for the American Public Power Association, says that if there were no import quotas on any petroleum products, oil companies would have to compete with foreign oil across the whole spectrum of petroleum products; thus prices generally would be reduced and the domestic refinery capacity for resid would exist.

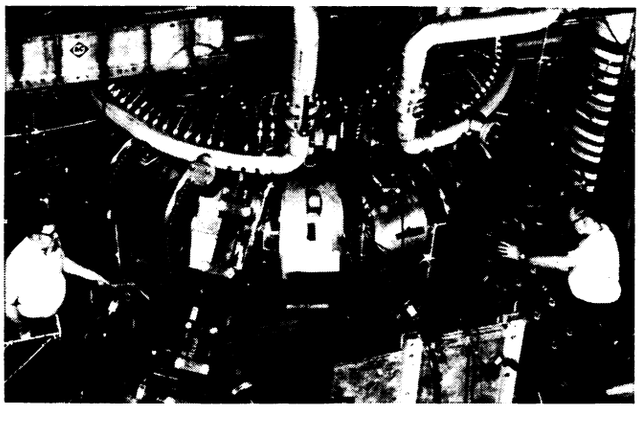
And Dr. Bruce C. Netschert of National Economic Research Associates Inc. says there is little doubt of growing monopoly control by the oil companies of all forms of energy. A succession of mergers during the past few years has given oil companies control of 26 percent of the coal industry, he says. Oil companies have long controlled most natural gas supplies, and oil companies also are rapidly diversifying into uranium production. Fry sees alleged natural gas shortages as a "natural gas strike" by the oil companies for higher rates from the FPC, a strike made possible by the fortuitous shortages of foreign resid and of the coal, whatever their cause.

Industry spokesmen, on the other hand, insist the energy industries are doing their best to provide needed fuels and that shortages are due to escalating costs, environmentalist pressures and inefficient regulation. Willard F. Rockwell, chairman of the board of North American Rockwell, recently suggested, for example, that more liberal antitrust laws governing energy industries—instead of more stringent ones as suggested by Dr. Netschert—are the answer.

The debate will not end soon. And some combatants are arguing that ways be sought to conserve energy resources by minimizing new demand. □

FUSION

Practice leads theory



Princeton Tokamak: As good as the Russian one, maybe a little better.

Princeton Univ.

From the basic principles of the behavior of electrically charged bodies in electric and magnetic fields, a theory can be derived that predicts the behavior of the plasmas of ions and electrons used in experiments aiming at controlled thermonuclear fusion. The only problem is that when experimenters made plasmas and tried to confine them in magnetic fields, this so-called classical plasma theory didn't work—the predicted and observed behaviors were different.

The result was a serious disappointment for theorists and experimenters alike, since the classical theory predicts an easier approach to the conditions of temperature, density and length of confinement necessary for a sustained fusion reaction than the experiments were showing.

From the experimental results theorists began to try to understand the behavior of the actual plasmas and to determine how the classical theory should be modified to make it work. Meanwhile experimenters went on trying to improve their experiments. In the last two or three years experimenters have achieved a number of significant improvements in confinement, but theorists are having as much trouble understanding the successes as they had understanding the earlier failures.

"I used to say," Dr. Harold P. Furth of Princeton University told the meeting of the Plasma Physics Division of the American Physical Society in Washington last week, "that when we understood it, we could make it better. But nature has foxed us and made it better before we understood it."

One of the most celebrated ways that nature has made it better is in a machine called Tokamak that was developed in the Soviet Union (SN: 10/17, p. 321). A Tokamak has a toroidal or doughnut-shaped chamber in which the plasma is held. A large electric coil is built around the toroid in such a way that a current flowing in the coil induces a current in the plasma just as a current in one coil of a transformer induces a current in the other coil. The plasma current both heats the plasma and generates a magnetic field to confine it.

The Tokamak not only held plasma for an unusually long time, but also produced a plasma that was exceptionally stable, lacking many of the disturbances that contribute to loss of plasma in other experiments. The Russian results started the U.S. Atomic Energy Commission on the construction of five Tokamaks. The first of these, at Princeton, has been operating since July.

The Princeton Tokamak is doing about as well as its Russian prototype and maybe a little better, says Dr. Edward Meservey, one of those who has been working with it. When the electric current in the plasma is 40,000 amperes, a plasma of 10^{13} particles per cubic centimeter can be contained for 3 milliseconds at temperatures up to 10 million degrees K. That is what the Russians get with the same current. The Russians claim 7 milliseconds confinement when they use a 100,000-ampere plasma current. So far the Princeton Tokamak is limited to currents under 50,000 amperes; improvements are under way to bring it to 80,000 amperes.

In the absence of a complete theoretical understanding of plasma behavior no particular approach is preferred in principle, and the current successes of the Tokamaks have not made the others roll over and play dead. Heating of plasmas by turbulence, by radial shock (theta pinch), by longitudinal shock (z-pinch) and by laser light are among those under study. Magnetic fields of many different shapes are being used in attempts to confine the plasmas.

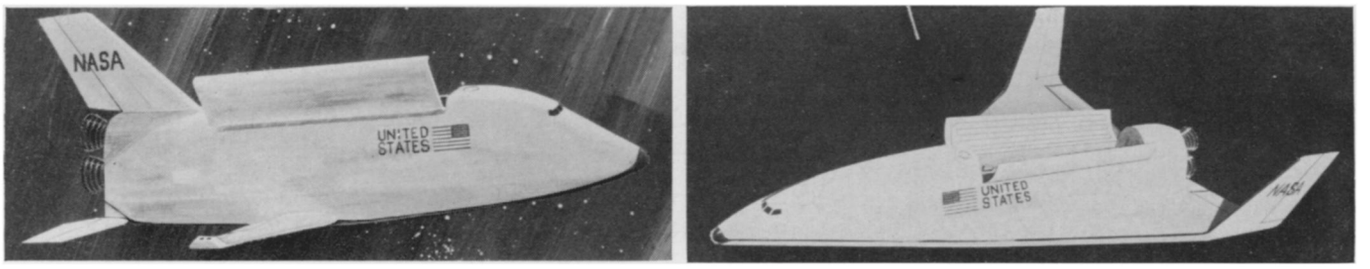
Plasmas created and heated by lasers are considered by many a particularly hopeful approach, but says Dr. J. L. Bobin of the Centre d'Etudes de Limeil in France, "Laser-created plasma is about as far from the Lawson criterion (a rule of thumb for self-sustaining fusion) as others."

Says Dr. Lev A. Artsimovich, who led the development of the Tokamak, "Nobody can say right now what kind of closed system is more promising. It may be Tokamaks; it may be Stellarators (a magnetically different kind of toroid). This ingenious idea (the Stellarator), which was created in the United States, should be studied further." □

STRAIGHT WING VS. DELTA

Choosing shuttle options

The National Aeronautics and Space Administration has placed high stakes —its future for the next two decades— on the reusable shuttle (SN: 8/22, p. 178). Its argument is that to maintain



NASA

Studies of shuttle design focus on differences between simpler straight wing and more complex delta wing.

a competitive space program, the cost of earth-to-orbit launch must be reduced from the current $1,000 per payload pound to about $100 per pound by replacing the expendable boosters (of all shapes) with a single, versatile, reusable one.

But the problem is not that simple. The Air Force is counting on NASA to make up for what the Air Force lost by cancellation of its Dynasoar and Manned Orbiting Laboratory programs. And the Air Force requirements are more stringent. They include a vehicle that is more maneuverable laterally once it reenters the atmosphere, and probably greater payload capacity. Since NASA is counting on multiple uses of the new bird—scientific, civilian and military—to get its program funded, the result is a constantly changing shuttle picture with a growing list of base line requirements. These requirements will determine a basic design question—whether the shuttle will have a straight wing or a delta wing.

And each day, more points are being claimed for the more complex delta wing.

The straight wing, which originated at NASA's Manned Spacecraft Center in Houston, was conceived as the simplest approach to getting into orbit and back again. Its design arose out of the original NASA requirements for a low cross-range vehicle—one less maneuverable than the Air Force needs. "MSC looks at a configuration as though we are going to have to build and fly it," says Christopher C. Kraft, assistant director of the center. "Our approach was to find the simplest path through the technical maze . . . find out where the problems were and try to avoid them rather than solve them." But a limited space budget and Air Force requirements place the straight wing in a new perspective.

Since the overall requirements for the shuttle are still in a state of flux, so is the design. "We are committed only to building the best vehicle for all purposes," says Kraft.

"Aerodynamically, the flight regime of the straight wing," says Maxime A. Faget, the father of the design, "is much more completely understood." It uses a traditional fuselage design compared with the complex delta shape. The major differences appear in flight speeds and heating loads.

The delta, tested extensively in the Dynasoar program, has better hypersonic and supersonic characteristics and fulfills Air Force needs; the straight wing can maneuver better subsonically. "The problem," says Faget, "is getting a 1,250- to 1,500-mile cross-range out of the straight wing." The question is: At what point after entering the earth's atmosphere and traveling hypersonically cross-range does the straight wing become technically inferior to the delta?

According to some wind tunnel heating statistics, the delta can maneuver up to 1,500 miles laterally. Because of its shape and angle of attack, its temperatures reach only about 3,000 degrees F. The straight wing, on the other hand, nears temperatures of 4,200 degrees F. Since the shuttle's economy depends on its reusability, a heat shield system must be designed to either withstand such temperatures or be economically replaced.

The current requirements are for a vehicle that can launch 25,000-pound payloads (although the Air Force may require greater payload capacity) to a 270-nautical-mile (space station) orbit at an inclination of 55 degrees. In addition to the studies examining the two-stage vehicle (booster and orbiter), several studies are looking at a stage-and-a-half shuttle—a single vehicle in which the fuel tanks would be dropped after launch.

Other questions yet to be resolved include the manned versus unmanned booster. If the two-staged shuttle is chosen, two vehicles will launch vertically simultaneously. This introduces abort and safety problems not encountered in the Apollo staging. An unmanned booster would permit concentration of crew safety on the orbiter. The booster could, according to drone proponents, land automatically.

Another area of pending decision is the desirability of having air-breathing engines on the orbiter for use after reentry. The engines would be needed, says Clarence Gay of the space station office at NASA headquarters, during initial flight tests. Later, if the engines were dropped, 16,800 pounds of payload capacity could be added.

How the shuttle develops, however, may not depend on either the Air Force or NASA but on Congress. The already dwindled space budget was vetoed and faces another round of debates in Congress before January. The shuttle is the prime target of some cost-cutting opponents. □

TARNISHED IMAGE

Assessing the campaigners

As winners and losers of both parties were taking stock of last week's off-year elections, some of the deepest soul-searching was to be found among political consultants—the new breed of campaign managers that many observers believe to have revolutionized electioneering in the United States.

Some behavioral scientists had not quite accepted the thesis of a revolutionary role of TV, computers, polling and communications theory in determining who gets elected. The response (see p. 378) of Dr. Bruce H. Westley of the University of Kentucky to an earlier story on campaign consultants (SN: 9/12, p. 229) was written before the returns were in. Such professional skeptics were joined by much of the nation's press and perhaps a number of politicians after the election. The results clearly showed that having a professional political consultant, even one of the best, was not a magical way to win at the polls.

The basic question, as Dr. Westley points out, is how much influence the mass media have over the voters—how effective they are in persuading people to vote one way or the other. And it is on this basic question that much theory about the process of communications and persuasion is still not clear.

One of the keystones of communications theory was laid down in the 1940's and 1950's, when studies of the spread of information concerning everything from Presidential candidates to refrigerators to new drugs indicated that there were two steps in the process. The mass media, this research suggested, were not the major means by