or to try the synthesis of superheavy elements. In recent years biologists have made predictions that nitrogen or neon ions would be far superior to γ-rays in treating deeply situated malign tumors. Space biology has its own problem: radiation effects of the heavy component of cosmic rays on the nerve tissue of astronauts during long, planetary space trips. The energies involved in the latter two cases are up to 500 MeV/nucleon.

In the present state of the accelerator technology, synchrotron is the only accelerator capable of accelerating ions of any charge-to-mass ratio to energies up to and above 1000 MeV/nucleon. There are, however, a few additional requirements to satisfy. A R. F. accelerating system with a very wide range of frequencies is necessary and the vacuum in the vacuum chamber has to be good enough to avoid excessive losse due to a charge change of ions.

The synchrotron in Princeton, N. J., U. S. A., started to operate as a proton machine in 1963. Its basic parameters are: $B \cdot R = 12.8\ \mathrm{T} \cdot \mathrm{m}$, acceleration time $T = 25$ ms, vacuum $(1 - 2) \cdot 10^{-7}$ torr. In 1969 a program was initiated for the conversion of the synchrotron into a machine capable of accelerating any ion up to uranium, to energies of 1000 MeV/nucleon. The first phase of the project consisted in the acceleration of nitrogen and neon ions. The choice of the ion species was dictated by the need for the most suitable radiation in cancer treatment. In later phases of the project the replacement of the existing epoxy vacuum chamber with a ceramic one is envisaged; this would improve the vacuum down to 10^{-9} torr, necessary for ions heavier than neon.

The mode of acceleration of nitrogen and neon ions is as follows. From a compact Penning ion source a mixture of nitrogen or neon ions in different charge states is extracted, accelerated in a 4 MV Van de Graaff and then the 2+component separated in a $B \times E$ mass spectrometer. By passing through a carbon stripping foil of 10 μg/cm^2 thickness the mean charge in the beam is increased to 5—6. The desired species is again separated in an electrostatic analyzer, injected into the main synchrotron ring and accelerated to the final energy.

On July 15, 1971 nitrogen ions were accelerated to 290 MeV/nucleon. This was the first time that heavy ions of cosmic energies have been obtained in the laboratory. In September the energy was increased to 530 MeV/nucleon. The intensity of the external beam was up to $2 \cdot 10^6$ particles per second. At the same time a series of biological experiments was begun.

Note added. On December 15 a neon beam was obtained, with an energy of about 500 MeV/nucleon.

2.11. Study of the phosphorescent component of NaI(Tl) and possibility of its application

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2.12. The K-Shell fluorescence yields of argon, chlorine and sulphur

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The fluorescence yields of noble gases neon, argon, krypton and xenon were measured[1-7)] by using the proportional counter. Recently, some modifications of the original method were introduced by which large corrections required previously were reduced, and by which the method became applicable for measurement on other gaseous compounds not disturbing the normal operation of the proportional counter[8]. In the present work the similar experimental arrangement was utilized.

For measurement of fluorescence yield for argon the multiwire proportional counter was filled with 15 mm of mercury of argon, 40 mm of methane and with helium up to 760 mm. Fig. 1. represents a spectrum obtained by use of incident radiation with energy $E_0 = 4{,}5$ keV from titanium target. The spectrum exhibits the main peak due to the Auger transition at energy E_0 and the escape peak at energy $E_0 - E_K$ due to the radiative transition with E_0 being the energy gap between K and L shells. The contribution to the spectrum due to the conversion of incident radiation in methane, determined separatelly, is represented in the same figure by the lower curve.

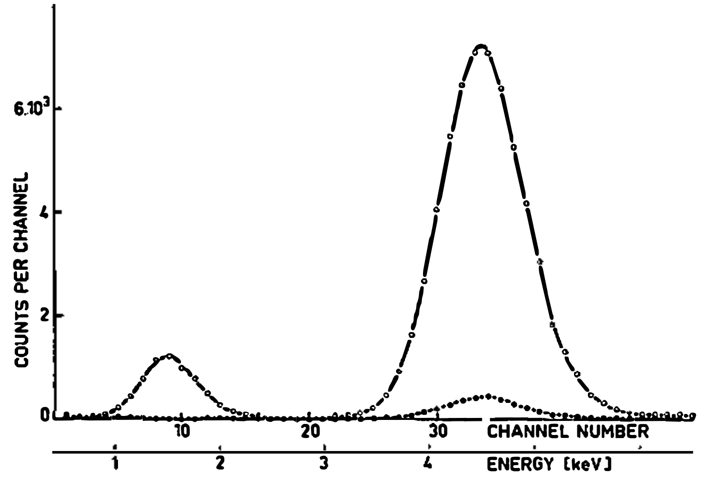

Fig 1.

For determination of fluorescence yield of chlorine the methyl chloride CH_3Cl was used as converter. The partial pressure of methylchloride not interfering the normal operation of proportinal counter was found to be 5 mm of mercury in the absence of helium. Therefore only methane was added up to 65 mm of mercury. The spectrum is represented in Fig. 2.

As a convenient compound for measurement on sulphur the dimethylsulphide was found. In this case an energy difference between main and escape peak in the case of titanium target was too small for accurate separation of both peaks and the measurement was performed using potassium K—X radiation.

Gas filling was 10 mm of mercury of dimethylsulphide and 60 mm of mercury of methane. As in the case of chlorine the use of helium was not possible because of decreasing energy resolution. For background measurements two methyl groups in dimethylsulphide were replaced by two methane atoms thus yielding the total presure 80 mm of mercury of methane. A typical spectrum with sulphur escape peak is represented in Fig. 3.

From the obtained spectra the relative activities N_m and N_e of the main and the escape peaks, respectively, were determined. These values have to be corrected for the escape of the electrons from the main counter and for the reabsorption of K fluorescent radiation of the investigated element. For the evaluation of ω_K the fraction $N_e/(N_e + N_m)$ with corrected values of relative activities has to be divided by the absorption efficiency of the K shell, determined by the K jump values[9].

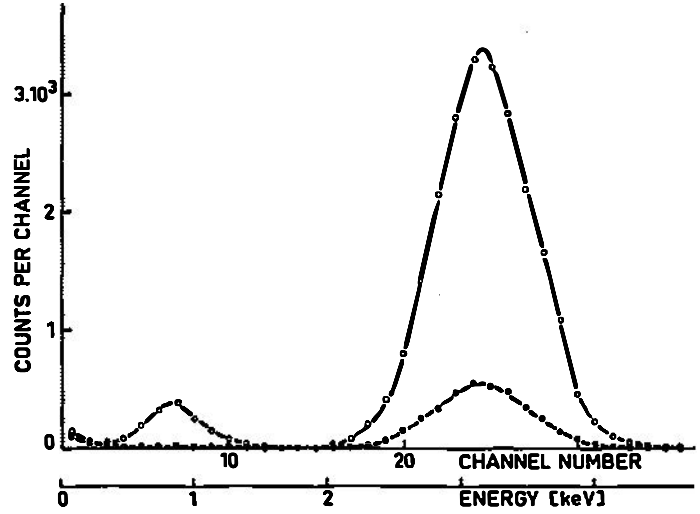

Fig. 2

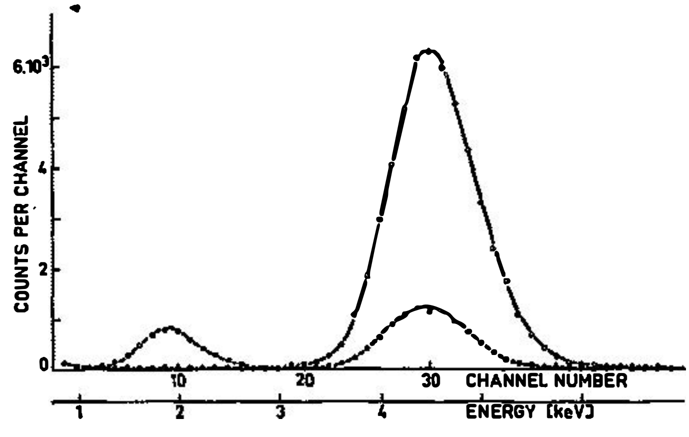

Fig. 3.

Thus for the fluorescence yields the following values result: for argon $(12{,}3 \pm 0{,}3) \cdot 10^{-2}$, for chlorine $(10{,}0 \pm 0{,}3) \cdot 10^{-2}$ and for sulphur $(8{,}2 \pm 0{,}3) \cdot 10^{-2}$.

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