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Superintensive pulse slow neutron source SIN based on kaon factory.

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Possibility of intensive pulse slow neutron source creation based on 45-Gev proton synchrotron of K-meson factory, planned to construction in INR AS USSR is considered. Calculated peak thermal neutrons flux density value, averaged on "radiating" light-water moderator surface of 100 cm^2 is $6.6x10^{17}$ neutrons/(cm^2sec) for pulse duration of 35 microseconds.

Creation of high-current proton accelerators for 50 Gev energy gives way for the following development of new neutron sources generation based on proton beams /1/. Possibility of intensive pulse slow neutrons source creation based on K-meson factory was considered earlier in /2/. This article deals with superintensive pulse neutron source SIN features based on K-meson factory with following accelerator parameters:

Proton energy (GeV)	45
Average current,μa	125
Pulse frequency,Pps	8.3
Pulse duration,μsec	4.4

General scheme of neutron source SIN is analogous to one of pulse neutron source based on Moscow meson factory (MMF-0.6) /3/. Fig. 1 shows neutron source geometry for calculations. Target is compact packing of wolfram rods cooled by water (volume water fraction about 20%). Target and light water moderator are surrounded by iron reflector also cooled by water. Neutron source with reflector are located in the biological shield made of iron and heavy concrete. Figs. 2 and 3 show the location of neutron source and experimental channels in the shield.Shield thickness in side direction is determined by cascade neutrons, in proton beam direction - by μ-mesons.

Calculation of heat generation and neutron flux density were carried out by SHIELD and MKT programs. Detailed description of calculation technique is presented in /2/.

Hadron cascade calculation was carried out for proton energy of 25 GeV. 383 vaporized neutrons with average energy of 3.3 MeV are produced per one incident proton in the whole system - including 250

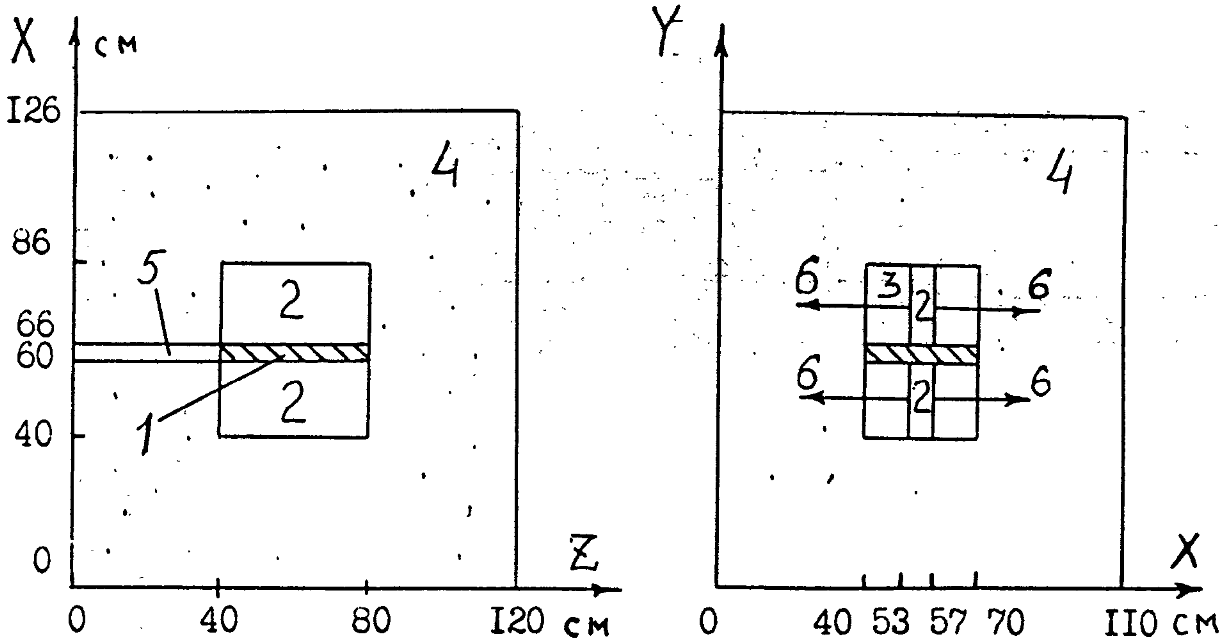

Fig.1. Neutron source SIN geometry for calculation 1 - target; 2 - water; 3 -vacuum; 4 - reflector; 5 - proton beam tube; 6 - experimental neutron channels.

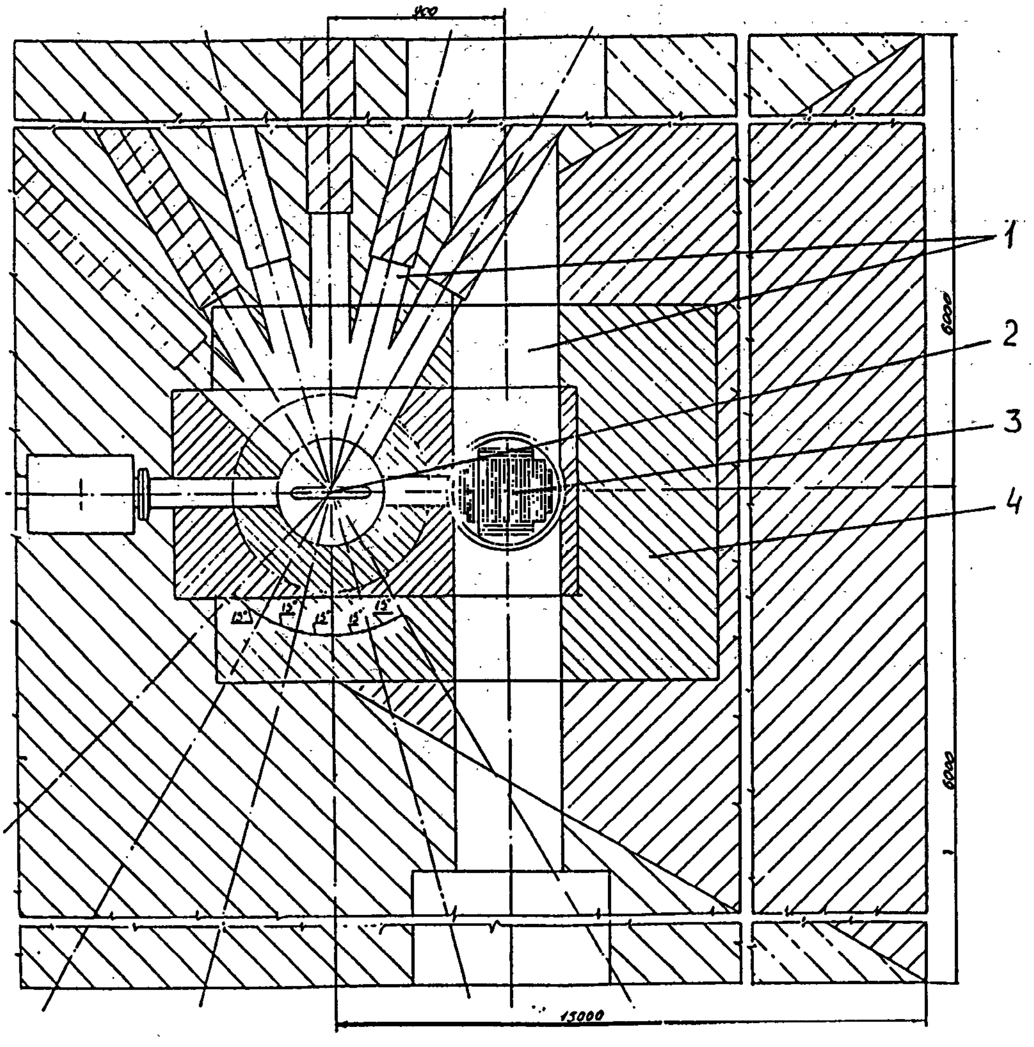

Fig.2. General view of SIN: 1 -experimental neutron channels; 2 - moderator; 3 - beam dump; 4 - shield.

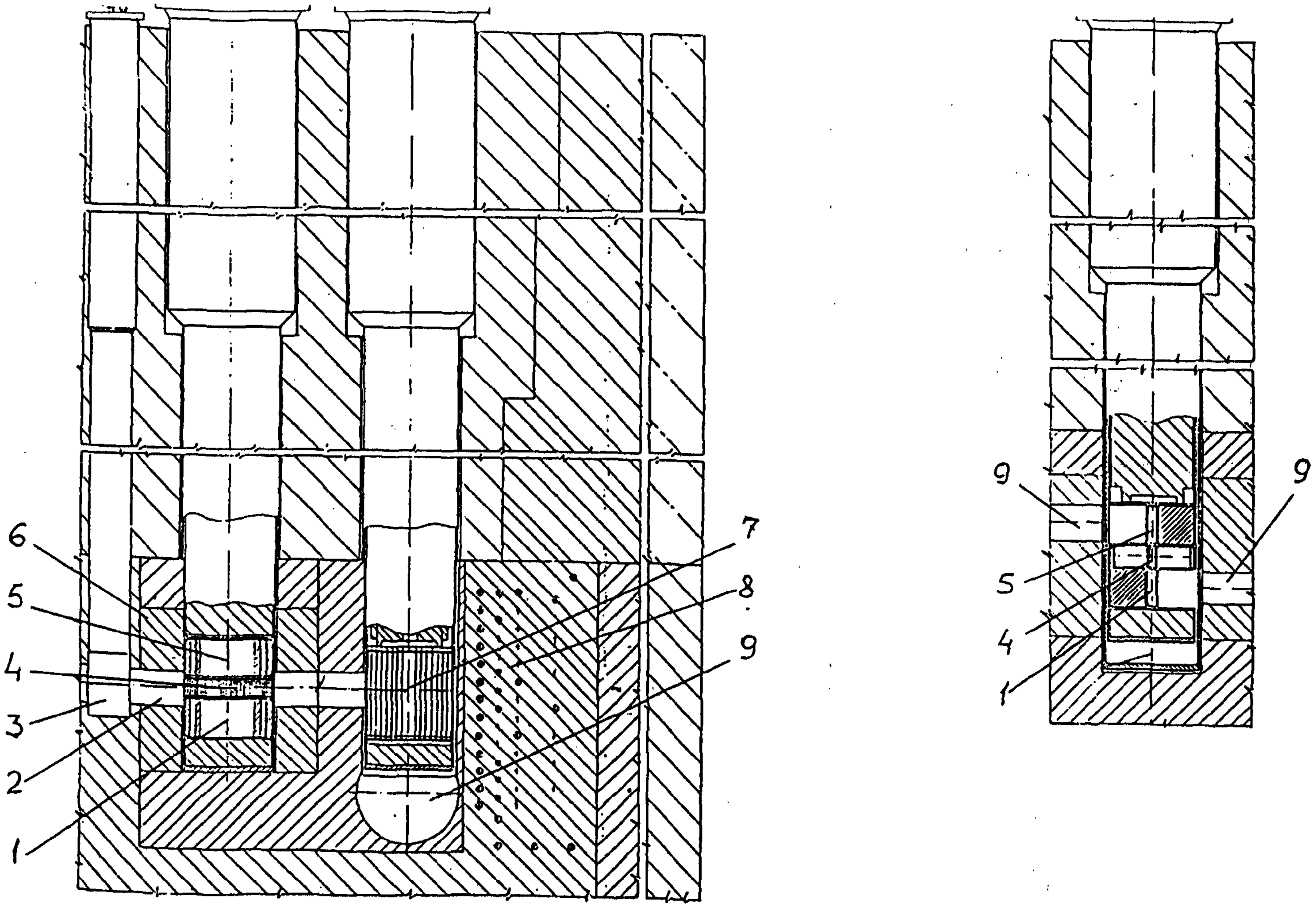

Fig.3. SIN vertical cross-section: 1 - water moderator; 2 - proton beam tube; 3 - vacuum switch; 4 - SIN target; 5 - liquid hydrogen moderator; 6 - reflector; 7 - beam stop target; 8 - heat shield; 9 - experimental neutron channels.

neutrons in wolfram target. Figs. 4 and 5 show neutron production distribution in wolfram target (20% of water in the volume) from the point proton beam.

Table 1 presents number of neutrons going from "radiative" moderator surface of 20*40 cm^2 to differential solid angles perpendicularly to the surface, calculated for one falling proton (Ep=25 GeV).

Efficient width θ of thermal neutron pulses (E < 0.215 eV) for moderator thickness of 3 cm is about 35 μsec. For moderator parameters presented above the average thermal neutron flux density $\overline{\Phi}$ = 5.9x10^{13} neutrons/(cm^2sec) and peak density is 2.0x10^{17} neutr/(cm^2sec) (Ep=45 GeV). For moderator of 10x10 cm^2 corresponding flux densities are: 2.0x10^{14} and 6.6x10^{17} neutr/(cm^2sec) respectively.

Table 2 shows thermophysical parameters for neutron target with dimensions 100x300x400 mm^3.

When Gaussian cross distribution of proton beam intensity has σ_x and σ_y dispersions, specified in the table, 90% of beam protons hit the target.

Time constant τ for cooling of wolfram rod is about $c\rho R^2/\lambda$, where c - specific heat, ρ - density, R - rod radius and λ - heat conductivity. This value τ = 82 msec is close to pulse period T = 80 msec and is sufficiently greater than heat-carrier transition time through half-target being 15 msec. It causes sufficiently pulse character of rod and heat-carrier temperature fields.

Table 3 shows relative data for radiation damages in first-wall materials of SIN, MMF-0.6 neutron sources and thermonuclear reactor with thermal load of first wall about 1 Mw/m^2. The radiation damages calculation were carried out by analogy with /2/.

Data for SIN are given for proton current of 125 μA and dispersions of 7.9 and 2.63 cm, for MMF-0.6 - for the current of 500 μA and 3 cm dispersion.

Fast neutron fluence of about 10^{22} neutr/(cm^2year) corresponds to K_{dpa} about 10 dpa per year. Expected material features alterations for such radiation dose are small.

Table 4 gives relative parameters for SIN, pulse fast reactor IBR-2 (Dubna), for ISIS neutron source /4/ and for neutron source based on MMF-0.6.

In conclusion we are like to acknowledge for support and for interest to the work A.N.Tavchelidze, V.M.Lobashev, V.D.Burlakov.

Table 1.

Angle, deg.	5	10	30	90
Neutron energy				
E < 0.215 eV	0.18	0.38	3.5	16.9
0.215ev<E<10,5Mev	0.36	1.2	12	60.5
E > 10.5 MeV	0.001	0.003	0.05	2.6
fraction, %	0.2	0.2	0.3	3.3
0 < E < 8	0.54	1.6	15	80

Table 2.

Proton beam	
Proton energy, GeV	45
Average current, μA	125
Pulse per sec	8.3
Dispersion σ_x, σ_y, cm	7.9, 2.6
Fraction of beam on the target,%	90
Target:	
Heat release, Mw	2.5
Size, mm	100x300x400
Rod length, mm	300
Rod diametr, mm	4
Max.aver.heat release,w/m^3	$1.3.10^9$
Max. wall temp.,^{0}C	135
Heating up per pulse,^{0}C	60
Coolant - H_2O :	
Initial temp.,^{0}C	30
Velocity, m/sec	10
Flow rate, m^3/h	290
α, w/m^{2}grad	5.10^4
Heating up on half length of rod,^{0}C	
Min	12
Max	16
Heating up - α,^{0}C	
Min	23
Max	62

Table 3.

Facility	Material	Damage production rate K_{dpa}, dpa/year	Helium production rate K_{He}, nuc/year x10^6	K_{He}/K_{dpa}x10^6
SIN (1st wall)	Fe	9	430	48
	Al	27	370	14
	W	6	750	130
MMF-0.6 (1st wall)	Fe	13	220	17
Thermonucl. reactor	Fe	14	150	11
SIN (target)	W	15	1200	80

Table 4.

Neutron source	Pulse width therm.neutr µsec	Peac flux dens.therm neutr/cm^{2}s	Av.flux dens.therm neutr/cm^{2}s	PPS	Fig.of merit, Φ_{av}/θ^2
IBR-2	215	$1.0.10^{16}$	$1.1.10^{13}$	5	0.16
IBR-2*)	120	$3.7\ 10^{16}$	$2.2.10^{13}$	5	1
ISIS**	35	$4.9.10^{15}$	$8.5.10^{12}$	50	4.5
MMF-0.6	35	$4.9.10^{15}$	$1.7.10^{13}$	100	9
SIN	35	$6.6.10^{17}$	$2.0.10^{14}$	8.3	110

*) Expected data after modernisation.

**) Evaluated data for target-moderator scheme analogous to the one of MMF-0.6.

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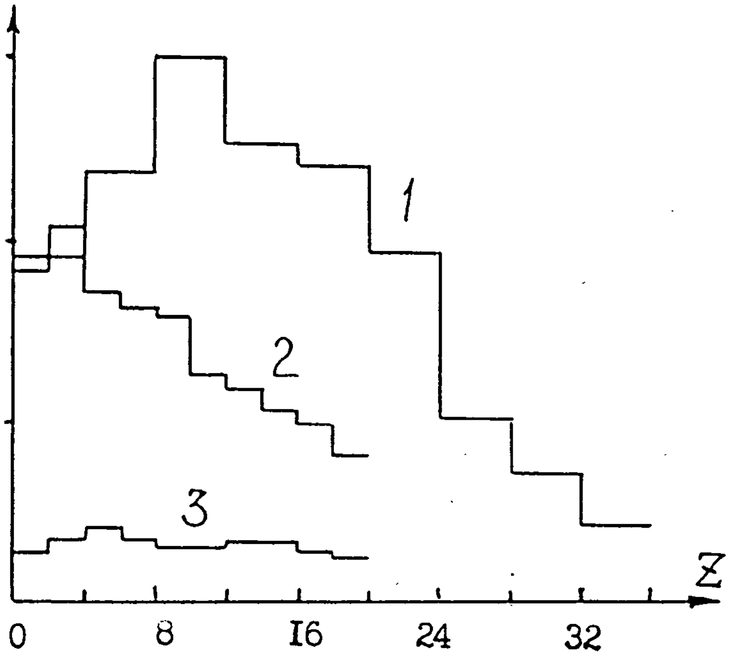

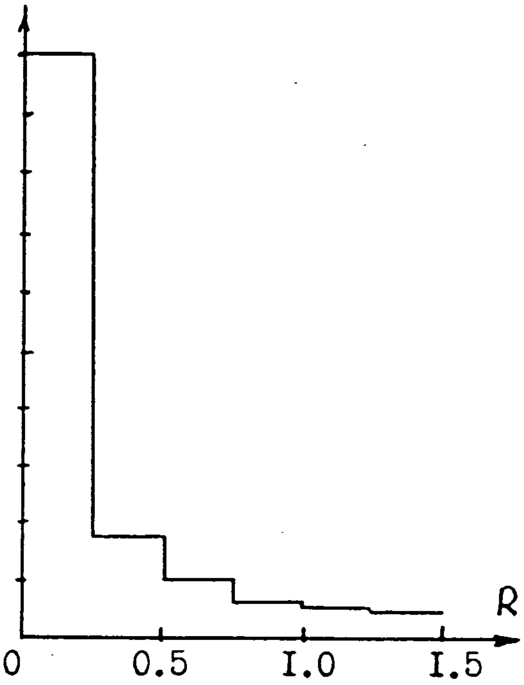

Fig.4. Z-dependence of vaporised neutron production density(1), of total heat release (2), of heat release without π^0contrbution(3).

Fig.5. R-dependence of vaporised neutrons production density.