APPLICATION

OF THE ADMINISTRATIVE BOARD OF THE EVANGELISMOS HOSPITAL

TO THE

INTERNATIONAL COOPERATION ADMINISTRATION, ATHENS, GREECE

We would like to inform you that the "EVANGELISMOS" Hospital is the largest one in our Country, having a capacity of 1200 beds. It has been operating since 1884 and now includes all departments of Medical Science.

The Hospital's Radiotherapy Department has been functioning since 1923 and more than 80 cases of malignant tumours are being treated daily with the aid of two 250 kv machines of the conventional type.

The development of Physics and Technology have brought about the creation of new aids for the treatment of malignant diseases, such as the 1000 to 2000 kv supervoltage machines and the other radiating sources (Co 60 etc), which prove the utter inadequacy of conventional units.

With a view to modernizing the Hospital's Radiotherapy Department, you are hereby kindly requested to finance the procurement of 2000 kv "Van de Graaff" unit.

Hereinafter are given full details regarding the purpose of the unit, the reasons which have urged us to choose a "Van de Graaff" unit (Numbers refer to bibliography), the building, the operation and maintenance of the unit, and the names of American specialists who can be consulted on the suitability and therapeutic value of the unit.

1. PURPOSE

a. Patients will have at their disposal all that modern radiotherapy can offer, free or at a reasonable cost according to Greek standards.

b. When the unit is not in use for treatment, it will be available to Greek Doctors and Radiophysicists for training in radiation problems.

c. The University of Athens, the Technical University, the Royal Institute of Research, etc. as well as the Hospital's Medical Staff, will be able to utilize the unit for research.

## II. SELECTION OF THE UNIT

The 2 Mev "Van de Graaff" unit is preferred inasmuch as it costs less than other resonance transformers of similar output, and possesses the following advantages over other nuclear machines using Co60.

1. Well-defined limits of the irradiated field because the radiating source is only about 2mm in diameter, i.e. it is approximately 10 times smaller than that of the Co60 source, resulting in the elimination of the penumbra. Thus, the irradiation of adjacent healthy tissue is avoided.1.

2. Accurate determination and checking of the position of the field by taking double exposure radiographs.3,4. The area of the image, corresponding to the irradiated field, is darker because it is exposed two times to the X-ray beam. In this way, the radiologist can decide a change in the shape, size or position of the field. Thereafter, a second confirmative radiograph is taken. The plates are then kept in the patient's file and may be used in future as ample proof of the treatment applied. Such accurate radiographs cannot be produced by a Co60 machines because of the large size of its radiating source.

3. The output of the "Van de Graaff" unit, which is high and of constant intensity, permits the utilization of large fields (up to 40x40 cm) by increasing the patient-to-unit distance, but without undue increase of exposure time.4. Thus the problem of overlapping irradiation, which arises when small fields are used, is practically overcome.

4. The field can be given any desirable shape by placing blocks of heavy metal in front of the unit's defining window. The fact that the source is small, while the space between unit and patient is large, makes this technique successfully applicable when using a "Van de Graaff".4.

5. Protection of radiosensitive organs (spinal cord, eyes, etc.) in rotational therapy. This technique, invented and applied at the M.I.T. by the Physicist Basil Proimos - who is to be our colleague in future - provides the possibility to protect any sensitive organ while treating the region around it to the full dose.2,4. This method cannot be successfully applied when using a Co60 machine, owing to the largeness of its source.

6. When the "Van de Graaff" is manufactured in such a way as to be readily convertible, it can be used as a cathode ray machine, which cannot be done in the case of Co60 units. Such conversion can be made by removing the gold target and allowing the stream of electrons to flow freely from the machine without becoming X-rays. Thus converted, the unit can be utilized as follows:

a. Cathode ray treatment of extensive superficial tumours. This is because the distribution of ionisation in depth proves that cathode rays are the best kind of radiation for the treatment of such tumours. For instance, in the case of 2 Meg cathode rays, ionisation reaches its maximum at a depth of a few millimeters under the surface of the skin and is eliminated at the depth of about 1 cm, i.e. neither the skin nor the underlying healthy tissue is affected or destroyed. The depth of irradiation is adjusted according to the depth of the tumour by regulating the voltage of the machine.5,6,7.

b. Cathode rays can also be used for sterilization. Without increasing the temperature, surgical sutures, bones and blood-vessels used in transplantations can be sterilized by applying a dose of $1 \times 10^6$ up to $2 \times 10^6$ Rad. Drugs and food are sterilized in the same manner.8,9.

7. Being a point source of penetrating X-rays, the "Van de Graaff" can be used in industry for making radiographs of heavy metal objects whose internal structure must be checked as to the existence of air-bubbles and other defects; a question of vital importance. In spite of the aforementioned advantages of the "Van de Graaff", preference is usually given

to the Co60 machines owing to their simplicity in construction and operation. On the contrary, the "Van de Graaff" unit is more complicated and requires to be maintained by a specialist. However, we have overcome this difficulty by engaging Mr. Basil Proimos, Physicist-Engineer, who has received special training at the M.I.T. for three years.

BIBLIOGRAPHY

1. Comparison of 2 Mev "Van de Graaff" and Co60 machines. Temple University Medical Center Philadelphia Pennsylvania.
2. Field Shaping and Selective Protection in Megavolt Radiation Therapy. Kenneth A. Wright, Basil S.Proimos et all Radiology Vol 72 No I pp 98-107 Jan. 1959
3. Treatment of Tumors of the Pelvic Cavity with Supervoltage Radiation. Hugh Hare M.S. et all.
4. Physical Aspects of two million volt X-ray Therapy. Kenneth Wright, Basil S. Proimos, John G. Trump. The Surgical clinics of North America. June 1959 W.B. Saunders Co vol 39 No 3.
5. Physical Aspects of Megavolt Electron therapy K.A. Wright et all Radiology vol 67 No 4 pp 553-560 Oct. 1956
6. High Energy Electrons for the treatment of Extensive Superficial Malignant Lesions. John G. Trymp et all MIT and Lahey clinic Boston.
7. High Energy Electrons for Generalized Superficial Dermatoses John Fromer, Magnus Smedal et all. A.M.A. Archives of Dermatology March 1955 vol 71 pp 391-395.
8. Electron - Irradiated and Freeze - Dried Arterial Homografts Annuals of Surgeary vol 147 No 4 April 1958.
9. Sterilization of Preserved Bone Grafts by High Voltage Cathode Ray Irradiation J.G. Trump et all M.I.T. The Hournal of Bone and Joint Surgery vol 38 - A, No 4 pp 862 - 884 July 1956.

III. BUILDING

The "Evangelismos" Hospital will allocate the plot and the expenditure required for the erection of a building suitable to house the "Van de Graaff" unit. The building will comprise the following:

a. Waiting room.
b. Patient checking room with four small closets for the patients to dress and undress.
c. Examination and preparation room.
d. Treatment room of suitable dimensions and with walls, ceiling and floor of appropriate thickness for the protection of the medical staff.
e. Doctor's office equipped with radiograph viewing apparatus, wherein the patients or their relatives can talk inprivacy with the therapist.
f. Physicist's office equipped with blackboard, wherein doses will be computed and new devises and techniques will be studied, etc.
g. Darkroom equipped with proper apparatus for the development of radiographs.
h. Small room equipped with bench and tools, for local repairs. Bottles

## IV. OPERATION AND MAINTENANCE

The staff responsible for operation and maintenance will be the following:

1. Panaghiotis D. Georgakopoulos, M.D.
   Doctor of the University of Athens - Special Surgeon and expert Radiologist trained at the Royal Marsden Hospital of London, at Erlangen, Germany, and at the Radium Hemmet, Stockholm. He has published about 30 papers relating to radiotherapy, amongst which:

   a. X-ray treatment of Hodgkin's disease.
   b. X-ray grid therapy.
   c. The importance of X-rays in the treatment of chordoma.
   d. Current concepts regarding the treatment of Ca of the breast.
   e. Reticuloenthotheliosis and its treatment with X-rays.
   f. X-ray treatment of lymbosarcomas.

The Hospital intends to send Dr. Georgakopoulos or someone else from his staff to the U.S.A. for six months' training on the operation of the "Van de Graaff" unit.

2. Basil S. Proimos, Mechanical-Electrical Engineer, Graduate of the Athens Technical University. Master of Science M.I.T. His Master's Thesis was on the subject: "Modification of SR 90 Emission for superficial therapy". An abstract thereof will be published in the British Journal of Radiology.

For three years he has been working as Physicist in the MIT laboratory concerned with the use of "Van de Graaff" machines in the treatment of deep and superficial tumours, as well as in the sterilization of products used in Pharmacy and Surgery. He has invented and developed the previously described method of synchronous protection in rotational therapy, as well as another method of synchronous rotational therapy which is under development and will be published in the american magazine "Radiology".

3. Miss L. Inglezi, M.D. - Radiologist
   Staff member of the radiotherapy department of our Hospital. She has received two years' training in the USA, andhas published several papers.

4. Special X-ray technician who will be engaged and trained on routine treatment procedures, taking and development of radiographs, etc.

5. One nurse.

Staff salaries and maintenance expenses will be met by the Hospital.

## V. PERSONS TO BE CONSULTED IN THE USA

1. HUGH F. HARE, M.D. Former Radiologist in Chief of Lahey Clinic in Boston. Now Radiologist of the tumor Institute Los Angeles. He first used supervoltage machines in rotational therapy. Now he is using two "Van de Graaff" there [illegible]

2. MAGNUS I. SMEDAL M.D. Radiologist in Chief of Lahey Clinic. He is using two "Van de Graaff" machines of 2Mev for therapy of deep tumors and one 4Mev for cathode ray therapy.

3. John G. TRUMP, Sc. D. Professor of Electrical Engineering and Director of the High Voltage Research Laboratory of M.I.T., Cambridge.

4. WILLIAM W. BUECHNER Sc. D. Professor of Physics M.I.T. Cambridge. He is using a 9 Mev Vande Graaff for nuclear research.

5. KENNETH A. WRIGHT M.S. Physicist at M.I.T. Specialist in Sterilization of grafts, bones etc. in therapy of deep and superficial tumors.

6. JOHN H. TEETER Director of Damon Runyon Memorial Fund for Cancer Research. 730 Fifth Ave. New York 19, N.Y.

It will be greatly appreciated if you will kindly undertake the expenditure required for the purchase of a 2000 Kv "Van de Graaff" unit, readily convertible for the production of cathode rays. The cost of this unit, together with its rotating table and installation expenses in Athens, amounts to approximately $70,000.

Being under the Protection of Her Majesty the Queen of the Hellenes, the "Evangelismos" Hospital has a very comprehensive social mission. Therefore, the possession of such a valuable piece of equipment will be of tremendous significance for our Country.

Sincerely yours
The President

Prof. S.Andreadis

HIGH VOLTAGE ENGINEERING CORPORATION

BURLINGTON · MASSACHUSETTS

TELEPHONE
BROWNING 2-1313
CABLE - HIGHVOLT

October 2, 1959

Professor Elias P. Gyftopoulos
Massachusetts Institute of Technology
Bldg. 10-179
Cambridge, Massachusetts

Dear ~~Professor Gyftopoulos~~: Eli 175

Attached is a copy of a letter which was sent to

Professor Dr. Symeonides at the University of Salonika.

Very truly yours,

Bob

Robert P. Gow
Export Division

RPG:jw
Enc.

Dont I write nice letters. ??

COPY

October 1, 1959

Professor Dr. Symeonides
Professor of Medicine
University of Salonika
Salonika, Greece

Dear Professor Symeonides:

Having learned of your interest in Supervoltage Therapy equipment we are happy to send you the enclosed information on the latest model Van de Graaff accelerator.

There are some thirty-five of these units installed in major cancer therapy centers throughout the world including MacWhirter's in Edinburgh and Palmieri's at Bologna, and we believe, as do many others, that these machines are the finest available anywhere for this application.

As you are well aware, the prime difference between Cobalt $^{60}$ and accelerators is the focal diameter of the source or spot, and the roentgen output at a 100 cm T.S.D. The small spot size in machine made radiation permits the utmost precision to be utilized in illuminating a given field; there is no gross penumbra and the integral or body dose can be held to a minimum; protective devices can be interposed between the target and the patient to shield major or radiosensitive organs, even when the area to be protected is small in size and adjoins or is part of the desired treatment field. In many cases, the ability of the radiologist to deliver a tumoricidal dose will be determined by how well he can shield the medulla, the lungs or the lens of the eyes. Because of the penumbra region in Cobalt$^{60}$ sources, such shielding is either impossible or only partially effective.

The high roentgen output is significant when sophisticated treatment fields are contemplated, for routinely these are made by shaping the field with lead blocks which are placed between the target

and the patient. To do this, T.S.D.'s of 100 cm or 125 cm must be used to avoid secondary electron contamination of the skin, (by the electrons knocked off the shaping mechanisms by the energetic gamma radiation). Where the roentgen output is nominal (i.e. 30 r/min. at a meter) then the length of time the patient must be kept in position in front of the source becomes excessive.

However, it is in major therapy centers that the accelerator becomes a prime requirement, for it is only with machine made radiation that the therapist has the ability to treat a great many patients daily and still give each the personalized treatment which his skill and experience say is necessary. Accelerators are a source which one starts and shuts down. There is no wasted radiation as with the isotope, and they are dependable. In England we have several Van de Graaff's which were installed ten years ago, still treating fifty patients daily!

Because of the geography involved, we would offer the following:

On the enclosed Pro-Forma Invoice we have quoted a 2 Mev Van de Graaff Particle Accelerator for supervoltage therapy F.O.B. our Burlington, Massachusetts plant.

In this price are included:

a) All spare components, with the exception of the main accelerator tube (which carries its own warranty), for a period of two years from final acceptance test of equipment in purchaser's vault.

b) Supervision of installation in Purchaser's vault by a Test and Installation Engineer from High Voltage Engineering Corporation.

c) High Voltage Engineering Corporation will arrange for the training of a radiologist from the Purchaser's establishment, in the latest therapy techniques and applications of the accelerator, at the Lahey Clinic -- M.I.T. research facility at the Massachusetts Institute of Technology at Cambridge, Massachusetts, U.S.A., such training period to be for eighty (80) days. High Voltage Engineering Corporation will transport to and from Salonika, by a first-class air passage, said Radiologist and pay him a nominal daily subsistance rate for the entire training period.

d) High Voltage Engineering Corporation will also arrange for the training of a technician selected by the Purchaser in the operation and maintenance of the Van de Graaff accelerator, such training to be given at High Voltage Engineering Corporation's plant at Amersfoort in Holland, and to be for a period of four weeks. Daily subsistance and a first-class air passage for this technician to and from Salonika are included in the purchase price.

This offer is made so that not only will the University have an accelerator, but it will have a Radiologist trained in its use and an operator or technician fully competent to do the routine maintenance as it is required.

When you have had the opportunity to read and evaluate this letter and its enclosures, I will be happy to answer any questions you may have. I trust too, that if there is any manner in which I may assist you or any of the members of your staff, you will not hesitate to call upon me, for I am delighted to be of service.

Very truly yours,

Robert P. Gow
Export Division

RPG:jw

Encl: 2 Copies Bulletin M-3
*Medical Reprints
1 Pro-Forma

*Comparison of Teletherapy Unit & Generator
Effect of Cathode Rays
Electron-Irradiated Arterial Homografts
Evaluation of 45-Mev Electron Accelerator
Four Mev Linear Accelerator at Newcastle
Investigation of Radiography
Nucleonics
Performance of 8 Mev Linear Accelerator
Physical Aspects of X-Ray Therapy
Radiation Therapy for Bronchogenic Carcinoma
Resistances of Microorganisms to Cathode Rays
Rotational Scanning with Supervoltage Radiation
The Stanford Medical Linear Accelerator (4) I. II. III. IV.
Superficial "Burns" of Skin and Eyes
Therapy of Malignant Lesions
Treatment of Cancer

PRO-FORMA INVOICE NUMBER HV-1776

October 1, 1959

To: University of Salonika
Salonika, Greece

Attention: Professor Dr. Symeonides

| Item No. | Quantity | Description | Price |
|---|---|---|---|
| 1 | 1 | 2 Mev Van de Graaff Accelerator Model M2-M for supervoltage therapy as per the specifications outlined on page 4 of the enclosed Bulletin M-3------ | $65,700 |

This Sales Price includes:

a) All spare components for a two year period beginning from the date of the final acceptance of the accelerator by the Purchaser. This does not include the main accelerator tube which is guaranteed pro-rata for 1000 hours of tube life or two years, whichever comes first.

b) Supervision of the installation in the Purchaser's vault by a fully qualified installation engineer from High Voltage Engineering Corporation.

c) The transportation by first-class air, of a Radiologist selected by the Purchaser, from Salonika to Boston, Massachusetts return, to be trained in therapy techniques and application at the Lahey Clinic, Massachusetts Institute of Technology research facility. This training period will be for eighty (80) days, and during this time High Voltage Engineering Corporation will pay the said Radiologist a daily subsistance allowance.

d) The transportation by first-class air of a technician selected by the Purchaser, from Salonika to Amersfoort, Holland return. This man to be trained at the Amersfoort plant of HVEC in the operation and routine maintenance of the Van de Graaff accelerator. The training period will be for a four-week period and during this time a daily subsistance payment will be paid by High Voltage Engineering Corporation.

Terms: Net, f.o.b., High Voltage Engineering Corporation, Burlington, Massachusetts, U.S.A.; subject to our Standard Conditions of Sale on reverse side of page 1.

Confirmed irrevocable letter of credit for sight draft of total price of apparatus, payable in U.S. currency to accompany order. Payments will be withdrawn from the bank on sight draft according to the schedule under Payments below. All sales are subject to approval for export by the United States Department of Commerce.

Payments:

1. 30% of net purchase price as down payment to accompany order;

2. 30% of net purchase price upon certification from High Voltage Engineering Corporation of the completion of the mechanical assembly of the Van de Graaff generator voltage source;

3. 30% of net purchase price upon certification from High Voltage Engineering Corporation of the satisfactory completion of the factory tests of the entire accelerator to specifications;

4. 10% of net purchase price upon certification of the shipment from High Voltage Engineering Corporation plant in Burlington, Massachusetts, U.S.A.

Shipping Estimate: Within 8 months from receipt of letter of credit, subject to prior sale and to governmental materials allocations or similar restrictions.

Robert P. Gow
Export Division

RPG:jw

6/30/58

# COST COMPARISON

| | Van de Graaff M-2 | 1-1/2 cm Source 20R/1M |
|---|---|---|
| **Capital Cost of Typical Installation** | | |
| Source | $52,000. | $32,900. |
| Therapy Vault (Van de Graaff 16'x20'x15' at $4/cu ft ) | 19,200. | 15,360. |
| Cobalt-60 16'x20'x12' ) | $71,200. | $48,260. |
| **Annual Cost** | | |
| 5 year amortization cost/year | $10,400. | $ 9,650. |
| Maintenance cost/year[1] | 4,570. | 1,100. |
| | $14,970. | $10,750. |
| **Radiation Output** | 85R/min/at 1 meter | 15R/min/at 1 meter[2] |
| **Treatment Capacity** | | |
| 10 cm depth dose (57% Van de Graaff 58% Cobalt-60) | 48.4 R/min | 8.7 R/min |
| Treatment time for a 200R tumor dose | 4.2 mins | 23 mins |
| Patient setup time | 10 mins | 10 mins |
| Total Treatment Time | 14.2 mins | 33 mins |
| Number of patients who can be treated in a 2,000 hour year allowing 33 mins/treatment for Cobalt-60 and 14 mins/patient for Van de Graaff | 8,500 trtmts. | 3,636 trtmts. |
| Cost/Treatment balanced against yearly cost of equipment | $14,970. / 8,500 (# trtmts.) | $10,750. / 3,636 (# trtmts.) |
| Cost per Patient | $1.76 | $2.95 |

1 The yearly maintenance costs for the Van de Graaff have been determined by assuming that High Voltage Engineerings Service Contract has been purchased, and the Main Accelerator Tube will only supply the number of hours for which it is guaranteed.
On this assumption, a further 2,000 tube hours will have to be purchased for a total cost/year of $3,250. The yearly Service Contract costs $1,320. for a grand total of $4,450/year.
We have given only the source replacement costs for the Cobalt-60 unit as maintenance dollars. Of course, from day to day maintenance is also required for Cobalt-60.

2 Estimating 3/4 maximum output from the Cobalt source over 5 years.

Source: 5,600 curies specific activity 50 2 cm diameter stacked 4 cm high.
Estimated output 3,240 rhm or 54R/meter.

Cost of Source: At $5/curie $28,000.) $64,000.
Mount: Cobalt Mfg. Mount $36,000.)

| | Van de Graaff M-2 | Cobalt-60 |
|---|---|---|
| Capital Cost of Typical Installation | | |
| Source | $52,000. | $64,000. |
| Therapy Vault (Van de Graaff 16'x20'x15' at $4/cu ft ) | 19,200. | 15,360. |
| Cobalt-60 16'x20'x12' | $71,200. | $79,360. |
| Annual Cost | | |
| 5 year amortization cost/year | $10,400. | $15,872. |
| Maintenance cost/year | 4,570. | 5,600. |
| | $14,970. | $21,472. |
| Radiation Output | 85R/min/at 1 meter | 36R/min/at 1 meter * |
| Treatment Capacity | | |
| 10 cm depth dose (57% Van de Graaff 58% Cobalt-60) | 48.4 R/min | 20.8 R min |
| Treatment time for a 200R tumor dose | 4.2 mins | 9.6 mins |
| Patient setup time | 10 mins | 10 mins |
| Total Treatment Time | 14.2 mins | 19.6 mins |
| Number of patients who can be treated in a 2,000 hour year allowing 33 mins/treatment for Cobalt-60 and 14 mins/patient for Van de Graaff | 8,500 trtmts. | 6,122 trtmts. |
| Cost/Treatment balanced against yearly cost of equipment | $14,970. / 8,500 (# trtmts) | $21,472. / 6,122 (# trtmts.) |
| Cost per Patient | $1.76 | $3.50 |

* Estimating 2/3 maximum output from the Cobalt source over 5 years.

# OPERATIONAL COMPARISON

## ECONOMICS

### Operating Cost

| | | | |
|---|---|---|---|
| Depreciation | $14,000. | | |
| Maintenance (Contract) | 2,500. | | |
| Tube 1-1/2 years | 5,400. | | |
| Interest Loan at 5% | 1,800. | | |
| Personnel - Nurse | 4,000. | 330 | 4000 - 4000 |
| Technician | 4,000. | 330 | 4000 600 |
| Radiologist | 20,000. | 1650 | 30000 |
| Power, Light, Heat | 520. | | |
| X-ray film, records | 3,000. | | |
| Cleaning, etc. | 725. | | |
| | $55,945. | | |

### Income

Number of patients per day -- 30
Charge per patient -- $10.
Income per year -- $75,000.
(50 weeks)

### Return

| | |
|---|---|
| First five years | $19,055. |
| Thereafter | 34,855. |

## COST OF FACILITY --- 2-MEV THERAPY VAN DE GRAAFF

| | |
|---|---|
| Machine | $52,000. |
| Installation (A) | 1,500. |
| Treatment room | 20,000. |
| Accessories (B) | 6,500. |
| | $80,000. |

Amortization -- 5 years 16,000. per year

| | |
|---|---|
| Bank Loan | 60,000. |
| Hospital Payment | 20,000. |
| | $80,000. |

Average Interest at 5% = $1,800. per year

NOTES:

A

| | |
|---|---|
| Freight | $ 600. |
| Rigging | 200. |
| Installation | 700. |
| | $1,500. |

B

Includes $6,000. for rotating chair

November 25, 1958

SUBJECT : Notes on the Van de Graaff for Professor E. Gyftopoulos, M.I.T.

(1) 2 Mev is in the right energy range if onelooks at the curve on bone, fat, and tissue absorption.

(2) The Van de Graaff has been designed to give a wide spectrum of optimum values to the radiologist at the lowest possible cost. These include, --very high roentgen output--very small focal spot diameter--ease of alignment--simplified controls--dependable operation--good depth dose figures.

(3) The roentgen output at a meter is guaranteed to be 75 r/min. In our latest tubes in test this is up to 94 ± 4 r/min at a meter. High output means (a) lower patient treatment time, (b) greater patient capacity, and (c) the ability to treat beyond 100 cm. In this latter advantage, as you know, if the treatment distance is increased then the depth dose becomes better (higher) but the application of the inverse square law decreases the output. This really means that you can't do it with Cobalt (because of the low output) without giving very long treatment times.

(4) The focal spot size is guaranteed to be no greater than 4 mm diameter. Usually its about 3 mm. It is, to all intents and purposes, a point source and Van de Graaff users are never involved in questions of gross field penumbra. Where the penumbra is large (anything from 8 mm to 2 cm) and the field is small (in children, for instance), then it is conceivable that there will be more radiation in the penumbra region than in the field itself. This is graphically illustrated on page 3 of our Bulletin M-2. Moreover, with large penumbra, very sophisticated beam shielding, and shaping, is not practical, and tumors located around the eyes, for instance, will have to receive routine treatment.

(5) With a Van de Graaff beautiful radiographs of a diagnostic type can bemade. This technique enables the therapist to see physically where the beam is passing through the tissue and to correct his alignment of the beam with regatds to the anatomical detail. While radiographs have been made with Cobalt-60, they are unquestionably much poorer in detail, and lack the preciseness which is characteristic of the small focal spot accelerators.

(6) The Van de Graaff is mounted pneumatically in a structure which utilizes all the recognized safety features. It can be raised and lowered, it can be tilted from 10° beyond the vertical to 10° above the horizontl. In operation it is very nearly noiseless and aligns itself smoothly and accurately from the hand control.

(7) The radiation control console has been designed for accuracy and simplicity. We have specifically stayed away from the flashing lights etc. of the more elaborate systems, and we have aimed at providing all that is necessary for precise control and nothing else. This, too, is illustrated and described in Bulletin M-2.

(8) Maintenance is required but it is nominal and can be performed routinely where the accelerator is not required clinically. It can be done by the hopital, or the establishment's electrical staff. The main accelerator tube is guaranteed for 1,000 hours pro-rata (we expect at least 1,500) and costs $6,500.00 to replace.

(9) The beam defining mechanisms permit fields of 25 cm x 25 cm or 30 cm x 14 cm to become available at a meter. By the use of the beam shaping fixtures, a wide variety of squares, circles, and rectangles are then readily and easily available. These are so made that less than 1% of the beam "escapes" in the forward direction.

(10) The 10 cm depth dose on a 10 cm x 10 cm field at a meter is 58%. At 125 cm it is about 60% and the output is then about 38 r/min.

(11) The cost installed in Greece is $58,700.00, plus the round ticket transportation charge to the Customer's site, for one of High Voltage Engineering Corporation Installations Engineers to supervise installation and acceptance tests.

The linear accelerator has all the above advantages. It is mounted in the same type of mount, uses the same type of beam defining system (modified for 6 Mev), and has a similar radiation control system.

In addition to these, it is variable in energy from 2 Mev to 7.5 Mev and has an optimum output of 200 r ± 20/min at a meter after filters have been used to "flatten" the field.

This equipment has been designed to give the utmost in clinical dependability. The power amplifier is rated for 5 mw. We are using it at 3 mw. The waveguide sections have been run at 15 Mev, we are using them at 6 Mev. In effect, the accelerator is operating far below its capacity.

The waveguide tube is completely sealed off during operation. This is done by mounting dual ion pumps for the exhausting of evolved gases. One pump will be used at a time. When it becomes necessary the second will be cut in. When both are saturated (or the accelerator filament requires changing), they can be removed and by replacing the ion pump filament made as good as new. The system is metal gasketed and there areno moving parts. This is a beautiful

system and means that the user will never be involved in the replacement costs of a sealed-off tube.

The Linac can be supplied with the ability to give 2 - 6 Mev electrons. This would mean an electronically-operated target.

| | |
|---|---|
| 6 Mev Linac without electron window | $107,800.00 |
| 6 Mev Linac with electron window | $118,800.00 |

These prices again do not include transportation charges for one of our Installation Engineers.

RPGow:td
Enclosures:
Pro-Forma Invoices HV-1408/9/10
Bulletin M-2
Specifications LS-7A1-108M, 2 copies