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A DEVICE FOR PLACEMENT OF COBALT-60
WITHIN RIGID OR FLEXIBLE TUBING FOR
USE IN CANCER THERAPY*

*
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It has been pointed out that radioactive cobalt-60 has properties¹

¹
NATIONAL BUREAU OF STANDARDS CIRCULAR 499 and Supplements

which make it peculiarly suited for use in the treatment of malignant
tumors by radiation therapy methods². A program was instituted in

²
MAYNEORD, W.V. Some applications of Nuclear Physics to Medicine.
BRIT. J. RADIOLOG., 1950, Supp. 2.
MYERS, W.G., Applications of Artificially Radioactive Isotopes in
Therapy I. Cobalt-60. AM.J.ROENTGENOL. & RAD. THERAPY, 60, 816-823,
1948.

the department of radiology at The Ohio State University Medical Center
in October 1948 to explore these suggested advantages and to attempt an
evaluation of the usefulness of cobalt-60 in clinical radiation therapy.

The unfolding of each new area of clinical application³ increased

³
MORTON, J.L., BARNES, A.C., CALLENDINE, G.W.Jr, MYERS, W.G. Individual-
ized Interstitial Irradiation of Cancer of the Uterine Cervix Using
Cobalt-60 in Needles, Inserted Through a Lucite Template. AM.J.ROENTGENOL.
& RAD.THERAPY, 65, 5, 1951.

MORTON, J.L., CALLENDINE, G.W.Jr., MYERS, W.G. Radioactive Cobalt-60 in
Plastic Tubing for Interstitial Radiation Therapy. RADIOLOGY, 56, 4,
553-59, 1951.

MESCHAN, I., EDWARDS, R.R., ROSENBAUM, P.J. Practical Physical Aspects in
Use of Radioactive Cobalt-60 as Radium Substitute. AM.J.ROENTGENOL. &
RAD. THERAPY, 65, 225-64, 1951.

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the quantities of activity being used regularly. This produced an associated need for satisfactory physical devices to aid in simplification of clinical procedures and also to assure safety to all personnel handling the radioactive material.

It has been necessary to supplement the commercially available equipment with special devices of our own design. This paper is a report of the present state of development of one of the devices designed to meet our needs.

To treat tumors as effectively as possible with radiation therapy, the irradiating agent (in our case cobalt-60) should be available in many different forms so that individualization of treatment may be achieved. For such types of irradiation techniques as interstitial implantations and surface mold applicators, linear sources of irradiating material are desirable in both rigid and flexible forms to meet variations in the structural aspects of tumor location, type, size, etc.

The mathematical theories upon which interstitial and mold radiation therapy are based¹ require variations in intensity of activity per

¹JAFHA, E.M. The Use of Co-60 in Gamma Ray Therapy. AM.J.ROENTGENOL. & RAD. THERAPY AND NUCLEAR MEDICINE. 69, 3, March 1953; and his references.

unit length of the linear sources when uniform dosage over a given region is desired. These variations may take the form of differences in linear intensities for different line sources. Also, variations are often indicated in the linear intensity along any one line source.

Any single linear intensity pattern may be accomplished by spacing small standard radioactive units from zero to several millimeters

apart by means of inert spacers. The spacers are necessary because the calculated spacing of the active units must remain intact throughout the period of irradiation.

These requirements have been fulfilled by using radioactive cobalt-60 in the form of wire stock cut into short standard lengths, with spacers of inert aluminum wire stock in varying lengths. The standard cobalt-60 "cartridges" have a 0.0508-cm (0.020-in.) diameter and a 0.300-cm (0.118-in.) length. Cartridges and spacers are inserted into either rigid or flexible tubing of 0.030-in. i.d. by 0.050-in. o.d.

Four criteria were established to govern the design of any method for fabricating the radioactive linear sources.

1. Fabrication time should be as short as possible. At the Ohio State University Medical Center emphasis is placed on individualization of clinical technique to each tumor encountered. Under this philosophy individually fabricated linear sources are necessary for each tumor. The fabrication time for each linear source becomes significant as the number of tumors treated increases.
2. Operation should be simple.
3. Exposure of the operator should be minimal. Exposure tolerances for personnel handling radioactive materials are 300-mr/wk total body radiation and 1000-mr/wk radiation to the hands⁵.

⁵ NATIONAL BUREAU OF STANDARDS. Safe Handling of Radioactive Isotopes, Handbook 42, September 1949.

An operator should encounter regular weekly exposures only at much lower levels than the maximum. Also, short-time exposure

rates should be low.

4. Possible jamming of materials should be easily and safely cleared. The possibility of radioactive material becoming lodged in the device and jamming the operation must be considered. The device must be so constructed that any jamming can be cleared easily and without overexposure to the operator.

Cobalt-60 disintegrates by beta particle emission (0.3-Mev) followed closely by two photons (1.17-Mev and 1.33-Mev)⁶. To satisfy

⁶ NATIONAL BUREAU OF STANDARDS CIRCULAR 499 and Supplements.

requirement three, sufficient distance and/or absorbing material is necessary between the location of the activity and the operator to reduce his irradiation to safe levels. At the levels of activity encountered (100-rhm to 500-rhm^{*}) it is advisable to utilize both

^{*} Dosage rate in roentgens per hour at a distance of 1-cm from a point source of radioactivity.

precautions.

Different methods of loading small cylinders into tubing have been studied. As a result of these studies a device utilizing a semi-automatic ramrod loading technique was developed. The device is shown in Figures 1 and 2. This "loader" is positioned in an indirect-vision work center. All controls are located outside lead protecting barriers.

Figure 3 is an assembly drawing of that section of the loader into which the Co-60 cartridges and spacers are positioned before insertion into the tubing. This section consists of a rod and sleeve assembly. In one side of the rod a small slot 0.027-in. wide is carefully milled to a depth of 0.026-in. This rod is fastened rigidly at one end by a

mounting bracket. To the other end of the rod is attached a cylinder head.

Concentric with the slotted rod is a cylinder in which is cut a V-shaped trough. This cylinder rides in two bushings and is free to turn on the rod. It is rotated by a worm gear and rack with appropriate bevel gears to facilitate operation of the control mechanism from outside the lead shield.

The cylinder trough can be lined up directly over the slot in the rod. When in this "slot-open" position, small cylinders dropped into the trough fall into the slot. Changing the relative positions of the trough and slot, by rotating the cylinder slightly, covers the top of the slot and effectively produces a tube 0.027-in. wide by 0.026-in. deep. Cartridges and spacers in the slot in this "slot-closed" position can be rammed from the slot without changing their relative positions.

Into the cylinder head (Figure 3) a 0.027-in. diameter hole is drilled. This hole aligns axially with the covered slot in the rod. Concentric with this hole is a 0.053-in. diameter hole drilled to a depth of 0.5-cm from the open end, thus creating a shoulder against which the tubing to be filled is positioned in a slotted cradle.

After the desired "load" consisting of Co-60 cylinders and inert spacers is positioned in the slot, and the correct tubing is placed against the cylinder head shoulder, the load is rammed into position in the tubing. The mechanism shown in Figure 4 facilitates this operation. This ramrod consists of a length of stainless steel wire of 0.026-in. diameter with supporting tubing to prevent buckling, and gearing to control its motion.

The slotted cradle is provided for holding the tubing while loading (Figure 5). The bottom of the slot is level with the bottom

of the 0.053-in. hole in the open end of the cylinder head. The cradle is in two sections, one fixed and the other pivoting at the cylinder head on two pivoting screws.

The pivoting is used to bend a 0.5-m long elbow onto the rigid tubing after loading (Figure 5-A). The end of the tubing away from the cylinder head is closed before loading, so the elbow also functions to seal the "load" into the tubing. The movable section of the cradle is operated from outside a lead protecting barrier by appropriate gearing.

When loading into flexible tubing, the cradle slot is covered by a Lucite plate (Figure 5-B). To retain the load in the tubing, one end is sealed before loading. After the load is rammed into position through the open end, the tubing is sealed behind the load with a warm soldering iron applied under moderate pressure.

After loading more than 5000 rigid and/or flexible linear sources over a period of two years, it is possible to study the degree of achievement of the criteria set up to govern the design of the device.

1. Rapidity of loading. Rigid aluminum needles are loaded at the rate of 18 to 24 per hour; nylon "threads" at the rate of 12 to 16 per hour.
2. Simplicity of operation. After 8 to 16 hours practice, a technician may operate the device at the above rate.
3. Exposure of operator. When the loader is used in conjunction with an indirect vision work center and an electromagnetic pickup, the exposure of the operator should never exceed 25-mr/day total body radiation in a 40-hour week of continuous loading. The hands should not receive more than 50-mr/day for the same period. These limits are well within the accepted tolerances of 300-mr/wk total body and 1000-mr/wk to the hands.

4. Reliability of operation. Jamming has occurred infrequently.

When it has occurred, it was possible to clear the trouble completely without resorting to direct vision or incurring overexposure.

SUMMARY:

A device for accurately positioning radioactive cobalt-60 cylinders in rigid or flexible tubing is described. The authors wish to thank Mr. Carl McWhirt and Mr. Henry Stephan for their technical advice and skill in translating the design into a satisfactory working device.

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Figure 1

FRONT VIEW

0 1 2 INCHES
SCALE

15

FIGURE 3

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FIGURE 4

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(A). CRADLE AS USED FOR LOADING AND BENDING RIGID TUBING.

(B). CRADLE AS USED FOR LOADING AND SEALING FLEXIBLE TUBING.

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