

METROPOLITAN-VICKERS ELECTRICAL CO. LTD.

THE  
METROPOLITAN-VICKERS  
4 MeV  
"ORTHOTRON" LINEAR ACCELERATOR  
FOR X-RAY THERAPY

S.A.S.D. 13

December, 1954.

Scientific Apparatus Sales Dept.

METROPOLITAN-VICKERS ELECTRICAL CO. LTD.

4 MeV LINEAR ACCELERATOR FOR X-RAY THERAPY

INTRODUCTION

The Linear Accelerator described below is similar to those ordered by the British Ministry of Health for installation in various parts of the United Kingdom. It is intended for use as a major super voltage equipment in a busy X-ray therapy department. Careful attention has been paid in design to simplify the operation of the machine so as to increase the speed with which treatments can be carried out. The mounting enables the direction of the X-ray beam to be altered easily whilst the operation of the equipment from the control desk is no more complex than that of a conventional 200 kV set.

The Metropolitan-Vickers microwave linear accelerator equipment is known by the trade name "ORTHOTRON".

PERFORMANCE

The maximum X-ray output specified by the Ministry of Health is 200 r/min. at 1 metre from the target, without additional filtration.

In the first machine now installed at the Christie Hospital and Holt Radium Institute, Manchester, 330 r/min. at 1 metre, without additional filtration, has been achieved. In normal operation, the Christie Hospital employ a dose rate of 100 r/min. after beam flattening and collimation.

The spot size is limited by collimation to 6mm. diameter.

At the specified X-ray intensity, the energy of the electrons is 4.0 MeV.

MOUNTING

The mounting is arranged so that the machine can move round the patient in an arc which lies in a vertical plane; this mounting is illustrated in Drawing D.5087033. The X-ray beam is used in a forward direction from the target so that the accelerator tube and X-ray beam are in line. The equipment is arranged for use with a 1 metre target/skin distance and the target is at a distance of 1 metre from the horizontal axis about which the machine revolves.

Adjustment of the beam direction is therefore made merely by rotation of the mounting. Rotation controls provide for movement in the clockwise or anticlockwise direction, as well as for slow speed control in both directions for purposes of fine adjustment.

There is a clear space of 6'0" (1.82 metres) between the mounting support and the plane of the X-ray beam (See drawing D.5087033). This permits adequate space for movement of the treatment couch described below.

The accelerator equipment is capable of rotation through an angle of  $135^{\circ}$ , from  $15^{\circ}$  beyond the vertical to  $30^{\circ}$  below the horizontal. It is necessary to provide a depression or pit in the floor to allow the accelerator to reach the lowest position or, alternatively, to use a flat floor when only  $15^{\circ}$  below the horizontal will be obtainable. Adjustable limit switches are provided to suit the range of angular movements required. The Company can provide as an optional additional item a retractable floor panel, with safety interlocks, to cover the pit required for operation of the accelerator between  $15^{\circ}$  and  $30^{\circ}$  below the horizontal.

The height of the Treatment Room required for the equipment is approximately 13'0" (3.93 metres).

#### CONTROLS

The controls required by the radiographer for the normal operation of the accelerator are grouped together on the sloping panel of a control desk which is shown on M.V. Drawing D.5087062. Additional controls required by the technician for setting up or adjustment of the machine are housed under a sliding panel on the flat surface of the control desk; this panel locks automatically when closed.

Controls for rotation of the mounting, as well as certain controls for the couch movement, are carried on a control pedestal located in the Treatment Room and mounted on castors for ease of movement.

Suitable safety circuits are provided which may be coupled to switches on the doors of the Treatment Room and Apparatus Room.

The vacuum pumping system may be run continuously or is capable of bringing itself into operation automatically when switched on, either manually or by means of a time switch. In normal operation, it is recommended that the accelerator be left pumping continuously (24 hours per day). Suitable vacuum protection relays are provided.

In a clinical equipment, the availability of replacing certain components quickly is of great importance so as to ensure continuity of treatment. It has therefore been arranged, by using a waveguide window, that the magnetron valve which provides the radio-frequency power can be replaced without disturbing the vacuum in the accelerator tube. The electron gun is fitted with a turret carrying four filaments so that a filament can be changed very rapidly in case of breakage.

### DIAPHRAGM SYSTEM AND X-RAY PROTECTION

The width of the X-Ray beam at a focal skin distance (f.s.d) of 1 metre is limited by fixed collimation to approximately 31.5 cm. diameter.

The beam defining system comprises two pairs of adjustable diaphragms which enable rectangular fields to be obtained, whilst additional fixed diaphragms are clamped into the system when circular fields are required. The maximum field size at 1 metre is 4 cm. x 4 cm. The maximum opening of the two pairs of diaphragms give widths of field of (a) 30 cm. (b) 25 cm. at 1 metre f.s.d. The diaphragm system enables a truly rectangular field of 30 cm. x 10 cm. to be obtained whilst the largest field which can actually be used is 30 cm. x 25 cm. with rounded corners approximately 31.5 cm. diameter. Six circular diaphragms are provided giving fields at 1 m. f.s.d. of diameters; 5 cm, 6 cm, 7cm, 8cm, 10 cm. and 12.5 cm.

The beam defining system is capable of rotation about the axis of the beam.

A fixed X-ray filter is fitted which will reduce the X-ray intensity on the central axis to be equal to that at the edge of the beam. There is provision for insertion of wedge filters when required.

An optical system is incorporated to indicate the irradiated area with a bright light. A retractable direction pointer with flexible tip to indicate the 1 metre focal skin distance is provided, together with a suitable back pointer. It has proved possible to keep the external diameter of the "nose" of the X-ray head to approximately 12.5 inches (32 cm) only.

Careful attention has been paid in design to reduce the extent of the penumbra and also to reduce the intensity of the radiation outside the X-ray beam.

An interlock circuit is provided so that, when the Treatment Room door is open, the accelerator tube is not energised; there is thus no danger to hospital personnel from stray radiation.

### EXPOSURE CONTROL

Two ionisation chambers placed in the X-ray beam are coupled respectively to a dosimeter used to measure the dose delivered and to a dose rate meter used to monitor the X-ray intensity. The dosimeter will read up to 600 r. full scale.

Arrangements are provided so that the exposure may be terminated either manually, by the action of a timer, or by the dosimeter. In all these cases, the dosimeter indicates the dose given.

### TREATMENT COUCH

This couch is illustrated in M.V. Drawing No. B.3057093/3; the design is based on the requirements of the British Ministry of Health.

Provision is made for a vertical lift of 32" (81 cm) so that by the use of a simple couch or a simple light-weight chair, either of which may be clamped in position on the "Float Table", the equipment can be used for treatment of either recumbent or seated patients.

In the Metropolitan-Vickers design illustrated in the drawing mentioned above, the float table can be retracted completely into the floor. The floor opening may then be covered by a removable panel so that the floor of the Treatment Room is completely free and unencumbered so as to allow positioning of any other clinical or experimental apparatus which may be desired.

The float table is arranged to give a free movement of +7.5" (+19 cm) along the couch axis and +6" (+15 cm) across the couch as indicated in the drawing. Suitable clamps and position scales are provided. In addition, the top section of the float table is arranged to give an additional coarse transverse adjustment of +7.5" (+19 cm); a longitudinal coarse adjustment of 21" (53 cm) is provided along the major axis of the couch by relative movement of the couch and top section of the float table. Both these coarse movements are intended to be preset using clamps and the final adjustments in setting-up are made using the +7.5" longitudinal and + 6" transverse table movements.

The couch is capable of rotation about the vertical axis and is fitted with an adjustable brake. The controls for raising and lowering of the couch jack, which is of mechanical type to assure maximum reliability, are carried on the control pedestal in the Treatment Room.

### SUPPLY

The equipment is designed to operate from a 415 or 400 v. 3-phase, 4-wire mains supply (20 kW outlet). The mains input is led to a voltage stabiliser which supplies the whole of the equipment and which is tapped for use on either 415v. or 400v. as required. By the use of this stabiliser, the mains input to the equipment is stabilised to +1% for mains input voltage variations of +6% to -15%. The actual power requirements during treatment at maximum output may rise to approximately 15.5 kW. Overnight, when only the pumps are in operation, the power consumption will not exceed 2.5 kW. As a rough estimate, the mean daytime consumption will be in the region of 9 kW during the hours the machine is in use, depending, of course, on the proportion of time during which the equipment is in use for treatment purposes.

#### WATER

A mains water supply of 5.5 imperial gallons/minute, maximum (25 litres/minute) is required. Of this, 1.0 gallons/minute is required constantly for the vacuum pump; the remaining 4.5 gallons/minute is required intermittently during periods when the machine is operating or under standby conditions.

#### INSTALLATION REQUIREMENTS.

Four cubicles housing auxiliary equipment are located in a room adjacent to the Treatment Room, as indicated in photograph 96428 attached, which shows one of several possible arrangements. Drawing D.5087034/4 gives, in schematic form, typical dimensions of the sizes of rooms required.

A Memorandum dated March 1954 gives details of installation requirements for architectural planning purposes.

#### APPEARANCE AND FINISH

Photograph No.SP/12688 attached shows the treatment unit and couch installation at the Christie Hospital and Holt Radium Institute, Manchester. The treatment unit, couch and control desk are finished in an attractive shade of cream cellulose enamel with chromium plated fittings.

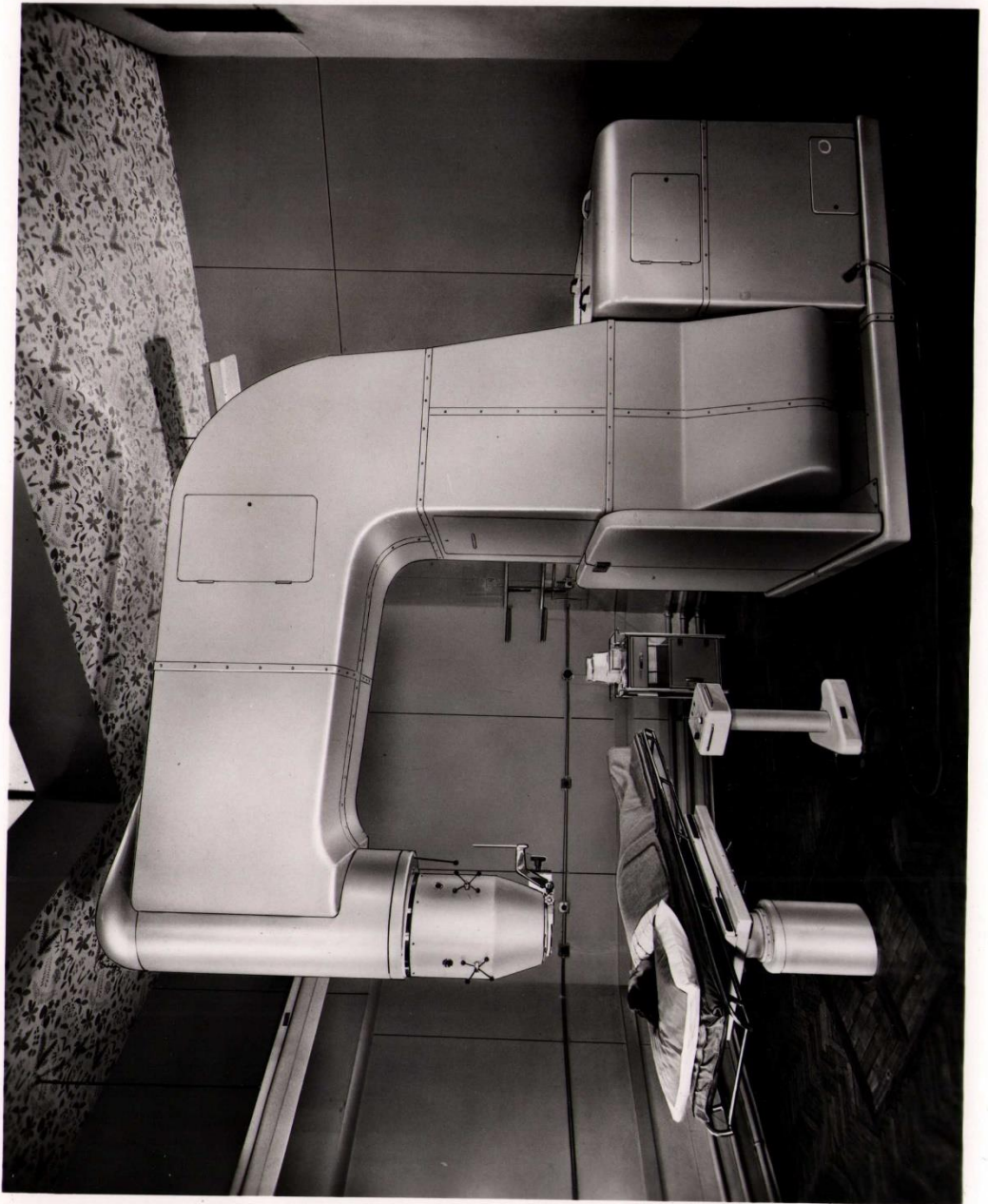
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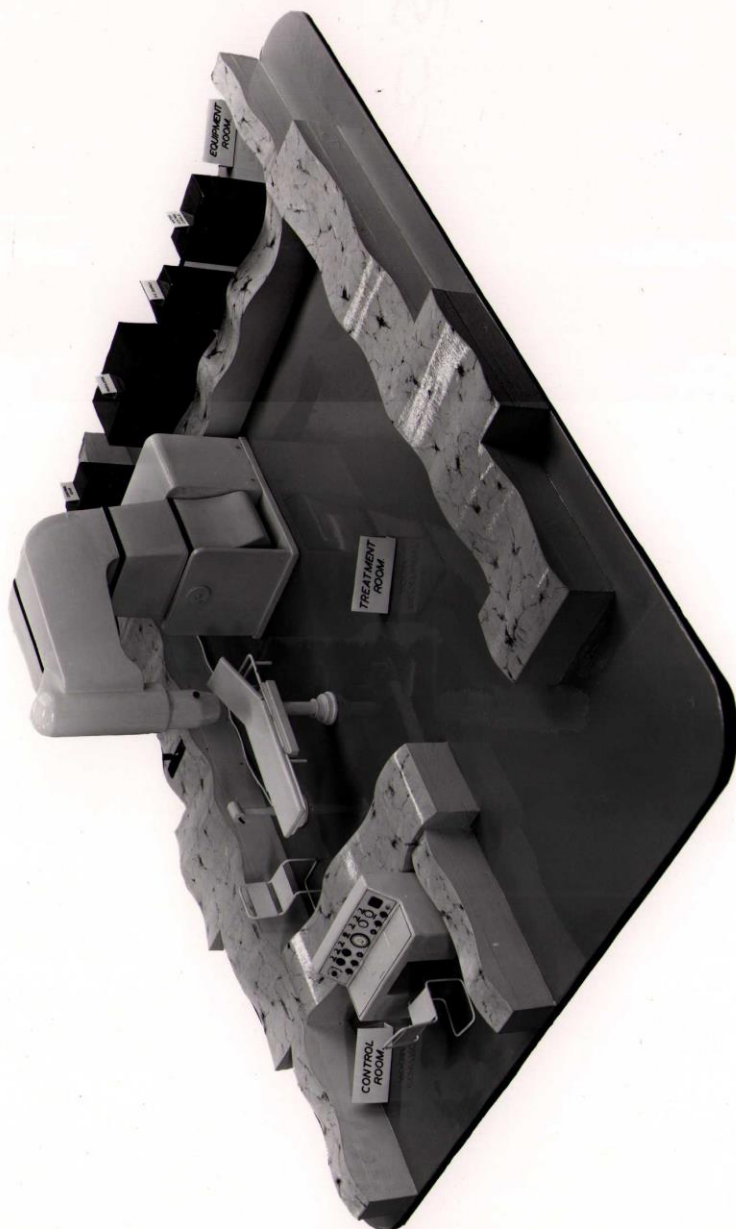
#### Photographs attached

- SP/12688 - 4 MeV Linear Accelerator ("Orthotron") at Christie Hospital, Manchester.
- 96428 - Model of 4 MeV Linear Accelerator Installation.

#### Drawings attached

- D.5087033/3 - Outline of Treatment Unit.
- D.5087062 - Outline of Control Desk.
- B.3057093 - Couch Movements, 4 MeV Linear Accelerator.
- D.5087034/4 - Outline of 4 MeV Linear Accelerator Installation.





Technical drawing of a mechanical part, showing two views: a top view and a side view.

**Top View:**

- Overall width: 12'-2"
- Base width: 4'-6"

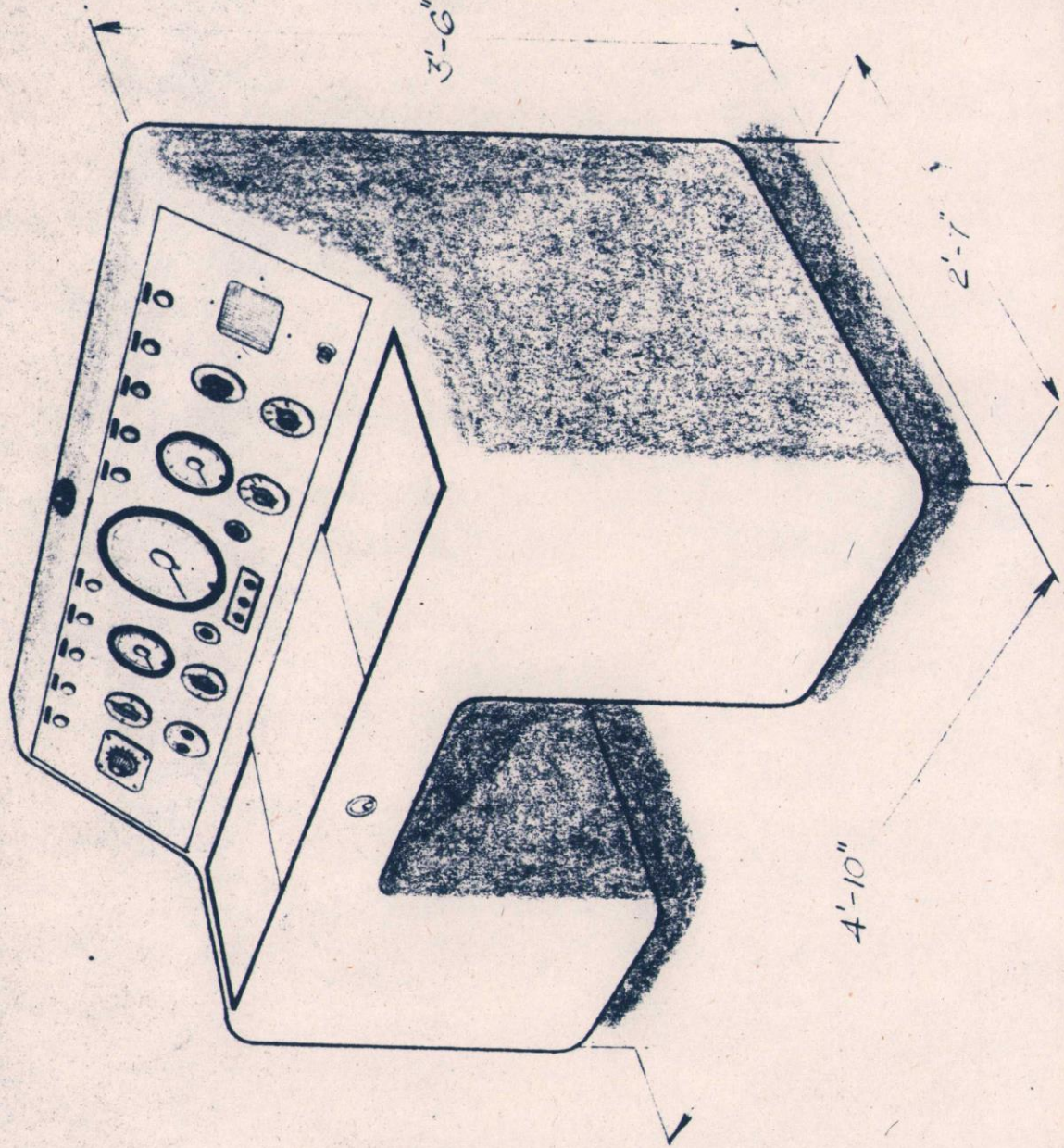
**Side View:**

- Overall height: 6'-0"
- Flange width: 3'-8"

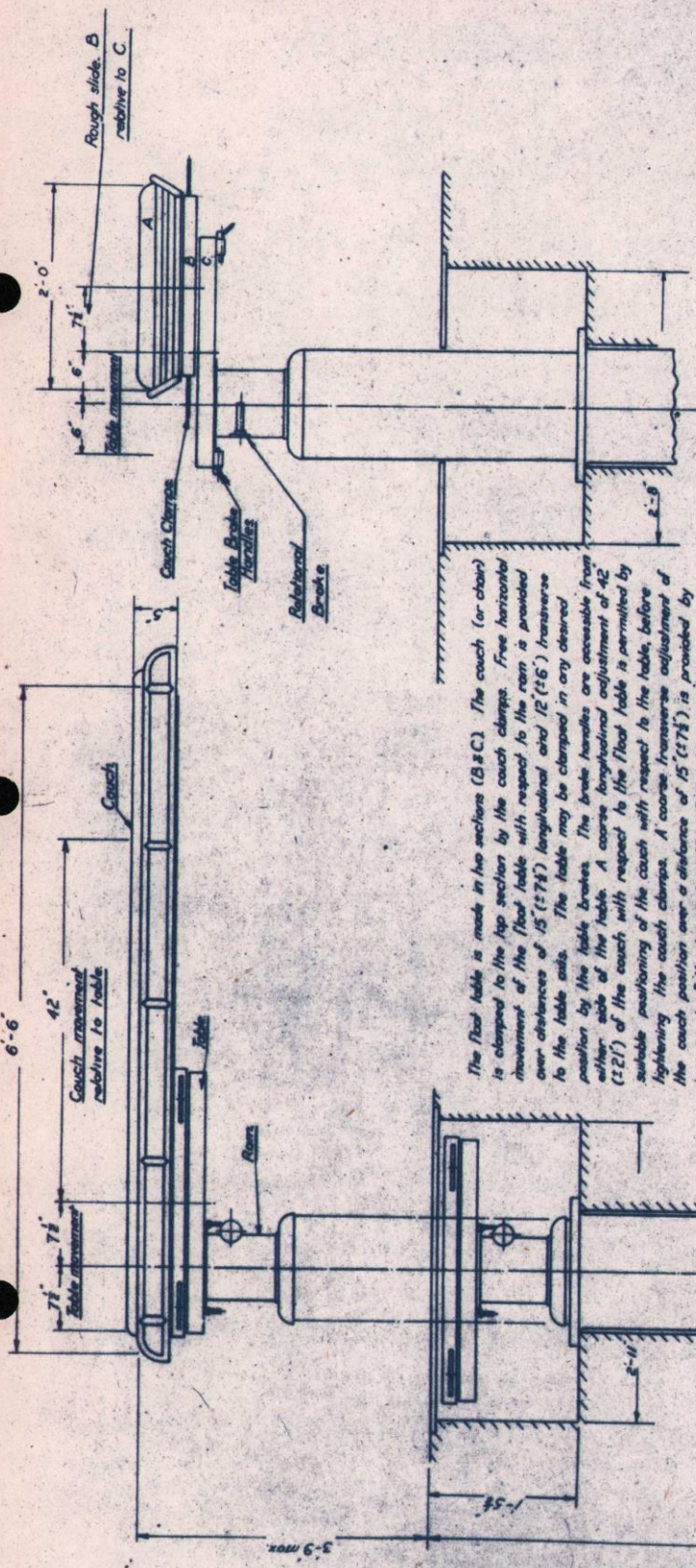
SCALE -  $\frac{1}{4}" = 1 \text{ ft.}$

[illegible]

OUTLINE OF CONTROL DESK FOR 4-MV. LINEAR ACCELERATOR



D5087062  
MVE 02-79



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PROPOSED COUGH MOVEMENTS

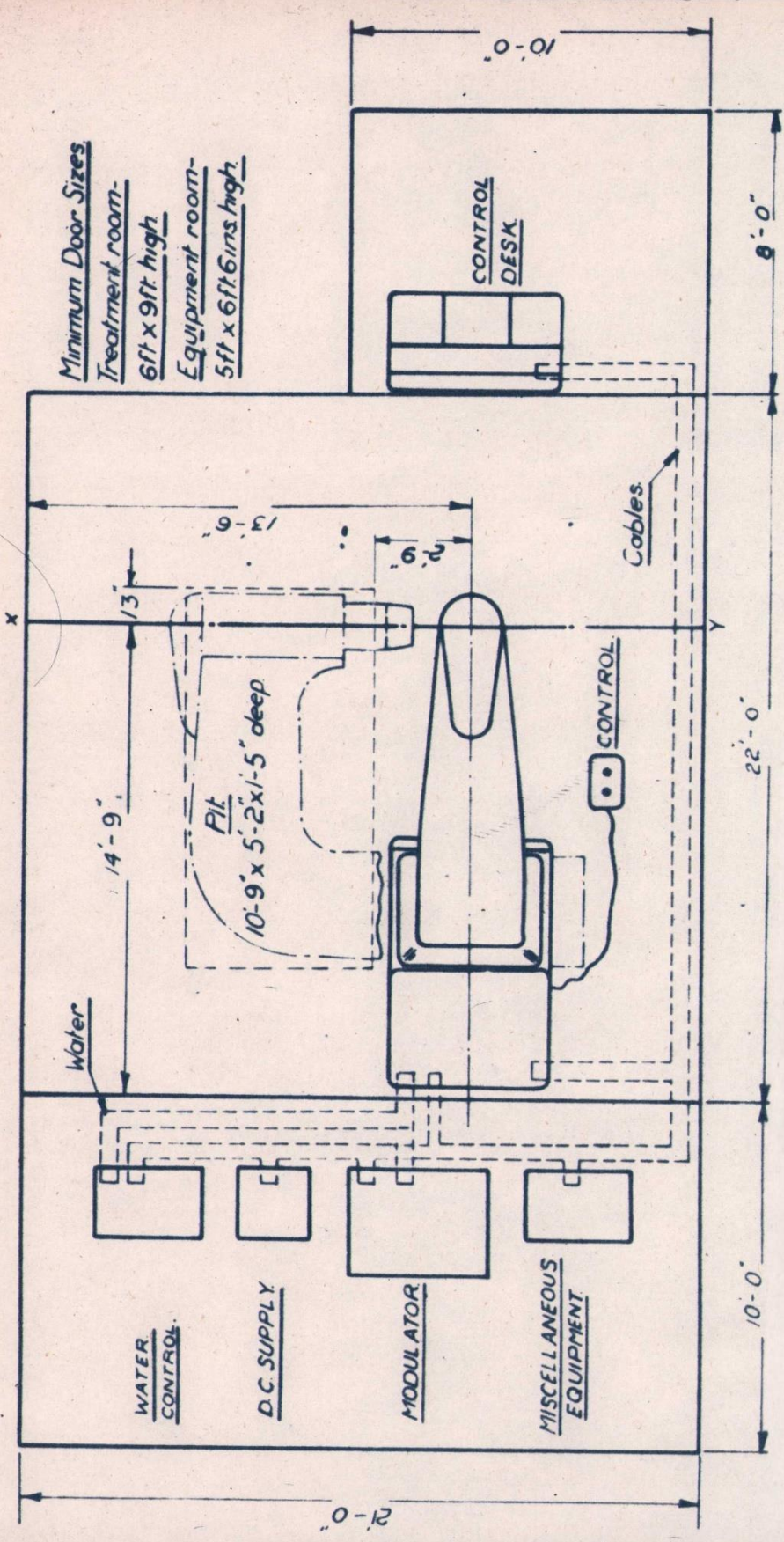
**4 MeV LINEAR**

# ACCELERATOR

SCALE - 1" = 1'-0" L.O. B 3057003

B3057093

Couch Mechanism Dog A2065171



Minimum Door Sizes  
Treatment room-  
 6ft x 9ft high  
Equipment room-  
 5ft x 6ft 6ins high

# OUTLINE OF 4 MeV. LINEAR ACCELERATOR INSTALLATION

SCALE =

Dimensions shown are minimum dimensions

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Runway & door	Water & Cable	Ducts added	Pit dms added	Treatment room dimensions	Water	D.C. Supply	Modulator	Miscellaneous Equipment	Control	Control Desk	Cables	Pit	10'-9" x 5'-2" x 1'-5" deep	14'-9"	1'-3"	1'-3"	1'-3"	1'-3"	1'-3"	1'-3"	9'-0"	22'-0"	21'-0"

**METROPOLITAN Vickers**  
 ELECTRICAL  
 MANCHESTER AND SHEFFIELD ENGLAND

Dwg. D5087034