THE FRASCATI STORAGE RINGS

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Frascati is developping two storage rings. The first (code name AdA = anello d'accumulazione = storage ring) designed for storing electrons and positrons of up to 250 MeV is actually undergoing the first tests, the second (code name Adone) a storage ring for electrons and positrons of up to 1.5 GeV, is still being planned.

The AdA team consists of C. Bernardini, G.F. Corazza, G. Ghigo, R. Querzoli and myself. The magnet was planned by Dr. Sacerdoti and built in Terni, the radiofrequency by Dr. Puglisi.

Adone is a national effort. A design team headed by Dr. Amman has the task of arriving at a specific design proposal by the beginning of 1962. Simultaneously a committee is preparing the experiments to be carried out with the machine. If by the beginning of 1962 it is found that the project has a reasonable chance of success from a technical point of view; it is expected that the machine should be working late in 1964.

Let me be very brief on the Adone project : electrons and positrons circulate in a magnetic ring designed to contain particles of up to 1.5 GeV energy. The energy losses are replaced by R.F. Injection is effected by means of a low energy (of between 50-200 MeV). The final energy is reached by raising the magnetic field to the desired value.

Fig. 1 shows what we think to be the general lay-out of the Adone laboratory. The design represents a machine with k=4. There are therefore 2k=8 zones of encounter, two of which may be taken up by the radiofrquency cavities, the rest being available for experimentation.

The main problem faced by the design group is the decision between weak and strong focusing for the magnet. Weak focusing requires a very powerful and at 1.5 GeV barely feasible R.F. Strong focusing on the other hand leads to a dedamping of the radial oscillations of the beam. This may give rise to a broadening of the beam, which in its turn might make it necessary to work at prohibitive intensities. Methods of overcoming this difficulty are being studied at the moment.

The first project - AdA was started in February 1960. It was clear from the beginning that this project would be a gamble, the calculated intensity of the machine being about a factor 500 less than what was needed for experimentation. It was nevertheless decided to go on with the project, mainly because it was hoped that experience in storage problems could be most rapidly gained in this fashion and that eventually ideas for increasing the intensity might be forthcoming.

AdA is a storage ring of 250 MeV (and this energy was chosen in view of the maximum energy of 1000 MeV of the Frascati synchrotron). This turned out to be a quite fortunate choice for several reasons:

(1) the resonance energy of $e^+ + e^- \rightarrow \pi^+ + \pi^-$ falls into this region

(2) the machine is small and apart from the magnet can be constructed entirely inside the laboratory

(3) there is no temptation to use strong focusing

(4) the circulating electrons emit a considerable amount of visible light (2×10^7 visible quanta / sec) so that they can be easily observed, without overtaxing the radiofrequency (energy requirement 500 volts / turn)

(5) the curve of the energy losses is sufficiently near the minimum (formed by the interplay of radiation loss and scattering) so that the vacuum requirements are not excessive.

The 8 ton magnet is shown in Figures 2 and 3. Note the 4 "quasi-straight" (half field) sections designed to accommodate respectively radiofrequency, injection ports and the experimental region.

The doughnut (see Fig. 4) is made of stainless steel and is evacuated by a titanium pump. We shall try to arrive at a vacuum of 10^{-10} mm which seems feasible if sufficient care is taken in the degassing.

Details of the injection ports are shown on Fig. 5. The targets (on which the γ-rays from the synchrotron are converted into electrons and positrons [$\frac{1}{10}$ rad. length of tantalium]) are movable in 3 dimensions.

The radiofrequency cavity is shown on Fig. 6. The present model is made of Cu : Q $\cong$ 1000. Maximum voltage up to 10 kV. Frequency 147.3 Mcs. The final cavity is made of stainless steel - silver plated.

The arrangement of the storage ring relative to the synchrotron is shown in Fig. 7. The ring is first charged with electrons, then moved on rails and charged with positrons.

A schematic representation of the "tower" is shown in Fig. 8.

Figure 9 shows the tower with the storage ring mounted for its first test.

The magnet - which had been constructed by the Terni foundry - arrived in Frascati at the beginning of December.

After assembly and electrical testing the first exposures to the beam were made in February 1961. To study the magnetic properties of the poles half revolutions of the electrons were observed. It was found that the magnet did not show any signs of saturation up to about 220 MeV and that there was still a useful region of width of about 1 cm at energies well above 250 MeV.

Another sequence of runs without radiofrequency was carried out in April. With a very thin plastic counter mounted inside the doughnut up to 80 multiple passages were observed.

These very preliminary tests allowed us to find the rough values of some of the parameters defining the positions of the various component parts of the machine and showed that the magnetic field was on the whole quite satisfactory.

All this time work was going on on the preparation of the dougnnut and cavity complex. Vacua of the order of 10^{-9} in a half doughnut had been achieved by the use of a homemade titanium pump, but the introduction of a copper cavity of rather unorthodox design introduced new problems. It was not found possible to degas satisfactorily and multipacting made it very difficult to achieve a good vacuum.

We therefore decided to postpone the vacuum problem in expectation of the arrival of the stainless steel silver coated cavity and to run the first accumulation tests with a best vacuum of the order of 5×10^{-6} mm. This was done on the 27th of May. It was our intention to then initiate the study of the "linear" aspects of the machine. A photomultiplier (6342) was attached to the observation window of the doughnut. Its output was fed over an "unmatched" 125 Ω cable and a 10 kΩ resistance to a voltmeter, which was later attached to a mechanical recorder.

It had been calculated that a single electron should thus give a pulse of about 10^{-8} volts against a background (with the synchrotron switched on) of 3×10^{-9}. Electrons have been accumulated on this run and a typical record is shown in Fig. 10. One small division of the abscissa represents 10 sec and a single electron gives s signal approximately equal to the vertical division. The mean lifetime of the electrons is about 20" corresponding well with what one would expect for a vacuum of about 5×10^{-6} mm.

It was found that :

(1) the machine could be displaced without disturbing the stored particles;

(2) that the magnetic field could be changed at will without loss (the signal diminished considerably at 150 MeV - as it should);

(3) that there is no difference within the accuracy of the present measurements between electrons and positrons.

The capture efficiency which we have observed is smaller than what one can calculate on the basis of a statistical theory.

We intend to study this discrepancy in the next run of the machine before going on to try to improve the efficiency of injection.

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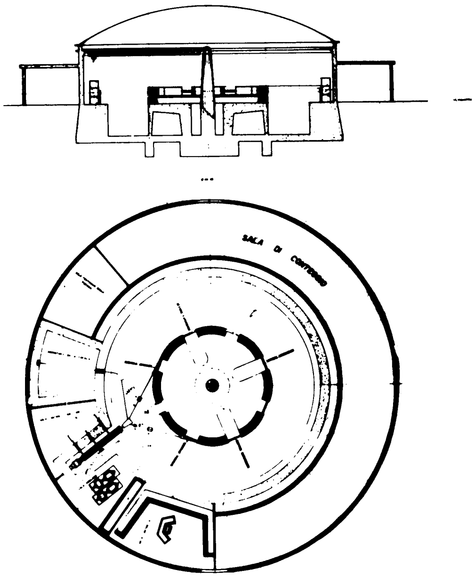

Fig. 1. General layout of Adone laboratory.

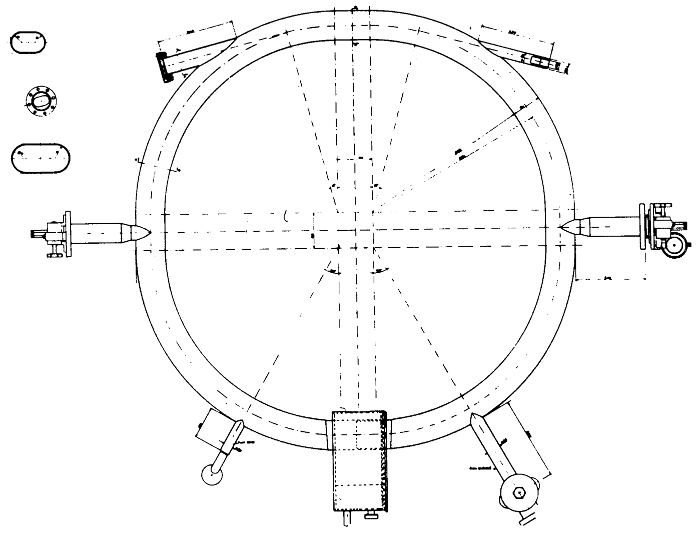

Fig. 2. 8 ton magnet for AdA.

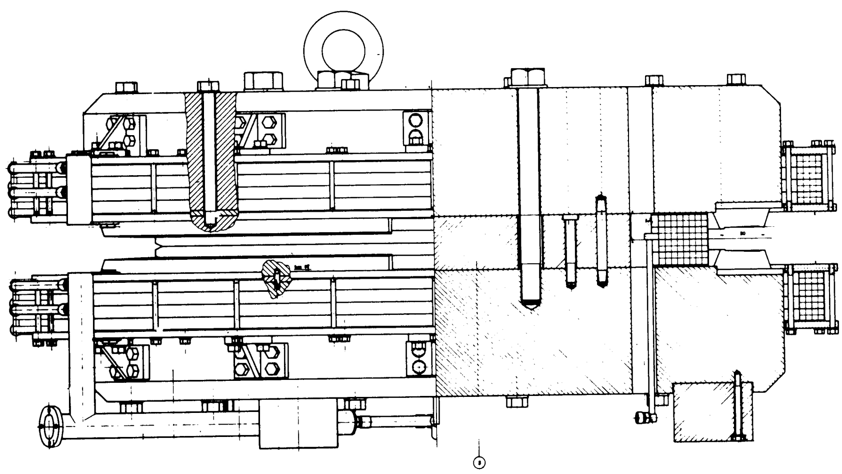

Fig. 3. 8 ton magnet for AdA.

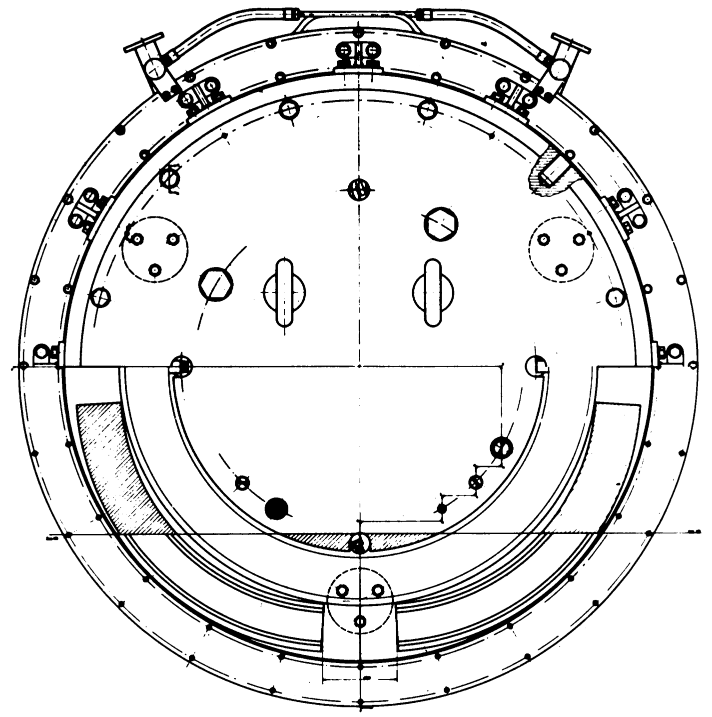

Fig. 4. AdA doughnut.

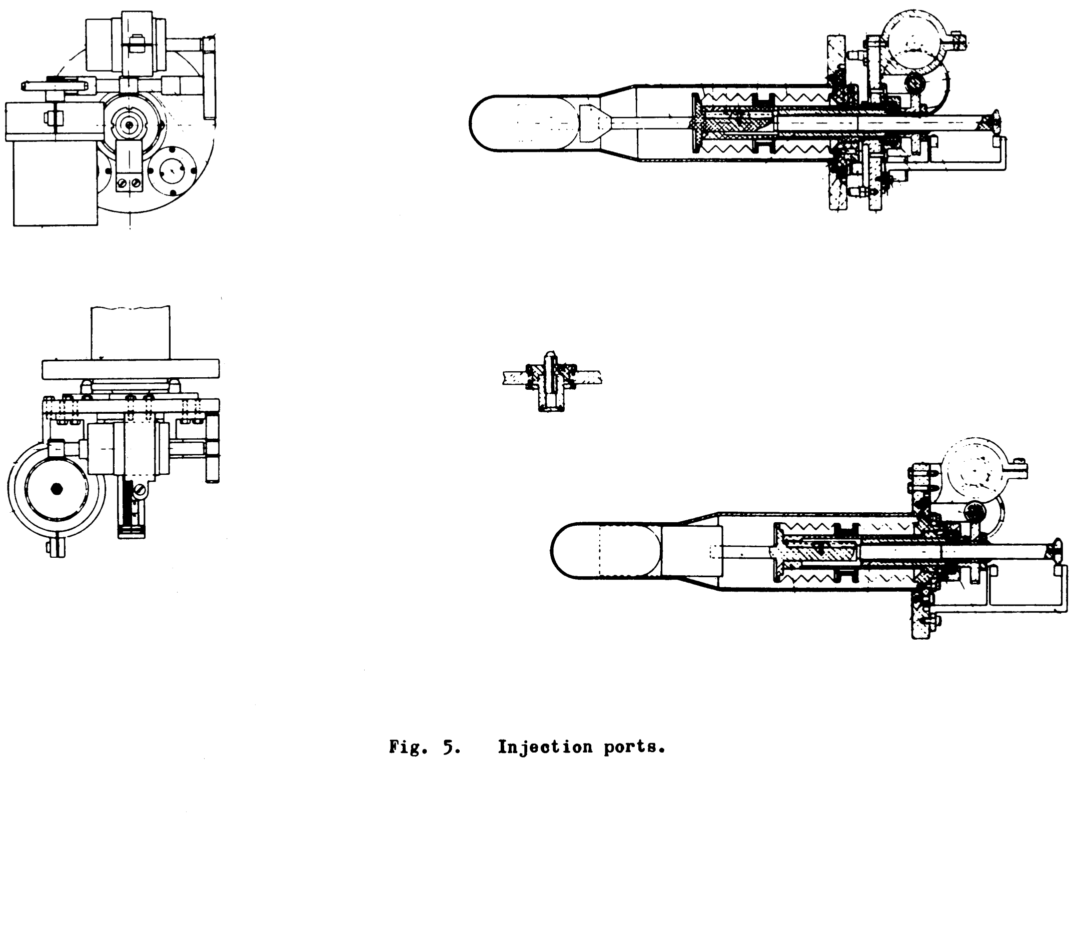

Fig. 5. Injection ports.

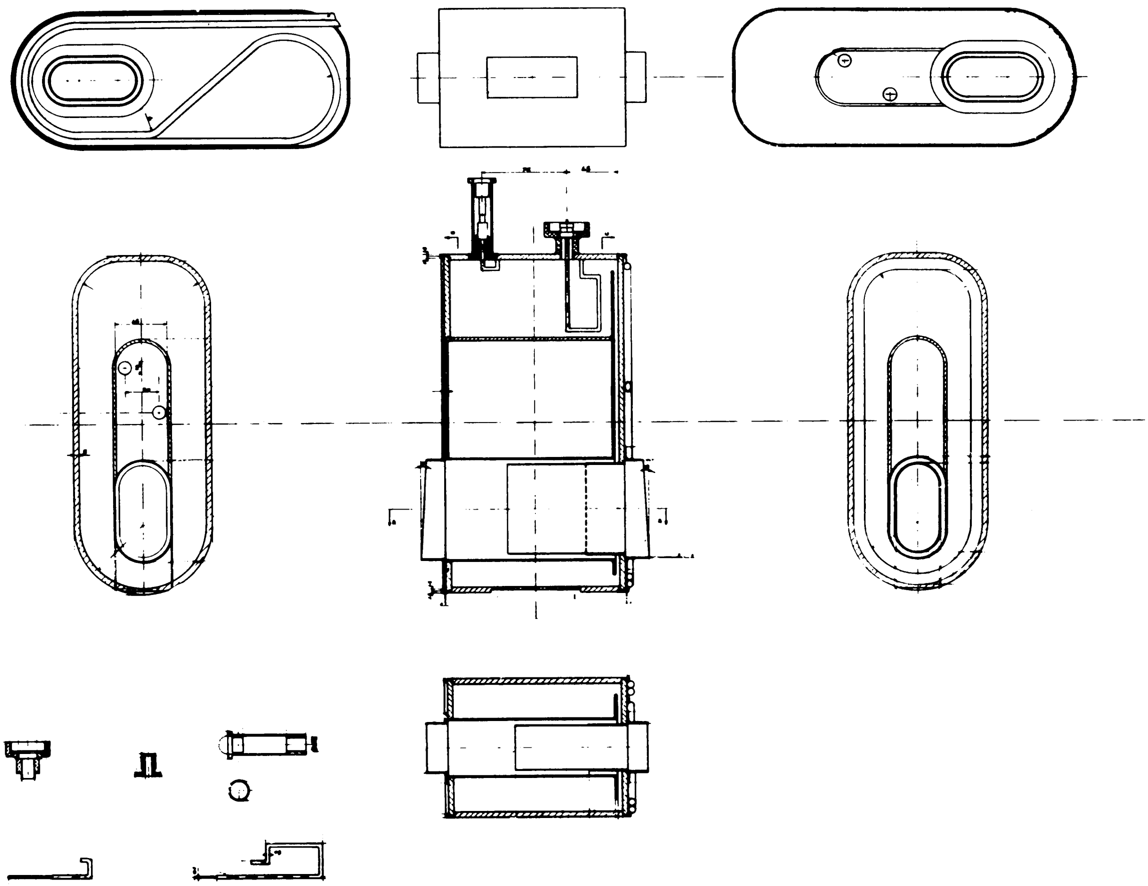

Fig. 6. Radiofrequency cavity.

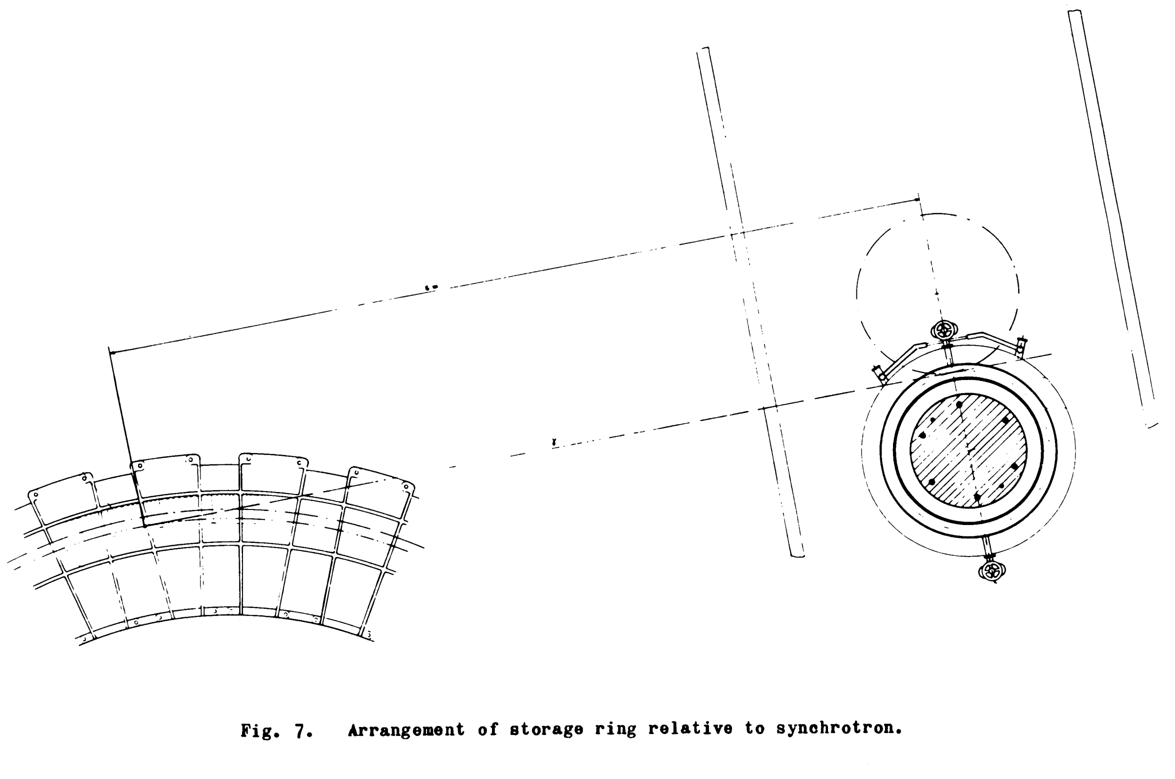

Fig. 7. Arrangement of storage ring relative to synchrotron.

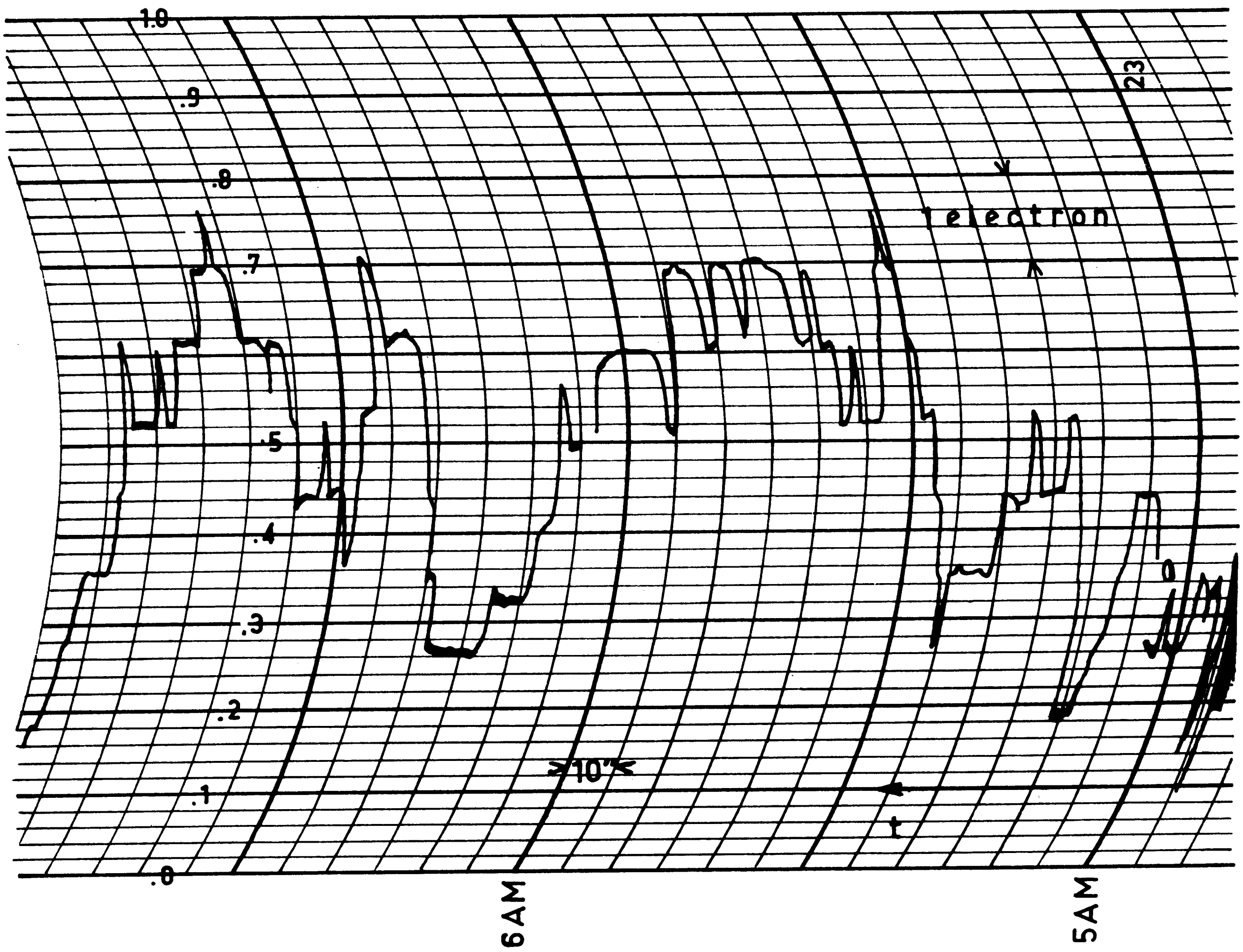

Fig. 10. Observation of electrons in storage ring.

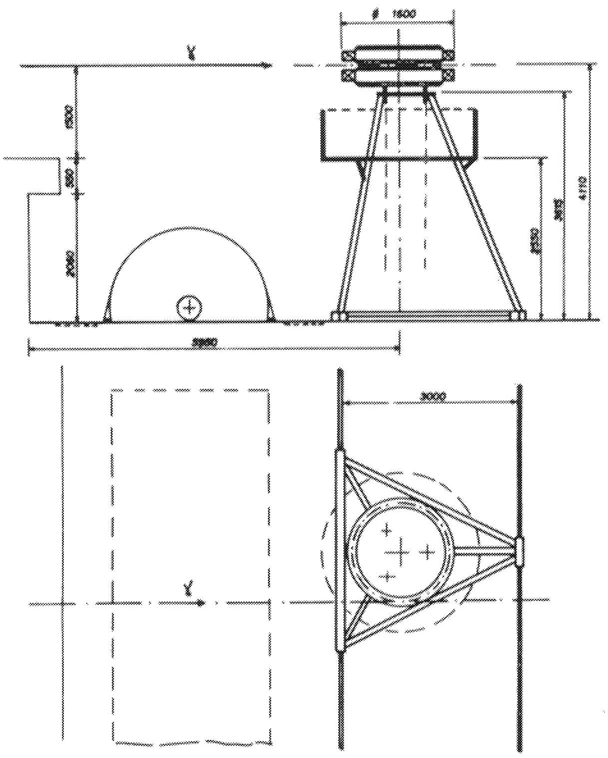

Fig. 8. Schematic representation of tower.

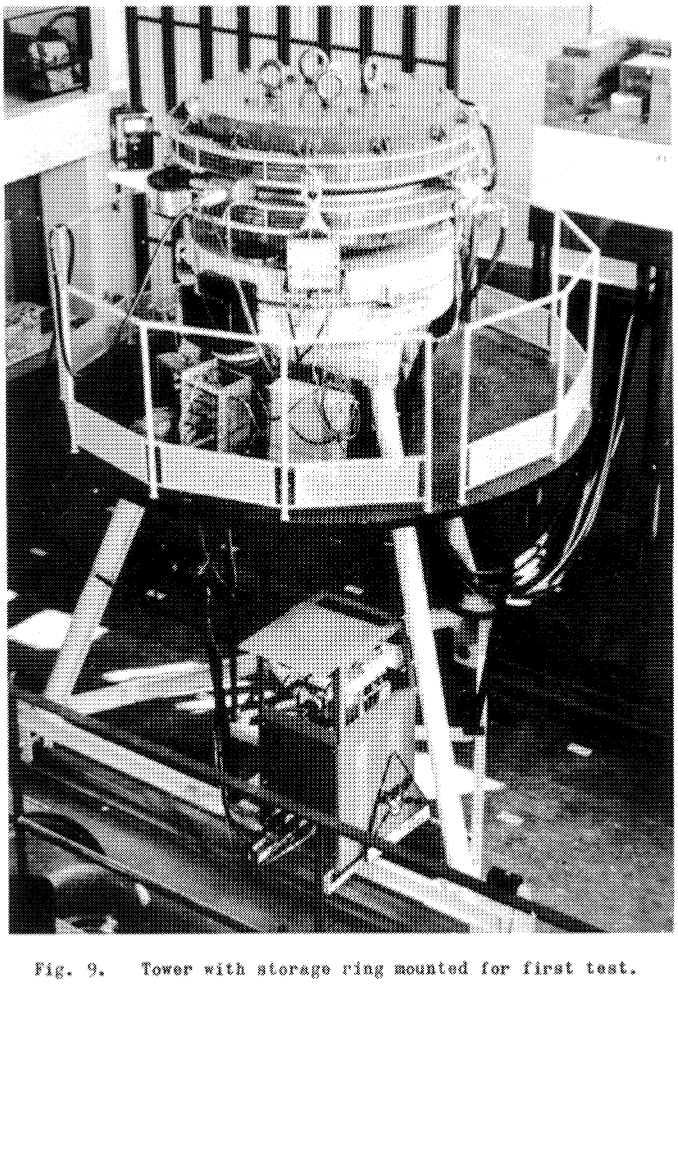

Fig. 9. Tower with storage ring mounted for first test.