A Progress Update for Employees of the Advanced Photon Source at Argonne National Laboratory

The Source

May 1993 Number 2

← *April 21, 1993 — steelworkers from Phoenix Steel Co. hoist into place the ceremonial final steel crossmember for the APS Experiment Hall. Affixed to one end of the white-painted beam, which had been signed by the Phoenix crew, is an American flag; the other end sports a fir-tree top symbolic of "topping off" the structure. Phoenix displayed impeccable timing. Not only did they erect more than 2700 tons of steel months ahead of schedule, they also wrapped up the job concurrent with the first day of the first 1993 DOE Energy Research Semi-annual Review of the APS. This bit of synchronicity provided review-committee members and other dignitaries with a combination sign-the-ceremonial-beam- and photo-opportunity.*

Booster Synchrotron installation ramps up

← *Ken Celmer (left, of MSI Contracting, Inc.) and Jim Biggs (ASD-Magnets), lower the top half of a Booster Synchrotron quadrupole magnet into place over the vacuum tube.*

Sixty-three years have passed since Ernest O. Lawrence built the first heavy-particle accelerator. In that relatively brief time span, Lawrence's application of his own principle of cyclotron acceleration (a charged particle bent onto a circular path by a magnetic field can cross the same accelerating gap many times) has produced an ongoing spiral of basic and applied science. Accelerator theory has evolved into applications which have been used to prove fundamental theories of matter while creating commercial spin-offs and still more applications (synchrotron-derived brilliant x-ray beams, for instance). Orbiting particle beams are being directed at answering esoteric questions, such as what occurred at the moment of the Big Bang, and at solving down-to-earth problems that impact on our technological, environmental, economic, and physical well being.

Which brings us to the APS and installation of the APS Booster Synchrotron, the latest descendant of Lawrence's work.

The APS Booster Synchrotron is housed in a 368-m-circumference

"Booster" cont'd on page 2

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"Booster" cont'd from page 1

tunnel, with inner dimensions of 9 ft high and 11.5 ft wide. The tunnel is buried under an earthen shielding berm on the infield side of the Storage Ring Tunnel tangential to the Early Assembly Area and adjacent to the Storage Bays.

The Booster is designed to receive "bunches" of 450-MeV (450 million electron volt) positrons from the APS Positron Accumulator Ring, and then raise the positron energies to 7 GeV (7 billion electron volts). This is accomplished by successive circulations (or "turns") around the machine during which the positrons gain 32 keV of energy per turn thanks to interaction with the Booster's radio frequency system. Synchrotron rf voltage will be provided by four 5-cell rf cavities operating at 353 MHz, the same frequency as the APS Storage Ring rf cavities. During the energy ramp, the rf voltage compensates for energy lost due to synchrotron radiation and increases the energy of the particles each time they pass through the rf cavity. The magnetic guide field is continuously raised to keep the increasingly energetic particles within the fixed circumference of the ring of magnets. Some 200,000 turns are required for the positrons to reach 7 GeV, at which point they can be injected into the Storage Ring.

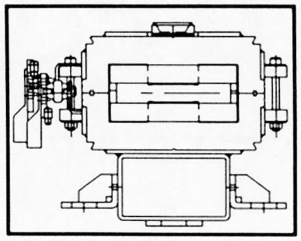
By April 21 (the date of the first 1993 Semi-annual DOE Energy Research Review of APS), installation of the first of 40 "cells" in the Booster had been completed. Each "normal" cell comprises 2 dipole bending magnets, 2 quadrupole magnets, 2 sextupole magnets, and 1 each horizontal and vertical corrector magnets (see box at right). Some of the 40 cells will have fewer dipole and sextupole magnets to allow spacing for the rf system, beam-diagnostics equipment, and pulsed kicker magnets.

Production of Booster magnets is proceeding on schedule for installation. The Accelerator Systems Division (ASD) Magnet

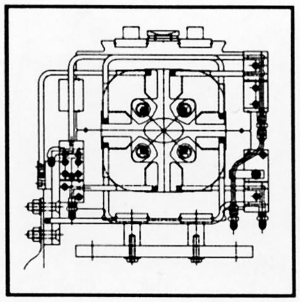
"Booster" cont'd on page 3

Beamstoppers Notebook Clip & Save

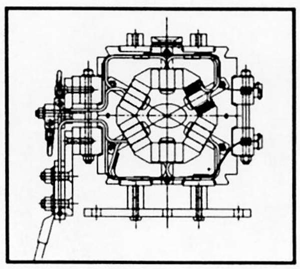
Know Your APS Magnets - The Booster Synchrotron



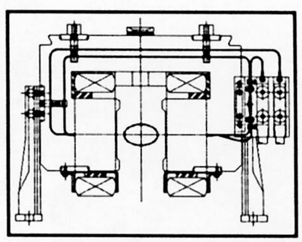
INJECTOR DIPOLE — As the name implies, this magnet has two poles generating magnetic fields. The 68 injector dipoles in the Booster steer the positron beam on an orbital path around the ring. The ASD Magnet Group is building the magnet cores, purchasing the coils from a vendor, and assembling the magnets in-house

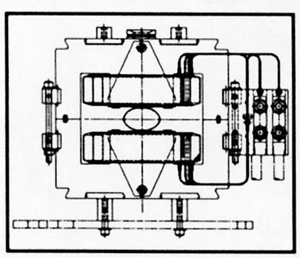


INJECTOR QUADRUPOLE — The 80 quadrupole magnets in the Booster focus (or control the size of) the positron beam. Without this function, the diameter of the beam would grow untilit scrapes the sides of the vacuum tube and the beam would be lost. The Magnet Group purchased all components (which were manufactured to APS specifications) and is assembling the magnets in-house



INJECTOR SEXTUPOLE — These 64 six-poled magnets. provide second-order refinements of the beam focus. The Magnet Group designed and procured all components and they are assembling the magnets in-house.





Computer-aided-design for Booster magnets by Glen Cherry, Mike Harkins, Steve Hanuska (all ASD), and Chuck Ostermeyer (EP). Conversions by Gary Hawkins and Dan Haid (both ASD).

INJECTOR VERTICAL (top figure) and HORIZONTAL CORRECTORS — The two types of corrector magnet control the position of the positron beam in, as the names imply, the horizontal and vertical directions. Without this correction, the beam would wander off course and strike the interior wall of the vacuum chamber. The Magnet Group has procured the magnet coils, and is assembling the magnet cores and the magnets themselves.

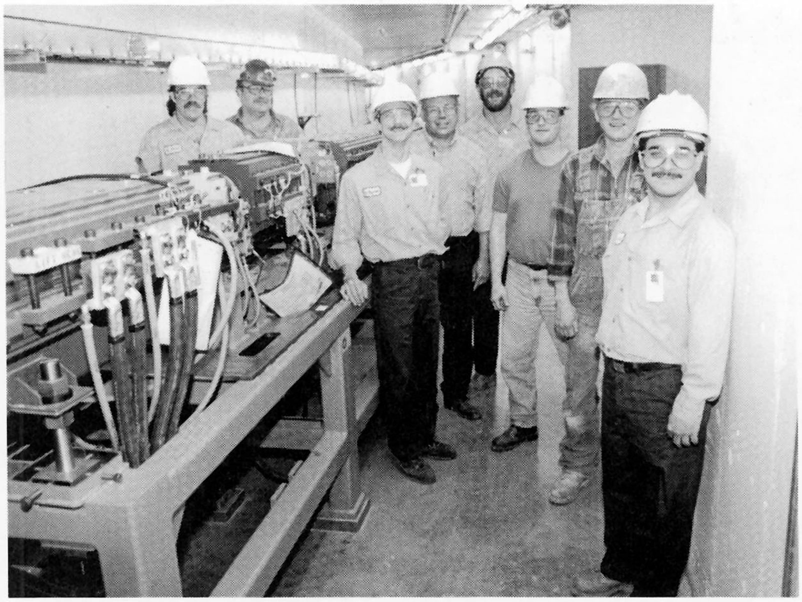
Two other magnets required for operation of the Booster Synchrotron (but not pictured here) are the septum and kicker magnets. They serve as the interface between the Booster and the low-energy and high-energy transport lines (LET and HET, respectively). The low-energy line transports the 450-MeV positron beam between the positron linac to the Booster; the high-energy line carries the 7-GeV positrons from the Booster to the Storage Ring. Kicker magnets are fast-pulsed magnets located in the Booster magnet lattice. The septum magnets are the last magnet before the Booster at the end of the LET and the first magnet in the HET.

"Booster" from page 2
Group is utilizing both in-house and procured fabrication capability to produce magnet components such as cores and coils. In most cases the production tooling was designed and built by the Magnet Group, and then used at the APS Magnet Facility in Bldg. 376 (the Gauss House) or shipped to the vendor for use. Final assembly of all Booster magnets is being accomplished either at the Gauss House, or in the case of the quadrupoles and sextupoles, in the basement of Bldg. 362. A designated team of key people works on each magnet type, with the rest of the Magnet Group work force rotating through, so that at one time or another, almost everyone has worked on almost every type of magnet.

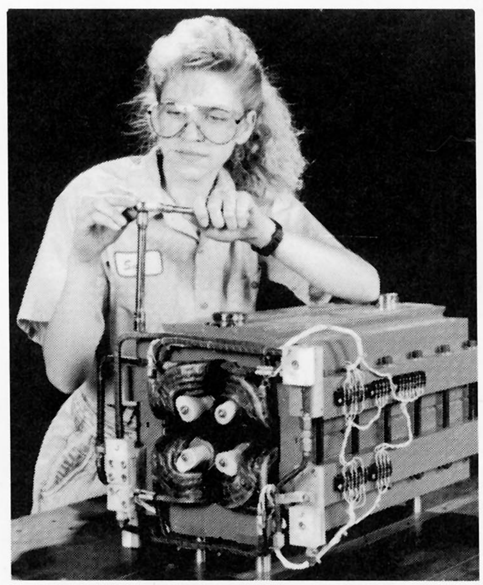
From the Gauss House, magnets are taken to the Magnet Measurement Test Facility in the Early Assembly Area. There, the members of the ASD Accelerator Physics Group check each one for magnetic-field quality.

An ultra-high-vacuum beam-pipe system runs through the center of the magnets. The vacuum beam pipe is made from 304 sections of elliptical, 1-mm-thick stainless steel tubes which were manufactured by a vendor. This thin metallic chamber, which is smooth inside, allows maximum beam space inside the magnets, and withstands atmospheric pressure. Ion pumps will be the primary tool for maintaining an average pressure of 10 nTorr in the ring.

The ASD Vacuum Group is fabricating the sections into 27 standard and 13 special beam pipes, which include vacuum pumps, beam-diagnostics, and provisions for rf systems.



↑ *The APS Booster Synchrotron installation crew. Behind the magnet string are Lead Technician Ed Theres (ASD-Magnets) and Jim Houtari (MSI Contracting, Inc.). Grouped in front of the magnets are (left to right) Dean Wyncott (ASD-Vacuum); Synchrotron Installation Coordinator Jim Biggs (ASD-Magnets); Steve Gorham (ASD-Magnets); Mike Bracken (ASD-Magnets); Ken Celmer (MSI); and Jesus Alvarez (ASD-Magnets).*



↑ *Sue Proper (ASD-Magnets) tightens the bolts on a Booster Synchrotron quadrupole These magnets are being assembled in the basement of Bldg. 362.*

The Booster installation process begins with members of the ASD Survey & Alignment Group, who use a template to mark the tunnel floor for the locations of the stands (see *The Source*, Number 1, March 1993, page 5). Workers from MSI Contracting, Inc., using the same template, drill holes in the concrete floor and bond stand bolts into the holes. After each stand is installed, Survey & Alignment returns and adjusts the stands to precisely predetermined x-y coordinates.

Installation-crew members hoist whole quadrupole and dipole magnets into place on the stands. Next, Survey & Alignment aligns the magnets to within a millimeter so that vacuum tubes can be laid in place without bending. The crew then removes the top half of the quads and dipoles in each cell, sets the vacuum pipe in place, and reattaches the magnet top halves. Sextupole, septum, and corrector magnets are installed after the vacuum chamber is in place.

"I answer to three people on questions of installation," said Jim Biggs, the Booster Installation Coordinator "and luckily, they're all on the same page." Steve Milton (ASD-Accelerator Physics), the Synchrotron Ring Manager, makes all decisions related to the physics of machine operation. For instance, Milton can shuffle the installation sequence of dipole and quadrupole magnets to equalize small variations in magnetic field strength around the ring; a dipole that was the 25th magnet to be built might go into the ring as the 22nd magnet. "Details on mechanical specifications come from Rudy Damm's groups in ASD," said Biggs. "Instalation coordination in terms of budget and schedule originates with Tom Mann [APO-System Integration & Installation Coordinator]."

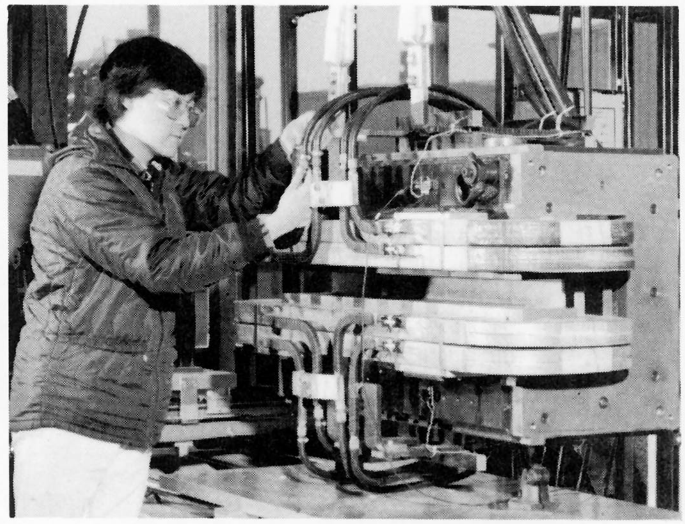
Commissioning of the Booster is scheduled to begin in December of 1993. ○

The APS ALD/PD milestones - 50 ways to please your funder

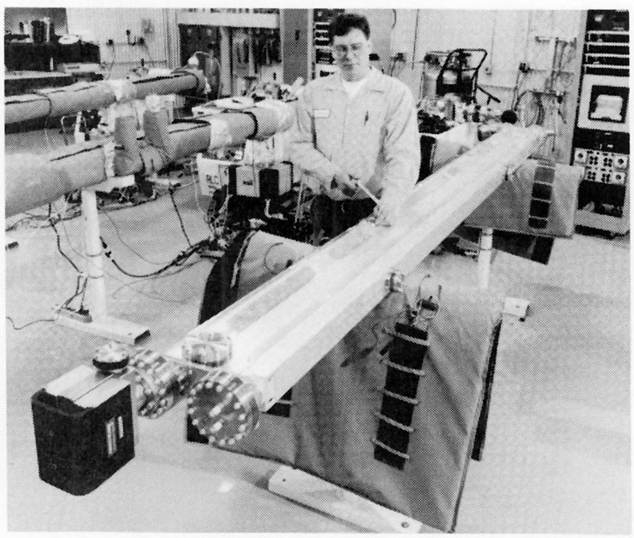
The imperatives of technology and organization...are what determine the shape of economic society.
—John Kenneth Galbraith

In Hollywood they call it putting the money up on the screen. At APS, we might call it putting the money out in the tunnels. No matter how it's phrased, the message is constant: Investors want their dollars spent wisely and well, with evident results.

On behalf of U.S. taxpayers, the Department of Energy is investing more than $467 million (Total Estimated Cost) in APS construction. The ultimate return on that investment will commence in 1996 when research begins. Until then, the best measure of the success of DOE's investment in APS is the appearance of high-quality technical components inside functional buildings on a predetermined and agreed-upon schedule.

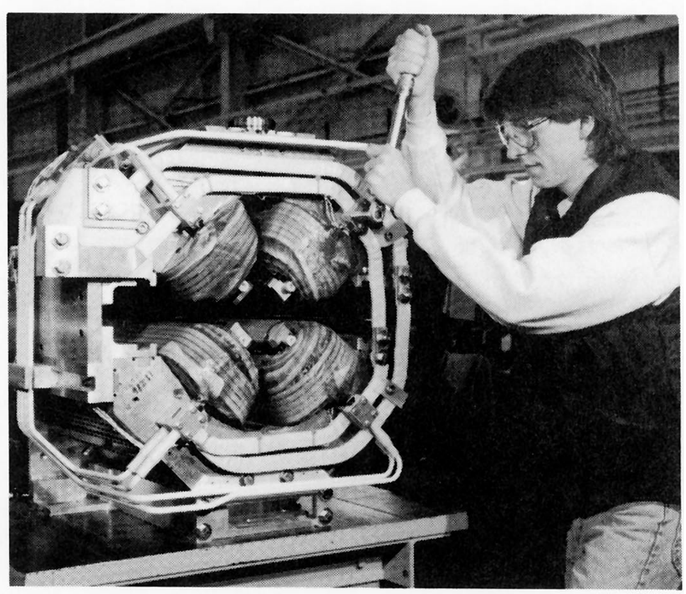


↑ ***ALD/PD Milestone #6** — Edmund Chang (ASD-Accelerator Physics) readies a 1-meter section of prototype Storage Ring dipole magnet for field measurement. The magnet section was fabricated and measured at the APS Magnet Measurement and Test Facility ahead of schedule.*



← ***ALD/PD Milestone #10** — John Crandall (ASD-Vacuum Science & Technology) with one of the first Storage Ring straight vacuum chambers.*

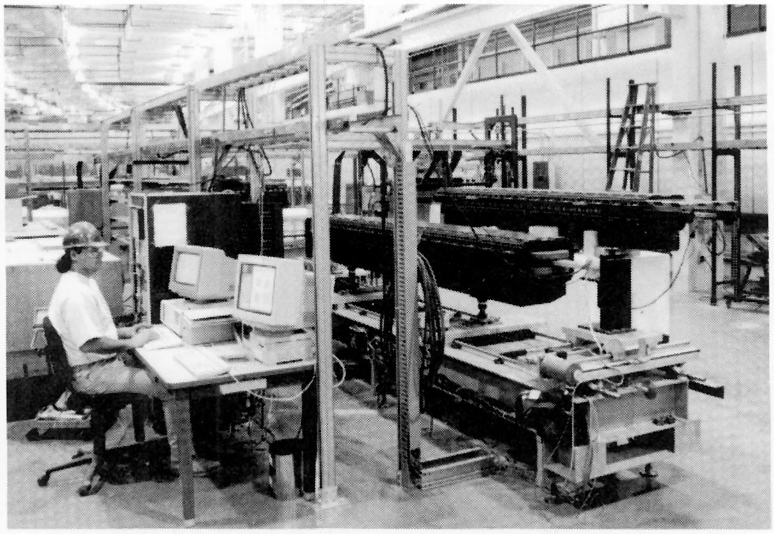
↓ ***ALD/PD Milestone #14** — Robert Wright (ASD-Magnets) tightens a coil lead on the first production Storage Ring quadrupole.*



For art and science cannot exist but in minutely organized particulars.
— William Blake

Schedules can be the bane or salvation of any enterprise (or

"Milestones" cont'd on page 5



↑ ***ALD/PD Milestone #18** — Gian Trento (ASD-Accelerator Physics) at the dipole measuring stand in the Magnet Measurement Test Facility (MMTF) The MMTF was relocated from the Bldg. 362 Highbay to the Early Assembly Area and brought online according to schedule.*

"Milestones" cont'd from page 4

sometimes both at once). Either you use the schedule or the schedule uses you. The APS has a formidable set of schedules for completion of various elements of the project that interface with a multi-leveled budgetary tracking system, which taken together (should) culminate in a completed, operating facility by a particular date. The trick, of course, is in sticking to the schedule.

Enter the APS Associate Laboratory Director/ Project Director's (ALD/PD) Milestones, which are listed on page 6.

"The idea behind the milestones," according to APS Project Director Ed Temple, "is that it is easy to say that any one thing does not have to be done today; we always have tomorrow. But since we have so many things to do, if we don't get that one thing done today, we also might not finish those things that must be done next week.

"The Project was aware that one part of the schedule had slipped, and that seemed to have become an excuse for not performing on the rest our schedule. That is an excellent way to set ourselves up for trouble later. Generally speaking, if one has a finite time in which to provide a specified product at a particular cost, one must do it the way one planned. If you don't, you will be late and you will have to spend more than you had originally counted on.

"So, the ALD/PD management group, which is the management body for this project, felt that it was imperative to identify a set of critical milestones and track those milestones as a way of measuring the health of the project.

"We have committed to deliver x-rays some good time before the end of the project. That's a nice situation to be in, but if we don't meet these milestones on the schedule that we've set forth, we won't be providing those x-rays early. And since we've based our cost estimates on this plan, we will be costing more than we've planned to cost," Temple said.

In January, technical group leaders and division directors were asked to identify the most important schedule points in the coming six months. Project management then identified 50 milestones, for an average of two per week.

Delay is preferable to error.
—Thomas Jefferson

An examination of the list on page 6 reveals that the milestones clearly add up to real progress toward an installed x-ray source. To date, the milestones are are being achieved at a 69% success rate (allowing a 7-day swing in either the plus or minus direction). The exceptions would appear to be conventional-facility milestones, but appearances can deceive.

"The milestones led us to the realization that several conventional-facility goals have not been met because we have, of necessity, set up a multi-layered organization, and it is difficult to get that organization to move quickly," noted Temple. "That is especially true if we need to change our conventional-facilities designs because of late-breaking technical component requirements. We have had to make such changes a number of times. This is not meant to be an excuse, it is a statement of fact, and even in the face of these changes we are striving to meet *all* the milestones." ❍

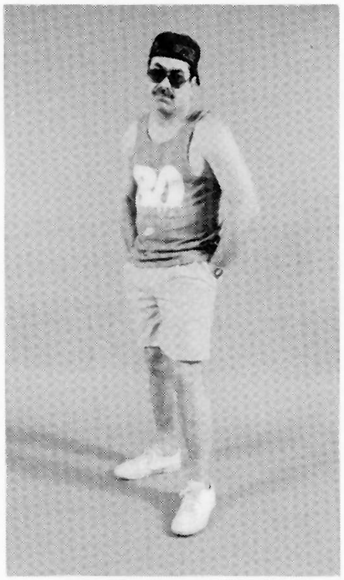
↓ ***ALD/PD Milestone #27** — The completed interior of the APS Storage Ring Tunnel at Zone #1 adjacent to the Early Assembly Area.*

The APS ALD/PD Milestones

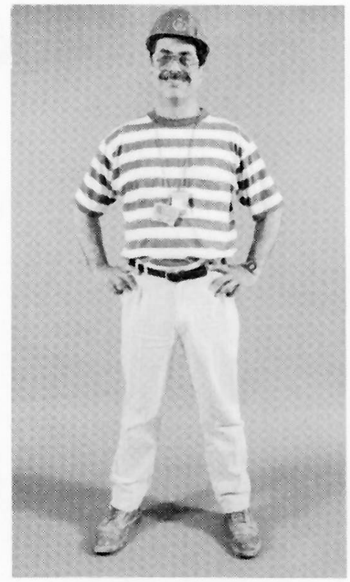
	TASK	MILESTONE	ACTUAL
1	Implementation of 10CAD for Conv. Fac.	01/27/93	01/25/93
2	Storage Ring 1-meter dipole assembly complete	01/29/93	01/25/93
3	High heat load monochromator awarded	01/31/93	01/25/93
4	Complete PAR septum design	02/01/93	02/01/93
5	Complete PAR kicker design & prototype	02/01/93	02/01/93
6	Storage Ring 1-meter dipole measured	02/05/93	02/04/93
7	Synchrotron first production quad assembled	02/05/93	02/04/93
8	Relocate magnet measurement facility	02/08/93	02/08/93
9	Synchrotron tunnel beneficial occupancy	02/08/93	02/10/93
10	First Storage Ring vacuum vessel (straight) under vacuum	02/15/93	02/15/92
11	Rf transformer/rectifier pad complete (West)	02/15/93	
12	Magnet/girder assembly area mech. complete	02/15/93	02/15/92
13	First Synchrotron rf transformer/rectifier received	02/22/93	02/22/93
14	First production Storage Ring quad assembled	02/23/93	02/23/93
15	Implementation of 10CAD	02/25/93	02/25/93
16	Storage bays beneficial occupancy 159 to 50	02/28/93	
17	Utility building operational	03/08/93	03/19/93
18	Magnet measurement test facility operational (EAA)	03/08/93	03/08/93
19	EAA building complete	03/10/93	
20	Utility building complete	03/15/93	
21	Linac positron target installed	03/17/93	
22	Implementation of 10CAD	03/22/93	
23	Blue-line survey of Storage Ring 20% complete	03/26/93	03/26/93
24	Insertion devices (5 - Und. A) award	03/30/93	03/30/93
25	First cell installed in synchrotron	03/31/93	04/07/93
26	First rf transformer/rectifier installed	03/31/93	
27	Storage ring 63-75 beneficial occupancy	03/31/93	04/22/93
28	Electron linac installed	04/08/93	04/08/93
29	Complete test and debug of sector 1	04/08/93	04/08/93
30	Rf extraction wing beneficial occupancy	04/12/93	
31	Synchrotron quadrant 2 magnet supports installed	04/13/93	
32	Synchrotron quadrant 2 magnets assembled, measured and tested	03/10/93*	
33	Storage Ring vacuum chamber (sections 1, 3, and 5) 20% production completed	04/30/93	
34	Exp. hall column 63-75 beneficial occupancy	04/30/93	
35	Storage Ring sectors 1, 3, and 5 girder integrated with magnets and vacuum systems 20% complete	05/03/93	
36	Storage Ring girders 50% production completed	05/06/93	
37	Synchrotron quadrant 1 magnet supports installed	05/11/93	
38	Linac section 3 installation and checkout complete	05/17/93	
39	Installation of 50% of PAR dipole vacuum chambers completed	05/24/93	
40	Synchrotron quadrant 2 corrector magnets assembled, measured and tested	03/10/93*	
41	Exp. Fac. optics coating facility Title II design complete	05/31/93	
42	Synchrotron power supply cabling complete from injection wing	05/31/93	
43	Synchrotron quadrant 1 magnets assembled, measured and tested	05/19/93*	
44	Storage Ring girder pedestal installation and alignment 25% complete	06/04/93	
45	Storage Ring sector 2 and 4 girder integration with dipoles and vacuum systems 20% complete	06/11/93	
46	Complete installation & alignment - 50% of PAR dipoles	06/15/93	
47	Linac sector 4 installation and checkout complete	06/15/93	
48	Synchrotron quadrant 1 corrector magnets assembled, measured and tested	05/19/93*	
49	Bending magnet front end component assemblies released to procurement	06/30/93	
50	Insertion device beamline front end component assemblies released to procurement	06/30/93	

* Schedule Changed

Safety in APS Beneficially Occupied Areas



↑ ***Wrong** — Meet Rafael Coll (ANL ESH), who enforces Argonne's construction safety program. Rafael is portraying the improperly-attired APS-site visitor. If Rafael met himself dressed like this, he would ask himself to leave the site and return with suitable accoutrements. He will do the same to you. Among Rafael's sartorial safety sins are: no hard hat, no safety glasses, no shirt sleeves, no pants legs, and no safety shoes. Rafael is also not displaying his site-access badge in a readily discernable location.*



↑ ***Right** — Rafael is now site-access correct from head to toe, and one can tell just by looking at him that he feels much better. He's wearing a hard hat, safety glasses with side shields, a shirt with sleeves that are at least quarter-length, trousers, and steel-toed safety shoes. And his site-access badge is prominently displayed. If Rafael met himself on the site dressed like this, he'd say "Hi" and continue on his way. He will do the same for you.*

As more and more areas in the APS facility are declared ready for beneficial occupancy, employees moving their work activities to the site may encounter some inconveniences and unique problems. These unavoidable circumstances will require that special consideration be given to how work is done in beneficially occupied areas.

Due to limited available laboratory space at ANL, APS management has decided that buildings on the APS site should be occupied as soon as construction activities permit, i.e., when they are ready for beneficial occupancy. Employees moving to the site might infer that they can continue working as they did in the laboratories or offices they formerly occupied. However, this is not necessarily the situation. As was pointed out in the article, "Beneficial occupancy: oxymoron or tenant's best friend?" [*The Source*, March 1993, page 2], the advantage of beneficial occupancy as it is being applied at APS is that deficiencies identified during early occupancy can be more easily corrected while the contractor is still on site There are draw-backs to this plan, however. For instance, when different disciplines are working concurrently in a particular area, there is often competition for the same resources such as utilities, use of access doors, and floor space. This results in the need for increased coordination and adjustment of work practices. Another problem resulting from concurrent occupancy is the increased risk of equipment damage or loss. Heightened vigilance, and control achieved by flagging off areas containing sensitive equipment and physically securing desirable items, will reduce losses.

But the number one potential problem arising from beneficial occupancy is a greater opportunity for personal injuries. The APS Project has, to date, an enviable safety record, both on the construction site and in the technical areas. Project management will continue to do whatever is necessary to ensure the safety of Project personnel, but a good deal of the responsibility lies with you. Again, heightened vigilance is called for. And the proper use of personnel protective equipment will further reduce the risk of injury to those working in areas where a variety of diverse activities are going on.

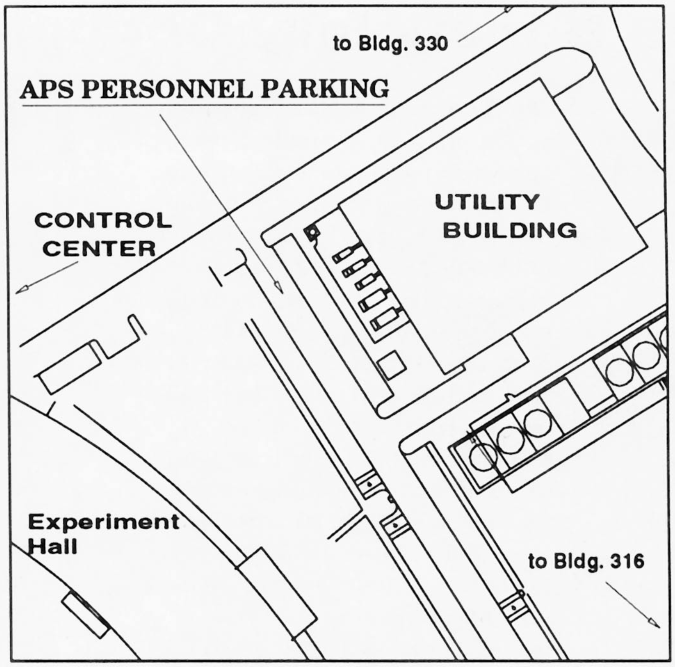
Hard hats, boots, and safety glasses have been required for access to the APS construction site. While construction activities in beneficially occupied areas continue, even at reduced levels, overhead and tripping hazards are still present. So special attention must be focused on the selection of appropriate personal protective equipment. The practice in the field of occupational safety is to adopt the highest standard of protection required for hazards present in a work area. This implies that boots which provide lateral support and toe protection, hard hats to protect against overhead hazards, and safety glasses to minimize eye irritations resulting from dust and blowing debris should be worn. Recently, APS and RUST Engineering [the APS construction management firm] safety personnel agreed that footwear requirements should be relaxed for individuals working in beneficially occupied areas on the site. Ankle-high boots are no longer required. Safety shoes, other than

"Safety" cont'd on page 8

"Safety" cont'd from page 7
sneaker style, may be worn in these areas. Jim Lang (ASD-ESH) is currently evaluating safety glasses to identify those which are more comfortable and have better optic characteristics than the clear plastic visitor safety glasses now available.

As construction activities are completed and personnel protective equipment requirements can be further relaxed, APS ESH will notify workers in the effected areas. For instance, in the Linac shielded enclosure area, hard hats are no longer required.

In a related note, APS employees who take vehicles onto the site are asked to follow the posted parking instructions.



Parking areas designated for APS personnel are clearly identified and are located away from construction-vehicle access points. The primary parking area for APS personnel is in the lot behind the Utility Building (shown at left).

We have few good reasons and no excuse for not wearing required safety equipment. Beyond the risk of personal exposure to a hazard, we could place the Project in peril of a significant programmatic impact if individuals on the APS are seen not wearing required safety equipment by our ever-vigilant DOE oversight.

- Richard Hislop

Recent visitors to the APS

Illinois State Representative **Lee Daniels**, (R-46th), and **Tom Renkes**, **George Hanesch**, **Lloyd Dunlap**, and **John Ewing**.

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James Stuchell, Legislative Assistant to U.S. Representative Harris Fawell (R-Illinois, 13th).

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Illinois State Senator **William F. Mahar** (R-19th), Chairman, Environment and Energy Committee.

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Paul Tippett, Board Chairman and CEO, Council of Great Lakes Industries.

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Illinois State Senator **Tom McCrackon** (R-41st), Illinois State Representative **Jim Meyer** (R-82nd), and Illinois State Representative **Judy Biggert** (R-81st).

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Kenneth Ciriacks, Vice President for Technology, Amoco Corp., Chicago.

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Takakazu Kuriyma, Japanese Ambassador to the U.S., and **Toshiaki Tanabe**, Japanese Consul General, Chicago.

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Jim Ritter, science writer, *The Chicago Sun-Times.*

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Walter Sullivan and **Merwyn Greer**, Stone & Webster Engineering Corp.

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Anita Huslin, general assignment reporter, the *Southtown Economist.*

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Douglas Wasitis, Legislative Assistant to U.S. Representative John Myers (R.-Indiana, 7th).

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Ann Atkins-Wright and **Mary Naylor**, Legislative Assistants to U.S. Sen. Paul Simon (D-Illinois), and **Todd Atkinson**, Deputy Director, Projects and Appropriations, for U.S. Sen. Carol Moseley-Braun (D-Illinois).

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Harlan Watson, Staff Director, Energy Subcommittee, House Science, Space & Technology Committee.

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Sergei Leskov, *Izvestia*, and **Maxim Tarasenko**, Moscow Institute of Physics and Technology Center for Arms Control.

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Evgeniy N. Avrorin, Scientific Director, Russian Federal Research Center, Institute of Technical Physics, and **Yuriy A. Trutnev**, Scientific Director, Russian Federal Research Center, Institute of Experimental Physics.

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The Source is a vehicle for enhancing communications within the APS Project on matters of technical accomplishments and progress, ES&H, research programs, and management news.

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