Experimental setup. The setup used in the present measurement is shown in Fig. 1. The circuit with the discharge tube is labelled by (1). The optical system (2) produces the image (3) of the light pulse emitted between the electrodes. The light from two different spots of the image (3) is conducted by means of two plastic light guides »Crofon« (a and a') to the cathodes of two RCA IP28 photomultipliers (4). The photomultipliers are connected to an oscilloscope (Tektronix 551) through two cathode followers (4). The time bases of the scope are triggered by the voltage pulse from the discharge tube.

Measurements and conclusion. The described method is a suitable tool for investigating the place and time dependence of the discharge ($I = I(t, x)$.) It was observed that a low intensity light pulse near the anode appeared first, followed by a high intensity light pulse near the cathode (Fig. 2). The time delay between these two light maxima decreased with increasing electrode voltage. The time delay was of the order of 100 nsec.

The light guides used can transmit only wave lengths corresponding to the deexcitation of neon ($3p$—$3s$) levels.

Light pulses from the discharge tube indicated that the density of the space charge was increased near the anode. The U. V. emission of neon and bromine (for $\lambda < 275$ nm) caused the secondary emission of electrons at the cathode. The electrons thus produced gave rise to an intense development of new avalanches near the cathode, followed by an increase in density of the space charge in this range.

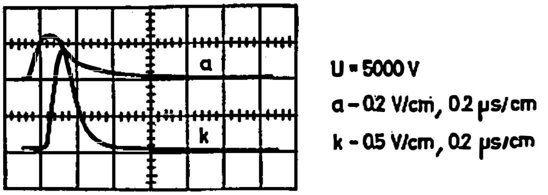

Fig. 2.

The dead time is defined by recombination of slow-mobility positive ions. In a cylindrical counter the discharge is developed mainly in the centre of the tube near the anode. The dead time of such a counter is longer in comparison with that of a parallel plate counter. One of the properties of the latter counter is that positive ions are concentrated near the cathode.

Reference

1) D. Srdoč: Nucl. Instr. and Meth. 21 (1963) 243.

2.10. Acceleration of nitrogen and neon ions to energies above 200 MeV/nucleon

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Until recently the scientific interest for heavy ions was more or less limited to energies below 10 MeV/nucleon. This range of energies was of special interest for nuclear physicists with their desire to explore problems of nuclear structure 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