the industry were $41 million, a 6.9 percent increase over the 1968 figure of $38.4 million. In the same period, utility advertising expenditures went from $290 million to $324 million, an increase of about 12 percent. This compares with total utility revenues in 1969 of $3.2 billion.

"They [the utilities] are trying to meet massive technological problems by massive advertising and sales promotion—this despite the energy shortage—rather than by the needed massive research and development programs," charges Metcalf.

If the automobile industry is doing the same, the facts may be public knowledge soon. Under the 1970 amendments to the Clean Air Act, the auto companies must report to APCO—and, presumably, to a National Academy of Sciences committee set up under the amendments—on their R&D expenditures.

Where the solution to the R&D problem lies is still a matter of conjecture. APCO frankly acknowledges it probably never will have the funds necessary to carry on the needed programs for pollution control R&D for automobiles, and it is relying on the 1970 amendments to force the auto companies into compliance with the new emission standards. But a Metcalf staffer suggests that the utility industry may never be innovative enough to do the R&D job. "Maybe the government has to do it," he says. □

Scyllac in operation at Los Alamos

Attempts to achieve controlled thermonuclear fusion, to gain energy for power production from the fusion of atomic nuclei, are proceeding in a variety of devices with a variety of names.

The basic problem is that a plasma of ions and electrons has to be held, usually by confinement in a magnetic field, for a sufficient time at a high enough temperature and density for enough fusions to take place so that the energy coming out of the process is greater than the energy it takes to maintain it.

One sort of device attempts to hold a relatively thin plasma for a long time. Since confining the plasma in a magnetic field is probably the most difficult of the three criteria to achieve, another sort of device attempts to trade off a short confinement time against high density and temperature. These devices are pulsed rather than steady, since the densities and temperatures desired can best be achieved by short compressing pulsations. If energy ever comes out of them it will come in bursts like a reciprocating steam engine.

This week the largest of the pulsed devices yet built, the Scyllac (SN: 10/17/70, p. 321) at the Los Alamos Scientific Laboratory in Los Alamos, N.M., began operation. Preliminary tests leave its designers and builders well satisfied.

Scyllac is what is called a theta pinch. It will ultimately be a toroidal, or doughnut-shaped chamber, 15 meters in circumference. At the moment it is a curved section, about a third or so of that.

When plasma has been placed in Scyllac, it will be subjected to a pinch. That is, the strength of the confining magnetic field will be suddenly increased. This will cause both implosion and shock, driving the plasma to the center of the tube and heating it.

Experience with smaller theta pinches at Los Alamos and elsewhere shows that temperatures and densities in the range appropriate to controlled fusion can be approached by this method.

Scyllac is designed to approach controlled fusion more closely than previous devices. The present section of it was tested this week by making within it a pre-ionized plasma. This is a preliminary step to the application of the magnetic implosion, the theta pinch itself.

Scyllac repeatedly made pre-ionized plasmas to the satisfaction of the physicists working with it. Contrary to reports elsewhere, though gratifying, this is not a breakthrough on the way to controlled fusion. The real test of whether Scyllac can do what it is designed to do, the turning on of the theta pinch, will be tried sometime in the next few months.

If that test is satisfactory, the remainder of the circle will be built. Still later, the Los Alamos physicists plan to build a seven-meter straight Scyllac, and with this they hope to approach nearer to an actual controlled fusion reactor than anything on earth.

If controlled fusion experiments continue to go as well as they have for the last few years, the best guesses as to when fusion power can be expected to be commercially available are sometime in the 1990's.

HEAVY-ION ACCELERATORS

American physicists worry

Studies of atomic nuclei have made frequent use of single particles as probes. Beams of accelerated protons, electrons, neutrons, pi mesons and other particles are struck against nuclei, and the results are studied for information on the behavior and structure of nuclei.

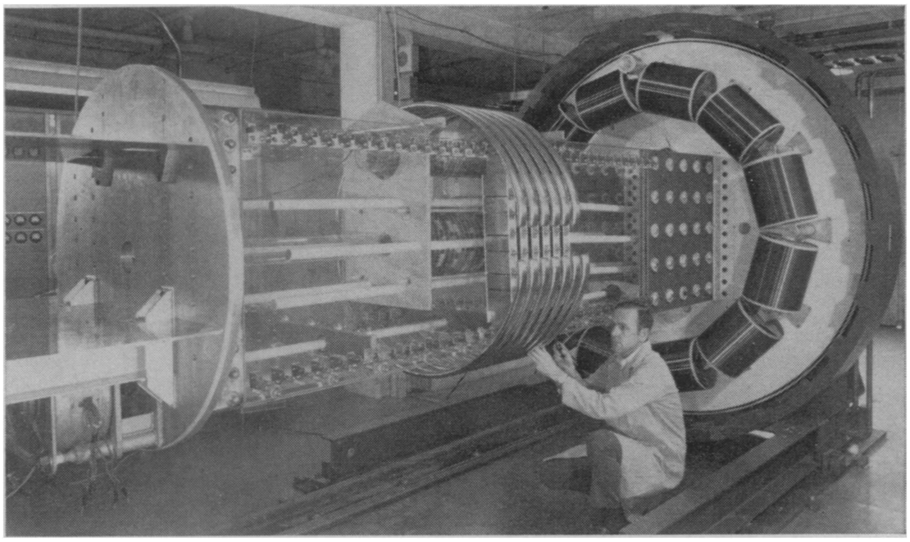
Now physicists wish to use whole nuclei of heavy elements, or more correctly, heavy ions, as the impinging particles. Striking heavy nuclei against other heavy nuclei, they believe, will enable them to manufacture superheavy nuclei with atomic numbers beyond the currently known 105 and to study what happens when two objects containing many neutrons and protons come together. This could throw light on complexities of nuclear structure not decipherable by other means.

In various parts of the world heavy-ion accelerators are being built to enable this sort of work to be carried out. Only one such machine is under construction in the United States, the Superhilac at the Lawrence Radiation Laboratory in Berkeley, Calif. The paucity of the American effort dismays many specialists in the field.

"We are entering a period of planned deficiency of heavy-ion equipment in the U.S.," says Dr. Robert Beringer of Yale University in summing up the discontent. The single new American machine, the Superhilac, is somewhat old fashioned, he told the 1971 Particle Accelerator Conference at Chicago last week (see p. 183). It is a reconstruction of the existing Hilac (Heavy Ion Linear Accelerator), "a redesigned 1950's linac," says Dr. Beringer, "a foursquare state-of-the-art machine at modest cost." He would like to see completely new designs tried, but given the Government's financial priorities, he finds it difficult to disagree that under current conditions Superhilac is the best available.

Nevertheless, he worries that the United States will fall behind Western Europe and the Soviet Union, where newer designs are being pursued with more vigor.

Heavy ions can be accelerated in either linear accelerators or cyclotrons. Both sorts have their partisans, and some people see advantages in both. The first of the new generation of heavy-ion accelerators, the machine called Alice at the Orsay Laboratory in France, combines a linear accelerator and a cyclotron. Alice can accelerate ions of carbon or neon to energies of about 20 million electron-volts per nuclear particle (nucleon). Its heaviest ions are xenon, to which it can give about 3 million electron-volts per nucleon.



LRL

Injector for Berkeley Superhilac: The one U.S. entry will be complete by 1972.

A linear accelerator under construction at Darmstadt in West Germany, Unilac, will be able to take neon or argon to nearly 20 million electron-volts per nucleon. It will be able to accelerate ions as heavy as uranium to 10 million electron-volts per nucleon. Unilac should be finished by 1975.

Physicists at the Dubna Laboratory in the Soviet Union are building a heavy-ion cyclotron, which they hope will be ready in 1972. Its planned performance should roughly parallel Alice's.

The Berkeley Superhilac is expected to be finished by the end of this year. Its maximum energy per nucleon will be constant at slightly more than 8 million electron-volts over a range of weights from argon to uranium.

The only other American project at all alive at the moment is the wish of Dr. Milton G. White of Princeton University to convert the Princeton-Pennsylvania Accelerator to a heavy-ion accelerator. The PPA is a proton accelerator of 3 billion electron-volts energy, which the Atomic Energy Commission closed for lack of funds. Converted to heavy-ions, it could give them energies in the range of billions of electron-volts per nucleon, enough, says Dr. White, to go beyond studies of nuclear structure to laboratory imitations of cosmic rays and the behavior of nuclear matter in cosmological events. He has a promise of money for the conversion if he can find enough users for the machine after the job is done. Other American proposals, from the Argonne and Oak Ridge national laboratories and several universities, have not been taken up.

An important part of the technology of heavy-ion accelerators is the development of efficient means for stripping electrons from the ions. The higher the charge of an ion, the easier it is to accelerate. Here, too, Dr. Beringer sees the United States falling behind. "Really high charge states are needed," he says. "I hear of breakthroughs in the U.S.S.R." But in the United States, he says, physicists have to be satisfied with fairly low charges like tenfold ionized uranium.

As a result of both lack of money and lack of progress in stripping, Dr. Beringer suggests Americans concentrate on making accelerators more efficient, perhaps by using superconducting materials. A good cheap accelerator, he says, would be "just beautiful and so American and maybe not far from realization." □

SECOND SATELLITE

Chinese in space again

The launching of the second Red Chinese satellite last week came less than a year after China's space debut, April 24, 1970 (SN: 5/2/70, p. 427). Although not too impressive if compared with the Soviet Union's 81 space launches during 1970 and the United States' 28, the launch will undoubtedly add fodder to the Defense Department's Congressional arguments to move ahead with the complete Safeguard missile system of 12 antiballistic missile sites.

In his annual report to the Congress this week, Defense Secretary Melvin R. Laird predicted that between 1973 and 1975 China could develop an initial force of operational ICBMs. The North American Air Defense Command keeps track of the launching and the orbits of such spacecraft, but there is still debate about the degree of sophistication of China's booster development.

The second Chinese satellite circles the earth every 106 minutes with an apogee of 1,800 kilometers and a perigee of 269 kilometers. □

SPACE SCIENCE PRIORITIES

Some treats, some headaches

The National Academy of Sciences' recommendations for space science in the 1970's contain at least some treats for all space disciplines and a few headaches for the National Aeronautics and Space Administration. Although the priorities listed by the NAS are not likely to produce television specials or tickertape parades, they will, if followed, keep a variety of scientists busy for the next decade. In addition, and perhaps most important, the projects may help answer such existential questions as, in the report's words, "How did our home in the universe come into existence, and How did life originate?"

The report, issued this week, is sure to become the bible of various scientists and Congressmen in their yearly dialogue with NASA. It summarizes the views of 14 members of the NAS Space Science Board's executive committee. While the report emphasises this bias, it does, in addition, summarize the views of seven working groups representing various space disciplines, and ten previously published studies. At least 137 space scientists and program managers are listed as participants.

Confronted with such an awesome array, NASA will most likely fulfill all the major priorities during the next decade, but the sequence in which the missions are flown may not be according to the NAS list.

What NASA did was ask scientists, under the auspices of the academy, to examine projects they would like to see flown, if limited to a certain budget level. But it is not clear if the scientists and NASA are working with the same money figures. The report lists priorities in three groups: base, intermediate and high level. The base missions recommended are supposedly based on the 1971 fiscal year budget of $566 million for the Office of Space Science and Applications (OSSA); intermediate and high level lists would be additions to the base flights if the budget were increased by 25 and 50 percent. However, the 1972 OSSA FY request of $750 million already exceeds the intermediate budget level priorities.

Among the priorities at the base level are projects such as small planetary probes, orbiters and flybys (centrating on Venus), astronomical observatories and telescopes and an earth-orbiting gyroscope. The report recommends an increase in earth observation satellites, sounding rockets and atmospheric balloons and a doubling of funds for data analyses of the tons of information already collected but not analyzed from previous space flights.