The interest to a problem of acceleration of the electron-ion beams increases at present. Linear accelerators with such beams which energy is more than $10^7$ MeV (x:1:101) can be effectively used for nuclides transmutation by means of proton or X-rays received during electron bombardment of some target [1]. Linear accelerators with beams which energy is less than $10^7$ MeV can be used as injectors in ion accelerators based on the collective methods [1]. Accelerators with beams which energy is less than $10^2$ MeV can be used for ion implantation with simultaneous neutralization of their positive charge by means of negative electron charge. It prevents microcircuits from discharge and damage [2].

The advantages of circular electron beams in proton synchrotrons were showed in the theoretical work [4] and the possibility of practical realization of such systems was demonstrated at the ion accelerators with electron rings [5]. These advantages consist in higher radial and vertical ion orbit stability and higher ionization by electron beam during the first acceleration stage.

In this paper various schemes of linear and circular accelerators with electron-ion beams are considered. The results received on accelerator with electron-ion beams, designed and performed in Moscow Engineering Physics Institute, were used as the basis of this suggestions.

Linear accelerator may be placed as it is shown on Fig.1(a). The HF structure contains identical toroidal cavities 1 connected to RF amplifiers 2 and inverter 3. Each cavity has two HF lines connected to common generators 4 which frequencies are $f_L$ and $f_e$ accordingly. These generators are united by mutual control system 5. The filters 6 and 7 (higher and lower frequencies) are included in each HF line between cavities 1 and amplifiers 2 to prevent influence of one generator on another. This structure can work in various regimes, that is on standing or on travelling wave with two frequencies and on standing wave with one frequency and travelling wave with the other frequency. Typical distribution of electrical HF field strength on the axis for various frequencies at the fixed moment for standing waves are shown on Fig.1(b,c). Dotted line shows the main harmonics for these cases. Theoretical analysis showed that if the electron beam is focused by solenoids and ions are focused by negative electron charge, and if electron velocity $v_e$ is considerably more than ion velocity $v_i$, the phase instability of electrons can arise in case if phase electron oscillation frequency is divisible to the frequency of "ion" wave.

It may be cited for example the next variant: $v_e = 0.0146 c$ (c-light velocity); $v_i = 0.9 c$; $f_L = 150 \times 10^6 Hz$; $f_e = 50 \times 10^6 Hz$. Analysis showed that the stable movement of ions and electrons simultaneously is possible if the beams parameters are the next: $E_e = 110$ MeV/n, $E_i = 240$ MeV/n, where $E_i$ - the electrical harmonics amplitudes for electrons and ions accordingly; $\theta_{OE}$ - the asynchronous phases. The potential gradient is defined as $dV/dz = E_e \sin \theta_{OE}$ (where $\theta$ is the particle charge).

The main difficulty in circular ion accelerator with electron beam is the turning of two beams. Authors suppose that this problem may be solved in a device shown on Fig.2. It contains two plates of the electrostatic deflector 1, placed in circular vacuum chamber on insulators 2. They are connected to high voltage source 3. Both ends of each plate are connected to secondary winding of transformer 4. Radial electric field created by means of source 1, and vertical magnet field created by means of currents $I_n$, provide simultaneous turning of electron and ion beams. The particle
The focusing of electron beams in deflectors may be performed by means of special configuration of magnet field, that is suitable currents in each deflector plate, as it is in synchrotrons. The ion beams may be focused by negative electron charge or by special configuration of electric field between deflector plates.

Described scheme may be useful for heavy ion acceleration. Their energy may surpass some hundred MeV, and the ion beam current may be higher than in other accelerators.

The accelerators dimensions may be decreased by increased strength $E_x$. It is possible because currents create "magnet insulation" regime, when field emission electrons does not move between deflector plates and cause the discharge.

It may be cited for example a variant, when the beams directions are the same, and $E_x = -5 \times 10^{-2}$ cm, if these directions are opposite, and $E_x$ the strength must be directed from the center of circulation, and it is necessary to perform the next conditions:

$$E_x = \frac{R(v_i + u_j) q_i}{q_e},$$

$$B_x = \frac{1}{R(v_i + u_j)} \left( \frac{u_i q_e}{q_i} + \frac{u_j q_i}{q_e} \right).$$

If the directions of the beams movement are the same and $E_x<0$, or if the directions are opposite and $E_x>0$, the strength must be directed from the center and it is necessary to perform the conditions:

$$E_x = \frac{2u_i u_j}{R(v_i + u_j)} \left( \frac{u_i m_i}{q_i} + \frac{u_j m_j}{q_j} \right),$$

$$B_x = \frac{1}{R(v_i + u_j)} \left( \frac{u_i^2 m_i}{q_i} + \frac{u_j^2 m_j}{q_j} \right).$$

The circular accelerator may be performed from such deflectors and linear RF structures, described before (Fig.1). RF accelerator may consist of linear ion accelerator structure and linear electron accelerator structure, each part is exited on various frequencies.

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