

problems that always crop up after rapid installation.

"There is a tremendous problem to get the computer to work at speeds required," adds Prof. J. C. R. Licklider of the Massachusetts Institute of Technology's electrical engineering department. "The amount of calculating depends on the complexity of what's going on in the environment. If the sky is full of decoys and lots of things are happening, present circuits can't do the job in time. The length of time increases drastically with the complexity."

But the area requiring the greatest attention is the software, the programming, that instructs the computer what to do. Because the computer programming must identify incoming missiles, distinguish between them and penetration aids, correct for blackout errors, guide the defending missiles to their targets and then arm and fire them in addition to checking and correcting, the job of getting such a program with its myriad instructions to work without a major hitch is overwhelming.

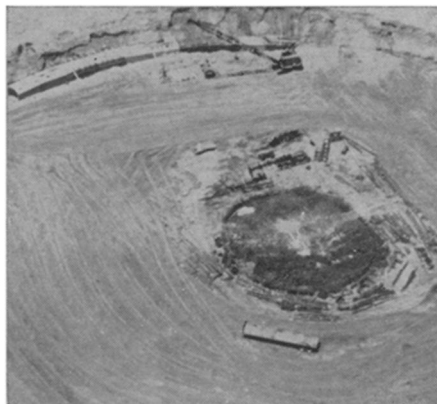
The final problem for the Safeguard system is testing. It compounds all the rest. There is no way other than nuclear war for a complete run-through of the system. At present it is being tested in a piecemeal fashion. For example, in 1970, an MSR and computer will be tested in an actual missile intercept at Kwajalein Atoll in the Pacific. This will be followed by the first intercept of multiple targets. Since the PAR is not built yet—a prototype test model is 40 percent complete and the PAR computer is 25 percent complete—it will not be tested at Kwajalein. Instead, as Secretary of Defense Melvin R. Laird informed a House appropriations subcommittee, "We have a radar out there which can be used to simulate PAR in the overall systems test. It operates on the same frequency as the PAR."

Commenting on the Defense Department test program for Safeguard, Dr. George B. Kistiakowsky, former Presidential Science Adviser and now professor of chemistry at Harvard University, says, "I would certainly feel a more reliable way of proceeding would be to set up PAR, MSR and missiles at Kwajalein, and then they could be exercised completely against reentry vehicles from Vandenburg (Air Force Base, Calif.)." Dr. Kistiakowsky feels that the two missile sites in Montana and North Dakota would not be satisfactory "for complete testing because you can't launch reentry vehicles against them."

Strictly speaking, whether or not the system will work is problematical. Opponents say it will not and amass facts to prove it. Supporters say it will and marshal their data. The only thing certain is that both sides hope they are never proved right. ◇

BUBBLES FOR BATAVIA

Planning for the giant



AEC

Scraping and tunneling at NAL.

The purpose of a national laboratory is to provide equipment not available elsewhere that scientists from all over the country and outside of it as well can come and use.

Use by visitors is expected to be especially large at the National Accelerator Laboratory now under construction at Batavia, Ill. (SN: 7/5, p. 7). When NAL is complete it will have the world's most powerful particle accelerator—with eventually 400 billion electron volts energy—and will be the only place in the world for physicists to go for certain experiments.

But physics changes while the NAL is being built. So the laboratory management has been holding a series of summer seminars in which staff members meet with physicists from universities and other institutions to discuss the kinds of research the university people are interested in doing and to see how the 200-400 GeV accelerator can be made to fit their needs as it is built.

"**We don't** want to build a machine that can't do what university people want to do," says Dr. Edwin L. Goldwasser, deputy director of NAL.

One result of this year's discussions, held at Aspen, Colo., is that NAL staff and consultants agree that the laboratory will need a large bubble chamber, and it now plans to build one in collaboration with Brookhaven National Laboratory. The multimillion-dollar item was included in the original plans for NAL but was removed as part of an economy drive.

Meanwhile a group of 12 or 15 Canadian physicists was meeting in Montreal to discuss what they would like to do if their Government accepts a proposal, now before it, to make some financial participation in the Batavia project (SN: 3/29, p. 305). For the experimentation they would like to do, the Canadians found they will have to build a magnetic spectrometer, a device that

separates different kinds of particles from one another. "The NAL will need some sort of particle spectrometer," says Dr. J. D. Prentice of the University of Toronto, and the Canadian physicists concluded that this could be a good contribution for them to make. (The proposal for Canadian participation is now being considered by the National Research Council of Canada, which is expected to make its decision in the fall.)

A large bubble chamber was one of the suggestions made when Canadian participation was first discussed, but now, says Dr. Prentice, "Brookhaven is so well set up for this, they're so far ahead that there's no point in forming a group in Canada for that."

According to present plans the NAL-Brookhaven bubble chamber would be 25 feet long and contain about 100 cubic meters of liquid hydrogen. It would be bigger than any that now exist although some European plans rival it in size. The laboratory's original plan, which envisaged a total cost of \$375 million, included \$30 million for such a chamber. The laboratory's estimated cost has now been trimmed to \$240 million. The bubble chamber now planned could be built for \$15 million, Dr. Goldwasser estimates, and the laboratory will ask Congress for a separate appropriation for this.

The need for the bubble chamber arises from the desire of physicists to study the neutrino. Study and simulation of the experiments that might be done in this line convinced the people meeting at Aspen that a bubble chamber, rather than electronic devices, would be required for particle detection.

Another line of experiment where the big accelerator will be especially useful is the search for new particles, both those expected and those unexpected by theory. Those that may be looked for include quarks (SN: 5/31, p. 538), intermediate vector bosons, (SN: 11/16, p. 500) and ultraheavy particles called resonances. One important point will be to determine whether there is an upper limit on the mass that particles may have. Some present experimental evidence seems to show that particles cannot be heavier than the mass equivalent of five GeV energy, but current theory does not include such a cut-off.

Another topic in which much interest was shown at Aspen was in study of electromagnetic forces by collisions among mu mesons. Physicists want to know whether the laws they have evolved for electromagnetic forces apply at subatomic distances, and mu-meson collisions give them an interaction that involves only electromagnetic forces. The big accelerator will provide a sufficient flux of mu mesons. ◇