AGI's executive director, Linn Hoover, were much more optimistic. "Jobs definitely will be available," for the relatively small number of minority graduates the professional societies hoped to support, Hoover said. Some other proponents of the plan argued that continuing government pressure on corporations to set numerical hiring goals for minorities, or "affirmative action plans" would help ensure the availability of jobs. And in any event, students who are earth science majors now won't appear on the market for another 4 to 10 years, by which time the market presumably will have improved.

One major theme that wove through the 3-day meeting was that a central difficulty in attracting blacks and other minorities into the sciences, apart from the prohibitive cost of education, lay in the quality of science education well below college level, down in the elementary and junior high schools. A number of black participants expressed the view that science instruction in urban schools contains little material that is familiar to a child whose environment is limited to asphalt and concrete, and that such children may be "lost to science" as early as the sixth grade.

William Bromery said he thought it necessary for any minority-assistance program "to go down below high school, even into the grade schools, where children first hear about rocks—if they ever do—to capture and hold their interest" before they learn to think of science as part of an alien and unattainable world. Hoover acknowledged that elementary and secondary education are "the real problems" and that "a lot more needs to be done in this area."

It is entirely possible, of course, that the geosciences' attempt to alter their social stratigraphy may fizzle out for lack of interest or from sheer impossibility. At the very least, however, the professional societies may be able to ensure that no minority student who chances into the earth sciences will be lost for lack of money or encouragement. And even that would seem an exemplary goal.

—ROBERT GILLETTE

High Voltage Engineering: Accelerating Away from Science

Accelerators are almost indispensable to nuclear physicists. If they function reliably, a scientist can publish prolifically; but if they don't, brilliantly conceived experiments may die. For the last 20 years most accelerators for nuclear physicists around the world have been built by the High Voltage Engineering Corporation in Burlington, Massachusetts, and the corporation has depended on nuclear physicists for almost all of its sales. But in 1970 High Voltage Engineering suffered huge losses when its greatest research gamble didn't immediately pay off, and today it is struggling to become profitable again as a company with a rather different composition—a miniconglomerate with most of its sales in products for industrial rather than scientific markets.

Like many firms near Cambridge, High Voltage Engineering Corporation started just after World War II as a spin-off from Massachusetts Institute of Technology with a few men struggling to put together a prototype in a garage near Harvard Square. Three people really made the company work. Robert Van de Graaff was noted as the inventor of the Van de Graaff accelerator that is pictured in many high school science texts. John Trump was a professor of electrical engineering at M.I.T. who wanted to use Van de Graaff accelerators for cancer therapy. Denis Robinson was a physicist with the air of a statesman who had been the wartime representative of the British government to the M.I.T. Radiation Laboratory. Van deGraaff became chief scientist, Trump technical director, and Robinson president. As nuclear research efforts increased after the war, the company found a growing market for its accelerators, which were far more reliable than the "homemade" machines that scientists had previously built.

High Voltage Engineering Corporation was often referred to as "Van's company." As a young boy growing up on an Alabama cotton plantation, Van de Graaff had developed an interest in machinery which later came to fruition when in 1931 he put together a working model of an invention for producing high voltages. This simple machine had the potential for producing high-speed beams of particles, and the perfection of sophisticated versions capable of higher and higher voltages became Van de Graaff's life's work.

As chief scientist of High Voltage Engineering Corporation, Van de Graaff was looked upon as nothing short of a genius and almost hallowed by his associates. According to Robinson, he was the "spiritual and scientific" head of the company, and a special research laboratory was built to bear his name and to be his birthday present in 1967, the year in which he died. All his thoughts about technical matters were recorded for several years before 1967 "in order that we might not lose any of his momentum," said Robinson several years ago.

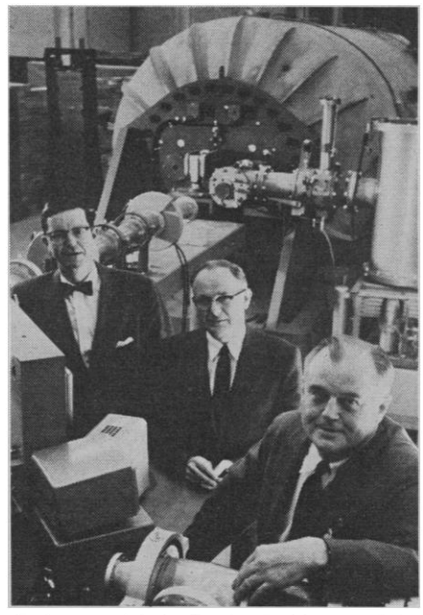
Some critics of Van de Graaff say that he was a ponderous thinker, and not the "world's cleverest experimental physicist." With hindsight it is clear that his legacy of technical ideas carried High Voltage Engineering Corporation into financial disaster when it continued to invest heavily in the construction of the machine that had been Van de Graaff's dream, the transuranium (TU) accelerator. The TU was to be the culmination of a successful line of tandem accelerators, a conceptually elegant machine that could reach 20 million volts and accelerate a beam of uranium atoms to energies of 1 billion electron volts. High Voltage Engineering Corporation (HVEC) invested more than $4.5 million in developing the gigantic accelerator, even though there were no orders for it, and the first machine is still to be sold. According to Jason Weisman, a former employee of HVEC, the paper work needed to justify such an expenditure, such as market analysis and projection of investment return, was never completed. Apparently HVEC liked the image of a science company, and continued to follow a formula that had worked well in the past.

The decision to go ahead with the TU accelerator started a sequence of events that fundamentally changed the character of the company. Even at the time of heavy investments by HVEC in the

construction of the TU in 1967 and 1968, the rapid decline of U.S. research funds was becoming evident. By the time the TU passed preliminary tests in December 1969, Robinson had received indications that the U.S. Atomic Energy Commission was not interested in funding such a machine. One month later the TU was put into mothballs. Soon afterward the Van de Graaff Research Laboratory in Burlington was also closed, and a major reorganization of "Van's company" began. The year 1970 ended disastrously with total losses of $3.7 million, 31 percent of stockholder investment for the entire corporation.

Since 1970 HVEC has diversified extensively. Today it is a miniconglomerate of more than ten subsidiaries with roughly equal status, of which the science division devoted to research accelerators is only one. Other industrial subsidiaries manufacture various plastics and large devices for electrical power transmission. Whereas 70 percent of sales at one time came from research accelerators, now 80 percent of sales are from industrial products. The transition was apparently a painful one in that a number of scientists left, including the man who succeeded Van de Graaff as chief scientist. Many scientists who left have started small companies specializing in the same technologies as HVEC; their number is sufficiently large that one ex-employee commented "if you rounded up all the people who have left and put them under one roof, what an innovative company you would have!" Inevitably since 1970 the visibility of the science division in the corporation has decreased, and some nuclear scientists have worried that the changing emphasis of the company might have a backwash which could adversely affect their research.

However, Robinson, who is now chairman of the board of directors, states emphatically that "Phasing over into modern industrial products is going on as fast as we could possible push it, but we at no time, and I repeat at no time, wanted to give up or have made any moves to give up on physics." He points to several factors that would continue to make the science division viable even though there have been no U.S. orders for new accelerators for several years, and several foreign orders have gone to a competing company. Specifically he cites the income from sales of spare parts and voltage-upgrading kits for existing accelerators, the likelihood of future orders for new accelerators if the competition should falter, and the resolution of the management "to keep it [the science division] alive because we believe such a technology is going to open up into other fields that we can't see at the moment."



(Left to right.) Denis Robinson, John Trump, and Robert Van de Graaff standing in front of a "King" tandem accelerator.

The competition to which Robinson refers is a small company in Middleton, Wisconsin, named National Electrostatics. Recently National Electrostatics has secured orders for major tandem accelerators from the University of São Paulo, Brazil, and the Australian National University in Canberra. Referring to Ray Herb, the president of National Electrostatics, Robinson says, "He has a long history of achievement with Van de Graaff machines, and it is still to be proven whether he can repeat the things he's been fighting for so long at distant points. I don't want to be a false prophet, I'm just waiting to see. The physics community is willing to give him every possible chance to show what he can do. That's hard for us, but according to the best traditions of fair play."

Indeed, many nuclear physicists are waiting to see what will be the outcome when the latest National Electrostatics machine, designed to reach 14 million volts, is turned on. Perhaps some of them favor the new company—as Pascal Levesque, president of HVEC, suggests—because physicists are fascinated with new designs. However, HVEC, like most companies, has had its share of consumer complaints. One of them is poor service. Kenneth Chapman of Florida State University in Tallahassee says that he and his colleagues "have had more than our fair share of little annoyances with detailed designs." G. C. Milton of the Chalk River Nuclear Laboratory, Chalk River, Ontario, recently had many difficulties with an Emperor accelerator. He said that a service representative sent by HVEC "set us back 1 week at least," and commented in passing that "I never thought they knew how the machines worked, only how to build them." Several other laboratories have also had difficulties with Emperor accelerators recently. Brookhaven National Laboratory had to replace major components (glass tubes through which the beam passes) in a new Emperor less than 2 years old, and at the Laboratoire de Physique Nucleaire in Strasbourg, France, the acceptance of an Emperor accelerator has been delayed while HVEC replaces all such tubes (a complete set is valued at about $250,000). "High Voltage tried to go too far too fast with the Emperor," according to Cornelius Browne of the University of Notre Dame, South Bend, Indiana.

Whatever the consumer gripes might be, HVEC is proceeding to take the TU accelerator out of mothballs for tests next fall, and it is still to be determined which company will ultimately hold the title to the world's highest voltage Van de Graaff accelerator.

The affair of the TU accelerator appears to have been a turning point for HVEC. Robinson sees that affair as the result of a collision between a corporate policy that was extremely generous to nuclear science and a national policy that was less generous. To quantify that generosity, he points out that in 1968 HVEC reinvested profits in research to the extent of 12 percent of sales. "We took risks of construction and development on every large machine," says Robinson. "If you keep doing that on a bigger and bigger scale, you'll get caught. This is the one we were caught on, the TU. We still haven't sold one yet, but I don't regard that as being caught because it will undoubtedly be required and paid for."

Some members of the community of nuclear scientists, however, think that the real gamble was building a device that didn't have sufficient scientific backing. It is well known that HVEC built its first tandem accelerator only after forceful insistence by nuclear physicists, and many argue that the impetus for succeeding machines also originated with the potential buyers. According to this view, the TU was the first machine built before nuclear physicists seriously demanded it, and HVEC made the mistake of assuming that, be-

cause it was a higher voltage machine, physicists would buy it. There are still well-respected nuclear physicists who advise moving by small steps toward larger Van de Graaff accelerators.

Whatever the reasons for the policy of dogged pursuit of the last plans of Robert Van de Graaff, it reversed, at least temporarily, a history of large profits, and forced the company to dramatically readjust its traditional devotion to pure science. Although the TU accelerator was very much what the company was about and may indeed have been "a beautiful machine," as one ex-scientist from HVEC said, its dismal failure in the marketplace to date is apparently a lesson that no legacy of ideas for research and development stays alive for very long. Bigger and bigger accelerators are not necessarily hot sales items, and filial piety may be no substitute for market research.—WILLIAM D. METZ

Spain (II): An Understanding with the Americans

In 1953 Spain and the United States signed a treaty which gave the United States use of air and naval bases in Spain. For Spain, the most concrete return on the bargain was a program of American military assistance, but the treaty also served as a diplomatic icebreaker for Spain after more than a decade of isolation brought on by the association of the Franco regime with Fascist Germany and Italy dating from the Spanish Civil War. The bases treaty has been renewed periodically, and the 1970 version has been expanded to include a variety of nonmilitary provisions, most significantly a "chapter" on scientific and technical cooperation.

The new version is titled "Agreement of Friendship and Cooperation between the United States and Spain" and in its preamble affirms the spirit of the "Treaty and Friendship and General Relations" between the two countries signed in 1902. That treaty was intended to restore amity after the Spanish-American War of 1898 which deprived Spain of the last remnants of her once great empire in the Americas and the Pacific. The Spanish really have more cause to remember the *Maine* than Americans, and the memory of that episode has strongly influenced the attitude toward the United States of many Spaniards still living today. For the military and governing classes it was a patriotic resentment of defeat and humiliation. The legacy was different for the influential intellectuals of the "Generation of '98" for whom the war brought the ultimate demonstration of corruption and incompetence in their government. For this remarkable group of writers, artists, educators, and social reformers, the war seemed a final dispelling of the illusions of empire and an imperative to deal with the problems of Spain at home. As for the United States, however, the Spanish intellectuals not only were offended by American jingoism but also saw Yankee commercial and cultural penetration as a threat to Hispanic civilization in Spanish America. It is an attitude which continues to influence Spanish intellectuals.

The postwar treaty on military bases was entered into on both sides in a largely pragmatic spirit. On the American side, with the Korean conflict and the Cold War on, the strategic advantages of acquiring bases on the flank of Europe for bombers and later for nuclear submarines outweighed inhibitions about dealing with the Franco regime. At the time there was opposition to the treaty inside the United States, and among U.S. allies, but the military carried the argument. The American attitude, and the fact that no treaty of mutual aid in case of attack was offered, offended Spanish pride and made for tough bargaining.

Hard-pressed Spanish liberals saw the treaty as a cynical political act by the United States, and many are still convinced that the United States saved the Franco regime from its economic mistakes in the 1950's. The U.S.–Spanish relationship, therefore, is a complicated one. At the official level relations have been based rather openly on mutual advantage. At the same time, Americans as individuals continue to feel a fondness and fascination for Spain and the Spanish which has nothing to do with Spain's strategic location or with its reliability as an ally.

The latest agreement assumes a fuller formal relationship between Spain and the United States and at the same time reflects Spanish concern about its competitive position. On the basis of the usual indices, Spain is still a developing nation, at least by European standards. And Spain is now entering a period when it must make important decisions about closer association with the industrially more advanced countries of the European Common Market. If it is to narrow the gap technologically, Spain must give a much higher priority to domestic research and development (*Science*, 7 July). And the United States is for Spain a logical source of aid and comfort in the R & D sector.

Up to now, U.S. assistance has been limited. Spain did not qualify for the massive technical assistance or reconstruction financing provided under the Marshall Plan and its follow ons, although the bases treaty did open the way to large loans on favorable terms. Official American aid has been restricted largely to a modest two-way traffic of academics, professionals, and technical people under the Fulbright-Hays program and other exchange programs operated through the State Department. American firms with Spanish subsidiaries and other foreign and multinational corporations operating in Spain have helped to raise Spain's technological horizons, but these operations have brought qualified benefits.

A recent report, *American Investments in Spain*, underwritten by the American Chamber of Commerce in Spain and published early this year, throws some light on the extent of current U.S. investment in Spain and its effects on the Spanish economy. The report combines a study by the Stanford Research Institute on "multinational company–host country" interactions with a survey of the views of Spanish opinion leaders on American investment.

The report puts the total value of American direct investment at the end of 1969 at $611 million. The major