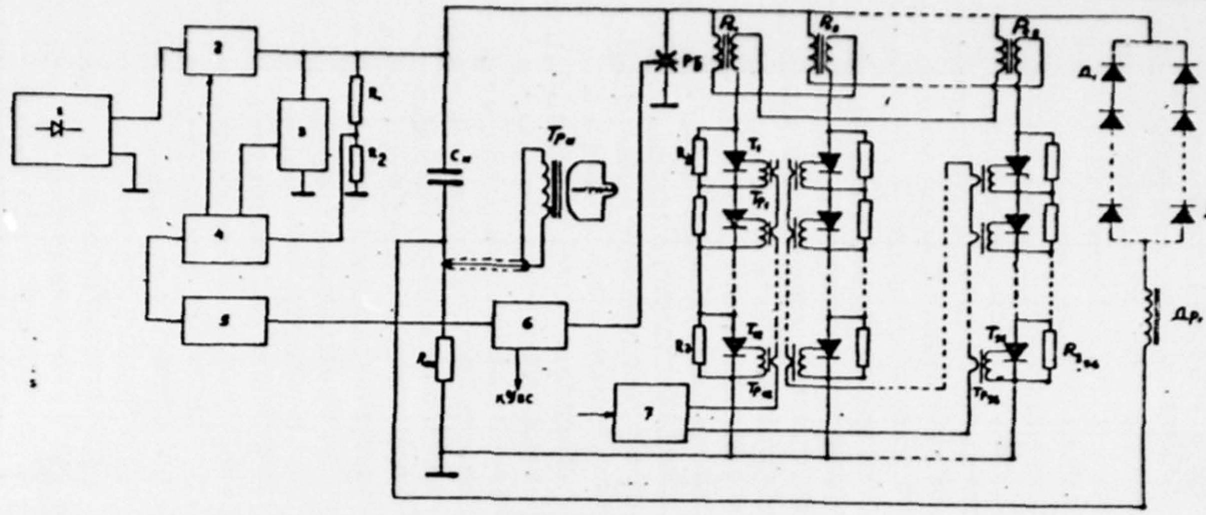

Fig. 1. Diagram of generator. 1 - rectifier, 2 - charger, 3 - discharge circuit, 4 - comparison circuit, 5 - parameter regulation circuit, 6 - thyristor protection circuit, 7 - starting generator, C_H - cumulative capacitor, Tp_M - pulse matching transformer, T_1-T_{96} - switching gates, Re_1-Re_8 - anode reactors, D_1-D_{40} - recharge diodes, Dr_1 - recharge choke, $R_{Д1} \div R_{Д96}$ - divider.

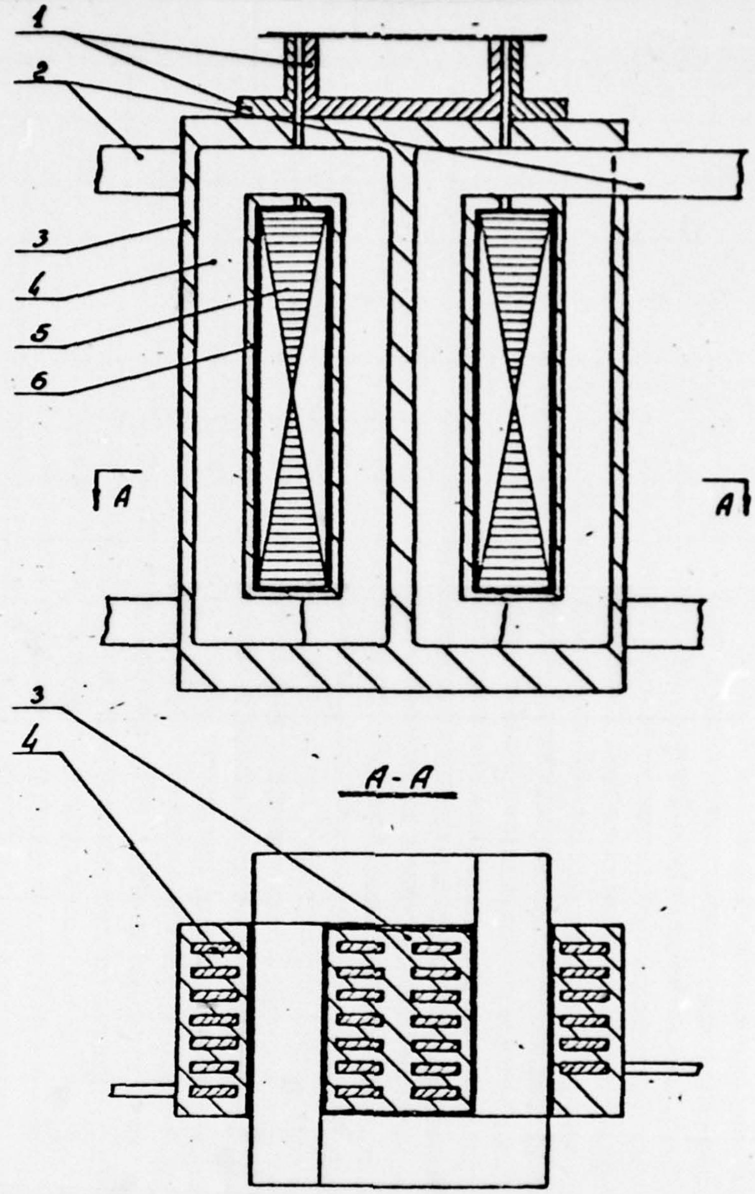

Fig. 2. Pulse transformer. 1 - low-inductance secondary winding tap, 2 - primary winding lead, 3 - secondary bulk winding turn, 4 - primary winding turn, 5 - magnetic circuit, 6 - magnetic circuit insulation.

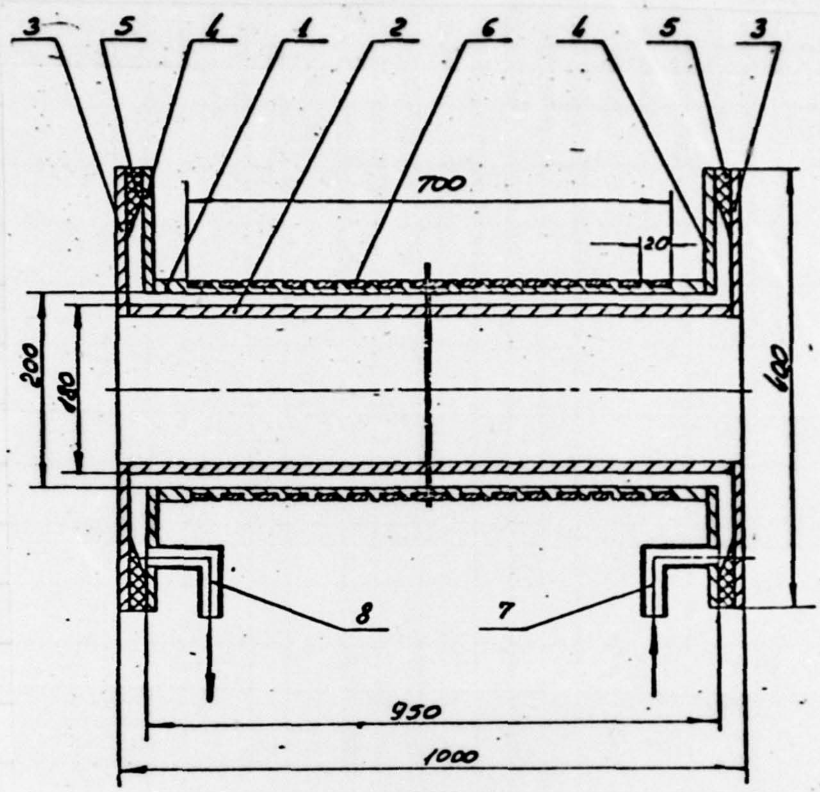

Fig. 3. Cutoff tube design. 1 - cathode, 2 - anode, 3 - end disks of anode, 4 - end disks of cathode, 5 - insulation, 6 - control winding, 7 - admission pipe, 8 - evacuation pipe.

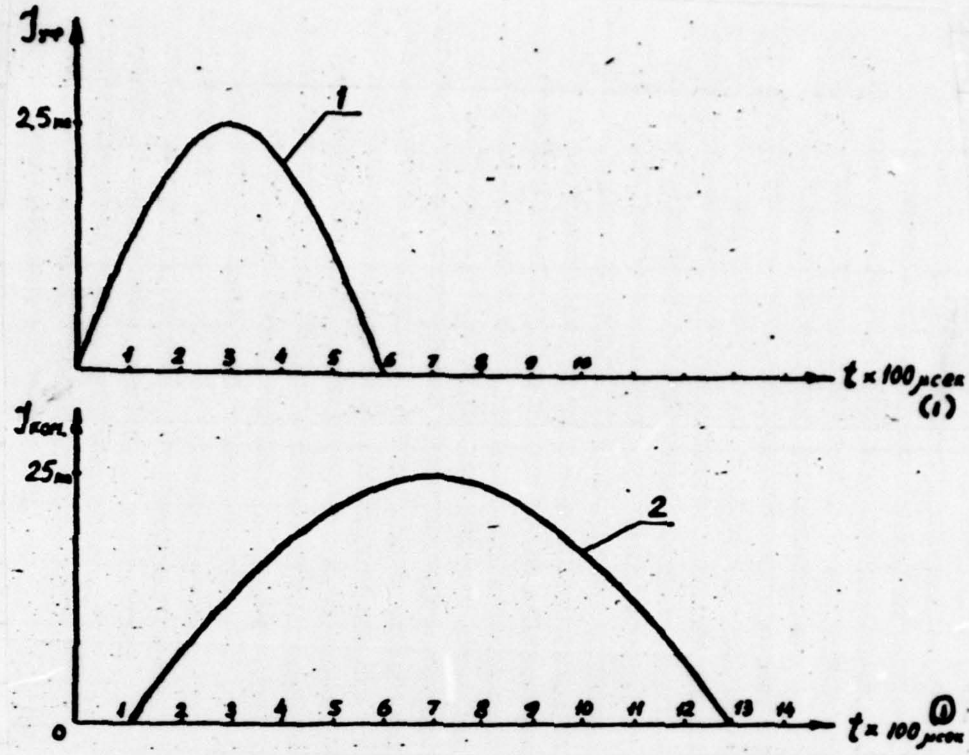

Fig. 4. Time diagrams. 1 - cutoff tube control current, 2 - current switched through cutoff tube.

KEY: (1) μs.

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