COMISSIONING OF THE LINEAR ACCELERATOR-INJECTOR AT THE TNK FACILITY

E.I. Zagorodnikov, V.N. Korchuganov, E.N. Kokin, Yu.G. Matveev, N.V. Matyash, A.S. Medvedko, V.V. Repkov, G.N. Ostreiko, S.I. Ruvinsky, G.V. Serdobintsev, S.V. Sinyatkin, A.G. Steshov, S.V. Tararyshkin, V.A. Ushakov, A.V. Filiptchenko, K.N. Chernov, I.N. Churkin, D.A. Shvedov, V.D. Yudin,
Budker INP, 630090 Novosibirsk, Russia
I.Yu. Boiko, N.N. Grachev, N.V. Spinko, V.P. Khramtsov,
Lukin State Research Institute for Problems in Physics, Zelenograd
A.M. Dolgov, O.E. Kil'disheva, "TIRA Co. Ltd", St. Peterburg
A.G. Valentinov, Yu.V. Krylov, D.G. Odintsov, Yu.L. Yupinov,
"Kurchatov Institute", Moscow

The industrial storage facility has been developed and manufactured at the Budker INP SB RAS. It contains an 80 MeV electron linear accelerator-injector and two electron storage rings: the lesser 450 MeV booster ring and the main 2.5 GeV storage ring. In 2002, the work on the accelerator assembling was begun. On December, 25 this year the accelerator was started up, and the current at the linear accelerator output was obtained. The linear accelerator schematic together with a description of the 6 meter long accelerating DAW structure which operates at 2.8 GHz, are presented in the paper. The first results of the accelerator start-up are as follows: the accelerated electron current of ~50 mA with the energy of ~55...60 MeV.

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1. INTRODUCTION

The industrial storage facility (TNK) has been developed at the Budker INP SB RAS in 1985. It includes an injector on the base of 80...100 MeV linear accelerator, and two storage rings: minor booster for energy of 450 MeV and major ring for the energy of 2.5 GeV.

The design parameters of the electron beam at the linac output are listed in Table 1.

TABLE 1

Beam energy	80 MeV
Energy spread	1 %
Beam pulsed current	~ 80 mA
Pulse duration	18 ns
Transverse emittance	0.1 mrad·cm
Repetition rate	1 Hz

By the year 1988, the equipment for two linear accelerators has been produced at INP SB RAS [1]. The first linac was commissioned in 1992 at specialized SR complex in the "Kurchatov Institute", Moscow [2,3]. The second one has been made for TNK complex in the Lukin State Research Institute for Problems in Physics, Zelenograd. In 2001, the decision about assembling was made, and commissioning of the injector in Zelenograd was scheduled for the end of 2002. In September 2002, linac accelerating structure was assembled at building ways in TNK building (Fig.1), and forevacuum was achieved. A waveguide channel was re-designed, manufactured, and shipped in November, 2002. In the beginning of December, the disc ceramic window was manufactured at the INP branch in Protvino, and assembling of the waveguide connecting linac with the "Olivin" klystron station was started.

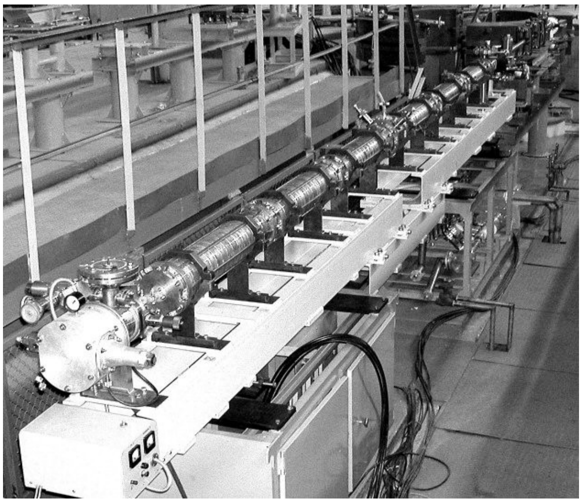

Fig.1. Linac accelerating structure at building ways

2. LINAC LAUOUT, PARAMETERS AND RESULTS OF PREINJECTOR START-UP

The functional diagram of the linear accelerator-injector of the TNK facility is shown in Fig.2. The linac operates in the energy accumulation mode for pulse duration of ~8 μs with excitation of a standing wave in the accelerating structure. Beam injection from a gun is come about at the end of this RF pulse.

RF power supply is provided by the "Olivin" klystron station at 2798.6 MHz. A pulsed diode electron gun (40 kV/3.5 A/18 ns, repetition rate up to 5 Hz) located coaxially with the linac and separated from it by the valve is used as an electron source. The accelerated beam from the linac output is transported by the EOC-1 channel into the booster storage ring. The current pulse is a ~18 ns packet which consists of ~50 microbunches.

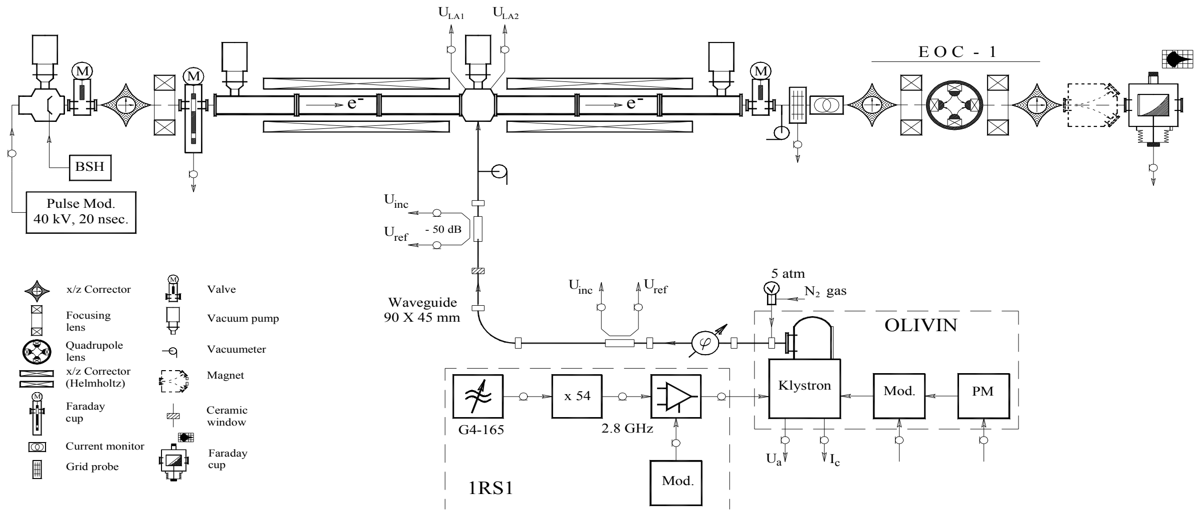

Fig.2. Functional diagram of 80...100 MeV electron linear accelerator-injector for TNK facility

The beam current is measured at the linac input and EOC-1 output.

In 100 MeV electron linear accelerator creation, the development, simulation, and manufacturing of the biperiodic accelerating structure with disks and washers (Andreev structure, DAW) [4,5] as regular brazed one meter long sections were on principle new. The six meter long linear accelerator was then constructed from theses sections. Attachment was realized by indium seals. DAW accelerating structure represents a single resonant volume with a high Q-factor due to the strong resonant coupling between cells. Power input is provided by the waveguide [6] at the linac center. Accelerating structure parameters are listed in Table [6].

Linac accelerating structure	DAW
Oscillation mode in linac	$\pi/2$
Oscillation type	E_{02}
Linac length	6 m
Operating frequency	2798.6 MHz
Effective shunt impedance	95±3 MΩ/m
Characteristic impedance	3.4±0.1 kΩ/m
Unloaded Q-factor	28000±100
Structure time constant (loaded)	~1.8 µs
Coupling coefficient in structure	43 %
Kinetic energy at 18 MW power level	90 MeV
Esmax/Eacc ratio (overvoltage coefficient)	~5.5
Achieved field strength on accelerating structure surface Esmax	~790 kV/cm
Accelerated pulsed current (for 100% particles)	0.6 A
Linac frequency drift	~50 kHz/°C
Linac heating stabilization temperature	33±0.1 °C

Oscillograms in Figs.3–5 represent the practical results and injector start-up chronology.

Oscillograms in Fig.3 show the beginning of linac accelerating structure conditioning on December 21, 2002. The multipactoring is observed in the central part of the structure near the coupling hole between the central cavity and waveguide power input.

Fig.4 presents the result of 3-day conditioning, when a stable linac operation was achieved, which allowed us to increase the incident RF power level from the klystron into the waveguide up to 8.5 MW.

That power was enough to transport the beam along the whole accelerating structure. The ~55 MeV accelerated beam at the linac output was obtained on December 25, 2002.

Fig.5 shows the accelerating voltage oscillogram (K1) and the Faraday cup capacitance voltage (K2) loaded on ~300 kΩ resistor (at the gun current pulse duration of ~18ns). The beam current front position is in the linac accelerating field maximum. That was the first observation of electrons accelerated on December 25, 2002, on the Faraday cup.

That result was replicated on December 26 immediately after the operating regime program loading and starting the whole RF system without additional conditioning.

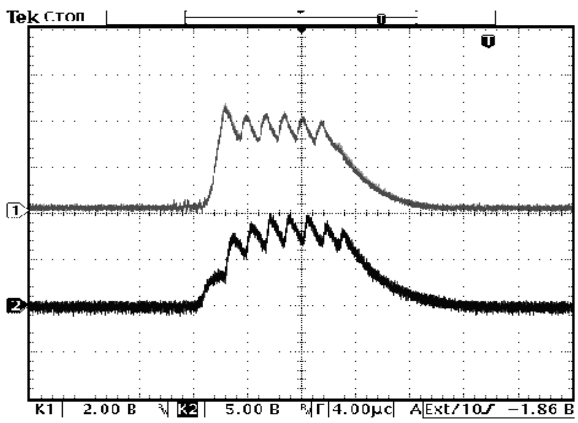

Fig.3. Start of the conditioning: upper line – voltage in the linac central part (Ucav); lower line – reflected wave voltage amplitude (Uref)

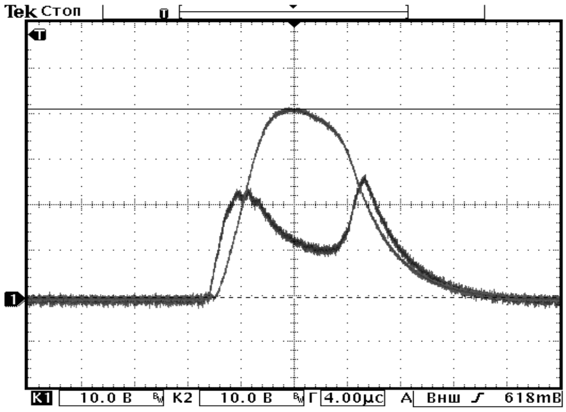

Fig.4. 25.12.02. After 72-hour conditioning: upper line – voltage in the linac central part (Ucav); lower line – reflected wave voltage amplitude (Uref)

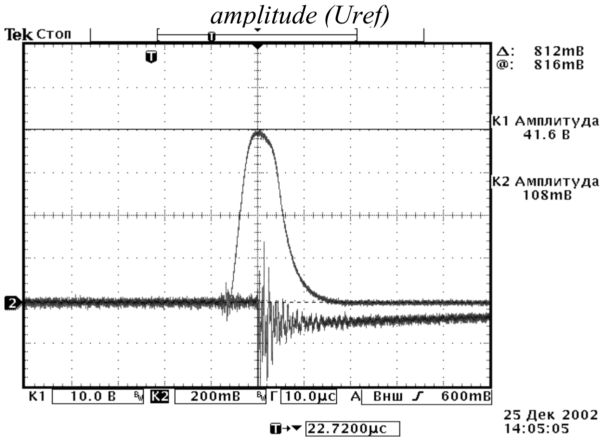

Fig.5. 25.12.02. Here comes the beam Uanode=190 kV. K1 – structure voltage Ucav, K2 – Faraday cup voltage. Scanning of 10 µ s/grad

3. CONCLUSIONS

Shipping of the linac equipment according to schedule allowed us to assemble and tune the injector on the base of the linear accelerator undertime. The accelerated electron current of ~50 mA with the beam energy not less than 55MeV was obtained at the linac output on December 25, 2002.

So, at present time two unique linear accelerators with biperiodical DAW structure created at our Institute successfully operate.

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[ТЕЛЯ–ИНЖЕКТОРА КОМПЛЕКСА ТНК
. ЛУКИНА, ЗЕЛЕНОГРАД

Е.И. Загородников, В.Н. Корчуганов, Е.Н. Кокин, Ю.Г. Матвеев, Н.В. Матяш, А.С. Медведко, В.В. Репков, Г.Н. Острейко, С.И. Рувинский, Г.В. Сердобинцев, С.В. Синяткин, А.Г. Стешов, С.В. Тарарышкин, В.А. Ушаков, А.В. Филипченко, К.Н. Чернов, И.Н. Чуркин, Д.А. Шведов, В.Д. Юдин, И.Ю. Бойко, Н.Н. Грачев, Н.В. Спинко, В.П. Храмцов, А.М. Долгов, О.Э. Кильдишева, А.Г. Валентинов, Ю.В. Крылов, Д.Г. Одинцов, Ю.Л. Юпинов

Технологический накопительный комплекс был спроектирован и изготовлен в ИЯФ им. Г.И. Будкера СО РАН. Он включает в себя инжектор–линейный ускоритель электронов с энергией до 80 МэВ и два накопителя электронов: малый накопитель–бустер на энергию 450 МэВ и основной накопитель на энергию 2.5 ГэВ. Приводятся функциональная схема линейного ускорителя и описание конструкции ускоряющей структуры с шайбами и диафрагмами длиной 6 метров, работающей на частоте 2.8 ГГц. Представлены первые результаты запуска ускорителя: получен ускоренный ток электронов ~50 мА с энергией ~(55...60) МэВ.

ЗАПУСК ЛІНІЙНОГО ПРИСКОРЮВАЧА–ІНЖЕКТОРА КОМПЛЕКСУ ТНК НДІФП ім. Ф.В. ЛУКІНА, ЗЕЛЕНОГРАД

Є.І. Загородников, В.М. Корчуганов, Є.М. Кокін, Ю.Г. Матвєєв, М.В. Матяш, А.С. Медведко, В.В. Репков, Г.Н. Острейко, С.І. Рувинський, Г.В. Сердобінцев, С.В. Синяткін, А.Г. Стешов, С.В. Тараришкін, В.А. Ушаков, А.В. Філіпченко, К.М. Чернов, І.М. Чуркін, Д.А. Шведов, В.Д. Юдин, І.Ю. Бойко, М.М. Грачов, М.В. Спинко, В.П. Храмцов, А.М. Боргов, О.Е. Кільдишева, А.Г. Валентинов, Ю.В. Крилов, Д.Г. Одинцов, Ю.Л. Юпинов

Технологічний накопичувальний комплекс був спроектований і виготовлений у ІЯФ ім. Г.І. Будкера СВ РАН. Він містить у собі інжектор–лінійний прискорювач електронів з енергією до 80 МеВ і два накопичувачі електронів: малий накопичувач–бустер на енергію 450 МеВ і основний накопичувач на енергію 2.5 ГеВ. Приводяться функціональна схема лінійного прискорювача й опис конструкції прискорюючої структури із шайбами і діафрагмами довжиною 6 м, що працює на частоті 2.8 ГГц.

Представлено перші результати запуску прискорювача: отриманий прискорений струм електронів ~50 мА з енергією ~(55...60) МеВ.