Accelerator Guide of Positron Generator Linac

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Abstract

A positron generator linac was constructed for the purpose of supplying a positron beam to TRISTAN. This linac facility consists of an electron linac and a positron linac. The former is composed of a sub-harmonic buncher, a prebuncher, a buncher, a regular accelerator guide and an electric gun. Latter is composed of a regular accelerator guide. Two kinds of accelerator guides having a different length; a 2 m and a 4 m accelerator guides are developed for positron linac. This report describes a structure, production and the characteristics of these accelerator guide in detail.

Structure

Positron generator linac consists of 6 acceleration units.

1) Acceleration unit structure

Each unit is composed of a klystron, waveguide components, accelerator guides and vacuum manifolds. A output power from klystron is transmitted to an underground tunnel room through a waveguide and is divided into 2 waveguides by a divider and is fed to each accelerator guide.

A microwave power that passed an accelerator guide is finally absorbed to a dummy load. Panoramic view of a standard acceleration unit is shown in Fig. 1.

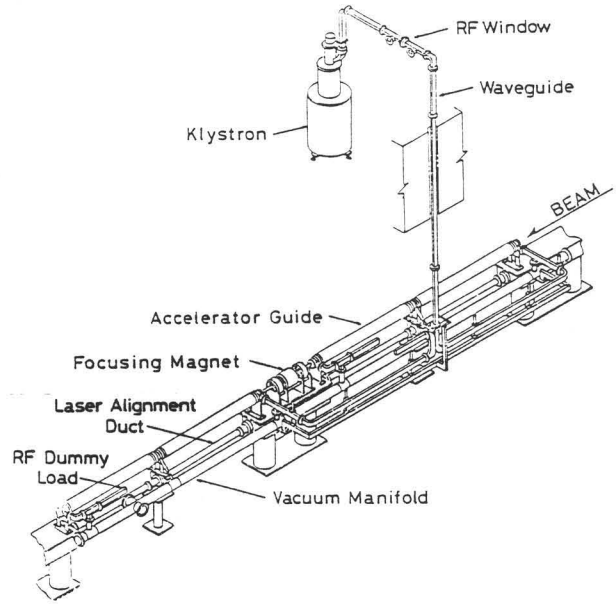

Fig. 1. Panoramic view of the standard acceleration unit.

2) Basic structure

All accelerator guides are disk loaded traveling waveguides with $2\pi/3$ phase shift. A regular accelerator guide was designed on the basic periodic structure that had 108 cavities. A hole diameter of a disk is gradually decreasing along an axis of an accelerator guide. The decreasing rate of the diameter is linear and was decided from a calculation of an energy gain required for this unit. It was designed so that an energy gain of an accelerator guide reaches to about 43MeV when a microwave power of 12.0 MW is supplied to a 4 m accelerator guide.

The disk hole diameter at an end of an accelerator guide was set to 19.7 mm . The decreasing rate of disk hole diameter in this case is 0.18mm/wavelength. Accordingly, a hole diameter of disk at an entrance of a 4m accelerator guide became 26.18 mm . The thickness of all disks was chosen to be 5 mm. Figure 2 shows the cross section of the disk.

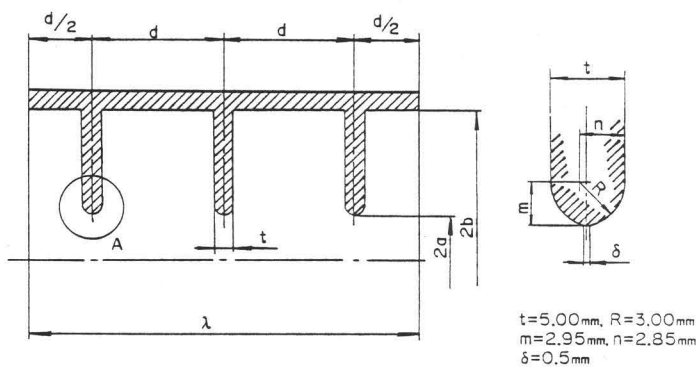

Fig. 2. Cross section of the accelerator guide.

3) 2 m accelerator guide

The length of an accelerator guide was restricted within 2 m due to a manufacturing limitation in a factory. An assembly of the accelerator guide is designed based on the periodic structure 54 cavities. One is the first half part of the basis structure and another is the second half part. These two types were used as a accelerator guides by connecting each other with a waveguide. Therefore this connected structure is equal to a 4 m accelerator guide. This outline is shown in Fig. 3. A focusing magnet and a monitor were set between 2 accelerator guides.

4) 4m accelerator guide

The 4 m accelerator guide was composed of an interface cavity and a pair of each assembly. The interface cavity has 3 periodic structures. This

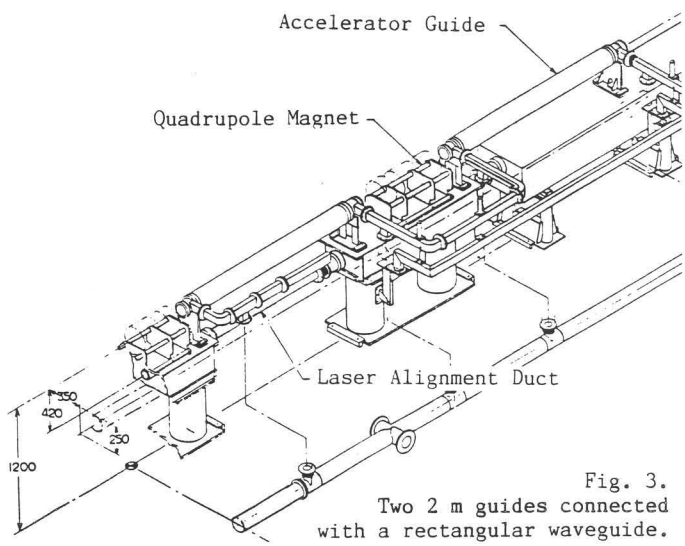

Fig. 3. Two 2 m guides connected with a rectangular waveguide.

cavity has a strong spring action toward an axis. An electric contact of a joined part was guaranteed by this spring action. In order to make an impedance matching easy at the joined part, a disk hole diameter of the interface cavity was chosen to be the same diameter. Its hole diameter of 5 mm was made to an outside wall. Each cavity has 8 holes and a whole joined part are shown in Fig. 4. The evacuation speed of the 4 m accelerator guide was increased by these holes.

5) dummy load

A new dummy load was developed for the positron generator linac. The dummy load was using SiC as a microwave absorption material. A shape of the absorption material is a horn-shaped cylinder and the inner part has a cave. The absorption material was directly cooled by the pure water passing through the inside cave. A detailed cross section of the dummy load is shown in Fig. 5. There were no serious problems about this dummy load after a year test operating.

Manufacturing

The accelerator guide was manufactured in the following procedure.

1) Material

In PF injector linac, vacuum melting copper (VMC) was used as a material. While high purity oxygen-free high conductivity copper (OFHCS) was used in a positron generator linac. The reason for this material change is as following: A casting reactor for VMC became superannuated and it was impossible to use: A refining technology was recently progressed in Japan and it is possible to get a good copper material.

The OFHCS was a refined electricity copper using the oxidizing carbon mono-oxide (CO). This special material was developed in Furukawa Electric Co. Ltd.

2) Cutting

Disks and cylinders were made of this copper material. At first they were made from a copper block and then pressed by the force of 2 tons to be deformed to the barrel shape. This hardened barrel was cut with a lathe and was processed to a cylinder again. Finally these parts were cut with a diamond bite. All cutting was carried out by using a highly precise lathe and finally the surface is finished like a mirror. Surface roughness was within 0.05 μm.

3) Assembly

Dimension of the part was inspected precisely with an air micro gauge. The part coming up to the standard is then sent to measurement.

This is carried out by using the cavity which consists of the examination part and other standard part. Deformation was determined from the resonant frequency of the cavity. The parts of disks and cylinders which passed this measurement were then arranged alternatively on a V block, and were assembled to a periodic structure. This structure conforms to a basic assembly of the accelerator guide.

This basic assembly was inspected by a microwave measurement. In other words, a number of frequency of $\pi/2$ modes of the cavity was measured in each unit cavity. This assembly was halt the bolt with a nut tightly during the measurement.

4) Electroplating

The outside of this assembly was electroplated with copper. Therefore outside of the assembly was fixed by this plating. We are calling this method as an electroforming method. A high speed electroforming method has been developed to raise a plating speed. By this development a production speed of an accelerator guide became 7 times faster. All basic assemblies of the accelerator guides were manufactured with this electroforming method. Even an accelerator guide of PF injector was manufactured with this method.

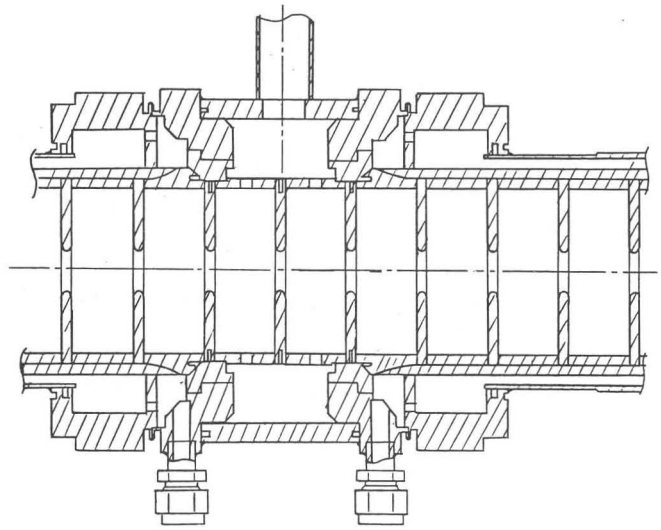

Fig. 4. Joint connecting two 2 m long accelerator guides.

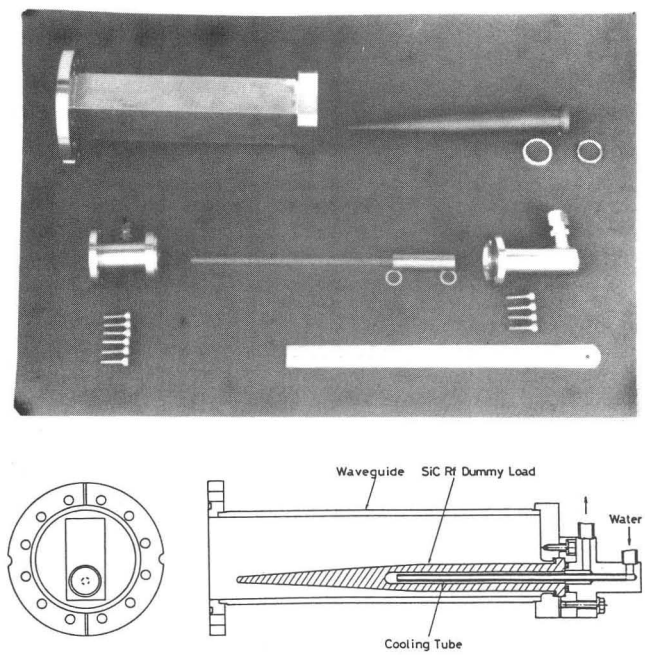

Fig. 5. Cross section of the dummy load.

5) Overall assembly

A cavity coupler was welded at the both ends of this assembly after an electroforming. To avoid heat deformation, welding was carried out by using an electron beam. Final inspection was performed with nodal shift method using a $2\pi/3$ modes. A panoramic view of a 4 m accelerator guide is shown in photograph 1.

Characteristics

Figure 6 shows the calculated value of the electric strength distribution on the central axis of an accelerator guide when a microwave power of 12MW is supplied to a 4 m accelerator guide. Figure 7 shows the relation between a hole diameter of disk and an inside diameter of cylinder along an accelerator guide.

An energy spectrum of a positron linac measured in a test operation is shown in Fig. 8. Characteristics of an accelerator guide is shown in Table 1.

Table 1 Characteristics of the Accelerator Guide

Operating frequency (MHz)	2856
Number of long accelerator guide (3.999 m)	9
Number of short accelerator guide (1.982 m)	5
Number of cavity per long accelerator guide	110
Number of cavity per short accelerator guide	54
Phase shift angle /cavity	$2\pi/3$
Field attenuation	0.685
Shunt impedance (M-ohm/m)	53.67-60.25
Group velocity (Vg/C)	0.0227-0.0084
Q-factor	13500-14200
Filling time (s)	0.960
Aperture of iris 2a (cm)	2.612-1.970
Aperture of cylinder 2b (cm)	8.333-9.189
Thickness of disk t (cm)	0.500
Output power/klystron (MW)	25
Average energy gain (MeV/m)	11.3

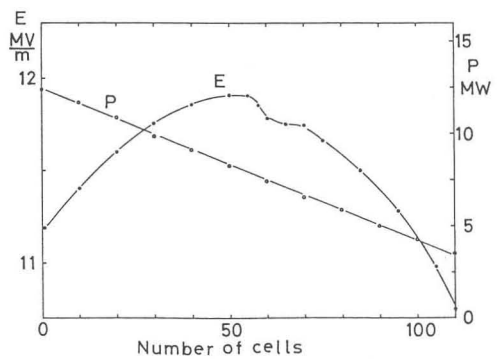

Fig. 6. Electric field strength on the central axis of the 4 m accelerator guide. Input RF power is 12MW.

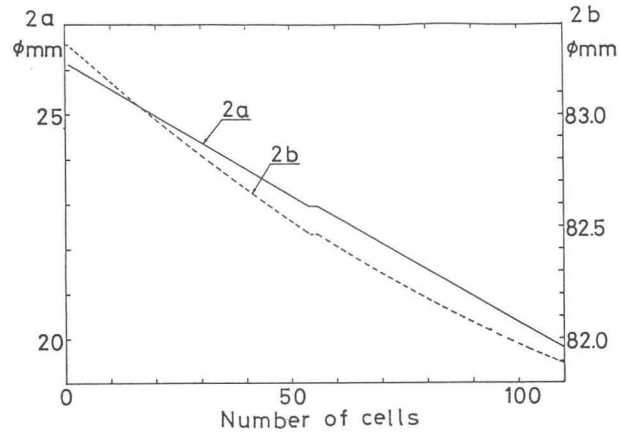

Fig. 7. Relation between the hole diameter of the disk and the inner diameter of the cylinder along the accelerator guide.

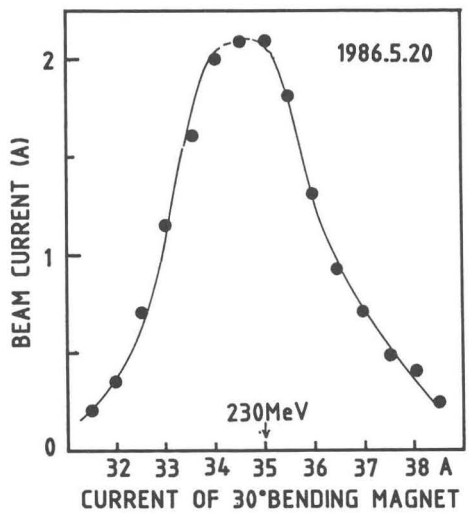

Fig. 8. Energy spectrum of electrons accelerated by the positron linac.