THE NEW BEVATRON INJECTOR

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Some efforts have been undertaken lately to improve the performance of the Bevatron accelerator and its experimental usefulness. Provisions have been made for an external beam, more shielding is being installed with improved foundations and preparations are being made to install a 20 Mev linac to serve as the proton injector. This linear accelerator will replace the original injector which was a 10 Mev linac. This linear accelerator employed grid focusing in the drift tubes, with consequent low beam intensity output.

Serious design work on the new 20 Mev linac started in the fall of 1960. During May 1962 this machine became operational. By now an output current of 25 ma is obtained with 1 millisec pulse length.

Present schedules call for installation of the Bevatron injector during September and October 1962, with possible operation at the end of this year. The following persons had the principal responsibility for the design of this linac: B. Cork, R. Johnson, R. Allison, R. Nimitz, R. Richter, E. Zajec and H. Hereward (CERN). Only one report has been published as yet in connection with this new injector. This is R. Allison et al., Report UCRL-9743, describing the development of the proton source.

The ion source used in the preinjector is a Von Ardenne duoplasmatron source, using tungsten filaments as the electron emitter. Filament life-times are, at present, limited to about 50 to 100 hours, with the ion source installed in the preinjector. With this ion source preinjector output currents of the order of 100 ma have been obtained. This is probably more than adequate to meet the maximum possible demands for linac and Bevatron. This in connection with actual observed performance of the linac whereby with 75 ma input current,an output pulse current of 25 ma was obtained. With a 1 millisec pulse length beam levels in the Bevatron could then be of the order of 10^{14} protons/pulse. Since shielding is designed for 10^{13} protons/pulse and space charge limits are likely to be reached at about the same intensity, there is no urgent reason to increase the intensity of the injector at this time.

It has been observed that the preinjector beam was misaligned with respect to the theoretical beam axis. This is apparently due to optical elements in the source region being misaligned by a few thousandths of an inch. The preaccelerator column is approximately 30 inches long with a total applied voltage of 460 kv. The voltage-multiplying stack is contained in a plastic enclosure filled with Freon to prevent sparking.

The 20 Mev linac is essentially identical to the first part of the BNL 50 Mev linear accelerator or the ANL 50 Mev linac. Its description therefore will be limited to significantly different parts only. A schematic layout is shown in Fig.1.

The drift tubes at the injection end of the linac have a bore opening of 0.54 inches. The quadrupoles used are water cooled dc magnets copied from the Argonne design. Their orientation and excitation are such that the following front end arrangement is obtained: $\frac{N}{2},\frac{S}{2}$,S,N,N,S,S,N,etc. This in contrast to the Argonne arrangement whereby N,S,N,S,N,S, etc. is used. Beam current transformers are installed in 3 drift tubes. At first these were located at the side of the quadrupole magnet. This did not result in satisfactory performance due to the fringing fields of the quadrupole magnets. Presently the current transformers are around the outside diameters of the quadrupole. It is necessary to put an epoxy insulator ring on the inside of the bore tube in order to prevent closing a loop through the ferrite ring.

The system is being fore-vacuum pumped by two Heraeus pumps arranged in series and capable of reaching 10^{-4} mm Hg pressure in 12 to 18 minutes starting from normal pressure. High vacuum is obtained with two 1000 ℓ/sec "Vac-ion" pumps and one 2000 ℓ/sec mercury pump. Operating pressures are normally around 1-1.5 $.10^{-6}$ mm Hg pressure.

With respect to the rf system a similar system as that used on the old Bevatron injector is employed. This incorporates the Eimac 3W 10,000 tubes, capable of 350 kw output. Of these eight are installed for excitation of the linac, although the possibility exists to install ten tubes.

Pick up probe holes are located at twenty locations along the tank. These holes are closed with an epoxy cone. This makes it possible to obtain field flattening with the use of one probe only, eliminating uncertainties about calibration and cable length, etc. Twenty loop tuners are incorporated for tank flattening. Initial Q measurements indicated values of approximately 40,000 as compared with expected theoretical values of 84,000. A number of changes were made; the spring rings in the end plates were replaced by nylon tubing wrapped with copper strips of 0.005 inches thickness, at the drift tube supports the spring rings are replaced by copper washers,pump out slots and welds were plated. This all resulted in a final observed Q value of approximately 70,000.

Power levels needed for excitation are of the order of 900 kw, this together with 500 kw needed for a 25 ma beam intensity results in required excitation levels of 1.4 Mw.

Tank "flatness" is now to within 10%. Apart from the usual discharges encountered for a week or so when first turned on, there has been little trouble with multipactoring and sparking.

Drift tubes are aligned transversely to within 0.005 inches from the theoretical beam axis. Longitudinal alignment is to within 0.050 inches.

The buncher is being fed from the linac tank by using a line of constant length. Phasing is obtained by moving the buncher gap assembly.

At present the following performance figures are available:

Beam output energy 19.3 Mev.

Preinjector emittance at 460 kev is π100 mm-mrad at a current of 50 to 75 ma.

Linac emittance at 19.3 Mev is π15 mm-mrad at a current output of 20 ma.

Discussion

H.B. Knowles (Yale): How much shielding is being used around the linac?

L. Smith (LRL): There is room for about 2 feet.

G.K. Green (BNL): Did the epoxy used in the drift tubes with current transformers deteriorate to any observable degree?

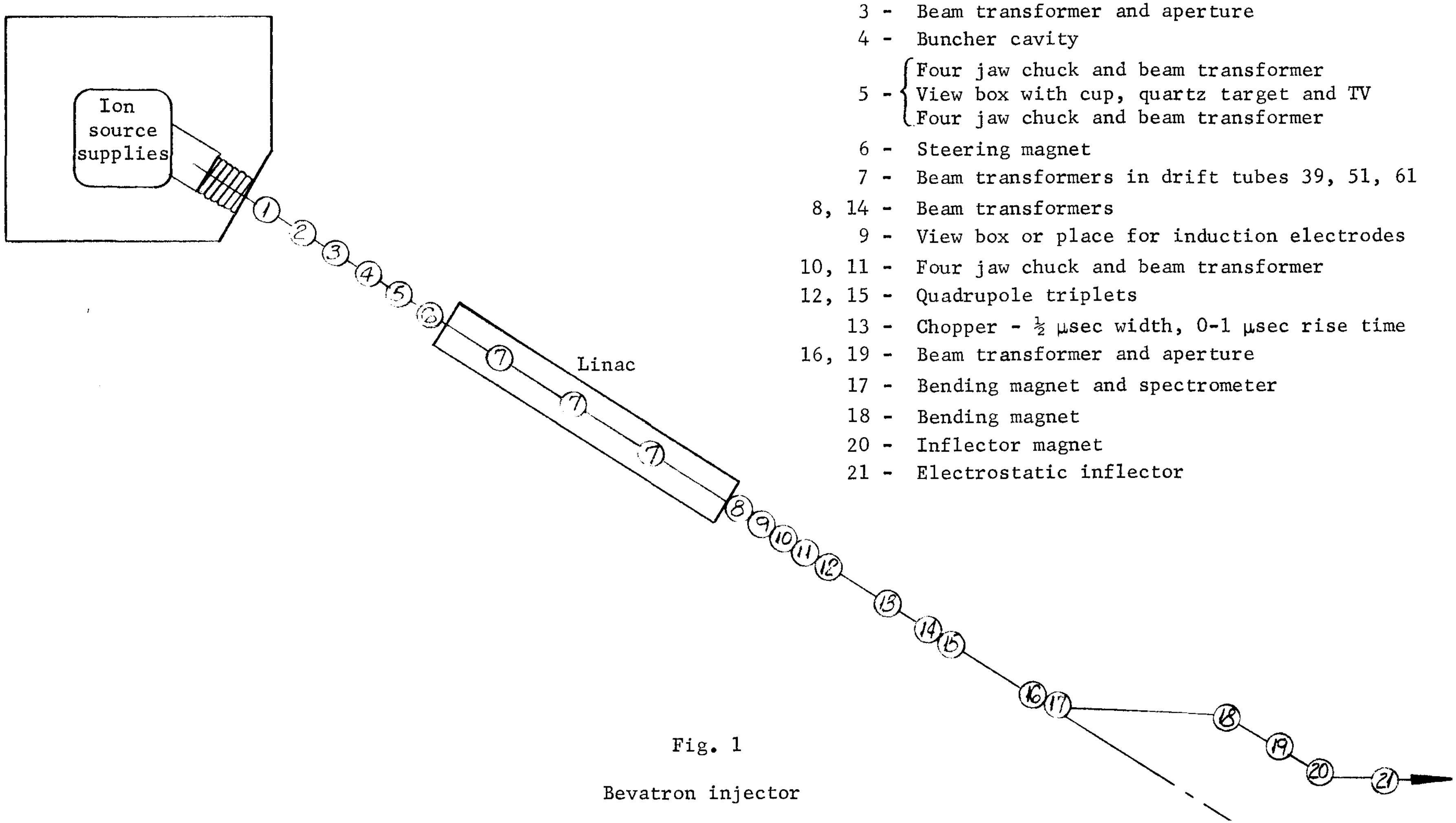
L. Smith (LRL): Up to the present time, no.

H.B. Knowles (Yale): What is the rf capture efficiency?

L. Smith (LRL): Without buncher this is 25%. With buncher an improvement of 50% to 80% over this figure is obtained. This is somewhat less than expected but might be due to slight beam misalignments.

J.P. Blewett (BNL): Are there grids in the buncher?

L. Smith (LRL): Yes.



1 - Solenoid focus coil
2 - Steering magnet
3 - Beam transformer and aperture
4 - Buncher cavity
5 - { Four jaw chuck and beam transformer
View box with cup, quartz target and TV
Four jaw chuck and beam transformer }
6 - Steering magnet
7 - Beam transformers in drift tubes 39, 51, 61
8, 14 - Beam transformers
9 - View box or place for induction electrodes
10, 11 - Four jaw chuck and beam transformer
12, 15 - Quadrupole triplets
13 - Chopper - ½ μsec width, 0-1 μsec rise time
16, 19 - Beam transformer and aperture
17 - Bending magnet and spectrometer
18 - Bending magnet
20 - Inflector magnet
21 - Electrostatic inflector

Fig. 1

Bevatron injector