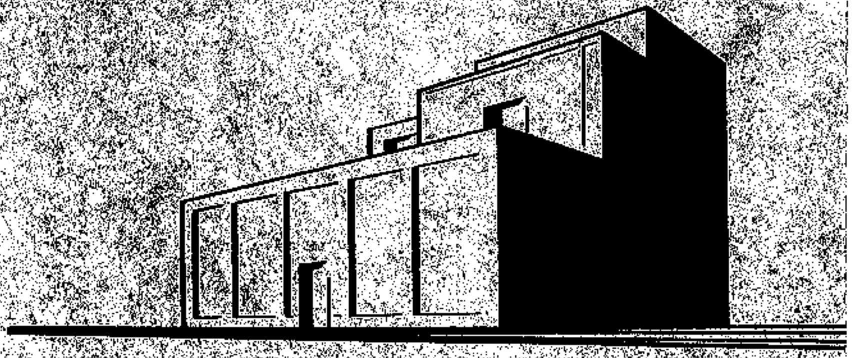
THE . . .

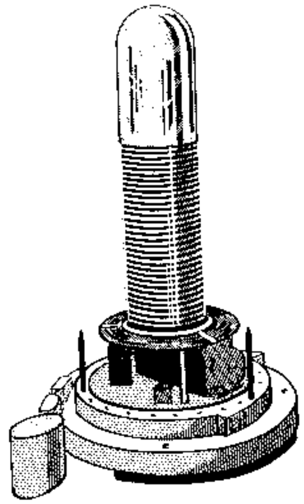
Van de Graaff

ACCELERATOR



U.S. NAVAL RADIOLOGICAL DEFENSE LABORATORY

SAN FRANCISCO 24 CALIFORNIA



USNRDL VAN DE GRAAFF

This booklet is designed to present a brief description of the U S N R D L facilities housed in Building 816. The principal item of equipment in this building is a two million volt (2 Mev) Van de Graaff electrostatic generator, an accelerator capable of producing very stable and easily controlled beams of electrons, protons, deuterons, tritons, neutrons, and x-rays. The name of Van de Graaff is derived from that of Dr. Robert J. Van de Graaff, of MIT, who developed the first such accelerator in 1931. The NRDL instrument is capable of producing an x-ray beam having an intensity greater than that from 1500 grams of radium (if it were possible to accumulate this quantity of radium, this being more than 3/5 of the total available world supply).

This is not a unique facility. Because of the precision, versatility, and basic simplicity of the Van de Graaff accelerator, many of the principal research laboratories throughout the world have these machines actively in use. Our Van de Graaff is one of over 40 such units designed and built by the High Voltage Engineering Corporation of Cambridge, Mass. for various laboratories, universities, and hospitals in the United States, England, France, and Mexico.

The Van de Graaff is only one of many types of accelerators, among which are Cockcroft-Walton generators, linear accelerators, cyclotrons, synchrocyclotrons, and synchrotrons. These devices produce particles whose kinetic energies range from a few hundred kev to over a billion electron volts (the cosmotron at Brookhaven and the bevatron at the University of California Radiation Laboratory).

A LONG FELT NEED

The idea of obtaining a high voltage accelerator for USNRDL is almost as old as the Laboratory itself. In the early stages of establishment of the Laboratory, serious concern was felt in regard to the lack of irradiation facilities for evaluation of radiac instruments. Determination of an instrument's ability to assess radiation hazards was, and is, a very important part of USNRDL's mission. Although contracts were let by the Navy for instruments designed to measure high intensity fields of ionizing radiations, no suitable sources were available for testing these instruments at a variety of energies in such radiation fields.

In June 1947 the first letter of inquiry was written to Dr. Van de Graaff. This brought referral to the High Voltage Engineering Corporation, manufacturers of electrostatic generators. Obtaining exactly the facility desired involved considerable investigation. The request for a 2 Mev Van de Graaff was finally made and approved, and the order placed for the $150,000 machine that required approximately a year to build.

WHY A VAN DE GRAAFF?

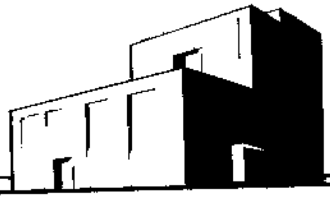
The Van de Graaff was chosen as the NRDL accelerator in preference to the many other types of available sources of nuclear radiation for several reasons: (1) it is a source of nuclear radiations within an energy range and having suitable intensities for much of the research being conducted at USNRDL; (2) the cost is lower than any other means of producing all the desired radiations; (3) it will emit radiations at the will of an operator; (4) the beam voltage can be held constant to better than 0.1%; and (5) it is commercially available, thereby eliminating the economic and experimental uncertainties of a developmental program. There are other sources of nuclear radiation which meet one or more of these requirements, some of which might be better instruments for particular laboratory programs. However, the Van de Graaff seems to be the accelerator best suited for the largest number of laboratory requirements.

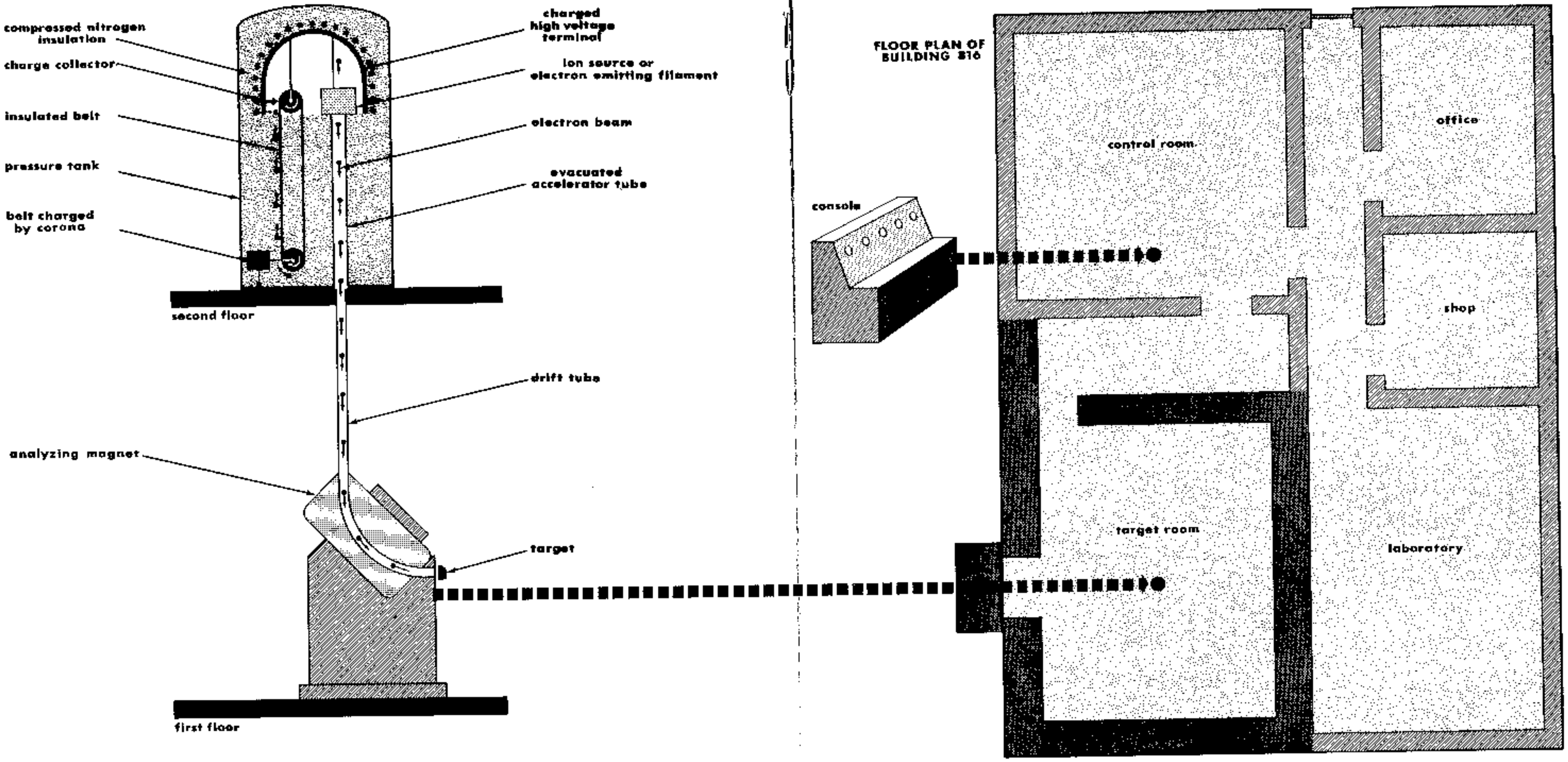
HOW THE VAN DE GRAAFF WORKS

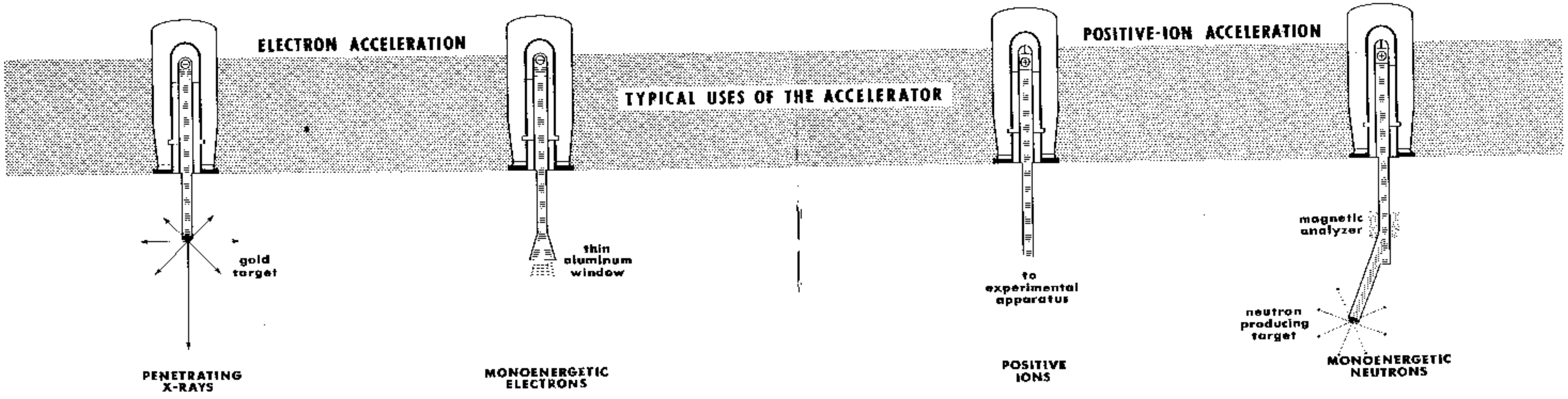
The accelerator itself is located on the second floor of Building 816. While most modern accelerators use a relatively small accelerating voltage, and apply this voltage in successive steps to the particle being accelerated until the particle reaches very high energies, the Van de Graaff actually utilizes high voltage directly. When the Van de Graaff is accelerating particles to an energy of 2 Mev, there is actually a potential of two million volts on the terminal at the top of the machine. This voltage is maintained by an insulating belt which carries electric charge to a charging comb within the terminal, as pictured in the diagram on the following page. Such voltages cannot be maintained in moist air at normal atmospheric pressure, so the whole system is enclosed in a gas-tight shell, within which, during operation of the Van de Graaff, is maintained an atmosphere of compressed nitrogen.

Electrically charged particles are made available for acceleration from a heated filament (for electrons) or a gaseous discharge (for protons and other positive particles) which are controlled by specially constructed apparatus within the high voltage terminal. A glass and metal tube, within which a very good vacuum is maintained, provides the only path for charged particles to escape from the high voltage end of the machine.

These particles are accelerated to extremely high velocities in the direction of the floor of the building. These particles have reached their maximum velocity when they leave the Van de Graaff itself. The evacuated tube, however, continues through the ceiling of the electromagnet target room directly below the accelerator room. There they may be deflected by an electromagnet onto specifically designated targets or they may move straight down the tube and bombard a target near the floor. Since x-rays and neutrons have no electric charge of their own, they cannot be accelerated within the machine. They are produced through the bombardment of special targets by protons, deuterons, or electrons.




compressed nitrogen insulation
charge collector
insulated belt
pressure tank
belt charged by corona
second floor
charged high voltage terminal
ion source or electron emitting filament
electron beam
evacuated accelerator tube
drift tube
analyzing magnet
target
first floor
FLOOR PLAN OF BUILDING 816
console
control room
office
shop
target room
laboratory


ELECTRON ACCELERATION
TYPICAL USES OF THE ACCELERATOR
POSITIVE-ION ACCELERATION
gold target
thin aluminum window
to experimental apparatus
magnetic analyzer
neutron producing target
PENETRATING X-RAYS
MONOENERGETIC ELECTRONS
POSITIVE IONS
MONOENERGETIC NEUTRONS

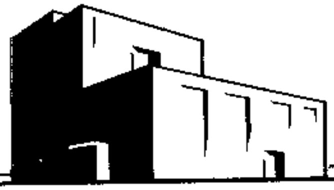
SAFETY FROM RADIATION

Of the various types of radiation produced by the Van de Graaff generator, neutrons and gamma rays are the most penetrating. The primary radiological safety problem is to control the external radiation exposure to personnel. In order to minimize the radiation exposure to personnel who are in or near the building, the target room is shielded with concrete walls three feet thick.

In addition to this shielding protection permanently mounted radiation detection devices are placed in various parts of the building to continuously measure the radiation levels. Portable radiation monitoring instruments are used to make detailed monitoring surveys whenever necessary.

During operation, all personnel entering the building are provided with film badges and pocket dosimeters that will accurately measure any radiation dosage that has been received. Routine processing of the badges is made, and in the event of radiological accidents, immediate processing to evaluate the degree of radiation exposure will be conducted.

For experiments involving radioactive solutions or targets capable of producing secondary contamination, air monitoring equipment is used to detect any possible airborne contamination, and special monitoring surveys are made to detect any removable contamination present due to spills or leakage. A hand and foot counter is available to facilitate checking for possible personnel contamination. Each new operating condition or experiment is carefully evaluated for any special radiation or health physics problems, and recommendations are made by Health Physics Division for minimizing possible radiological hazard to personnel.



ABOUT THE BUILDING

The Van de Graaff Building, #816, is a completely air conditioned, windowless, concrete structure, located adjacent to the new home of NRDL, Building #815. Its ten rooms are divided into two stories. The upper floor is reserved for the Van de Graaff accelerator itself, and to spaces for operation of building mechanics, such as ventilation and heating. The ground floor is devoted to a Nucleonics Division laboratory and control room which contains the console for controlling the operation of the generator; a chemical-biological laboratory; the target or analyzer room which is situated directly beneath the Van de Graaff; an office, machine shop, and two rest rooms. Cost of the building was approximately $300, 000, and maintenance is assigned to Administrative Department.

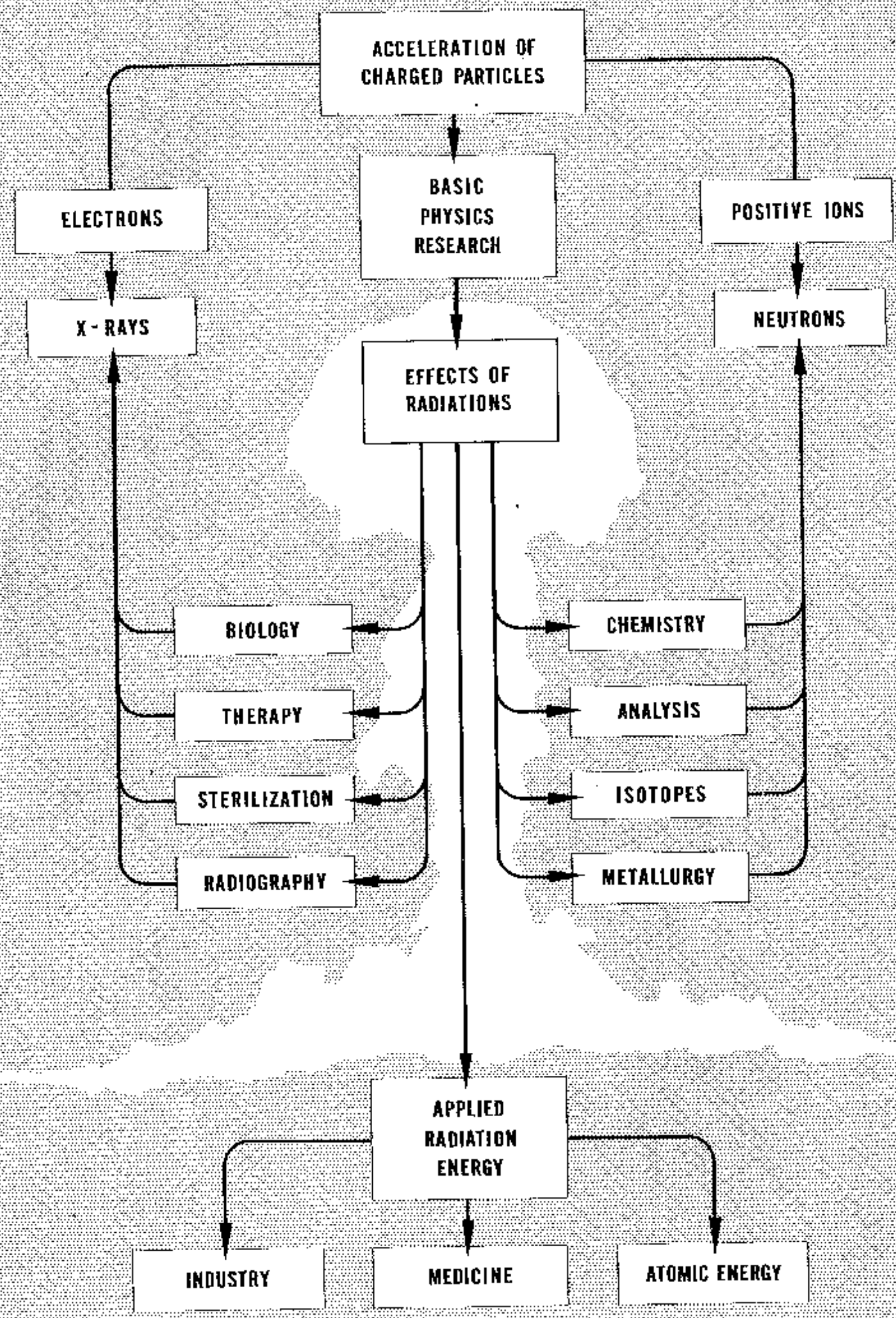
One of the unique features of the building is the 30-ton door at the south end. This door is 4 feet thick, and is operated by a remotely controlled hydraulic system. It will be used primarily for bringing in large equipment for experimental purposes. When open the door permits the adjoining closed area to be used as a 100-foot gamma-ray range.

AVAILABLE FOR ALL

Responsibility for the operation of the Van de Graaff, including planning, scheduling, and coordination of its use, is assigned the Scientific Department, and further delegated to the Accelerator Branch, Nucleonics.

Although initially intended for instrument evaluation, the generator will also be utilized by all the scientific divisions for approved programs. Use of the facility will be planned and arranged by the Van de Graaff Scheduling Committee.

Besides the instrument studies, current plans are to use the machine as a source of radiation for studies of damage to materials, studies of various artificially produced nuclear radiations, physical measurements of dosage produced by nuclear radiations, and many other interesting projects. Potential uses for the Van de Graaff are innumerable. The versatility of this generator is shown by a diagram on the following page.



ACCELERATION OF CHARGED PARTICLES
ELECTRONS
BASIC PHYSICS RESEARCH
POSITIVE IONS
X-RAYS
NEUTRONS
EFFECTS OF RADIATIONS
BIOLOGY
THERAPY
STERILIZATION
RADIOGRAPHY
CHEMISTRY
ANALYSIS
ISOTOPES
METALLURGY
APPLIED RADIATION ENERGY
INDUSTRY
MEDICINE
ATOMIC ENERGY