U.S. science: Signs of sluggishness

How fare science and technology in the United States? Still strong in comparison with other nations but showing many signs of weakening in the last few years. This is the conclusion one draws from a detailed compilation of statistical indicators of the strengths and weaknesses of U.S. science and technology published in the seventh annual report of the National Science Board. The report, *Science Indicators 1974*, marks the second time in four years the Board has devoted its annual report to science indicators. The 26-member Board, currently headed by Norman Hackerman, President of Rice University, is charged by Congress with providing an annual report on the status of science in the United States.

The Board itself draws no general conclusions, instead summarizing dozens of statistical indicators. Some highlights:

- The proportion of the gross national product spent for research and development has declined steadily over the last decade in the United States (to 2.4 percent) while growing substantially in the Soviet Union, West Germany and Japan.
- The United States was the largest producer of the scientific literature sampled from 1965 to 1973 in all fields except mathematics and chemistry, where it was second to the Soviet Union. But U.S. research publications in physics, engineering and chemistry have declined.
- A majority of a sample of major technological innovations of the past 20 years were produced by the United States. But the proportion of innovations of U.S. origin declined from a high of 80 percent in the late 1950s to some 55 to 60 percent since the mid-1960s. Japan and West Germany showed noted increases.
- The United States had a favorable but declining "patent balance" between 1966 and 1973. The decline of 30 percent was due primarily to increases in the number of patents awarded by the United States to West Germany and Japan and the decreasing number of patents granted to the United States by Canada and the United Kingdom.
- The United States had an increasingly positive balance of payments from technical "know-how" over the 1960-73 period. Four to five times more patents, licenses and manufacturing rights were sold to other nations than purchased.
- The interval between invention and innovation (market introduction) is shortest in Japan (3.6 years), followed by West Germany (5.6 years), the United States (6.4 years) and France (7.3 years).

As in the 1972 report, the Board also attempted to measure public attitudes toward science and technology. It again commissioned the Opinion Research Corp. of Princeton to repeat its survey. The survey provides little support for the idea that Americans are hostile to science and technology. Seventy-five percent of the public believe science and technology have changed life for the better, up five percentage points from 1972. In a ranking of nine professions, scientists and engineers ranked second and third in both 1972 and 1974 (physicians were first). Some 78 percent (up from 72 percent in 1972) described their general reaction to science and technology as one of "satisfaction or hope" or "excitement or wonder," with only 5 percent as "fear or alarm." □

MS virus: Cause maybe, cure no

Werner and Gertrude Henle, virus researchers at Childrens' Hospital in Philadelphia, are still trying to recover from their latest piece of successful research. They and several colleagues have been studying the cause of the degenerative disease multiple sclerosis and have made some significant progress in recent weeks. But somehow, during press coverage of their work, "a viral *candidate* for the cause of multiple sclerosis" became "the virus that *causes* multiple sclerosis," and, Henle says, calls started pouring in from the desperate relatives of multiple sclerosis victims.

"It is so disheartening," Henle told SCIENCE NEWS, "that their hopes were raised falsely. What we have found, unfortunately, has no direct effect on patients. We are searching for the cause of multiple sclerosis, not the 'cure.'"

Multiple sclerosis is a slow, progressively debilitating disease of the central nervous system that occurs mainly in young adults and is characterized by paralysis, tremor and speech disturbances. The Henles and others, including George and Patricia Merz, P. C. Licursi and R. I. Carp of the Institute for Basic Research on Mental Retardation in Staten Island, have found in the past five years that the disease may be caused by a virus infection and severe autoimmune response.

The Henles followed up earlier animal studies with a study of multiple sclerosis patients in which they found a small agent (25 to 30 nanometers across) in association with tissues from most of the patients. They also found that 80 percent of the patients and about 30 percent of their families and nurses carry antibodies against the particles.

"We still have to prove that this small particle really is the virus associated with the disease, and not just a 'passenger virus' that happens to be there." But the findings do show, Henle says, that a virus may set off antibody formation and a mild form of the disease in the normal individual and that only in exceptional cases does the disease develop. "It may be an autoimmune disease," he says, "in which large numbers of antibodies are formed in some individuals, and these, in turn, attack the nervous system."

Right now, Henle says, his team is developing better techniques to find the agent and measure antibodies. But even confirming the agent as the causative virus wouldn't help patients, he says, since there is no chemical or antibiotic therapy for virus diseases. "In time, perhaps, a vaccine might be developed to *prevent* the disease, but not to treat it." □

Neutron stars may be element factories

The conventional way to try to make superheavy chemical elements (those much heavier than uranium), which no longer exist on earth if they ever did, is to use ion accelerators to bombard one heavy nucleus with another in the hope that the two will fuse and make the desired superheavy nucleus. The method has worked with elements up to atomic number 106, but so far has not gone further. Nuclear theorists expect to find an "island of stability," a group of nuclei in the range around 110 that ought to be relatively more stable than others. Some of these could prove to have practical uses as some of the lighter transuranics have (for example, plutonium in power production and explosives or californium in medicine).

Theoretically, it has been a moot question whether nature makes or ever made such superheavy elements. Some scientists think the laboratory experiments may, in fact, be trying to improve on nature. Now, in the Feb. 26 NATURE, a Russian and a Polish scientist, V. M. Chechotkin of the Institute of Applied Mathematics in Moscow and M. Kowalski of the Institute of Experimental Physics at the University of Warsaw, propose that nature does make such things. It happens in neutron stars, they calculate.

If you were looking for heavy nuclei, neutron stars might be a good place to start. They have masses up to a few times that of the sun, but the matter is squeezed down to densities like that of an atomic nucleus. In fact, some theorists regard the interior of a neutron star as a kind of pathologically supercollossal nucleus. There is a tremendous excess of neutrons in a neutron star compared to their proportion in normal nuclear matter. In 1947, Maria Goeppert-Mayer and Edward Teller recognized that in a neutron-rich nuclear fluid, extremely heavy nuclei might evolve and then produce lighter elements by spontaneous fission.

Such conditions would be present in neutron star envelopes, which would have a chemical composition of nuclei with atomic weights between 200 and 500, plus free neutrons. Instabilities in the neutron star could eject such matter from the surface. Chechotkin and Kowalski calculate what would happen to it after ejection. By 0.4 seconds after ejection more than half of the original nuclei, which start out at atomic number 161 and atomic weight 644, evolve by capturing free neutrons until they reach atomic number 184 and weight 736. By half a second after ejection nearly all the nuclei in the ejected matter have so evolved.

These ultraheavy nuclei then undergo spontaneous-fission and beta-decay chains to produce both superheavies and the heavy elements already known to chemistry. Chechotkin and Kowalski consider the known density of heavy elements in the universe and the best present estimate of the number of neutron stars (a billion) and conclude that the outlined process could produce the heavy elements under the assumption that 10 percent of the envelopes of the neutron stars form heavy elements and are ejected.

Thus, the space in the neighborhood of neutron stars may be enriched with heavy and superheavy elements, and some of these could find their way to the surfaces of other nearby stars. Such a process could explain the presence of heavy elements on the surfaces of stars (such as promethium 145 in some Ap stars) that processes within the stars do not seem to be able to account for. □

Probing space for gravity waves

Gravitational waves are, according to Einstein's theory, gravity's analog to electromagnetic waves such as light, radio and X-rays. Electromagnetic waves are generated by accelerated motion of charged bodies. Gravitational waves ought to be generated by accelerated motion of massive bodies. The passage of electromagnetic waves can be detected by jiggles that they cause in the motion of charged bodies. Likewise, the passage of gravitational waves should be detectable by jiggles in the motion of massive bodies they encounter.

For technical and scientific reasons, gravitational waves are far more difficult to detect than electromagnetic ones. Nevertheless, about seven years ago Joseph Weber of the University of Maryland reported that he had detected them, but no one else has seemed to be able to confirm his finding. Now an American and a Russian physicist, Kip Thorne of the California Institute of Technology and Vladimir Braginsky of Moscow State University, propose a spacecraft experiment to try to confirm the existence of the waves.

Weber was looking for fairly high frequency, short waves (in the range above 1,000 hertz). He used metal bars for detectors. The passage of the waves should produce extremely minute fluctuations in the surfaces of the bars. Thorne and Braginsky propose an antenna that would use the earth and a space probe flying beyond Mars to detect extremely long waves, 10 million kilometers or more in length with periods of 30 seconds or greater. The Thorne and Braginsky proposal is floated in the Feb. 15 ASTROPHYSICAL JOURNAL.

As waves of this length passed through the solar system, they would cause fluctuations in the motions of the spacecraft and of the earth. The difference could be measured by the Doppler shift in the radio signals that track the spacecraft.

The basic idea is not new, but the proposal is made practical now by what Thorne calls "a revolution in clockmaking" led by John Turneaure of Stanford University. Instead of using atomic vibrations as frequency standards, the new clocks will use classical electromagnetic waves standing in a superconducting waveguide. They promise to increase precision by a factor of 50 to 500 over current hydrogen-maser clocks. This should be sufficient to control the frequency of the spacecraft tracking signal sharply enough to distinguish the gravity-wave-induced Doppler shift.

The proposal is being made separately to the Soviet and U.S. space agencies. A joint experiment is not feasible because the Soviets keep their deep-space tracking data closely secret and would be highly unwilling to share them. □

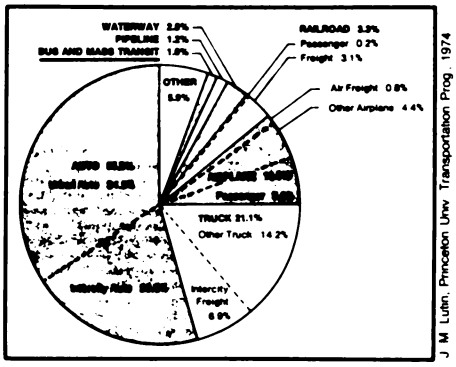
Mass transit: Limited impact

Just increasing mass transit facilities and their use can have only very limited impact on efforts to improve energy conservation and the economy, according to a new study by the congressional Office of Technology Assessment (OTA). Such measures would have to be combined with stringent, direct restrictions on private automobile use in order to be effective, the report concludes.

The findings, summarized in the OTA report *Energy, the Economy and Mass Transit*, are simply the latest confirmation of that well-known phenomenon, the "love affair" between Americans and their cars. Even totally eliminating fares on urban mass transit systems would apparently not dissuade auto commuters, and though it would increase transit ridership by 60 to 80 percent, the effect on fuel conservation would be almost negligible. The effect on unemployment would also be modest: Each million dollars of capital investment for mass transit results in about 80 man-years of employment (some 3 percent more than highway construction), and building new subway systems and the like tend to affect employment only locally.

Such conclusions strike at the heart of ambitious schemes for solving the nation's energy and economic ills through vast public works projects aimed at rapidly improving urban mass transit systems. On the other hand, combining improved transit service with direct penalties on auto use could result in substantial savings. The automobile accounts for 98 percent of fuel used in urban passenger transportation and 13.6 percent of the nation's total energy use. The passenger miles produced by a unit of energy during rush hour is 15 times greater for a bus than a car, and more than 27 times greater for a subway train. And despite the trend to smaller cars, automobile fuel efficiency continues to decline.

Penalties on private auto use would have to be pretty severe, however, to show any effect: During the recent oil embargo, most people apparently cut back on discretionary auto travel rather than switching from cars to mass transit. Estimates from OTA indicate that such direct restraints as $1.50 per day increase in the price of commuter parking would have a greater effect on transit ridership than a 50 percent increase in the price of gasoline, which in turn would have 10 times more effect on reducing gas consumption than the maximum "pure-transit" strategy, including free fares. (Such free mass transit would cost about $5 billion a year and could be financed by a gasoline tax of as little as 15 cents per gallon, applied only in metropolitan areas.)



Consumption of energy by transportation.

Meanwhile, existing funds for improving transit facilities have encountered interesting local resistance: The vast majority of federal funds made available in 1974 for public transportation are being used by communities for operating expenses rather than facility improvement. This is true despite a substantially greater requirement for matching local funds. The OTA notes that if the Urban Mass Transportation Administration (UMTA) had more flexibility in setting requirements for matching funds, it could encourage communities to initiate new transit programs. □