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Subcommittee
No. 2

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MEETING OF SUBCOMMITTEE NO. 2, SMALL SOURCE DESIGN

June 12, 1954

Members Present: Dr. Henry Jaffe - University of Southern California
Dr. James F. Kelly, Jr. - Crieghton University
Mr. John H. Tolan - Emory University
(Representing Dr. H. Stephen Weens)
Dr. Marshall Brucer - ORINS Medical Division
Mr. J. Howard Harmon - ORINS Medical Division

Members Absent: Dr. John A. Isherwood - Baylor University Graduate School
Dr. Harold W. Lewis - Duke University

CURRENT STATUS OF HECTOCURIE MACHINES:

The Subcommittee reviewed the current status of the hectocurie teletherapy units and was informed that the design recommended by the Teletherapy Evaluation Board is now on a production basis. The Subcommittee was also informed that the Picker X-ray Corporation has a design under construction, and that the Westinghouse Company is considering the design problems of the hectocurie unit.

Dr. Brucer stated that he had been informed that the United States Atomic Energy Commission had approved research grants for four TEB member universities.

The Subcommittee reviewed briefly the current availability of high and low specific activity cobalt 60 for teletherapy sources. This material is now being published as a quarterly report.

The current quoted sales prices of hectocurie units were compared to the construction cost of units being built by individuals.

RELATIONSHIPS OF FACTORS INVOLVED IN THE DESIGN OF LOW CURIAGE UNITS:

The Subcommittee discussed the increasing interest in very low curiage units in 5 to 300 curie range. A preliminary chart was shown to give the relationships of factors involved in the construction of low curiage units. This chart is not ready for publication but will be presented at a joint meeting to be held in Rockford, Illinois on July 22.

DESIGN CRITERIA FOR LOW CURIAGE UNITS:

The Chairman reviewed the possibility of using multiple sources in opposing positions. Two opposing units may be supported in opposite positions on a "C" frame, or multiple units may be suspended on ring supports. The "C" and ring supports may, or may not, be designed for rotational therapy.

The Subcommittee reviewed the standard capsule, which was designed for sources in the hectocurie range. It was agreed that another capsule should be designed for sources in the curie and multicurie ranges. The necessity for a modified design for very low curiage units was emphasized when the standard source capsule was scaled onto the diameter of the shielding required for very low curiage units.

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The Subcommittee agreed that the design criteria for curie and multi-curie units should follow, in general, the criteria established for the hecto-curie unit, with the addition of a light localizer. A selection was made of the ranges to be emphasized to manufacturers.

COST OF COBALT 60 FOR TELETHERAPY SOURCES:

Dr. Brucer discussed the cost of cobalt 60 for hectocurie and kilocurie teletherapy units, and briefly reviewed the cost analysis which was included in the minutes of the meeting of the Third Industrial Conference on Teletherapy. The minutes of this meeting have been previously sent to all TEB members.

RECOMMENDATIONS FOR FUTURE PROGRAM OF SUBCOMMITTEE NO. 2:

On a motion by Dr. Jaffe, seconded by Dr. Kelly, the Subcommittee recommended the building of three pilot models in the range of 10, 40, and 150 curies; the initial effort to be an engineering study to determine that the machines will not exceed an estimated price in the range of practicability. It was agreed that other isotope sources should be included in the study. Since cesium 137 is still a few years off, europium 152-154 will be emphasized.

J. Howard Harmon

J. Howard Harmon
Executive Secretary

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MINUTES OF THE AUGUST 30 MEETING OF SUBCOMMITTEE NO. 2

Low Curiage Source Design

Members present:

Dr. Paul Riemenschneider - University of Syracuse
Dr. C. C. McClure - Vanderbilt University
Mr. John Tolan - Emory University
Dr. J. F. Kelly, Jr. - Creighton University
Dr. Marshall Brucer - ORINS Medical Division

Members absent:

Dr. Henry Jaffe - University of Southern California
Dr. Robert Reeves - Duke University

Present at the invitation of the Subcommittee:

Dr. Frank E. Hoecker - University of Kansas
Dr. I. Meschan - University of Arkansas
Dr. Carl E. Nurnberger - University of Tennessee
Dr. James E. Lofstrom - Wayne University
Dr. Frank Morgan - Emory University
Dr. George Cooper - University of Virginia
Dr. Gilbert Fletcher - M. D. Anderson Hospital
Dr. Norman Simon - Mt. Sinai Hospital
Dr. Robert P. Ball - Oak Ridge Consultant
Mr. L. J. Bulliet - W. F. and John Barnes Company
Mr. Emil Galvanoni - W. F. and John Barnes Company
Mr. Gene Stober - Keleket Corporation
Mr. Tom Carraher - Keleket Corporation
Mr. J. W. Wilde - Instrument Engineer, ORINS
Mr. H. E. Kimble - Instrument Maker, ORINS

Dr. Brucer opened the meeting at 9:00 a.m. with a brief discussion of the original objectives of Subcommittee No. 2.

1. To use the cobalt 60 now available.
2. To design a "limited use" machine.
3. To follow all NCRP Subcommittee No. 9 recommendations.
4. To keep "costs" consistent with "limited use".

The source container shown at the meeting is designed to use the cobalt sources now available, but sufficient shielding to take a 600 curie source has been built into the design. This was done in recognition of the fact that larger sources should be available within a few years. Mr. Bulliet of the W. F. and John Barnes Company, in a discussion of cost, said that their accounting department had not yet caught up with the engineering department and that he did not know the cost of the machine. These cost data will be made available as soon as possible. Dr. Brucer pointed out that the design was started in May, was approved in June, and that the machine was delivered in August. This achievement is remarkable in an age that glorifies administrative paralysis. Dr. Brucer said that the necessity for using Hevimet as shielding material on the source wheel had added about $1200 to the cost, but that he had approved it in order to maintain the Lederman idea of removing mass from the shoulder and head region.

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The industrial participants were reminded of the Subcommittee's insistence that the price of the machine be kept at the level of 250 KVP X-ray equipment. The Subcommittee in turn was told of a design meeting in June with McClure, Tolan, Bruccer, and Barnes and Keleket representatives. At this meeting each item on the machine was considered for cost reduction or replacement with cheaper quality. We believe there is no further way to reduce cost through engineering. Any reduction of the costs must now come through administrative and production methods. The Subcommittee was asked to review the design and to look for unnecessary features particularly as they relate to cost.

The group then adjourned to the cobalt room to inspect the machine. Following the showing, the machine was taken apart to show construction details.

After much informal discussion the group returned to the conference room and discussed the following points in considerable detail:

I. <u>The Design of the External Surface</u>.
There were no criticisms of the general shape of the shield. It allows, as expected, ample room for the patient to be placed in all treatment positions. The final decision on this particular shape or external configuration will depend upon the health physics surveys after loading. Following the meeting, a preliminary test survey was done with a small source. Some of the immediate results are included in these minutes, although they were not a part of the Subcommittee deliberations. With a 2 curie source of cobalt 60 in place, a set of 96 hour exposures with "Kodak no-screen" type film completely surrounding the machine at contact distance revealed only a faint fogging which was too light to interpret. With the machine in "off" position, and without a cone in place, there was a narrow pencil leak on the cone as expected from the design. This appears to read about 1 mr/hr/curie. With the cone in place it cannot be measured. Since there is no significant leakage in the design the large source will be loaded within the next week.

II. <u>Opening and Closing Mechanism</u>.
The mechanism is excellent. The 3-way solonoid air valve heats up on prolonged use. This is a commercial item that can be replaced with a better valve. Only one piston is being used at 80 pounds pressure. The Barnes Company should consider activating both pistons, each one at 40 pounds pressure, if this will lessen maintenance problems on the piston washers and if it does not add substantially to the cost. The rotation period is about 3 seconds and is remarkably smooth. The timer should be adjusted to read with the beam light rather than with the activating push button. The mechanism for the control panel is excellent. The "on-off" light system is a positive indication of the position of the source and appears to be fool-proof. Some of the members felt that the air piston is a major advance over other methods of rotating the wheel.

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III. The Internal Wheel Loading Plug.
The plug housing the internal rotating wheel was removed and demonstrated. With the present loading mechanism there is no conceivable need for ever again removing the plug. The manual opening and closing wheel is difficult to operate. It might be better to serrate the edges or to use an open spoke wheel. A hole and wedge pin has been put into this model to mechanically hold the source "on" for purposes of 8 hour measurements and 24 hour health physics surveys. Such a device is NOT recommended for any except experimental machines.

IV. Design of Cones.
The cone design is a special problem and cannot be discussed without isodose curves and build-up studies. Most members felt that the electron shield should be moved back into the cone. Some felt that a few centimeters should be cut off the cone extension and lucite positioning cones should be place outside the beam limits. When preliminary data are ready the Subcommittee will be recalled to consider cone design. Copies of the Richardson paper on build-up will be distributed when available and before recalling the committee.

V. Loading Device.
Following the recommendations of the Subcommittee and also the stated policy of Subcommittee No. 1, the machine was designed for field loading. During the assembly of this machine Mr. Bulliet and Mr. Kimble suggested that the loading mechanism could be improved by removing the snap ring and letting the source float in the race way as a free bearing. No one can think of any objections and it is so recommended to the Barnes Company. However, even with this snap ring device now in place, it is very simple to load and unload the machine. During the first loading of a 2 curie cobalt 60 source, every possible thing went wrong. In spite of the fiasco, Brucer got less than 10 mr exposure on one loading of 2 curies. This is with no special shielding. It appears that the large source could be loaded in the field with less than 1 r exposure. The only expense will be a $1.50 pair of pliers, some lead bricks, a vacuum cleaner, and a mirror.

VI. Suspension.
A Keleket wall stand was used in the present prototype model. The base plate on this wall stand was objected to and should be removed. A permanent flush floor plate should be used. The fork can then be shortened by about 6 inches. At the rear of the stand the air mechanism projects unnecessarily into the wall area. This mechanism should be repositioned to allow the stand to fit close to the wall. No motor box should be on the stand. The side arms should be moved back as far as possible. The shield should be suspended at the center of gravity to get rid of the pendulum effect in extreme positions. The position of the adjustment wheels was discussed. Following the meeting,

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the suggestion for changing the plane of the wheels was tried by some members. If the plane of the adjustment wheel is rotated 90° it becomes impossible to reach the wheels with a bed under the machine. Hence, the committee's recommendation to change the plane might be a serious error. It is recommended that the Barnes Company prepare a ceiling mount. The committee would like some cost estimates from the Barnes Company on ceiling and wall mounts.

The committee then made the following recommendations:

1. Source shield.
   The design is approved with some suggestions.

   a. There should be labels for the moving parts of the cone device.

      1) Rotate - remove
      2) Rotate - locked
      3) "On-off" lights should be placed on the machine as recommended by NCRP Subcommittee No. 9. (This suggestion has been added by Brucer. It was not discussed in committee.)

   b. If possible the two locking devices for the cones should be incorporated into one locking device. If this is not possible, the cone locking device should use a rotating handle with a fast screw thread similar in operation to the cone rotating device.

   c. Since the Subcommittee meeting, the health physics survey indicates that the following statement should be engraved around the master cone base plate: "Do Not Leave Machine Without A Cone Insert." If the Subcommittee disagrees with this suggestion, it will be withdrawn.

2. Fork design.
   The design was approved with some suggestions.

   a. The fork should be shortened in its forward extension as much as possible.

   b. The plane of the adjustment wheels should be rotated 90°. (Further study indicates that this might be a serious error.) With the machine in some positions it is possible to reach the wheel at all times. However, if the plane is rotated in some positions, it is impossible to reach the wheel. The Barnes Company is urged to study the problem before adopting the suggestion. (This statement is counter to the Subcommittee's recommendation, but has been agreed to by 2 members of the Subcommittee following the meeting. If there are any objections, we will reconvene the Subcommittee for reconsideration.)

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3. Motions of the machine.

   a. The Subcommittee recommended keeping the up and down motion. The cone should clear (at the highest position of the machine) the sitting height of a tall man. This places the cone at about 55 inches and the source at about 65 inches. The down motion should be extended as low as possible.

   b. The Subcommittee approved the shield tilt of 225°. A method is inherent in this shield tilt for stopping the tilt at any position in the arc.

   c. The Subcommittee recommended that the fork rotation question be delegated to the manufacturer after the manufacturer has checked on the cost significance of this motion and the cost of the mechanism. The Subcommittee could not reach agreement on whether a tilt of the fork was necessary. Some members felt that fork rotation was undesirable from the point of view of room shielding. Other members felt that it was necessary from the standpoint of the maneuverability in setting up patients.

   d. The Subcommittee recommended that a ceiling suspension be prepared by the manufacturer at his option. The ceiling suspension was highly recommended by some members of the Subcommittee.

4. The Subcommittee recommends that manufacturers make every effort to agree on a standard source container design.

5. Base Plate.

   The Subcommittee recommends that a base plate for pointing and positioning gadgets be attached close to the top, next to the cone device.

At the close of the meeting Dr. McClure suggested that the Subcommittee extend their appreciation and compliments to the Barnes Company for the excellence of design, their beautiful workmanship, and the remarkable speed of execution. This suggestion was passed as a motion of the Subcommittee. Mr. Bulliet complimented the Keleket people for their cooperation in getting a wall stand prepared and shipped in great haste. The meeting adjourned at 4:30 p.m.

Marshall Brucer, M.D.

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June 13, 1953

MEMORANDUM TO: ALL MEMBERS OF THE TELETHERAPY EVALUATION BOARD

SUBJECT: MEETING OF SUBCOMMITTEE NO. 2

Pursuant to the instructions from the Executive Committee, a meeting is called for Subcommittee No. 2 on the Design of Small Curiage Units for 9:00 a.m., 30 August 1953, in Oak Ridge, Tennessee. The purpose of this meeting will be to view, discuss, and finally approve a low curiage unit. It is expected that a unit will be available on this date. Since the deliberations of this subcommittee will be of interest to all members of the Teletherapy Evaluation Board who are contemplating the purchase of a low curiage unit, the meeting will be open to all members of the TEB.

On or about August 15 a memorandum will be sent to all members of the TEB requesting information on who will attend and the time of arrival so that reservations and transportation can be arranged.

Marshall Brucer

Marshall Brucer, M.D.

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April 23, 1953

TO: Riemenschneider and other members of Subcommittee No. 2

At the end of the meeting of April 12, Dr. Riemenschneider brought up the question of the similarity of depth dose distributions in the 200 kv isodose curves from Dr. Ball's machine and the curve from the cobalt^{60} machine. I think I fumbled the answer on this one. We've gone into the matter a little bit more carefully.

The explanation for the apparent similarity in some of the depth dose curves lies in the method of measuring depth dose. In general, there are two ways of measuring depth dose. (1) A practical method very often used, and in fact preferred by such people as Carl Braestrup because it gives a quicker approximation for the practicing radiotherapist. It is the type of curve in which 100 per cent skin dose is defined as the dose at the hypothetical skin surface but measured in air. Hence, there is no back scatter from the body. The dosage at any depth is related to this 100 per cent but is measured in a water phantom. (2) A theoretically more correct way of measuring depth dose so that the differences in isodose curves can be compared between machines of different energies, is in the case where 100 per cent skin dose is defined as the dose at that point underneath the skin where the dosage reaches its peak. Although the peak dosage may fall at different depths at different energies (and under different irradiation conditions, different field sizes, etc.) usually the difference is relatively small. It is measured in millimeters as compared to the centimeter depth dose levels, and a good standard way is to select a theoretical peak dose depth for any specific energy.

If we take an example which is fairly close to some actual measurements that have been made, we can get a picture shown in the following table.

	200 kv	cobalt^{60}
Dosage in air at skin distance	100	100
Dosage in water phantom 10 cm beyond skin	45	50

The dosage at 10 cm is somewhat higher for cobalt^{60} since the energy is higher, hence, the absorption in tissue will be lower and a greater portion of the radiation flux reaches 10 cm of depth.

If these same measurements are to be made according to the second method, the contribution from back scatter and the penetration of electrons beneath the skin are going to depend on energy and for low energy radiation the peak dosage will be slightly below the skin

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surface and the back scatter will cause a considerable build up of dosage early in its penetration of the tissue. There is about thirty per cent added to the air dose measurement at 200 kv when the dosage is measured at peak value in a skin-like material. For the cobalt^{60} energy with more forward scatter, less back scatter and increased penetration of the electrons that are formed, the skin dose measured by the second method is only 105. Using the same tentative figures as shown in the first table the readings of the table are now converted to the following:

	200 kv	cobalt^{60}
Dose in skin at peak value	130	105
Dosage in water phantom at 10 cm below the surface	35	48

These figures will be modified as the source is moved farther and farther from the skin surface; there is an apparent build up in dosage at depth. This is due wholly to the inverse square correction. The reason for the difference in dosage at any depth is due to two factors. First the amount of tissue penetrated determines the amount of absorption of energy from the beam and this factor is measured by an absorption coefficient. The absorption coefficient does not change with a change in source-skin distance. (This statement is false but it brings up a complicated series of questions which consider corrections too small to worry about right now; for all practicable purposes it can be considered a good first approximation.) If table 1 had been measured as 100 r at 50 cm then in a vacuum without any absorption a cobalt^{60} beam would be reduced by a factor of $\frac{50^2}{60^2} = 0.69$, therefore, the 100 r is reduced to 69 r by the inverse square factor alone. The change from 100 cm to 110 cm is $\frac{100^2}{110^2} = 0.83$, therefore, the reduction is only seventeen per cent at a meter compared to thirty-one per cent at a half meter, hence, no matter what the energy of radiation, moving the source farther from the skin will increase the depth dose. Beyond 70 or 80 cm any additional improvement is relatively small.

At 10 cm depth makes a big difference at 30 cm source-skin distance. The radiation is reduced to fifth-six per cent just by the divergence of the beam. At 50 cm a 10 cm depth is still important, the reduction is to sixty-nine per cent. At 80 to 90 cm source-skin distance the curve is beginning to flatten out, at 80 cm the reduction is to seventy-nine per cent, at 90 cm it is to eighty-one per cent, at 100 cm it is to eighty-three per cent. From here on it doesn't pay to move much farther out from the cone since it is necessary to move all the way to 200 cm to get to a ninety per cent reduction. To get to ninety-eight per cent it is necessary to move all the way out to 10 meters. For this reason the importance of the difference between 80 and 100 cm

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source-skin distance is debatable and our design for the big machine need not stress extremely long source-skin distances.

Where high intensity is easy to achieve but very high voltage is as hard to achieve as in x-rays or in the Van de Graaf machine, one should move out to farther source-skin distances to make use of each additional percentage depth dose. However, where high intensity is hard to get and high voltage is easy to get as in the isotope sources, then the source- skin distance should be moved in to 70 or 80 cm so that one can make use of each additional percentage increase in intensity. (This inverse square business holds true only for point sources and there is a significant correction for sources the size that we usually use. The corrections are only academically important, actually the simplified statement holds true very well in spite of coherent scatter, forward scatter, etc. all of which complicates the idea.)

The pictures we showed of depth dose were a comparison of Ball's 200 kv unit as measured by the first method. His curves were made for a very practicable purpose. The cobalt curves we showed were measured by the second method for comparison with other machines, hence, the apparent similarity of the depth dose picture.

Marshall Brucer

Marshall Brucer, M.D.

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MINUTES, APRIL 12, 1953 MEETING
TELETHERAPY EVALUATION BOARD - SUBCOMMITTEE NO. 2
SMALL SOURCE DESIGN

Members present: Dr. Henry Jaffe -- University of Southern California
Dr. Robert Reeves -- Duke University
Dr. Paul Riemenschneider -- University of Syracuse
Mr. John Tolan -- Emory University
Dr. Marshall Brucer -- ORINS

Visitors: Dr. Robert P. Ball, Radiologist, Oak Ridge General Hospital
Mr. J. W. Wilde, Instrument Engineer, ORINS
Mr. H. E. Kimble, Instrument Maker, ORINS

Members absent: Dr. C. C. McClure -- Vanderbilt University
(Absent due to illness. Came in to Oak Ridge on 19-20 April 1953 to review Subcommittee #2 proceedings.)
Dr. J. F. Kelly, Jr. -- University of Nebraska
(Absent due to illness.)

Dr. Marshall Brucer opened the meeting with a review of previous discussions on the design principles of teletherapy units, outlining the problems encountered to date in designing a small "head and neck" therapy unit, and sketched, for purpose of discussion, a suggested design which would solve most of these problems. Because of the anatomical conformation of the head and neck region, the primary principle to be followed in any small unit is to remove as much mass as possible away from the cone of the machine in two planes. This can be done by placing the source at a 45° angle to the normal angle of rotation of the shutter mechanism.

There followed a discussion of the sizes and specific activities of Co^{60} sources currently available, or expected to be available in the near future. The sources presently available are 1 cm in diameter by 0.2 cm, 1 cm, 2 cm, or 4 cm in length and have activities of 85 to 140 curies per inch of length. There are also available 1/8 inch diameter rods 1/8, 1/4, 1/2, and 5/8 inches in length. These smaller rods have activities of from 10 to 15 curies per inch of length. Several design patterns were discussed which would allow the build up of about 300 curies in a 2 cm diameter source. A double overlapping clover leaf design is considered to be the most economical in space and curiage. Based on this information the committee agreed that the small therapy unit should be designed for an approximate maximum of 45 r/min, at 30 cm Source-Skin Distance.

Dr. Jaffe suggested the committee review advantages and limitations of a small therapy unit of this size and design. Dr. Riemenschneider discussed the flexibility of the small Co^{60} therapy unit versus 250 kV x-ray unit. Also, he pointed out that a 250 kV x-ray unit would cost approximately $15,000 as against an estimated cost of $10,000 (or less) for the small "head and neck" unit. The committee reviewed the following factors both for and against the small unit.

1. Possibility of a high tumor-skin dose ratio in tumors approximately 5 cm below the surface of the skin.

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2. Since the unit must be used in contact with the skin at 30 cm, the inverse square reduction in exposure rate is considerable. It probably will not be suitable for any form of deep therapy.

3. With correct cone designs it is possible to use the unit in intravaginal and intraoral therapy.

4. It can be designed with extraordinary flexibility in manipulation but this will depend directly upon the amount of money allowed for the suspension mechanism.

5. Because of the short source-skin distance, the unit is not practical for any form of rotational therapy.

6. It has many of the advantages of the radium pack but will be superior in its depth dose and output.

7. It requires a very small space for the machine itself; however, with each increased degree of freedom in motion, there will be an additional requirement for shielding of the room.

8. It is competitive with a million volt unit at short distances in all respects except exposure rate.

Dr. Jaffe brought up a number of questions relative to initial cost, replacement of sources, and routine maintenance. As listed the cost of multicurie sources is $100 per 2 curies plus $5 per curie or fraction thereof above 2 curies. There will be a loading charge of anywhere from $500 to $1500, however, this depends upon the difficulty of loading sources and whether the sources are just incapsulated or are loaded into the shield. In addition, there is of necessity a shipping charge for the shield or isotope carrier which would differ for each university, depending upon the distance from Oak Ridge and the mode of transportation. The replacement cost would occur at approximately eight year intervals. Mr. Tolan, in summarizing the discussion, expressed an opinion that these costs are comparable to replacement cost for x-ray tubes. The committee then discussed the service or maintenance costs of custom built units versus service costs for commercial x-ray units. Dr. Riemenschneider pointed out that the type of maintenance required on the small source unit under discussion was not of a specialized nature and was well within the scope of any mechanical shop; except for the maintenance of a source wheel. It was agree that any proposed engineering design, if of a simple nature, could provide trouble free operation for several years.

The committee then held an informal discussion of the various factors involved in the design of any unit. Mr. Wilde demonstrated a simple design shown in Figure 1. Mr. Wilde's estimates are that a prototype unit some similar to the design demonstrated would cost approximately $12,000 to engineer and build, whereas on a second unit the cost might be reduced to approximately $8,000. It was emphasized that these estimates are independent of source costs and installation costs. The ORINS design was tentatively accepted in principle to facilitate the discussion of various specific factors which would influence any particular design.

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A. Size of Fields at Skin Distance

Dr. Brucer pointed out limiting factors affecting the portal size at the skin surface, such as the relative weight of various size cones, types of material used in fabricating cones, visual and transmitted penumbra problems, the source-skin distance, the problems of cone contact with irregular surfaces, etc. Dr. Jaffe lead a discussion on the desirability of using maximum size portal versus multiple fields. The committee discussed the probability of a continuously variable diaphragm arrangement. The variable diaphragm being developed for the cesium machine was outlined, however, the committee agreed that the size and cost of such a mechanism made it impracticable for the small therapy unit. A motion by Dr. Reeves, seconded by Dr. Riemenschneider, and approved by the committee, recommended a minimum 2 cm diameter, and a maximum 10 cm diameter field at skin surface. This is to be considered a minimum requirement. If an engineering study shows it to be practical, the maximum size should be increased to a 12 cm diameter field. Following this motion the committee agreed on the fabrication of a number of experimental cones to be at 4 x 6, 6 x 8, 8 x 10 rectangles; 2, 3.5, and 6.5 cm circles. The committee requested that the cones and holding devices be designed to permit rotation of the cones.

B. Treatment Distance

It was brought out that the source-skin distance intimately effects such other factors as field size, penumbra, dose distribution, source curiage, and in addition affects such mechanical items as the balance of the unit. Discussion around these factors brought out other possible uses of a small therapy unit in addition to tumors in the head and neck areas. It was the unanimous opinion of the committee that in spite of the design restrictions imposed by the small curiage source many uses were possible with the suggested design. Dr. Jaffe moved that the committee adopt a 45 r/min output at 30 cm source-skin distance as a goal to be reached. The motion was seconded by Dr. Reeves and carried without objection.

C. Size of Co^{60} Sources

Dr. Brucer outlined the number and specific activity of Co^{60} sources expected to be available for the next five years. The committee was informed that cobalt sources are available in the following sizes, as listed in the radioisotopes catalog.

Diameter	Activity per inch of length	Lengths available
0.5 mm	0.2 mc - 25 mc	2 mm to 6 cm
1.0 mm	1 mc - 100 mc	2 mm to 6 cm
1/8 inch	10 mc - 15 curies	1/8", 1/4", 1/2", 5/8"
10 mm	84 mc - 140 curies	2 mm, 1 cm, 2 cm, 4 cm

The committee discussed the desirability of various source sizes and shapes which could be made from the materials now available. On motion by Dr. Reeves, seconded by Dr. Riemenschneider, the committee voted for a source container slightly greater than 2 cm diameter with the sources arranged in a double clover leaf design. With this arrangement, approximately six 1 x 1 cm rods plus one 1/8 x 1/2 inch rod would be used. This allows for the minimum self shielding and depending upon the specific activity of the material should yield greater than

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250 and less than 350 curies. Such a source would cost about $1800 and should approach a 45 r/min output at 30 cm. There is some question on the flatness and symmetry of the isodose curves with such a source design, however, this can be determined only by experiment.

D. Allowable Penumbra

The committee discussed isodose curves and the penumbra problems which might be produced with the source design recommended. A report was given on Dr. Richardson's work measuring the isodose curves around the Canadian Source as used in the ORINS - M.D. Anderson Co^{60} Unit. For comparison Dr. Robert Ball discussed the isodose curves around the Oak Ridge General Hospital's 250 kV x-ray therapy unit. The penumbra on even these small curiage sources can be expected to be better than that shown for the 250 kV x-ray therapy unit and much better than those shown for the various radium packs throughout the country. However, it is not expected that with such a large source and small collimating distance the penumbra will be anyway near as sharp as that shown for the large Co^{60} machine. To a certain extent the large penumbra can be overcome by bringing treatment cones up to contact with the skin. The recent work on electron build up with the large cobalt machine was discussed and it was shown that the excessive electron contamination in the first few millimeters of skin can be markedly minimized provided proper precautions are taken in the design of electron filters over the end of the cone.

E. Light Localizer

The committee was of the opinion that in a small curiage source machine it was probably advantageous to bring the cones up to contact with the skin, in which case there was no necessity for a light localizer. Dr. Reeves moved and Dr. Riemenschneider seconded the motion that with the short source-skin distance machine no light localizer was required. Other committee members concurred.

F. Timing Mechanism

The committee discussed the design of the source wheel and the expected operating speeds with the source wheel moving into the "on" and "off" position. Without voting the committee agreed that much of this depends upon what can be engineered and agreed on an estimated one second build up of dosage, (less than 1% of total dose) during the "on" and "off" movements.

G. The Shutter Mechanism

Dr. Brucer outlined a shutter mechanism consisting of a doughnut wheel operated from the control panel, complete with timer switch, signal lights, and master key lock switch. Mr. Tolan questioned the ability of the cogwheel and worm gear mechanism to be as efficient as an axle drive. It was explained that the original design feature was the result of an attempt to locate the drive mechanism in the most advantageous position with respect to the center of gravity of the unit so that the shutter drive could float inside of the fork suspension. This would avoid bulky projections at the treatment end of the machine. Mr. Wilde discussed other possible shutter drive arrangements which would locate the driving mechanism in the desired position, however, these alternate arrangements placed gears within the shielding head and the committee expressed a desire to eliminate

any machinery which could be repaired only on dismantling and exposing the source. Dr. Tolan pointed out that the cogwheel would have to be built of high alloy metal to withstand eight years wear of the high speed on the worm gear design suggested and asked for further discussion on possible use of an axle drive. It was pointed out that the arrangement of a wheel at an angle puts any axle drive in such a position so as to locate an exterior obstacle in a forbidden area, however, it was felt that some arrangement must be made which will place all gears and bearings on the outside of the unit. The committee expressed agreement on the general design ideas, although they disagreed with the specific design suggested. The discussion was closed with a consideration of the recommendations of the new NBS Handbook on Protection from Incapsulated Sources which will demand some extention for manually shutting off the beam.

H. Shielding Materials

The committee reviewed the cost factors in various shielding materials which could be used. It was immediately agreed that the cost factor alone made it necessary to use lead as the prime shielding material. There is still a possibility of using small pieces of more dense materials in strategic locations within the design.

I. Suspension Mechanism

The committee agreed, after much discussion, that no matter what the design of the shielding unit, the problem of suspension depends to a large extent on the individual needs and specifications available to each user. Whereas, it might be possible for one university to use a wall mount, another university may find it more economical to use a ceiling mount. It was agreed that the prototype unit should be designed with a specific suspension mechanism but that this suspension might have to be modified for each university. For the prototype unit it was agreed that the suspension mechanism must provide for a verticle motion of the yoke between two feet and five and a half feet above the floor, a 360° rotation of the yoke, and tilting of the head through an arc of 180°. It was agreed not to attempt to put in a horizontal movement of the yoke. It was suggested that an investigation be made immediately of the commercially available suspension mechanisms, and to compare their design and cost with a specially constructed model. The one criticism of most commercially available suspension mechanisms is that few are designed to carry the load required of even a small curiage unit. Mr. Tolan showed the committee descriptive literature on one typical commercial x-ray suspension unit which might be adaptable to a small Co^{60} unit.

J. Loading of Replacement Sources

The committee discussed the desirability and the advantages and disadvantages of field loading of replacement radioactive sources. There remains considerable disagreement on the necessity for field loading versus loading by a vendor such as the Oak Ridge National Laboratory. In the case of universities located within a short distance from Oak Ridge, it is probably far more economical not to attempt the field loading device within the design, however, in the case of organizations a long distance from Oak Ridge, a lack of field loading equipment would be a serious handicap. Mr. Wilde is of the opinion that any design can easily be adaptable to any field loading device, however, some central organizations would have to have and be responsible for such a piece of equipment. The committee did not vote for either arrangement, however, the members did express a definite

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desire for a field loading design provided it is practicable.

K. Automatic Versus Manual Controls of the Suspension Mechanism

Dr. Jaffe discussed the desirability of motor controls versus manual controls for at least the fine adjustments on any therapy machine. It was his opinion that radiologists in general were currently in favor of manual controls. The committee agreed that fully automatic operations of all movements was too costly, but that it was necessary to have motor operation of the shutter device and any motion which covers a considerable distance. In the case of the present design this would be only the vertical movements of the yoke. All members expressed an opinion that manual operation of vertical motions were necessary for fine adjustments. At this point Dr. Jaffe and Mr. Tolan expressed the desire for the prototype unit at least have a maximum possible freedom of movement as specified in Item I. Excepted from this statement are the horizontal "in" and "out" motions which are easily obtainable by positioning the patient in a chair or on a treatment table.

Dr. Jaffe made a motion that Subcommittee No. 2 approve the preliminary design as detailed above and authorize ORINS to proceed with fabrication of the pilot model. The motion was seconded by Dr. Riemenschneider and unanimously voted by the committee. Dr. Brucer expressed a desire that the committee review the progress and development of the pilot model prior to the October meeting of the full TEB board. A tentative date sometime in September was agreed upon for the committee's second meeting.

Dr. Jaffe questioned the feasibility of the Institute or some industry building other units simultaneously with the pilot model. It was suggested that the fabrication of a number of units might lower the per unit cost. Dr. Brucer informed the committee that the Institute could not undertake the manufacture of teletherapy units for sale, and explained that the ORINS procedure of building the prototype unit of necessity would be one of simultaneous fabrication and design. It is expected that complete engineering plans will not be available before completion of the pilot model. The committee was informed that "as-constructed-prints" will become public property upon completion of the pilot model and that patent rights will all be, by the terms of our contract, in the hands of AEC.

Although Dr. McClure was unable to attend the April 12 meeting of the subcommittee due to illness, he was able to come into Oak Ridge on the 18th of April. During his visit Dr. McClure went over the discussions and deliberations of the April 12th meeting of the Subcommittee No. 2 and adds his concurrence to the deliberations.

Marshall Brucer, Chairman

Copies distributed to the entire Teletherapy Evaluation Board without review by the committee. Committee members are requested to make any deletions or additions felt necessary. Any such corrections will be distributed by the Oak Ridge Institute of Nuclear Studies, Medical Division.

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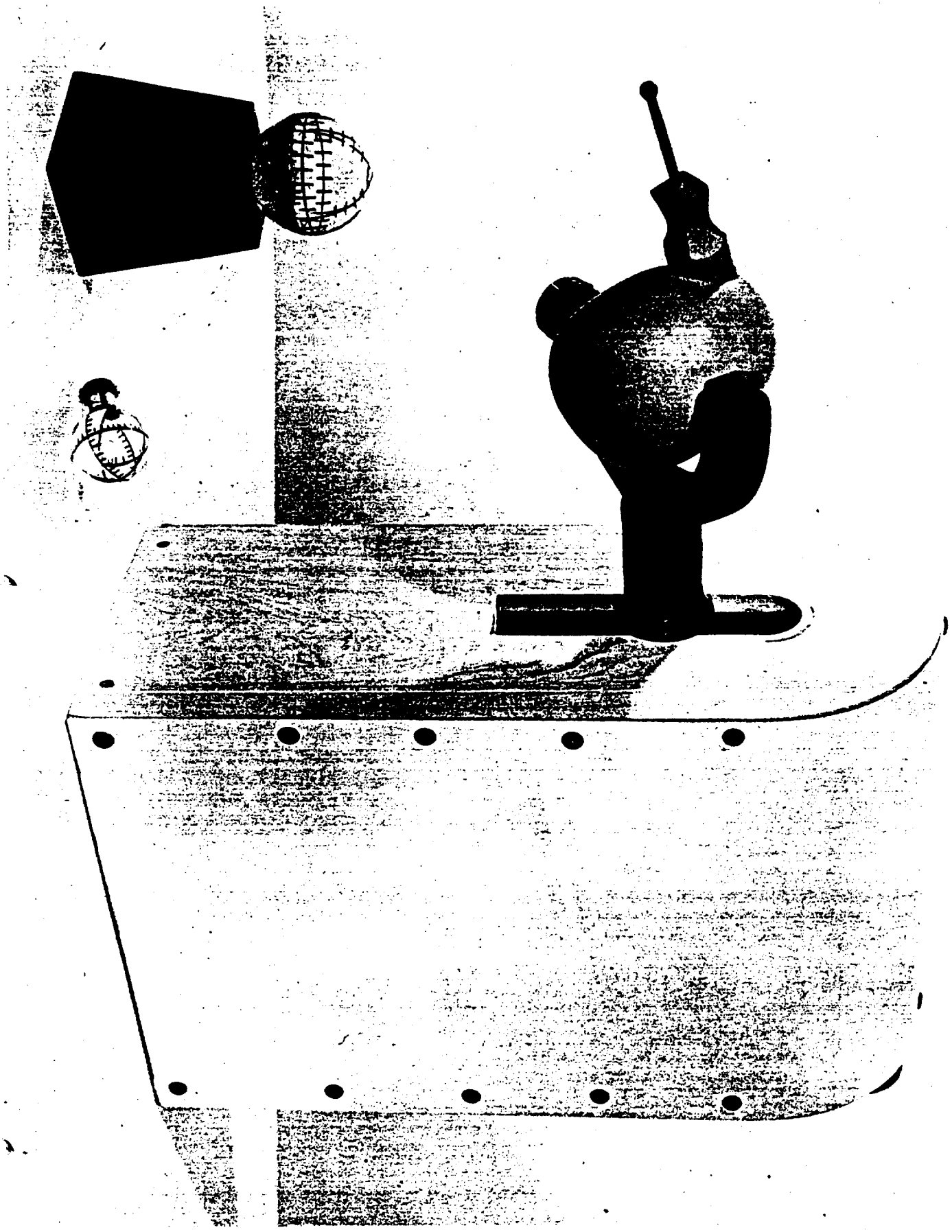

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SMALL SOURCE Co^{60} UNIT

AS DISCUSSED BY SUBCOM. #2

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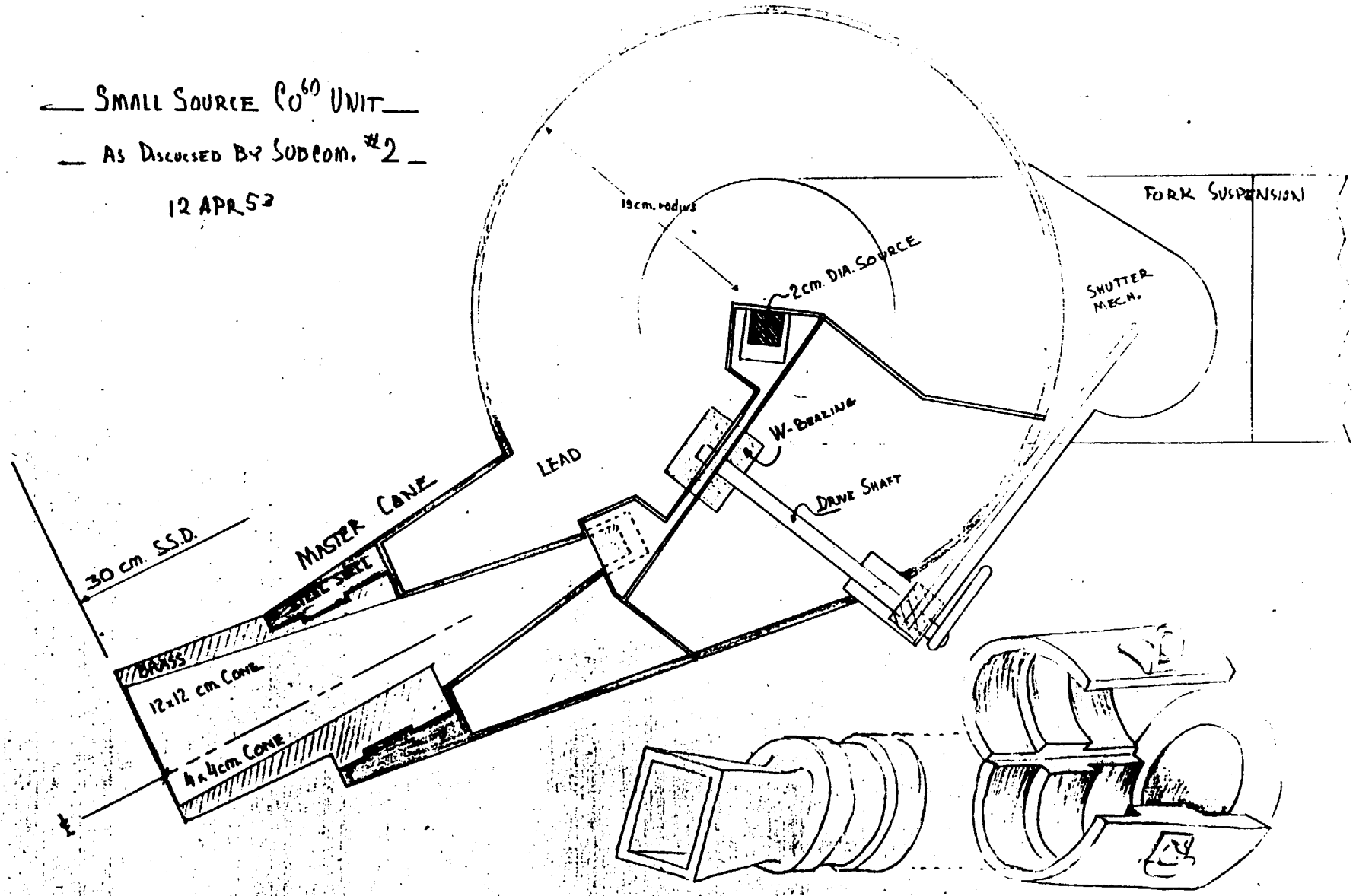

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April 3, 1953

MEMORANDUM TO: SUBCOMMITTEE NO. 2 - SMALL SOURCE DESIGN

Meeting April 12, 1953 - 9:00 a.m.

AGENDA FOR MEETING

1. Discussion of design of small "head and neck" unit.

We have prepared for tentative discussion a design following some of the principles talked of in previous meetings and announced by other workers. A number of very specific questions must be answered to decide if this design is acceptable to the Committee.

a. Size of fields at skin
b. Choice of treatment distance
c. Size of source and the concurrent problem
d. Allowable penumbra
e. Timing mechanisms
f. Light localization device
g. Shutter mechanism
h. Shielding materials and their cost

2. Discussion of the necessary suspension mechanism for a "head and neck" unit.

For example, if it is possible to use an already available x-ray tube stand, we could save considerable expense.

3. Source availability and source design.

4. Problems of procurement of small source machines.

5. Review of previous committee work, if time is available.

6. Adjournment by 4:00 p.m.

Marshall Brucer

Marshall Brucer, M.D.

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