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BUILDING, SITE, UTILITIES, AND SERVICES FOR THE BERKELEY 88-INCH CYCLOTRON

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ABSTRACT

The development of the building project and its adaptation to requirements imposed by site, time schedule, and the accelerator is described. Included are such matters as the allocation and organization of building space in relation to accelerator operation and research function, provision for possible future changes, and the influence of the selected site and its topography on the building design. Factors that determined the choice of materials are discussed. The types of utilities for present and planned future needs, especially the high-purity water systems, are summarized. A brief description is given of illumination and building colors.

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1. Preliminary Planning

The original designation of limits of the 88-inch-cyclotron building project for budgetary purposes was based principally on the data from the existing accelerators at the Laboratory. Although the Laboratory scientists had specified the basic requirements for the accelerator, very little thought had been given to all the environmental components necessary to carry out the research work. After tentative approval of the project, preliminary planning was begun in the fall of 1958. Informal contact was established among the many people who were to gather and evaluate data, and translate the information into the vast number of parts composing the building project. As more and more details were added to the design picture, a general organizational relationship was developed between the various functions (fig. 1). A kind of design philosophy evolved—based on safety, convenience, and simplicity—which served as a guide in formulating answers to the many problems. Since a site had not yet been chosen, all planning was directed toward an ideal solution, particularly with respect to functional (or area) relationships.

In the budget proposal a building of about 17 000 ft^2, gross, had been visualized. During the design period this grew to 34 000 ft^2. The major part of this growth was caused by the addition of radiochemistry laboratories and the placing of noisy equipment indoors. No allowance for this increase in building

†Work done under the auspices of the U. S. Atomic Energy Commission.

scope had been made in the time schedule of the overall project. It was evident that the time element for the building construction (including design) had become a critical factor. A delay here could indeed delay the whole project, so much importance was attached to any measures that would reduce building-construction time.

2. Building Site

The increase in building-project size complicated the problem of using the site that was eventually selected. The advantages of the site with respect to its location near the University of California campus and the Lawrence Radiation Laboratory Chemistry Building outweighed other considerations. Because of the limitations of this site, the present building plans had to incorporate provisions for future expansion. Among the most important limitations imposed by the site were restrictions in size with respect to future horizontal expansion, and proximity to a residential neighborhood. After the site selection had been made, work could begin in fitting the building project within the limits set by cost, time, and natural environment. The determination of the size and relationships of the various areas worked out during the preliminary studies proved to be very useful. In the adaptation of this "presite" plan, advantage was taken of the steep hillside by creating terraces for the principal building parts. The elevations of these terraces were calculated to achieve balance between excavated and compacted earth. This resulted in a 2-acre site, which allows some space for future expansion.

To save time the site was prepared during the summer, prior to the completion of the building-construction documents. Delays normally caused by inclement weather were thus avoided.

At the preplanning stage, it had been agreed that the cyclotron should be surrounded on all sides with portable shielding blocks. This was a requirement based on experience with the other accelerators at our Laboratory, which had demonstrated the need for the greatest amount of flexibility. The shielding walls were to be of adequate thickness to permit unlimited time occupancy on all sides. However, on the side where the beam normally would be extracted, limitations on occupancy would be set by the adequacy of the shielding of the external beam. Safety standards set the wall thickness at 10 ft of 150-lb/ft^3 concrete. The total space required by the cyclotron enclosure, together with estimated need for experimental area and so-called staging area, determined the dimensions of the high bay to be 80 by 150 by 45 ft. Cost estimates of various crane sizes (e.g., capacity and span) and high-bay spans helped pin down the 80-ft width as an economical optimum width. The size of the largest shielding block, existing experimental magnets, and other Laboratory cranes were determinants in the selection of a 30-ton hoist and an auxiliary 5-ton hoist for the 88-inch-cyclotron crane. Since the space under this crane would be the most expensive, all other areas not requiring crane coverage were placed under a low-bay structure.

The weight of the cyclotron, the shielding, etc., dictated the location of the high-bay space on the cut portion of the site, where loads up to 10 000 lb/ft^2 could be carried. The rest of the areas were located on the downhill and south end (fig. 2). The position of the high bay on the site permitted approximately 150 ft along the direction of the external beam to be used for experimental setups, and also provided space for future expansion of the high and low bay.

Proximity to the residential neighborhood indicated the placement of all noisy equipment indoors. A basement was therefore created to accommodate equipment of this kind, as well as electric equipment, and the building heating and ventilating plant. The hillside slope gave us the advantage of truck access to the whole basement.

All utilities were carried to the pit under the cyclotron through a tunnel. The placement of the cooling tower, heat exchangers, and associated pumps on the uphill side of the building gave us a better distribution of the utility lines in the tunnel (fig. 3). It also created an isolated area for heat exchangers containing potentially "hot" cooling water.

The tunnel could be used as a second access, and as an emergency exit from the cyclotron cave and pit. The uphill part of the tunnel could also be used for a large exhaust duct from the cyclotron pit. Areas for experimental counting equipment, cyclotron control, shops and offices were placed above the basement on the downhill side. Areas for internal target extraction and radiochemistry caves were placed on the opposite or uphill side, radiochemistry laboratories at the south end. All of these areas, in accordance with the preplanning philosophy, were kept behind or south of a line drawn through the beam exit or north cyclotron shielding wall.

The foundation under the building consists of continuous and spread footings. All structural material below the main-floor level is reinforced concrete. The floor-load capacity is 3000 lb/ft^2 in the high bay and 125 lb/ft^2 for the low bay. Except over the basement, all slabs are on grade. Bell caissons carry the weight of the cyclotron shielding roof through the north and south walls of the shielding enclosure. The monolithic 3-ft-thick cyclotron foundation is structurally separated by a 1-in. space from the rest of the slab in the pit. This was done to minimize transfer of vibration from other parts of the building. The low-bay steel structure is structurally separated from that of the high bay by discontinuity in the structural framework. This prevents most of the vibrations set up by the crane from reaching the electronic equipment.

The floor surrounding the control and counting rooms (which are separated by an accordion-type partition) has been depressed to provide space for all electric wires to the electronic racks constituting the walls of the inner rooms. Slots in the depressed floor lead directly to the electrical equipment in the basement below.

Originally it had been our intention to construct the building of reinforced concrete, but due to the critical time schedule it was decided to use industrial steel-frame construction with insulated steel panels (figs. 4 and 5). This choice proved to be a time saver in that it prevented a number of unpredicted delays from pushing the completion date far behind schedule.

3. The Building Ventilation System: Radioactivity

The various aspects of radioactivity were dealt with extensively. Local wind patterns were studied to find the best locations for exhaust from rooms, hoods, glove boxes, etc. where radioactive materials would be handled and accidental "spills" might occur. Since the operation of the cyclotron would increase the level of radioactivity of the air inside the shielded enclosure, it was decided to draw filtered air from the high bay through the enclosure and exhaust it into the updraft airstream from the cooling tower. This procedure would keep radioactivity in the air at a minimum and would prevent the contaminated air from leaking through the cracks in the shielding walls into the high bay. The capacity of this ventilation system (variable from 4 000 to 12 000 cfm) was made large enough to cool some of the electrical gear in the pit, thus reducing somewhat the cooling water loads.

The exhaust ducts from the hoods and glove boxes in the radiochemistry laboratories are taken out through the uphill wall and directed upward via separate screened blower platforms. This arrangement will permit us to add a future second story to the low bay without interrupting the research work. Future exhausts of various designs may be added without a disturbing effect on the present appearance of the building.

The radiochemistry laboratories, offices, and shops are supplied in the conventional manner with filtered and tempered air from a central plenum. The air supply to the laboratory area has been designed somewhat less than the expected exhaust, so that a negative pressure, and consequently air inflow through the cracks, is maintained to prevent spread of possible radioactivity.

4. Heating and Air Conditioning

The ventilation and heating systems are so laid out that the second story can be added to the "low bay" wings, and the high bay can be extended several bays without providing additional space for the equipment required by these systems. These changes would mean that the size of the initial systems would need to be about doubled. Space is now allotted for one additional boiler, several blowers, rights-of-way for duct and piping, and additional chillers.

The control and counting rooms are air conditioned with chilled water to provide cooling for the transistorized circuitry. These areas have their own ventilation and air supplies.

5. Utilities: General

The municipal-type utilities provided were generally already available from the immediate environment.

Electric power, city water, gas, sewer, telephone, fire alarm, and public address were all extensions of the existing Laboratory systems, and required no extraordinary arrangements. Roads, fences, walks, and dry compressed air are also furnished by the Laboratory. In the San Francisco Bay Area, private utility companies provide water, sewers, and drainage—all at nominal costs.

A particle accelerator, such as the 88-inch cyclotron and its associated laboratories, does require several fairly exotic internal "utilities," namely, high-purity cooling water, tower water, acetylene, aged methane, oxygen, special

active-sewer and monitoring tanks, emergency power, demineralized or distilled water, and chilled water for air conditioning. Although not strictly a utility, the high-vacuum system should also be mentioned here, and its associated cascaded refrigeration systems for supercooling baffles and traps. These exotic systems account for a considerable portion of the thought and investment required to make this machine operative.

6. Emergency Power

Exhaust fans, emergency lights, radioactivity-monitoring devices, fire alarm, etc., require an unfailing source of electrical energy. The electrical system must be so designed that a casual power shutdown will not create safety hazards or disrupt research projects. To meet this requirement, a 30-kVA diesel-driven automatic-starting generator is being installed. An underground oil-storage tank of 550-gal capacity will provide 140 h of emergency power.

7. Electric Power

The basic power requirement for the initial machine was met by a 2-MVA unit substation, which transforms the primary 12-kV 3-phase power to the distributed secondary 480-V 3-phase with stepdown transformers for 120/208 V, and 220 V for auxiliary power and building utilities.

The transformer pad is designed to allow the easy installation of another 2-MVA unit substation and additional magnet power supplies.

8. Cooling System: General

We have found that, in general, the overall cooling capacity should match the incoming electric power. Any electric energy not absorbed by cooling water is more than offset by the air conditioning loads imposed. Consequently, a 2-MW-capacity cooling tower removes heat from the four separate cooling-water systems. A space is provided for an additional 2-MW cooling tower.

In Berkeley, a 65°F design wet-bulb temperature is used, and tower water at 75°F maximum supply temperature is generally expected. The primary-cooling-water design supply temperatures is 85°F maximum, with typical rises through the cooled equipment of 18°F.

The tower is an induced-draft redwood-filled open-deck type set on a concrete basin. Its cement-asbestos exterior was chosen to blend aesthetically with the building exterior.

9. Tower-Water System

Most of the tower water is used to cool the primary systems through shell-and-tube heat exchangers. Some is circulated in the building for conventional cooling chores, such as air conditioner and other refrigeration condensing water, mechanical-vacuum-pump jacket cooling, etc. The tower-water piping is predominantly steel. A careful program of tower-water treatment has been instituted to control corrosion and algae.

10. The Low-Conductivity Water (LCW) and Active-Low-Conductivity Water (ALCW) Systems

High-voltage equipment, water-cooled vacuum tubes, cyclotron dee, rf cavities, magnets, etc. require a clean cooling water, low in dissolved solids (electrolytes). It has been found both desirable and necessary to provide an extensive sophisticated primary-water system using demineralized water of 5 micromho, or less, conductivity at a pressure of about 100 psig. Cooper, brass, and stainless steel piping and pumps have been found the most suitable for handling the extremely corrosive demineralized water and keeping it clean. The shell-and-tube heat exchangers used with the 88-inch cyclotron are of all-monel construction, with the LCW (and ALCW) in the shell. Vinyl-lined steel surge and storage tanks are provided, and the pumps for these systems are all-bronze, trimmed with stainless steel.

The LCW system is the general-purpose high-voltage cooling system. It is distributed throughout the building to the power supplies, laboratories, the bombardment areas, and experimental areas.

The ALCW system is a separate system which cools the machine itself, particularly those parts where activity may be induced directly in the cooling water. The ALCW pumps, heat exchangers, and surge tank are located, as previously indicated, on an isolation pad on the east side of the high bay of the building in such a location that the contact with personnel will be at a minimum.

Demineralized water is supplied to both systems by a small mixed-bed demineralizer which reduces the 60- to 150-micromho city water to 0.5 to 5 micromho conductivity suitable for use in these systems. A 1- to 5-gpm slip stream is recycled from the LCW system through the demineralizer to keep the solids in this system from accumulating. The ALCW system has its own disposable-type demineralizer cartridges and filters for recycling.

11. Bottled Gases

The shops and laboratories require, of course, oxygen and acetylene for their operations. These are provided from conventional manifolds at the building exterior.

A special "aged methane" system supplies methane that has been allowed to stand at least two weeks following removal from the well, through interior piping to the counting equipment.

12. Waste-Monitoring System

Normally, active wastes are to be stored in special containers provided in the laboratories and hot target areas. These containers will be carefully stoppered, then removed to a disposal yard when required, in accordance with good current practice for disposing of active materials.

However, as a second line of defense, the floor drains and sinks in the laboratories and target areas, and the drainage from the ALCW area are fed into a special active sewer which drains into two phenolic-coated 1000-gal retention tanks arranged in parallel. These tanks are intended primarily for holdup or retention, one being sampled and dumped while the other is filling. Should there be an intolerable amount of radioactivity in a given batch of retained sewage, it can be precipated and pumped into a tank truck and hauled away. A recording device permanently records the amount of sewage handled.

13. Color and Light

The exterior color of the building was selected in accordance with prevailing views about blending as much as possible with the natural surroundings. Some small departures were made to accent the structural simplicity. In spite of the use of commonplace materials, and limitations in color selection, a certain elegance has been achieved.

The same simplicity and restraint regarding colors has been applied on the inside. With the exception of the structural members, which are beige, the principal color throughout the building is eggshell white with contrast (or accent) color provided by equipment, furniture, etc. This gives a pleasant light atmosphere and encourages cleanliness and good housekeepingg. As a consequence, safety hazards are reduced. The light-colored resilient tiles in the low bay add both to the pleasant feeling and to the custodian's daily exercise.

All rooms have fluorescent lighting except the high bay, where a combination of mercury and incandescent light was chosen as the most practical. With respect to daylight in the high bay, only diffused glare-free light would be acceptable. Sun rays or excessively bright light would interfere with the reading of dials, scopes, etc. The problem was solved very successfully by using milky-white plastic

panels projecting into the rooms along the top of the 45-ft-high side walls. In the control and counting rooms a ceiling of plastic grating provides a shadow-free light which is dimmable to zero candlepower. Draft-free ventilation is supplied through the same ceiling. The rest of the building—with the exception of basement, and the radiochemistry laboratories—has clear windows, which afford the occupants a sweeping view of much of San Francisco Bay and the surrounding communities.

14. Close Integration of the Accelerator and Building Designs

In conclusion it should be noted that everyone involved on the 88-inch-cyclotron project directly or indirectly contributed to the overall planning and design of the building. An intimate working relationship was established from the beginning between the accelerator and building—project people. Decisions were in general made by consensus, which in our opinion helped substantially to integrate the accelerator and the associated equipment and utilities with the building and site. Through this coordination it was possible to anticipate, and hence avoid, many problems. Cooperative effort also contributed greatly to the achievement of simplification in the overall design.

FIGURE CAPTIONS

Fig. 1. Grouping and functional relationships of areas.

Fig. 2. Building and site plan.

Fig. 3. Isometric section through building and site.

Fig. 4. Aerial view of building.

Fig. 5. South and entrance view of building.

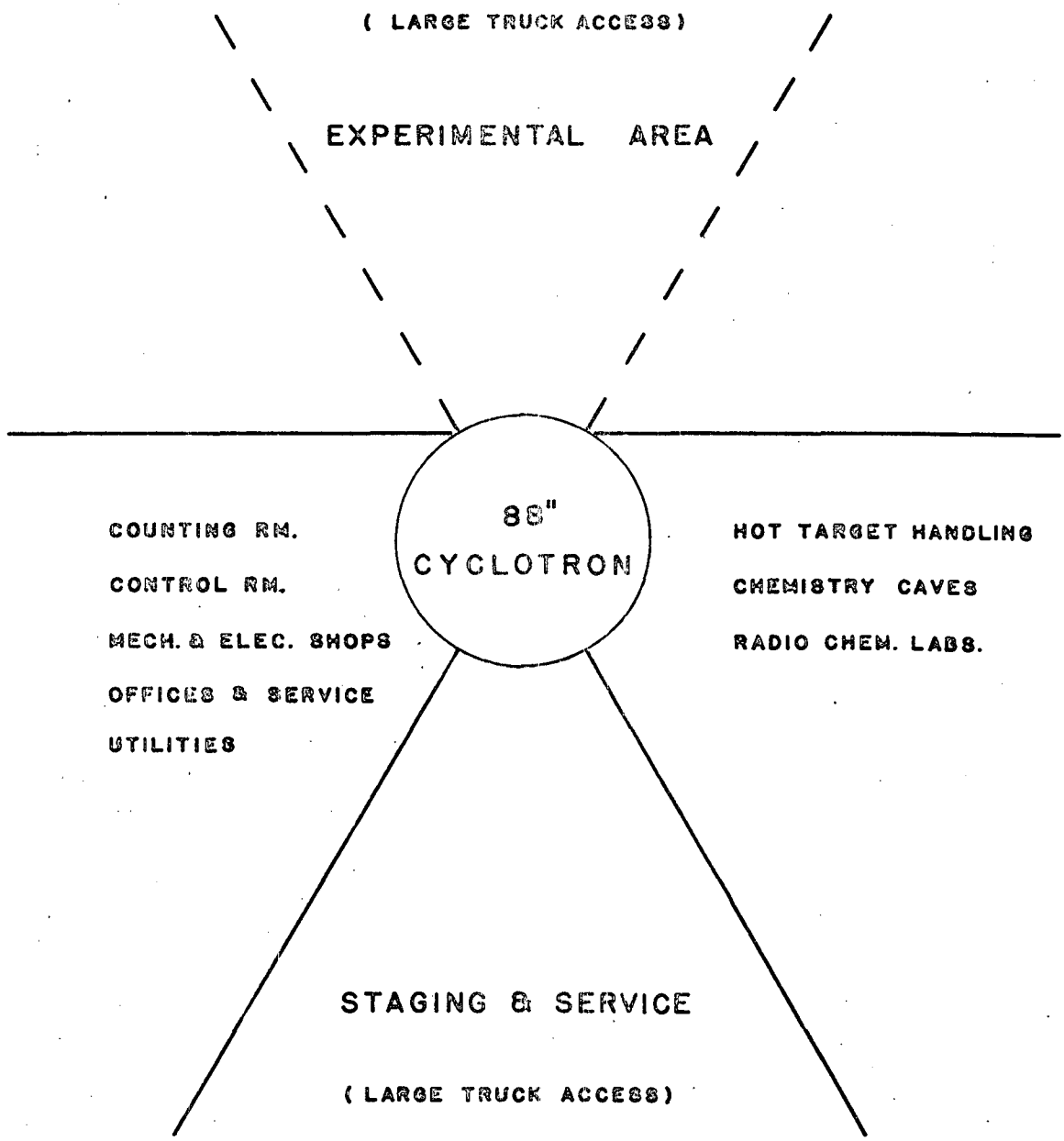

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Fig. 1.

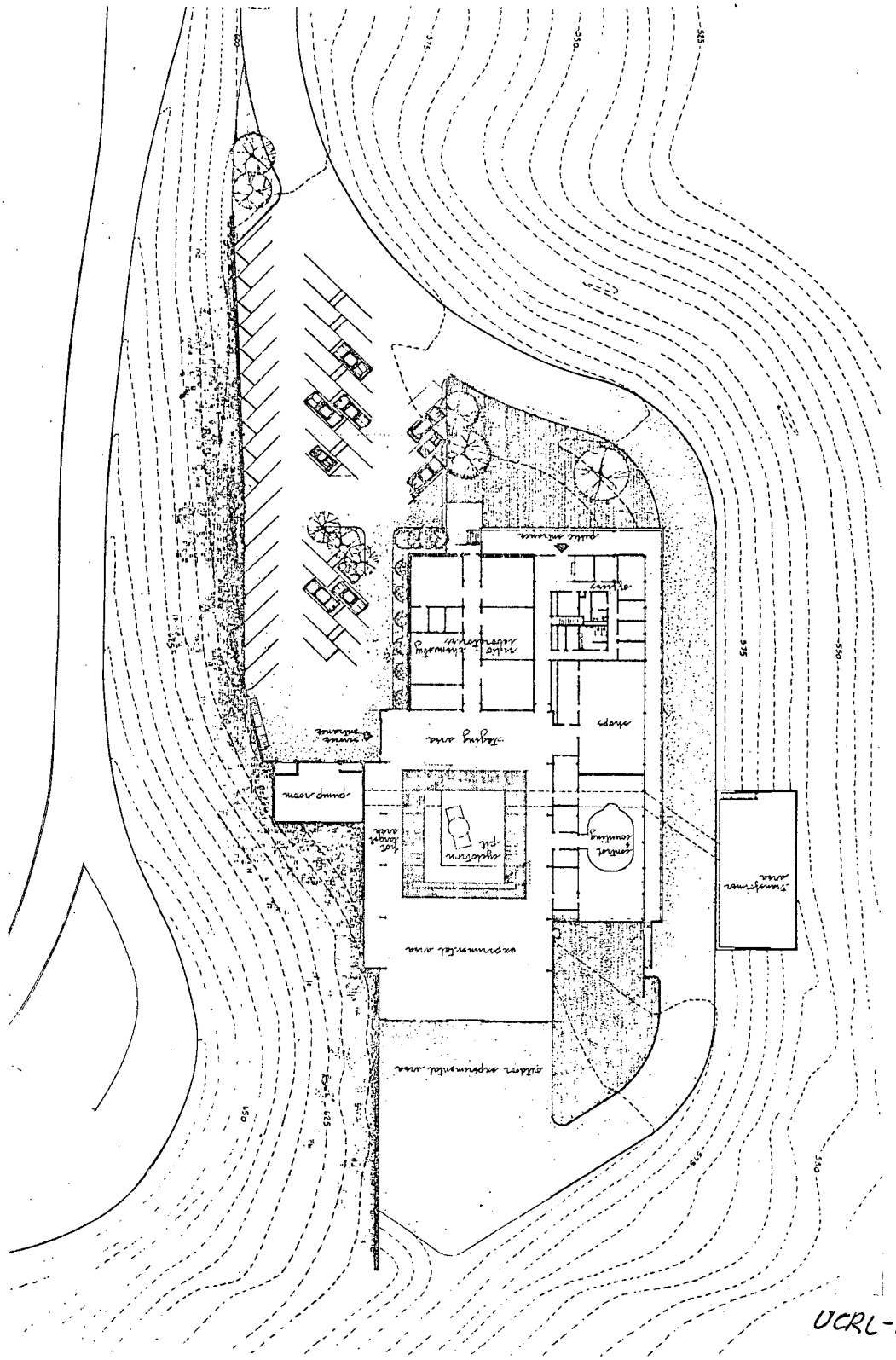

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Fig. 2.

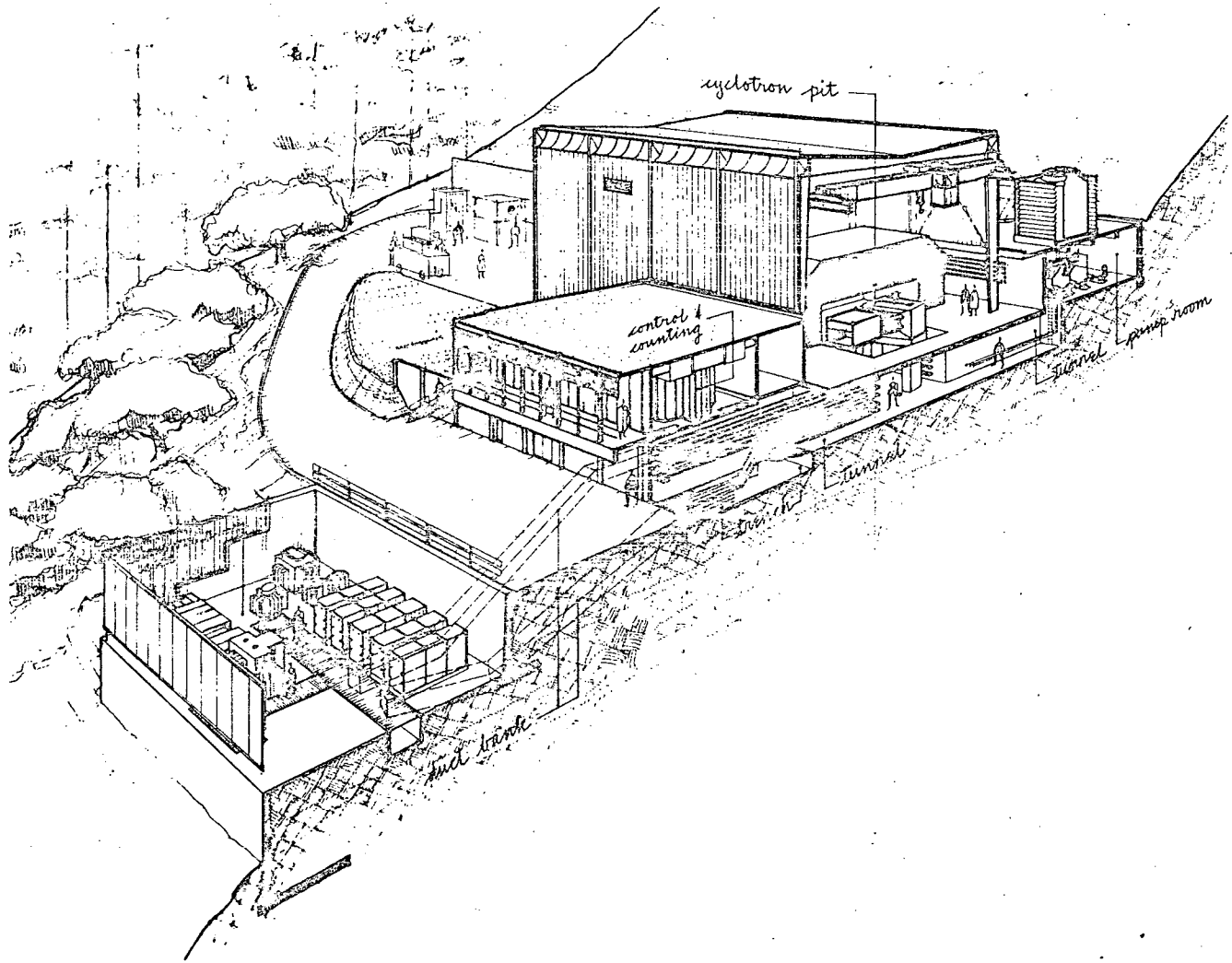

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Fig. 3.

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COTTON CONTENT

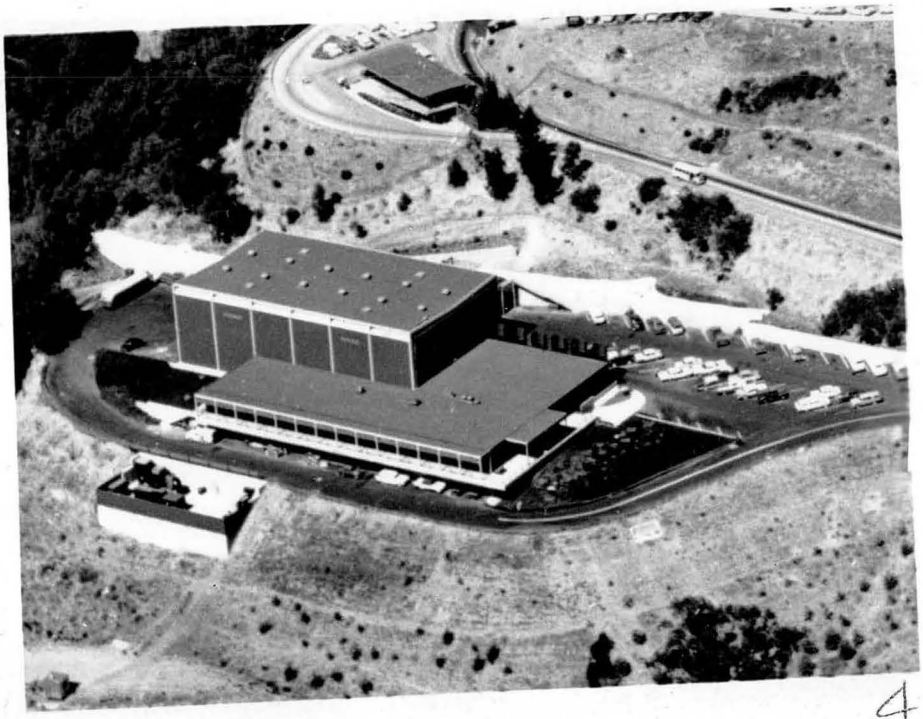

Fig. 4

Fig. 5

MILLERS FALLS
ESTABASE