DEVELOPMENT OF HIGH GRADIENT ACCELERATING CAVITIES

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§1 Introduction

A requisition for high energy accelerator from high energy physicists have been increased over ten times per ten years in a range of energies, they have proposed such some super big accelerators as next future projects, and those scales have been escalating year after year and expanding to several tens Tev for the hadron collider and also to several TeV for the lepton collider. 1)

It is impossible for some technical difficulties to build a circular ring for the lepton collider with TeV energy. One of the difficulties is for such a syncrotron radiation as energy loss of a circulating particle which is exponentially increasing in proportion to 4th power of the particle's energy, and if the energy of circulating particles would be increased near by the TeV range, then their energy loss per a circular into the collider will become the same order with that of their own. On account of this difficulty, it is assumed that a lepton collider for high energy shall become such an accelerator as a linac without synchrotron radiation loss.

A workshop for future plans was held in Octber 1982 and epochal technologies for new accelerators were discussed. In order to obtain high accelerating gradients, use of either intense laser power or extremely high power microwaves is considered, and Japanese reseachers have being studying both theoretically and exerimentally along the latter since November 1982.

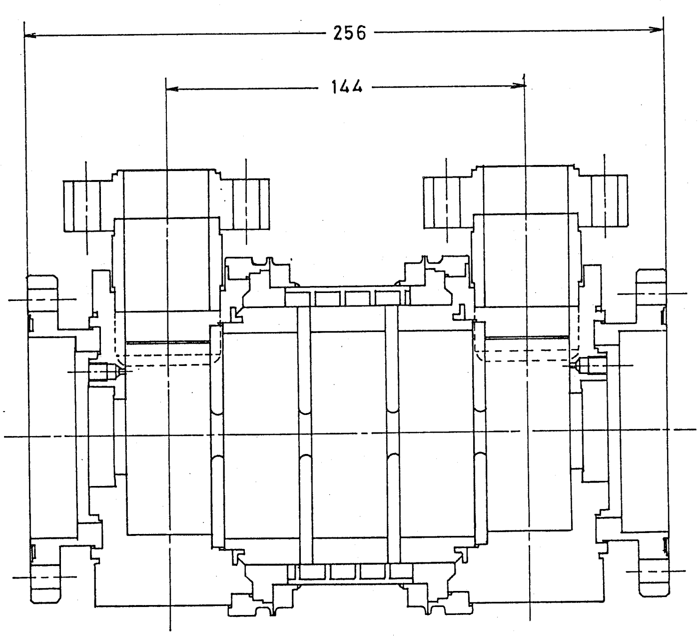

Fig. 1. Crossection view of the disk loaded guide for investigating of discharge phnomena.

Owing to the realization of such a proposal as a TeV linear collider for a next future project, it will be requisite for the accelerator to make oneself high gradient and for its constraction to reduce the ratio of cost per performance to a minimum. And also, it is necessary for a progressive project to eagerly promote research and development of new accelerator technologies.

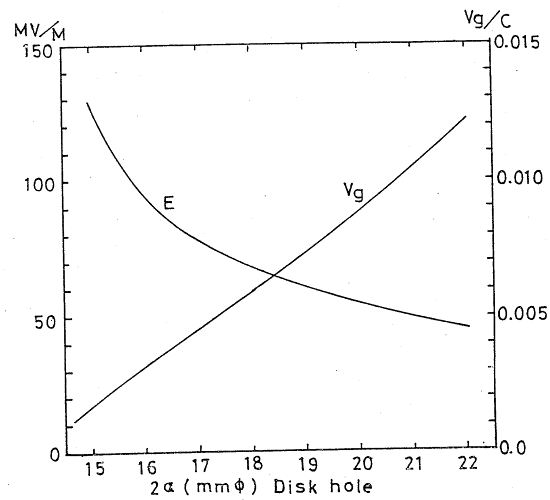

Fig. 2. Variation of electric field strength and group velocity as a function of disk hole diameter 2a. The field strength with flowing power of 100 MW peak.

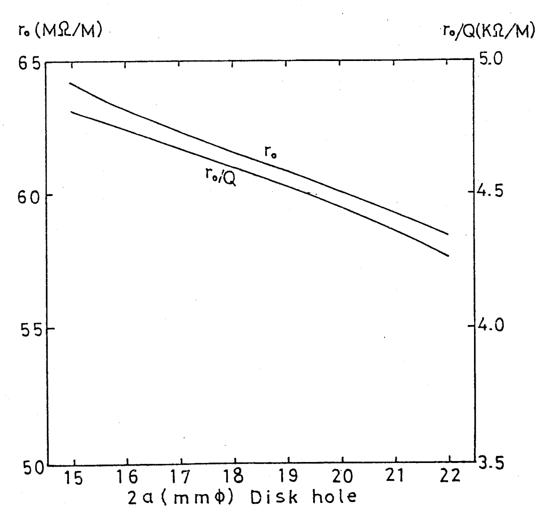

Fig. 3. Variation of shunt impedance and R0/Q as a function ofdisk hole diameter 2a. 2

However the linac is an expensive accelerator, if the 1 TeV lepton linear collider is constructed with the present accelerator technologies, then it's the length will be estemated to be more than 100 KM and its construction budget will be also estemated at the enormous expenses over 2 trillion yens. 2)

$ 2 Testing guide

It is important for increasing a reliability for the high gradient accelerator to study how to induce high gradient electric field and how to reduce electric discharge.

In order to investigations of some discharge phnomena, a fabrication of a testing guide was proposed.

Such a guide was designed as a small disk-loaded guide, and it will be installed into a resonant ring and taken various examinations as discharges genarated by the induced high gradient inside of one's own.

The guide is composed of 3 cavities and two coupling cavities, the crossection view of its structure shows in detail in Fig. 1.

Disk hole diameter of the guide is closely related with the field strength within the guide. This relation as shown in Fig. 2 was obtained from an extrapolation of some experimental data. Fig. 2 and 3 also show the extrapolated characteristics (field gradient E, group velocity Vg, shunt impedance R0 for the fundamental space harmonics, and R0/Q) for variable diamter of disk holes.

All disk holes of the guide was decided on a diameter of 16 mm. If RF power of 100 MW would be flowing through the disk holes, then their accelerating field gradient will be at about 100 MV/M by this decision.

Characteristics for the testing guide gives in Table 1.

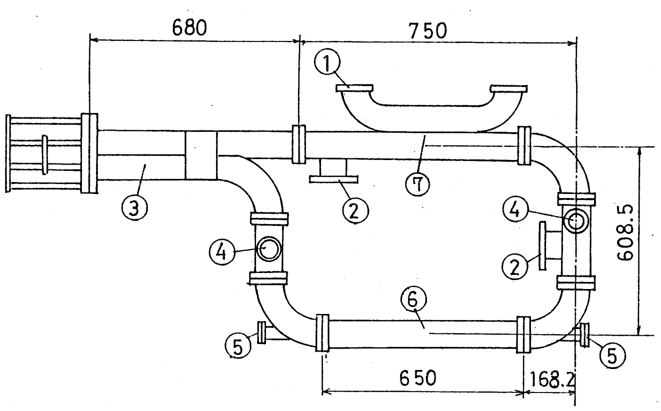

Fig. 4. Layout of resonant ring for investegation of discharge phenomina.
1 Input port. 2 Exhaust ports. 3 Phase shifter.
4 Directional couplers. 5 Viewing ports.
6 Testing device. 7 10 DB coupler.

The resonant ring was designed by RF group's crew for researching and developing of a RF ceramic window for high power and is under the installation. A coupling coefficent and insertion loss of the ring were set up to be respectivily at about -10 DB and -0.3 DB. If the RF power of 25 MW would be supplied from a klystron to the ring, the flowing power into the ring without loading will reachs at 100 MW.

The resonant ring layout gives in Fig. 4.

Table 1. Characteristics for the testing guide.

Operating frequency (MHz)	2856
Number of cavities	3
Length of accelerating guide (cm)	10.5
Phase shift per cavity	2 pi/3
Shunt impedance for the fundamental space harmonics (M-Ohm/m)	63.2
Q factor	13330
Attenuation parameter (Neper/m)	0.7063
Group velocity (Vg/C)	0.0032
Filling time (ns)	110.1
Diameter of disk hole 2a (cm)	1.60
Average electric field strength for flowing power of 100 MW (MV/m)	92.18

$ 3 Example of special accelerator guide

The linear collider is in need of enormous expense not only for its costruction but also for its operation. It positively needs to progress researchs and developments for such an accelerator as completely exceeds the present accelerators at both of the accelerating field strength and the power loss reduction. 3,4)

In order to increase the luminosity of linear collider, either a single beam or micropulse beam of relativistic particles will be accelerated into the collider.

The special accelerator guide was conceived as candidate for linear collider application which overcame the described difficulties and made the best use of the special condition as the extreme short pulse beam.

If the accelerating particles are relativistic and it's duration time is extremely short, and if the flowing RF power is very swiftly transmitted into the accelerator guide, the duration time of flowing power will be permitted to shorten as shown in Fig. 5. However, the RF duration time dt must continue for more long time than the factor L(1/Vg-1/C), where L is the length of the accelerator guide, C and Vg are light velocity and group velocity respectively.

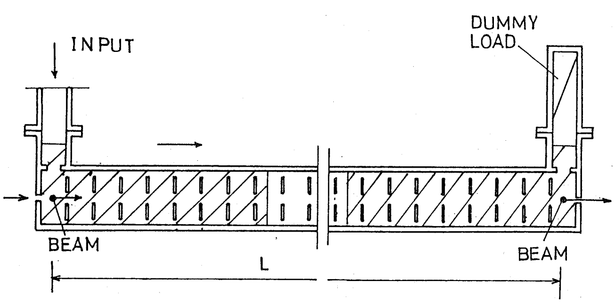

Fig. 5. Crossection view of an accelerator guide showing pulse duration of flowing power with single micropulse particles.

If such a guide is excited by the supreme flowing power, it is possible that a single micropulses of relativistic particles will be accelerated to very high energy at very high acceleration rates with a minimum investment in transmmited power. A developement of super RF power source, LASERTRON, is also advanced with rapid strides. 5)

A developement for an accelerating structure with large group velocity has been promoted with the progressive improvement of the special disk and washer accelerator guide for TRISTAN project. 6)

The alternative accelerator guide has been designed for an economizing linear collider by Noguchi recently.

This guide as shown in Fig. 6 was arranged to have a structure like the disk-loaded form, and the accelerating mode TM 01 was calculated at 1.5 GHz with PI/2 mode. The calculated Brillouin diagram shows from a fundamental mode to highr order modes in Fig. 7. Table 2 gives specifications of scaling paramers based on above data. The guide is under the installation for examining effect of stems.

Table 2

Operation frequency (MHz)	2856
Q factor	24176
shunt impedance for	
fundamental space harmonic (M Ohm/M)	61.2
(R/Q)	2531
Diameter of desk hole 2a (CM)	2.33
Accelerating mode	2PI/3
Group velocity (Vg/C)	0.4
Ep/Eacc	3.38
Attenuation (nep/m)	0.00309

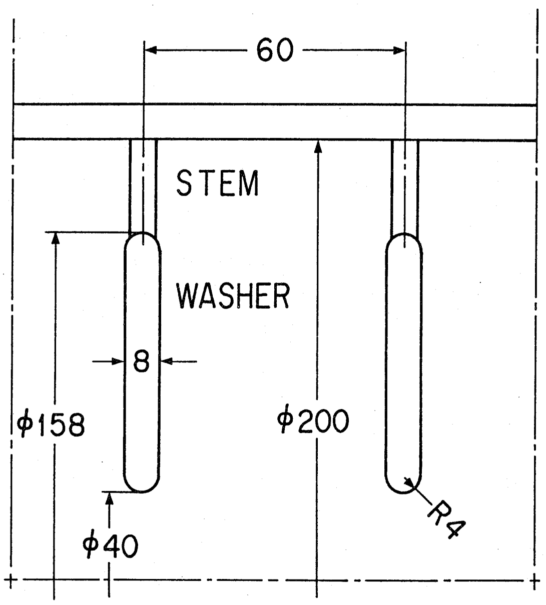

Fig. 6. A quadrant crossection view of accelerator guide structure for large groupe velocity.

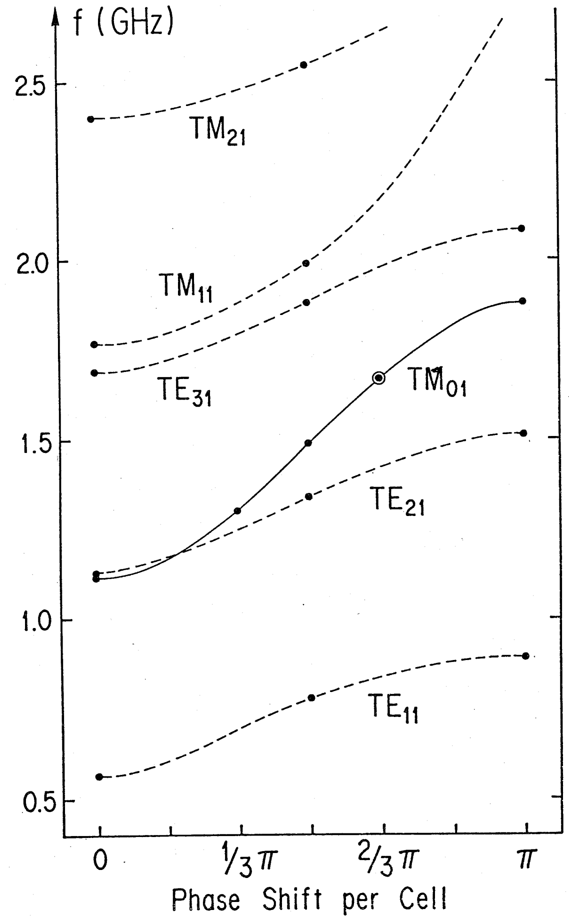

Fig. 7. Brillouin diagram for the disk loaded accelerator guide with large group velocity.

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