Nuclear Safety (I): The Roots of Dissent

It is somewhat confusing that concern over nuclear plant safety has increased recently. Some explanation is undoubtedly to be found in sensationalist publications . . . but the most important reason appears to be the widespread lack of knowledge of both the excellent safety record of the nuclear power industry and the extreme efforts, unprecedented in any other industry, to assure that nuclear plants are designed, constructed, and operated with the highest attention to public and employee safety.—The U.S. Atomic Energy Commission, in a statement to the congressional Joint Committee on Atomic Energy, February 1972

This is being advertised as a no-risk business and that's not true. We don't know that reactors are unsafe, but we're concerned about their being as safe as the manufacturers would like you to believe. Maybe it's time the AEC told the public that if people want to turn the lights on they are going to have to expect to lose a reactor now and then, and possibly suffer great dislocations and property losses as well.—A senior reactor safety engineer, National Reactor Testing Station, Idaho Falls, Idaho

The great public debate over radiation standards that flared up 3 years ago has peacefully declined in recent months, probably because the Atomic Energy Commission (AEC) decided to impose strict new limits on the nuclear power plant emissions that sparked the controversy in the first place. But even as that furor was dying down, a new one was swiftly rising in its place —this time over the ability of reactor safety systems to guard against a disastrous accident, should a nuclear plant suddenly lose its cooling water. Expressions of puzzlement from the AEC notwithstanding, the indications are that this new debate over reactor safety comes as less of a surprise than the commission's remarks to Congress would suggest.

To be sure, the AEC has spent tens of millions of dollars in the past 25 years to ensure the safety of nuclear power plants. And it is probably true, as the AEC claims, that the fears of an ill-informed public and the eagerness of "sensationalist" publications have helped to magnify and distort the risks inherent in nuclear plants.

Nevertheless, the new issues of nuclear safety are real. What is more, they appear to be a direct outgrowth of serious internal troubles that have been building up for several years within the AEC's $53 million reactor safety research program.

The new safety debate has centered mainly on the adequacy of backup cooling systems in nuclear plants; the technical substance of this issue has been discussed in previous articles (see *Science*, 5 May). This current article, and others to follow, trace the roots of the issue to problems in the management of the nuclear safety program, and to an intense discord that has developed between the AEC and its national laboratories. This first installment outlines the major grievances of safety researchers and the turbulent history of their program. A second article will discuss long delays in key research projects, and a third will take up the safety program's relations with the AEC's entirely separate regulatory arm.

The internal problems of the nuclear safety program are complex, but there are two main ones. First, at a time when more and more of the nation's utilities are building increasingly powerful nuclear plants, the safety program has accumulated an enormous backlog of unfinished research and unanswered questions. Construction of large experimental facilities the commission itself has repeatedly described as urgently needed has fallen years behind schedule. One nuclear test facility at the AEC's National Reactor Testing Station in Idaho that was supposed to have been finished in the middle 1960's is still being built, and it shows little promise of producing useful data before the middle 1970's. By then, as many as 80 nuclear power plants that were to have benefited from these data will be near completion or in operation.

There are, in addition, dozens of "problem areas" in the safety of conventional water-cooled reactors that remain unresolved. Many of these problems are described in a 1970 AEC publication entitled "Water Reactor Safety Program Plan." The plan outlines 139 unsettled safety questions, and designates 44 of them (in the document's emphasis) as "*very urgent, key* problem areas, the solution of which would *clearly* have *great impact*, either directly or indirectly, on a major critical aspect of reactor safety."

The second major problem concerns the attitudes that safety researchers themselves, working in the national laboratories, hold toward all this unfinished business; a series of interviews during the past 2 months reveals that many of them are genuinely worried about it.

In Washington, the official position is that completion of this work certainly would be desirable, but that, in the meantime, nuclear plants are being designed with sufficient "conservatism" to make up for any uncertainties in their performance. In the national laboratories, however, a number of safety researchers are far less confident. "We are not trying to be accident-mongers," one project manager says. "But we don't think our tools are adequate for proving this assertion."

As the new debate has grown during the past 2 years, first internally, then out in public view, scientists and engineers in the safety program have come to believe that their work is linked to a vital national issue. At the same time, those interviewed say they have also become convinced that the AEC, in its eagerness to develop a thriving nuclear industry—and to get on with building the breeder reactors it has dreamed about for 20 years—has deliberately bypassed tough safety questions still hanging over ordinary, water-cooled reactors.

These beliefs are thoroughly entangled with widespread feelings of discontent over important changes that have occurred in relations between the AEC in Washington and its national laboratories. During the past several years, much of the old autonomy the laboratories had enjoyed for two decades has been supplanted by a forceful new style of management

from Washington. And along with the new management has come a new emphasis on applied research and engineering tasks that seem inappropriate, if not distasteful, to many. Researchers and administrators in the laboratories do seem to recognize that, to some extent, these changes are an inevitable result of advances in nuclear technology. But they are nonetheless unhappy with what they consider to be a practice of "overmanagement" by Washington that allows little opportunity to appeal and debate decisions as to which research is important and which is not. The end result of all these feelings has been a deep, and for some, a rather bitter estrangement from AEC headquarters that has done nothing to speed the laggard pace of safety research.

To put things in an organizational context, it should be noted that all of the $53 million the AEC plans to spend on safety research this year will flow through the agency's main "promotional" branch, the Division of Reactor Development and Technology (RDT). This division holds jurisdiction over all civilian reactor R & D—including safety research and the commission's most prominent undertaking, the multibillion dollar breeder program. (Whereas this arrangement may make good sense from an administrative point of view, many of the AEC's critics—both inside and out—regard it as a built-in conflict of interest, in the sense that a single unit of the agency is responsible both for encouraging the growth of an industry and for supporting research with a high potential for raising embarrassing questions about the industry's safety. Thus, one of the key questions to be answered is whether the RDT has been able to discharge both duties with equal enthusiasm. Its critics contend that it has not.)

This year, roughly half the $53 million earmarked for safety will go into water reactor studies—the focus of concern—and half into breeder safety. Of the water-reactor money, about $6 million is destined for Oak Ridge National Laboratory to pay for a miscellaneous assortment of eight to ten projects involving 75 scientists and engineers. Some of this also goes for research contracted by Oak Ridge to a small number of universities and private firms.

The remaining $20 million for water reactor safety is destined for the National Reactor Testing Station (NRTS), where the AEC's "operating contractor," the Aerojet Nuclear Corporation, does most of the nation's water reactor safety research. About 120 scientists and engineers at Idaho draw their salaries from this money. Technically, all are employees not of the government but of ANC, a subsidiary of the Aerojet-General Corporation that exists solely for the purpose of running the Idaho installation.

Thus, in criticizing AEC policies, the dissident scientists and engineers at Oak Ridge and Aerojet place themselves in the difficult position of biting the only hand that feeds them—namely, the RDT, and more precisely, the division's controversial director, Milton Shaw.

A former aide to Vice Admiral Hyman G. Rickover, Shaw supervised the design and development of the nuclear propulsion plants aboard the aircraft carrier *Enterprise* and the cruiser *Long Beach* before taking up his present job in December 1964. Over the years—and in spite of criticism from the laboratories—he has acquired a reputation in Washington as a strong and competent administrator. A man of engaging bluntness, Shaw readily concedes that dissension exists in his safety program, though he says the reasons are not entirely clear to him.

"Unquestionably, people are unhappy, and morale at Idaho is poor," he said in a recent interview, "but sometimes it's hard to know why." Shaw suggested that some of the enmity may be a natural backlash to several traumatic but necessary management shakeups at Idaho over the past few years. He also spoke of an "unwillingness" in the laboratories to adapt to changes imposed by an advancing technology. Beyond this, he said, the closeness of researchers to their work may make the possibility of nuclear accidents "seem more real than it is" and thus may inflate the urgency of safety research in their eyes. There are, moreover, strong feelings among Shaw's staff that the laboratories simply are "hungry for contracts" and are willing to exaggerate safety problems to get them—an accusation the researchers angrily deny.

What, specifically, are the laboratories' grievances? During interviews, research administrators at Oak Ridge and Idaho expressed a variety of allegations, which will be examined in

Briefing

Review Stalls Cancer Plan

The National Cancer Plan, which will detail the strategy of the national effort that is supposed to speed us efficiently on our way to new triumphs in the fight against cancer, has run amok of the Washington bureaucracy. So the National Cancer Institute (NCI), which invested close to $1 million and the labor of more than 250 U.S. scientists in drawing up the plan, originally, if tentatively, scheduled for release by the end of last June, must now hold back until its work has been reviewed by the Office of Management and Budget (OMB), the Office of Science and Technology (OST), and the Institute of Medicine, part of the National Academy of Sciences (NAS). So much for efficiently cutting through red tape.

As things stand now, the cancer plan, which has yet to be completed in its final form, will be kept under wraps until the reviews have been completed—after the presidential election. Then, it is expected that in November or December the White House will unveil the plan as an executive document. Like the National Cancer Act which became law last year, it might be another "Christmas present to the nation."

In the original scheme, the cancer plan required the approval of the Cancer Advisory Board and the elite, three-man Cancer Advisory Panel, headed by banker Benno C. Schmidt. Then the OMB got into the act because the plan makes 5-year dollar projections that it felt it had to approve. The OST then decided it would be a good idea to have a look, too. The only premier scientific body left out, by this time, was the NAS which, like the OST, is going to review the science in the plan. (The idea of asking for an academy review apparently came from within the Nixon Administration, not from the NAS or NCI.) NAS president Philip Handler discussed the academy's participation last month at Woods Hole during dinner with NCI director Frank J. Rauscher, Jr., and Robert Q. Marston, director of the National Institutes of Health. Handler asked the Institute of Medicine to take on the review.—B.J.C.

more detail later. Among these were charges that:

► Between 1968 and 1971 the RDT bootlegged money from water reactor safety to accelerate the breeder, and in the process killed or cut back a number of key research projects that had just begun to raise questions about nuclear plants coming up for licensing.

► Shaw had shown considerable indifference toward urgent needs of the regulatory branch for technical help during this period, and for several years forbade direct contact between safety researchers and the AEC's regulatory staff.

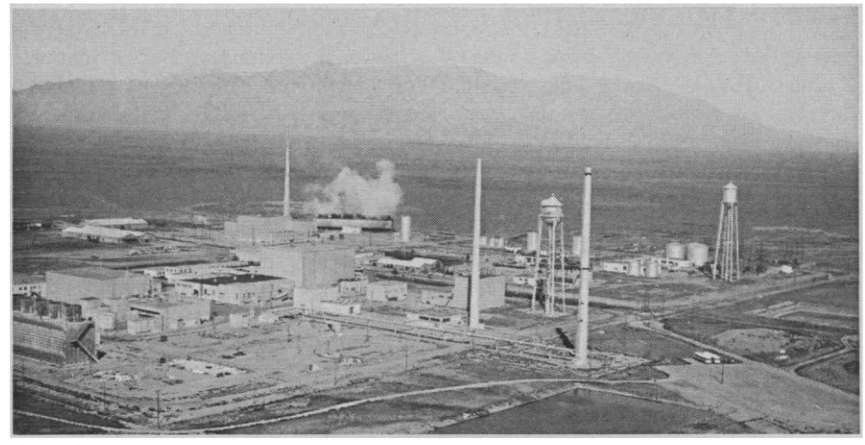
► Shaw allowed reactor manufacturers to pass judgment on new research proposals from the laboratory, and tended to skirt questions the industry insisted it had solved, even though safety researchers disagreed. Some of those interviewed said they considered this an effort to curry the industry's financial support for the breeder.

► Shaw had used contractors at Idaho as a scapegoat for long construction delays on major test facilities for which he himself was largely responsible.

Besides all this, there is a profound dissatisfaction with Shaw's tight control over RDT programs in the laboratories. His style of administration is often described in the laboratories as "vindictive" and "autocratic" and one that is not above "forcing out" competent research managers who persist in their dissent from official thinking. An Oak Ridge administrator in the middle of the feud with Washington summarizes this view:

> It's no secret that there has been a trend away from science and toward more engineering work in the laboratories for a good number of years, and this is understandable, given the state of the technology. I don't regard it with disfavor, although we would like to do more science. . . . My big complaint about Shaw's setup is that too often it runs on the assumption that the chief is always right, rather than in a manner consistent with the public welfare where open debate takes place. In my view, the wrong people are in charge of water-reactor safety.

In talking about their grievances, critics both at Oak Ridge and Idaho uniformly insisted on anonymity. They contended that use of their names in connection with criticism of AEC policies or officials would, in all probability, cost them their jobs. As evidence, several named colleagues who had once held high-level positions in the safety program and had been shuffled to "nothing jobs," they said, after clashing with Shaw. "His is a vindictive administration," said one man who supervises a large-scale project at Oak Ridge, "and people are frightened."



One of several reactor and laboratory complexes at the AEC's National Reactor Testing Station near Idaho Falls. Aerial view is northwest toward Lost River Mountains.

At the Idaho facility the level of anxiety seemed even higher, and not without reason. In an interview, Charles Leeper, a physicist who became president of Aerojet Nuclear last year, emphasized that it was essential that the company maintain good relations with its "customer"—in this case, the RDT and its director. "I'm accustomed to dealing with the Air Force," Leeper said, "and I've watched program managers go down the chute right and left because they had trouble with the customer."

Prior to this reporter's arrival at Idaho Falls, where the NRTS maintains its administrative offices, Leeper said he reminded his senior staff of a standing rule that only he would express the company viewpoint. Others, he said, were free to voice personal or professional opinions, but only under this proviso: that if any employee's comments "sour his relationship with the customer, we cannot guarantee that after some time has elapsed that he will still be in his same position. We would, however, make every effort to find him a suitable opening in this organization, or elsewhere in Aerojet, or allow him to look beyond the company."

For some Aerojet staff, discretion thus ruled out talking in company offices. They did, however, consent to make arrangements for evening meetings at a designated spot on a back street in Idaho Falls, followed by a drive to private homes some miles away.

That men nationally recognized in their profession should feel impelled to such maneuvers suggests how far relations between the commission and the Idaho installation have deteriorated. For a fair perspective on the long trail of events that led to this situation it is worthwhile to trace the early history of the NRTS, its mission and self-image, and the ways in which both were sharply transmuted in the mid-1960's.

The Idaho facility had a fitful beginning in the late 1940's as the newly formed Atomic Energy Commission began roughing out its ambitious peacetime plans for military and civilian reactors. The commission had chosen the freshly organized Argonne National Laboratory near Chicago to lead its reactor R & D programs, and it came close to going a step further and picking Argonne as the place to build a series of large experimental reactors—among them the first breeder, the first prototype propulsion plant for nuclear submarines, and the AEC's powerful Materials Testing Reactor.

The AEC changed its mind on this point largely at the behest of physicist Edward Teller, who argued that the "calculated risks" taken by the Manhattan Project during the stress of war could no longer be justified, least of all in the suburbs of what was then the nation's second most populous urban area. Adherents of the Argonne site—among them Enrico Fermi, Robert Oppenheimer, and Glenn Seaborg—complained that Teller and the safety advisory group he headed for the AEC had exaggerated the dangers of a nuclear accident, but Teller prevailed. In 1947, the commission began a search across the West for a place to establish a remote proving ground.

The site that the commission finally

selected, an old Navy gunnery range 30 miles west of Idaho Falls, could scarcely have been more remote. Even today, as in the 1940's, the overwhelming impression a visitor receives of the NRTS is one of vast emptiness. Nearly the size of Rhode Island, the site sprawls across 893 square miles of sand and sagebrush and the black, contorted lava flows of the Snake River plain. Snowy peaks of three mountain ranges—the Bitterroot, Lemhi, and Lost River mountains—embrace the site on its western boundary. To the east, more than 100 miles across the flat desert (and well beyond the site's perimeter) three sharp spires of the Tetons are visible on the clearest days. Within the proving ground, clusters of reactors and laboratories are scattered miles apart.

Boom Times in The 50's

During the 1950's and early 1960's, the testing station grew rapidly—in fact, well beyond the commission's initial expectations—as Congress, at the urging of the Joint Committee on Atomic Energy, pumped more than $2 billion into military reactors and the AEC's burgeoning efforts to promote civilian power reactors. In 1949 the AEC thought it eventually might build as many as 10 reactors in Idaho; by the mid-1960's, 40 dotted the landscape and 9 more were completed or under construction by last year. The total investment in hardware at the NRTS has since passed $500 million and the work force, though down from a peak of 5500, remains nearly 4000.

Despite its great cost and historic importance to nuclear technology though, the NRTS somehow always remained the ugly duckling in the commission's collection of research establishments, never quite achieving recognition as a full-fledged national laboratory. For one thing, institutional arrangements lent an overall incoherence to the installation that made it seem to outsiders as more of a melange of independent activities than a unified laboratory. It was thought of mainly as the place where separate groups—the Navy, Argonne, Westinghouse, General Electric, and others—went to build experimental reactors in secure isolation not only from the public, but, as things worked out, from each other as well. Above all, Charles Leeper says, NRTS is still chiefly a proving ground. "One problem," he says, "is that some people would like it to be a national laboratory, but it is not."

Even so, a collective sense of identity as an important and distinctive research institution did manage to take root over the years. It flourished, interestingly enough, within the nuclear division of the Phillips Petroleum Company, which the AEC hired in 1950 as the site's operating contractor. During the next 15 years, the Phillips contingent provided a full range of "housekeeping" services for the site, and it operated (and helped to design) a dozen test reactors for the commission. Along the way, Phillips acquired several hundred scientists and engineers, many of them reactor physicists and materials scientists who made important contributions to the scientific base for advanced designs of reactors.

Within Phillips the first semblance of a coherent safety research program appeared in the 1950's. It grew quickly, in step with the general pace of reactor R & D. As the program expanded it acquired a certain cohesiveness and esprit, nurtured partly by the exotic nature of its work—the abnormal behavior of nuclear plants—and partly by a large measure of freedom the commission granted it in choosing which problems demanded first and closest attention.

Reminiscing about happier times, one manager at Idaho described the mission of the safety program and its liberal relationship with the AEC this way:

> The commission put us out here 15 years ago to learn about abnormal reactor behavior and to think about what would happen if one of these machines went out of control. . . . You have to understand that an operating, pressurized water reactor contains an immense amount of stored energy—the equivalent of 50,000 pounds of TNT in the mechanical energy of the circulating hot water alone, and 50 to 100 times that in thermal energy. The whole problem comes down to containing *this* energy to squeeze a little more out of the nuclear fuel, and to *controlling* this energy in the event of an accident.
>
> This is such an extremely complicated area that, historically, Washington was content to let us tell them what their designs didn't cover, and to make research proposals. In effect, they let us tell them what we should be doing in reactor safety.

This prolonged honeymoon began a swift decline in 1965, shortly after Shaw took command of civilian reactor programs. By last year, the relationship had fully reversed itself: Now the NRTS, and the safety program in particular, function on a short, tight leash from Washington. Research proposals are subjected to painstaking scrutiny by teams of engineers under Shaw; money available and the tasks assigned to Idaho vary from month to month under strict control from headquarters.

"Isn't this reasonable?" Leeper says rhetorically. "The highly creative days and the permissive times are behind us, and the demands now are for a hard bitten reduction to economical practices."

The researchers themselves agree that times are hard all right, but not quite in the same sense. During one conversation three senior scientists and engineers complained that the budget now fluctuates wildly, that Washington often assigns new tasks without allocating more money, and that the emphasis in research programs continually varies—all with little explanation from Washington. Said one project manager:

> The budget has become a year-long confusion, a continuing battle. It gets rewritten four or five times a year; the year before last it was reprogrammed no less than 12 times. We are constantly having to accelerate some projects, decelerate others, and shift people from one thing to another. All of this gives the safety program a great instability and generally slows our progress.

Another critic at Idaho added this commentary:

> It has been impressed upon us that we are a captive contractor, and this is one of our main complaints. It means that we're not allowed to pick up contracts from elsewhere—from the AEC or the industry—in times of slack budgets. We're forever having to hire professional people, lay them off, hire them back. . . . Under manpower ceilings set in Washington, we sometimes have more money to spend than people to spend it on. After awhile, guys get tired of being shuffled from one job to another, or of pumping gas and selling real estate in town, waiting to be rehired, and they leave. It's pretty hard to keep research teams together under these conditions. . . .

Shaw says that when he took over in 1964, reactor R & D programs in all the national laboratories were in a "deplorable" state. Research on water-cooled reactors, he says, was poorly coordinated among the laboratories, frequently redundant, and heavily entwined with basic research ventures to an extent that it was no longer appropriate for a technology presumably on the brink of commercial status.

As he saw it, there were two main tasks at hand: To wean the industry

from government support of water reactors, and to marshall his forces for a concerted thrust on the commission's prime objective—an economical breeder. By all accounts, he took on both these tasks with immense energy and with a lesson learned from Admiral Rickover—namely, that a tough, centralized management stressing a "disciplined engineering approach" both to research and to construction of new reactors may not win friends, but it gets results.

The results so far are mixed, but certainly few friends have been won. Within months after taking office in December 1964, Shaw began a series of drastic reorganizations at Idaho that finally brought the demise of the Phillips organization last year, the rise of Aerojet in its place, and a continuing series of purges of old Phillips people from the new Aerojet structure.

Simultaneously, amid this turmoil, Shaw began imposing a rigorous and unfamiliar regimen of quality control standards and procedures on research projects in all the AEC's laboratories, Idaho included. It was all part of the new era of engineering discipline, and it was necessary, Shaw says, in order to rectify slipshod practices in the conduct of research. But to workers in the laboratories, the new regulations and the paperwork that came with them placed a staggering and, they felt, inappropriate and unnecessary burden on their work with little benefit in return.

"Engineering is the name of the game," says Shaw, an engineer.

"When he came in, science died," says a physicist at Idaho.

Thus, by 1967, the present conflicts had been kindled, and the forces were set in motion that would bring safety research of the highest priority to a virtual standstill.—ROBERT GILLETTE

Herbicides: DOD Study of Viet Use Damns with Faint Praise

An in-house, for-official-use-only study prepared in the Department of Defense (DOD) has concluded that herbicides were of only limited usefulness in the Vietnam war and, in effect, damns them with faint praise.

The report is the first major review of the military effectiveness of herbicides and was intended to complement the ongoing National Academy of Sciences (NAS) study of the ecological and physiological effects of herbicides. The study's conclusions are so far from a glowing endorsement, that they could signal an important weakening in DOD support for herbicides and possibly even a change in the Administration's exemption of herbicides from international arms limitations treaties. The treaty which would affect herbicides, the 1925 Geneva Protocol, is currently stymied in the Senate, thanks to President Nixon's "interpretations" that riot control agents and herbicides are not included under the agreement. The United Nations, by a vote of 80 to 3, has voted the contrary.

The three-volume study, titled *Herbicides and Military Operations,* was conducted between May 1971 and January 1972. The group that performed the work was the Army Corps of Engineers Strategic Studies Group (ESSG), a type of in-house think tank that, according to a variety of officials, has a high reputation for objectivity in the sometimes-warring factions of the Pentagon.

The first two volumes, obtained by *Science*, carry a survey of the experience of several hundred military officers who had direct knowledge of or participation in the herbicide program in Vietnam. The third volume, which is classified, contains some data on specific missions and computer wargames of herbicide use in future conflicts, such as in Western Europe. It was the focus of an article 2 weeks ago in the Washington *Post*, having been obtained by Daniel S. Greenberg, publisher of the *Science & Government Report* newsletter.

The ESSG study was conducted as part of an overall review of the implications of herbicide use which Secretary of Defense Melvin R. Laird was requested to make by Congress in October 1970. According to nondefense sources, the purpose of commissioning it was to present the strongest possible case in favor of herbicides; but instead, the field data from Vietnam simply did not support a ringing endorsement.

The ESSG study concludes rather weakly by comparison with the enthusiasm typical of military reports: "Herbicides can be useful as a specialized support to military operations as long as several specific circumstances exist." And, later, "significant net changes occurred after spraying. But the evidence is not sufficient to attribute the net changes to direct or indirect effects of herbicides delivered from fixed wing aircraft. . . ." Still later, "Herbicides were useful in supporting military operations in RVN in selected instances." Comparing the Vietnam experience with potential future conventional wars, it summarizes: "Herbicides are a significant aid to military operations in counterinsurgency and of less value in terms of force requirements in conventional (linear) warfare."

There are three critical points in the first two volumes of the ESSG's study, at which the effectiveness of the defoliation experience in Southeast Asia appears very questionable. The most obvious of these are the responses to a question asked at the end of each questionnaire about future need for herbicides. The results are shown in Table 1.

Even though the question was phrased as broadly as possible, that is, not specifying what "future conflicts" or "needs" might arise, the officers answered with an extraordinarily large number of "no" and "perhaps" replies. A number of those familiar with military reporting, including Congressman Les Aspin (D–Wis.) who is himself a former DOD analyst, see the "perhaps" and "no"