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AN EASY WAY OF IMPROVING THE FLATNESS OF THE RADIATION FROM A LINEAR ACCELERATOR

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Because of the predominantly forward emission of rays from the target of linear accelerators operating in the megavoltage region, it is essential that flattening filters be inserted in the beam in order to provide a therapeutically useful beam of radiation. The degree of flattening necessary is, to some extent, a matter of opinion, but it would be sensible that the flatness should be at least as good as that of a Cobalt beam and preferably better. The flattening filters are usually made of heavy metal, and are designed from a knowledge of the emission pattern of the target and the absorption characteristics of the filter material used.

It very often happens that the characteristics of the beam as measured differ from those expected from the design, and it is common for the flattening filter to be altered experimentally (by removing metal at the appropriate places) in order to produce the desired degree of flatness. This may be a difficult procedure as it involves removal of the flattener from the generator, a machining procedure to remove small amounts of metal from a complex shape, and subsequent replacement of the flattener in exactly the same position as before.

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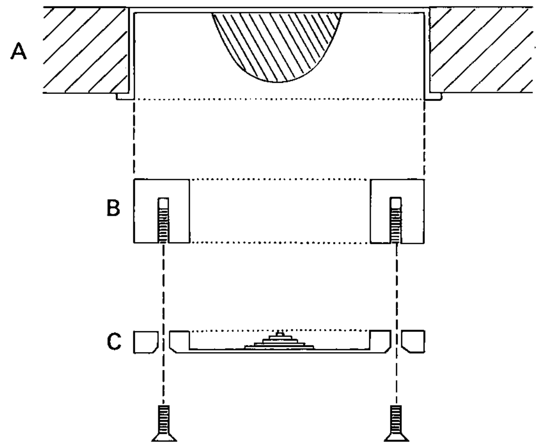

Fig. 1. Mounting of auxiliary filter. A) Turret with flattening filter. B) Split ring. C) Auxiliary filter.

The linear accelerator in use at this hospital is the Mevatron 8 Model, made by Applied Radiation Corporation. This machine is capable of operation in 1 MeV steps from 3 MeV to 10 MeV. Different flattening filters are available for each energy; the flatteners are made up in the form of domes, mounted in cups fitted into holes in a rotating turret, the appropriate flattener being automatically positioned by rotation of the turret on selecting the desired energy. At present, we have used our machine only at 8 MeV.

The manufacturers' specification for this machine called for a 'flatness of $\pm$ 2.5 per cent over a 25 cm square field and preferably over a 30 cm square field'. In our case, the beam was found to be flat to $\pm$ 3.5 per cent over a 30 cm square field.

Unfortunately, most of this variation occurred in the middle portion of the field, resulting in the 95 per cent decrement line lying too close to the central axis of the beam, and the 90 per cent decrement line being near the field edge, giving rise to undesirable curvature of the isodose curves. The obvious way to correct this defect would have been to add extra metal to the center of the beam flattener. In our machine, it was difficult to alter the flattener for the following reasons: (1) The flattener is made of tungsten alloy; small changes in dimensions are difficult to make, especially since the flattener is mounted in a cup. (2) It was deemed undesirable to remove the flattener from the machine to effect the necessary alterations, as this was mechanically difficult; it would have proved impossible to replace the flattener in exactly the same position, as the cup was a loose fit in the turret hole and shims had been found necessary in order to position the flattener optimally.

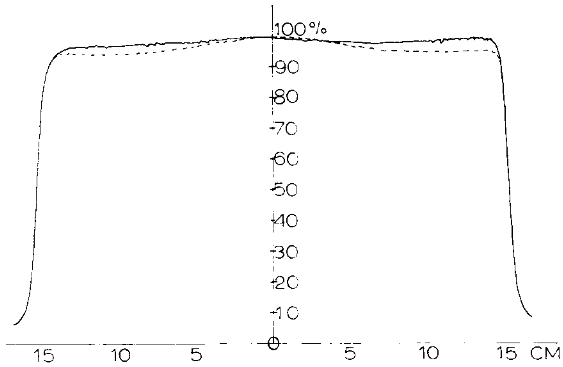

Fig. 2. Beam profiles before (- - -) and after (———) auxiliary filter has been fitted.

For this reason, we made up an auxiliary flattening filter from thin brass sheets which were available in the department. No attempt was made to provide a smooth correction, but the auxiliary flattener was made up in steps, by considering the intensity changes desirable over chosen areas of the beam, and the thickness of brass necessary to produce these changes. In our machine, mounting of this auxiliary flattener was difficult. The base of the main filter was inaccessible, and therefore the auxiliary filter had to be placed on the domed side. There was less than 3 mm space available between the top of the dome and the surface of the turret, and little clearance was available between the turret surface and other components in the head of the machine, and it was therefore essential that the auxiliary flattener should be contained entirely within the main flattener cup. Great difficulty was experienced in fixing this auxiliary, as there was no space for screws and no adhesive suitable for use in such a high-radiation environment was known to us. We therefore made a split ring, which could be fitted into the cup and expanded so as to grip the inside of the cup by driving a screw down a tapered tapped hole in the split. The auxiliary filter was then mounted on a plate which could be screwed to the ring. The arrangement is shown in Fig. 1. Other mounting methods could doubtless be designed to suit other machines.

In practice, thin sheets were cut to the appropriate size, and the filter made up by sticking these sheets together with cellotape. The experimental filter could then be mounted easily, and tested by ionization chamber measurements in a water phantom. When the flatness was deemed satisfactory, these sheets were replaced by a plate turned to the experimentally-determined profile. As it happened, the first attempt at correction was thought satisfactory; the technique proved very easy experimentally, and any changes necessary could be made and tested quickly. The improvement produced by this technique is shown in Fig. 2, consisting of diagrams of the scans at 2 cm depth before and after fitting of the auxiliary flattener, and it can be seen the 95 per cent decrement line has been moved out very nearly to the edge of the beam. The whole procedure took less than one afternoon's work and could easily be extended to any desired degree of accuracy. The auxiliary flattener has been in position now for nearly two years; periodic inspection has revealed no slackening of the expander screw, and there appears to be no danger of the assembly falling out.

Acknowledgement

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SUMMARY

A simple procedure is described whereby the flatness of the radiation from a linear accelerator may be improved without difficult operations on the flattening filter. This is done by means of an auxiliary (or 'shimming' filter). Alterations to the auxiliary filter are easily made and checked experimentally; the technique could be applied to any other energy than the one investigated.

ZUSAMMENFASSUNG

Ein einfaches Verfahren wird beschrieben, mit dem die Feldhomogenität der Strahlung von einem Linearaccelerator ohne schwierige Operationen am Ausgleichsfilter verbessert werden kann. Das geschieht durch einen Hilfs- oder „Auffüll-" Filter. Änderungen am Hilfsfilter sind einfach durchgeführt und experimentell überprüft; diese Technik konnte für jede andere Energie verwendet werden, nachdem die eine untersucht worden war.

RÉSUMÉ

Les auteurs décrivent une technique simple permettant d'améliorer la planéité de la radiation d'un accélérateur linéaire sans interventions difficiles sur le filtre de planéité. Celui-ci est réalisé au moyen d'un filtre additionnel (ou « shimming » filter). Il est facile de modifier le filtre additionnel et de contrôler expérimentalement ces modifications; cette technique pourrait être appliquée à toute autre forme d'énergie que celle d'un accélérateur linéaire.