in addition to the college departments there would also be university departments made up of all faculty members in a particular subject in all the colleges. The chairmen of the university departments would be appointed by the chancellor after consultation with the dean of graduate studies, and these university departments would oversee graduate education.

As a further superstructure to harbor research, institutes would be created. These are envisioned as interdisciplinary efforts in particular fields of research. These institutes generally would be located within colleges having strength in pertinent fields, but some might also be separately administered by the university.

On paper, the San Diego formula looks like a crossing of the familiar American plan and the system evolved in Britain's senior universities. Whether aspects of the Oxbridge system, with its federation of independent, separately endowed colleges and its time-tried unwritten constitution can be transplanted successfully remains to be seen.

Reconciling the demands of the college, the university, and the statewide university system in one institution will not be easy. And the biggest strain on UCSD's a priori plan will come as enrollment and faculty size grow and pressure is applied from outside for the university to accept more students faster.

Critics of San Diego claim that the university has had advantages not enjoyed by other new general campuses of its generation—Santa Cruz on the San Francisco peninsula and Irvine near Los Angeles, for example. San Diego has been living through a grace period when investments are heavy in relation to educational output. But the time is coming when the university will have to justify itself to the bookkeepers, since equity and the rules demand that the cost per student be comparable on all U.C. campuses.

The multicollege approach, in other words, must prove competitive with the monolithic university. UCSD partisans argue that it can, since good planning will avoid a duplication of facilities.

In case of serious trouble there is an escape route for UCSD, since the colleges will be added successively and there would be opportunity in the early stages of expansion to modify or change the shape of the university.

The San Diego faculty, however, seem convinced that they are not living a Utopian dream. The San Diego plan, they argue, provides a practical way to achieve the principle of tying research and teaching closely together.

One faculty member summed up the high expectations for both students and faculty at UCSD when he said, "we plan to treat the undergraduates like graduate students and the graduate students like colleagues." Beginning next September the question of whether students and faculty are up to such standards of performance will be put to the test.

Things may in fact not work out exactly according to the grand design. But the idealism, self-confidence, and academic daring in evidence at San Diego should make the university in the coming years one of the most interesting experiments in American higher education.—JOHN WALSH

Nuclear Stockpile: Data Suggest That in Absence of Clear Policy Reserves Just Growed and Growed

The cutback in production of fissionable materials announced simultaneously 2 weeks ago by Premier Khrushchev and President Johnson is not, as both were at such pains to emphasize, "disarmament." In terms of capacity to wage war, the cutback is essentially an agreement to continue arming at a somewhat slower rate than formerly. In other terms, however, the event is more significant, for it marks the first time the U.S. and the U.S.S.R. have shown the requisite common sense and courage to free themselves from a nuclear equivalent of the doctrine of conspicuous consumption. The two countries apparently reached this stage independently: the Administration had planned to cut back production of nuclear materials anyway (an earlier cut was announced in January), and merely enhanced its reputation for peace-making, as well as for economy, by persuading Khrushchev, who has rather similar needs, that this was a good time for him to do the same.

The result is an excellent example of an emerging pattern of Soviet-American understanding, the more secure for being rooted in self-interest. There is no written agreement and no plan for verification of compliance. But at the same time there is no threat to national security, and no self-sacrifice. We would maintain the production cut even if the Russians did not, for as Johnson has made abundantly clear, the production capacity in question represents surplus capacity. Khrushchev has said a trifle vaguely that he is discontinuing the construction of two big plutonium-producing reactors, and substantially reducing the production of uranium-235. Johnson, totaling the cutbacks announced in January with those presented last week, has committed the U.S. to a 40-percent reduction in production of enriched uranium and a 20-percent cutback in production of plutonium. Using almost identical phrasing, the two leaders said that more fissionable material would be allocated to peaceful uses. (Great Britain, which ceased nearly all production of fissionable material about a year ago, supported Johnson's move; France, seeking an independent nuclear deterrent, appeared uninfluenced by it.)

More interesting than the question of what is being cut back, however, is the question of what it is being cut back from. The full story of how our nuclear stockpile began and how it grew is difficult to unravel, because most of the relevant facts are classified. But some information is available, some inferences can be drawn, and a rough picture of the development of the system can be assembled.

In 1947 when the Manhattan Project was handed over to the newly established civilian Atomic Energy Commission, the United States had two gaseous diffusion installations for producing enriched uranium at the Oak Ridge, Tennessee, site, and three reactors for producing plutonium at Hanford, Washington. From the late 1940's to the middle 1950's, congressional interest in things atomic intensified, and more facilities for producing nuclear materials were added at Oak Ridge and Hanford. In addition, gaseous diffusion plants were established at two new sites—Paducah, Kentucky, and Portsmouth, Ohio—and additional plutonium reactors were established at a site at Savannah River, South Carolina. The grand total, at the end of 19 years of cold war, is three gaseous diffusion plants (Oak Ridge, Paducah, and Portsmouth), with 12 processing buildings, and two plutonium reactor sites (Hanford and Savannah River), with 13 reactors currently in operation. During the same period, seven chemical separation plants were built, of which four (two at Hanford, two

at Savannah River) are now operating, and two heavy-water plants were built, one of which is currently in operation. The Savannah River plant also produces tritium; and other supporting activities go on at several sights. As the cutbacks take effect, between 1965 and 1968, four of the reactors (three at Hanford, one at Savannah River) and two of the gaseous diffusion plants (at Oak Ridge) will be shut down, and other gaseous diffusion plants will be operating at a reduced level. A new plutonium reactor is being readied at Hanford, but the AEC says that its operation will not neutralize the 20-percent cutback cited by Johnson.

How much the development of our nuclear enterprise has cost is hard to discover. Capital investment in equipment for producing nuclear material appears to total about $4.9 billion. For the period 1954–1963 certain other costs can be calculated: The AEC appears to have spent about $4.658 billion for procuring raw material, about $6.760 billion for turning it into fissionable material, and about $4.482 billion for developing and fabricating nuclear weapons. A reasonable round number for the cost of producing nuclear material since the end of the war was estimated by physicist Ralph Lapp at about $25 billion.

What's in and what's out of those numbers, though, and how much went strictly for weapons, is a little hard to say. Since the total amount of fissionable material produced is classified, the proportion devoted to civilian reactors, for example, cannot be separated out, and certain related costs cannot easily be added in. If the $25-billion figure seems low, it is mainly because only a relatively small cost of producing weapons—the cost of the nuclear warhead—is paid for by the AEC; the hardware costs are budgeted by the Department of Defense. In any event, the cutbacks, in large part because they are spread over a large number of installations, will result in savings in the entire program of only $110 million between now and 1968.

The number of people contributing to the AEC program is also tricky to measure. About 21,000 people are directly engaged in producing fissionable material. Of these, about 3000 will be affected by the cutback. Also a part of the system are the 26,000 or so employees of AEC contractors who actually produce the weapons (again, this is the warheads; other work is in the province of the Pentagon). And, in addition, there are the workers who help produce the huge amounts of electric power the AEC installations consume, and the people who perform the numerous other services—both near the sites and away from them—that keep the projects going.

The total accumulated output of this vast and costly chain of effort—not an ounce of which has been used in combat since Nagasaki—has been perhaps America's most tightly guarded secret. The secrecy has made it almost invulnerable to outside criticism, and few have tried to take it on. One exception is Lapp, who was among the first to notice and criticize the degree of "overkill" the U.S. was assembling.

Lapp, whose interest in atomic weapons dates from his work on the Manhattan Project, has worked out several ways of obtaining rough estimates of the size of the nuclear stockpile. One way, he pointed out in a recent speech at Brandeis University, is to work from available statistics on uranium procurement for the past decade. From 1954 to 1963 the AEC purchased 187,725 tons of natural uranium. "Assuming an input of 150,000 tons to the separation plants and an average yield of 7 lbs/ton, the ten year production totals 525 tons of weapons grade uranium," Lapp stated. He estimates the total stockpile (including that for the years 1947–1953) to be around 650 tons

The accuracy of this kind of reasoning is of course open to question, and, although he gives other calculations that corroborate his answer, Lapp himself regards it as a very rough estimate. Nonetheless, although his analysis has been called "fantastic" by Representative Chet Holifield (D–Calif.), who is a member of the Joint Committee on Atomic Energy and therefore has access to classified data denied Lapp, no better data have ever been made available. And, even granting considerable imprecision, it is hard to avoid the impression that Lapp is at least on the right track, both for the superficial reason that denunciations of him ring hollow and for the more serious reason that the cutback itself supports his thesis that the nuclear stockpile is "overadequate."

When stockpile tonnage is translated into explosive power, the meaning of the term *overadequacy* becomes clearer, for every pound of fissionable material contains the explosive equivalent of 8000 tons of TNT. A single ton contains enough material for more than 200 fission bombs and a vastly greater number of hydrogen bombs. Even when allowance is made for the diversity of military uses of nuclear materials—strategic weapons, tactical weapons, and antimissile systems—it is clear that the stockpile, together with continuing production, must be very generous. For once you have built weapons, the demand on the stockpile is relatively static, though the stockpile keeps growing. And, although the weapons themselves may get outmoded, the fissionable material does

Public Health Service Travel Policy

The Public Health Service has revised its policy with respect to travel to Canada on the part of grantee scientists. A similar National Science Foundation policy was noted in *Science*, 24 April. Effective 1 May, travel between the United States and Canada is considered domestic travel insofar as the use of grant funds is concerned. The revised definitions are as follows:

"Domestic travel is that which is performed within the grantee's own country. For the purpose of charges made to Public Health Service research grants made to institutions within the United States, domestic travel is defined as all travel performed within or between the continental United States, Alaska, Hawaii, Guam, American Samoa, Puerto Rico, the Virgin Islands, and the Canal Zone. Travel between the United States, including the areas indicated above, and Canada, is also considered as domestic travel for grants made to institutions within the United States or Canada. Other travel performed to, between, or within a country other than the grantee's own country is defined as foreign travel."

not, and can be transferred from one weapon to another as military styles change. Just how generous the resulting stockpile actually is can be calculated in numerous ways: one way is that adopted by President Johnson, who, without going into the intricacies of the overkill argument, announced on 21 January that "this country and the Soviet Union already have produced enough explosive force to equal 10 tons of TNT for every man, woman and child on the face of this earth." The stockpile, in any event, is big enough so that the President has ordered a substantial slowdown, convinced that U.S. security will not be even marginally affected.

How did we arrive at this state of nuclear superfluity? The secrecy which has surrounded the stockpile—in sharp contrast to the bravado with which the number of missiles, submarines, and other military hardware is regularly announced—has certainly played a role. Although one reason for the adoption of a policy of secrecy was the fact that, for a long period after World War II, America's atomic power was a good deal less than an awed world imagined it to be, the result of the secrecy was to insulate the entire weapons program from public scrutiny. Secrecy also strengthened the hand of members of the Joint Committee on Atomic Energy in developing influence over their uninitiated congressional colleagues, since it was impossible for outsiders to argue with the Joint Committee's definitions of necessity.

Role of Congress

The development of the bomb had been kept secret even from most members of Congress, and Joint Committee members were the first to get a semblance of atomic education. The superior knowledge acquired by the embryo committee during the postwar fight over military versus civilian control of atomic energy gave the committee a particularly authoritative and exclusive character which it has been careful to retain. Because its jurisdiction follows the atom, the committee has always pushed for atomic expansion. Lately, as possible uses for atomic power have increased, the Joint Committee has encouraged the application of nuclear power to a number of fields. In the early days, however, influenced by the war in Korea, by deep suspicion of the Communists, and by the conviction that nuclear power would both revolutionize warfare and make it more economical, the JCAE focused its attention on more warlike matters. Typical of the congressional exuberance which encouraged the first great expansion of nuclear capacity was a resolution introduced by former Representative Carl Durham (D–N.C.), an early chairman of the Joint Committee, in September 1951. After a lot of "whereases" enthusiastically detailing the flexibility and economy of nuclear power, the resolution concludes "that it is the sense of Congress that an allocation of 3 cents in each military dollar for our best and cheapest weapon is unreasonably and imprudently small; that the Army, Navy, and Air Force must each be rapidly equipped with atomic weapons in far greater number and variety, looking toward more security for the United States at lower annual defense budgets; and therefore be it further resolved, that the United States must go all out in atomic development and production."

Supplementing congressional enthusiasm for the new weapon as a cause of nuclear expansion was the military's habit of accepting anything that was proffered; underlying it was the intensity of the cold war, which encouraged the view that accumulation of destructiveness had in itself a deterrent effect. For, unbelievable as it seems, until last winter, when the Department of Defense completed its first long-range study of projected needs for nuclear materials—a study that established the feasibility of the current cuts—procurement was determined simply by the ability of the AEC to produce. Annually, the Pentagon would ask the AEC how much fissionable material it could produce, and it would formally request receipt of whatever amount the AEC was capable of supplying. Since the funds for the warheads came out of the AEC's budget, not out of the Pentagon's, fissionable material was not in competition with any other Pentagon requirement. Stated simply, there were no constraints whatever, and the stockpile went skyrocketing. Occasionally the Joint Committee suggested that someone take a look at this non-system, but until Kennedy took office and initiated the study which led to the cutback, neither the extravagance nor the provocativeness of the stockpiling attracted any serious attention. And, however compelling the arguments in favor of a cutback, it is a safe guess that without the blossoming Soviet-American détente the cutbacks would not have been made, for until very recently, the fear was strong on both sides that any letup in the pace of acquisition would be interpreted by the other as irresolution.

Even with the cutbacks, of course, the stockpile will continue to grow. Shutdowns always mean hardships—and political tribulation: that is another reason why these have come so belatedly. It appears from the way the cutbacks are distributed that the human consequences were kept firmly in mind, for more money could probably have been saved by shutting down some plants entirely. Even with the cutbacks, the United States will hardly be running on a nuclear shoestring. On the contrary, the main object appears to be only to replace the practice of irrational hoarding with a more calculated system of accumulation. Dipping into the nuclear capital itself, or relying solely on it, appears still to be unthinkable.—ELINOR LANGER

Announcements

Jefferson Medical College and Drexel Institute of Technology, Philadelphia, Pa., have announced a cooperative program leading to the Ph.D. degree in **biomedical engineering**. The program, scheduled to begin with the fall semester, is designed for persons who intend to specialize in teaching and research. Participants may enroll in either college and will take courses in the life sciences at Jefferson, in physical and engineering sciences at Drexel. Additional information is available from LeRoy Brothers, Dean of the College of Engineering at Drexel, or William Sodeman, vice president for medical affairs at Jefferson.

The Office of Naval Research and The Institute of Management Sciences invites manuscripts on "**capital budgeting of interrelated projects.**" The author may be a student, or have received his last academic degree within the past 7 years. Papers must provide reports of research that "yields either increased knowledge or improved ability to deal with important classes of problems" in the area, and preference will be given manuscripts in which the research stresses mathematics, statis-

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