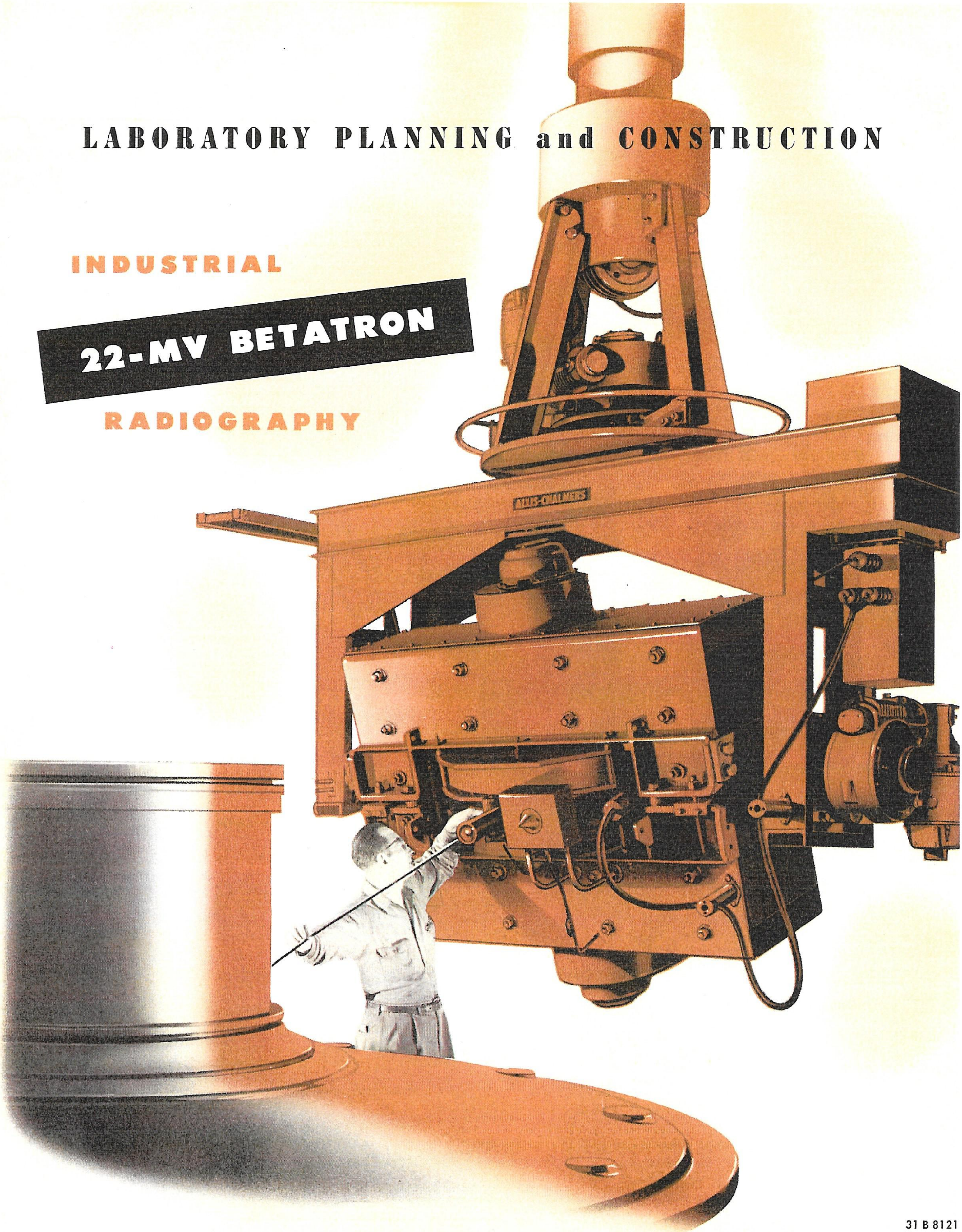
LABORATORY PLANNING and CONSTRUCTION

INDUSTRIAL

22-MV BETATRON

RADIOGRAPHY



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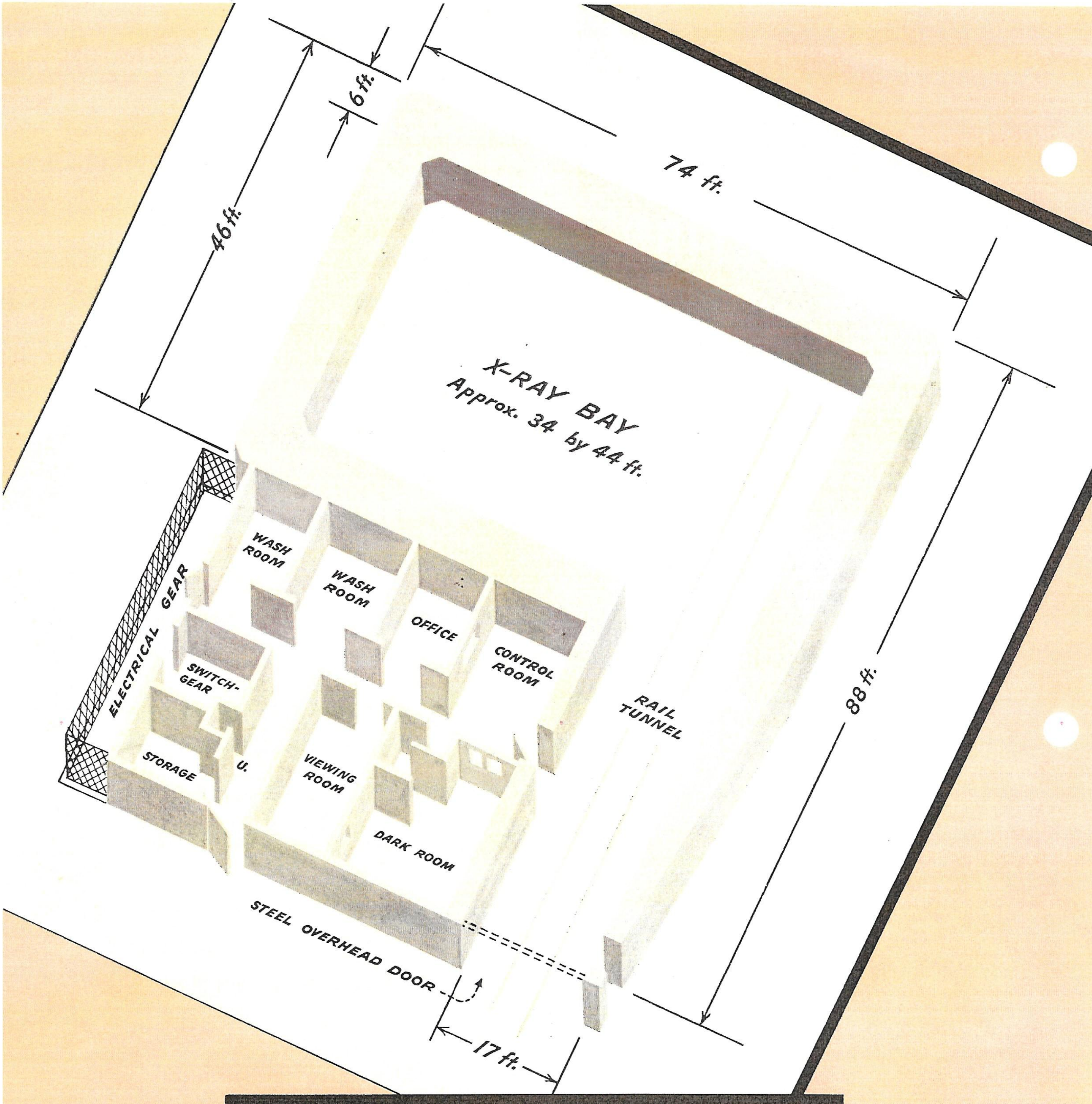
ALLIS-CHALMERS MFG. CO. • MILWAUKEE 1, WISCONSIN



FLOOR ARRANGEMENT

FEATURES

AMPLE WORK AREA — X-ray bay has "elbow room" for work pieces up to 20 feet long and 25 tons; darkroom permits efficient arrangement of equipment; viewing room contains radiograph files.

CONTROL AND DARKROOMS HANDY TO X-RAY BAY — saves steps for operators.

AMPLE PROTECTION — 6-foot thick walls effectively contain radiation.

ACCESS TO BAY BY RAIL AND TRUCK.

LABORATORY PLANNING and CONSTRUCTION

The Allis-Chalmers Betatron Laboratory, put into operation in 1952, has proven to be an efficient, well-planned inspection facility. A study of its features provides a good basis for planning a similar installation.

Two Basic Considerations

Provisions for an efficient work handling system and ample protection of personnel from radiation were fundamental in the planning of the laboratory. The first was important because a study of anticipated work revealed actual exposure time would range around two minutes per exposure for more than 75% of the work whereas receiving, positioning, and returning the work, because of size and weight, would consume considerable time. Therefore, it was concluded that efficiency of the laboratory would be almost completely determined by work handling methods employed.

The second was equally important because X-radiation is dangerous. Therefore, planning was directed towards positive containment of the X-radiation within the X-ray bay and provision of safety devices which would prevent accidental exposure.

Laboratory Site

The site chosen, a fill of waste foundry sand on a bluff at the edge of the shop yards, was a compromise in regard to nearness to other activity and convenience for work haulage by rail or motor truck. It is isolated to the extent that requirement for insulation of surrounding areas from radiation was not excessive. The location is also relatively free of ground vibrations from shop presses and hammers.

Laboratory Arrangement

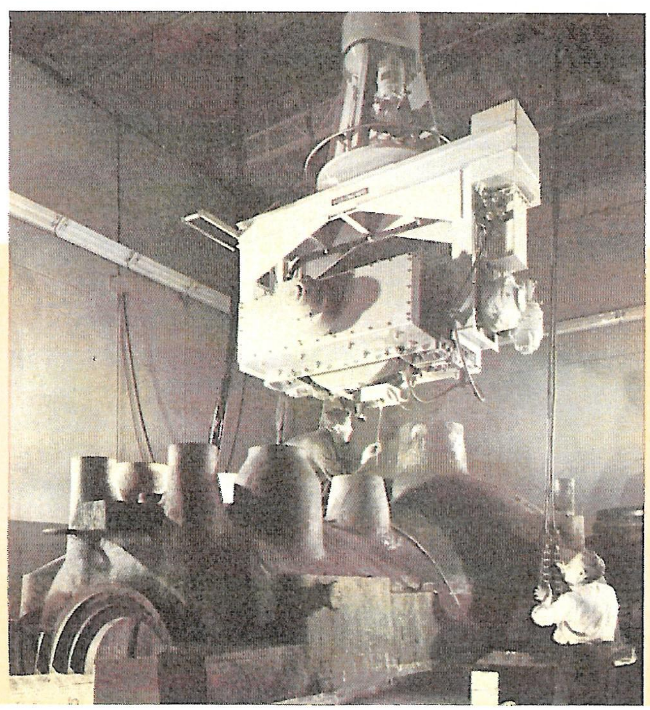
An "L" shaped area consisting of an X-ray bay, which houses the betatron, and a rail tunnel comprise the major portion of the laboratory. Inside of the "L", as shown by the drawings of the floor arrangement, are the auxiliary rooms, including the office, control room, darkroom, and viewing room. A penthouse that houses heating and ventilating equipment is above these rooms.

Work Handling

Work, hauled between the shops and laboratory by either rail or truck, is brought into the bay through the tunnel. In the bay, a 25-ton heavy-duty bridge crane is used to move the work into position on either steel horses or the floor, and for reloading. The betatron itself, supported by a 7½-ton bridge crane, is arranged so that it can be moved over the entire floor. It can also be raised vertically to 20 feet above the floor and rotated through 360° in a horizontal plane, 170° in a vertical plane.

With this arrangement, the betatron, instead of the work, can be moved into position for each exposure. Since work handled ranges up to 25 tons in weight, 20 feet in length and is irregular in shape, this arrangement is most practical and efficient. Further convenience is gained when work is of such nature that it need not be unloaded. For this, the betatron can be moved to the rail tracks for radiography on the flat car or else trucks hauling work can be driven into the bay.

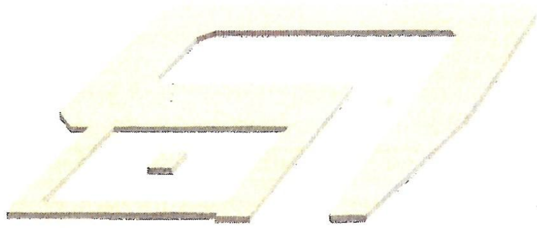
(Continued on page 6)



An example of work handled by the laboratory is this lower half cylinder for the intermediate pressure section of a 125,000-kw steam turbine. Because the betatron provides the means for determining the quality of components which could not be checked before, it has effectively rounded out the company's nondestructive testing system and has resulted in 100% quality control of all critical components. Equipment for ultrasonic inspection is also housed in the laboratory since radiography and ultrasonic testing make an extremely useful team when used together.

CONSTRUCTION OF LABORATORY

The walls of the X-ray bay serve as radiation barriers. Because of this, they were made of steel re-inforced concrete, 6 feet thick to a height of 20 feet above the floor. The portion above grade level was made with no voids or discontinuities by casting it in one round-the-clock operation. Walls of the rail tunnel were cast during the same pouring to prevent seams where they join the bay wall. Approximately 1000 cubic yards of concrete were used for these walls. To prevent sagging or cracking from stresses due to their weight or temperature variations, they were constructed in the following manner.

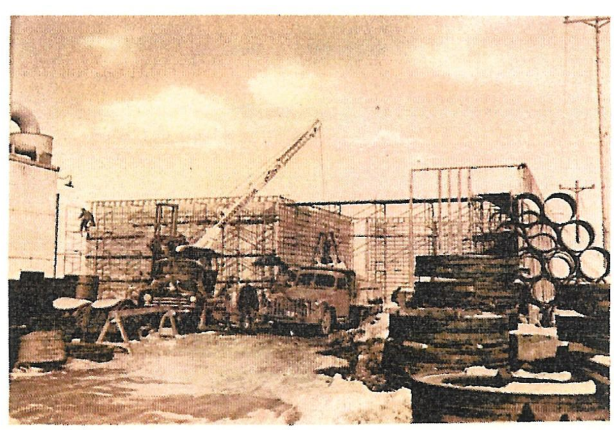


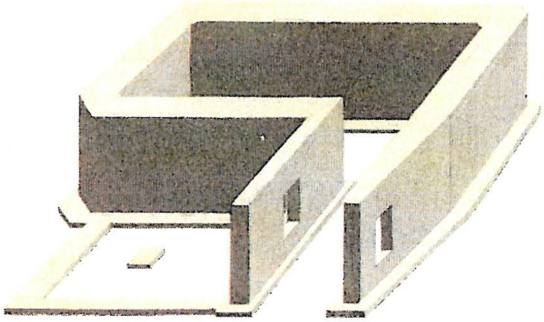
1 Foundation

Spread footing of reinforced concrete resting 6 feet below grade provides a stable foundation in the fill of waste foundry sand. The portions supporting the 6-foot thick wall are 13 feet wide, $2\frac{1}{2}$ feet thick. Two 12 by 6-inch keys as well as dowels were cast in the foundation for locking with the walls.

2 Erection of Forms for Main Walls

A web of re-inforcing rods was installed for each face of the 6-foot thick walls to knit them together securely. Two webs instead of one were used as an added precaution against cracking. The forms, held together by tie rods, were faced with Masonite for the interior surface and with plywood for the exterior so that these surfaces would present a smooth appearance. After the forms were removed following the pouring, the tie rods were burned off and the cavities repaired to continue the smooth finish.





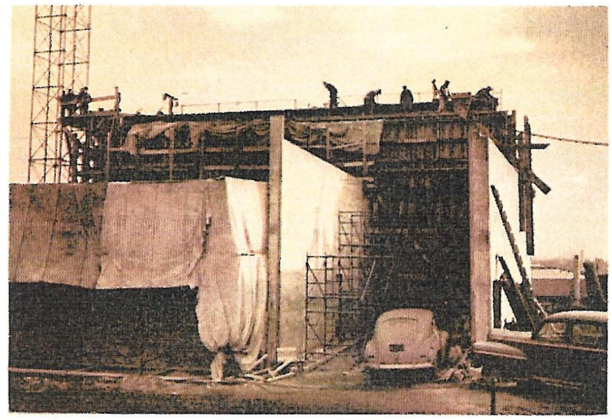
3 Finished Bay Walls

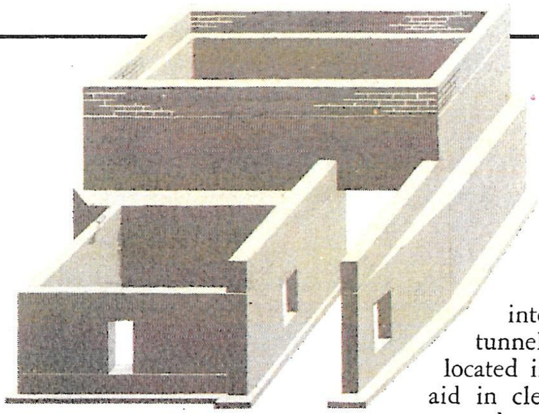
Six-foot thickness of walls extends to 20 feet above floor line, corresponding to maximum vertical travel of betatron. Top surface of wall was given a six-inch drop towards the exterior to shed rain and snow.

The exterior wall of the rail tunnel tapers from 6 feet to 20 inches at the door. This reduction was permissible since the intensity of the X-ray is attenuated as the distance from the source increases. Since limit switches prevent aiming the betatron into the tunnel, the interior wall is not subjected to direct radiation and, therefore, was made only 16 inches thick.

4 Forms for Superstructure

A 10-foot high, 32-inch thick re-inforced concrete extension to the main walls was cast and brick work started following the completion of the main walls. The extension supports rails of the two bridge cranes. Interior surfaces of the main wall and extension are flush. Lintel across rail tunnel is a re-inforced concrete beam. Canvas was used to protect workmen from near zero weather.



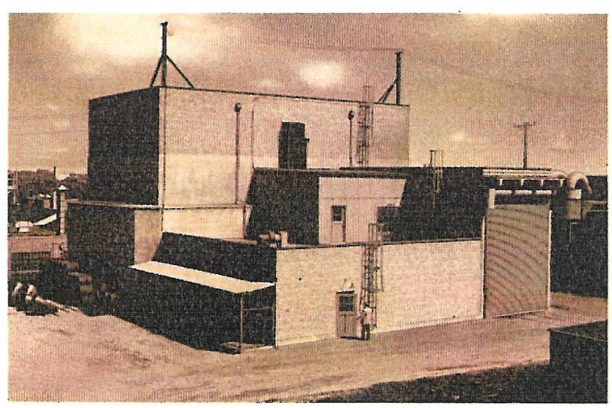


5 Completion of Brick Work

Superstructure above the bay walls, in addition to the 32-inch thick concrete walls, consists of a 12-inch brick wall to the roof. The roof consists of structural steel beams and purlins, precast light-weight concrete decking, insulation, and built-up three-ply roofing. Exterior walls of auxiliary rooms are also of brick, 12 inches thick, and the interior divisions are metal lath and plaster. Floors of the X-ray bay and rail tunnel are 12-inch thick re-inforced concrete slabs laid on the ground. A drain is located in the tunnel floor to remove snow and rain brought in on castings and to aid in cleaning. Floors of the auxiliary rooms are 6-inch thick slabs laid on the ground and are covered with asphalt tile flooring.

6 The Completed Laboratory

View of the completed laboratory shows the penthouse above the control room and adjacent to the upper wall of the bay. It is constructed of corrugated asbestos cement siding fastened to structural steel framing. Power supply transformers, set on a concrete slab, are housed in a wire enclosure outside the auxiliary rooms; the enclosure is covered by a corrugated asbestos-cement roof. This location is adjacent to the room containing the betatron capacitor racks and switchgear. A steel roll-up door closes the rail tunnel.



Laboratory Planning and Construction

(Continued from page 3)

Safety Precautions

Careful thought was given to safety requirements in arranging the controls of the machine. Limit switches, interlock switches and warning devices were installed to make operation of the betatron as fool-proof as possible. A key operated master switch, installed in the bay, provides anyone in the bay a means of making the machine inoperative.

Auxiliary Rooms

The control room, containing two electrical cabinets for operation of the betatron, was located adjacent to the tunnel to save steps for the operators. Pass boxes for delivering film to the darkroom are just inside the doorway from the tunnel.

A large window area gives the office unity with the control room. The viewing room is large and well ventilated and does not become uncomfortable during long sessions of studying radiographs. A heatless type film dryer is installed in the wall between the viewing room and darkroom and serves as a pass box.

The darkroom is large enough to be airy as well as to permit convenient and efficient arrangement of equipment. Since the volume of film handled is not large, no automatic equipment is used. Precise solution temperature controls, as well as an adequate supply of hot water, aid in proper film development.

Radiation Check

After completion of the laboratory, tests made with radiation meters throughout the building proved that no hazardous radiation escaped from the X-ray bay and tunnel. Film strip left at random places outside of the exposure area for long periods of time, verified the meter indications.

Cost

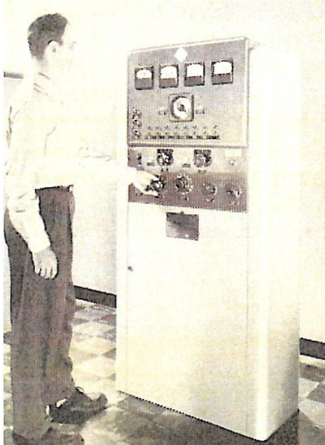
Cost of the laboratory can be broken down as follows:

Betatron Installed Complete	$125,000
25-Ton Bridge Crane Installed Complete	40,000
Building, Plumbing and Electrical Fixtures	165,000
Laboratory Equipment, Furniture	12,000
Total	$342,000

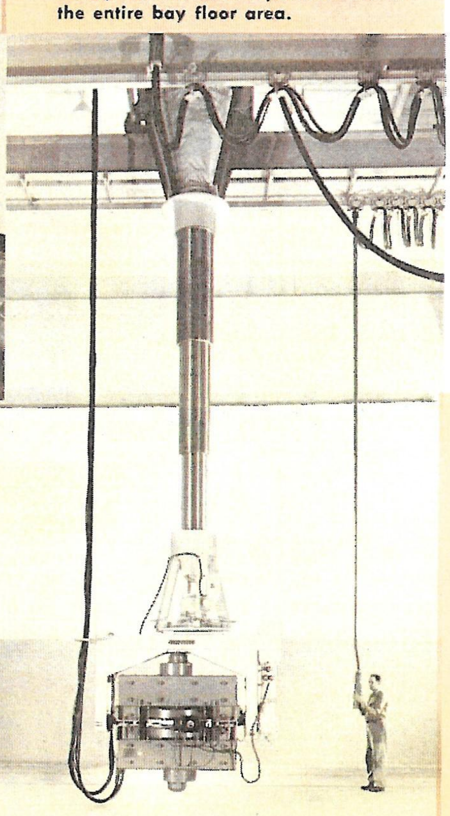
Results

The laboratory was completed and put into operation in September, 1952 and has been used extensively since then, often on a three-shift basis. Work handled has included inspection of every important casting, forging and weldment used in fabrication of machinery produced by the company, custom radiography for other companies, and pure research on industrial radiography problems.

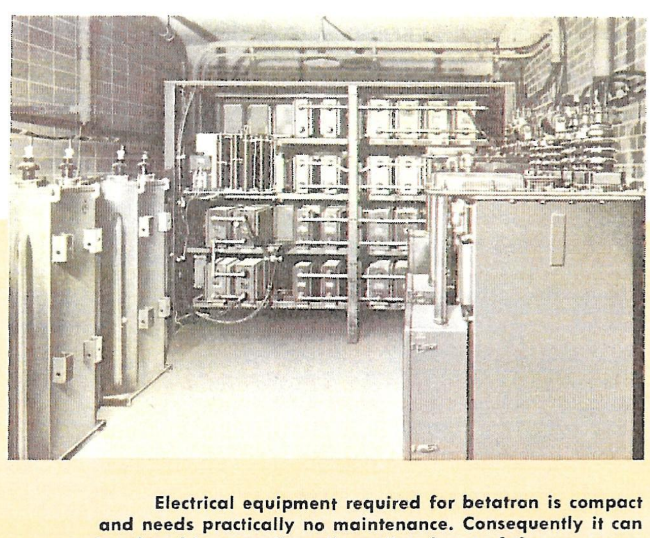
In less than one year, the cost of the entire betatron installation has been completely amortized by savings resulting directly from its use.



Interior of control room is neat, roomy and well lighted. Asphalt tile covering on floor makes cleaning easy and aids in keeping dust level low. Cabinet in foreground has control panel for the 22-mv betatron.



View of interior of bay shows roomy work area as well as suspension of betatron. The telescoping tube permits the betatron to be raised to a height of 20 feet above the floor and is rigid enough so that there is no pendulum effect. Suspended from a bridge crane, the unit can be positioned over the entire bay floor area.



Electrical equipment required for betatron is compact and needs practically no maintenance. Consequently it can be placed in a small, well-ventilated, out-of-the-way area. All transformers may be placed outdoors if necessary.

GENERAL CONSIDERATIONS

New vs. Conversion

Requirements for an efficient work handling system and for ample protection of personnel from radiation for betatron radiography differ greatly from those for lower-voltage facilities. Therefore, much alteration is normally required to make an existing radiography facility suitable for betatron use. Experience has proven that such alterations may be nearly as expensive as a new laboratory but still do not offer nearly the convenience that could be provided in a new structure specially designed for the requirements of a betatron.

Alterations to provide adequate radiation protection involve thickening of walls, usually encroaching on floor space, and addition of shielding material to doors, making them cumbersome. Work handling equipment alterations usually require addition of heavy-duty bridge cranes.

While these alterations make use of the betatron possible they usually do not permit efficient use. Consequently, a very careful study of the advantages and disadvantages of converting existing facility weighed against construction of a new laboratory is required.

Location

Location of a laboratory is a matter of convenience for work haulage, weighed against protection from radiation for activity in the area surrounding the betatron, as well as space and foundation requirements and consideration of the type of work to be radiographed.

If a wide variety of work is to be handled, such as for general manufacturing, a centrally located general purpose laboratory accessible by both rail and truck will serve best. This is especially true if use of the laboratory is to be extended to neighboring companies.

If a betatron is installed in an existing building, alterations to accommodate the betatron are a compromise between what would make an ideal installation, which is usually impossible because of space limitations, and a temporary makeshift arrangement. Such installations are never very versatile. They are usually suited to efficient handling of only a narrow range of work. If, however, work is uniform and highly repetitive, an installation to be made in an existing building can be arranged to permit assembly line inspection.

Construction

Location of the laboratory is a primary factor in determining the type of structure to use. If feasible, an economical installation could be made in a hill side where earth would serve as the radiation barrier. The usual site, unless the betatron is to be installed in an existing building, requires a building similar to the Allis-Chalmers laboratory. Experience has proven reinforced concrete construction most satisfactory, as well as economical.

Work Handling Equipment

A careful study of work to be handled is necessary to determine what handling facilities are required. In general, if work varies greatly in weight, size and shape, a work handling crane and steel horses or platforms are all that are practical. For this work, a motorized dolly can be arranged for hauling between plant and laboratory or work may be hauled by shop locomotive or truck, depending on the distance from laboratory to shops.

For work which is fairly uniform, a jig such as a turntable can be used to advantage.

Facilities

Basic requirements for a laboratory, in addition to the X-ray bay, are a control room, darkroom, office viewing room, and wash rooms, as well as space for electrical gear, heating, and ventilation equipment and storage. Because advantages are gained by coordinating the use of the betatron with other non-destructive inspection methods such as low-voltage radiography, ultra-sonic testing and magnetic particle methods, provision for use of these methods is also practical. Facilities for repair of castings may also be linked to the laboratory.

Heating and Ventilating

The thick walls required in the laboratory are effective insulation from climatic changes. However, opening of the large doorway to the bay counteracts their effect. Therefore, adequate heating is required for maintaining a comfortable temperature in the bay during cold weather. A ventilating system to exhaust air from under the roof of the X-ray bay is required to remove dead air, heat given off by the betatron (equivalent to 20 kw) and heat absorbed by the roof from the sun. The latter makes frequent air changes necessary in warm weather to prevent accumulated heat from decomposing insulation on crane components.

Auxiliary rooms, with the exception of the viewing room, require normal heating and ventilating. The viewing room, because of heat given off by the viewing lights and frequent crowding by plant personnel, requires special ventilation to remove stale air.

Darkroom

Volume of film handled for betatron radiography is not large except when a production line set-up is used. Therefore, only simple essential equipment is needed in the darkroom. Since film used with the betatron is standard X-ray film, special equipment is not necessary. It is necessary that precise solution temperature controls and adequate hot water be provided so processing of film will be uniform.

Office and Viewing Room

Office space required is that needed to accommodate one supervisor plus room for conferences. The viewing room has about the same size requirement plus room for file cabinets for storing radiographs.

Location of Electrical Gear

Electrical gear requires approximately 200 sq ft of space. A good arrangement is to install it on a second floor, above the auxiliary rooms. For convenience of operators, the control room should be as near to the bay as practical.

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