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Liquid Type Variable Compensator for Heavy Charged Particle Therapy and for Conformal Photon Therapy

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INTRODUCTION

Heavy charged particle therapy such as proton-beam and heavy ion-beam therapy necessitates range compensator called bolus to adjust heavy charged particle energy according to the tumor depth at the location.
Bolus is a plate with uneven thickness, and created for each patient's irradiation port from polymers by machining processes(1).

A solid type variable compensator using variable strips of solid applying filtered-back-projection technique has been proposed previously by one of the authors(2). The variable compensator is not yet put to use mainly due to its wide area necessitated.
A liquid type variable compensator is proposed in this work which necessitates less area compared to solid type variable compensator.
In conformal photon therapy, the intensity of photons on the location should be made uneven in the area for each irradiation angle. One of the solution may be ultra high energy narrow photon beam scanning technique(3). Another is one dimensional intensity modulation employed in PEACOCK(4). The third is moving multi-leaf collimator in which wide beam is collimated narrowly and each spot is irradiated by designated dose(5). In these method, organ motion by respiration etc., is not sufficiently compensated.

METHOD and RESULTS

Elastic membrane containing suitable liquid should be deformed by many strong threads such as of polyimide. The membrane should be resistant to radiation such as ethylene-propylene rubber. The thickness of the liquid layar that radiation beam should pass is made uneven depending on the location. Charged-particle-beam lose the energy depending on the thickness, while photon-beam lose the intensity depending on the thickness.

Fig.1 shows the structure of traditional compensator for proton-beam or heavy ion-beam therapy, while Fig.2 shows schematically the structure of the liquid type variable compensator.

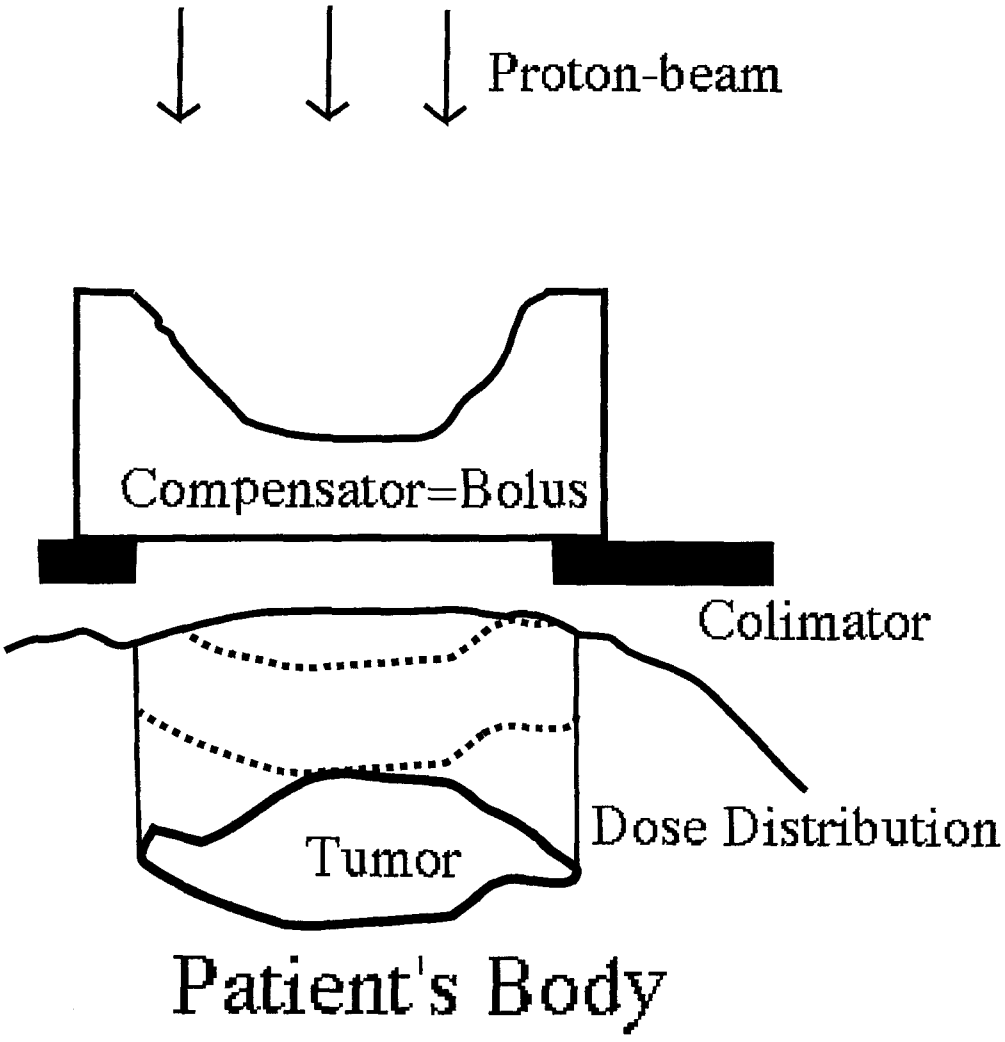

Fig.1 Application of compensator in proton beam therapy: In order to adjust the energy of protons depending on the local tumor depth a compensator named Bolus is placed at the upstream of patient.

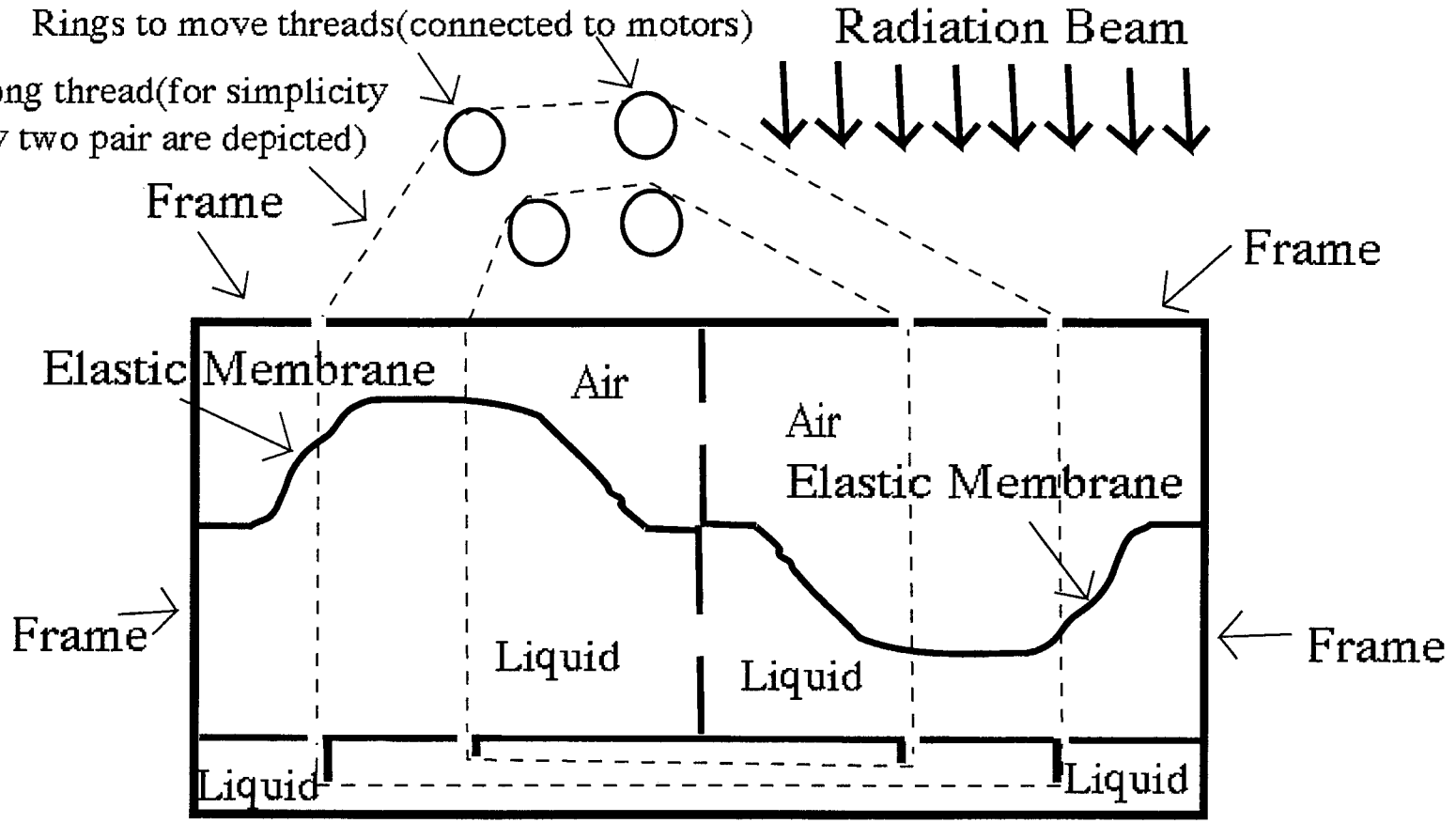

Fig.2 Schematic view of liquid type variable compensator:Elastic membrane containing liquid is moved by strong threads and the shape of liquid is changed resulting change of liquid layer that radiation must pass. The right hand constitutes the compensator while the left hand side is to keep the volume of liquid container constant.

Liquid type variable compensator utilizing silicon oil seems to suitable for charged particle-beam, while that utilizing mercury or heavy metal salt solution seems to be useful for photons.
The penetration of thread through elastic membrane should be avoided to prevent liquid leakage. Instead connectors sealed inside the membrane and protruding small connecting rings from the membrane should be connected to threads at each side of the membrane.

DISCUSSION

Operation of variable compensator should be monitored by many modalities for quality assurance of the treatment. One of the modalities seems to be ultrasound-echo-technique applied to the unirradiated left part of the variable compensator in the liquid part from lateral side and from bottom side of the liquid container(Fig.2). Another modality may also be ultrasound-echo-technique in the air. Other possibilities may be laser beam reflection technique from above (in the air;Fig.2) or X-ray transmission measurement. When this variable compensator is to be installed in gantories, these modalities for quality assurance seem to be indispensable, as the gravity force changes its direction.

CONCLUSION

A liquid type variable compensator is proposed for charged particle therapy and conformal photon therapy. For quality assurance of the treatment the development of modalities for monitoring the shape of the liquid surface is emphasized.

(References)

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