PRESENT STATUS OF THE JAERI - LINAC

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ABSTRACT

The JAERI Linac has been used as a pulsed neutron source for measurement of neutron cross sections. The high intensity and the short pulse operation of the accelerator are needed for improving the counting statistics and time resolution in neutron time-of-flight experiments. In order to meet these requirements, the pulse repetition rate was incresed from 300 pps to 600 pps in April, 1984, with an increased average electron current of 53μs, and since then, stationary operation of 600 pps has been continued with a beam energy of 110 MeV and a pulse width of 25 ns. Some modifications and improvements of the rf power system were carried out in last fiscal year to increase repetition rate. A new electron gun has been designed and constructed in 1983 to obtain shorter pulse width (5$\sim$10 ns). It will be installed in the accelerator this year, after modifing the gun modulator circuits.

This report will describe briefly the modifications of the rf power system, the experience of the 600 pps operation and the characteristics of the new injection system.

diode are mounted in the same unit of an oil-filled tank made from the 3 mmt aluminum plate. This saves one unit of tank and a high voltage power connecter in each modulator unit.

The thyratron trigger system to switch the hydrogen thyratron (ITT-KU275C) is changed by replacing the small thyratron (5C22) to the SCR circuit (IR 68RS160). A new rack shown in Fig.2 is prepared to mount the thyratron and to assemble its associated circuits such as filament, reservoir power supply, auxiliary electrode power supply and SCR driver circuit in the same place. This new mount provides improved earth level and reduce the noise and damage due to the electric discharge.

The master trigger generator and the delay circuit to synchronize the relationship of the trigger system are also changed to the one based on the transister circuit and mounted in a NIM module. The delay time to each modulator unit and gun pulser unit can be adjusted by a step of 0.1μs within the limit of 10μs. This system is planned to operate automatically on the micro-computer basis.

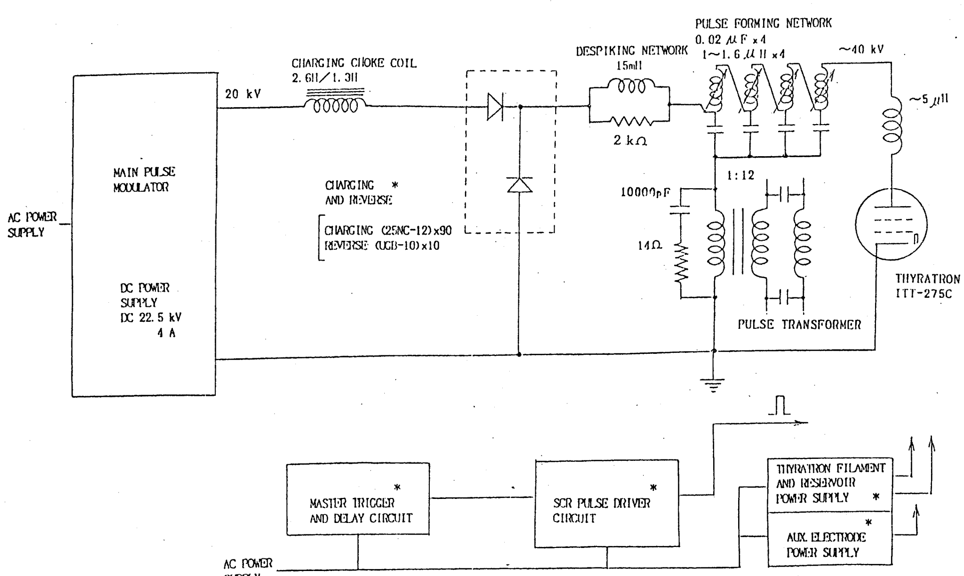


Fig. 1 A block diagram of the improved pulse modulator and the associated circuits

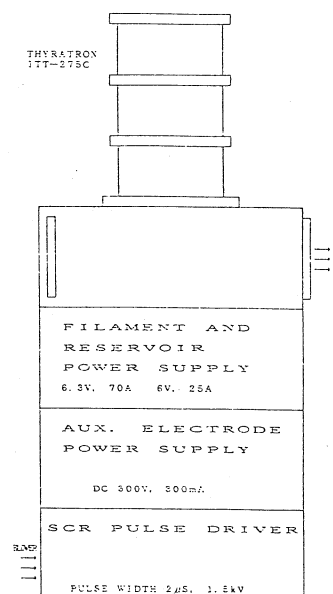


Fig. 2 A new rack prepared to mount a thyratron and to assemble its associated circuits

MAIN PULSE MODULATOR AND THE ASSOCIATED CIRCUITS

In the previous pulse modulator, troubles happened frequently with the cooling system of the end-of-clipper circuit and insulation of a high-power, co-axial cable assembly, even in the 300 pps operation. These problems had to be solved for continuous stable operation of 600 pps (120 hours/week). A block diagram of the improved pulse modulator and associated circuits is showned in Fig.1, indicating the modified or replaced parts with asterisks. The end-of-clipper circuit to dicipate inverse change to the PFN was replaced to the reverse circuit which consists of a series combination of assembled diode elements (UGB-10). This new reverse circuit and the charging

SELECTION OF THE MODULATOR PULSE WIDTH AND EXPERIENCE OF THE 600 PPS OPERATION

Filling-times and group velocities of the JAERI Linac are given in Table 1. The accelerator consists

No of Accelerator tube	Length (m)	vg/c	Filling time (μsec)
Buncher	0.68	0.0197	0.15
1 ~ 2	2.198	0.0185	0.36
3 ~ 5	2.98	0.0172	0.58

Table 1 Accelerator length, group velocity and filling-time of the JAERI Linac

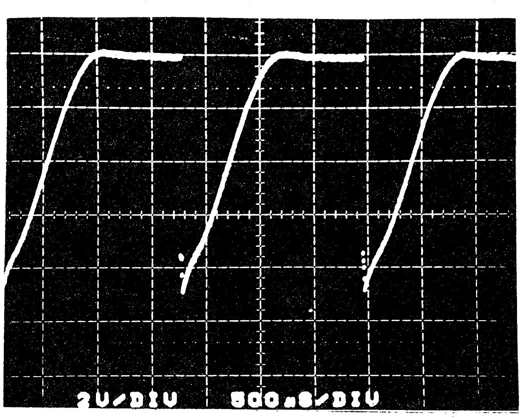
KLYSTRON	MAXIMUM DUTY FACTOR	EXPECTED DUTY FACTOR FOR 600 PPS	EXPERIMENTAL DUTY FACTOR FOR 600 PPS
KLYSTRON ITT-8568			
BEAM VOLTAGE	0.0012	0.00064	0.00108
RF POWER	0.0009	0.00048	0.00072
BOOSTOR KLYSTRON TH-2346			
BEAM VOLTAGE	0.001	0.0009	0.00108
BOOSTOR KLYSTRON 4KP3SN			
BEAM VOLTAGE	0.0025	0.0009	0.00108

Table 2 Duty Factors of klystrons

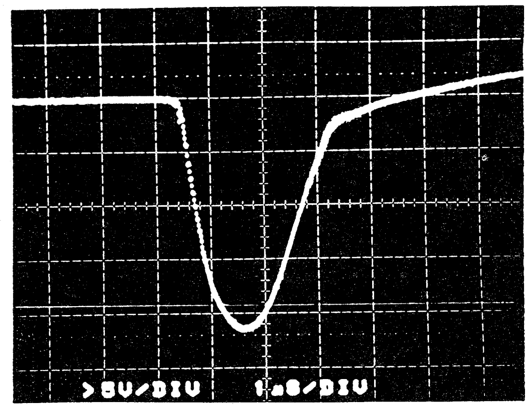
of a buncher (0.68 m) and five accelerator tubes (2x2.198 m and 3x2.98 m). Since the electron beam is usually accelerated with a pulse width of 30 ns, the minimum rf pulse length is only required to be nearly 0.6μs. The PFN of the modulator consists of 12 sections with fixed capacitors of 0.02μF and tunable inductors of approximately 0.1μH. These parameters of the PFN were selected to match the designed values of the pulse duration which was for the original 300 pps operation.

The maximum values of duty factors, supplied by the manufacturer, are given in the second column of Table 2, which correspond to the klystron beam voltage pulse length of 3.5μs and the rf pulse length of 2.5μs with the repetition rate of 360 pps. For accomplishing our ultimate goal of the 900 pps operation, the present pulse length will be needed to reduce by about 1/3 under the same duty factor; 1.06μs for the beam voltage pulse and 0.8μs us for the rf pulse length. The expected duty factors for 600 pps, which are calculated with these pulse lengths, are given in the third column of Table 2. On the other hand, from the test operation of 450 pps carried out last year (Dec., 1983 - Jan., 1984) by using the 4 PFN sections (1/3 of the previous one), the pulse length of 1.8μs for the klystron beam voltage and 1.2μs for the rf pulse were obtained experimentally. The duty factors for also 600 pps, which are calculated with experimental pulse widths of 450 pps, are given in the fourth column of Table 2. These duty factors are found not to exceed the maximum duty factors.

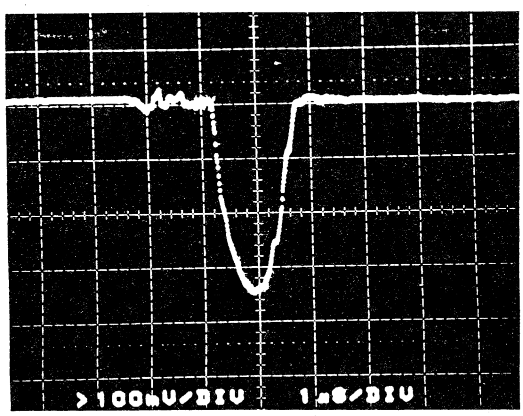
After one week test in April, 1984, stationary operation of 600 pps was started. Various modulator pulse waveforms observed at 600 pps are shown in Fig.3.



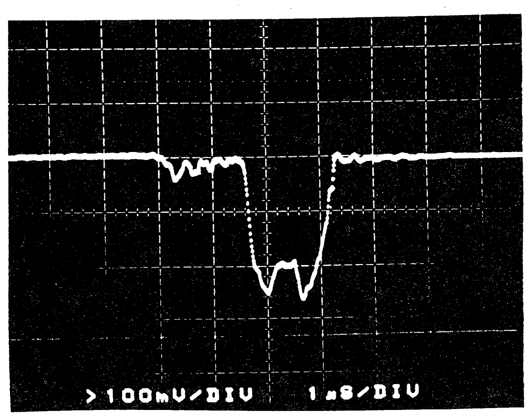
2 V / DIV
500 μS / DIV
Fig. 3-a PFN charging



5 V / DIV
1 μS / DIV
Fig. 3-b Klystron beam voltage pulse



100 mV / DIV
1 μS / DIV
Fig. 3-c RF output pulse



100 mV / DIV
1 μS / DIV
Fig. 3-d RF beam loading

Fig. 3 Pulse modulator waveform at 600 pps operation

The Linac has run satisfactorily for more than 400 hours except a dielectric breakdown occurred in a capacitor of the PFN during the text operation. The radio frequency noise levels are found not to be serious to the circuits of the micro-computer and the detectors operated with the TTL-level.

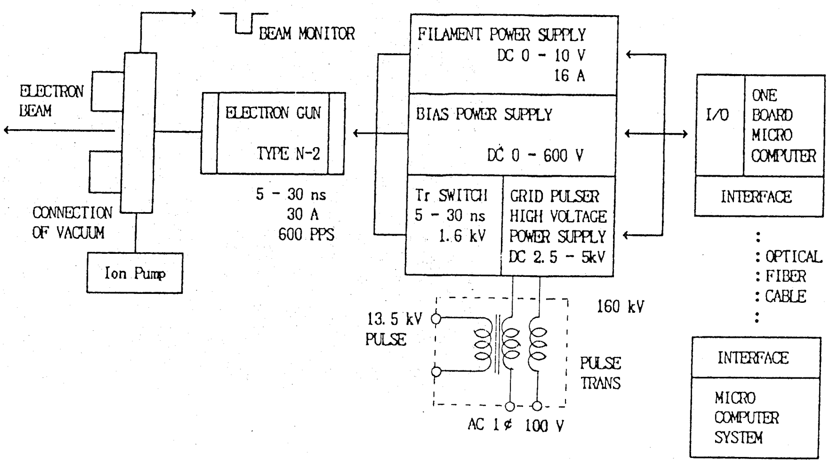


Fig. 4 A block diagram of the new injection system

1	anode
2	vacuum flange ICF203
3	corona ring
4	ceramic vacuum envelope
5	electron repeller
6	wehnelt electrode
7	filament, grid, cathode assembly (hatched)
8	vacuum flange ICF70
9	insulator
10	vacuum flange ICF203
11	vacuum flange ICF203
12	50Ω co-axial tube (tapered)
13	co-axial connector (HN-R)

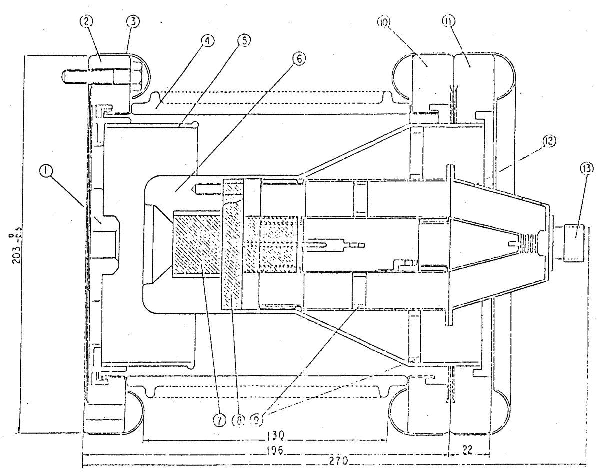


Fig. 5 The design drawing of the N-2 type injector

THE NEW ELECTRON GUN AND ITS ASSOCIATED CIRCUITS

The maximum peak currents from the present electron gun are obtained to be 4 A and 6 A with pulse widths of 30 ns and 20 ns, respectively, which correspond to the accelerated beam current of 120 nC in each pulsed beam. However, the peak current for narrower pulsed beam is limited due to several problems such as the low electron acceptance and transmission to accelerator tube and the insufficient voltage from the gun grid pulser. A block diagram of the new injection system to solve these problems is shown in Fig.4. Main improvement consists of the replacement of the electron gun itself to the new one of type N-2. The design drawing of the electron gun assembly is shown in Fig.5. The electron trajectories are shown in Fig.6, which were calculated with the computer analysis program by solving the Poisson equation. Preliminary test of the new impregnated cathode (the NJRC - E type) showed that the electron emittion current of 11 A/cm^2(1050°C) were obtainable.

The filament, cathode and grid, shown as the hatched part in the figure, are accurately assembled in the factory and easily mounted (dismounted) on the vacuum flange ICF-70. The vacuum envelope made from ceramics allows to raise the cathode potential up to 160 kV. The characteristics of the new gun is given in Table 3.

The gun modulator is also modified by replacing the 5C22 switch tube to the transister switch for the grid pulser. The trigger pulse is transmitted by the photo coupler through optical fiber. The microcomputer is used to control the grid bias, the pulse width and cathode voltage.

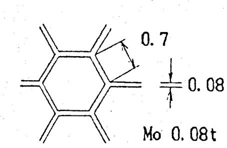
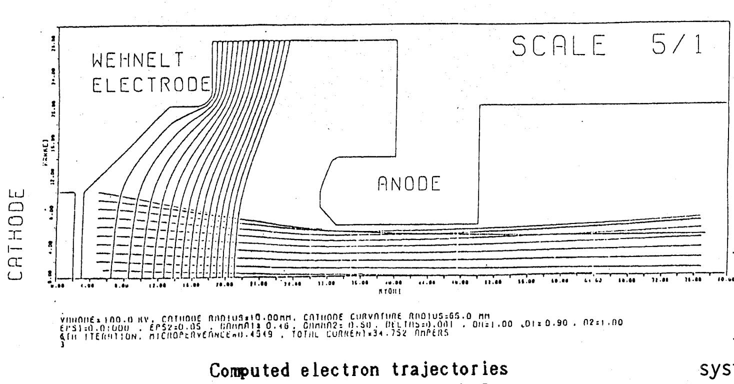
structure	pierce, triode, co-axial
cathode voltage	120-160 kV
anode current (peak)	30 A
grid voltage	480 V
bias voltage	370 V
cathode diameter	20 mm¢ (3.14 cm^2)
electron emittion density	9.5 A/cm^2 (1025°C)
cathode shape	round, fat
cathode material	NJRC-E (IMPREGNATED)
mesh shape	hexagnal, gold electroplating
mesh size (mm)	
grid-cathode distance	0.7 mm
grid-anode distance	28 mm (variable)
grid, filament, cathode	assembled in factory
vacuum envelope	ceramics

Table 3 Characteristics of new N-2 type electron gun



Computed electron trajectories

Fig. 6 and equipotential in the N-2 type gun

The maximum peak current with this new injection system is expected to be 12 A with a pulse width of 10 ns. This corresponds the same accelerated beam current of 120 nC as the 20 ns operation. The new gun will be installed in Dec., 1984.