# THE USE OF SERIES *BA* PERMANENT MAGNETS IN STEERERS OF THE BEAM EXTRACTED FROM THE ELECTRON LINAC

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Relying on the results of test bench simulation and magnetic measurements, barium plates BA (typical size is 180x80x16 mm) were used to manufacture "dipole magnet"-type units with a constant field of intensity up to 1.8 kOe in the working gap of 3 to 3.5 cm in height. The operating experience with the accelerators KUT has shown that these devices are convenient in service, are easy-to-transport and can be used to advantage to solve various problems in electron beam formation and steering at the exit of the accelerator.

PACS: 07.55.+k

Extension of the class of radiation works on the external electron beam from the accelerator KUT-20 [1] has given rise to a problem of searching new devices for beam extraction and irradiation field formation. For the long-term treatment of large-scale objects one uses successfully electromagnetic scanners we have developed [2], but for the work with converters one needs an extracted electron beam of a maximum density (power) and, respectively, of a minimum cross-section that, as a rule, leads to failure in the foil of the exit window. Therefore, besides development of special exit windows of a small area (see, this volume), in the course of time, a demand arose to have a device of "fast technology". For example, a scanned electron beam in air is contracted again and is concentrated into required sizes. It is advisable that this device be independent, movable, not requiring power supplies and evacuation and its assembling and disassembling should take a few minutes of the accelerator time.

A search has shown that a similar device can be realized on the base of metal-laminated series BA magnets the properties and features of which are described sufficiently e.g. in [3].

In the course of selecting and designing the device construction, barium anisotropy plates 2BA (typical size is 180x80x16 mm) were used in different combinations - from single to composite units by thickness and lengths. The criteria were: electron energy 15…25 MeV, working gap of 3 cm in height, maximally possible values of the strength of a magnetic field and its integral length along the beam path.

At first from available single magnets the plates selected were by a maximum residual magnetization and by their identity: in five points (on angles and in center) on top side and on lower side, without substrate of steel and with substrate. It has been established, that in the case with steel the strength on the surface increases by ~30% and as "flattens out" throughout the surface being on average 550 Oe.

To study experimentally the magnetic field distribution in the assumed working gap and on its edges we have assembled a dummy including four plates and a standard C-core from the magneto-discharge- type vacuum pump with poles each of which comprising two plates fastened together and a gap of 3 cm in height. Fig.1 gives the results of measurements allowing to conclude that the value of the strength inside the gap, uniformity and behaviour of field decrease at the edge are in conformity with requirements to the "classic" C-core magnet (electromagnet) that provided the basis for development of the design of the whole device.

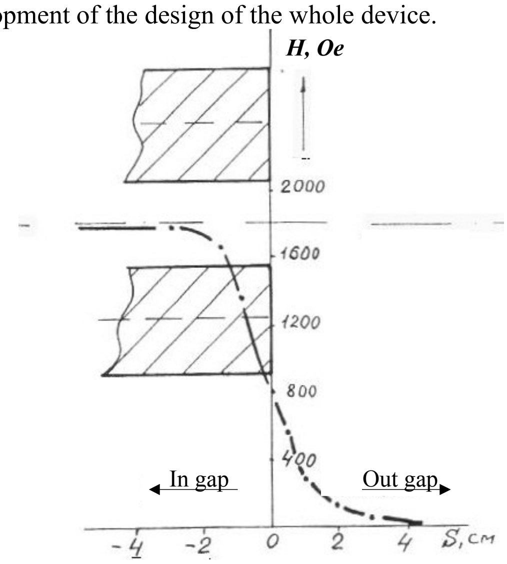



***Fig. 1.*** *Magnetic field distribution in the median plane of the dummy*

In Fig.2 shown is the schematic diagram of the double magnet with parallel- and antiparallel fields designed for "contraction" of the electron beam scanned by the electromagnet of the scanner. In essence, these are two identical magnets spaced at a 3 cm distance in which the field directions inside the working gap are opposite, and in the central part the field is compensated (Fig.3,a,b).

Each of poles of a single magnet is a composite bar of three magnetic laminas. Around the side perimeter the bar is rigidly tightened with a stainless-steel strip. The C-core is made from soft iron laminas (St.3); it bears some important functions: frame, core of the reverse magnetic flux and "amplifier" of lamina magnetization. The poles in the assembly are fastened by point welding to the upper lamina and lower lamina of the core. Both magnets are rigidly joined together with the use of two other nonmagnetic laminas. These laminas, as well as the main steel walls have longitudinal slots for bolts that provides adjustment and positioning of working magnet gaps.

In Fig.4 the scheme of the experiment on determining the efficiency of the device developed is shown. The accelerator produced electron beam of an energy ≈ 25 MeV and a pulsed current ≈0.5 A was scanned by a scanner electromagnet (2) onto an exit window foil (3) as a band (4) having a length of about 9 cm, and then in air the beam failed into the gap of a double magnet (5).

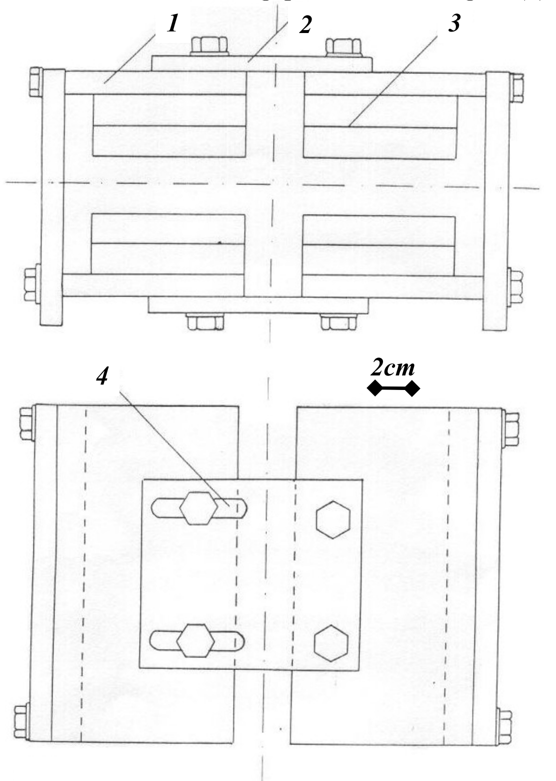
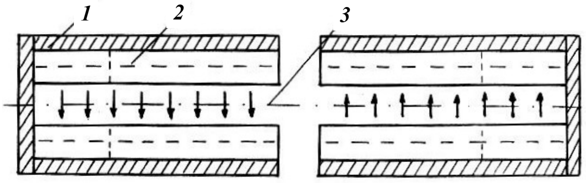
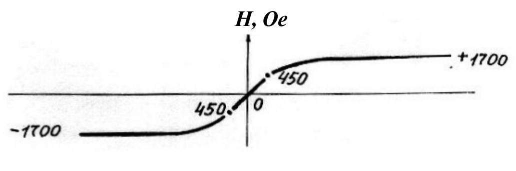



***Fig.2.*** *Schematic diagram of the magnet with an antiparallel field: 1 - magnetic circuit (St3 steel); 2 - connecting plate (duralumin); 3 - pole; 4 - adjusting slot*




***a)***




***b)***

***Fig.3.*** *Direction (**a**) and field value (**b**) in the real magnet: 1 - magnetic circuit; 2 - pole; 3 - median plane of beam scanning (see fig.5,a)*

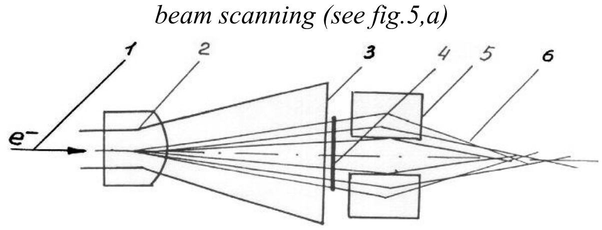
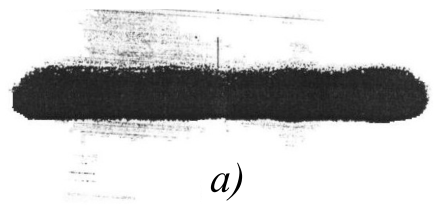
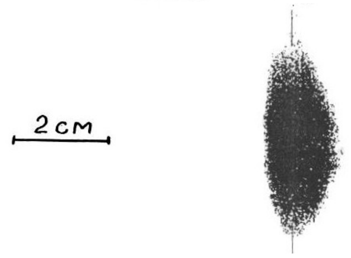



***Fig.4.*** *Scheme of the experiment on determining the magnet efficiency*
*1 - accelerator produced beam; 2 - electromagnet of the scanner with the scanner chamber; 3 - exit window; 4 - electron beam scanned with the scanner; 5 - magnet with an antiparallel field; 6 - trajectory of the beam being "contracted"(schematics)*

The effect of the antiparallel magnetic field is seen in fig.5: the transversal phase beam volume (5,a) is transformed into the longitudinal one (5,b), the beam is concentrated around the original accelerator axis. The longitudinal spread of "focal" distances of some beam envelopes, seen in fig.4, is explained by the imperfection in the angular optics of the magnetic track, the optimization of which at the first stage has not been specified.



*a)*




*b)*

***Fig.5.*** *Beam image: at the exit window **(a);** behind the magnet **(b)***

In the course of adjustment and alignment of the exit window with a minor diameter, when the scanner electromagnet (fig.4, pos.2) did not turned on and then did not been at all, there appeared an urgent necessity of operative determining the energy of extracted not scanned electron beam. In this case, the above described antiparallel magnet was transformed (by 180° "inversion" of one half and by joining together both parts) into an one-piece planoparallel dipole magnet having the following characteristics: $H_0 \approx$ 1.75 kOe, $D_0 \approx$3 cm, width of good field region ≈ 11 cm, effective length of field along the beam trajectory ≈ 17 cm. In this performance the device was applied as a portable quasi-spectrometer of the electron beam in air directly behind the exit window by the methods of [4]. Thanks to this feature we have checked out during a short time the accelerator KUT-20 operation conditions by the beam current and electron energy, that allowed to put the acelerator into standard operation for different programs.

The authors thank O.A.Repikhov and V.A.Popenko for management and participation in the experiment with a beam at accelerators, Z.M.Kolot for the appreciable help in presentation of graphic information.

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## ПРИМЕНЕНИЕ ПОСТОЯННЫХ МАГНИТОВ СЕРИИ БА В УСТРОЙСТВАХ УПРАВЛЕНИЯ ВЫВЕДЕННЫМ ПУЧКОМ ЛУЭ


***А.Н. Довбня, Л.К. Мякушко, А.Е. Толстой, В.А. Шендрик***



На основе стендового моделирования и магнитных измерений из бариевых плиток **БА** (типоразмер 180Х80Х16 мм) изготовлены блоки вида “дипольный магнит” с постоянным полем напряженностью до 1.8 кЭ в рабочем зазоре высотой 3...3.5 см. Опыт применения на ускорителях КУТ показал, что такие устройства удобны в эксплуатации, легко транспортируемы и могут успешно решать различные задачи по формированию и управлению пучком электронов на выходе ускорителя.


## ЗАСТОСУВАННЯ ПОСТІЙНИХ МАГНІТІВ СЕРІЇ БА В ПРИСТРОЯХ КЕРУВАННЯ ВИВЕДЕНИМ ПУЧКОМ ЛПЕ


***А.М. Довбня, Л.К. М’якушко, А.Ю. Толстой, В.А. Шендрик***



На основі стендового моделювання та магнітних вимірювань з барієвих плиток **БА** (типорозмір 180Х80Х16 мм) виготовлені блоки типу “дипольний магніт” з постійним полем напруженістю до 1,8 кЕ в робочому зазорі висотою 3...3,5 см. Досвід застосування на прискорювачах КУТ показав, що такі пристрої зручні в експлуатації, легко транспортуються та можуть успішно вирішувати різноманітні задачі з формування та керування пучком електронів на виході прискорювача.