idly diminishing resource base forces a slowdown in industrial growth. Because of natural delays in the system, both population and pollution continue to increase for some time after the peak of industrialization. Population growth is finally halted by a rise in the death rate [symbolized in the graph by the letter 'D'] due to decreased food and medical services [as well as pollution]." Likely, say the researchers, it would not happen this way; instead, some less predictable event, such as world war, would intervene sooner. The graph illustrates the *best* possible outcome of unchecked current trends.

Their graph "Stabilized World Model II," represents one possible rationally planned alternative. It is not the ideal one, according to the researchers, but the one they believe most closely approaches what could realistically be accomplished given inevitable constraints. The model is of a world approaching a "steady state" or "equilibrium" condition, where an average family size of two children is achieved by 1975, where death rate (D) and birth rate (B) are thus approximately equal and where capital investment in new equipment is likewise approximately equal to depreciation of old equipment. Nearly all economic growth in this model is in services (S) rather than in goods. Resources are declining, but at a slow enough rate so that technological innovations such as recycling, substitutions and longer-lasting and more easily repaired machinery can cope with depletion.

The widespread belief that purely technological solutions will be found was expressed at last week's symposium by Philip G. Abelson, editor of the journal SCIENCE. Abelson was particularly optimistic about the potential for new sources of energy, such as fusion power, to create vast new technological alternatives. The MIT authors point out, however, that entropy, not just in the production of energy but in its use, as well, could knock such optimistic views into a cocked hat. Already, say the authors, man-caused heat losses in the Los Angeles Basin are 5 percent of absorbed solar radiation; they project that the figure will go to 18 percent in the year 2000.

But the authors themselves agree with some of the criticisms of their work. Their resource projections, they concede, are based on an extremely high degree of aggregation of many variables. The projections of the effects of pollution on human morbidity and mortality are virtually without an empirical base because the data are not available. And the book itself is sometimes grossly oversimplified for a popular audience; in the graphs shown with this article, for instance, relative quantities are not expressed—sometimes because they would complicate beyond easy comprehension but sometimes because figures do not exist. The authors insist, however, that they are fully aware of these flaws and that they still stand firmly by their basic conclusions.

The largest objections are bound to be ideological ones. A clear implication of the study is that equality of distribution must be achieved between individuals within nations as well as between nations (with an equilibrium worldwide per capita income of about $1,800 annually). ". . . Let [the equilibrium condition, if it must be] be an equilibrium in which equality has not forced the destruction of freedom and liberty," cautioned Health, Education and Welfare Secretary Elliot L. Richardson at the symposium.

And, added Edward P. Morgan, ABC radio commentator, "I suspect that the reaction to this book is going to be sharp from the reactionaries . . . who are so wedded to a life style the Chamber of Commerce has made sacred." □

NAL accelerator makes first 200-GeV beam

After years of preparatory work and design studies and some stiff political fighting over the site, ground was broken for the National Accelerator Laboratory near Batavia, Ill., on Dec. 1, 1968. Last week, on March 1, a beam of protons at the design energy, 200 billion electron-volts (GeV), was run through the accelerator for the first time.

The first test beam to pass through the accelerator was on June 30, 1971. At the time the laboratory management hoped to tune it up to the design energy by some time later that summer, but they were suddenly faced with a massive problem regarding the machine's large magnets. Difficulties in the electrical insulation in the magnets (thought by some to be due to moisture) caused short circuits. The process of identifying the faulty magnets, removing them from the accelerator ring and reconditioning them severely slowed the tune-up program, but the achievement of a beam at design energy still comes before the date envisioned in the original planning, summer 1972.

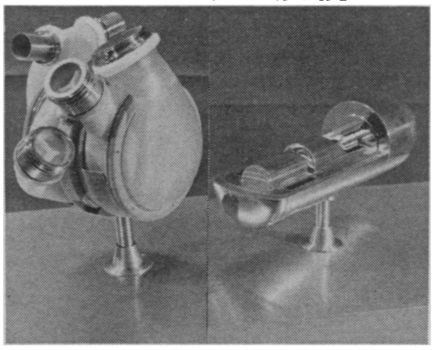
In the international accelerator sweepstakes—if there is still such a race after the beating that fundamental physics budgets have taken in the last few years—the energy leadership now returns to the United States after several years' sojourn in the Soviet Union. Actually Batavia took the lead three weeks before March 1, when a 100-GeV beam was run. This surpassed the 76-GeV energy of the synchroton at Serpukhov in Russia, previously the world's most energetic. To celebrate, the Batavia staff opened a bottle of vodka that Soviet visitors had left them for the occasion.

The Batavia management is aiming at still higher energies. During construction a way was found to get a 500-GeV beam from the accelerator. It involves work on the power supply, and this will be undertaken after the water cooling system for the magnets is brought into operation.

At present, the magnets are air-cooled, and this limits the accelerator's pulse rate. The 200-GeV beam was run at one pulse per second to allow the magnets to cool. As soon as the water-cooling system has been tested, the Batavia management intends to extract a beam and run it into a 30-inch bubble chamber for a series of exploratory exposures to show what it does there.

Meanwhile, one experiment is already running and has been since the energy reached 100-GeV. It is a proton-scattering experiment, in which the accelerator beam is run against a target of plastic material made from melted-down Baggies and placed inside the accelerator. No one in the world yet knows what happens when 100-GeV protons strike other protons in an accelerator, but in a few months, if all goes well, the group from the University of Rochester, Rockefeller University and NAL that is doing the experiment will have the answer. □

NHLI's calf has a nuclear heartbeat


NIH

NHLI heart (left) and nuclear engine.

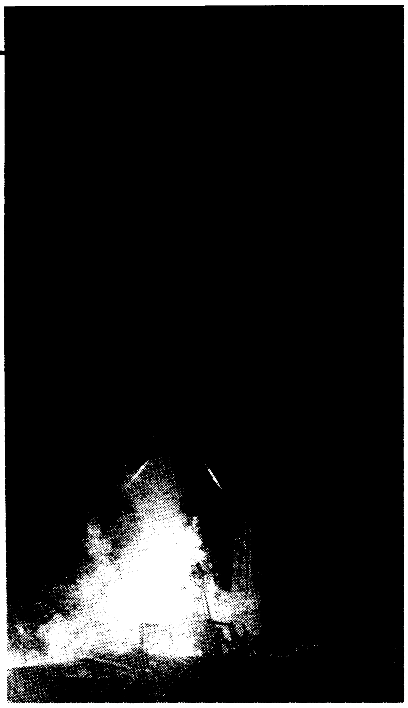
When a human heart becomes diseased or wears out, it must be repaired or replaced or death results. Heart transplants provide one way of replacing a defective heart, but the process is extremely costly and the new heart may be rejected by the body.

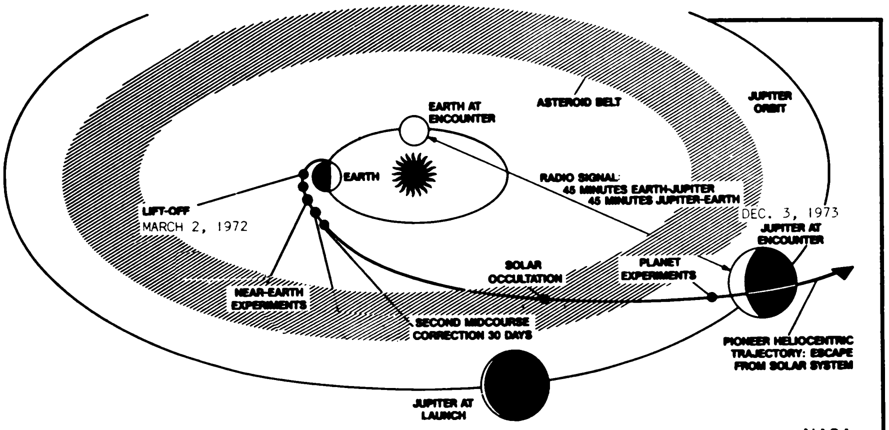
An alternative is an artificial heart. Last week the National Heart and Lung Institute announced that a team of researchers led by Lowell T. Harmison, head of the Medical Devices Applications Branch has developed a total heart-replacement system and a small nuclear engine to drive it.

Two nuclear engines have been tested, a miniature steam engine and a modified Stirling engine. The nuclear energy source is about 100 grams of plutonium 238. The engine is encased in a three-layer metal capsule that is designed, says Harmison, to withstand "incredible accident conditions." The prototype engine, designed for test implantation in a calf, is a cylinder weighing about 2.5 kilograms and measuring 7.6 by 20 centimeters. The human version, to be implanted in the abdomen, would be slightly smaller. Ultimately, says Harmison, it might be reduced sufficiently in size to be put between the ventricles of the artificial heart. The engine could be used to power a total replacement heart or a heart-assist system.

The implantable artificial heart, similar to the natural heart in general structure, can be powered either by the nuclear engine or by electricity. A heart-assist system with the nuclear engine was implanted in a calf in mid-February to verify the procedure for implantation; the artificial heart, powered electrically, has also undergone short-term tests in animals. No long-term tests have been done yet. This will be the next step. Harmison estimates that nuclear-powered artificial hearts might become available for use by humans by the end of this decade. The cost of implantation would be comparable to that for a transplant, but long-term follow-up costs would be less. The system will be designed to operate for 10 years.

The NHLI researchers emphasized that much remains to be done. The long-term animal studies will have to determine: the reaction of the rest of the body to the system; the responsiveness of the system to changing physiological needs and instantaneous energy demands; the effects of excess heat emitted by the system on surrounding tissue. In addition, says NHLI head, Theodore Cooper, a great effort has been and will be devoted to the economic, sociological and psychological implications of the device. □





NASA

Pioneer 10 begins journey through the asteroids to Jupiter and beyond.

Pioneer 10 begins journey to Jupiter

Pioneer F (renamed Pioneer 10 after launch) finally got off on its 22-month journey to Jupiter March 2 after a four-day delay. The launch was delayed three nights by shear winds above Cape Kennedy and one night by an Air Force launch.

Other planetary payloads have been launched, but Pioneer 10 has a special ring to it (SN: 11/13/71, p. 330). It will be the first craft to navigate through the asteroid belt (beginning in early July), and on to a rendezvous with Jupiter Dec. 3, 1973. It will then cross the orbit of Uranus in 1980 and at some point beyond the orbit of Pluto (about 5.8 billion kilometers from the sun) leave the solar system. Carl Sagan and Frank Drake of Cornell University estimate that with a residual interstellar velocity of 11.5 kilometers per second, it will take Pioneer 10 some 80,000 years to travel one parsec—about the distance to the nearest star. After mid-course correction burns early this week, Charles F. Hall, project manager of Pioneer, said the craft would exit the trailing edge of the solar system (in relation to the solar system's direction of rotation within the Milky Way galaxy). It is thought now that the craft will be headed in the general direction of the star Aldebaran. Should Pioneer 10 head for that star, it would take an estimated 1.7 million years to get there.

The spacecraft carries a plaque designed to show any intelligent civilization from another system that might intercept Pioneer 10 from what part of the galaxy and from which planet in the solar system it came and when it was launched (SN: 2/26/72, p. 135).

The Jupiter probe left earth at a speed of 51,800 kilometers per hour —the fastest that any manmade object has ever flown. It passed the moon in 11 hours.

As a result of this week's mid-course corrections, Pioneer 10 is expected to pass within 135,000 kilometers of the surface of Jupiter and within 400,000 kilometers of Io, 300,000 kilometers of Europa and 500,000 kilometers of Ganymede, all moons of Jupiter. Three instruments aboard recorded data as the craft went through the earth's radiation belts and crossed the boundary of the earth's magnetic field.

A hexagonal surprise in superconductivity

It took 50 years after the experimental discovery of superconductivity for theoretical physicists to reconcile the phenomenon with the laws of physics. There is still no reliable theory that predicts where and when superconductivity should appear, and its appearance occasionally surprises experimenters.

Such a surprise has come to a group working at Bell Telephone Laboratories in Murray Hill, N.J. The investigators, H. E. Barz, A. S. Cooper, E. Corenzwit, M. Marezio, B. T. Matthias (also of the University of California at San Diego) and P. H. Schmidt, have found superconductivity at quite high temperatures in lithium titanium sulfides. It was, reports Matthias, "an entirely new and quite unexpected phenomenon."

The transition temperatures for complete superconductivity in these compounds ranged between 10 and 13 de-