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CYCLOTRONS:**

BIOLOGICAL RESEARCH FACILITIES

Berkeley, California

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BIOLOGICAL RESEARCH FACILITIES

Robert L. Fulton, Lee R. Glasgow, and Nicholas W. Gianni

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MODIFICATIONS TO 88-INCH AND 184-INCH CYCLOTRONS:
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November 14, 1963

ABSTRACT

New biological research facilities and modifications at the 88-inch cyclotron, and modifications to the medical cave at the 184-inch cyclotron are described. Equipment at the 88-inch cyclotron includes a quadrupole magnet and various devices for beam monitoring, dosimetry, and subject alignment. Improvements to the medical cave at the 184-inch cyclotron include heavier shielding, hydraulic shielding door, 8-in. -diameter beam transport system, relocated control room, animal-rotator, and human-positioner translator.

INTRODUCTION

The increase in biological research at our Laboratory under the NASA Bioradiological Research program has necessitated certain facility improvements. Authority and funding for these improvements were given by NASA Purchase Order R41-Amendment 1, dated 23 March 1962, "Modifications to 88-inch and 184-inch Cyclotrons."

This report describes these modifications, which are nearly complete. Only the construction of a beam wobbler and portable biological laboratory for use at the 88-inch cyclotron remains to be done.

MODIFICATIONS TO 88-INCH CYCLOTRON

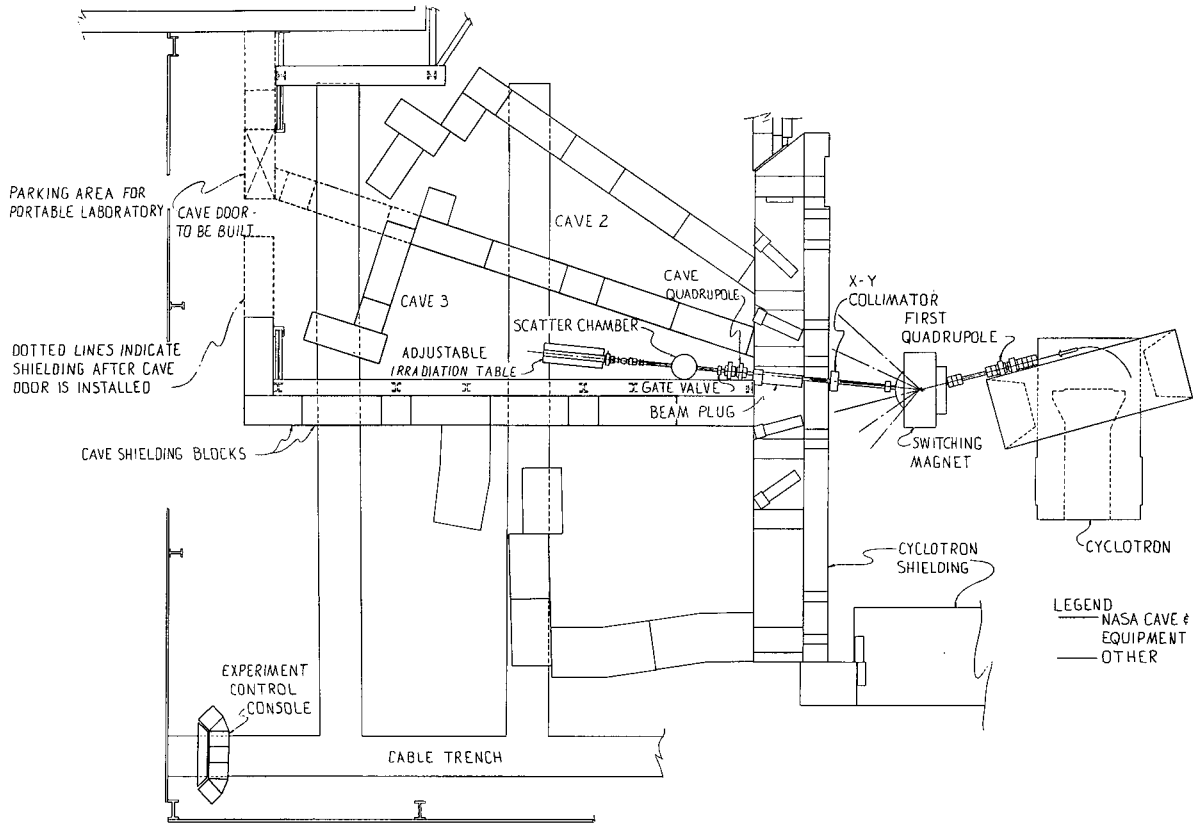
No facilities for biological research were included in the original plans for the 88-inch cyclotron so a cave and its related equipment had to be provided. The work included the following:

- (a) The cave
- (b) Cave equipment
- (c) Cave electronics
- (d) A quadrupole and beam optics
- (e) Cyclotron pulsing equipment
- (f) A portable biological laboratory
- (g) Central-nervous-system research equipment.

Cave

Cave 3 is the location for biological experiments and some nuclear chemistry experiments. Figure 1 shows the cave, beam plug, switching magnet, and cyclotron. The cave shielding is shown as it is temporarily installed, with the entrance via a maze at the rear. Dotted lines indicate the location of an electrically operated door which is to be installed early in 1964. With the installation of the door the maze will be removed and the cave enlarged to its final size. The door will service both caves 3 and 2 and will be interlocked with each cave's beam plug for safety. The beam plug cannot be opened unless the cave door is closed, and upon opening the cave door the beam plug closes.

The cave-wall shielding is 3 ft thick, the center 1 ft being steel and the rest ordinary concrete. The roof blocks are 2 ft thick, and of ordinary concrete.



MUB-2228

Fig. 1. General arrangement of cave 3.

Supply and return cooling-tower water is available in the cave for the quadrupole and for other uses. Compressed air is also available. A vacuum system, including a mechanical pump and piping, is installed in the cave for preliminary pumping of the beam tube before opening it to the main cyclotron tank vacuum.

Cave Equipment

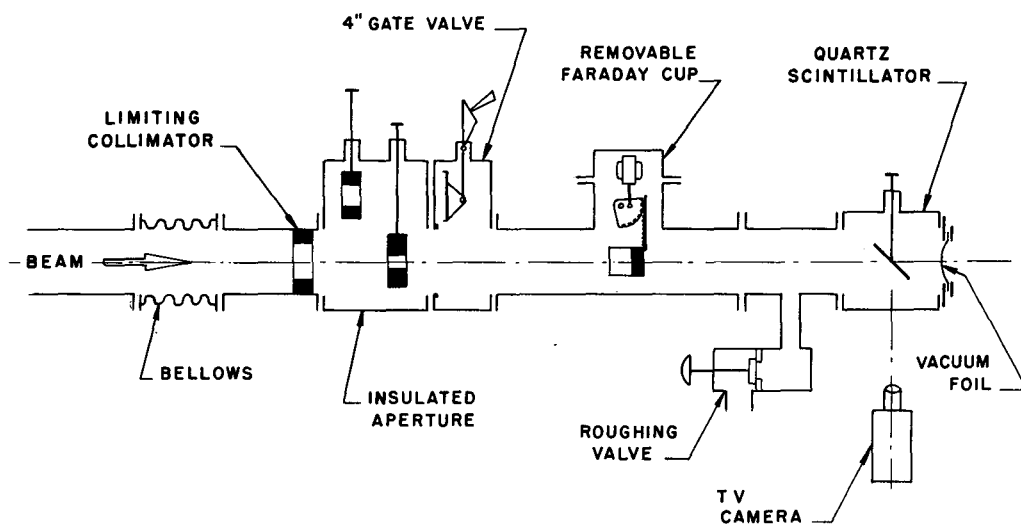
The main functions performed by the cave equipment are: (a) beam monitoring and control, (b) subject alignment, and (c) dosimetry and beam absorption and collimation.

There are a number of points along the beam path where beam current can be monitored by the cyclotron operators. These points are--starting at the cyclotron--the five-finger probe, X-collimator, X-Y collimator, insulated aperture, Faraday cup, and beam-defining aperture. The operators also have an assortment of other probes that can be inserted into the beam path at different points to locate the beam. Beam current can be read at the experiment console from the insulated aperture, Faraday cup, and beam-defining aperture.

The items forming the last of the beam tube are used to control and monitor the beam. They are shown schematically in Fig. 2. Arrangement of these units is flexible and can be set up according to the requirements of the experiment.

The insulated aperture is actually two graphite blocks, one with a 1-1/2-in. -diameter aperture and one with a 1/2-in. -diameter aperture. Either of these blocks, together with the limiting collimator upstream, prevents stray particles from continuing down the beam tube. The graphite blocks can be manually pulled from the beam path by their support shafts.

The removable Faraday cup is patterned after those in use at our Laboratory's Heavy Ion Linear Accelerator (Hilac) and is installed in a tee-section made of standard beam tube. The cup contains a graphite block thick enough to stop the most energetic particles available, and serves two purposes. Since the cup is electrically insulated the beam current can be read from the charge collected on it, thus allowing the cyclotron operators to "tune up" the machine by directing the beam at the cup. Also, the cup can be remotely removed from the beam path by a solenoid controlled from the experiment console, so that the cup can be used as a beam shutter.



MU-32616

Fig. 2. Schematic diagram of beam-tube equipment.

The quartz scintillator allows a quartz plate to be placed manually at a 45-deg angle to the beam path. The scintillation caused by the beam striking the quartz can then be observed by a television camera through a lucite port in the beam tube. This picture can be transmitted to the cyclotron control room for monitoring during tune-up.

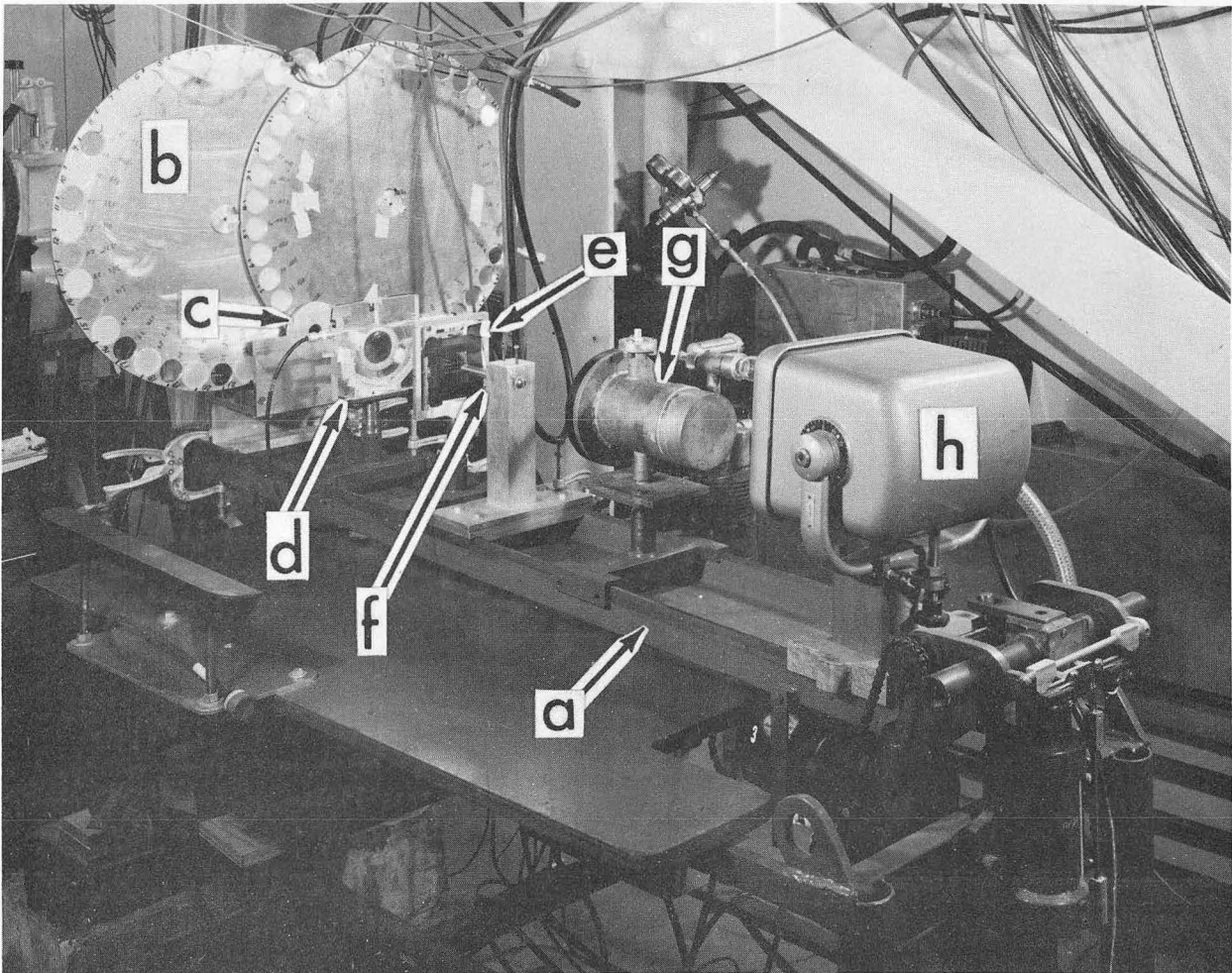
Alignment of the subject to be irradiated is accomplished at the adjustable irradiation table. This table and its alignment rail were originally funded by the AEC and used in the medical cave of the 184-inch cyclotron. These had been in storage several years and required extensive renovation. The alignment rail was checked for straightness, the electric rail-adjustment motors were cleaned and repaired, new limit switches were installed, and the entire unit was rewired. New controls were designed and built that would prevent overtravel of the adjustments. Two control units are available: one is at the experiment console, the other on a 6-ft cable at the table itself. By using the control at the table and a transit, the rail can be aligned optically by one technician. The control unit at the console can be used remotely to provide precise alignment with the beam.

A variety of fixtures is available for use on the alignment rail, including an x-ray unit, pointers, cross hairs, and film holders. Figure 3 shows some of these alignment fixtures. An animal-holder, also originally used at the 184-inch cyclotron, is available for holding monkeys in certain positions for irradiation.

A Faraday cup for use in air on the alignment rail was designed and built. The required vacuum of 1×10^{-4} Torr or better is provided by a charcoal sorption pump. This unit eliminates the need for diffusion or mechanical pumps while it is in use on the alignment rail, thus permitting a simpler and more compact unit. The charcoal pump will need only occasional regeneration which can be done when the unit is not in use.

Equipment for dosimetry and beam absorption and collimation is available for two types of operation. The present operation is with protons up to 50 MeV, deuterons to 60 MeV, and alpha particles to 120 MeV. If maximum penetration of the subject is not required, the greater ranges of these particles allow dosimetry and beam absorption and collimation to be done in air.

Three types of ionization chambers were designed and built for dosimetry. These included three 5-foil units with a 2-mm sensitive gap and 50-mm-diameter collector, and three with a 10-mm-diameter guarded collector.



ZN-4046

Fig. 3. Adjustable irradiation table: (a) alignment rail, (b) absorber wheel, (c) collimator, (d) ionization chamber, (e) cross hairs, (f) pointer, (g) Faraday cup, (h) x ray source.

Two units with variable gap and variable diameter collector were also built (Fig. 4). The gap on these units can be varied from 1 to 13 mm and the collector diameter from 4 to 48 mm in 12 steps. Figure 5 shows schematics of the three different types of chambers.

A carefully aligned fixture, mounted on the alignment rail, holds both the beam-defining aperture and the absorber-wheel assembly. The various beam-defining apertures are 1/4-in. brass plates. A holder that centers the apertures on the beam center line is located immediately downstream of the absorber wheels.

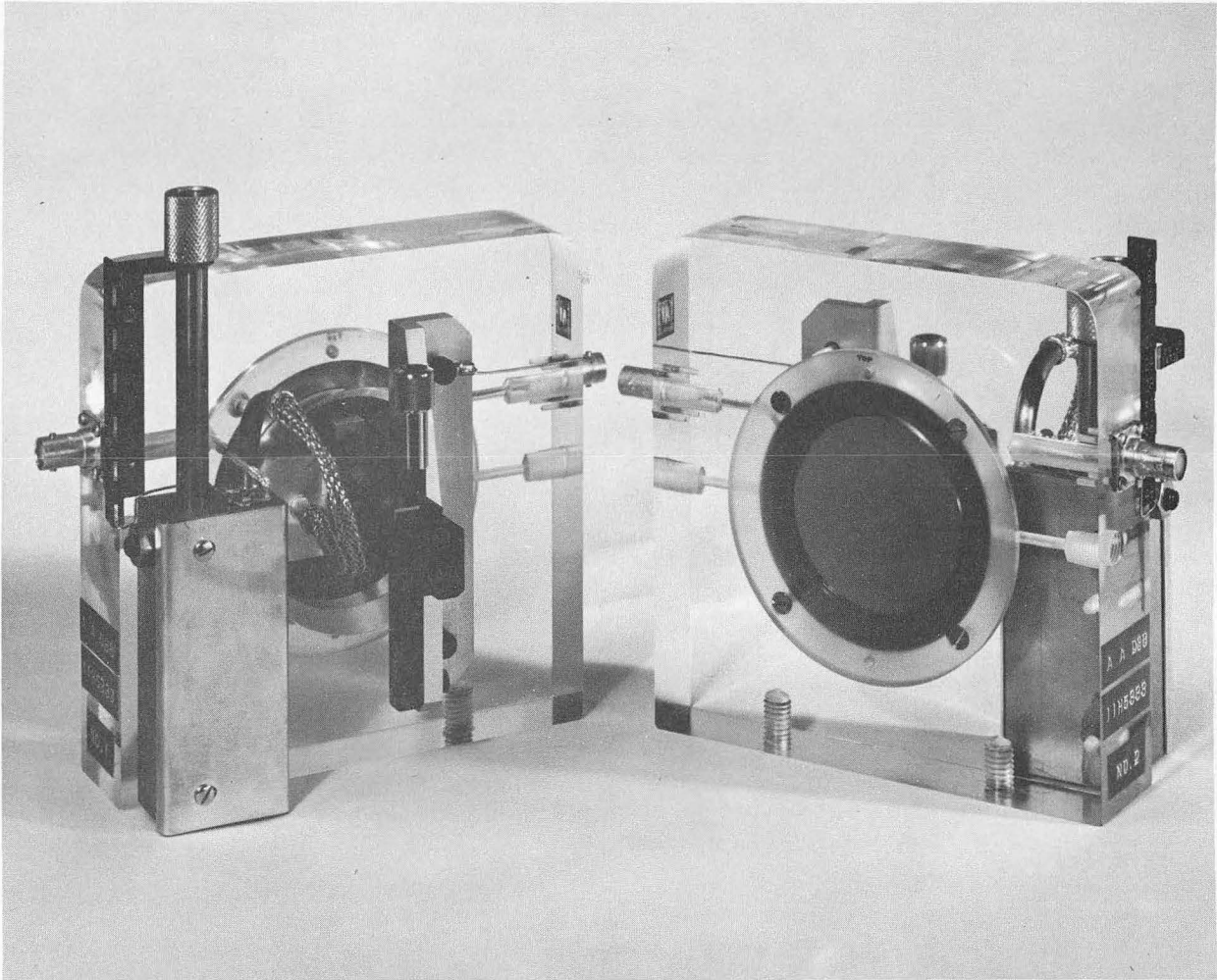
The absorber-wheel assembly has two wheels, each containing aluminum and lucite absorbers of various thicknesses. Each wheel can be rotated by individual servomotors controlled from the experiment console. Maximum absorber thickness is 0.694 in.; intermediate thicknesses are available in 0.002-in. increments.

Heavier ions such as neon, oxygen, nitrogen, and carbon will be available in the future at energies up to approximately 10 MeV/nucleon. For these particles, with their much shorter ranges in air, the dosimetry and beam collimation and absorption must take place within the beam-tube vacuum. To do this, an ozalid holder was adapted from the design of those used at the Hilac, and was increased in thickness to accept graphite beam-defining apertures. This unit provides a means of changing aperture sizes without breaking the beam-tube vacuum. Tuning foils with one current-reading foil and another high-voltage foil are available for dosimetry and beam monitoring.

An absorber-positioning device that places the absorbers inside the vacuum was designed and built. This unit has five wheels, each containing nine absorbers and one clear opening. The wheels are individually operated by positive-locking geneva mechanisms with remote read-out, since the wheel positions cannot be checked visually during operation.

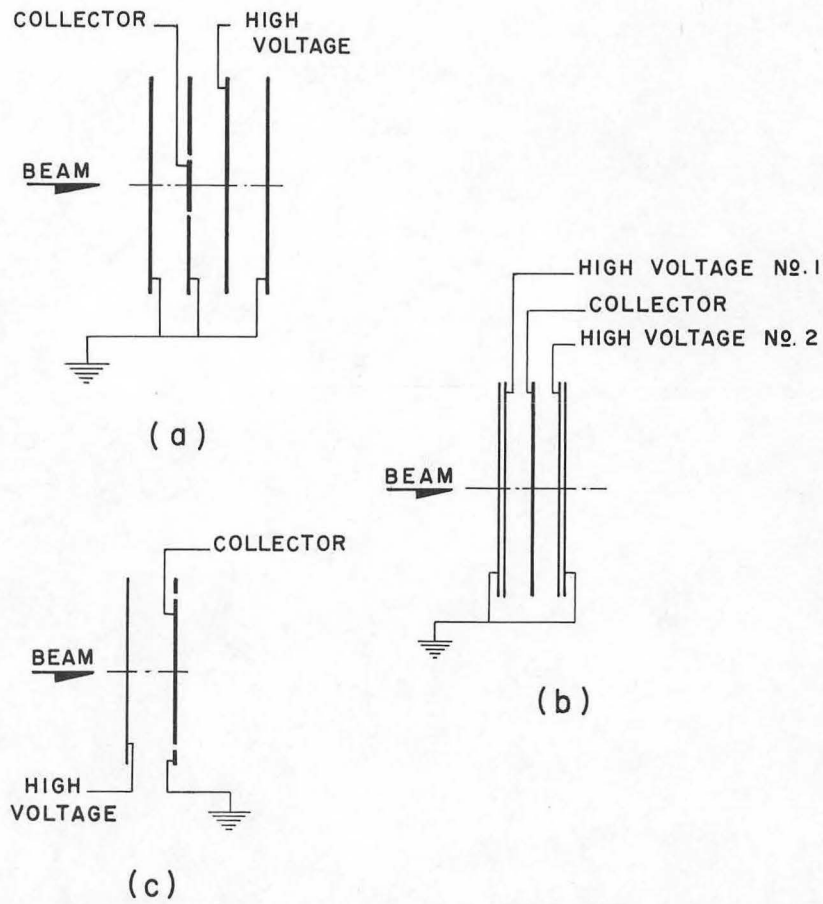
Cave Electronics

The electronic equipment is housed in the experiment control console located in the northwest corner of the building (Fig. 1) over the cable trench. The console, shown in Fig. 6, has a writing surface and five racks for equipment. Table I lists the equipment installed in the console. Control units for the remotely controlled cave equipment, television monitors, power supplies, and recording equipment are included. Patch panels at the console and in the



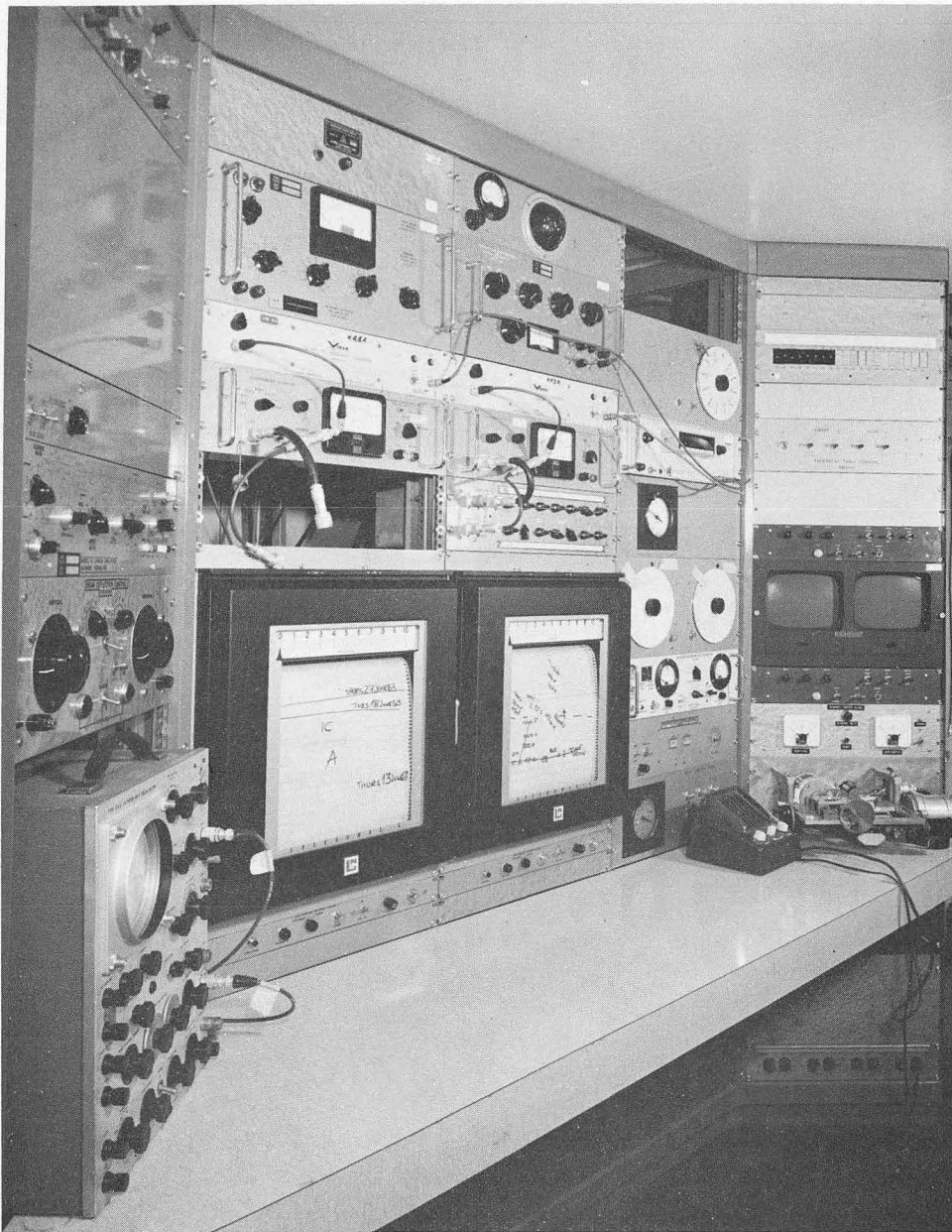
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Fig. 4. Variable gap - variable collector ionization chamber.



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Fig. 5. Ionization-chamber schematics: (a) 10-mm-diameter guarded collector, (b) 50-mm-diameter collector, (c) variable gap-variable diameter collector.



ZN-4048

Fig. 6. Experiment control console.

cave provide flexibility in cabling arrangements. Five RG58 cables also connect the console and the cyclotron control room. Two-way speaker systems connect the console with the cave and the control room.

Table I. Console equipment.

<u>Quantity</u>	<u>Unit</u>	<u>Quantity</u>	<u>Unit</u>
2	500-5000V dc power supply ^a	1	Gaspar I
1	0-500V dc power supply ^a	1	Integrating beam electrometer
2	Electrometer ^a	2	TV monitor
2	Electrometer discharge panel	2	Remote TV pan head control
2	L & N recorder	1	Adjustable irradiation table
2	Resistance-capacitance box	1	Beam control
2	Voltage-to-frequency converters ^a	1	Faraday-cup control
1	Digital frequency ratiometer ^a	1	Faraday-cup timer
1	Linear amplifier model VI ^a	1	Absorber control
1	Oscilloscope	1	Emulsion position control

^aOn loan or obtained from other funds.

Recent experience has shown that the 88-inch-cyclotron beam is insufficiently homogeneous in particle density for use in some biological work. An electromagnetic device called a "beam wobbler" has been proposed. A small version of this type of unit, designed for use at the Hilac, has been tried and found effective for beams smaller than 6 mm in diameter. However, the need for beams much larger than this is foreseen, and a larger unit must be built.

Quadrupole and Beam Optics

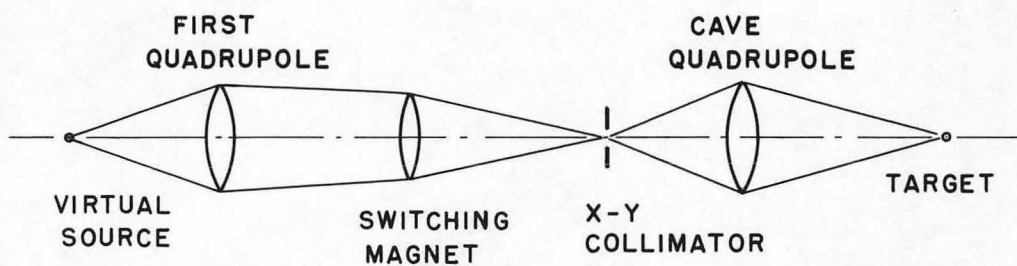
A 4-in. doublet quadrupole and its power supplies were built to provide a focused beam in the cave. The power-supply capacities are 286 A at 70 V each. The quadrupole itself is installed at the front of the cave. An X-Y collimator, with independent remotely controlled jaws, is installed just inside the main vault, between the steering magnet and the cave quadrupole.

Along with the first quadrupole, located between the cyclotron tank and the steering magnet, these units establish the beam optical system. Members of the 88-inch cyclotron engineering group performed studies on the beam optics of this system and suggested the present mode of operation, shown schematically in Fig. 7. (Hermann Grunder and Frank Selph kindly performed this work.) In this mode the X-Y collimator is the focus of the first quadrupole and switching magnet, and is therefore the real source for the cave quadrupole. Thus the size, shape, and location (in a plane perpendicular to the beam axis) of the cave quadrupole source can be varied by moving the jaws of the X-Y collimator. Another possible mode of operation is to eliminate the focus at the X-Y collimator, using a slightly convergent beam from the switching magnet to the cave quadrupole. This way the beam nearly fills the entire beam tube, and the X-Y collimator can be used to cut down the beam area and intensity.

Cyclotron Pulsing Equipment

The 88-inch cyclotron was designed to provide a continuous beam, but pulsed-beam operation will be required for many biological experiments. To modify the machine for pulsed-beam operation, the oscillator control circuits were changed and a pulse generator and control panel were built. The pulse generator allows a pulsing interval of from 0.3 to 1.6 sec. Pulse duration can be varied from 1 to 100 msec. There is also a 60-cps mode of operation with variable pulse lengths. In addition an external trigger may be used, allowing single or random pulses from another source.

For pulsed-beam operation the signal from the pulse control panel is fed into the oscillator regulator in place of the reference voltage used during continuous-beam operation. Through the oscillator regulator and modulator, the pulse control varies the oscillator voltage. During the "off" portion of the pulse cycle the oscillator voltage is below the threshold, and the beam is not accelerated. The oscillator voltage is then raised to the correct value and a pulse of beam is extracted before the oscillator voltage drops again. Since the operating and threshold voltages change with the particle being used, the pulse control can vary both of these voltages.



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Fig. 7. Schematic diagram of the beam optics used for cave 3.

Portable Biological Laboratory

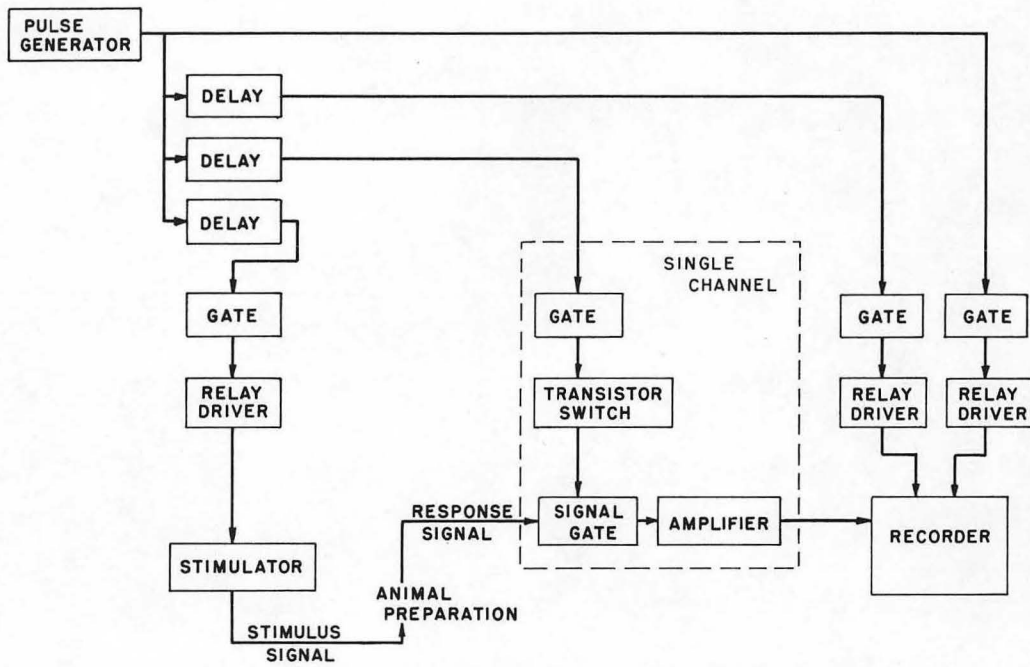
A fixed animal preparation room was indicated in the original plans for this work. However, further investigation showed that a portable laboratory would be usable at both the 88-inch and 184-inch cyclotrons. A van mounted directly to a truck chassis was selected as providing the greatest mobility. It can be used as a preparation room at any of the accelerators, and also for transporting animals from the animal house to the accelerators.

Specifications for the van body and truck chassis have been written and are included in the Appendix. The interior of the van will be completely lined with stainless steel and will be made waterproof. Provisions are included to allow steam cleaning by connecting a steam line to a penetration in the van wall. The interior of the van will be equipped with an operating table, surgical lamp, and four stainless steel tables—all removable. Connections for a water supply will be included, along with a water heater and sink. A blower unit with a Cambridge absolute filter will provide ventilation air. The electrical system design includes a main circuit breaker, ten interior outlets, five overhead fluorescent fixtures, and circuits for the water heater and ventilation unit.

Central-Nervous-System Research Equipment

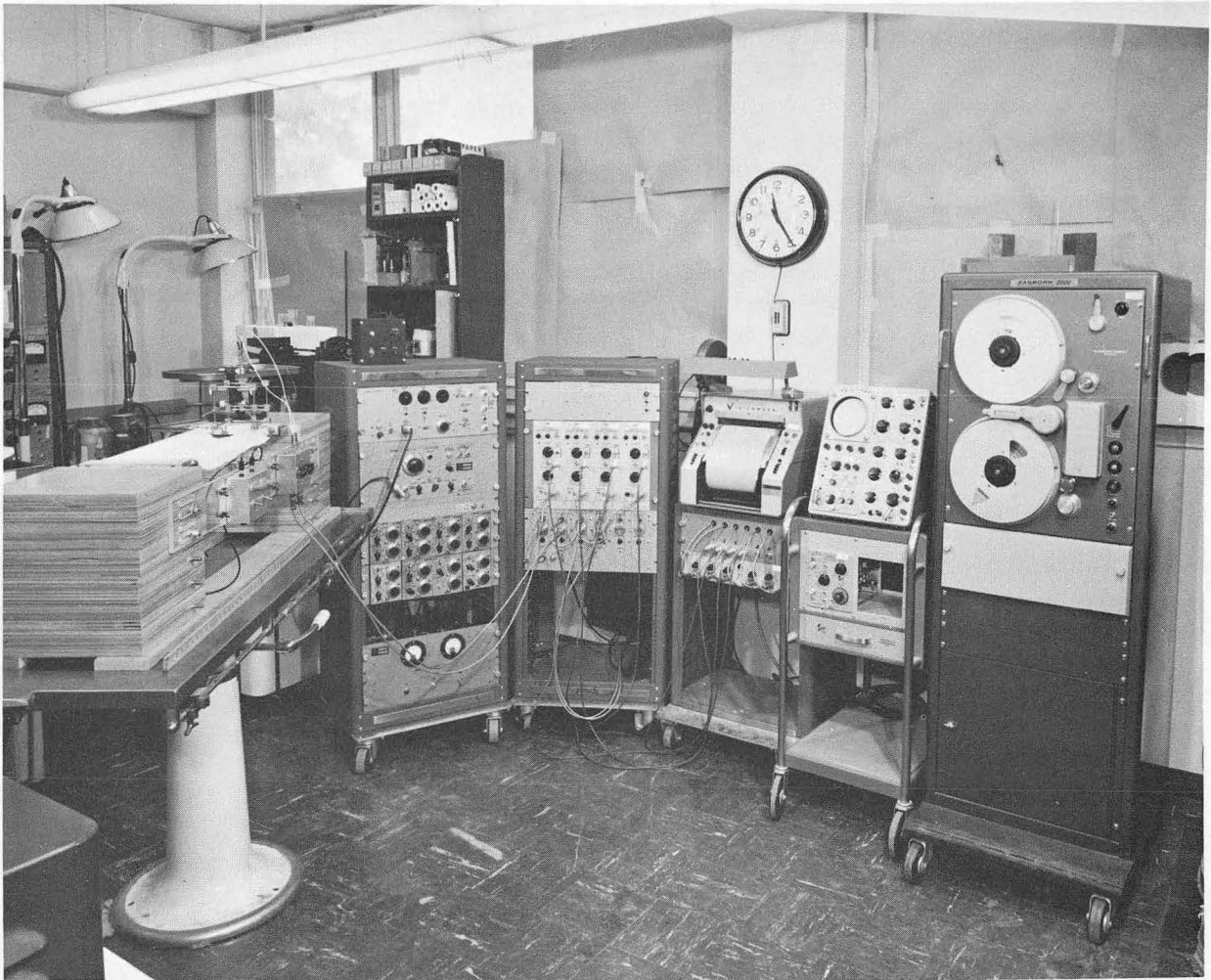
A stimulating and recording system, electrodes, and a stereotaxic system have been built for use in studies of the brain of small animals. At present the stimulation is done with electrodes, but equipment is being prepared to allow the use of the 88-inch cyclotron beam as the stimulus signal.

The stimulating and recording system includes a pulse generator, stimulator, signal delay-gates, amplifiers, and recorders. Figure 8 is a block diagram of the stimulating and recording system. Time-base synchronization for the stimulator, signal gates, and recorder is provided by the pulse generator. The stimulation signal is sent to the animal preparation from a Grass 54 stimulator. The signal delay-gates make it possible to gate out the stimulation signal while recording the responses. This must be done to prevent amplifier saturation by the stronger stimulation signals. The response signals from the preparation pass through signal-gate units and Tektronix Model 122 preamplifiers into the recorders. Recorders are a Honeywell Visicorder oscillograph and a Sanborn 2000 AM-FM tape recorder. The system is designed for a maximum operation of six channels. Figure 9 shows the system together with the animal-preparation equipment.



MU-32619

Fig. 8. Block diagram of stimulating and recording system.



ZN-4049

Fig. 9. Stimulating and recording system, and physiological preparation equipment.

For the ECoG electrodes, two 0.008-in. -diameter tungsten wires are insulated with varnish and bonded together. An electrical shield is added by vacuum coating with aluminum over the varnish. The electrode wires and shield are connected to a three-pin receptacle. This unit is then slipped into a No. 19 hypodermic needle frame and the receptacle bonded to the frame. The completed electrode assembly is held in a pin vise and placed in the brain with a micromanipulator.

The stereotaxic head frame is a 4-1/4-in. cube of 1/8-in. -diameter stainless steel rods. This attaches to the animal's head by a tooth bar and three pointers inserted into holes drilled in the skull. The animal's body is supported by a canvas sling attached to a small stretcher.

An x-ray alignment fixture has been designed to provide lateral and anterior radiographs of the animal's head. The images will be superimposed on reference grids fixed to the head frame. This will allow structures within the brain to be located with respect to the reference grids and to the head frame. It is planned to make an electrode carriage system that will attach directly to the head frame. Electrodes that are referenced directly to the head frame can then be placed in the brain.

MODIFICATIONS TO 184-INCH CYCLOTRON MEDICAL CAVE

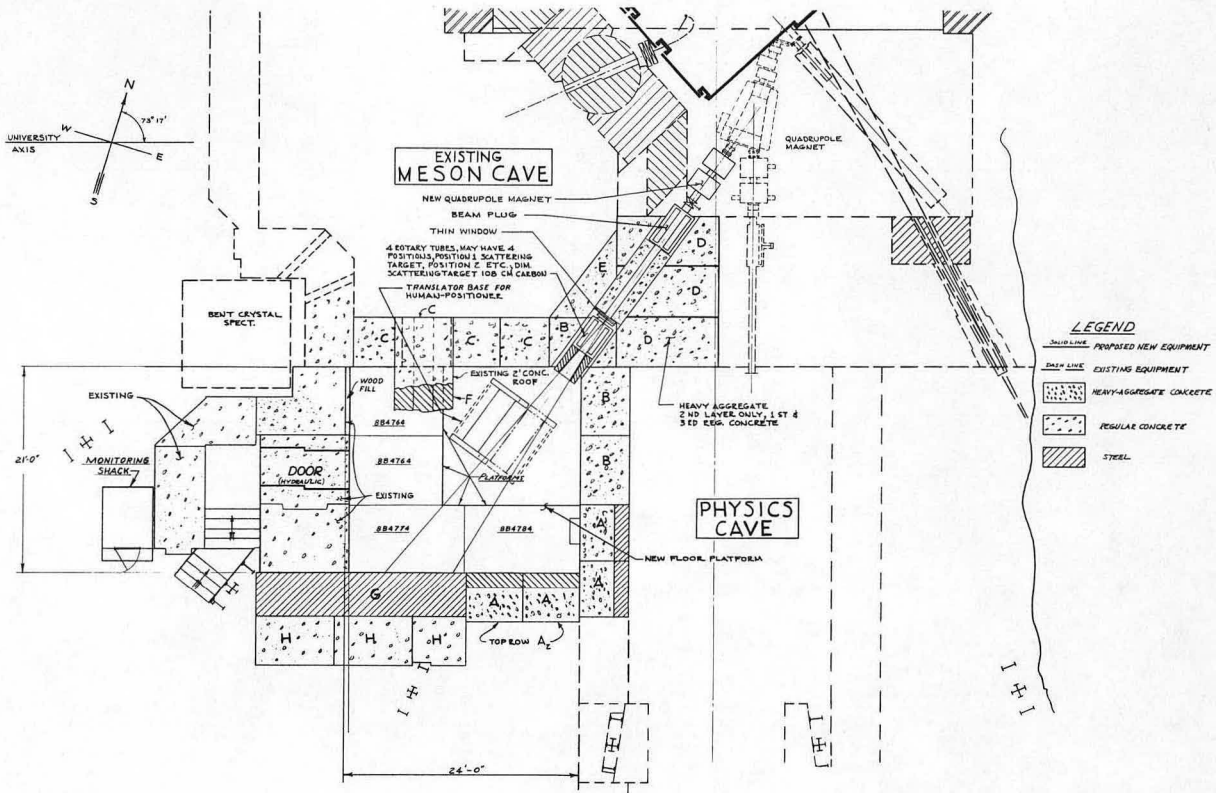
In order to conduct omnidirectional animal irradiation for the NASA program at the 184-inch cyclotron medical cave, it was essential to make major modifications to the cave. These changes were as follows:

- (a) A larger cave with increased shielding
- (b) A stronger floor and a steel working platform
- (c) A new beam transport system
- (d) New electronic equipment
- (e) A new animal-rotator
- (f) A new human-positioner translator.

Cave and Shielding

The original cave had a floor area of 17 by 18-1/2 ft. Its shielding walls were approximately 5 ft of ordinary concrete with a density of 150 lb/ft³. The roof was 150-lb/ft³ concrete and was 2 ft thick.

Figure 10 shows the completed modifications to the cave. Referring to Fig. 10, the thickness of the west wall was increased to 9 ft of 150-lb/ft³ concrete.



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Fig. 10. General arrangement of medical cave.

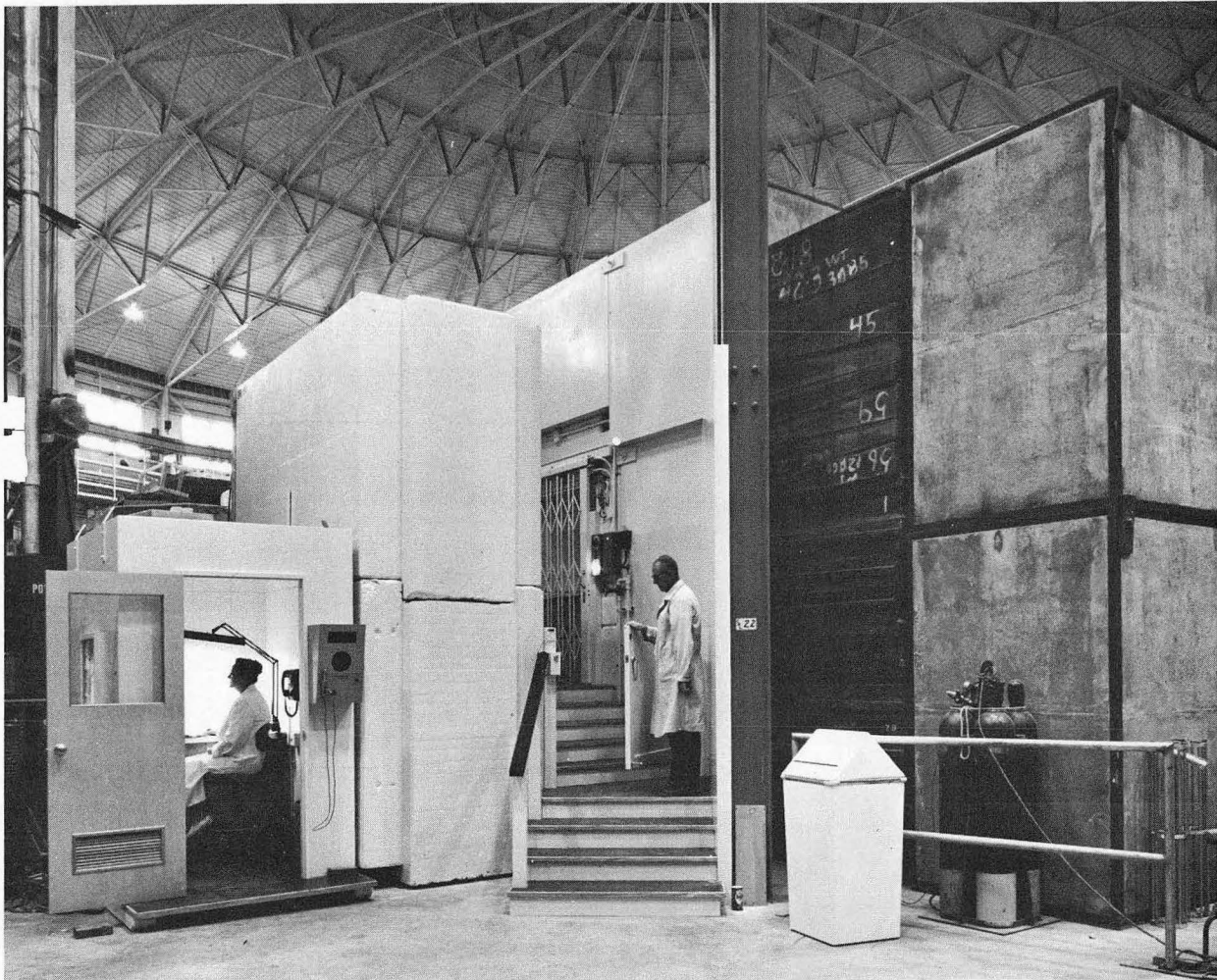
In the north wall the thickness of 5 ft was retained but the density of the blocks was increased to 300 lb/ft^3 by using a heavy-aggregate material called ferrophosphorous. These blocks therefore have an equivalent thickness of 10 ft of ordinary concrete.

In the east wall the 5-ft thickness was also maintained, and the first two vertical rows of blocks (counting from the north wall) are also composed of 300-lb/ft^3 aggregate. The last two vertical rows are composite blocks. These blocks consist of $1\text{-}1/2$ ft of steel and $3\text{-}1/2$ ft of heavy aggregate. This combination gives an equivalent thickness of very close to 12 ft of ordinary concrete. This east wall is the common wall between the physics cave and the medical cave, and plays an important part in keeping radiation levels down in the medical cave when experiments are being carried on in the physics cave. Since this is a common wall, part of its cost was paid for out of cyclotron accelerator improvement funds.

The south or rear wall consists of two vertical rows of composite wall blocks identical to those described above. The rest of the back wall consists of $4\text{-}1/2$ ft of steel armor plate backed with 5 ft of ordinary concrete. This combination of steel and concrete gives an equivalent thickness of almost 20 ft of 150-lb/ft^3 concrete. This thickness is required in this area because the full energy of the beam strikes here. The steel wall is constructed of large pieces of armor plate piled one on top of the other, and was stabilized with steel shims and heavy-aggregate grout until the proper height of 16 ft was attained. This system makes a rather permanent wall, of course, but the intent was to get the most shielding for the money by that construction method.

Figure 11 is an outside elevation of the medical cave, showing shielding, monitor shack, maze, and hydraulic door. The shielding blocks on the right are part of the south wall. The roof shielding was modified by adding 12 steel roof blocks 2 ft wide by 2 ft deep by 28 ft long. The 2-ft-thick concrete roof blocks are then placed on top of the steel. An equivalent thickness of $8\text{-}1/2$ ft of 150-lb/ft^3 concrete is thus obtained. It is necessary to keep total roof thickness down in order to maintain clearance for the overhead crane.

The increased shielding thicknesses allow people to work in the medical cave in preparation for an experiment while the beam is on in the physics cave. This was not possible before. The converse should also be true: When a high-energy beam is run in the medical cave it should be



ZN-4050

Fig. 11. Medical-cave entrance

possible to work safely in the physics cave and in the area immediately surrounding the medical cave. This fact permits a freer scheduling of time for animal experiments. Previously it was only possible to run experiments using high-energy protons in the medical cave at limited times when the area could be blocked off. Now experiments can be conducted whenever experimental time is available.

Shielding Door

Originally the medical cave had only a maze entrance, which is still used, as shown in Fig. 10; however, in order to run high-energy beam for experiments in the NASA program it was necessary—in addition to providing more shielding wall thickness,—to add a solid shielding door. This door consists of 150-lb/ft³ concrete 9 ft thick by 4 ft wide by approximately 13 ft high, weighing 68 000 lb.

The door is actuated by an oil-driven hydraulic cylinder. The cylinder is 8 in. in diameter, has an 82-in. stroke, and operates at a working pressure of 1350 psi. The hydraulic pump system is driven by a 30-hp electric motor which closes the door in approximately 30 sec. The opening is done with a combination of gravity and a controlled flow of oil through a metering valve.

The door itself is so constructed that when it is open it is in a pit in the floor and the top of the door serves as the floor of a passageway into the cave area. The hydraulic cylinder is in the pit beneath the door and simply raises the whole door into position to close the hole in the cave wall. A door constructed in this way takes up a minimum of floor space but does fix the position of the wall in which it is placed.

There is a system of interlocks that prevent the cyclotron from operating if the door is not properly closed or if a leak in the hydraulic system causes it to open inadvertently. Another interlock system prevents the door gap from becoming more than about 1/2 in.; if the gap becomes larger the hydraulic system is started and the door is closed again. There are safety gates with switches that prevent the door from being actuated unless they are properly closed. One last safety feature is two emergency hand valves, one inside and one outside, which allow the door to be opened in case of a power failure or other unpredictable circumstance.

Cyclotron Floor Reinforcement and Cave Platform

The entire concrete floor under the medical-cave area was replaced with a new concrete reinforced slab capable of supporting 11 000 lb/ft². When the new slab was installed the pit for the cave door was also constructed. The reinforced floor permits the heavier shielding wall loads to be supported safely..

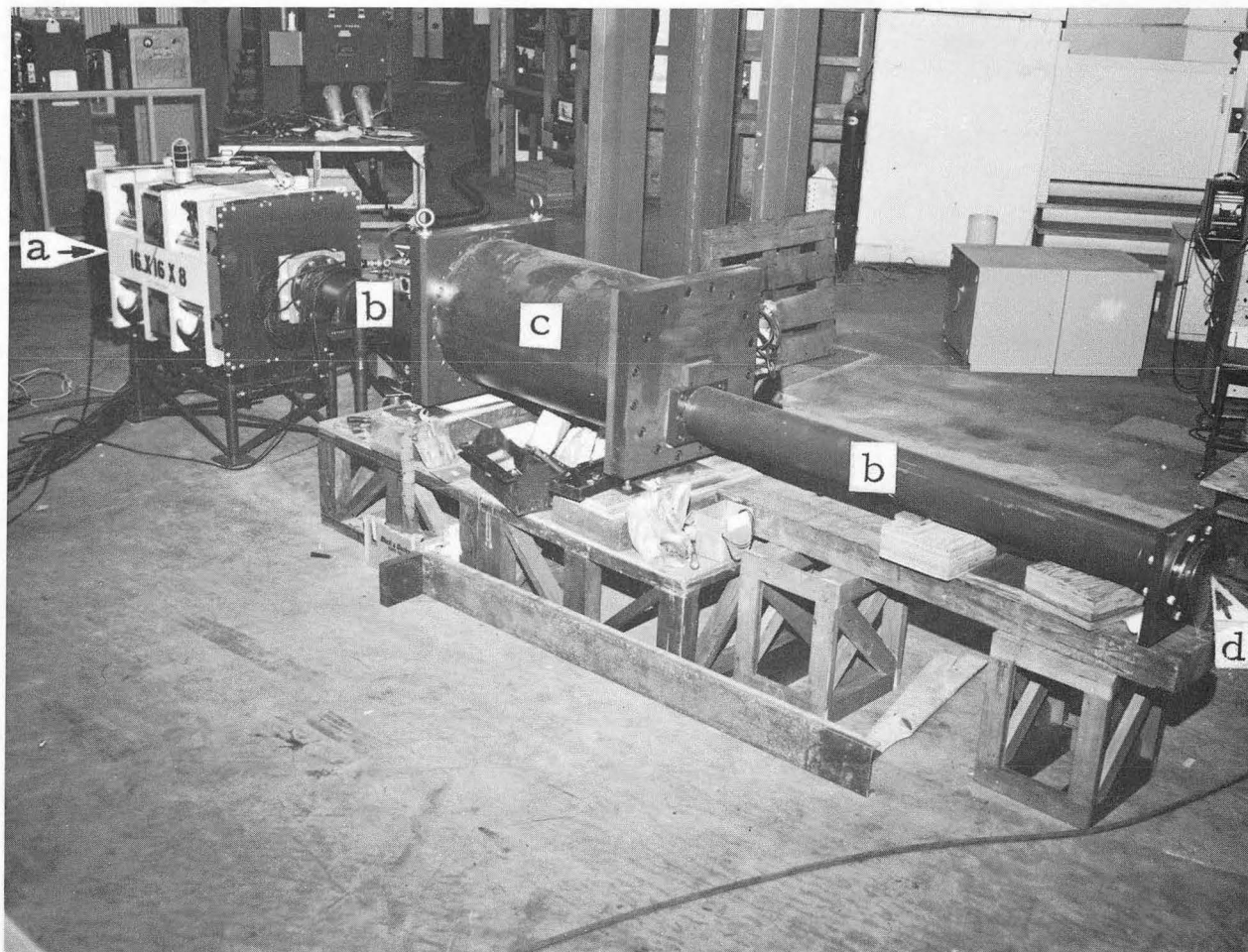
The working floor area surrounding the human-positioner was originally constructed of wood, similar to floors in a typical frame home. These floors have been replaced with heavy-duty steel platforms which have been carefully leveled and grouted in place for maximum stability. Five of these platforms surround the area occupied by the human-positioner and will provide a solid foundation for the animal-positioner. The floor area immediately surrounding the human-positioner is still a wood-frame construction. This was desirable in order to permit more flexibility in the arrangement of the human-positioner mounting system.

Beam Transport System

The beam transport system was redesigned to increase the beam intensity (total number of particles) available for experimental use in the medical cave. The beam vacuum tube diameter was increased from 6 to 8 inches. The beam plug, which cuts off the beam from the medical cave, was enlarged to accommodate the new beam-tube diameter. A new 8-in. -diameter aperture quadrupole magnet was added at the upstream end of the beam tube next to the cyclotron steering magnet. The beam tube passes through the quadrupole magnet gap. The quadrupole in effect gathers as many particles as it can get from the cyclotron steering magnet and focuses them for their trip down the beam tube. The larger diameter beam tube permits more particles to enter and the focusing magnet prevents them from colliding with the walls on their downstream journey. Figure 12 shows the quadrupole, beam plug, and beam vacuum tube before installation in the cave wall.

The beam vacuum tube is terminated in a thin vacuum window just ahead of the scattering-target turret. The scattering target serves a two-fold purpose: It provides (a) a means of controlling beam energy by placing various thicknesses of absorbers in the beam path and (b) a means of producing a diverging scattered beam so that large areas can be irradiated.*

* Cornelius A. Tobias, Modification of 184" Cyclotron Facilities for Space Radiation Studies, in Supplement to Biology and Medicine Semiannual Report, UCRL-10211 Supplement, Spring, 1962.



ZN-4051

Fig. 12. Beam transport system: (a) quadrupole, (b) beam tube, (c) beam plug, (d) vacuum window.

The scattering-target turret is 30 in. in diameter by 42 in. long. It contains four 8-in. -diameter holes at 90-deg intervals. Any one of these holes may be rotated into the beam path and various absorber thicknesses may be placed in the holes. This system provides a means of meeting almost any specified energy requirement with a minimum of effort.

Additional Electronic Equipment

Purchases of major electronic equipment included a Tektronix Model RM45A oscilloscope with plug-in preamps, closed-circuit TV system, Moseley X-Y plotter, photometer, and equipment console.

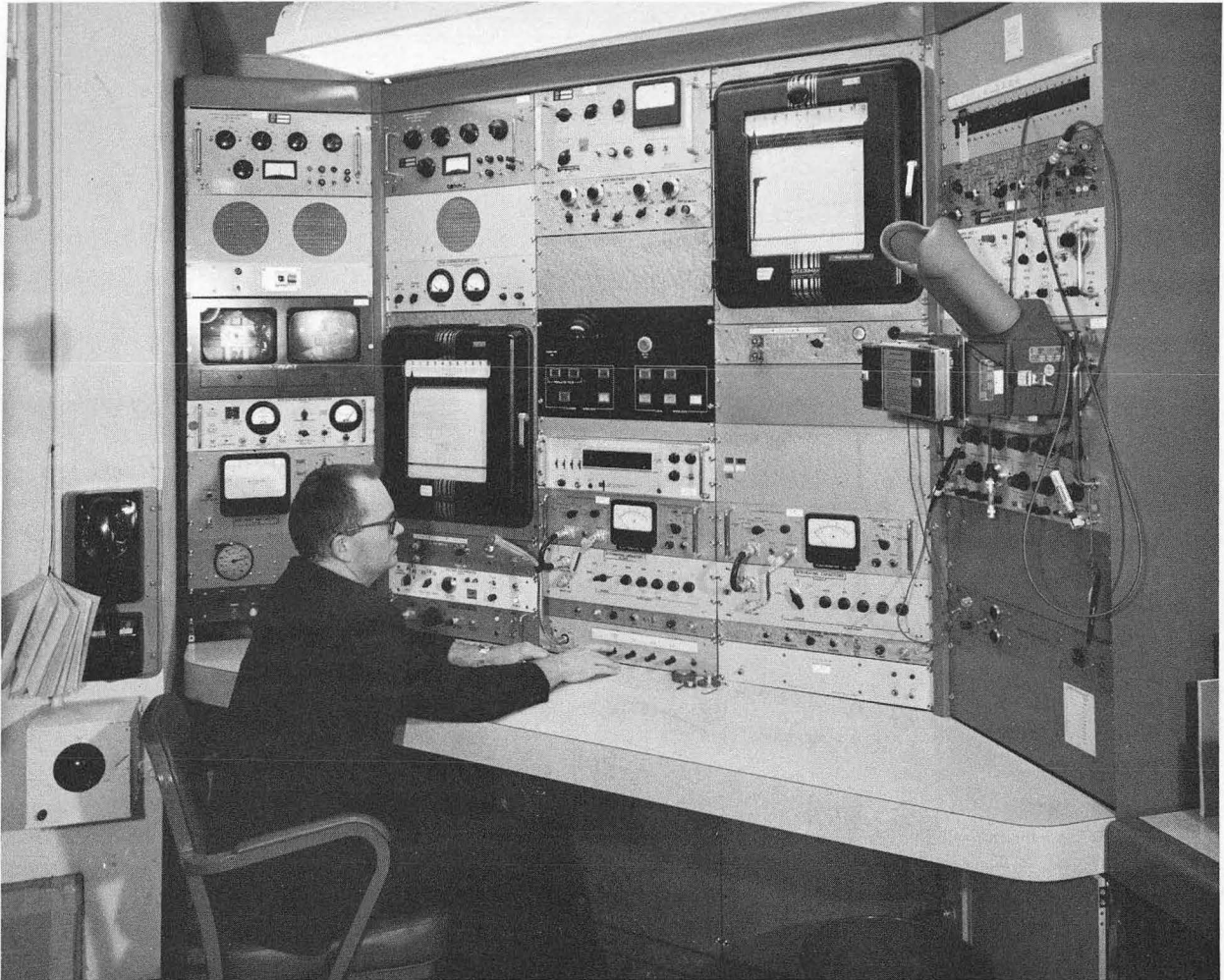
The medical cave control room and control equipment (Fig. 13) were moved from building 6 to building 10 because of space limitations. New patch panels were installed in the control room and the cave. Communications systems are available from the medical cave control room to the cyclotron control room and to the medical cave.

Animal-Rotator

An animal-rotator, shown in Fig. 14, has been constructed to allow omnidirectional irradiation with the direct beam. The animal, in a holder such as the one shown on the rotator, can be rotated about a horizontal axis. The peripheral velocity of the horizontal drive rollers is adjustable from 2.56 to 51.2 ft/min. The entire upper portion of the rotator also rotates about the vertical shaft. The rotational velocity about the vertical shaft varies sinusoidally with time--the period of one revolution varying from 0.787 to 15.7 min. Maximum capacity of the unit is 300 lb.

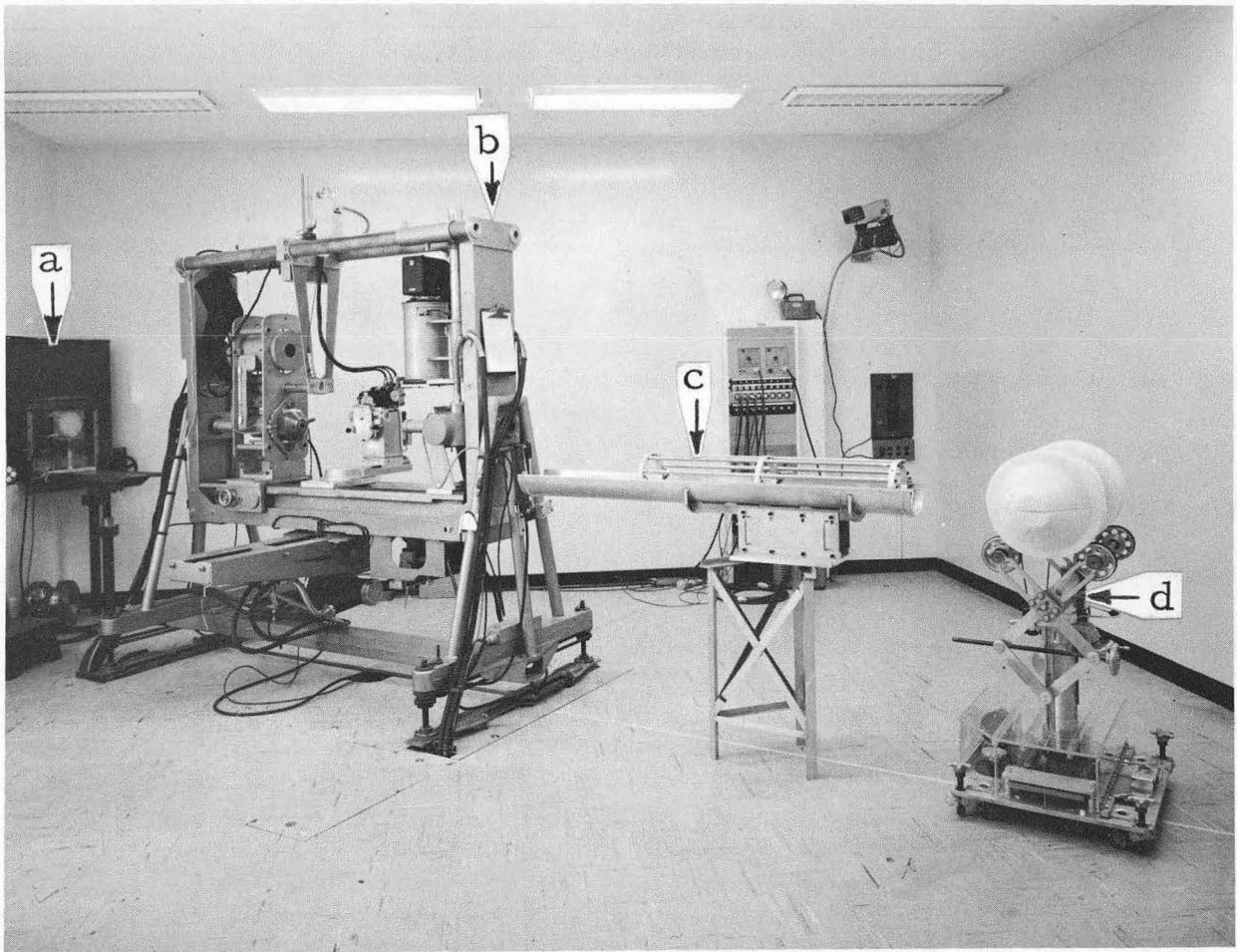
Human-Positioner Translator

In order to remove the present human-positioner from the beam path when using the animal-rotator, a new human-positioner base was built. This translator allows the human-positioner to be moved to the side when not in use (Fig. 15) and assures its return to correct alignment with the beam when replaced (Fig. 16).



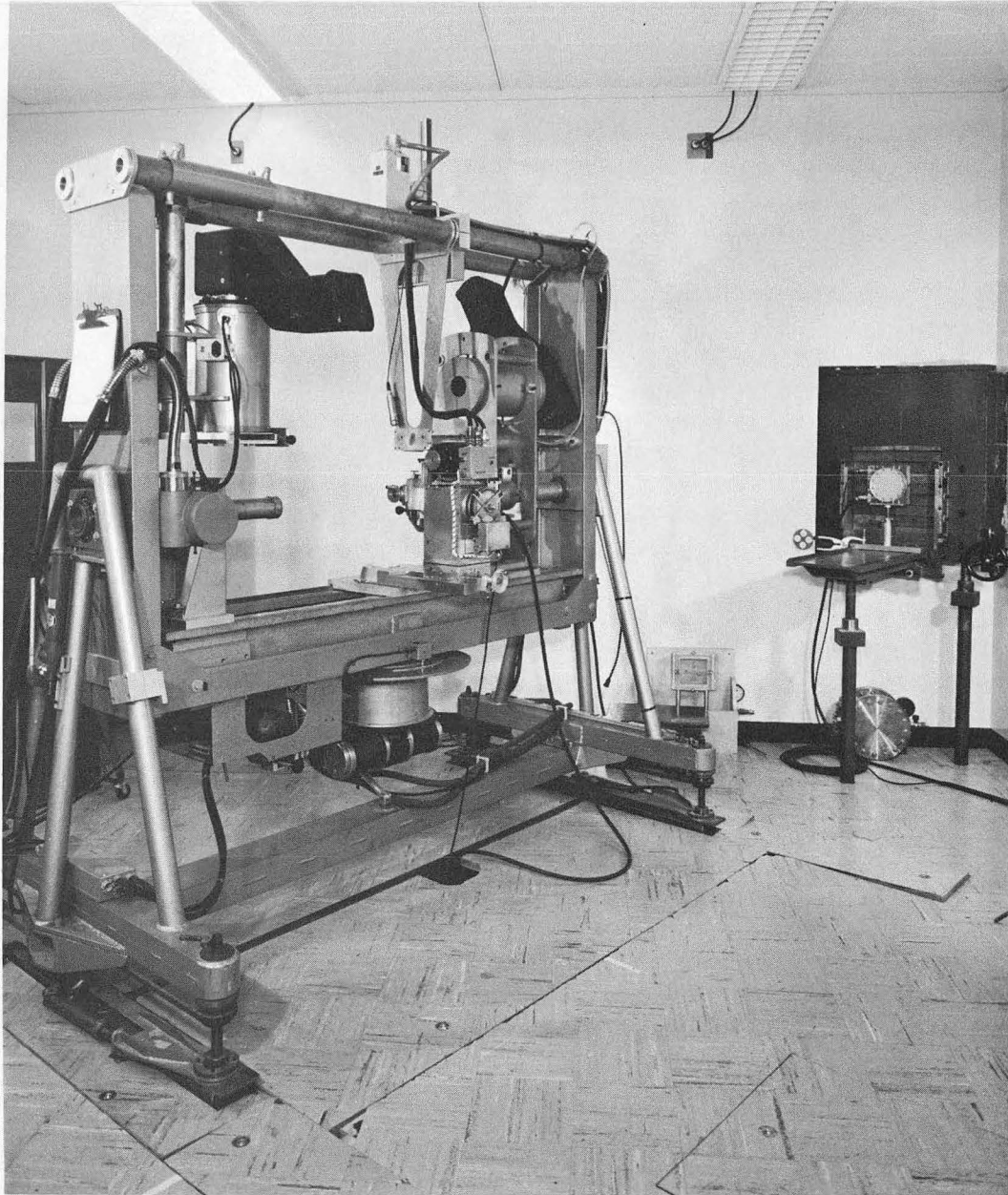
ZN-4052

Fig. 13. Medical-cave control room.



ZN-4053

Fig. 14. Interior view of the medical cave: (a) scattering-target exit, (b) human positioner, (c) scattering-target loading device, (d) animal-rotator.



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Fig. 15. Human-positioner removed from the beam path.



ZN-4055

Fig. 16. Human-positioner aligned with the beam.

ACKNOWLEDGMENTS

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The assistance of Dr. Elmer Kelly at the 88-inch cyclotron and Mr. James Vale at the 184-inch cyclotron is greatly appreciated. Also appreciated is the help of William Bulger, Jr. in coordinating the electronics work at both locations.

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WRITTEN BY Robert Fulton	DEPARTMENT Mechanical Engineering	LOCATION Berkeley	DATE April 22, 1963		
TITLE PORTABLE BIOLOGICAL LABORATORY - VAN BODY				CHECKED BY <i>[Signature]</i>	

SECTION A: GENERAL1.0 SCOPE

This specification covers a truck van manufactured and equipped for use as a portable biological laboratory.

2.0 DRAWINGS AND DATA

2.1 Drawings no. 10K5556, 10K5541, and 5R4411 are furnished and are part of these specifications.

2.2 The data given in these specifications and drawings are as exact as could be secured, but their absolute accuracy cannot be guaranteed. The drawings, specifications, distances, etc. will be governed by existing conditions in the van. The supplier shall take the data with this understanding.

SECTION B: MECHANICAL3.0 MATERIALS

3.1 All materials and components shall be provided and installed by the supplier.

3.2 All fittings, fixtures, and fastenings, exposed to the van interior, shall be Type 304 stainless steel, unless otherwise specified.

3.3 The van shall be mounted by the supplier on a truck chassis to be furnished by the University at Berkeley, California.

4.0 REQUIREMENTS AND COMPONENTS4.1 Dimensions

Minimum inside dimensions of the finished van shall be 180 inches long by 87 inches wide by 87 inches high.

4.2 Van Body

4.2.1 The basic structure shall be a truck body of standard construction with the approximate dimensions of 16 ft long by 96 inches wide outside by 90 inches high inside. This body shall have all necessary clearance lights and reflectors to comply with ICC regulations.

4.2.2 Four section rear doors with a minimum total opening of 85 inches wide by 78 inches high shall be provided.

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4.3 Interior Skin

- 4.3.1 All interior surfaces shall be of Type 304 stainless steel, 2B finish, 24 gage minimum thickness.
- 4.3.2 All seams shall be hard-soldered or welded watertight. These seams shall be ground flush.
- 4.3.3 All interior corners shall be rounded with a 1 inch maximum, 1/2 inch minimum radius.
- 4.3.4 The stainless steel sheets shall be fastened to the van framework so as to present a minimum of surface discontinuities to catch dust and dirt.
- 4.3.5 The door sill shall be flush with the floor to allow drainage.
- 4.3.6 A two-inch diameter stainless steel floor drain shall be provided in the van floor, located as shown on drawing 10K5556.
- 4.3.7 A three-inch diameter stainless steel watertight penetration shall be provided above the rear door as shown on 10K5556. The seam between the penetration and the interior skin shall be hard-soldered or welded watertight.
- 4.3.8 The interior surfaces shall be free of deep scratches or weld spatter.

4.4 Insulation

Three inches of glass fiber mat or rigid foam insulation shall be installed in the walls, ceiling and doors.

4.5 Water Supply System

- 4.5.1 A water supply system, including a sink, faucets, hot water heater, and connecting piping, shall be installed.
- 4.5.2 The sink shall be of stainless steel with a bowl approximately 22 inches by 16 inches by 7 inches deep, and shall be mounted securely to the wall at the location shown on 10K5556. Stainless steel legs attached rigidly to the sink shall be used to support the front edge of the sink. Any penetrations of the stainless steel interior wall for support of the sink shall be hard-soldered or welded watertight.
- 4.5.3 A chrome-plated double valve faucet unit shall be installed on the sink.

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- 4.5.4 A Wessix Catalog No. 50CKT3018 side-arm water heater, or equal shall be installed in the skirt compartment (See Section B paragraph 4.9.2) nearest the sink.
- 4.5.5 Piping shall be type "L" copper tube with solder fittings except where located inside the van. Piping inside the van shall be stainless steel. All penetrations through the stainless steel interior wall shall be made watertight.
- 4.5.6 Drain piping shall be 1 1/2 inches diameter, untrapped, and shall terminate in the water heater compartment as a male 3/4 - 11 hose coupling.
- 4.5.7 Supply piping shall be 1/2 inches diameter. The water heater supply and sink cold water supply shall be brought together in the water heater compartment and terminated as a female 3/4 - 11 hose coupling.

4.6 Ventilation Unit

- 4.6.1 The ventilation unit shall be a Cambridge Filter-Blower Model 2A-65, or equal.
- 4.6.2 This unit shall be installed on the street side rear door in the location shown on drawing 10K5556. The mounting shall be steady enough to support the ventilation unit during normal road travel.
- 4.6.3 The penetration through the door for the supply air shall be 3 inches diameter minimum of stainless steel and have all joints hard-soldered or welded watertight.

4.7 Exhaust Grille

A Tuttle and Bailey Model A-82 Register, 6 inches by 12 inches, with Multishutter damper, or equal, shall be installed in the curb side rear door as low as conveniently possible. See drawing 10K5556. The door penetration shall be made watertight.

4.8 Hold-downs

Nineteen 1/4-20 NC stainless steel threaded studs shall be mounted on the interior walls as shown in drawing 10K5556. These studs shall be securely fastened to the body frame and shall have a minimum of 1/2" of threads extending from the interior wall. The joints between the studs and the stainless steel interior wall shall be hard-soldered or welded watertight.

4.9 Skirt and Compartments

- 4.9.1 A skirt, a minimum of 18 inches high with cutouts for the rear wheels, shall extend fully along both sides of the van.

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4.9.2 Each skirt shall include three compartments, two in front of the wheel openings and one behind. These compartments shall be a minimum of 18 inches deep and 16 inches high with the maximum width governed by the space available. The compartments shall be covered by doors hinged at the bottom and provided with tumbler locks using the same key.

4.10 Rear Bumper

A full width rear bumper shall be included. The top surface of the bumper shall be a minimum of 12 inches wide and approximately 20 inches above the ground for use as a step. Another step shall be provided at a height approximately halfway between the bumper top and the body floor. This second step shall be centered on the rear of the body and shall have minimum dimensions of 24 inches long and 8 inches wide. Step treads shall be made from "Super Diamond", or equal, steel floor plate and complete assembly galvanized after fabrication.

SECTION C: ELECTRICAL

5.0 MATERIAL

- 5.1 All material shall be furnished by supplier as shown on drawings and as required to furnish a complete working 120/208/240 volt electrical package.
- 5.2 Supplier shall also furnish all 12 volt dc equipment for a legally operated vehicle on the State of California highways.

6.0 INSTALLATION INSTRUCTIONS

- 6.1 All work shall be done in a workmanlike manner and conform to the NEC and electrical safety orders of the State of California.
- 6.2 All conduit inside van proper shall be concealed. Steam cleaning of van interior necessitates that all connections be watertight.
- 6.3 Conduit shall be of both rigid iron and flexible metallic tubing. Rigid iron for straight runs and flexible metallic tubing at load center for equipment right-of-ways into van walls. No running threads permitted.
- 6.4 All wire #12 TW except as noted in Paragraph 6.9 and drawing no. 5R4411.
- 6.5 Install fluorescent fixtures on ceiling surface and seal conduit entrance so as to make watertight.
- 6.6 Use liquid tight flexible metallic tubing for electrical heater run.

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- 6.7 Install load center and receptacle as shown on drawing No. 10K5556. Receptacle to have screw cover and to clear compartment hinged cover when closed.
- 6.8 Install 10 duplex receptacles on walls as shown in type FS boxes with spring covers. See drawing 10K5541 for mounting in stainless steel wall.
- 6.9 Install FSA box on left rear lower corner for ventilation unit. Supply three #14 wire cord and cap to reach this receptacle from ventilation unit and to clear door operation.
- 6.10 Make up portable power cord as shown on drawing 5R4411.

7.0 TESTS

- 7.1 Fan, lights, receptacles and heater are to be operated by 120/208/240 volt, 60 cycle 3 phase connection made thru the portable power cord. With all breakers on, measure the current in AØ and CØ and record.
- 7.2 Correct any discrepancies.

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WRITTEN BY Robert Fulton	DEPARTMENT Mechanical Engineering	LOCATION Berkeley	DATE April 22, 1963	
TITLE PORTABLE BIOLOGICAL LABORATORY - TRUCK CHASSIS			CHECKED BY <i>RF</i>	

1.0 SCOPE

This specification covers a truck chassis of standard manufacture on which a 16 ft long by 8 ft wide aluminum body will be mounted. This unit will be used solely as a biological laboratory.

2.0 REQUIREMENTS

- 2.1 Minimum cab-to-axle dimension, 115".
- 2.2 Minimum gross vehicle weight, 11,000 lb.
- 2.3 Side view mirrors suitable for use with eight-foot wide van body.
- 2.4 7:00 x 18 tires.
- 2.5 Spare wheel and tire.

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