EXPANSION OF THE BEVATRON EXTERNAL PROTON BEAM EXPERIMENTAL FACILITIES*

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Summary

The External Proton Beam Channel has seen intensive utilization since its installation at the Bevatron. A program now in progress will further enhance its versatility by increasing target areas, beam intensities, experimental floor area, shielding and utilities. We describe here the physical facilities, among which is a truly unique overhead crane design. The proton beam operation and characteristics are discussed in the Bevatron Experimenters Handbook.[1]

History

When the Bevatron resumed operation in February 1963, after being shut down for a major improvement program, an external proton beam (EPB) had been added to its other experimental facilities.[2,3] After a period of study and development, the first focus was initiated with a major momentum channel operating by August 1963. By September 1964, the second and third focus areas were in full operation with major experiments. This facility proved to be the most reliable, flexible and of the highest intensity EPB at any high-energy accelerator.[4,5] In the ensuing period, however, each new major experimental channel pointed up the need for improved facilities and space, inasmuch as the third focus and backstop were installed out-of-doors between the Bevatron building and the bubble chamber building (Fig. 1). The drawbacks of this location are: (a) lack of experimental space, (b) no overhead crane, (c) inadequate load-bearing capacity of earth fill in this area, and (d) minimal utilities.

By the end of 1964, study was underway to improve facilities and to provide for expansion. A program which took proper cognizance of funding difficulties and experimental scheduling was adopted, and would see this improvement project eventually completed in several steps over many fiscal years. This program includes a dual-channel EPB, shielding and its support foundation, expanded EPB experimental area, overhead material handling, and installed utilities with distribution systems.

Building

The only possible direction of expansion was to the north, with these restrictions: (a) immediately north athwart the EPB channel was the bubble chamber building; (b) to the west was a 110-ft deep canyon; (c) to the east was the existing staging building with a precipitous hill immediately behind. The most effective utilization of existing facilities called for the expansion of the EPB experimental area into and beyond the area occupied by the bubble chamber building. The resulting structure is a clear span 144-ft-wide steel frame building, with 60-ft-wide bays, which extends out somewhat radially from the existing circular building as shown in Fig. 2. By specifying that the overhead crane (cab clearance 33 ft) be able to pass comfortably over the bubble chamber blockhouse, we set a building height (52 ft to bottom of truss) which was also adequate for construction over and around the bubble chamber building while it was still in use. Figure 3 clearly shows this in progress. For this phase of the expansion there will be 20 000 ft^2 of roofed, heavy-duty (2000 psf) area with 300 lineal feet of utility tunnels. The layout of the tunnels will be "H" shaped, with two legs running parallel to the column line and a connecting tunnel. The east leg will connect with an existing tunnel. North of this roofed area will be an open area of 17 000 ft^2 with crane coverage to be used for experimental area, heavy-bulk storage as well as the assembly of large equipment. This area will eventually be enclosed for experimental hall usage. Total combined area will be approximately 37 000 ft^2.

Crane

The junction between a circular and a rectangular building posed quite a problem for overhead material handling. Since this area is prime experimental area, it was vital that lost motion and time through double handling be held to a minimum. A design was evolved which enabled the same single 30/10 ton overhead crane to handle material in that peculiar junction area as well as in the rest of the building. Basically the operator cab and hooks are side hung from a trolley which travels on curved tracks conforming to the curve of the existing circular building (see Fig. 4). The single 145-ft bridge girder is straight but skewed in order to pick up the trolley load at its maximum eccentricity. Thus, the eccentric moment is reduced to a minimum structural design problem. The end structure and trucks which tie together the straight girder and curved trolley track provide the stability required. It has been estimated that this design costs only 10 to 15% more than a conventional double-girder crane with the same capacities and features. In fact, an independent study by consultant engineers established that in terms of \$ cost/ft^2 coverage, this design would be the most advantageous of several alternatives. Another attractive feature is that there is no additional maintenance problem from mechanical switching and/or supplementary handling arrangements.

Safety

Current safety policies and experiences with regard to the design of buildings to house equipment containing explosive and flammable fluids were considered in the building design. Hazardous fluid-filled devices will be locally housed and vented to the atmosphere. The decision was made to take maximum advantage of the mild Berkeley climate and to dispense with the building heating. This also made possible the use of open monitors in the roof of each bay to prevent gas accumulation under the roof and to ventilate continuously by natural convection. Continuous flushing is assured by having the walls above the 20-ft height project 4 ft out beyond the columns with an open-grating floor. This projection will serve also as a utility galley. Roof panels are designed to lift as hinged panels with internal pressures of 1/2 psi. The bridge girder will be under slight nitrogen pressure to keep out hazardous gases. Potentially hazardous areas are monitored locally with continuous service flammable gas detectors. Building tunnels will also be pressurized to prevent downward seepage of heavy gases.

Utilities

Utility tunnels were chosen in preference to trenches, because of their greater versatility and use factor. The finished costs of the trenches with heavy-duty manhandleable covers were about 10% less than tunnel costs, but the tunnels would always be accessible regardless of what may be over the tunnel. Utility access from tunnels to the floor above are through 2-ft square hatches spaced 13 ft apart, paired for electrical and mechanical utilities separately. This spacing was dictated by commercial bus ducting modules. A cross section of the tunnel will be 6 ft wide by 7 ft high with electrical power on one side and mechanical utilities on the other. Electrical power will be 480-V ac in bus ducts. Portable distribution boxes on the floor will be plugged in through the hatches and the ac power will be distributed to local rectifier units. Low conductivity water will be distributed by portable manifolds supplied by tunnel main lines through hatch openings. Some 110/120-V convenience outlets will also be available at the hatch openings under the covers.

Shielding Foundations

The most significant improvement will be a heavy-duty foundation which will permit heavier shielding to be used for the EPB channel, which in turn will permit higher beam intensities than presently permissible. The original backstop area was on filled land and the heavy shielding load had caused settlements as much as 3 inches in the 3 years of operation. This, of course, made beam-transport alignment quite a maintenance problem. The new foundation will have poured concrete friction piles into the rock with a 3-ft-thick concrete cap to limit settlement to 1/4 inch. The first area (nearest the Bevatron) will have 28 caissons and 2500 psf capacity; the second area will have 50 caissons and 3500 psf capacity; the backstop area will have 67 caissons with 5000 psf capacity for a total of 145 caissons with depths from 30 to 60 ft and a diameter of 24 inches.

Shielding

The shielding design calls for 10-ft-thick walls with 225 lb/ft^3 density in the slot area 4 ft above and below the beam centerline. The roof will be 6 ft thick and of 225 lb/ft^3 concrete over the focal target areas and the backstop area. Total tonnage of blocks will be 4240 tons of ordinary 155 lb/ft^3 and 5270 tons of 225 lb/ft^3. Of this, 2540 tons ordinary and 2470 tons heavy concrete will be existing. The focal target areas will also have additional local modular shielding. Backstop shielding normally will use uranium, steel, and 225 lb/ft^3 concrete, according to experimental demands and space limitations. The criteria used in the shielding design is such that the neutron background on the experimental floor will be below tolerance for a proton beam intensity of 1 to 2×10^{12} protons per pulse at 12 pulses per minute each channel.[6,7] The shielding is adequate for workers to be in one channel when a 30-in.-long uranium beam plug is in place, while beam operation continues in the other. Labyrinth arrangement is used with locked access gates remotely controlled from the main control room through TV monitors. This arrangement has been successfully employed both as part of the main machine and EPB shielding since 1963.[8]

Channel Layout

Since the Bevatron beam centerline is 94 inches above the floor, the EPB transport components are installed on a steel decking platform 46 inches above the floor. In conjunction with a depressed aisle at the second focus area, a relatively-unhampered passage will handle pedestrian traffice, even with secondary beam channel components bridging the aisle. The utilities servicing the beam-transport components are arranged so that the mechanical services will be above the platform and the electrical service below. There will be a vacuum pumping station on top of the center shielding island as well as some power supplies for the backstop area. The electrical power for the EPB channel magnets will be fed mainly from supplies in a deep tunnel which was part of the 1962 improvement program.

The beam-transport system was designed by Dr. T. Elioff to provide a maximum of target areas with great flexibility.[1] The dual channel arrangement can operate simultaneously on alternate pulses, or split pulses with a pulsed magnet arrangement, or share long and short beam spills by the added operation of a kicker magnet.

As many as eight channels can be set up simultaneously using the EPB, although not all may be compatible in beam requirement. The present schedule calls for full operation of the EPB by October 1967, with five secondary beam channels (see Fig. 2). Beam quality will also be improved by vacuum coupling the EPB channel with Bevatron vacuum to the first focus. A rapid plunging beam stop in the first focus region will prevent accidental low-energy spill from going down any secondary channel.

Progress Schedule

The initial step was underway June 1965 with the construction of a 5-MW cooling tower with a circulating capacity of 2400 gal/min. This large circulating capacity is contrary to good industrial practice, but is well suited to experimental operation practices. In september 1965, a 6.2-MW transformer bank installation was started. The addition of these facilities alleviated a very critical situation. May 1966 saw the beginning of boring operations for the craneway caissons, some of which went to depths of 120 ft. January 1967 was the start of building enclosure. Other schedules are as follows:

1. Heavy-duty foundation floors and tunnels: begin March 1, 1967, complete August 30, 1967.

2. Crane delivery: March 15, 1967.

3. Second focus experimental physics operation: June 1967.

4. Third focus experimental operation: October 1967.

References

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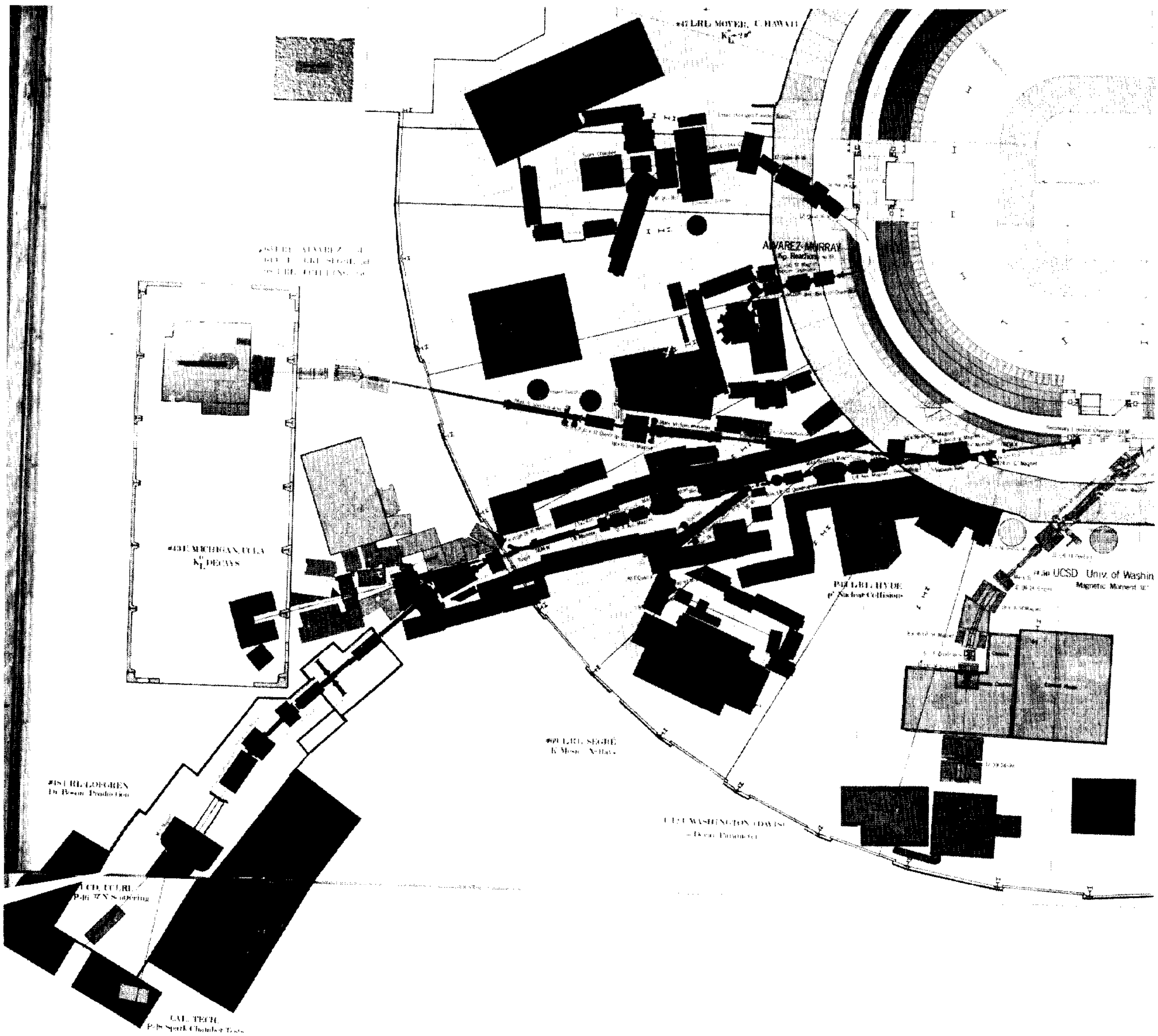

Fig. 1. Bevatron experimental areas as of December 1966.

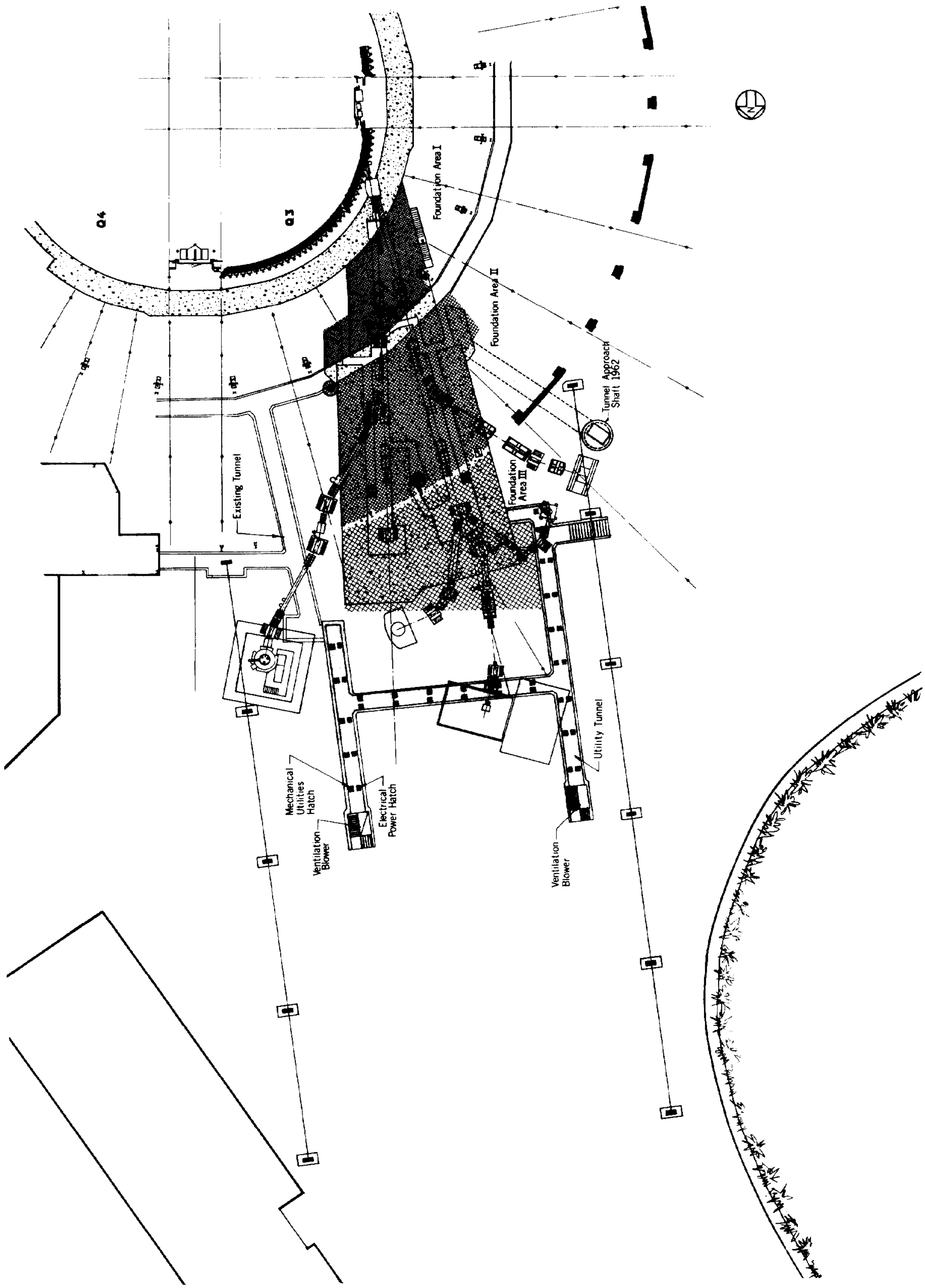

Fig. 2. General layout of EPB experimental hall and proposed secondary beams for October 1967.

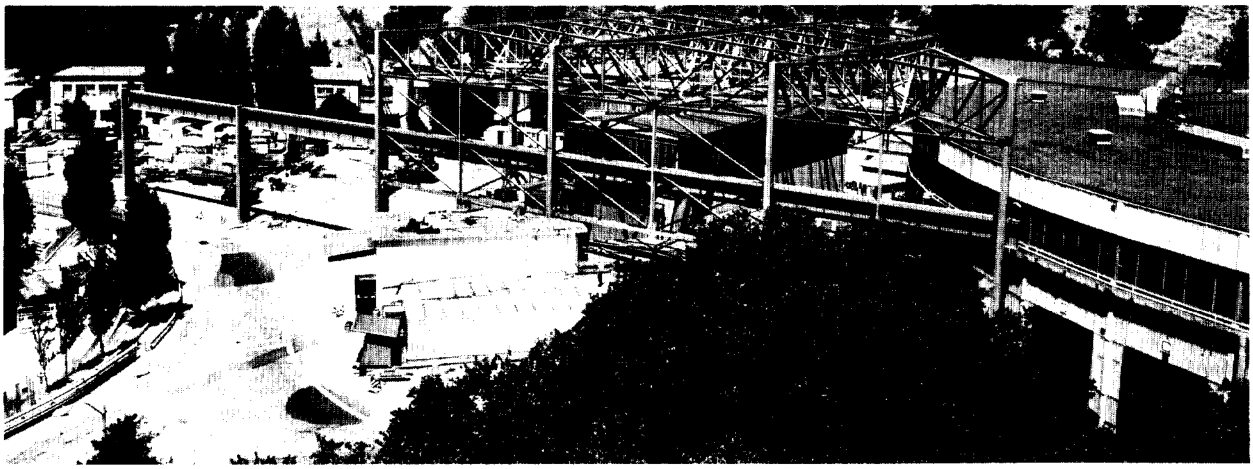

Fig. 3. Construction progress July 15, 1966, new steel framework around existing bubble chamber building.

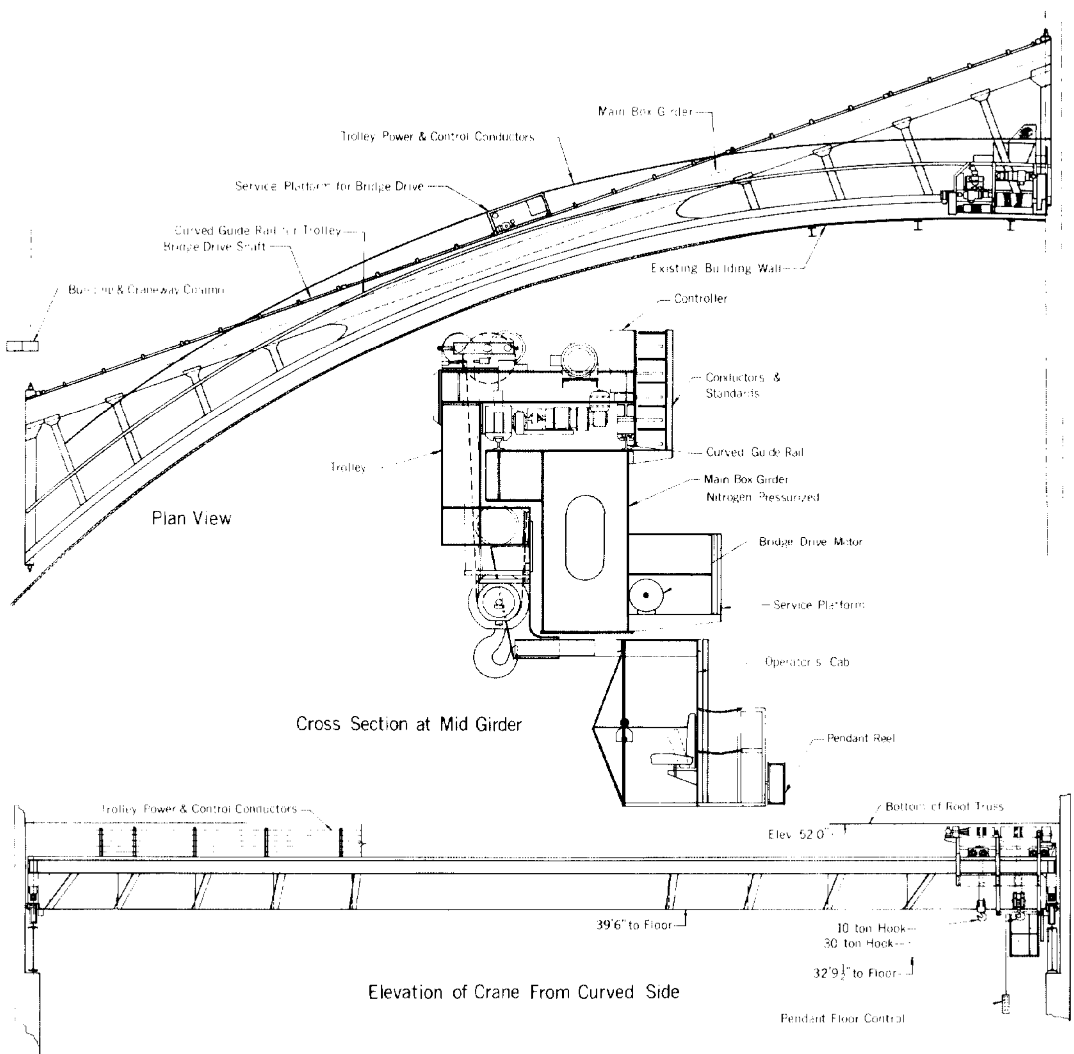

Fig. 4. Curved crane.