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TO PROMOTE NEGOTIATIONS FOR A COMPREHENSIVE TEST BAN TREATY

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HEARING

BEFORE THE

SUBCOMMITTEE ON ARMS CONTROL, INTERNA-
TIONAL LAW AND ORGANIZATION

OF THE

COMMITTEE ON FOREIGN RELATIONS

UNITED STATES SENATE

NINETY-THIRD CONGRESS

FIRST SESSION

ON

S. Res. 67

CALLING ON THE PRESIDENT TO PROMOTE NEGOTIATIONS
FOR A COMPREHENSIVE TEST BAN TREATY

MAY 1, 1973



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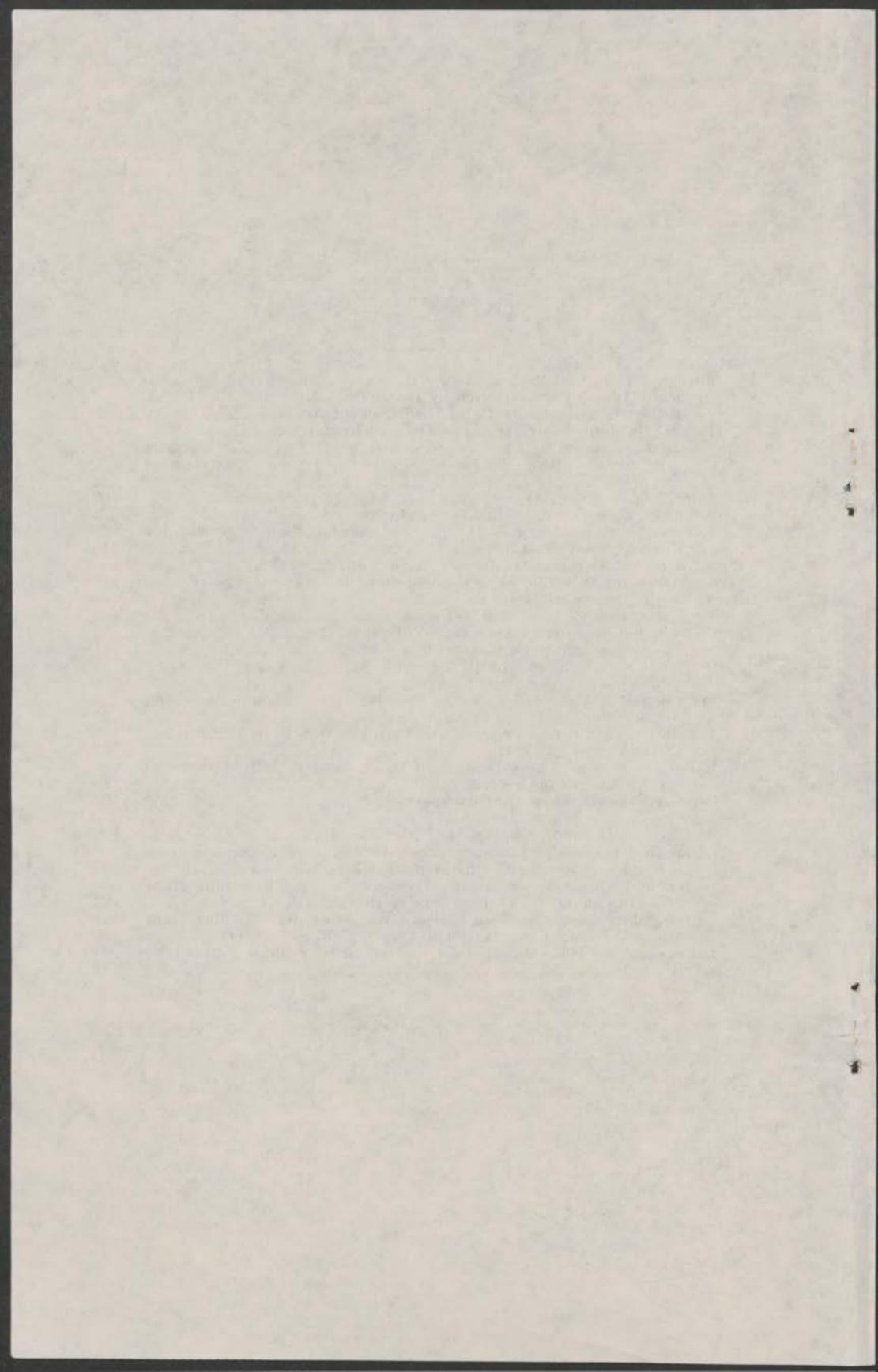
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TO PROMOTE NEGOTIATIONS FOR A COMPREHENSIVE TEST BAN TREATY

TUESDAY, MAY 1, 1973

UNITED STATES SENATE,
SUBCOMMITTEE ON ARMS CONTROL,
INTERNATIONAL LAW AND ORGANIZATION
OF THE COMMITTEE ON FOREIGN RELATIONS,
Washington, D.C.

The subcommittee met, pursuant to notice, at 10 a.m., in room 4221, New Senate Office Building, Senator Edmund S. Muskie (chairman of the subcommittee) presiding.

Present: Senators Muskie (presiding), Humphrey, and Case.

OPENING STATEMENT

Senator MUSKIE. Today, the Subcommittee on Arms Control, International Law and Organization is holding hearings on Senate Resolution 67, a bill that calls on the President to promote negotiations for a comprehensive test ban treaty. Specifically, the resolution proposes that it be the sense of the Senate that the President, one, should propose an immediate suspension on underground nuclear testing to remain in effect so long as the Soviet Union abstains, and two, should set forth promptly a new proposal to the Soviet Government and other nations for a permanent treaty banning all nuclear tests. Today's hearings are a continuation of the hearings on the prospects for a comprehensive test ban treaty held by this subcommittee in July 1971 and May 1972.

[Text of Senate Resolution 67 and coordinated executive branch comments follow:]

[S. Res. 67, 93d Cong., 1st sess.]

RESOLUTION Calling on the President to promote negotiations for a comprehensive test ban treaty

Whereas the United States is committed in the Partial Test Ban Treaty of 1963 and the Nonproliferation of Nuclear Weapons Treaty of 1968 to negotiate a comprehensive test ban treaty;

Whereas the conclusion of a comprehensive test ban treaty will reinforce the Nonproliferation of Nuclear Weapons Treaty, and will fulfill our pledge in the Partial Test Ban Treaty;

Whereas there has been significant progress in the detection and identification of underground nuclear tests by seismological and other means; and

Whereas the SALT accords of 1972 have placed quantitative limitations on offensive and defensive strategic weapons and have established important precedents for arms control verification procedures; and

Whereas early achievement of total nuclear test cessation would have many beneficial consequences; creating a more favorable international arms control

climate; imposing further finite limits on the nuclear arms race; releasing resources for domestic needs; protecting our environment from growing testing dangers; making more stable existing arms limitations agreements; and complementing the ongoing strategic arms limitation talks; Now, therefore, be it

Resolved, That it is the sense of the Senate that the President of the United States (1) should propose an immediate suspension on underground nuclear testing to remain in effect so long as the Soviet Union abstains from underground testing, and (2) should set forth promptly a new proposal to the Government of the Union of Soviet Socialist Republics and other nations for a permanent treaty to ban all nuclear tests.

DEPARTMENT OF STATE,
Washington, D.C., April 30, 1973.

HON. J. W. FULBRIGHT,
Chairman, Committee on Foreign Relations,
U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: The Secretary has asked me to reply to your letter of February 22, 1973, requesting coordinating Executive Branch comments on S. Res. 67, concerning underground nuclear weapons testing and negotiations for a comprehensive test ban treaty.

As you know, this Administration, like its three predecessors, favors the conclusion of a comprehensive test ban. In his initial message to the Conference of the Eighteen-Nation Committee on Disarmament, now known as the Conference of the Committee on Disarmament (CCD), in Geneva on March 18, 1969, the President said, "The United States supports the conclusion of a comprehensive test ban adequately verified." Ambassador Martin of the United States, in his opening address to the CCD on February 20 of this year, reaffirmed United States support for an adequately verified comprehensive test ban, and stressed that "We continue to believe that only adequate verification provides the necessary confidence to sustain an arms control agreement of the importance of a comprehensive test ban." As this statement implies, we believe that the best way to make progress toward a test ban is through resolution of the verification problem. A mutual moratorium would lack many of the safeguards of a formal international agreement, and therefore, we do not believe it would be a prudent step at the present time.

Mindful that serious issues remain regarding verification of a comprehensive test ban treaty, the United States has been making determined efforts to resolve the verification problem. Last summer at the CCD, the U.S. tabled a working paper which reviewed progress and problems in seismic verification. Research on these problems is continuing. Progress is being made in developing techniques to improve identification of low magnitude seismic events, "anomalous" events, and "mixed" events, in clarifying the possible utility of unmanned seismic observatories, and in improving understanding of methods of clandestine testing that might be used to evade a comprehensive test ban. As a part of the research effort, improved seismic instrumentation and data transmission systems are to be made operational in the near future.

Despite this progress, not all of the difficulties with respect to effective verification of a comprehensive test ban have been resolved. We are continuing to devote substantial resources to achieving resolution of the difficulties that remain.

The Office of Management and Budget advises that from the standpoint of the Administration's program, there is no objection to the submission of this report.

Sincerely,

MARSHALL WRIGHT,
Acting Assistant Secretary for Congressional Relations.

INTENTION OF S. RES. 67

Senator MUSKIE. The intention of S. Res. 67 is moderate. It does not obligate the United States to cease testing all nuclear weapons. It does not even specify the terms under which the United States would take the initiative to move toward a cessation of nuclear testing. It does ask the Executive to accept the reality that a comprehensive test ban should

be actively pursued and it puts the Senate on record as favoring new initiatives at the highest governmental level aimed at concluding a treaty prohibiting all nuclear testing.

STATEMENTS FAVORING CESSATION OF NUCLEAR TESTING

Since the early 1960's we have heard many public statements by U.S. officials in favor of a cessation of all nuclear weapons test explosions. By signing the 1963 Limited Test Ban Treaty and the 1968 Non-Proliferation Treaty [NPT] our Government has committed itself to work toward a comprehensive test ban. Most recently, Henry Kissinger, President Nixon's Assistant for National Security Affairs, said in Moscow last May when asked about the possibility of America's actively pursuing the conclusion of a comprehensive test ban treaty: "We have been, in principle, prepared to do this. The obstacle has been the debate about inspection, and we are willing to restudy the issue."

The 1971 and 1972 hearings of this subcommittee produced much testimony—from both administration and private witnesses—about new advances in verification techniques and in favor of a cessation of all nuclear testing. Unfortunately, there has been no positive legislative action as yet on this matter. This year, I am hopeful that S. Res. 67 will be acted on favorably by the Senate.

CHANGE IN WORLD'S STRATEGIC SITUATION

Since last year's hearing, the world's strategic situation has changed substantially as a result of the conclusion of the SALT I accords, limiting the development of anti-ballistic missiles and strategic offensive weapons. Most of us are agreed that these accords were a good beginning, but only a beginning, of attempts to bring the dangerous and costly arms race under control. The strategic accords concluded thus far have revolved around the quantities of nuclear weapons possessed by the United States and the Soviet Union. Clearly, we must now move in the direction of qualitative controls. And a comprehensive test ban treaty is a critically important step in that direction.

REASONS TO ACT NOW

The reasons to act now are compelling. Because of the ARM Treaty, there is no longer a need for more advanced strategic defensive weapons. Improvements can be made in non-nuclear technology as national security needs dictate. And there is no prospect now of a dramatic breakthrough in nuclear technology that would give either this country or the Soviet Union a dramatic and decisive advantage over the other.

At the same time, the necessity of concluding a comprehensive test ban treaty in order to prevent the spread of nuclear weapons to non-nuclear nations is increasingly important. And a comprehensive test ban would strengthen the Non-Proliferation Treaty of 1968 by imposing the same testing constraints on the nuclear powers that are already imposed on the non-nuclear nations by that treaty. Consequently, if we continue to pursue nuclear testing, we face the prospect not of enhancing our own security but of decreasing it. Now is the

time for this country to work actively toward the conclusion of a comprehensive nuclear test ban treaty. I am hopeful that today's hearings on S. Res. 67 will spur new U.S. efforts toward achieving this objective.

Our first witness for today's hearing will be Senator Edward Kennedy.

STATEMENT OF HON. EDWARD M. KENNEDY, U.S. SENATOR FROM MASSACHUSETTS

Senator KENNEDY. Mr. Chairman, I appreciate the opportunity once more to address the Subcommittee on Arms Control and Disarmament on the need for a comprehensive test ban treaty, CTB.

Senate Resolution 67, which I introduced along with Senators Mathias, Hart, Humphrey, Case and you, Mr. Chairman, hopefully will offer an opportunity for the Senate to clearly endorse immediate, serious and concentrated efforts by the executive branch to secure a test ban treaty.

SENATE RESOLUTION 67

Senate Resolution 67 was introduced on February 20, 1973. It represents the joint efforts of the chief authors to provide a single legislative vehicle for the expression of our belief that a comprehensive test ban treaty, CTB, is long overdue. Thirty-three Senators have now joined in support of this resolution.

The resolution urges the President first, to propose an immediate suspension of underground nuclear testing to remain in effect so long as the Soviet Union abstains from underground testing, and second, to set forth promptly a new proposal to the Government of the U.S.S.R. and other nations for a permanent treaty to ban all nuclear tests.

Essentially we believe that an immediate suspension would, as it did 10 years ago, emphasize both the seriousness and the sincerity with which we intend to pursue negotiations for arriving at a test ban treaty. The resolution also calls for a new proposal to reflect the changes in the world, the changes in our relationship with the Soviet Union, and the changes in our own technological capacity which the past decade has produced.

HISTORICAL PRECEDENT FOR SUSPENSION OF TESTING

The historical precedent for a suspension of testing is well known. In late December 1962, correspondence between President Kennedy and Premier Khrushchev indicated a renewed interest in seeking a ban on nuclear testing.

Informal contacts took place during the spring. Then, 10 years ago this month, Senator Humphrey led 33 other Senators in introducing a resolution supporting test ban negotiations.

Two weeks later on June 10 at American University, President Kennedy announced a moratorium on atmospheric testing to remain in effect so long as the Soviet Union abstained from testing. He announced as well the start of negotiations toward a permanent treaty. He said then, "Such a moratorium is no substitute for a formal binding treaty, but I hope it will help us achieve one."

On July 26, our chief negotiator, Ambassador Averill Harriman, initialed an agreement in Moscow and it was formally signed on August 5 by both President Kennedy and Premier Khrushchev.

I believe that a similar initiative by President Nixon could well produce a similar result, a result which would complete the unfinished business of a decade. For in the treaty that the Senate ratified on September 24, 1963, are included the words: "Seeking to achieve the discontinuance of all test explosions of nuclear weapons for all time, determined to continue negotiations to this end." Yet after more than 600 meetings of the Conference of the Committee on Disarmament, [CCD], at Geneva, it is clear to all that neither the United States nor the U.S.S.R. has seriously pursued a test ban treaty.

RESULTS OF FAILURE TO PURSUE TEST BAN TREATY

As a result of that failure, the promise of the partial test ban treaty itself has not been fulfilled. There has been no atmospheric testing by the signatories and the level of radioactive pollution has been minimal. However, the world has hoped there would be other consequences, less testing, fewer weapons, lower military expenditures. These hopes were stillborn, swept aside by the frantic pursuit of more potent weapons of destruction.

We have tested underground at least 249 times, the Soviet Union has tested at least 77 times. The exact numbers remain classified.

We do know the cost of those tests. In the past 10 years, we have expended more than \$2.7 billion on testing alone. In the past 10 years, the defense budget also shows that we have spent \$75 billion for strategic forces. The Brookings Institution estimates the actual cost at \$150 billion.

And this year is no different. The budget proposes to spend \$176 million more on testing weapons. Despite SALT and despite detente, the budget also shows requests for strategic forces are on the upswing. A Brookings analysis soon to be published will show an increase in the fiscal year 1974 budget of \$1.4 billion for strategic forces alone.

Are we more secure today because of these vast expenditures and because of our aggressive testing program? I seriously doubt it. For during this past decade, the United States and the Soviet Union have stockpiled enough megatonnage to virtually obliterate all life from this planet. We have multiplied our warheads from 1,830 deliverable warheads in 1963 to 5,900 today. And the Soviets have played nuclear catch-up, multiplying their stockpile from 210 warheads to 2,200. We have expended enormous sums of money, but we have not purchased greater security for either nation.

PRESENT MOMENT OPPORTUNE FOR NEW INITIATIVE

I am convinced that the present moment is opportune for a new initiative to turn the minds and energies of man away from the spiraling arms race of the past decade.

Within a few months' time, General Secretary Brezhnev will be arriving for a summit meeting with the President of the United States. Last year's summit concluded with the SALT accords and rising opti-

mism around the world at the sight of the two most powerful nations agreeing on a system of mutual restraint.

An extremely fitting and appropriate conclusion to this year's summit would be for the two leaders to announce a mutual moratorium on testing and to speedily conclude a treaty permanently banning all nuclear tests. It would respond as well to the August 5, 1973, target date of the United Nations for ending all testing, the 10th anniversary of the formal signing of the partial test ban treaty.

The timeliness of a CTB is underlined by SALT I. A comprehensive test ban is the logical next step in arms control. Perhaps more than any other single accord, a CTB would complement the SALT numerical limitations by placing qualitative checks on the nuclear arms race and would give impetus to the other negotiations now underway at SALT II, at MBFR [Mutual and Balanced Force Reductions] and at the disarmament conference.

BENEFITS OF HALT TO TESTING

Today, all mankind lives beneath an unsteady nuclear sword, and all nations face an equal threat from the accidental or deliberate use of nuclear weapons. The benefits therefore of a halt in testing extend far beyond the boundaries of this Nation. They extend to all nations.

First, a comprehensive test ban treaty, CTB, would mesh a potent qualitative restraining with the quantitative limits imposed by the SALT I agreements. For, as Dr. Kissinger stated, on May 29 in Kiev regarding SALT: "This agreement, if it is not followed on by other negotiations, will, over a period of time, permit a qualitative race."

The ABM treaty of SALT I has removed any need for the development of new warheads for offensive weapons to penetrate a Soviet ABM. Too, it has removed the need for testing ABM warheads by prohibiting further ABM deployment.

Yet, the budget proposals of the President are ample evidence that demands for new offensive systems will continue despite the invulnerability of our deterrent and despite the unquestioned retaliatory capacity of our nuclear striking force.

There would be a minor, though tangible, benefit for the United States in freezing qualitative warhead improvements at this time. For there is every indication that a halt in testing now would make far more difficult the Soviet effort to secure an operational MIRV. But each side would benefit in the knowledge that no substantial improvement in warheads could be tested and this in itself would put a damper on the pressure for further qualitative improvement in weapons systems.

Ambassador Myrdal stated the matter best in Geneva: "Only a ban on further testing," she said, "can stop the competition for qualitative proliferation; that is, the quest for 'product improvement' which is the most dangerously destabilizing element in the arms race."

Second, a CTB would reinforce the nonproliferation treaty and this perhaps would be one of its most significant benefits.

For since 1968, while some 78 nations have ratified the treaty, another 70 have not. The holdouts include those who are most capable of achieving nuclear capacity—West Germany, Japan, Israel, Egypt,

India, Pakistan, and Brazil. Recently in Japan and in other nations as well, there has been renewed talk of going nuclear, an event that could not help but mark a serious perhaps fatal step backward in the effort to secure world peace.

And these nations look with appropriate disdain at the clamor for their accession to the nonproliferation treaty while the superpowers engage in perpetual and extensive testing underground.

As the Swedish delegate told the CCD on March 8, "A halt would also considerably strengthen the nonproliferation treaty. How could two of the original parties to that treaty, who are still conducting large series of tests, hope to persuade all other nations that nuclear weapons would not be to their advantage?"

His rhetorical question directly affects the status of France and China as well.

Any hopes of seeing the inclusion of China and France in the full panoply of arms control measures sometime in the future clearly is less likely while the United States and the Soviet Union continue testing. Also, with regard to China, her recent ratification of participation in the nuclear-free Latin America treaty—Treaty of Tlatelolco—is a promising sign. What seems clear, however, is that if the United States and the U.S.S.R. do not lead the way, then there is no hope whatever of drawing the other nuclear powers and near nuclear powers into a pledge of nuclear abstinence.

BENEFITS OF CTB

Third, a CTB would eliminate the continuing environmental hazard of underground testing.

While it may not be the overriding reason for conclusion of a treaty, the removal of the environmental dangers of continued testing cannot be overlooked. Despite all of the precautions of the AEC, one of every four underground tests has vented, sending radioactive particles into the air. In addition, there are other dangers. A 1968 panel of eminent scientists noted that underground nuclear explosions possess the potential to precipitate earthquakes and even tidal waves. Regardless of the improbability of such an occurrence, the unleashing of massive power by underground testing presents risks that we discover too often only after the tests have occurred. We are too little versed in the delicate balance between man and energy on this planet to continue to take such risks with our environment.

Fourth, a CTB would permit a substantial amount of resources to be redirected away from weapons testing and production to non-military needs. This year's budget calls for \$176 million for testing by the AEC and \$425 million for production of weapons.

President Eisenhower said in 1953:

Every gun that is made, every warship launched, every rocket fired, signifies, in the final sense, a theft from those who hunger and are not fed, those who are cold and are not clothed.

The \$176 million for testing alone would pay the annual salaries of 19,500 elementary schoolteachers.

Finally, a CTB would have an enormous psychological impact on all nations. It would symbolize more than any other action the deter-

mination of the superpowers to put the nuclear genie back into the bottle. There can be no doubt that the conclusion of a CTB would create a positive arms control environment in which SALT II and other negotiations toward nuclear disarmament could go forward.

Mr. Chairman, these are the benefits that a comprehensive test ban treaty would provide and these are the reasons why I believe the Senate should go on record in favor of immediate steps to attain that objective.

ISSUE OF ADEQUATE VERIFICATION

The only remaining obstacle according to administration spokesmen is the issue of adequate verification. No one denies that one must have a verification procedure to assure compliance with the agreement. Yet the official U.S. position for the past decade has been that adequate verification requires onsite inspections.

Today, the demand for onsite inspection has lost whatever merit it ever possessed. In 1963, when we were willing to agree to a treaty with seven onsite inspections, we had extremely primitive seismic capabilities. We now have the capacity, attested to by our leading seismologists, to detect underground events and distinguish between earthquakes and explosions, down to a level of 2 kilotons in hard rock. This was the conclusion of the Woods Hole seminar of the Advanced Research Project Administration [ARPA] of DOD and it has been reiterated in the past several years by a long list of eminent seismologists.

Yet, despite these developments, Acting Director of ACDA [Arms Control and Disarmament Agency], Philip J. Farley, has stated before this subcommittee, "We have not had occasion to review formally the precise number and have not either introduced or determined privately a new number since we last spoke of seven, I think it was in 1963." Thus, there has been no change whatsoever in our position in the past 10 years despite the enormous refinements in our seismic verification capabilities.

And it should be noted, as well, that onsite inspection itself is of limited utility in any case. Dr. Lukasik, ARPA Director, testified before the Joint Committee on Atomic Energy in 1971, that only two techniques of onsite inspection had proved of any use: visual inspection and radiochemical analysis. Yet he acknowledged that "sufficiently deep burial will preclude surface effects and seepage of radioactive gas to the surface."

Dr. Franklin A. Long, former Assistant Director for Science and Technology of the Arms Control and Disarmament Agency has described the new seismological capability as being extremely close to the situation where we can distinguish between earthquake and nuclear explosion whenever we detect an underground disturbance. In that situation, onsite inspection becomes virtually meaningless.

With regard to seismic capabilities, I would note that the U.S.-Soviet environmental agreements of last year include provision for the installation of earthquake measurement instruments in both countries. It is possible the U.S.S.R. might agree to the installation of similar black boxes which would provide an additional improvement in our seismic monitoring. In February, the Soviet delegate stated at the

CCD: "International cooperation in exchanging seismic data would be of great importance in this matter. The U.S.S.R. is willing to carry out such exchanges within the framework of an agreement on the cessation of nuclear weapon tests."

And we do not have to rely on seismic monitoring alone to enforce compliance.

ADEQUATE VERIFICATION ISSUE

There is additional assurance provided today by observation satellites which are refined to a capability unknown 10 years ago. Satellite photos would be able to detect construction artifacts at a test site, such as drilling, roads, borehole casings, or towers. After a test, a satellite photo would pick up subsidence craters, changes in vegetation, and other indicators of a change in the Earth's surface. When we are aware that satellite photos can distinguish details down to a diameter of a few feet, then clearly we have an enormous new verification potential available to us.

It should also be noted that these two verification technologies, satellite photography and seismology, would not operate independently. The value of the two would be greater than the sum of the parts, since an evader would have to evade both simultaneously.

Furthermore, we would have traditional intelligence-gathering means to add to the risk of the nation attempting to evade the treaty.

Thus, William C. Foster, Director of ACDA from 1961 to 1969, states in a letter to me in support of this resolution: "Although verification of a CTB once required onsite inspection, nuclear test detection and identification technology is now such that we can enter safely into a test ban agreement using existing national means of verification, without onsite inspection." I would like to submit the letter and a full statement as well from Mr. Foster, now chairman of the Arms Control Association. [See appendix p. 137.]

Further evidence that onsite inspection is no longer a legitimate obstacle to the conclusion of a CTB is its absence from the SALT agreements.

They affirm the adequacy of national means of verification, and they do so under conditions in which seismic verification is not even available as a method of detection.

Dr. Kissinger stated: "We are confident that the national means of verification are sufficient to give us the highest degree of confidence that this agreement will be lived up to, or that we will know it almost immediately if it is not lived up to."

He was supported strongly by former ACDA Director, Ambassador Gerard Smith, who said: "As a matter of fact, if I had my 'druthers' and could have onsite inspection instead of our present national means, there would be no question in my mind that we would be much better off with national means of verification."

The SALT accords also provide a verification process which could be used as a model for CTB. For both sides have agreed not to interfere with national means of inspection, and both sides have agreed not to use deliberate concealment to impede verification. A standing consultative commission also has been established where questions con-

cerning fulfillment of the treaty obligations can be raised. Essentially it is the failure of the other party to supply an adequate response which could trigger the withdrawal clause contained within the treaty. A similar procedure could be established in a CTB agreement.

This procedure and the technology we have to back it up would provide the same assurance in a CTB that the SALT verification provisions afford, the assurance that the risk of discovery of any cheating outweighs from the Soviet viewpoint any benefit they might obtain from a secret test.

The Soviet Union has a vested interest in the web of arms control agreements which has been erected over the past decade. They know that this carefully balanced creation would fall to pieces at the first sign of a treaty violation. They know, too, that our present verification capabilities make the risk of discovery enormous.

POSITION SUMMARY

In summary, this is our position: The United States is committed in two solemn treaties to negotiate determinedly toward a comprehensive test ban treaty. Over the past 10 years, our strategic force has expanded enormously. During the same period of time, our ability to detect tests with seismic and satellite reconnaissance methods has improved enormously. Yet there has been no new proposal to achieve a treaty.

Furthermore, all agree that the logical next step to the SALT I agreements is a treaty limiting qualitative improvements. The comprehensive test ban would provide that qualitative brake. And it would impede the spread of nuclear weapons to other nations. Thus, the unfinished business of the sixties has become an imperative next step for the seventies.

Finally, a mutual moratorium has been successfully used in the past as a stimulus to a final treaty. Why not try it again and break the logjam that has held up test ban negotiations for 10 years?

Mr. Chairman, I share the recent view of United Nations Secretary General Kurt Waldheim that "only a political decision is now necessary to achieve final agreement."

Now is the time for the United States to demonstrate the political will necessary to reach agreement on the cessation of all nuclear testing.

We have an obligation to do so under two international treaties, but we have an even greater obligation to our children, to see that the world they inherit is free from the shadow of nuclear destruction.

Mr. Chairman, I would like to ask that the complete statement be printed as read. I have indicated the letter from Mr. Foster. We also have a very extensive statement, I believe, by Senator Mathias, also Senator Hart, and a number of enormously useful letters of correspondence that relate to different aspects of the issue. The list includes men who have spent a lifetime in the area of disarmament and arms control. I would like to ask that they be printed in the appropriate place in the record. [See appendix.]

Senator MUSKIE. Without objection, that will be done, and may I compliment you, Senator Kennedy, on an excellent statement. I think that within the confines of the statement itself without the supporting

material, you have laid out the case for S. Res. 67 about as well as it can be done.

I think that at this point Senator Case has a statement that he didn't have an opportunity to make. I would like to give him that opportunity.

Senator CASE. Thank you, Mr. Chairman.

I join in the view of expressing appreciation to Senator Kennedy for a very fine statement. It is comprehensive, and it lays the ground very well for action here.

Without objection, I ask that I be allowed to place in the record a short statement of my own.

[The statement of Senator Case follows:]

STATEMENT OF SENATOR CASE ON S. RES. 67

The resolution before this subcommittee today calls upon the President to propose an immediate suspension of underground nuclear testing to the Soviet Union. This suspension would remain in effect so long as it is respected by the Soviet Union. The resolution further calls for a new proposal to be made to the Soviet Union and other nations for a permanent treaty to ban all nuclear tests.

I sponsored this resolution when it was introduced in the Senate on February 20, 1973, and I earnestly hope that favorable action by this committee and passage by the Senate can be speedily accomplished.

From every standpoint, the time is at hand for the Senate to affirm support for a new initiative on the part of this government.

For almost ten years, the United States and the Soviet Union have been deadlocked in the negotiation of an underground nuclear test ban treaty. For ten years, the United States has insisted upon—and the Soviets have resisted—on-site inspections as a means of verifying compliance with such a treaty.

At the beginning of this period, U.S. insistence upon on-site inspections was probably justified in view of our then-relatively primitive ability to verify compliance solely by seismic monitoring stations on our own soil or on that of countries bordering on the Soviet Union.

But since then there have been great advances in seismic monitoring techniques. The significance of these advances is that the United States may now be able safely to rely upon these monitoring techniques and drop or modify its insistence upon on-site inspections.

Some arms control experts may question whether any further improvement in our seismic monitoring capabilities is necessary. Others may still argue that our capabilities for policing a test ban treaty are not sufficiently reliable and sensitive to deter some form of covert underground testing.

Whatever the outcome of this debate among the technicians, it presents no argument against revising our negotiating position in light of the *unquestioned* technical advances of the past decade.

In this regard, I believe it should be underlined that the Defense Department has greatly stepped up efforts in the past year to improve even further our capabilities to monitor an underground test ban.

Two years ago, when I first began to investigate our capability to monitor such a treaty, it took a major effort on my part to force the Defense Department to admit the advances that had been made.

One year ago, the program of exploiting the great scientific advances which had been made in this field was at such a low ebb, that I felt impelled to introduce legislation to transfer responsibility from the Defense Department, which then had jurisdiction, to the U.S. Arms Control and Disarmament Agency.

According to press reports, much has changed in recent months and Defense Department efforts to capitalize on these scientific achievements reportedly have received a new urgency and high degree of priority. According to one account, a new initiative is now underway to relocate and upgrade monitoring equipment throughout the 20-station seismographic network that the U.S. has throughout the world.

I applaud this development. But it is all the more important that this new momentum be maintained—in this connection, that we in the Senate now affirm our support for this movement towards a treaty ending all nuclear tests:

Since the conclusion of the Limited Nuclear Test Ban Treaty, in 1963, the rate of nuclear testing has actually increased.

The non-nuclear powers have become increasingly restive at the prolonged delay in ending nuclear testing. The Nuclear Non-Proliferation Treaty itself is further endangered with the passage of every day—and we have been specifically warned by nations who have not yet ratified it that time is running out.

Absent an agreement, the United States and the Soviet Union will feel impelled to continue their inexorable competition to refine their warheads.

As the first step in the effort finally to resolve this long-standing impasse, I urge my colleagues to support this resolution.

REASON RESOLUTION IS NECESSARY

Senator CASE. As cosponsor of this resolution, I have been asked why I believe a resolution is necessary. The implication is: Are you criticizing the administration for dragging its feet? Well, I'm not, and I do want the administration representatives who are in this room and elsewhere to know this. I regard this resolution as a constructive rather than as a critical exercise.

This is an area in which public opinion is not out front. It is an area in which a certain amount of leadership is necessary to make progress. I regard this resolution as evidence that the Congress will stand behind initiatives in this area by the administration which we think are useful and which we have no reason to suggest they are not willing to make.

As I have said before in another hearing before this committee, I think it is more essential now than it has been in the past when there was no question that the administration's prestige might not be as high as it ought to be or as we would like to see it at the moment. This is the time when it is more important than ever that there be a closing of ranks on policy matters between the executive and the legislative branches. That is what this resolution, if it is accepted by the administration, can do.

For the rest, I think, my statement speaks for itself.

Senator KENNEDY. If I could just react and respond, I want to certainly indicate to Senator Case who has spent so many years of his life in this area of study and made such important contributions, that is exactly the spirit in which the cosponsors, both sides of the aisle, have advanced this resolution.

I think all of us are extremely hopeful, as Senator Case has pointed out, that it would be an indication of the support for the administration if it takes those steps which have been outlined. We came here today with a balanced group of Members of the Senate from both sides of the aisle, some 33 Members. I dare say that there are an additional number who have indicated to those of us who have been chief sponsors of this proposal, their support as well.

So I think that Senator Case has stated the sense with which this proposal has been advanced, and I would certainly hope it would be considered in that light.

Senator CASE. Thank you.

Thank you, Mr. Chairman.

Senator MUSKIE. I think the point that both of you have made could be emphasized is that it is related to the problem of generating public support for a new major policy change. I compare this often to the

developments in the environmental field which finally triggered public interest and concern and support.

We have had dirty water around a long time; yet an awareness of that was not sufficient to really mount a massive public concern. It was only when air pollution became very visible and people were sensitive to the fact that they were breathing this filth and couldn't escape it that the emotional content of the issue began to mount, and we began to get some tough air pollution legislation and also water pollution legislation. We achieved a limited test ban treaty because people realized they couldn't escape the radiation in the atmosphere. It was accumulating, concentrating in unknown and, in some cases, unmeasurable dimensions, and the prospect of that, I think, injected an emotional content into the issue which gave us the limited test ban treaty and later the nonproliferation treaty.

Now, I think, what the three of us and our associates feel is that, with the elimination of that emotional content, we may have created an obstacle to further progress in this field, and I think that's another reason that makes it important that we take part in this initiative.

I would like to ask just two or three questions, Senator Kennedy, to emphasize the simplicity of the approach in S. Res. 67.

CALL FOR MORATORIUM ON FURTHER TESTING

First of all, you call for a moratorium on further testing. This is a tried and true device which you so well pointed out in your statement, and it has led on previous occasions to the achievement of agreements. So this is not a risky kind of venture.

I recall that in the fifties, and especially the 1956 Presidential campaign, such a suggestion was regarded as revolutionary and risky beyond any reasonableness. Yet President Kennedy undertook it in 1962, and it very quickly resulted in a limited test ban agreement. And so the simplicity of that approach, I think, ought to generate some reassurance that you and I and Senator Case are not wild men.

NO UNILATERAL UNDERTAKING TO SET DOWN TREATY TERMS

The second point I would make is that we are not undertaking unilaterally to set down the terms of the treaty which the United States would require. As a matter of fact there are no terms at all in S. Res. 67. We are simply asking for the beginning of the negotiation process, and that is a simple proposition. It does not bind us to anything from which we cannot back off, and does not bind us to any risks that we would not be allowed to measure.

ADEQUACY OF EXISTING NATIONAL MEANS OF VERIFICATION

The third point—and I think those two points are easy for the public to understand—is that I think we need some enlightenment on the question of verification which you touch upon, I think, so effectively in your statement.

Now, do you personally believe that there have been sufficient seismological advances in recent years to provide the United States with an acceptable level of competence in our ability to identify significant violations of the comprehensive test ban treaty?

Senator KENNEDY. Well, I certainly do, Mr. Chairman. And I think that the case has been made by experts, some of the witnesses that will appear before you today. I also would note the very splendid statement of William Foster who has spent such a considerable period of time in the field of arms control. At one time, he believed in the importance of onsite inspection and now has stated, although adequate verification of a CTB once required onsite inspection, nuclear test detection and identification technology is such that we can enter safely into a test ban agreement using existing national means of verification without onsite inspection.

I think that statement is accurate. It represents the best judgment of those who have followed this subject closely over a long period of time, not only those of us in the area of public policy, but also those that have given virtually a lifetime to the technology of verification. Not only in the fields of seismology, aerial and satellite reconnaissance and in traditional intelligence gathering, we have the kinds of protections essential from a security point of view.

Finally, Mr. Chairman, we have recognized and I think very appropriately so, that the benefits of the ABM treaty and the agreement on limitation of offensive weapons with the Soviet Union, and the overwhelming risk of detection outweighs any potentially small advantage that might be conceived by the Soviet Union to justify an isolated instance of cheating.

The potential risk which exists, even if we were talking about the Soviet Union moving ahead with the various types of gymnastics that would be necessary to coincide explosions and earthquakes or to detonate a limited type of explosion in a cavity, is so marginal, and the technological benefit that would come from it would be of such little value, that the issue of onsite no longer can justify delaying a test ban treaty.

We have given up the concept of onsite inspection in the area of biological warfare because we felt that there was such an overriding importance and responsibility to try and reach some agreement in the area of biological warfare, that any risk was worth taking. The same holds for the NPT. Certainly a CTB is of equal importance from a public policy point of view.

Senator MUSKIE. The point you make, then, seems to be twofold: One, that we've enlarged our capacity to make positive identification of seismic events. We have done so to the point that, second, the risk to the Soviet Union in undertaking tests in that environment of technology is so great that we can rely on deterrents to inhibit them from undertaking to cheat.

Those have been persuasive arguments, as you have said.

POSSIBILITY OF SENATE RESOLUTION 67 WEAKENING U.S. NEGOTIATING
POSITION ON VERIFICATION

One other question with respect to testimony to be submitted later today, since you will not have an opportunity to report at that time. In his testimony John Foster of the Defense Department argues that Senate Resolution 67, by tacitly accepting the Soviet position on national means at the outset, would actually weaken our present position in attempting to negotiate to require verification capabilities.

How would you respond to that?

Senator KENNEDY. First of all, I am willing to accept, as an individual Senator, the fact that onsite inspections would not be necessary, but our resolution does not propose that. I think this resolution is an umbrella under which many of us can find agreement, and I am sure there are different members who support the basic proposal as you have outlined yourself, that have different kinds of views on the specifics of verification.

I do not think it in any way would bind us. Perhaps there would be those—and perhaps Mr. Foster—and I will look forward to reading his testimony—would feel in some way that it at least outlines the parameters of the verification issue and thus stick us with the position. Those of us who are supporting the resolution at the outset ought to make quite clear that it does not attempt to enunciate a specific bargaining proposal.

As I say, national means of verification would satisfy me, but I do not think it really should be interpreted, as one who has been active in the development of the resolution, along with yourself and Senators Case, Hart, and Humphrey and Senator Mathias, to bind any of the members on that particular issue.

Senator MUSKIE. The resolution does not in fact propose any negotiating position, and I think it is conceivable that the 33 Senators who have cosponsored might differ with each other as to what the initial negotiating position should be, and that many of them may, indeed, support some limited form of onsite inspection.

But, in any case, we do not have to put that question at this point nor answer it in the resolution.

Senator KENNEDY. It seems that the present negotiating position requires seven onsite inspections. Obviously, there has been a 10-year change in technological and other considerations since that time. We are urging at this time a new proposition, a new proposal to achieve a CTB, and this is really the justification incorporated in the resolution.

Senator MUSKIE. As a matter of fact, I think Mr. Foster ought to be commenting on the statement of his, and the one Mr. Kissinger made in Moscow last May to which I referred. It was, and I repeat it, that we have been in principle prepared to do this. The obstacle has been the debate about inspection, and we are willing to restudy the issue.

Now, that statement suggests greater flexibility on this point than the single statement I have quoted from Mr. Foster's testimony, and if he subscribes to the Kissinger statement, then it seems to me he could subscribe to Senate Resolution 67.

Senator Case?

POLICY DECISION NOT BEING MADE

Senator CASE. I think you have covered the matter very well. It is well to bring out that what we are doing here is not making a policy decision, but that we are urging that the matter be deliberated; that we move from our present position, which is static, to an active position of seeking a solution on the basis of a change in the general knowledge in this area, and also of political developments.

Senator MUSKIE. Thank you very much, Senator Kennedy, for excellent testimony and documentation.

Senator KENNEDY. Thank you.

Senator MUSKIE. Our next witness this morning is Mr. Philip J. Farley, Acting Director of the U.S. Arms Control and Disarmament Agency.

Mr. Farley, it is a pleasure to welcome you again to this subcommittee, and I invite you to present your testimony.

Mr. FARLEY. Thank you, Mr. Chairman.

I believe, Mr. Chairman, that you have my prepared statement. As you requested in your letter inviting me to appear, I would propose to go somewhat more briefly through the line of thought in that statement rather than reading it in its entirety, if that is agreeable to you.

Senator MUSKIE. It would be fine.

It is agreeable to us to handle it in any way that is useful.

Mr. FARLEY. Thank you.

STATEMENT OF PHILIP J. FARLEY, ACTING DIRECTOR, U.S. ARMS CONTROL AND DISARMAMENT AGENCY; ACCOMPANIED BY DR. JACK F. EVERNDEN, CHIEF SEISMOLOGIST, ARMS CONTROL AND DISARMAMENT AGENCY

Mr. FARLEY. What I have presented in my statement is an executive branch view, both on Senate Resolution 67 and on the question of a proper manner to pursue our objective of a comprehensive test ban.

RECOMMENDATION FOR MUTUAL MORATORIUM

With regard to the first recommendation of Senate Resolution 67 for a mutual moratorium, in our view such a moratorium would necessarily lack many of the safeguards of a formal international agreement. Therefore, the administration does not believe that such a moratorium would be a prudent step to take at this time.

Acting Assistant Secretary of State Wright, Mr. Chairman, has addressed a letter yesterday to Senator Fulbright in his capacity as chairman of the Senate Foreign Relations Committee, setting forth this view at somewhat more length, and we'd like to request that this be included in the record.

Senator MUSKIE. Without objection, it will be included. [See p. 2.]

ADEQUATELY VERIFIED COMPREHENSIVE TEST BAN FAVORED

Mr. FARLEY. In our view, then, it would be better to direct our efforts toward a comprehensive test ban treaty, adequately verified, as is urged in the second operative clause of Senate Resolution 67, and that is the matter to which the rest of my remarks are addressed.

I want to state again formally that this administration, like its three predecessors, favors the conclusion of a comprehensive test ban, adequately verified. The reasons for this are, I think, not a matter with which there is dispute, as I noted in listening to Senator Kennedy's presentation and to your opening remarks, Mr. Chairman. I think there is a broad area of agreement. The kinds of reasons which tend to favor such a test ban are its effect on limiting United States-Soviet and other nuclear arms competition, the impetus and support it would give to our efforts of nonproliferation, its political significance as a gesture

by which we respond to a widespread feeling in the world community, and finally, the contribution it would make to allaying the concerns about possible adverse effects of underground nuclear tests on the environment.

Now, we certainly do not contest that improvement in our nuclear weaponry could be hindered by a comprehensive test ban, and that this in turn might hamper our efforts to cope with future threats.

It has also been pointed out that there could be problems of maintaining confidence in the reliability of existing warheads if there is not testing.

For reasons such as these, there would be some adverse impact on our military posture. However, our view is that the military impact on us of a comprehensive test ban would be acceptable since other parties would be similarly constrained if they abided by their obligations under the treaty.

Abiding by the obligations under the treaty is, of course, the crucial element, and adequate verification to give us assurance of compliance by others is thus crucial to the acceptability of a comprehensive test ban from the security point of view.

I might say as a matter of some interest that this question of whether it is military considerations that are preventing the United States from accepting the ban on underground nuclear weapons tests was raised in the Geneva discussions last year, and the U.S. representative, Ambassador Martin, responded directly in the negative. The United States is prepared to give up the advantages we gain from nuclear weapons testing, but of course, only if we can be assured that others abide by the same restrictions.

PROBLEM OF PEACEFUL NUCLEAR EXPLOSION

Another problem which has been identified before, Mr. Chairman, is the problem of peaceful nuclear explosion [PNE]. Such explosions would provide opportunities for conducting weapons development. Before a comprehensive test ban would be possible, some resolution of this problem must be made. If negotiating a satisfactory mechanism proved difficult, one possible approach in the interest of making progress might be to agree to suspend them until a system of adequate safeguards could be developed and negotiated.

Senator CASE. By this do you mean safeguards against transfer of the technology?

Mr. FARLEY. Or actually using the peaceful nuclear explosion as an occasion for testing new weapons concepts or modifications.

Senator CASE. Thank you, Mr. Chairman.

NECESSITY OF BROAD ACCEPTANCE AND EFFECTIVENESS OF TREATY

Mr. FARLEY. So I, and of course, the administration, note frequently that the advantages of a comprehensive test ban will be obtained only if the treaty achieves broad acceptance and is effective in stopping nuclear tests. If some parties to the treaty could conduct a significant amount of nuclear testing without the knowledge of the other parties to the treaty, one or more of the advantages could be nullified and the treaty operate to the disadvantage of those still abiding by it.

EFFORTS TO IMPROVE VERIFICATION CAPABILITIES

As a result, the United States has always insisted on adequate verification for a comprehensive test ban; that is, verification which would provide the United States with an acceptable level of confidence in our ability to identify significant violations should they occur. We have devoted a great deal of effort to improving verification capabilities. I think it is fair to say that the advances such as were referred to by Senator Kennedy, are overwhelmingly the result of efforts that have been put forth by the United States.

Last summer we presented to the conference of the Committee on Disarmament in Geneva, a summary of the progress that has been achieved in seismic verification and the problems that still remain to be solved.

Mr. Chairman, I would like to request permission to insert that report and the tabling speech by the U.S. representative into the record at the conclusion of my statement.

Senator MUSKIE. Without objection that will be done.

Mr. FARLEY. And work is being done on an updated presentation for another conference on seismic verification which is scheduled to be held during the forthcoming summer session of CCD.

I then proceed, Mr. Chairman, in my statement to discuss in some detail the problems to which we are currently directing priority attention, and the progress which is being made. I can pursue that at such length as the committee wants, but I might just say in summary at this time that the result of all of this is that definite progress is being made. Remaining problems are being actively pursued, and we feel that rational design of networks for dealing with particular problems will soon be possible.

NECESSITY OF SOME ONSITE INSPECTIONS

However, I must emphasize that we have not found it feasible to define the threshold of capability under a comprehensive test ban required by the United States consistent with its national security. Any seismic network will have its inherent limitations. While seismic capability has improved, so has understanding of the military potential of nuclear tests of lower yields. As a result of this factor and the limitations of our seismic and other national means of verification, it remains our position that onsite inspections can help in deterring possible violations of a comprehensive test ban, and we continue to hold the position that some onsite inspection is necessary to supplement our national needs.

SOVIET AND OTHERS INSISTENCE THAT NATIONAL MEANS ARE SUFFICIENT

The Soviets and some other countries, however, have continued to insist that national means are sufficient for CTB verification, and this continues to be a matter of dispute in international disarmament quarters. We are continuing to participate actively in the international discussions at the CCD in Geneva and the United Nations in New York on various approaches to a comprehensive test ban.

This has been a subject of key interest to many countries, and we have considered their views very carefully while at the same time sharing the results of our research here. As a result, we expect to present our latest findings to the CCD seismic experts meeting this summer as we did last summer in our working paper on progress and problems in seismic verification.

CONCLUSION

In conclusion, Mr. Chairman, the United States remains committed to a goal of an adequately verified comprehensive test ban, and we are actively pursuing solutions to the problems of verification both through our technical research and at the negotiating table.

That concludes a summary of my prepared statement, Mr. Chairman.

As you requested, I am accompanied by Dr. Jack Evernden, who is a seismologist on the Arms Control and Disarmament Agency staff. We will try to respond to your questions.

[Mr. Farley's prepared statement follows:]

STATEMENT OF PHILIP J. FARLEY, ACTING DIRECTOR OF THE U.S. ARMS CONTROL AND DISARMAMENT AGENCY

Mr. Chairman, I am pleased to be here today to present testimony relative to consideration by the committee of Senate Resolution 67, which would express the sense of the Senate that the United States should propose an immediate suspension of underground nuclear testing to remain in effect so long as the Soviet Union abstains from underground testing, and should set forth promptly a new proposal for a permanent treaty to ban all nuclear tests.

With regard to the first recommendation of Senate Resolution 67—a mutual moratorium—such a moratorium would necessarily lack many of the safeguards of a formal international agreement. Therefore, the administration does not believe that it would be a prudent step to take at this time. Rather we believe our efforts would be better directed toward the achievement of a comprehensive test ban treaty, adequately verified, as urged in the second operative clause of Senate Resolution 67. As a result, my remarks will be addressed to the advantages of, and the obstacles to, such a treaty.

This administration, like its three predecessors, favors the conclusion of a comprehensive test ban, adequately verified. In his initial message to the Conference of the Eighteen-Nation Committee on Disarmament, now known as the Conference of the Committee on Disarmament (CCD), in Geneva on March 18, 1969, the President said, "The United States supports the conclusion of a comprehensive test ban adequately verified." Ambassador Martin of the United States, in his opening address to the CCD on February 20 of this year, reaffirmed U.S. support for an adequately verified comprehensive test ban.

The advantages of a comprehensive test ban adequately verified would be as follows:

First, it would contribute to efforts to prevent the spread of nuclear weapons to additional countries. It would do so in two ways—by creating an even more significant practical obstacle than the Limited Test Ban Treaty to the independent development of nuclear weapons by parties which have not yet acquired them; and by reinforcing the Nonproliferation Treaty;

Second, it would contribute to our efforts to limit the United States-Soviet nuclear arms competition. It would do so by impeding further improvements by either side of the nuclear components of offensive and defensive nuclear weapons, since testing is important both in developing such improvements and in evaluating their effects.

Third, it would be responsive to a widespread desire in the world community for an end to nuclear weapon testing; and

Fourth, a comprehensive test ban would help allay concerns about possible adverse effects of underground nuclear tests on the environment.

It cannot be contested that improvement in our nuclear weaponry would be hindered by a comprehensive test ban, and this in turn might hamper our efforts to contend with future threats. Of course this constraint would apply to all parties to such an agreement and such mutual constraint would be, indeed, an objective of the agreement.

It has also been pointed out that there might be difficulty in maintaining confidence in the continuing reliability of all existing warheads without testing. In some cases to date defects have developed in a particular type of warhead. Under a CTB, any such defects would have to be remedied by means not involving nuclear testing, including the substitution of a previously tested warhead. It would appear that, given sufficient funding, any loss in reliability could often be avoided or delayed.

Thus, the military impact of a comprehensive test ban on our nuclear posture would be acceptable, since the other parties would be similarly affected, if they abided by their obligations under the treaty. Adequate verification to give us assurance of compliance by others is thus crucial to the acceptability of a CTB from the security point of view. I shall address the issue of what is required for adequate verification a little later.

The question whether there are military considerations that are preventing the United States from accepting a ban on underground nuclear weapon tests was raised in the CCD in 1972. The U.S. Representative replied that the answer is no: The United States is prepared to give up the advantages derived from nuclear weapon testing, of course, only if we can be assured that others are abiding by the same restrictions.

One additional problem with respect to a comprehensive test ban that should be mentioned is peaceful nuclear explosions, because of the possibility of conducting weapons development in conjunction with a peaceful nuclear explosion program. It would be difficult to detect such development even with onsite inspection by international observers. The Soviets have an active program in this field and certain nonnuclear countries have expressed interest in peaceful nuclear explosives. Before a CTB would be possible, some resolution of this problem must be made. If negotiating a satisfactory mechanism proved difficult, one possible approach might be to agree to suspend them until a system of adequate safeguards could be developed and negotiated.

In previous appearances before this committee, I noted that the advantages of a comprehensive test ban would be obtained only if the treaty achieved broad acceptance and was effective in stopping nuclear tests. If some parties to the treaty could conduct a significant amount of nuclear testing without the knowledge of the other parties to the treaty, one or more of the advantages I have listed earlier could be nullified and the treaty would operate to the disadvantage of those still abiding by it. As a result, the United States has always insisted on adequate verification for a comprehensive test ban, that is verification which would provide the United States with an acceptable level of confidence in our ability to identify significant violations, should they occur.

The United States has continued working vigorously on contributing to the solution of the verification problem. Some \$300 million has been committed to research and development on detection and identification of underground nuclear tests since the early 1960's, primarily in the area of seismology. Last summer the U.S. presented to the conference of the Committee on Disarmament in Geneva a summary of the progress that has been achieved in seismic verification and the problems that still remain to be solved. Mr. Chairman, I request permission to insert that report and the tabling speech by the U.S. Representative into the record at the conclusion of my statement. Work is now in progress on an updated presentation for a conference of experts in seismic verification, which is expected to be held during the forthcoming summer session of the CCD. Dr. Jack Evernden, a specialist in the seismic verification area who has been working actively on this problem in close collaboration with ARPA as a member of the ACDA staff for about 2 years, is with me today, as you requested. He is prepared to answer specific technical questions in his area of expertise. It might be useful, however, Mr. Chairman, if I were to give a brief overview of the situation as it appears at the moment.

In response to a question submitted by Senator Case in connection with the hearing on the ACDA authorization last spring, Ambassador Gerard Smith, former ACDA Director, stated that various characteristics of seismic signals are adequate, in principle, to serve as the basis for discriminating earthquakes

and explosions down to magnitude 4.0 on the Richter scale. As work has progressed, additional support has been obtained for this position. It is my understanding that theoretical considerations suggest these characteristics appear to hold for discrimination at smaller magnitudes, although it is difficult to acquire sufficient observed data to prove this empirically.

Knowing how to accomplish identification in principle is quite different, however, from doing it in practice. Complications arise in achieving an operational capability to apply discrimination criteria to all events of interest. This difficulty arises from three basic problems.

First, establishing depths of focus of small earthquakes or explosions—that is, those observed at comparatively few stations—is very difficult without the availability of data from stations within a thousand kilometers or so of seismic events. If sufficiently accurate depths cannot be established, proper application of a criterion such as the ratio of surface wave to body wave magnitudes, well known as the $M_s:m_b$ criterion, may be impossible. Without good depth estimates, it is difficult to identify the so-called “anomalous events,” which are seismic events having surface wave magnitudes so low that, if such events are considered to be very shallow, then the nature of the events cannot be discriminated by the $M_s:m_b$ criterion.

Second, a number of events in the U.S.S.R. of significant magnitude are unidentifiable by teleseismic networks because of inability to separate their surface waves from those of larger earthquakes occurring in the U.S.S.R. or elsewhere. This creates a set of unidentifiable events in which an explosion cannot be distinguished. More capable seismic networks than we now possess are required to limit this set of “mixed” events to a small number.

Third, the network requirements and complexities involved in effectively combating deliberate efforts at evasion of a comprehensive test ban need to be considered.

Analyses conducted by ACDA and ARPA are directed at assessing the quantitative parameters controlling and describing these problems and their solutions, and progress is being made in all three of these areas. As indicated in the U.S. CCD paper of last August, certain data will only be available if records are obtained at short distances from seismic sources. As analysis has progressed, the role of close-in seismic observatories for increasing detection and identification capabilities has become clearer, pointing to the possible utility of unmanned seismic observatories or “black boxes.” I referred to this aspect in my earlier testimony and current research is attempting to quantify the above problems in such a way that valid estimates of USO network characteristics can be generated. At the same time, ARPA and ACDA efforts directed toward the development of “black boxes” are underway so that highly reliable instruments can be built using the latest available technology. As I noted earlier, it is the U.S. position that a CTB depends upon an adequate verification capability and we are working continuously to learn the details of how that capability may be achieved. In addition to the effort I have described, which is primarily oriented toward analysis of various concepts, improved seismic instrumentation and data transmission systems are to be made operational in the near future to aid in obtaining data to address the remaining problems.

The result of all of this is that definite progress is being made, remaining problems are being actively pursued, and we feel rational design of networks for dealing with particular problems will soon be possible. However, I must emphasize that we have not found it feasible to define the threshold of capability under a CTB required by the United States consistent with its national security. Any seismic network will have its inherent limitations. While seismic capability has improved, so has understanding of the military potential of nuclear tests of lower yields.

As a result of this factor and the limitations of our seismic and other national means of verification, it remains our position that onsite inspections can help in deterring possible violations of a comprehensive test ban and we continue to hold to the position that some onsite inspection is necessary to supplement our national means. The Soviets, and some other countries, however, have continued to insist that national means are sufficient for CTB verification, and this continues to be a matter of dispute in international disarmament forums.

The United States is continuing to participate actively in international discussions at the CCD in Geneva and the United Nations in New York on various approaches to the achievement of a comprehensive test ban. This has been a sub-

ject of keen interest to many countries, and we have considered their views very carefully, while at the same time sharing the results of our research with them. Again, we expect to present our latest findings to the CCD seismic experts' meeting in Geneva this summer, as we did last summer, in our working paper on progress and problems in seismic verification.

In conclusion, Mr. Chairman, the United States remains committed to the goal of an adequately verified comprehensive test ban and we are actively pursuing solutions to the problems of verification, both through our technical research and at the negotiating table at the CCD.

STATEMENT BY AMBASSADOR MARTIN TABLING U.S. WORKING PAPER ON SEISMIC VERIFICATION AT CCD, AUGUST 24, 1972

Bulgarian delegation hopes that all countries of the world will send positive and comprehensive replies to the Secretary General of the United Nations in accordance with the requirements of Resolution 2833 (XXVI), and that preparatory work for a WDC will start very soon.

Mr. MARTIN [United States of America]. I would first like to take great pleasure in joining the previous speakers in welcoming Lord Chalfont to our meeting. He has contributed so much to the work of the committee in the past.

Also before beginning my prepared statement, I would like to say that I have listened very attentively to the statement of our colleague from Japan. Mr. Nisibori, who spoke on the same subject as my own today. I am sure that we will wish to study Mr. Nisibori's statement with very great care.

I will now begin my prepared statement.

During this summer session there have been a number of interventions addressed to the subject of the comprehensive test ban (CTB). Many speakers have characterized this issue as the most important one before this Conference.

Mr. Ignatieff, the representative of Canada, emphasized among other points the importance of the CTB as a limitation on future military developments. Mrs. Myrdal, the representative of Sweden, who with patience and persistent effort has stimulated our discussion of this subject, once again has raised important questions on several aspects of a CTB. Secretary General Waldheim, in his opening address, emphasized that the CTB would play a major role in furthering the cause of nonproliferation, a view with which we fully agree. Although we cannot agree with all the views that various speakers have expressed, we do agree that a CTB is an extremely important measure.

Our position on the CTB is well known. Nevertheless, we believe it is timely once more to restate it and the rationale behind it. We welcome the questions which have been addressed to us and are happy to provide answers to the extent we are able.

In essence the U.S. Government supports the achievement of a CTB treaty which is adequately verified. What constitutes adequate verification, however, has been and continues to be the fundamental point of difference between us and many other delegations, including the Soviet Union. I will return to this later.

I would first like to consider the questions raised by Mrs. Myrdal. She asked, in effect, if there were nuclear test requirements for new strategic deterrent weapons such as the Trident submarine and the B-1 bomber which were preventing the United States from accepting a ban on underground nuclear weapons tests at this time. The answer to this question is "No." It has been the consistent policy of the U.S. Government to support the conclusion of a CTB in an adequately verifiable agreement.

Mrs. Myrdal's question brings to the forefront one of the important aspects of nuclear weapon testing as it relates to a comprehensive test ban. One of the basic reasons for testing is to make a total weapon system as effective as possible for achieving its military objectives. Some nuclear weapon tests are thus directed toward the development of a nuclear warhead which, in combination with the nonnuclear characteristics of a particular weapon system, will maximize the military effectiveness of the entire system.

The United States is prepared to give up the advantages derived from nuclear weapon testing only if we can be assured that other treaty partners are abiding by the same restrictions. If one party to a CTB accepted this restriction while another party, by means of clandestine testing, continued to improve the military

effectiveness of its systems, this could in time lead to an adverse effect on strategic stability. Even if all parties to a treaty abided fully by all treaty provisions, a lack of adequate verification capabilities could foster uncertainties about whether other nuclear powers were actually complying with the treaty in all respects. Such uncertainties could, under some circumstances, lead to strategic and political instability because of the efforts that one nation might make to hedge against unknown but feared developments elsewhere. One of the objectives of arms limitations, I am sure we would all agree, is increased stability, not additional instability.

The thought has been expressed many times that the nuclear weapon developments that might be attempted clandestinely under a CTB verified by national means would have only minor technical and military significance. We must take exception to this. Nuclear weapon tests at relatively low yields can be of military significance for strategic weapon systems. In addition they can be significant for tactical nuclear weapon systems. Unfortunately, the restrictions of military security hamper a detailed discussion of this important consideration. However, I wish to note the annual report of the U.S. Atomic Energy Commission, which states that over half of the listed nuclear weapon tests carried out by the United States are in the low-yield category; that is, with explosion yields of less than 20 kt. Tests at such yields can therefore be significant for the development of strategic and tactical nuclear weapon systems.

At this point it is appropriate to turn to the aspect of this subject which has dominated our discussion of a CTB—the detection and identification of seismic events. Mr. Ignatieff and Mrs. Myrdal have both expressed an interest in a status report on the use of large seismic arrays for the detection and identification of seismic events. Today I would like to introduce a working paper dealing with current progress and problems in seismic verification. This paper reviews the progress made toward attaining the research objectives outlined in the U.S. working paper of June 1971. In today's working paper we describe the current status of the use of large seismic arrays for seismic identification, and the current status of research in other important aspects of the seismic verification problem. The paper also discusses our plans regarding future research directed toward resolving some of the important problems that still remain. Let me describe in layman's language the principal features of this rather technical paper.

Section I reviews our assessment of the detection capabilities of the large seismic arrays and the status of the research in the United States related to very long-period seismometers and their capabilities. In the past year two significant developments have occurred. With regard to short-period arrays, there has been at LASA an important improvement in the techniques for automatically detecting events, reducing the threshold for the automatic detection of events almost to the limit for this array. Second, high-quality data from the full NORSAR array have provided a means of estimating the ultimate threshold for the detection of P-waves by that array. The development of automatic detection methods for NORSAR is now underway. With respect to the long-period arrays, sufficient data have now been obtained to estimate their detection thresholds in certain areas.

For example, preliminary analysis indicates that LASA and NORSAR can detect Rayleigh waves from Kurile-Kamchatka earthquakes of about surface-wave magnitude 3.1 and 3.0, respectively, whereas ALPA can detect Rayleigh waves on events of about surface-wave magnitude 2.6 from this area. During the next year, studies of other earthquake zones are planned. Perhaps more important, high-quality data from all these arrays and from the very long-period experiment stations have become available for documentation of the capabilities and limitations of identification criteria at low magnitude.

Seven stations of the very long-period experiment have been operating during the past year and three others are nearing completion. The very long-period experiment has demonstrated that high-gain instruments can be installed in such a manner that their capabilities are restricted only by seismic noise. It has also demonstrated that careful installation of instruments can significantly lessen the levels of such noise. Results from the very long-period experiment suggest that, rather than using data at periods of only 20 to 40 seconds, data from as broad a band as possible, extending from about 10 to 50 seconds, should be employed. We have seen that the capabilities attained at the prototype very long-period experiment station are attainable at other sites. Although we are only now attaining the technical capability of analyzing these data fully, initial analysis supports

the concept of the general applicability to earthquakes of the criterion based upon the relationship between the magnitudes of surface and body waves. But we must always keep in mind the existence of occasional anomalous events, which I will discuss next.

Section II of the working paper reviews several important remaining problems in seismic verification. First is the problem of some anomalous earthquakes which, for reasons not clearly understood, generate seismic signals whose character is not distinguishable from explosions by the criterion based on the ratio of surface-to-body-wave magnitudes. Although these events occur occasionally at body-wave magnitudes above 5.0, their number increases substantially at lower magnitudes. Our working paper presents a compilation of information on this phenomenon. We can conclude that, for events in the Tibetan-Himalayan region, the criterion based on the ratio between surface-and-body-wave magnitudes will not by itself positively identify explosions smaller than about body-wave magnitude 5.0.

It should be noted that, although the compilation was done for seismic events in one particular region, such events have been noted on some occasions to occur in some other regions as well. Continuing research may permit us to understand the causative mechanism of such events and place limits on where they may occur in some other regions as well. Continuing research may permit us to understand the causative mechanism of such events and place limits on where they may occur in the future; we may also be able to derive other criteria for the proper classification of such events.

A second important problem is that posed by the interference of long-period signals from two or more discrete seismic events. In some cases the interference of the signals can be so severe that any extraction of useful information of the later-arriving signal is almost impossible. In this case it would not be possible to employ a criterion based on surface waves for identification. In other cases and with certain techniques, the problem becomes more manageable. It is possible in such cases to separate the interfering surface waves of the two seismic signals, thus allowing use of a criterion based on the relationship between the magnitude of surface and body waves. In the working paper a detailed description is given of the use of arrays and of analytical techniques of separating mixed events. In the examples studied, the number of mixed events which could not be effectively separated was reduced to 6 percent of the original number. Possible approaches which may enable an even greater improvement are described.

A third problem is that posed by technically possible evasion techniques. The working paper contains (1) a table summarizing the known techniques available to clandestine testing, (2) the estimated yield limits for such testing in the context of detection capabilities of stations remote from the event, and (3) the constraints on the tester. One of the principal objectives of the U.S. research program is to devise measures which can be incorporated into seismic verification schemes in order to detect and thereby deter attempts at implementing techniques for clandestine testing.

Section III discusses some of the approaches to research suggested by the problems discussed in section II. Of these approaches I would like to single out just one which merits particular attention. This is a cooperative multinational project which has recently been undertaken under the aegis of the Lincoln Laboratory of the Massachusetts Institute of Technology. Participating groups are in Canada, Sweden, Norway, the United Kingdom and the United States.

This study will seek to achieve for a specified time interval a compilation of basic seismic data for nearly all seismic events in the Northern Hemisphere of body-wave magnitude 4.0 and greater. The number of potential events being considered is about 5,000.

For the first time we will be in a position to accumulate a single list of events which will form a common and agreed data base for comparative studies. The study will seek to answer a number of scientific and operational questions related to detection and discrimination by using all available seismic data. Without such a comprehensive study it has not been possible to evaluate or predict network performance.

The rest of this section of the working paper discusses future communications systems and data analysis, seismic instrumentation, study of improved seismic networks, and counterevasion research.

Our seismic research effort has not been restricted to teleseismic means. Research is continuing on the feasibility and the problems of developing tamper-resistant, tamper-indicating low-maintenance, unattended seismic observatories involving minimum intrusiveness. Our study includes an analysis of the vulnerabilities of these observatories to possible evasion by the host country, and an analysis of their possible effectiveness for improving identification. On the basis of our research to date we believe that unattended seismic observatories can be a useful addition to verification capabilities, though they are not the equivalent of onsite inspections.

I feel this would be an appropriate opportunity to comment on one of the issues raised by the representative of Canada, Mr. Ignatieff. He requested further information on the use of techniques based on the relationship between the magnitudes of surface and body waves in order to distinguish earthquakes from explosions. Summarizing, we have concluded from our research that we understand how to identify by teleseismic techniques about 90 percent of earthquakes down to those having a body-wave magnitude of 4.5; we also recognize that there are events which cannot be identified with current discriminants. In principle—and this is most important—seismic discrimination by the surface-body-wave magnitude criterion of about 90 percent of earthquakes down to body-wave magnitude 4.0 appears feasible. However, more work still needs to be done to determine precisely what seismic capabilities will be achievable.

I would like now to turn to another of Mrs. Myrdal's questions. She asked for technical details of, and the observational basis for, the congressional testimony given last summer by Dr. Carl Walske of the U.S. Department of Defense. In that testimony he said that in the Soviet Union there would annually be about three unidentified seismic events above body-wave magnitude 4.5, and about 25 unidentified events above body-wave magnitude 4.0. The estimated 25 unidentified events constitute about 10 percent of the annual number of seismic events in the Soviet Union at bodywave magnitude 4.0 and above as determined by teleseismic means. These will consist primarily of mixed events and anomalous events such as are discussed in our working paper. The paper suggests that unidentifiable mixed events alone account for about 6 percent of total detected events. However, this figure is based on a limited set of events. It may well be that the percentage of mixed events will increase when all events of body-wave magnitude 4.0 or greater are investigated. The 6 percent figure also does not include anomalous events in the Soviet Union or other factors such as instrument malfunction. Therefore the 10 percent estimate for teleseismic identification criteria is a fair assessment of the problem. Since it has been estimated that about 250 events occur each year in the Soviet Union at magnitudes of 4.0 and above, this leads to the estimate of 25 unidentified events in this magnitude range cited by Dr. Walske. The importance of these numbers is, of course, that they represent a not insignificant set of seismic events which cannot be unequivocally established as earthquakes and thus potentially could be underground explosions. This set of unidentified events forms a natural background of ambiguous events which could give cause for concern.

Mrs. Myrdal has asked us to define what we mean by adequate verification. We do not believe that, as has been assumed in some theoretical studies, this question can be addressed in simple numerical terms. We consider adequate verification as that which would reduce to an acceptable level the risk that clandestine test programs of military significance could be conducted under a CTB. In the last analysis, a determination of what constitutes adequate verification can only be made on the basis of a careful assessment of all of the current and potential risks against the current and potential availability of the means for deterring and, if necessary, discovering attempts to conduct testing clandestinely. We must assume that any party seeking to violate a CTB by clandestine testing would take sophisticated precautions in order to minimize the seismic signals or explosionlike characteristics of its tests. Or, to put it another way, such a party would seek to make the explosions look seismically more like earthquakes. Some of these techniques have been discussed in the 1968 SIPRI report and were also discussed in the last CTB experts meeting. We have to face the fact that, if only national systems are used, even with advanced seismological techniques, there will still be a substantial number of unidentified or ambiguous natural seismic events. These could provide a background against which some number of clandestine nuclear tests could be hidden. On the basis of seismic

means alone there could be no objective way to resolve the true character of such events. Onsite inspections, however, could provide just such a method—and it is in fact the only method that we know which could identify the nuclear character of some seismic events. Thus, onsite inspections can be useful in helping to deter a country from conducting prohibited tests by increasing the chance that any significant violations will be discovered. This, in turn, will increase the probability that clandestine testing will not be judged to be worth the risk. We regard this increase in verification capability as necessary.

An additional aspect of the verification problem is found in the difficult issue of how peaceful nuclear explosions could be accommodated within a CTB while simultaneously insuring that such explosions will not be used for weapon development. This problem arises from the fact that peaceful nuclear explosive devices are inherently indistinguishable from devices suitable for military purposes.

I have commented today on various issues and questions raised by the representatives of Sweden and Canada. We have also submitted a status report on the progress of our large seismic array program. Together with this report we have submitted a description of our current and planned research which we hope will further our understanding and capabilities in the area of seismic verification. We sincerely hope that our efforts will be helpful to the members of the Committee.

All delegations here have stressed the importance of a comprehensive test ban as an arms-control measure. We share this view of its importance. All delegations have also recognized that the question of verification is a vital issue. The United States has already expended a very great effort to build up and improve verification capabilities, and, as the President of the United States has said on a number of occasions, the United States will continue to support efforts to improve worldwide seismological capabilities.

The CHAIRMAN (Yugoslavia). On behalf of the Cochairman, I should like to request that this morning's official meeting be followed immediately by an unofficial meeting for the purpose of consulting the Committee with respect to the questions raised at our last plenary session by the representatives of Canada and Mexico.

The Committee agreed.

[The meeting rose at 12:50 p.m.]

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

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A review of current progress and problems in
seismic verificationContents

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Introduction

The scope of the ongoing United States program, Project VELA, devoted to research into seismic verification of an underground test ban has been previously reported to the Conference in a working paper of August 1971, CCD/330. The present paper reviews the progress towards attaining the research objectives outlined at that time, and discusses certain residual problems presently preventing seismic verification down to low magnitudes. It also outlines some directions that are currently being pursued in seismic instrumentation, seismic systems, and deployments to assist in the solution of these problems.

Section IRecent Progress in Seismic Verification Research

The U.S. Large Array Program is now halfway through its two-year evaluation program. Available data indicate the capability of these arrays as research tools and their potential for seismic monitoring systems. In the companion Very Long Period Experiment, seven stations have been in operation during the past year and three others are nearing completion. The results of this experiment indicate the value of careful emplacement of instruments to ensure that the residual noise is in fact earth noise and pose some interesting questions as to the emplacement and seismometer bandwidth of future installations. This section is a review of progress to date in these programs and indications for future research.

Signal Detection Capabilities of Large Arrays

Research has continued on the detection capabilities of the three large seismic arrays developed under the U.S. research programs. These are the Large Aperture Seismic Array (LASA) in Montana, the large Research Array in Norway (NORSAR), and the Alaskan Long Period Array (ALPA). During the past year, two significant developments have occurred. First, there has been an important improvement in the techniques for automatically detecting events at LASA, bringing the automatic seismic event detection threshold close to the limit for this array. Second, high quality data from the full NORSAR array have provided a means to estimate the ultimate P-wave detection threshold for that array and the development of automatic detection methods is now well underway. Turning to the long period arrays, sufficient data have now been obtained to estimate their detection thresholds for seismic events. Summaries of both short-period and long-period detection thresholds are described below. High quality data from all three arrays have become available for the initial studies of capabilities and limitations of identification criteria at low magnitude.

Capability to Detect Short-Period P-Waves

P-wave detection thresholds of short-period arrays are ultimately limited by:

- (a) The amplitude and variability of the ambient noise which exists in the earth at the detection site.
- (b) The improvement in effective signal-to-noise ratio which can be achieved by combining the outputs of all of the sensors of the array, and
- (c) The reduction in amplitude of seismic signals of interest caused by filtering and combining signals from the array's sensors.

These parameters are measurable, and may be used to determine the ultimate threshold of an array. The first two parameters, measured in the frequency band of the P-wave signals of interest, define the irreducible noise at the output of the array, and hence the amplitude of the minimum detectable P-wave signal. The third parameter is then used to define the P-wave earth motion input required to produce the minimum detectable signal at the array output. This earth motion may then be interpreted in terms of earthquake magnitude.

The limiting threshold for LASA has been established for several years, and reported in several publications of Lincoln Laboratory and the Seismic Data Laboratory [Ref. 1, 2]. These studies indicate that the ultimate teleseismic detection threshold of the LASA array is about m_b 3.9 (LASA magnitude) at the 90% confidence level. Based on recently acquired data from NORSAR, we may now estimate that the ultimate teleseismic detection threshold is about 4.1 (NORSAR magnitude) for that station at the 90% confidence level. Details of these estimates are given in Table I.

Developing the capability to approach these ultimate detection thresholds by automatic means has been one of the goals of the U.S. seismic research program. Last year it was reported to the CCD that equipment for automatic event detection had achieved a threshold of $m_b = 4.2$ at the 90% confidence level for LASA. Since then, improvements in the computer logic for recognizing earthquake signals has lowered this threshold to $m_b = 3.9$.

This threshold was verified by counting the number of earthquakes detected in small magnitude increments and observing the magnitude level at which the number of detected events no longer increase as expected. Figure 1 shows the incremental histograms of 4,884 seismic events automatically detected by LASA at distances between 30° and 85° . The body wave magnitudes are those determined directly by LASA, which agree closely with magnitudes reported by the U.S. National Oceanic and Atmospheric Administration. The general trend of increasing numbers of events detected as the magnitude decreases continues from magnitude 6 down to magnitude 4. The rate of increase drops sharply just below magnitude 4 as increasing numbers of earthquakes which are known from other evidence to occur are no longer detected by LASA. The incremental histogram implies that 90% of the expected number of $m_b = 3.9$ earthquakes are detected, confirming that this is the current threshold for automatic event detection at LASA.

Table I

ULTIMATE SHORT-PERIOD THRESHOLDS FOR LASA AND NORSAR BASED
ON MEASURED EARTH NOISE AND OBSERVED SIGNAL LOSSES

	LASA (345 sensors)	NORSAR (132 sensors)
Earth noise input, single sensor. 90% probability that input noise in the 0.4-3 Hz passband will be equal to or less than this amplitude	2.6 mμ (rms)*	4.5 mμ (rms)
Array noise output, optimum real-time processing. 90% probability that array output noise in the 0.4-3 Hz passband will be equal to or less than this amplitude	0.5 mμ (rms)	0.45 mμ (rms)
Minimum detectable signal on array output, 90% confidence. 3 x rms of 90% array output noise	0.9 mμ (o-p)**	1.35 mμ (o-p)
Minimum detectable input signal, 90% confidence. Input signal required to produce minimum detectable output signal at 90% confidence in presence of array output noise. Based on 3 db loss caused by filtering and intersensor incoherence	1.3 mμ (o-p)	1.9 mμ (o-p)
Teleseismic detection threshold, 90% confidence. Average teleseismic magnitude (300-800) derived from minimum detectable input signal, based on $\bar{m} = 3.8$ + log A/T	$m_b = 3.9$	$m_b = 4.1$

* rms = root mean square, .707 x maximum amplitude

** o-p = peak amplitude measured from the base or zero line

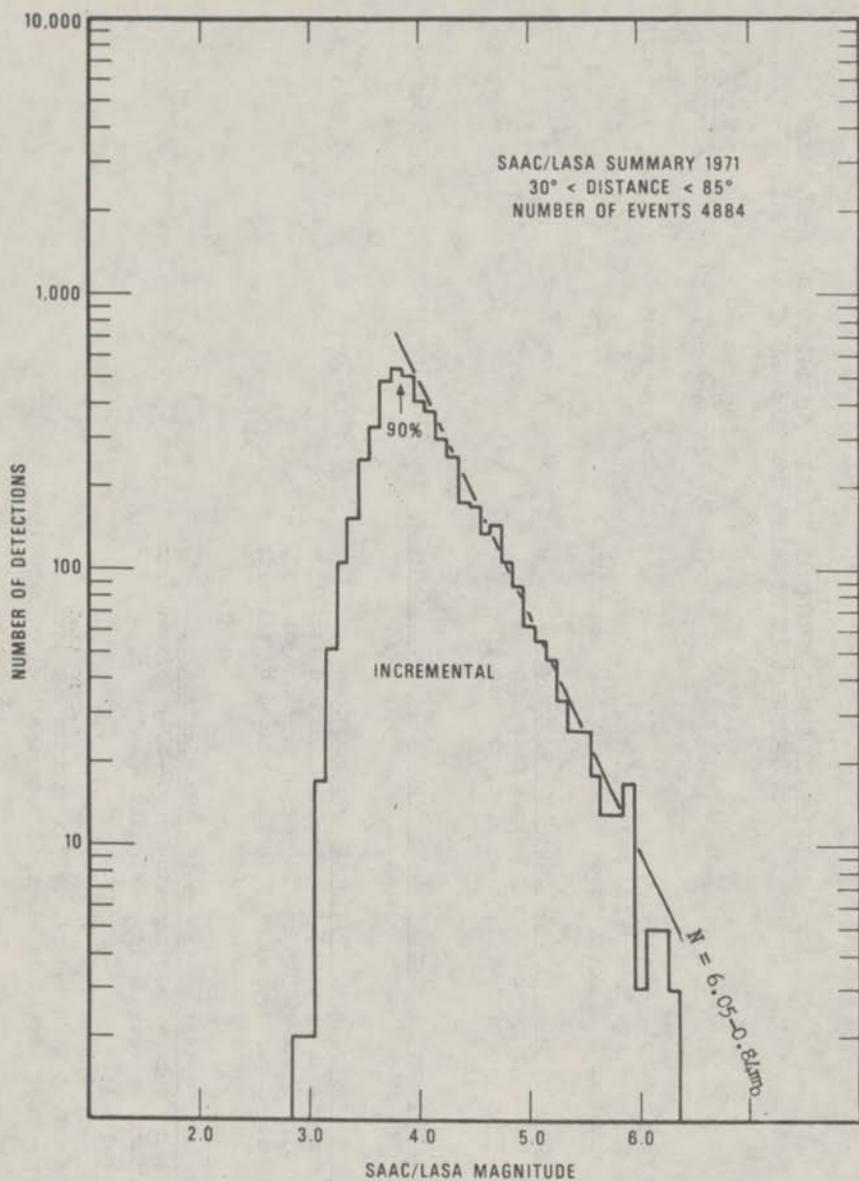


Figure 1. Number of detected events versus LASA bodywave magnitudes.

Automatic event detection methods at NORSAR have not yet been fully developed to take advantage of signal and noise characteristics at that site. Accordingly, the lowest possible automatic event detection threshold at that station has not yet been achieved. Preliminary data similar to that given for LASA in Figure 1 suggest that the current automatic event detection threshold of NORSAR is near $m_b = 4.4$ (90% incremental). Although NORSAR's ultimate short-period threshold will not quite equal that of LASA, its long-period characteristics are equally as good. Furthermore NORSAR and LASA are now providing crucial data needed for research on events in regions of common coverage.

Capability to Detect Long-Period Waves

An initial evaluation of the long-period detection capabilities of NORSAR, LASA, and ALPA has recently been completed. The earthquake source region chosen for the study was the Kurile-Kamchatka area which is about 60° from NORSAR and LASA and 30° from ALPA. The processing used was filtering and beamforming of vertical seismometers augmented by matched filtering when required. It appears that this is very close to optimum processing for those arrays. A preliminary estimate of the 90% incremental detection thresholds for Rayleigh waves, in the absence of interfering events (which are discussed separately later), were determined to be $M_s = 3.0$ for NORSAR, 3.1 for LASA, and 2.6 for ALPA. These values were obtained from histograms of numbers of earthquakes vs magnitude in a manner similar to that discussed previously for short-period detection thresholds. A simple correction to normalize these magnitude values to a common distance indicates that all three arrays can detect surface waves down to a magnitude of M_s 2.5-2.6 at 30° . Further data may modify these estimates.

To determine the utility of the large long-period arrays for the discrimination problem, it is also necessary to know the threshold of these arrays in terms of body wave magnitude. That is, for an event of given m_b we want to know the probability of detecting Rayleigh waves to be used in criteria such as that based upon $M_s:m_b$. The correlation of body wave and surface wave magnitude is complicated by the fact that surface wave magnitudes are dependent upon the depth of the seismic event, and a determination of the depth of focus is important to this correlation. We are currently investigating this problem, particularly in a comprehensive study of worldwide data (see Section III), with a view to defining the body wave magnitude of shallow focus earthquakes corresponding to the surface wave magnitude thresholds of the large arrays for various seismic areas of the world.

Very Long Period Experiment

The Very Long Period Experiment has two principal objectives. The first is to demonstrate that high gain instruments can be installed such that their performance is limited only by earth noise and to demonstrate that careful siting of the instruments can markedly reduce the amount of earth noise. The second is to exploit the fact that the instrument response was designed to be at a maximum where the earth noise level is at a minimum between 30 and 50 seconds (Figure 2). It was anticipated that this favorable "window" for viewing surface waves from earthquakes and explosions would reveal new characteristics that might supplement our previous experience at periods in the vicinity of 20 seconds. Of particular importance was the hypothesis that there might be a greater separation of the earthquake and explosion population on the $M_s:m_b$ plot than exists at 20 seconds.

Seven stations have been used extensively in recent studies. The seven existing stations are listed in Table II, together with their geological settings. The base noise levels for the vertical, North-South, and East-West horizontal components at 20 seconds and 40 seconds with a passband of 0.013 Hz are shown in Table III. During particularly noisy periods, however, the noise levels can be an order of magnitude greater than the base levels at 20 seconds due to microseismic storms. Base levels, therefore, represent the quietest conditions at the stations recorded to date. The locations of the stations and their 30° area of coverage are shown in Figure 3.

The results indicate that careful design of seismometer, instrument container, and vault has resulted in an instrument which is sufficiently insulated from the environment that we can have confidence that it is recording only ground movement. This is an important achievement because full utilization has been made of the instrument gain, as much as 100,000, at periods of 35 to 40 seconds. The equivalent earthquake m_b detection capability of the first four stations built for various seismic areas of the world is shown in Figure 4. This figure indicates that these four stations give an m_b 4.3-4.4 in the Kamchatka-Kurile region and an m_b 4.5 or less capability in most areas investigated. An enhanced capability could be achieved by more stations, possibly as small arrays, and by digital data processing.

The stability of the noise level at 40 seconds is apparently greater than that at 20 seconds. This stems from the origin of the noise components at two periods, that at 20 seconds being from microseisms and that at 40 seconds from local

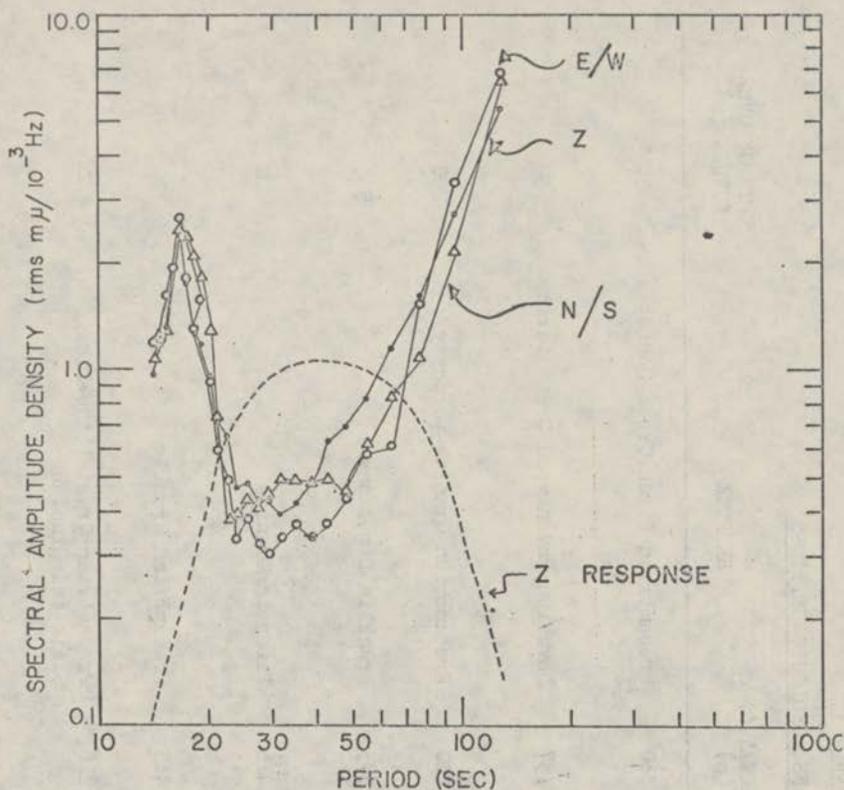


Fig. 2 The three-component, vertical, North-South, and East-West, noise spectra at Ogdensburg, New Jersey, compared with the vertical component instrument response curve.

TABLE II
STATION LOCATIONS, GEOLOGIC SETTINGS

STATION	LATITUDE	LONGITUDE	ELEVATION (m)	BEDROCK	DEPTH OF OVER- BURDEN (m)
Fairbanks Alaska	64°53'N	148°00'W	330	Precambrian Birch Creek Schist	20
Charters Towers Australia	20°05'S	146°15'E	357	Devonian Ravenswood Granodiorite	30
Eilat, Israel	29°33'N	34°57'E	200	Precambrian Granite-porphry	200
Ogdensburg New Jersey	41°04'N	74°37'W	373	Franklin Limestone	543
Chiang Mai Thailand	18°47'N	98°58'E	416	Triassic Granite	0
Toledo, Spain	39°51'N	4°00'E	465	Precambrian Granite	20
Konigsberg Norway	59°38'N	9°35'E	216	Precambrian Crystalline-like Slate and Granite	340

TABLE III

RMS Base Noise Levels at 20 and 40 Second Period
With 0.013 Hz Band Width at Both Periods
(At Least 8-Hour Samples)

Station	20 Seconds			40 Seconds		
	Vertical	North-South	East-West	Vertical	North-South	East-West
Fairbanks Alaska, USA	9	5	3	7.3	7	7
Charters Towers Australia	4.6	3.5	5.2	3.6	11*	11
Eilat, Israel	3	**	3.2	2	**	3
Ogdensburg New Jersey, USA	8	8.6	8	3.2	7	7
Chiang Mai Thailand	10	10	10	3.1	12	12
Toledo, Spain	4.3	4.3	13	3.7	11.5	16
Konigsberg Norway	3.6	4	4.5	1.6	3	2.7

90% Confidence Level, 2.2 db Spread

* Daytime average level -- night-time level is 3.6 mu.

** Instrument malfunction.

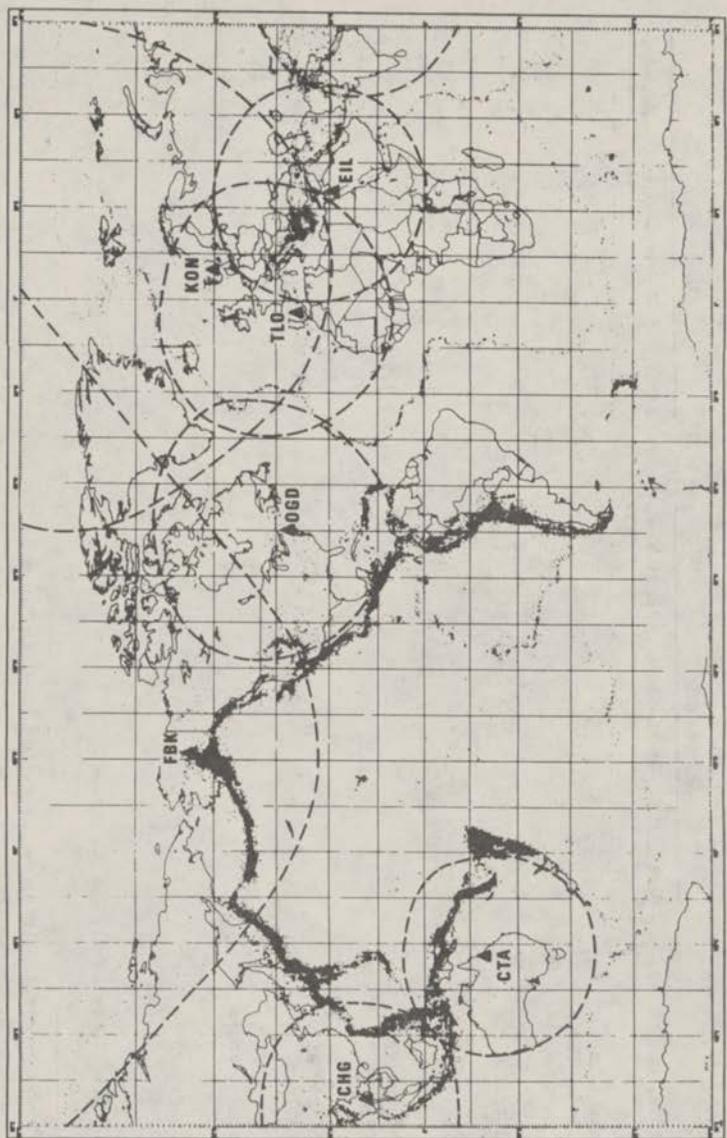


Figure 3. The distribution of the very long period experiment sites and their 30° coverage area. World seismicity during 1961-1969 is also shown.

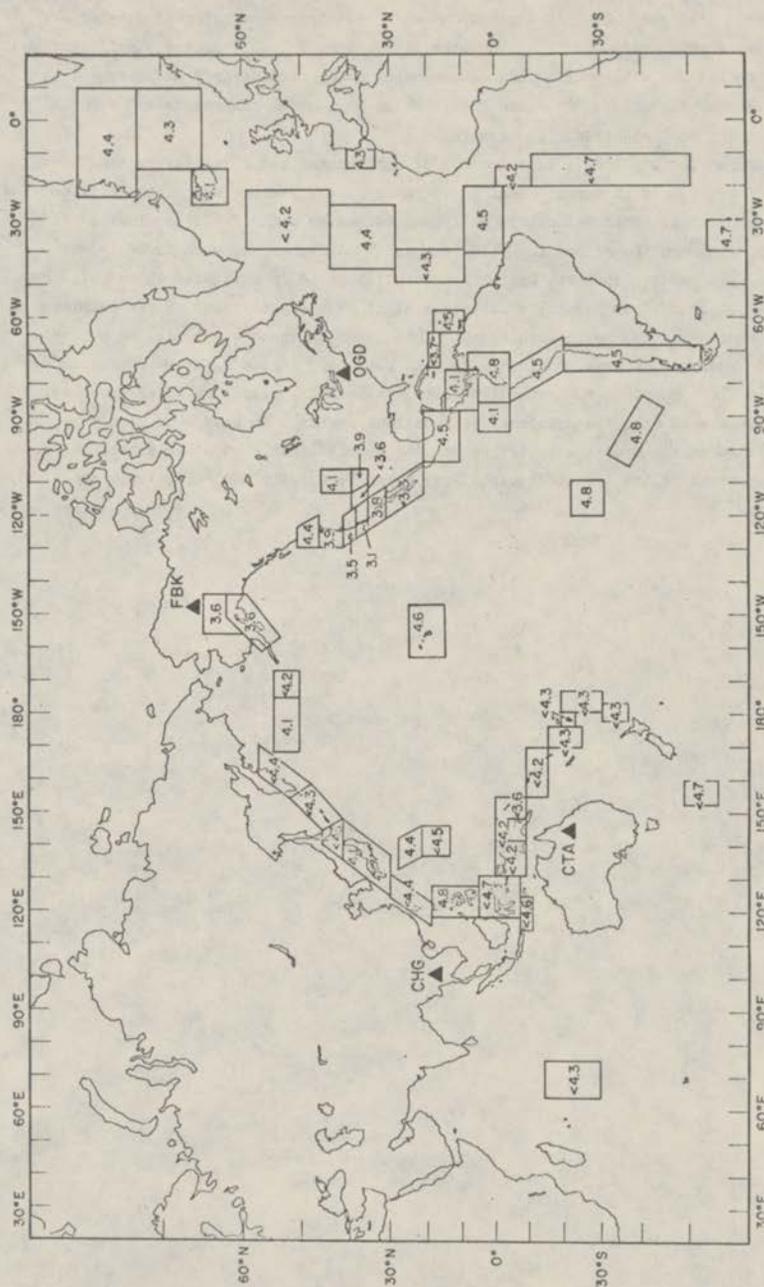


Fig. 4 The Seismic Capability, in Terms of m_b Equivalent, of the Very Long Period Experiment Stations for Some of the Seismic Areas of the World. The m_b values are those for single station detections.

atmospheric perturbations. At depth these different origins might have greater significance than at the surface since the microseisms do not decrease significantly with depth but the atmospheric-induced component does, particularly with respect to the horizontal signals due to earth tilt. These horizontal components are especially important for the detection of Love waves.

Based on results from a large number of earthquakes and a relatively small number of explosions it appears that no increase in the average separation between earthquakes and presumed explosions will be obtained by using $M_s(40):m_b$ instead of $M_s(20):m_b$ although the spread in $M_s(40)$ values at a given m_b appears to be less. Azimuthally-dependent spectral criteria have still to be investigated in detail. By the utilization of deep boreholes advantage might possibly be taken of the suppression of atmospheric-induced noise with depth. This is an approach which will be pursued further. Analysis of data obtained under the Very Long Period Experiment program has supported the concept of the general utility of the $M_s:m_b$ criterion to earthquakes, always keeping in mind the existence of anomalous events. We have seen that the capabilities attained at the prototype station are attainable at other sites. We are only now attaining the technical capability to analyze fully and effectively the VLEE data.

Section II

Important Remaining Problems

Some detailed studies over the past year have attempted to provide quantitative information on several problems which were discussed previously but for which no precise data have been available. For instance, it was suggested in the U.S. Working Paper last year that the $M_S:m_b$ criterion for seismic discrimination might fail occasionally, for reasons unknown. Such events, sometimes referred to as false alarms, appear in the explosion population on the $M_S:m_b$ plot. Another question unanswered previously was the extent and severity of the mixed event problem at low magnitudes. This phenomenon has been investigated further and is reported in this section. Finally, of continuing concern is the possibility of evasion. The current U.S. research into possible clandestine testing techniques and research into ways of deterring such testing is reviewed briefly.

Anomalous Events

A number of effective discriminant criteria may be successfully employed for distinguishing between signals from earthquakes and explosions. One of those in extensive use is a comparison of amplitudes of long-period surface waves and amplitudes of short-period body waves; i.e., the so-called $M_S:m_b$ criterion. It is intended to be applied to shallow focus (depth less than 60 kilometers) events. It has been found that in most cases such earthquakes have much higher M_S values for a given m_b value than do explosions.

For reasons not thoroughly understood at this time, some earthquakes are inefficient generators of Rayleigh waves. These events, most of which appear to be of shallow focus on the basis of the Preliminary Determination of Epicenters by NOAA, give surface wave magnitudes that are so low that they are statistically indistinguishable from explosions by the $M_S:m_b$ criterion. Although these events occur occasionally at magnitudes slightly above $m_b 5$, their numbers increase substantially at low magnitudes; this is largely because there are more seismic events at low magnitude.

To document this phenomenon, a study was made of $M_S:m_b$ characteristics of earthquakes in a region comprising the eastern Himalayas and parts of Assam and Tibet. This region was chosen because there had been previous indications that anomalous Rayleigh wave energy was associated with some seismic sources in the area.

Fifty-three earthquakes occurring between 1963 and 1970 within the region, bounded by latitudes 27°N and 34°N and longitudes 92°E and 100°E, were selected for study. Epicentral characteristics are listed in Table IV. Stations whose data contributed to the analysis were Shillong, Poona, and New Delhi, India; Kabul, Afghanistan; Quetta and Lahore, Pakistan; and Chiang Mai, Thailand. It was decided not to obtain Rayleigh wave data from more distant stations although the proximity to the seismic zone of the stations used could introduce some bias. All individual station magnitudes were normalized to the mean values from the network on large events to minimize possibilities of bias when signals were detected at only a few stations.

Surface wave magnitudes were computed by three methods, using the Prague, Marshall and Basham, and von Seggern formulas with only slight differences in the results. The data presented in this paper are based solely on the method of Marshall and Basham (including depth corrections) since this technique is gaining wide acceptance.

The plot of $M_B:m_b$ is given in Figure 5 for all events whose depth is estimated to be less than 60 km. The shaded area encloses all explosion data for Central Asia (Eastern Kazakhstan and Sinkiang) shown by Marshall and Basham [Ref.3].

The $M_B:m_b$ plane in Figure 5 is divided into three parts by the lines

$$M_B = m_b - 1.0$$

$$M_B = m_b - 1.5$$

It will be observed that the M_B and m_b values of the Marshall and Basham explosion population lie below the line $M_B = m_b - 1.5$. It should be understood that the points which are plotted are subject to normal statistical error. Accordingly, an event with mean M_B and m_b values which plots somewhat above the explosion zone may, nevertheless, be statistically indistinguishable from an explosion by this criterion. Region I, above $M_B = m_b - 1$, can be safely characterized as containing only earthquakes. It is clear from Figure 5 that the values of $M_B:m_b$ for numerous earthquakes in this area below about $m_b 5.0$ cannot be distinguished with confidence from explosions. The conclusion of this study is that for events of this area, the $M_B:m_b$ criterion by itself is not a positive identifier of explosions smaller than $m_b 5.0$, although it should be pointed out that an event as high as $m_b 5.5$ was observed to lie within the explosion population. While the examples of anomalous events given here are derived from a particular region, such events have been noted on some occasions to occur in some other regions as well (Ref.4).

TABLE IV
List of Events

DATE MO DAY YR	ORIGIN TIME	COORDINATES		DEPTH KM	M _b	M _s **	GEOGRAPHICAL REGION
		N.LAT.	E.LONG				
07 05 63	7 19 15.8	27.7	92.1	*	4.2	3.90	Assam, India
10 08 63	2 51 6.0	28.6	95.1	24	5.4	4.33	Assam, India
11 16 63	11 39 37.8	28.1	95.1	37	4.7	3.93	Assam, India
01 07 64	4 50 37.0	29.8	98.7	46	5.0	4.38	Eastern Tibet
01 27 64	5 29 27.0	29.2	97.2	*	4.9	3.87	Southern Tibet
04 30 65	7 13 23.1	28.3	96.0	*	4.4	3.96	India-China Border
06 04 65	15 56 56.0	31.7	95.2	*	5.0	3.87	Tibet
07 31 65	16 36 53.8	32.7	93.2	*	4.9	4.27	Tibet
07 31 65	17 7 52.6	32.7	93.1	*	4.7	4.81	Tibet
07 31 65	19 1 9.4	32.8	93.0	*	4.4	4.40	Tibet
07 31 65	21 44 47.8	32.7	93.1	21	4.9	4.60	Tibet
08 01 65	14 14 1.7	32.6	93.6	*	5.5	3.94	Tibet
08 01 65	20 9 17.9	32.6	93.3	32	5.3	4.78	Tibet
08 02 65	17 49 47.0	32.8	93.3	*	4.8	4.35	Tibet
10 06 65	8 3 3.2	29.2	96.1	27	5.4	4.10	India-China Border
12 09 65	20 26 4.0	27.5	92.5	22	5.3	4.47	India-China Border
01 31 66	2 35 5.8	27.9	99.6	*	5.6	4.87	Yunnan Prov., China
03 14 66	4 42 50.0	32.4	97.4	*	4.9	4.46	Tibet
05 27 66	14 35 5.0	27.4	96.5	51	4.8	4.34	Burma-India Border
09 11 66	15 55 20.0	27.0	95.8	37	5.0	3.77	Burma-India Border
09 26 66	5 10 58.1	27.5	92.6	*	5.6	5.26	India-China Border
09 26 66	6 3 48.0	27.6	92.7	*	4.2	3.59	India-China Border
03 11 67	16 56 48.7	28.4	94.4	7	5.3	4.69	India-China Border
03 14 67	6 58 4.6	28.4	94.3	24	5.9	5.54	India-China Border
07 07 67	22 56 30.8	27.8	92.2	*	4.9	3.71	India-China Border
08 15 67	9 21 2.3	31.1	93.7	*	5.7	5.07	Tibet
02 16 68	5 37 54.2	33.7	95.1	*	4.8	4.51	Tsinghai Province, China
06 28 68	20 34 55.3	30.1	95.1	44	4.8	3.58	Tibet

TABLE IV (contd.)

DATE		ORIGIN TIME	COORDINATES		DEPTH KM	M _b	M _s **	GEOGRAPHICAL REGION	
MO	DAY		N.LAT.	E.LONG					
06	30	68	5 4 10.0	30.2	94.8	42	4.8	3.40	Tibet
07	01	68	3 11 10.0	30.3	94.5	28	4.3	3.00	Tibet
07	04	68	6 45 58.0	30.3	94.9	*	4.7	3.46	Tibet
07	13	68	6 5 54.2	30.3	94.6	*	5.0	3.46	Tibet
07	14	68	18 12 41.0	30.3	94.8	22	4.9	3.54	Tibet
07	15	68	5 9 5.9	30.3	95.0	22	4.8	3.39	Tibet
07	16	68	22 23 7.0	30.3	94.8	40	4.8	3.45	Tibet
07	23	68	20 51 47.9	30.3	94.9	30	4.9	3.43	Tibet
07	26	68	12 44 3.0	29.4	95.0	*	4.9	3.45	India-China Border
08	23	68	12 1 16.5	30.3	94.9	*	4.8	3.46	Tibet
08	24	68	14 26 7.4	30.0	95.1	56	4.6	3.35	Tibet
08	25	68	17 55 5.3	30.4	94.8	19	4.8	3.28	Tibet
08	29	68	19 51 24.6	30.2	95.1	*	5.0	3.48	Tibet
09	01	68	5 59 26.6	30.3	94.8	20	5.0	3.59	Tibet
09	03	68	17 45 54.1	30.2	94.8	53	4.9	3.43	Tibet
09	04	68	1 40 4.0	33.5	97.5	*	4.8	4.05	Tsinghai Province, China
09	11	68	3 7 32.0	30.3	94.9	38	4.3	3.52	Tibet
08	15	69	7 15 37.0	30.2	95.0	*	5.2	3.57	Tibet
11	24	69	2 1 9.3	30.6	98.9	12	4.6	4.00	Tibet
02	08	70	19 7 30.0	31.1	93.5	*	4.5	4.05	Tibet
05	08	70	11 8 8.4	32.8	95.2	35	4.5	3.55	Tibet
06	24	70	0 43 1.9	28.9	95.6	*	4.8	4.53	India-China Border

* Depth constrained to 33 km.

** Calculated according to the formula of Marshall and Basham (1971) including depth correction. For those events with constrained depths, the depth correction was applied as if they were at 33 km.

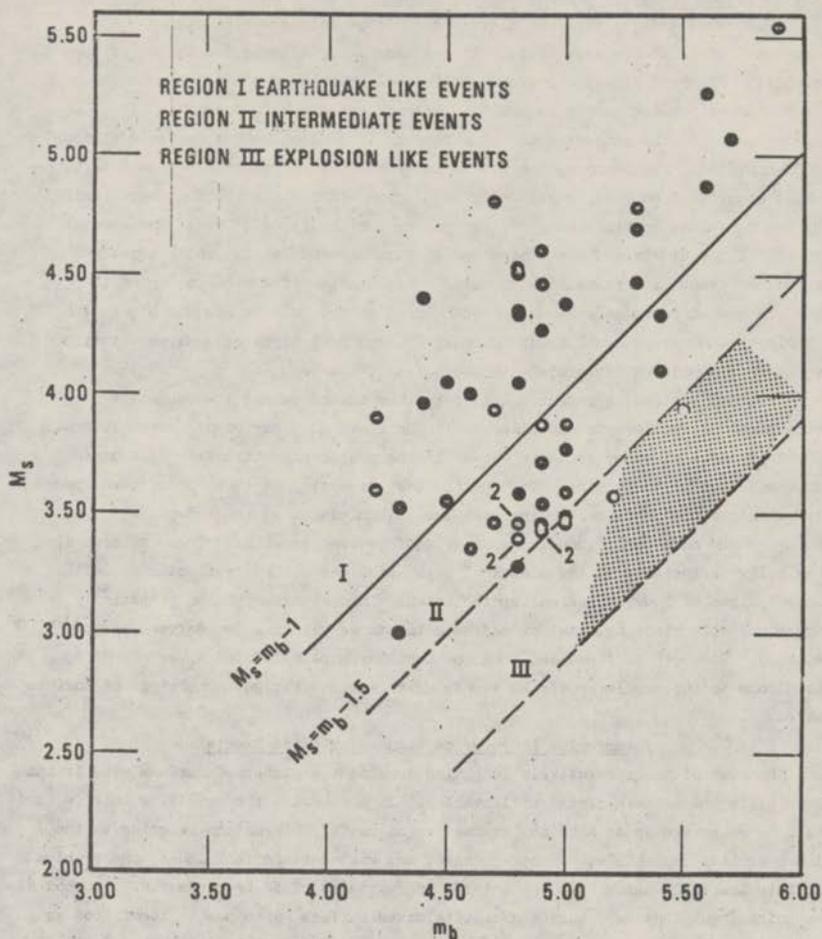


Figure 5. The m_b values are from NOAA. The M_s values are calculated according to the Marshall and Basham method with depth corrections included. Earthquakes have calculated depths 60 km or less or have had depth constrained to 33 km. Stippled area contains Marshall and Basham's observations of explosions in eastern Kazakh and Sinkiang.

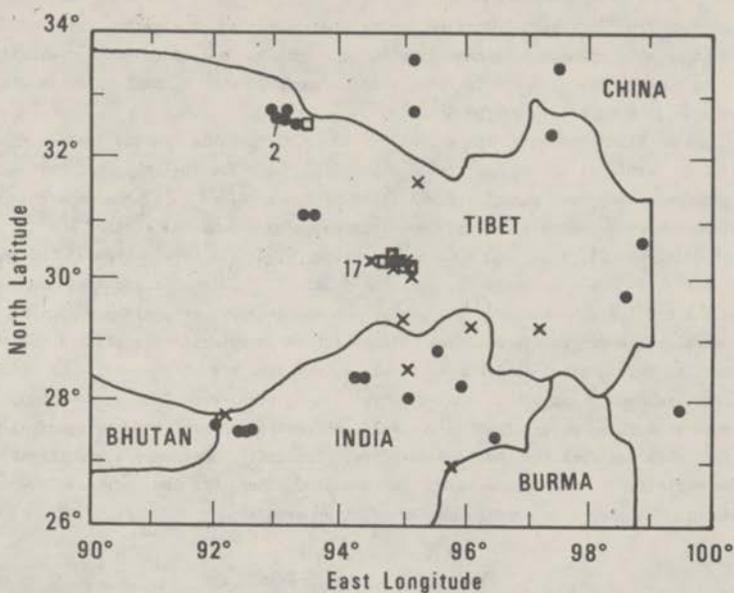
The cause and geographical distribution of anomalous earthquakes are an important field of research because it may assist in defining the extent of the problem. Figure 6 shows each event plotted and symbolized to indicate to which of the three populations in Figure 5 it belongs. A striking feature of the distribution is the concentration of explosion-like $M_s:m_b$ values centered at about 30°N and 95°E . Furthermore, the events in question occurred mainly in one sequence which occurred from June to September 1968. Two other clear regions characterized by low M_s values relative to m_b values can be distinguished. One is the frontal region of the Himalayas, also described by Marshall and Basham, which shows such anomalous events intermingled with normal earthquakes. The other occupies the eastern end of Assam and the north-south trending mountain ranges which join the Himalayas and extend south toward Burma. The observed magnitude characteristics would thus appear to correlate with geological features.

Perhaps continuing research will permit us to understand the causative mechanisms of such events and place limits on where they may occur in the future. The importance of other criteria for achieving proper classification of anomalous events is clearly indicated. Perhaps the most promising of those under development for events of $m_b 5$ and smaller involves the determination of focal depth with greater accuracy and more confidence than has heretofore been possible. These methods are basically refinements of the classical ones which use surface reflections, calibrated travel times of P waves and calibrated travel times of other phases (especially S where suitable stations exist or can be established within a few degrees of the source). Research on these and other methods may hopefully find a variety of solutions to the problem posed by events which are inefficient generators of surface waves.

Interfering Long-Period Signals or Mixed Events

Because of their relatively long time duration, a number of surface wave trains from different seismic events will overlap. In some cases the resulting interference will be so severe as to make any extraction of useful information relating to the later arrival impossible. In other cases, and with certain techniques, the problem is more tractable and allows the interfering wave trains to be separated. It should be pointed out that many earthquakes with mixed surface waves can be identified as earthquakes by a variety of other techniques, among which are establishing depth of focus and location by use of short-period data.

There are three distinct circumstances in which interference may occur, each causing different degrees of difficulty in effecting separation of the component events. The first is when signals from two events of approximately the same



- Earthquake like events ($M_S > m_b - 1.0$) (Region I of Figure 8)
- x Events intermediate between Explosion like and Earthquake like ($m_b - 1.5 < M_S < m_b - 1.0$) (Region II of Figure 8)
- Explosion like events ($M_S < m_b - 1.5$) (Region III of Figure 8)

Figure 6. Geographical distribution of various $M_S - m_b$ types. $M_S - m_b$ values were corrected for mean station magnitude differences prior to averaging. Marshall and Basham's method was used in the M_S calculations.

magnitude from different locations arrive simultaneously at a seismic station. The second is when signals originate from two discrete but nearly co-located events having roughly the same origin time, and the third is when a small event is mixed in the coda of a much larger earthquake.

As an illustration of the extent of the problem, Table V shows the percentage of mixed events at six single stations providing data for the Very Long Period Experiment. Expected signal arrival times at the stations for Eurasian events were calculated from origin times and locations given by a combined list of NOAA (including WSSN), IASA, and NORSAR epicenters. The data were collected between January 1, 1972 and February 20, 1972. A total of 155 signal sources within Eurasia are the data base for the study. On the average, about 16 per cent of the total possible single station observations showed interfering signals. An interfering signal in this context is taken to be one which, from visual inspection of actual seismic records, lies within the wave train of an event preceding it in time on the record to such an extent that no reliable information on amplitude or spectral content may be obtained from the combined waveform. Proximity to seismic areas causes some variation in this percentage. For example, Chiang Mai and Charters Towers both had a higher than average number of mixed events.

TABLE V
PERCENTAGE OF MIXED EVENTS AT
SINGLE STATIONS OF
THE VERY LONG PERIOD EXPERIMENT

	No. of Events Recorded During Study	Percent Mixed at Single Station
Charters Towers, Australia	154	19
Fairbanks, Alaska, USA	133*/	14
Konigsberg, Norway	154	14
Ogdensberg, New Jersey, USA	154	16
Toledo, Spain	133*/	12
Chiang Mai, Thailand	77*/	22

*/ in operation during only part of the period of the study.

TABLE VI
 SUMMARY OF INTERFERING (OR MIXED) EVENT OBSERVATIONS
 FOR SELECTED VIPE NETWORKS

Network	Number of Days Operational	Number of Events Analysed	Events Not Mixed	Number of Events Mixed at:					
				1	2	3	4	5	6 Stations
Charters Towers, Australia Fairbanks, Alaska, USA Ogdensburg, New Jersey, USA Kongsberg, Norway	5	44	26	18	11	7	4		
Charters Towers, Australia Fairbanks, Alaska, USA Ogdensburg, New Jersey, USA Kongsberg, Norway Toledo, Spain	27	70	48	22	12	9	7	1	
Charters Towers, Australia Fairbanks, Alaska, USA Ogdensburg, New Jersey, USA Kongsberg, Norway Toledo, Spain Chiang Mai, Thailand	25	41	18	23	11	9	6	4	3

The effect of a group of VLPE stations acting as a network is shown in Table VI. Since all the stations were not operable over the entire period of the study, results are given when 4, 5, or 6 of the stations were taken together as a network.

The tabulation shows that only in 92 out of 155 events was there no interference at all, but that the number of mixed events for which signals were obscured at all stations of the network was reduced as the number of stations in the detecting network was increased. Distribution of the totally mixed events as a function of magnitude was as follows:

TABLE VII

<u>Magnitude</u>	<u>$m_b < 4.0$</u>	<u>$m_b 4.0 \text{ to } 5.0$</u>	<u>$m_b > 5.0$</u>
Number of events for which all stations in network recorded mixed signals	3	3	2
Number of events in population	41	99	15

The largest of eight mixed events noted above occurred simultaneously with an m_b 5.0 event some 600-700 km away, so that the arrival times of the two were nearly the same at all stations. The signals from three intermediate magnitude events were mixed with large signals from m_b 5.5 events not occurring within Eurasia. Signals from the three low magnitude events were masked by either the signal or the coda from events outside Eurasia of magnitudes greater than m_b 4.5.

The above discussion centered upon the reduction of the mixed event population by the use of a geographically distributed network. Beamforming capabilities of an array can also be used as an effective means of separating mixed events. In particular, the frequency-wave number analysis technique has proved most effective.

Frequency-wave number ($f-k$) analysis is fundamentally beamforming in the frequency domain. The method takes advantage of the fact that signal-to-noise ratio is frequency dependent; therefore, beamforming is performed frequency by frequency. Since frequency-domain array analysis procedures are computationally faster than their time domain equivalents, many beams can be examined rapidly. In practice this means that the azimuth and velocity of a signal need not be assumed; one merely accepts the beam with the maximum power. The position of this maximum in the wave-number domain defines the azimuth and velocity of the signal, its amplitude being a function of ground motion amplitude and hence related to the seismic magnitude. A typical representation of a wavenumber spectrum at a period of 18.3 seconds is shown in Figure 7 (A). A large coherent signal from the northeast causes a power peak in

the wavenumber plane at a point corresponding to its azimuth and velocity, the velocity being inversely proportional to the distance from the origin of the wavenumber co-ordinates. The same wavenumber spectrum is shown in relief in Figure 7 (B).

The capability of f-k analysis to separate interfering signals is illustrated by comparing Figures 7 and 8. In Figures 7 (A) and 7 (B), a suspected small signal coming from the south is completely dominated by the large signal. However, the f-k technique allows us to remove the main peak along with its associated sidelobe and, thereby, bring out the smaller signal as shown in Figures 8 (A) and 8 (B). The analysis is, of course, done entirely by the computer and these illustrations merely give a visual representation of the results of the data processing.

The technique will allow the measurement of the magnitude of interfering events provided that the signals are less than a seismic magnitude apart in energy and the azimuthal separation is greater than 20° . Since the analysis is done in the frequency domain, in principle the spectral content can be preserved and spectral discriminants still utilized. In practice, however, some degradation of spectral information will probably occur. This is a subject of current research.

The utility of the f-k analysis technique for the separation of mixed events was tested in two recent studies. In the first, conducted from May 1, 1971 to January 23, 1972, signals from earthquake sources in the Kurile Islands were recorded at LASA (77 events) and NORSAR (74 events). In the second, 94 events were recorded at LASA, NORSAR, and ALPA from February 20, 1972 to March 1, 1972. The number of events mixed before f-k processing was applied, and after it had been applied, are shown for each array in Table VIII. Also shown is the effective reduction by the use of more than one array as a network in a similar fashion to the VLPE study. Array processing brings the mixed event population down to about 20 per cent and f-k analysis techniques improve the situation to just below 10 per cent. The use of multiple arrays reduces the number still further to about 6 per cent. The residual mixed events are due to nearby co-located events or very large events with long codas.

The problem of a small seismic event being mixed in the coda of a very large earthquake might be alleviated by the use of a network of high sensitivity broadband instruments close to the seismic zones. While the coda energy from a large earthquake tends to be omni-directional, it also tends to be concentrated at periods

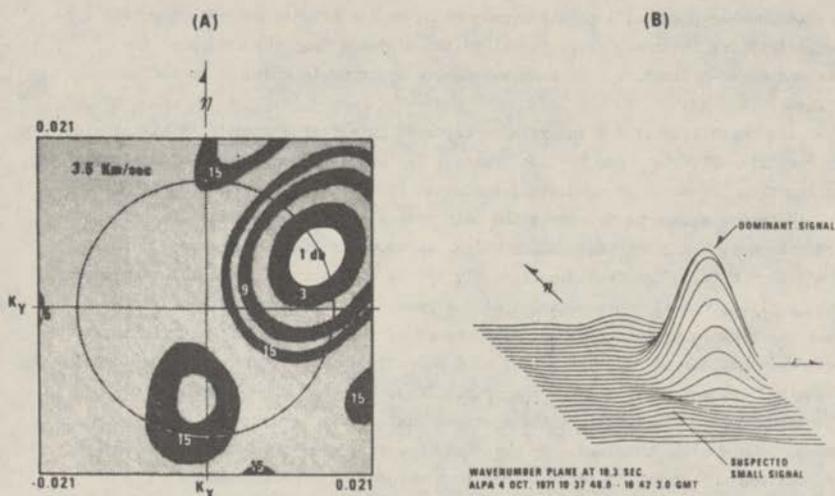


Figure 7. Frequency wavenumber representation of two interfering signals. The wavenumber plane is shown on the left and a relief version is shown on the right.

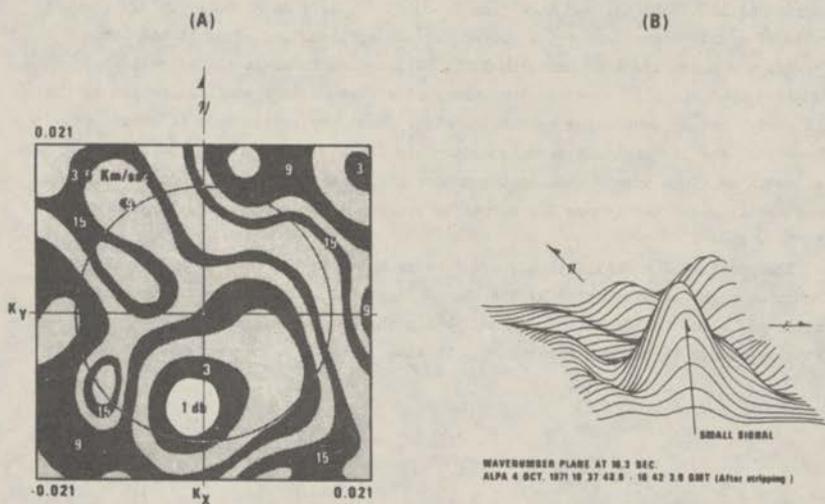


Figure 8. Case shown above with dominant signal removed thereby enhancing the small signal. The right hand illustration is a relief version of the wavenumber plane shown on the left.

TABLE VIII

The effect of f-k space analysis on the separation of mixed events in two recent studies of events in the Kurile Islands and Eurasia

Study	Region Studied	Duration of Study	Number of events Studied	Mixed at a Single Array		Mixed with Multiple Arrays After f-k Analysis	
				Before f-k Analysis	After f-k Analysis	2 Arrays	3 Arrays
Using NOBSAR and LASA	Kurile Islands	1 May 71 to 23 Jan 72	74	16	6	5	-
				17	6		
Using ALPA NOBSAR LASA	Eurasia	20 Feb 72 to 20 Mar 72	81 95 102	19	10	-	6
				18	8		
				18	8		

of 18-20 seconds and longer. By contrast, the signals from a nearby event tend to still retain shorter periods around the 12-14 second range. Broadband instrumentation coupled with digital equipment, both to utilize the inherent dynamic range and to perform adaptive filtering, might be useful in separating signals in the frequency domain.

Some possibilities open up, therefore, for mitigating the mixed event problem by a combination of small high quality long-period arrays for array processing separation and high gain broadband instruments close to seismic zones. Although it might be anticipated that this approach to a network will reduce the residual long-period non-detections, it is conceded that the separation of residual mixed events, particularly from co-located or very large events, remains a significant problem which may impose a limitation on long-period seismic detection in areas of interest for monitoring a test ban.

EVASION

There are inherent limitations to verification systems which mean that nuclear testing at some level can be carried out without seismic detection and identification. Recent work described in the previous two sections highlighted some of these problems. Even though further research may reduce the number of anomalous events, there are likely to be some events each year whose source identity cannot be determined by teleseismic means. We have also seen that there is always likely to be some residuum of overlapping events whose signals interfere to such an extent that they cannot be separated and identified teleseismically. There may even be a few occasions per year when the world's seismometers, both long and short period, may be rendered largely useless for verification purposes by a very large earthquake. These inescapable occurrences of natural phenomena continue to be a cause of concern because they could conceivably offer a potential violator of a comprehensive test ban additional opportunities to test without detection, let alone identification. It should be pointed out that the extent to which clandestine testing might be possible depends on the capability of the monitoring facilities available.

Our program of evasion research is oriented to understanding the potential techniques that could be used for clandestine testing in order to develop approaches that can improve the deterrence against such testing. Most U.S. research to date on this problem has focused on obtaining a better understanding of seismic coupling, yield/magnitude relationships as a function of rock type, and methods which might be used to decouple seismic energy. We have also been conducting theoretical studies

concerned with the so-called "multiple explosion" technique. In our studies, the simulated explosions are sequenced so that in the composite seismogram the short-period body waves are reduced (depressing m_b) and the long-period surface waves are reinforced (increasing M_s). The result is an earthquake-like signal, both in general appearance, and in $M_s:m_b$ ratio. Thus far, "identification" of the "event" as a multiple explosion using accepted diagnostic aids and discriminants has not been possible.

Another series of studies are underway to evaluate the likelihood of detecting and identifying the seismic signal from an explosion hidden in the signal from either a nearby earthquake or a distant large earthquake and its aftershocks. The detection problem is, in effect, similar to that already discussed for mixed events, and the present inability to separate certain events makes this evasion technique a subject for particular attention.

The emphasis of our current research is being directed toward determining the capabilities and limitations of seismic techniques that may be used to foil the earthquake-simulation and hide-in-earthquake evasion technique.

Table IX summarizes current information on evasion potential. It suggests estimated yield limits for various evasion techniques which are considered technically feasible. Despite known constraints on the tester, including yield limitations, high cost, and the possibility of detection, we cannot be confident that they will suffice to deter a potential evader. It, therefore, seems important to improve the seismic means for detecting such tests.

TABLE IX

<u>EVASION TECHNIQUES</u>	<u>ESTIMATED YIELD LIMIT TO AVOID DETECTION*</u>	<u>CONSTRAINTS ON TESTER</u>
TAMPED SHOT IN LOW COUPLING MEDIA	1 - 2 KT**	LOW YIELDS; RELATIVELY FEW AREAS OF LOW COUPLING MEDIA, MOST IN UNDEVELOPED REGIONS; EVADER WOULD PROBABLY TEST IN SEISMIC REGION.
DECOUPLING CAVITY	50 KT	LARGE VOLUME OF ROCK OR SALT REQUIRED; LONG PREPARATION TIME; EXPENSIVE.
DETONATE FOLLOWING NEARBY EARTHQUAKE	50 KT	DEVICE MUST BE PRE-POSITIONED; LOCAL EARTHQUAKES MUST BE ABOUT ONE SEISMIC MAGNITUDE LARGER THAN EXPLOSION; DECISION TO TEST MUST BE MADE VERY QUICKLY
DETONATE FOLLOWING LARGE DISTANT EARTHQUAKE	100 KT	DEVICE MUST BE PRE-POSITIONED; EVADER WOULD PROBABLY HAVE TO TEST IN SEISMIC REGIONS; 1 OPPORTUNITY EVERY 1-2 YEARS TO CONDUCT SEVERAL SIMULTANEOUS EVENTS IN A SERIES; DECISION TO TEST MUST BE MADE QUICKLY.
MULTIPLE SHOT SIMULATION OF EARTHQUAKE SIGNAL	100 KT	REQUIRES MULTIPLE EMPLACEMENT HOLES; EVADER WOULD HAVE TO TEST IN SEISMIC REGIONS. REQUIRES CONSIDERABLE TESTING EXPERIENCE.

* Estimates based on detection capabilities of stations remote from event.

** Could be as high as 10 KT dependent upon the availability of sufficiently deep
low coupling media.

Section IIIFuture Research

The problems discussed in Section II suggest some promising avenues of further inquiry that should assist in their solution. For example, our inadequate data base for events of low magnitude for many of the seismic areas of the world can be rectified by the deployment of higher quality seismic stations with higher gains in quiet sites. Additionally, as more low magnitude events become detectable, the problem of handling more high-quality digital data will present a task of major proportions in data processing and system management. Finally, increased knowledge about evasion techniques may suggest ways to deter clandestine testing; countermeasures to evasion should be actively pursued. This section seeks to outline some of the new approaches to research suggested by the unresolved problems in seismic verification.

A Multi-National Seismic Cooperation Study

At the present time we do not know with any degree of confidence how many seismic events there are in every area of the world above magnitude 4.0. To address this problem a cooperative multi-national project has recently been undertaken under the aegis of the Lincoln Laboratory of the Massachusetts Institute of Technology. It utilizes the detection logs, rather than the more conservative seismic bulletins of the participating groups, and will seek to answer a number of scientific and operational questions related to detection and discrimination by using all available seismic data.

Data recorded for a period of one month, 20 February to 19 March 1972, has been selected for this extensive study with participating groups in Canada, Sweden, Norway, the United Kingdom and the United States. In addition, the analog records of all other groups submitting data to the US National Oceanic and Atmospheric Administration have been incorporated in the data base. Finally, a list of events from non-seismic regions, or which for some reason cause difficulties with some discriminants, and other recent special events of particular interest, is being compiled for study by the various groups. The number of potential events being considered is about 5,000 although the process of event authentication promises to reduce this figure to under 1,500. Event authentication means that detection of an event is made by at least three WSSN stations or one detection at a local standard station corroborating the same detection by an array.

Although the work is only in its initial phase, it is hoped that the final bulletin will contain very nearly all events in the Northern Hemisphere of m_b 4.0 and greater and that by using modern data acquisition systems and computer techniques for data integration and manipulation such a capability might be achieved routinely. Of course, some events smaller than m_b 4.0 will be detected too but not with sufficient reliability to be useful. Another parameter which requires evaluation is a more precise estimate of the number of times small events are masked by occasional very large events.

Data already compiled have included bulletins from the US National Oceanic and Atmospheric Administration, NOR SAR and IASA; detection logs from NOR SAR, IASA, Yellowknife, Bagfors, and Warramunga; arrival times and amplitude measurements for Warramunga, Guaribidinaur, Canadian network stations, and other measurements reported to NOAA. Film records of selected WSSN stations will also be utilized and every attempt will be made to reprocess array data for possible events not originally reported by the arrays. For the first time we will be in a position to accumulate a single list of events which will form a common and agreed data base for comparative studies, almost an impossibility up to this time.

It is anticipated that the work will be completed by October, 1972 at which time the results will be distributed by Lincoln Laboratory to all participants and other interested workers.

Future Communications Systems and Data Analysis

One of the important issues which was mentioned in our earlier paper (CCD 330) was that optimum verification system performance requires a good deal of operating experience before it is actually achieved, and is crucially dependent on the quality of system management. Preliminary results of the multi-national cooperative experiment is revealing that there are likely to be as many as twenty thousand events above m_b 4.0 per year. This will pose a data management and processing problem of major proportions.

The approach to this problem which the US is now undertaking will have three facets. First, each high quality station or array will have a comprehensive signal processing system including techniques for maximizing signal-to-noise ratios for various wave types, azimuths, and frequency bands; automatic event detection; signal editing and storage; and a means of reprocessing data on request.

Second, there should be regular but not necessarily real time transmission of processed data from the individual station to an analysis center or centers. Modern satellite communication systems, already in existence and commercially available at economic rates, have made communications on a worldwide basis simple in principle. A map of current ground stations and the three COMSAT satellites is shown in Figure 9. They possess the unique advantage in a worldwide seismic monitoring context that the data would be available to all who would wish to use it, the only requirement being a link to a satellite communications ground station. Simple though the concepts may be, many details must be investigated. These include data format; the means of interfacing with the satellite link; data rate, including trade offs between continuous low rate and short bursts of high rate transmission of accumulated data; and sufficient two-way transmission to permit data to be extracted from as well as deposited in the data bank.

Third, consideration will have to be given to the functions of the data bank and central data analysis centers. The important seismic parameters for an operating system will have to be specified, such as location, time of origin, depth, magnitudes, spectral data and other possible discriminant material, and improved means for computing them will have to be developed to handle the great numbers of events which occur worldwide. The development of the recently operational network of interacting computers - called the ARPANET - encourages us to explore these possibilities without being limited by computers. This net provides high quality remote access to a number of large special and general purpose computers in the United States. The Seismic Array Analysis Center (SAAC) in Alexandria, Virginia, is linked to this net, and this provides the Center with the capability of utilizing the largest and most sophisticated computing facilities available. A further development which promises to be more valuable from the point of view of a data bank is a mass storage device having a capacity of approximately 10^{12} bits of data. This is adequate to store the unedited data from 25 nine-element long period arrays operating for approximately three years.

Seismic Instrumentation

The results of recent research make it important to review our current thinking on seismic instrumentation. The results obtained from the Very Long Period Experiment seem to indicate that rather than restricting analysis to periods of 20 or 40 seconds, it seems much more profitable to use as broadband data as possible. An extension of the pass band of long-period instruments is indicated by the fact that earthquakes occurring within 20° have a richer frequency spectrum in the region of 12-14 seconds

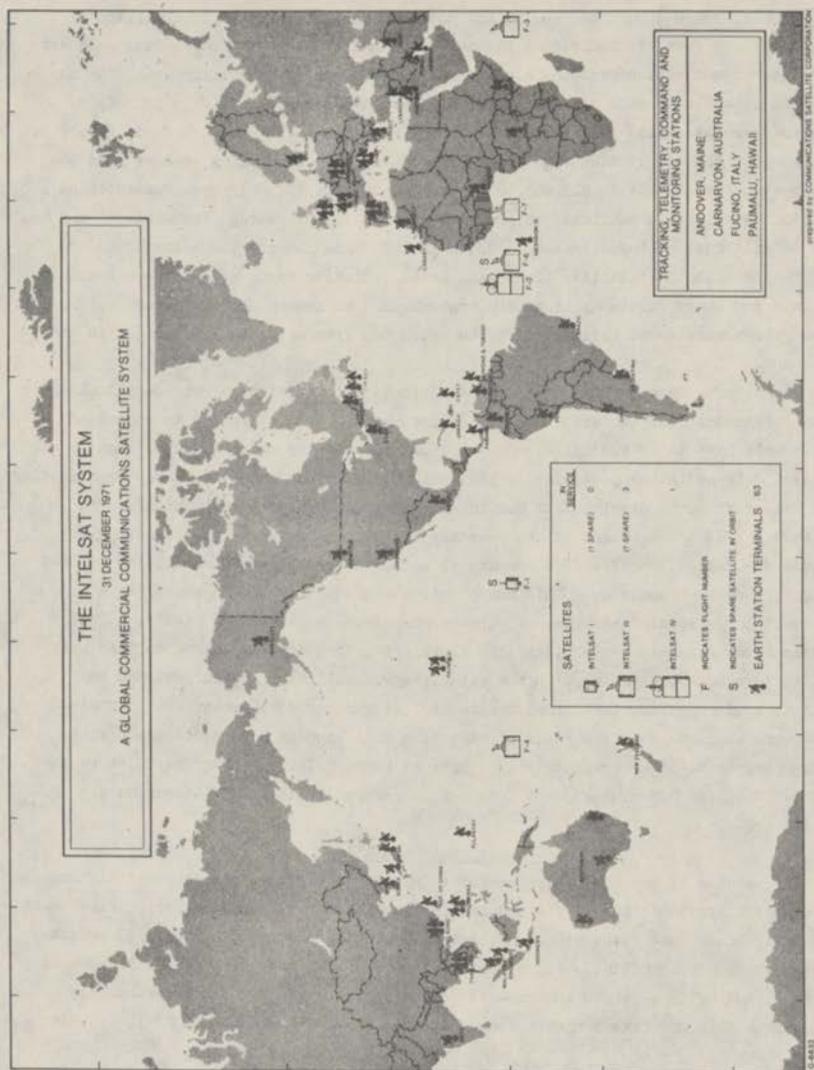


Fig. 9 The Intelsat System

than at greater distances. There is a prospect, therefore, of seeing relatively short range earthquakes against the background of the coda from a large earthquake whose dominant period is likely to be of the order of 20 seconds. These facts combine to suggest that in future research we should record broadband from about 10 to 50 seconds.

Recent research has been devoted to develop a reliable broadband instrument. Hitherto, analog recording has precluded the realization of the potential of the broadband instrument since instrument band passes were designed to eliminate seismic noise, specifically at the 6-second and $\frac{1}{8}$ -second microseismic peaks. With the introduction of digital recording, the large dynamic range can be exploited and the prewhitening of the noise by analog filtering avoided.

An instrument with a good response curve from periods of one second to d.c. has been constructed. This essentially means that this instrument, with digital recording, and perhaps notched filtering to remove the 6-second microseismic peak, has the potential of obtaining data presently obtained by both long and short-period instruments. The instrument can be packaged in a way that it contains its own temperature and pressure environment and, in addition, is small enough for use in a 7-inch diameter borehole. This latter feature is of considerable importance because it opens up the attractive possibility of economically deploying instruments below the zone of locally-generated atmospherically-induced earth noise. The horizontal components of the long period ($t > 20$ seconds) earth noise are particularly sensitive to deep burial, and it is the noise in these components which at surface sites severely inhibits the detection of potentially useful Love waves. The noise is not only high in these components at the surface but is highly unstable due to storms and diurnal changes due to atmospheric loading causing earth tilt. Love waves have been less investigated for this reason.

The instrument and other similar new developments are currently being evaluated at the Fouta Forest Observatory alongside more conventional long-period instruments in surface vaults. A borehole experiment will be undertaken to establish the advantages to be gained operationally from the deployment of this seismometer at depths up to 5,000 feet, particularly to explore the utility of Love wave data as a factor in seismic discrimination.

Improved Seismic Research Networks

Studies of identification criteria which have been conducted to date reveal deficiencies in the data base available for research. For example, the previously described events in Asia having low $M_b : m_b$ ratios are so remote from the large arrays and from all but one of the stations of the Very Long Period Experiment that only

limited information can be obtained from these stations. In addition, some other promising criteria which might identify these events (e.g. Wadati's method for determining focal depth using S-P [Ref. 5]) require high quality data recorded within several degrees of the source. Valuable as they are for most general seismological studies, data from standard WSSN stations are inadequate to support the desired research. In particular, the stations do not have sufficient effective gain to record data from the low magnitude events of interest, and the photographic recordings are not suitable for the necessary computer analyses.

As a consequence of these considerations, and as an adjunct to the communications study and other studies related to the consideration of monitoring a test ban, the US is planning a program for selectively upgrading selected WSSN stations. Sites would be chosen at locations where they can be expected to produce data needed for important investigations. Small arrays may be needed at a few locations to attain necessary detection thresholds and to assist in mixed event separation. Digital recorders will be needed for high dynamic range and efficient analysis. As currently envisioned, about 20 stations of the WSSN might be improved with advantage. Planning is, at present, in the preliminary stages and hence cannot be reported to the Conference at this time.

Counter-Evasion Research

The principal objective of the research program into evasion techniques is to devise measures which can be incorporated into seismic verification schemes to detect, and thereby deter, possible attempts to test clandestinely. It is important to determine the quantity and character of seismic data which will sufficiently deter such testing and to design a seismic verification system which meets those specifications.

A number of new approaches to the evasion problem are being examined using spectral analysis of both long and short-period data as well as broadband signals. Further research on coda suppressions as a means of limiting testing opportunities is required. Performance comparisons need to be made for various beamforming techniques, filters, and spectral processors as a means of separating and identifying events. Continued work on short-period discriminants is required since this may prove to be the only useful positive counter-evasion approach at low magnitude levels. Network characteristics, particularly station location, may be able to reduce the likelihood of successful evasion by simulating an earthquake or hiding the explosion signal in the coda of a natural event. Research on these subjects is continuing.

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Senator MUSKIE. Thank you, Mr. Farley, and your full statement will be included in the record.

I would like to ask two or three preliminary questions and give it back and forth to Senator Case.

ARGUMENT CONCERNING MUTUAL MORATORIUM'S LACK OF SAFEGUARDS

First of all, you make a comment on the first recommendation of Senate Resolution 67, a mutual moratorium, and you make the point that such a moratorium would necessarily lack many of the safeguards of a formal international agreement.

Well, that same argument could have been used against the moratorium of 1962; could it not?

Mr. FARLEY. I believe there is some difference here. As I have stressed in my statement, we are currently in a situation where there is very clear cut and sharp differences as to an essential element of any comprehensive test ban—verification provisions. We just don't have a common basis on which to proceed on a moratorium. I believe we were in a somewhat better situation in the earlier occasion.

Senator CASE. Why, because it could be detected in the atmosphere?

Mr. FARLEY. Well, that was one principal reason, and the other was that there was a better focus as to what negotiations we were going to attempt to achieve by the limited test ban.

Senator MUSKIE. There's one issue involved here. That's verification. You mean you have to have agreement in advance of negotiations as to how you're going to resolve that issue before you begin negotiations for an agreement?

Mr. FARLEY. Given the very sharp difference in the Soviet position that nothing beyond national means is required, the moratorium would be in effect to accept de facto the Soviet position and suspend the tests with nothing beyond national means of verification, and from that base we could then start to negotiate an additional requirement to supplementary onsite inspections.

Senator MUSKIE. Their position is no more immovable than ours; is it?

Mr. FARLEY. If we had a genuine negotiation we would find the answer to that question.

HOW DO WE BEGIN GENUINE NEGOTIATION?

Senator MUSKIE. How do we begin a genuine negotiation?

Mr. FARLEY. What we attempt every year in the Geneva Conference and also in the New York discussion as well as in the Committee of Experts, to which I referred, to see if we can find some ground on which we can begin genuine negotiations.

Senator MUSKIE. Doesn't someone have to take an initiative in order to get into a genuine negotiation?

Mr. FARLEY. I think to have a genuine negotiation there has to be an interest in finding a solution, a real solution, on both sides.

Senator MUSKIE. How can you explore that unless you're actually in the negotiations?

Is there a difference between the initiative to get into the negotiations and the nature of the negotiations themselves once they've been launched?

Mr. FARLEY. We are not here, of course, in a situation where we need to find a forum to join in discussions of this subject. It is a matter which comes up annually. There is an opportunity to see if there is a basis for beginning serious negotiations.

Senator MUSKIE. Mr. Farley, it seems to me that we're not so much in a forum as we're in a rut. If we had proceeded with this kind of reasoning in connection with the China initiative, or the Moscow initiative, those initiatives would never have been taken. President Nixon departed from conventional contacts with Peking. There were none at all, of course.

You could bypass them and try a dramatic new way of establishing contact by sending Mr. Kissinger on secret missions.

Isn't this a matter of sufficient importance and magnitude to suggest an initiative, especially one that's been tried successfully before? This is not as irrational or risk-taking as you might suggest.

Mr. FARLEY. This is a case in which we go to Geneva every year. We do not need an initiative to do that, to meet with the Soviets.

Senator MUSKIE. On how many occasions in that yearly journey, Mr. Farley, have we gone with the feeling that this time, somehow, we're going to get negotiations started?

Have they not just become a routine exercise in this obscure rhetoric that the public never understands?

Mr. FARLEY. This is our hope every year, that this would be the year when the matter will come under serious negotiation.

Senator MUSKIE. Well, it seems to me that the nature of that, the climate of that determination, is much like the rhetoric we get before this committee every year. You have made virtually the same statement 3 years running, the same cautious, careful, avoidance of risk approach every year now.

If you approach Geneva in the same fashion, I don't see much encouragement for the hope that a real initiative is being contemplated.

Mr. FARLEY. We are dealing here with matters of security significance, with a matter where we feel that the security of the country requires an adequate verification arrangement, and we have not found the means to discuss what we consider an essential element in this. This seems to me not a rhetorical approach, but a responsible approach to the problem.

Senator MUSKIE. Well, we are learning these days that words are not enough to solve the problems, that we need action. Both sides took positions 10 years or more ago and we are not about to budge from those. We go through an annual exercise of rhetoric in Geneva but there is no evidence of any response or any willingness to respond to changes.

SIGNIFICANT CHANGES SINCE 1962

Let me ask you this: What do you think have been the significant changes, if any—

Mr. FARLEY. I am sorry.

Senator MUSKIE. Let me ask you this: What do you think have been the significant changes, if any, that have taken place since 1962 which

ought to encourage us to believe that the prospects for agreement may be improved? What are the encouraging changes that have taken place? The significant changes.

Mr. FARLEY. Right. I think one would have to place first the very massive work that has been done in improving our understanding of seismic means of detection and identification, the establishment of the fact that it is clearly possible on now theoretically understood principles to discriminate between earthquakes and explosions. We have been able to devise theory, techniques and instruments which, when put into a suitably designed network, would give us an actual capability to detect earthquakes or other events and discriminate at levels at which it was just speculation in 1962-63 to think we might be able to detect and identify.

I think it is relevant and encouraging that we have had progress in other areas of arms control which seems to us to mean that one ought to be able also to come to grips with this problem and work out a solution. I think I would add, as one other relevant consideration, that I believe the expectations and hopes from peaceful nuclear explosions are somewhat less high than they were some time ago, and that encourages me to think that that also is a problem to which we could find and negotiate a satisfactory solution. This is a case, of course, in which not only the two major nuclear powers but some of the non-nuclear states have some interest also.

Senator MUSKIE. Do you think the development of satellite photography is a development that ought to be taken into account?

Mr. FARLEY. In our estimates of what we can do and what we need for verification we take into account all our means of verification, yes.

Senator MUSKIE. Do you think that the negotiation of the SALT I agreement is also a significant development that ought to be taken into account?

Mr. FARLEY. Yes. I did not mention SALT when I said very significant progress in disarmament in recent years. That is, of course, the most important milestone there. I think it is significant.

Senator MUSKIE. So we have had three significant developments since 1962 that ought to be taken into account but not sufficiently to change our position. Is that your position?

Mr. FARLEY. It has not changed the view that some onsite inspection is required to supplement other national means of verification, that is correct.

Senator MUSKIE. So 10 years of progress means we end up where we were 10 years ago.

Mr. FARLEY. Until there is some readiness to negotiate on this key issue we are at an impasse.

DEGREE OF CHANGE REQUIRED TO CHANGE U.S. POSITION

Senator MUSKIE. What degree of significant change would be required to budge us even an iota from that position?

Mr. FARLEY. I indicated in my statement, Senator, that we cannot at this point say that there is a stage of technical capability with national means alone which when achieved and demonstrated would enable us to dispense with onsite inspection. The rationale is somewhat different.

Senator MUSKIE. I remember a story from my State, which used to be a very Republican State, a story at a testimonial dinner for a State legislator who served for 30 years. A newspaperman made the observation to him, "Well, Senator, there have been a lot of changes in the legislature since you have been there." He said, "Yup, I have been agin every one of them."

Mr. FARLEY. I hope you are not implying, Senator, that I was against all the improvements or against any of the arms control agreements which we have made.

Senator MUSKIE. I just assume you represent an official position and it is that official position that I am questioning, not you, Mr. Farley—

Mr. FARLEY. Yes.

Senator MUSKIE. For whom I have a great deal of respect. But in order to explore the position, I have to direct questions to you.

HAVE WE TABLED SPECIFIC PROPOSAL AT GENEVA?

Have we tabled a specific proposal at Geneva?

Mr. FARLEY. What we have done annually is present our concept of the basis on which a negotiation should proceed and agreement be negotiated. We have not tabled a specific treaty text.

WHEN ARE WE GOING TO TAKE AN INITIATIVE?

Senator MUSKIE. When are we going to take an initiative? You have used Geneva as an argument for not proposing a moratorium as an initiative. Just advancing concepts are not initiatives. Are they, in your opinion?

Mr. FARLEY. I have not, and I am sorry if I have used the pronoun, I should say we have not seen this as a matter in which the question is whether or not we take an initiative. We have seen it as a question: Are we doing what we think is right and as much as we think possible to move toward the goal of an adequately verified comprehensive test ban? We would stand, I think, fully on our record against that criterion. I have indicated why we do not believe the specific initiative of a moratorium would be constructive in moving toward that objective.

Senator MUSKIE. What do you have in mind as an adequate initiative? Do you believe that the Limited Test Ban Treaty and the Non-Proliferation Treaty impose no obligation on us to take initiatives?

Mr. FARLEY. The principal initiative which we have taken, and we have been the ones who have made the overwhelming preponderance of the contribution, has been in actually resolving in practice the question of how one would carry out the seismic monitoring of a comprehensive test ban.

Senator MUSKIE. How can you consider that much of an achievement if it does not result in any change in our position?

Mr. FARLEY. Well, we do not believe, Senator, that our position is the only one which it is required to change in this situation.

Senator MUSKIE. If both parties take that view, we are not going to get any change in either position. Are we?

Mr. FARLEY. What we hope can be done through rational international discussions of the kind we get, both at the political level and in the technical groups, is to get a broad understanding of what it is reasonable to specify in the way of verification requirements so that the right case will prevail. We do not think that our case is wrong or that the initiative should consist of giving it up.

Senator MUSKIE. But we have taken no diplomatic initiative in the last 10 years pursuant to the responsibility imposed upon us by the Limited Test Ban Treaty and the Non-Proliferation Treaty. Is that right?

Mr. FARLEY. We believe that a comprehensive test ban is a desirable thing to achieve. We believe it should be adequately verified. We have done all in our power to make adequate verification possible. I do not think that is nothing. We take these obligations under the two treaties that you mentioned very seriously, and we work at them in our verification improvement program and, as I said, annually in our effort to see if we have yet reached the point where there is a common basis of understanding which would enable us to proceed with specific drafting of the treaty.

Senator MUSKIE. In answer to my question, have we taken a diplomatic initiative, your answer, therefore, is no.

Mr. FARLEY. You mean, have we taken a specific dramatic separate step in advancing our position on every conceivable occasion—

Senator MUSKIE. I don't insist on the dramatic. Have we taken a undramatic diplomatic initiative?

Mr. FARLEY. We have taken a position every year by stating our position to proceed promptly to a comprehensive test ban adequately verified.

Senator MUSKIE. So our initiative has been to express our readiness. Is that our initiative?

Mr. FARLEY. As I explained our major problem, which seems to be the one which stands between us and getting this matter out of its present unfortunate situation, is verification. We are making a major effort to try to resolve existing difficulties, so as to make the greatest possible contributions from national means.

Senator MUSKIE. In other words, we are in a rut, and we find it very comfortable.

MEANING OF MR. KISSINGER'S STATEMENT CONCERNING INSPECTION

What did Mr. Kissinger mean when he said in Moscow, with respect to inspection: "And we are willing to restudy the issue." What did that mean in diplomatic terms?

Mr. FARLEY. In what?

Senator MUSKIE. Diplomatic terms. I want to get away from this unilateral technological program of ours. When he said, "We are willing to restudy the issue," did he mean to imply that he was willing to reconsider it, that we were willing to reconsider the issue vis-a-vis the Soviet Union? Is that what that language meant?

Mr. FARLEY. We used a precise word which was "restudy."

Senator MUSKIE. But he said it in a diplomatic setting in connection with the signing of the SALT I agreement. I am sure he was not

unaware of the possibility that using that word might imply that our position was flexible enough to be subject to change. Did he mean that?

Mr. FARLEY. We have restudied the question. Our position is the one which Ambassador Martin stated in the Geneva Conference in February and which I stated today regarding our view of what is required for an adequately verified agreement.

Senator MUSKIE. In other words, we have restudied the issue and our position has not changed.

Mr. FARLEY. Because we believe that the reasons which led us to that position remain right; yes, sir.

Senator MUSKIE. I think your position is clear at this point, so I yield to Senator Case. Senator Humphrey will come soon, I think, to spell me on this. Thank you.

Senator Case, you may take over.

RECENT DEFENSE DEPARTMENT INITIATIVE CONCERNING SEISMIC NETWORKS

Senator CASE. Mr. Farley, in regard to your statement, you say that "more capable seismic networks than we now possess are required to limit this set of mixed events to a small number."

Now, it is my understanding that the Defense Department in recent months has shown a new initiative in relocating and upgrading monitoring equipment for about the 20-station seismic network that we have throughout the world. Is that your understanding?

Mr. FARLEY. That is my understanding.

Senator CASE. Then this is perhaps a move in the direction of meeting that particular point?

Mr. FARLEY. It is a move in that direction, yes.

Senator CASE. Are you hopeful that it can be carried to the point where this particular second point of yours will no longer be a factor?

Mr. FARLEY. I would like to give you a brief answer and then ask Dr. Evernden if he would either correct or stand with what I say, but it is my understanding that the principal activity now sponsored by the Defense Department through ARPA [Advanced Research Projects Agency] could be best thought of as constructing and operating very important experimental facilities to prove out in practice both some of the theory, the techniques and the instruments which have been developed, that they are not, strictly speaking, designed in themselves as a seismic network designed to carry monitoring capability to the level that I referred to in this sentence. That would require something deliberately designed and deployed for that purpose rather than for an experimental purpose. But I wonder if I could ask Dr. Evernden—

Senator CASE. I would hope to have that, but I would like to make this point. As you know, last year I introduced legislation which would have had the effect of transferring this function from the Defense Department to your agency. You resisted it, the Defense Department resisted it. But I had hoped that the recent activity in the Defense Department may have been at least encouraged by my suggestion that these networks ought to be developed by your agency because you are the ones most interested, and having the primary responsibility for application of this technology for detection purposes.

I hope you are not going to say now that this activity on the Defense Department's part has no relation to a monitoring capacity but rather to something else. The reason I interrupted you and made the point is that your answer a bit skidded off in that direction. That it was not going to be very helpful for this purpose.

Mr. FARLEY. I am sorry if it was misleading.

Senator CASE. What?

Mr. FARLEY. I am sorry, but the primary purpose of this activity, which is managed by the Defense Department with the ARPA organization, is to test methods for improving our capability for seismic detection and identification.

My point was only that these stations are primarily experimental rather than an operational network.

Senator CASE. Then this does not involve any activity toward putting in place equipment that might be effective for this purpose.

Mr. FARLEY. Well, they certainly make a contribution. They are good stations. These are good stations, and they improve our capability.

Senator CASE. They do.

Mr. FARLEY. Yes.

Senator CASE. You are clear about it. I see Dr. Foster also indicated that he agreed with that statement. I am glad to hear it, because I have been concerned that we have not been active enough in this area.

WHY RUSSIANS CHANGED THEIR POSITION

Why did the Russians change their position? At one time—I believe 10 years ago—they had indicated they would accept three onsite inspections. Isn't that true?

Mr. FARLEY. That is true. At the time of negotiation of the Limited Test Ban Treaty, as I recall their position, they were willing to accept three stations on their soil and three annual onsite inspections. Shortly after the conclusion of the Test Ban Treaty they announced that their position was that national means were adequate and these additional measures were not needed, and they have adhered faithfully to that position ever since. I am very humble about speculating on Soviet motives, Senator.

Senator CASE. Were there any specific developments that you know about that caused this change in position?

Mr. FARLEY. No, I do not know of such a reason.

Senator CASE. Or was there any sort of thing that you imagined may have happened?

Mr. FARLEY. No, I don't know of anything of which I have enough basis for speculation to want to put it on the record.

Senator CASE. What I am really getting at is, was it your thought that they really didn't want a test ban?

Mr. FARLEY. Their position remains as, for instance, enunciated by Chairman Brezhnev in their formal disarmament statement of policy, that they are in favor of the ending of all nuclear tests by everyone anywhere—including underground—and they participate in the diplomatic discussions in Geneva although, interestingly enough, not the discussions of seismic experts. So this seems to be still an objective of their policy.

Senator CASE. It is a stated objective at least.

Mr. FARLEY. That is right.

Senator CASE. As it is a stated objective of ours, stated again in your statement this morning.

Mr. FARLEY. That is correct.

FEELING IN U.S. GOVERNMENT ABOUT ENDING ALL TESTING

Senator CASE. In our Government, is there substantial feeling that this is not very wise, that we ought not to give up the ability to learn more about nature, and also that we ought not to give up the chance of discovering for all purposes more of the secrets of nuclear activity, and so forth?

Mr. FARLEY. I think the way I would answer that, Senator, is that our style of looking at problems like this is to examine the pros and cons of taking a course of action, and I think most of us in the Government would recognize, perhaps with different degrees of fervor, that there is more to be learned by nuclear testing, that nuclear testing is necessary even if you are going to have effective continued laboratory work. That there are specific applications of improvements in nuclear weapons technology which one can now foresee, and that beyond those there is always the uncertainty, but the possibility, that something more novel, more unpredictable might turn up, and there is generally, I think, a feeling that this is an area where we have the kind of technological aptitude which is quite important to continue to exploit. These are considerations which we weigh when we conclude—as I have said we do after weighing them—that, provided the other fellows give these up too, we are prepared to give them up, but we are giving something up.

Senator CASE. Would you say that this feeling that it is desirable to continue testing is held with varying degrees of intensity in different areas of our governmental structure?

Mr. FARLEY. That was about the phrase I used and I hope I won't be asked to push it any further than that.

Senator CASE. No. But would you say that the same statement could be made in regard to the belief in the desirability of achieving a comprehensive test ban treaty—that there are varying degrees of fervor with which that is held?

Mr. FARLEY. I think that is undeniable.

Senator CASE. It is almost an axiom to say that. You wouldn't want to say it was trite?

Mr. FARLEY. I would say that with respect to any human being.

Senator CASE. Who would hold the high sense of urgency about the desirability of a comprehensive test ban treaty.

Mr. FARLEY. I heard some very eloquent spokesmen already this morning and I would hate to place anybody higher on the list than Senator Kennedy and Senator Muskie.

Senator CASE. Well, you would include me in there, too.

Mr. FARLEY. You submitted your statement for the record without reading it.

Senator CASE. I am talking about the executive branch. [Laughter.]

Mr. FARLEY. As I said, in general, our exercise is one of looking very carefully at the pros and cons and balancing them, rather than the

matter of trying to settle the thing by fervor and argument, so I don't know that I can respond usefully to that question.

Senator CASE. If everybody is going to be a judge, nobody is going to be a prosecutor.

Mr. FARLEY. "Advocate," I think, is the word.

Senator CASE. Well, advocate is another way of putting it. You know it was always my hope that your agency was going to be an advocate. Do you have an advocate's division in your agency?

Mr. FARLEY. I think generally, Senator, we consider it part of our responsibility to see—

Senator CASE. I am not playing with words, you know. I feel very seriously about this.

Mr. FARLEY. I was going to give you a serious answer. I think we consider part of our responsibility to see, in this assessment of pros and cons, that the pros, all of them, are fully advanced and that the reasons why they should be given weight are presented as fully and as forcefully as possible.

LACK OF ADVOCACY OF COMPREHENSIVE TEST BAN

Senator CASE. It has bothered me for quite some time. You always come up here with this balanced position—not that I object to balance. I suppose the older I get, the more Burkean I become concerning a belief in balance. But someone has to be the advocate, and I don't see it in the agency. I think the very fact that you are given two jobs, for instance, one of representing the United States in negotiations, and secondly, presenting the administration position up here, is troublesome. I don't suggest setting up another agency in the Government. We have enough. But I do suggest that something is lacking, and I wish I knew how to provide it. This isn't said in personam at all. I agree with what Senator Muskie said, that you are a great guy and that you are under wraps.

I used to think if I were going to go into this as a lifelong specialty I would want to get into the Arms Control Agency. I know that many young people went into it with this in mind. Now this outlook has changed and ACDA is now a "balanced view operation," a kind of a bureaucracy which keeps things from exploding and presents the administration point of view to the public.

Mr. FARLEY. Well, I am a little troubled by the record that is being made. It seems to me, and it is important, to draw a distinction between advocacy of an official position such as we have presented here this morning and advocacy of positions within the executive branch which is where we spend most of our days and hours. And I think one has to ask whether there is gain or loss if one establishes an agency which is committed to be simply an advocate for an almost preestablished position on any issue. We would not then have the Arms Control Agency speaking to you today, and, as I say, I am not sure whether you would, from your point of view, find that to be a gain or a loss. I do not accept your statement about attitude among young people coming to work in ACDA. We always have more absolutely first-rate young people who want to work for us than we can take on. So, on just those two points, I did want to say something to comment on your remarks.

Senator CASE. Certainly. It is encouraging to have you indicate your continued belief in the soundness and validity of the agency for its purposes. I still maintain it isn't the agency I thought we were creating, and I don't know what to do about this.

Dr. EVERNDEN. Do you have something that you would like to develop while we are waiting for Senator Humphrey? Or do you want questions?

Dr. EVERNDEN. What is your desire?

Senator CASE. Draw your microphone a little more close to you, please.

ROLES OF ACDA AND DEFENSE DEPARTMENT

Mr. FARLEY. Could I come back to one observation you made which I think might give Dr. Evernden a chance to say something that would be of interest here? You spoke of your concerns about the respective role of the Arms Control Agency and the Defense Department, particularly ARPA. We told you last year we are ourselves quite easy about this relationship. We think the ARPA program is a good program; we don't think even if we get the money we could conceive or run it any better. We do think there is a role, however, for ACDA, as the agency which has the primary executive and statutory interest in advancing arms control, to try to be constantly aware of the progress that is either achieved by the ARPA seismic improvement program or the progress that is in prospect, to see that it is properly and constructively applied to what we are doing.

If you would like I think it would be possible for Dr. Evernden to say something about the kinds of things we concern ourselves with which are based, of course, on the much more massive ARPA effort, and we depend on it, but we try to extend it in this area in such a way as to make the maximum contribution to resolution of verification issues.

Senator CASE. Surely. And just to further explain my own concern, might I say that I have the feeling that while your agency and the Defense Department are going to make progress and move in the right direction, you are never going to achieve the objective.

Mr. FARLEY. I think, Senator, I have said enough in the earlier exchange with Senator Muskie so that my views are on the record.

Senator CASE. Yes.

Dr. EVERNDEN. Well, then—

PRESENT SEISMIC CAPABILITY COMPARED TO 10 YEARS AGO

Senator CASE. Dr. Evernden, would you compare the present state of seismic capability with that of 10 years ago when we got the limited test ban treaty?

Dr. EVERNDEN. Well, I think it is fair to say that over that 10-year period we have essentially transformed our understanding of how to, if you will, tell seismic signatures of earthquakes from those of explosions. As you know, 10 years ago the conventional wisdom was that this essentially could not be done. Today there is no one who believes that. We testified to you—I mean my seismological brethren and others—that we essentially today do know that within the seismogram recorded at adequate signal-to-noise ratio there is more than

enough information to distinguish the seismic signature of an explosion from that of an earthquake.

I may be deemed an enthusiast on this by some, but I firmly feel—
 Senator CASE. You have to have a balanced view. [Laughter.]

Dr. EVERNDEN. That is right. I feel it is a balanced view—that we understand today that these differences are of a very high level, and we essentially know most of what there is to know about telling the differences between earthquakes and explosions by seismic criteria.

The unfortunate aspect of all this, of course, from the point of view of some, is that it does not lead to an identification capability to some arbitrarily low level based on arbitrary networks. Thus, as in the statement, it is really very difficult to design a network which would be totally external to the U.S.S.R. and China that could reduce the number of unidentified events of magnitude 4.0 or greater, say, to less than 10 or something like that.

Senator CASE. Have there been studies that support this general view, critical studies?

Dr. EVERNDEN. Yes. We can certainly design networks and we have conducted these sorts of studies at ACDA in the last year or two, it is also true that we could essentially eliminate that number of unidentified events if we had the right to deploy within the Soviet Union 15 or 20 simple seismic stations. We do not now have that right. We do not now know whether that right is negotiable but it is one technical solution to the problem.

From the seismological point of view, it is a far simpler solution than a solution based on elaboration and expansion of a complex network external to the U.S.S.R. It brings other assorted benefits also which I can go into if you wish.

Senator CASE. I can certainly accept this if it is true.

Dr. EVERNDEN. The fundamental problem is that the Earth is noisy, that microseisms are there plaguing one. When the signals are too low, you are just barred from acquiring the information that you wish.

Senator CASE. Barring by external—

Dr. EVERNDEN. Yes; when you are too far away, that is right. One of the—

UNMANNED SEISMIC OBSERVATORIES

Senator CASE. What about this black box business?

Dr. EVERNDEN. Well, that is another name for what we call unmanned seismic observatories.

Senator CASE. Unmanned.

Dr. EVERNDEN. Yes.

Senator CASE. Don't these observatories present a real possibility of the solution to this problem?

Dr. EVERNDEN. It presents a technical solution down to a lower signal level than we can get at present.

Senator CASE. I am sure that is a fair statement and I am sure nobody would question that.

Dr. EVERNDEN. That is right.

Senator CASE. But does it go far enough for practical purposes?

Dr. EVERNDEN. Well, the answer to that is outside seismology. It will certainly get you essentially all magnitude 4.0 events and it will

get you many somewhat lower than that. Now whether that would be enough is somebody else's decision.

Senator CASE. Excuse me, just to be sure I understand, will this not only detect such events but tell whether it is natural or man-exploded events?

Dr. EVERDEN. In the case of overcoming background noise, it will tell whether they are explosions or earthquakes. Even against this system there might be an occasional problem with deliberate evasion, in the neighborhood of magnitude 4.0. There might be occasional doubt, but it wouldn't be very often. But what this would do would make evasion at magnitude 4.0 a very difficult task.

Senator CASE. And this system would cover Russia fairly extensively, fairly comprehensively?

Dr. EVERDEN. That is right. One of the conditions we have to make clear is that the seismological capabilities that I attach to such a network assumes that the stations have been deployed as I or some other American, using "I" here as an American seismologist, as I would deem required to do the task. They have to be where you need them to do the job; they have to be of a certain quality; and they have to be of guaranteed reliability in the sense that you can be sure that the data you get from them are valid data. This, in the past, has been somewhat of a problem with USO's [Unmanned Seismic Observatories].

In this context, ACDA recently completed a feasibility study as to whether a more tamper resistant, reliable USO could be designed based on present technology, and the upshot of that feasibility study was that it does seem that such a station can be developed. ARPA has, with its greater moneys than ours, picked up the ball on that study and is funding development of some of the components that were defined in the ACDA feasibility study. So we collectively do feel, I mean both ARPA and ACDA, that these most certainly could play a significant role, and a very important role, if they could be properly deployed in proper numbers with the proper capability, with the proper assurance of data reliability.

RUSSIAN ATTITUDE TOWARD USE OF UNMANNED DETECTION INSTRUMENTS

Senator CASE. Could I ask Dr. Farley at this time what the Russian attitude toward possible use of these unmanned detection instruments is.

Mr. FARLEY. Their statement of their position on anything going beyond national means of verification operating outside their territory has been that they do not believe it is needed. They have not, to my knowledge, specifically addressed and refused the concept of black boxes but, as I indicated earlier, they have refused to engage in technical discussion of how you make either national means or supplementary means such as these seismic observatories practical or what their capabilities would be. So you have really mainly a body of either absent or negative but not conclusive evidence, and since it seems to us not conclusive, it seems to us worth the effort to prove this technique out and have it available.

Senator CASE. I certainly want to encourage you as strongly as I can in that direction.

Have you anything further that you want to put into the record, either of you? If you have you can send it up on reflection when you have a chance to look at the transcript.

Mr. FARLEY. I don't believe I have anything to volunteer at this time.

SIGNIFICANCE OF RUSSIAN ABILITY TO TEST BELOW DETECTION THRESHOLD

Senator CASE. Just one second. The staff has suggested, and I would like very much to have this on the record and ask Dr. Evernden how significant it would be if the Russians could test below a detection threshold.

Dr. EVERNDEN. That is not a seismological question. I am sorry, sir, but I really am not competent to give a statement about the meaningfulness to the Russians of testing below a, say, 4.0 threshold. I can tell you what systems it will require if you would like that capability.

Senator CASE. Go ahead.

Dr. EVERNDEN. I mean I can tell you how to build networks to give you a capability to detect magnitude 4.0, but I have no competence for telling you the significance to the Russians for testing below that level.

Senator CASE. Is there anything else before I surrender this rare occasion on which I am chairman of the committee? [Laughter.]

IMPORTANCE OF TESTING FOR PEACEFUL USES

I ask you if you would, each of you, make such comment as you want on the importance of testing for peaceful uses.

Mr. FARLEY. I don't believe, Senator, that I can really go beyond what I said earlier; namely, that I think expectations are somewhat more modest now. I should add one thing, and that is that one country which has a particular active program in this field of use of nuclear explosions for peaceful purposes is the Soviet Union. Their program is many times the size of ours now and that is a factor which we have to consider when we are asking will we be able to handle that problem in the context of the comprehensive test ban agreement.

Senator CASE. Are they getting anything out of it? What are they doing?

Mr. FARLEY. They seem to believe so. They use it for—they have tried excavation projects in the past, they have tried, as I understand it, using nuclear explosions for snuffing out gas well fires. They have had other explosions for creating cavities for storage purposes, and so forth. I am probably omitting some major elements of their program, but they do have an active and extensive program and one to which they seem to attach importance.

Senator CASE. It is still going on.

Mr. FARLEY. Oh, yes.

Senator CASE. And they are able to operate without violating the test ban treaty.

Mr. FARLEY. That is correct. It is required that they conduct contained explosions, but that is the parameter of their program now.

Senator CASE. You are not excited about the possibilities so far as the United States goes, I take it.

Mr. FARLEY. I don't feel I am that much of an expert. There seems to me no doubt technically you can do a number of things with nuclear explosions in fields such as those I named which the Russians are active in. It then becomes a mixed economic and environmental problem as to whether using a nuclear explosion is the method of choice for a particular thing. Certainly PNE's are not yet demonstrated as capable of a major contribution.

Senator CASE. Have you an observation, Doctor?

Dr. EVERNDEN. My view is essentially the same as that of Mr. Farley.

Senator CASE. Mr. Chairman, these gentlemen have been on the witness stand for a long time, and unless you have some questions you want to address to them we ought to go to the next witness.

Senator HUMPHREY [presiding]. There were a number of questions prepared as the result of discussions with Senators concerned with the comprehensive test ban. I join with Senator Kennedy in proposing such a resolution in Congress, and have long been a supporter of it.

UNIDENTIFIABLE EARTHQUAKES GIVEN BEST POSSIBLE SEISMIC DETECTION UNIT

First, it is quite evident, I gather from what has been said here, that there is testimony to the effect that seismic detection is a greatly improved science. Is that correct, Dr. Evernden?

Dr. EVERNDEN. Yes, sir.

Senator HUMPHREY. Given the best possible seismic detection network, could you give us any idea of how many unidentifiable earthquakes might be expected per year within the Soviet Union?

Dr. EVERNDEN. The best possible estimate has to be sort of qualified and then magnitudes attached. I would guess the best logistically and politically feasible network external to the U.S.S.R. that could be deployed would probably have, because of various causes, 10 or so unidentified events of magnitude 4.0 or greater per year. If a far simpler network were deployed outside the Soviet Union but, as was mentioned earlier, 15 or 20 black boxes or USO's were deployed within the appropriate areas of the Soviet Union, the number of unidentified events at 4.0 could be made, I think, essentially zero.

Senator HUMPHREY. That is if you could have the black box within the Soviet boundaries itself.

Dr. EVERNDEN. Yes.

NUMBERS OF USO'S REQUIRED

There is one point which I think would be useful here to get on the record. Yesterday, as you might expect, I was reading the hearings of your committee and the joint committee on this subject. One thing that arose—there was a discussion about the use of USO's and it was stated that numbers like 200 or so of these were required. The number I gave today is 15 or 20 and I thought it might be useful to help specify how the difference between 15 and 200 arises. The 200 were designated

at a time when it was assumed that decoupling could be done in numerous media and that one had to have a capability of seeing events of magnitude 3.0 or less everywhere within the Soviet Union.

The state of understanding today on that is—I believe everybody would agree—that the construction of cavities adequate for decoupling even several kilotons is only possible in salt dome areas and is not possible in granite masses. Therefore, the monitoring equipment to discern these smaller magnitude events need only be deployed in salt dome areas. These areas are very restricted and there are no earthquakes in the salt dome areas of the Soviet Union. This is a matter of historical knowledge as detection of a seismic event in a salt dome area constitutes identification as an explosion. Therefore, the real problem may be differentiating a small tamped chemical explosion from a decoupled larger nuclear explosion. These two factors of localization of critical areas and ease of identification as an explosion mean that most of the 200 stations believed required in the past don't need to be deployed against the problem because the problem does not exist in those terms.

POSSIBILITY OF ESTABLISHING NETWORK MINIMIZING U.S. RISK

Senator HUMPHREY. Are you of the opinion then that a network could be established that would minimize any risk to the United States if we were to enter into a comprehensive test ban treaty?

Dr. EVERNDEN. If having the detection identification capability to 4.0 or a bit below—below 3.0 in salt dome areas—would meet that standard, why, yes. But I don't know whether it meets that standard.

Senator HUMPHREY. You are speaking now of the threshold so to speak. Is that correct?

Dr. EVERNDEN. I mean, you have the national security context in your question, sir?

Senator HUMPHREY. Yes, sir.

Dr. EVERNDEN. And all I can do is specify as to what kind of network I can build, the authority to do it.

Senator HUMPHREY. What do you think the degree of risk would really be?

Dr. EVERNDEN. I am afraid I am here as a Government seismologist.

Senator HUMPHREY. Pardon.

Dr. EVERNDEN. I am afraid I am here as a Government seismologist. For everybody, yours is a very subjective question and I don't think I can say anything that would be useful.

U.S. CAPABILITY OF POLICING COMPREHENSIVE TEST BAN

Senator HUMPHREY. Finally, are we capable of policing a comprehensive test ban using only national means of verification and not involving equipment on Soviet territory?

Dr. EVERNDEN. I fear that that question should be asked at another time to somebody else or maybe Mr. Farley can answer that better than I.

Mr. FARLEY. I didn't mean to interrupt.

Senator HUMPHREY. Please go ahead, Mr. Farley.

Mr. FARLEY. I have testified that it is our view that we still require more than our national seismic and other means of verification for adequate verification of a comprehensive test ban at this time.

Senator HUMPHREY. Our national seismic, but what about other nationals? What if you could enter into agreements with, for example, the Scandinavian countries, Iran, or Outer Mongolia?

Mr. FARLEY. Now some of the stations which we fund are operated by other countries. For instance, the NORSAR station is operated by Norway but funded in large part, conceived and designed and operated in accordance with conditions established here. I think that is a very practical means. It does seem to us important, as Dr. Evernden indicated in talking about the unmanned seismic observatories, that their location, their adequacy, their method of operation be in accordance with U.S. standards and criteria, if they are to serve the purpose that we would place on them.

Senator HUMPHREY. Yes, I am not disputing you on that point. The point I am getting at is if those standards or if the equipment meeting U.S. standards were strategically placed in lands of other countries outside of the Soviet Union, would it be possible to monitor effectively a comprehensive test ban treaty?

Dr. EVERNDEN. Sir, our understanding of national means, is that it is all means available to us.

Senator HUMPHREY. Yes, sir.

Dr. EVERNDEN. It does not mean means deployed within the national boundaries of the United States.

Senator HUMPHREY. I understand.

Dr. EVERNDEN. So when we say a capability by national means, it is a capability based on assumed capability of stations in most of the areas you are addressing.

Senator HUMPHREY. Then your conclusion is what?

Dr. EVERNDEN. So, the conclusion I gave before was that a network based solely on national seismic means, thus a network deployed wherever we can get stations outside the Soviet Union and China, would have difficulty in identifying by seismological criteria the last 10 or so events of magnitude 4.0 or so coming from within the Soviet Union. However, if we could use a much simpler external seismic network than that one but could deploy 20 USO's inside the U.S.S.R. the problem at magnitude 4.0 and somewhat below would essentially disappear.

Senator HUMPHREY. Thank you very much.

We thank you both, very much.

[Questions submitted to Dr. Evernden and his responses follow:]

RESPONSES TO QUESTIONS SUBMITTED TO DR. EVERNDEN, ACDA, BY SENATOR MUSKIE FOR THE RECORD

Question 1. (a) Could you provide specific information as to the portions of the Soviet Union in which there is little or no seismic activity that might complicate explosion detection? (b) Could you pinpoint the areas of greatest probability of natural seismic activity and discuss the various means of differentiating between natural events and explosions in these specific areas?

Answer. The attached outline map taken from the testimony by Dr. S. J. Lukasik in hearings before the Subcommittee on Research, Development, and Radiation of the JCAE, October 27 and 28, 1971 (Chart 26, page 60)¹ indicates

¹ Attachment No. 1.

the seismic regions of the U.S.S.R. If the four major seismic regions on that map are numbered 1 to 4 from west to east, the level of seismicity in each is approximately as follows:

Region	Percent U.S.S.R. seismic activity	Number of of $m_b \geq 5.0$ (per year)	Number of of $m_b \geq 6.0$ (per year)
1.....	7	2	0.2
2.....	8	3	.3
3 ¹	4	1	.1
4.....	74	25	2.0

¹ Includes area of scattered epicenters west of region 3 of chart 26.¹

Sakhalin Island, on the western edge of the Sea of Okhotsk, includes about 6 percent of U.S.S.R. seismic activity, while the broad zone indicated on chart 26¹ as extending northwest from the Sea of Okhotsk includes about 1 percent. All other regions of the U.S.S.R. are essentially aseismic, that is, there is little or no seismic activity to complicate seismic verification.

The answer to the last part of Question 1 depends upon precisely what information is desired. I will presume the question to be a request for a generalized discussion of the interrelationships of critical characteristics of earthquakes of the several regions and generalized identification criteria.

Region 1. *Caucasus*—Essentially all earthquakes in this area have depths of less than 70 km. Most are less than 50 km and nearly all have depths greater than 15 km. Therefore, depth of focus determinations must be of high quality. Since no earthquakes in this area have appeared anomalous (possibly because there are essentially no strike-slip earthquakes in this area), determination that an earthquake is within the crust of the earth (that is, depth less than or equal to 50 km.) is probably adequate since $M_s:m_b$ should successfully identify such shallow-focus events. First motion, and long period criteria other than $M_s:m_b$ (Love wave, comparison of details of Love and Rayleigh spectra) are all very useful if the data are obtainable. Due to the interplay of the national boundaries of the U.S.S.R., the source mechanisms of many of its earthquakes, and the locations of those earthquakes, first motion is a largely useless criterion for a verification network external to the U.S.S.R.

2. *Tashkent, etc.*—The situation here is quite similar to that in the Caucasus except that a few deep events occur along the southern portion of the region.

3. *Irkutsk to Kazakh*—Many of these earthquakes appear to be very shallow (20 km or less), with depths for some events reaching 50 km or so. This means that very refined procedures of depth determination are required. In addition, infrequent anomalous earthquakes appear to be possible in this area. Refined depth determinations may be required to identify such events properly. For most events, $M_s:m_b$ or other long period criteria must be the basis of identification if accurate depths are not available.

4. *Kamchatka/Kuriles*—Here, the interplay of location and depth of focus creates a markedly different situation. The capability to locate an earthquake within 15–20 km. of its correct location, plus the ability to establish depths as greater or less than 50 km. will successfully identify nearly all earthquakes in this area, since such shallow focus events are in most cases tens of kilometers at sea. The small residuum of events could be identified by more accurate depths, plus $M_s:m_b$ and other long period criteria.

Sakhalin Island.—Both very deep earthquakes and quite shallow events occur in this area. The former are identified by their depths, the latter must be identified by long period criteria if very accurate depths cannot be obtained.

¹ Attachment No. 1.

ATTACHMENT No. 1



HGB, USGS for ARPA, DoD, 1971

U.S.S.R. SEISMICITY

Question 2. (a) What is the feasibility of decoupled explosions in cavities within the Soviet Union? (b) Can cavities be constructed in salt deposits or anywhere else in sufficient size to be useful? (c) Are salt domes or other natural or manmade cavities located in seismic areas in the Soviet Union? (d) If so, where? (e) Is there a difference in decoupling factors between mine cavities and cavities made by explosions? (f) What has our research demonstrated as to the feasibility of detecting and identifying decoupled explosions in salt domes?

Answer. This question is understood to address what are termed "fully decoupled" explosions.

(a) This is a simple question in one context, a difficult one in another. It is certainly feasible for the Soviets to decouple something like a 1 kiloton explosion by mining sufficiently large cavities. Due to unique and unevaluated engineering aspects of constructing large freestanding air-filled underground cavities (i.e., several hundred feet in diameter) of controlled shape, it is my personal opinion that no definitive answer as to the feasibility of mining cavities adequate for fully decoupled explosions of even 10 kiloton can be made. Investigations of which I have knowledge indicate a minimum condition for construction of such cavities is that the cavity must be in a large homogeneous salt mass. The unevaluated parameter is the behavior of natural salt masses when such large holes are generated within them. Strong differences of opinion exist which have remained unresolved for years as no one has ever attempted to build holes of relevant diameter. Feasibility of constructing holes adequate for full decoupling of 10 kiloton has not been demonstrated. Holes for decoupling explosions as large as 50 kiloton or more appear at this time to be infeasible.

(b) Again, one must define useful. If one considers holes adequate for decoupling 1 kiloton explosions (200-foot diameters) to be useful, the answer to the question is probably yes. If 10 kiloton is the definition of useful (hole diameter required is 425 feet), the question is factually unanswerable. See (a) above.

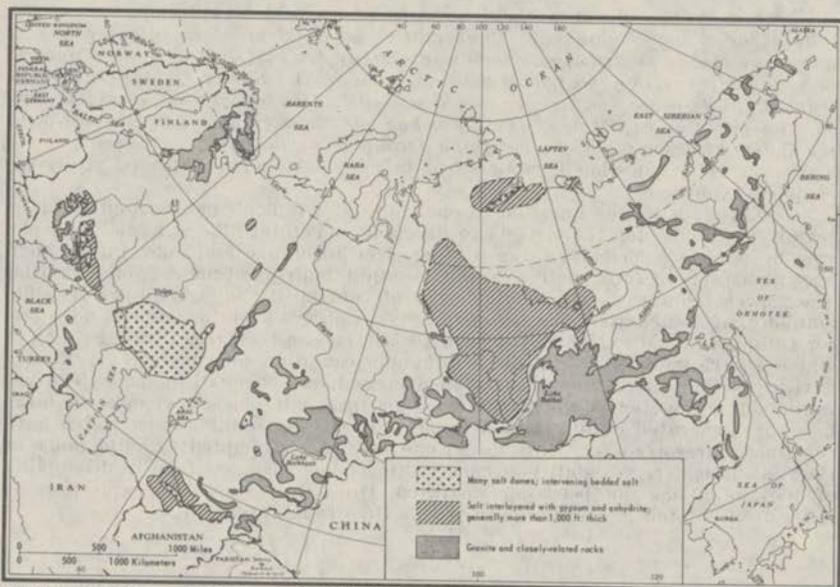
(c) As regards salt masses useful for building large cavities, studies indicate that homogeneous salt masses four to five times larger in all dimensions than the diameter of the hole to be made are required. Most salt masses shown on the attached chart from the hearings referred to in question 1 above (chart 24, page 56)² are useless as sites for constructing large cavities. The most technically feasible place is the area of very large salt domes at the north end of the Caspian Sea. Smaller salt domes occur in three or four other small areas, but use of these in clandestine tests would appear to pose problems not present in the area north of the Caspian Sea. Comparison of the attached chart with that referred to in question 1 indicates absence of natural seismic activity in any of the salt dome areas of the U.S.S.R. Detection of a seismic event in these areas constitutes identification as an explosion. As regards natural cavities, there do not appear to be any that would be useful for clandestine testing.

(d) See (c).

(e) Data available on the Cowboy series of high explosive detonations in mined cavities in salt indicate a probable decoupling factor of about 75 at frequencies of 1 Hz. Since the average decoupling factor observed for the Sterling nuclear explosion in the exploded cavity created by the Salmon nuclear explosion was also about 75, there appears to be a close correlation between decoupling factors for explosions in mined and exploded cavities.

(f) Assuming a decoupling factor of 75, a 1-kiloton explosion would yield approximately an m_b 1.8 signal, a 5-kiloton explosion and m_b 2.5 signal, a 10-kiloton explosion an m_b 3 signal. Signals of these m_b values can only be detected by seismometers in the proximity of the salt dome areas.

ATTACHMENT No. 2



MGB, USGS for ARPA, DoD, 1971

U.S.S.R. DISTRIBUTION OF SALT AND GRANITE

Question 3. (a) Could you comment on the feasibility of the evasion technique of detonating multiple explosions to simulate earthquakes? (b) How feasible would it be to try to evade a comprehensive test ban by hiding an explosion in a very large earthquake?

² Attachment No. 2.

Answer. Answers to both (a) and (b) depend strongly on assumptions about the quality of the operational verification network. When yield values for avoiding seismic detection or identification are quoted, they must be tied to specific assumptions about the capability of the assumed verification network in order to be meaningful.

(a) It is my personal opinion that evasion schemes based on the idea of multishot simulation are bound to fail if multiazimuth, multirange, multiphase seismological data are available. I am confident that this opinion is shared by virtually all seismologists who have considered the problem. The presumed credibility of this scheme is based upon the unstated assumption of the availability of only limited data and limited data analysis.

The simulation of the complexities of earthquake seismograms, such complexities being induced by the basic asymmetries and high content of shear energy of earthquakes, is just not possible by firing of numerous explosions. Any network adequate to even reasonably well control evasion efforts based on hiding-in-an-earthquake scenarios would be more than adequate to thwart multishot evasion efforts.

(b) It is very difficult to give a simple answer to this question, the answer is so critically tied to the particular scenario details and the network characteristics. A few generalities will be attempted. In my view, evasion based on hiding-in-an-earthquake is by all odds the most credible approach to evasion at yields of several kilotons against a verification network deployed at teleseismic distances. However, there are definite limits to this evasion scheme. For example, investigations of the interrelationships of hiding opportunities, event magnitudes (m_b , M_s), and network characteristics suggest that, against present WWSN³ capabilities, several opportunities per year exist conceptually for successful hiding by the U.S.S.R. at M_s 5.0 with only a 10 percent chance of the surface waves being seen. However, in all these cases, there would be at least a 90 percent certainty that body waves from an earthquake having such M_s values would be clearly recorded by numerous short period instruments since the equivalent body wave magnitude would be relatively large ($m_b \geq 5.5$). Although detection of short period signals without detection of long period signals might constitute an unidentified event, the statistical probability of an m_b 5.5 earthquake occurring within the U.S.S.R. with its surface waves hidden in those of another earthquake even once every few years is small. Also, the event would be sufficiently large that successful identification by short period criteria might be very probable. In general, I would guess that successful evasion against a quite capable external network would occasionally be possible at m_b (20 kilotons or so in hard rock). As pointed out in my earlier testimony, deployment of 20 or so unmanned seismic observatories (USO's) appropriately throughout the Soviet Union as an adjunct to external capabilities would essentially eliminate this type of evasion opportunity at m_b 4.0 and it would seriously restrain evasion opportunities at m_b 3.5.

The above discussion is predicated upon use of distant worldwide earthquakes. If the emphasis is on scenarios using nearby earthquakes, a major restraint on evasion by this means is the required level of seismic activity in the vicinity of the shot. As pointed out in the first question, only Kamchatka/Kuriles can expect to have even one magnitude 6.0 event per year. Studies suggest that at least one magnitude difference between explosion and earthquakes should be allowed, and since the earthquake should be within 600 km or so of the explosion to employ this particular evasion scheme, there would be much less than one opportunity per year at any specific site in the U.S.S.R. outside Kamchatka/Kuriles at m_b 4.0. Studies have been conducted of detecting evasion by this scheme in Kamchatka/Kuriles. To my mind, these studies indicate that external verification systems could be deployed which would seriously restrain any efforts of this type. Another important parameter of this evasion scheme is the expected yield versus magnitude relationship for explosions in Kamchatka/Kuriles. If m_b versus yield values in Kamchatka/Kuriles are similar to those in Amchitka (a not illogical assumption in light of their similar geological environments), an m_b 4.5-5.0 signal would be associated with a yield of 1 kt or so. Deployment of the USO's mentioned above would lower these thresholds even further.

Question 4. Please describe the possibilities of evasion by testing in dry alluvium within the Soviet Union. Could you estimate the highest probable yield at

³ Worldwide seismic network.

which tests could be conducted with the expectation that there would be no detectable surface effects?

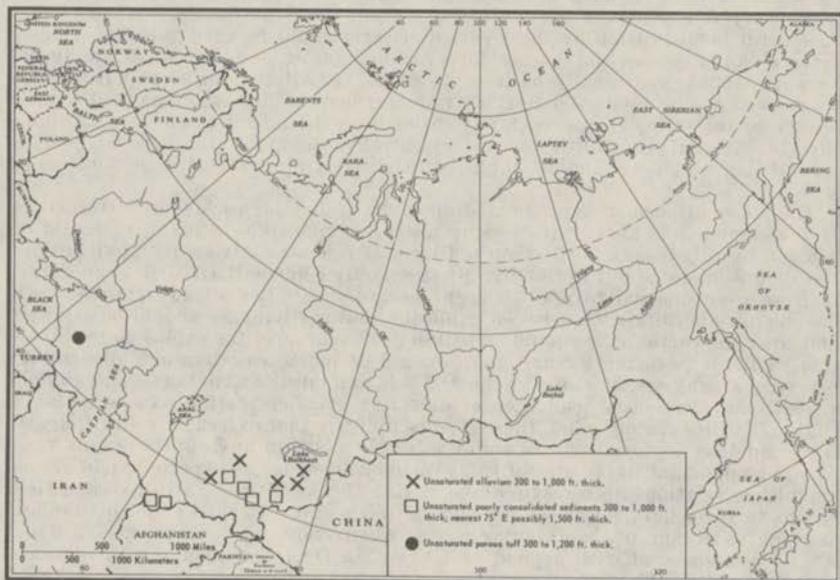
Answer. The conditions for existence of deep dry alluvium are so restrictive and so unusual that all recent studies of which I know agree that thicknesses of material such as at the U.S. Nevada Test Site may be unique and almost certainly do not exist anywhere in the U.S.S.R. Either studies based on a small set of fundamental geologic, climatic and hydrologic conditions, or studies based on meticulous analysis of all available data arrive at the same conclusion, that is, that chart 23, page 54 from the hearings referred to in question 1⁴ describes the general distribution of this material within the U.S.S.R. There are small scattered deposits of possibly 1,000-foot thickness in desert or near-desert areas in the southern end of Uzbek U.S.S.R.

I cannot see how it would be possible to have elsewhere in the U.S.S.R. the co-occurrence of all conditions necessary for the formation of such material.

At NTS, U.S. Nevada Test Site, the scale depth in dry alluvium to prevent a surface collapse crater is at least 600 feet and possibly greater. Using a 600-foot scaled depth, and allowing 100 feet below the explosion to prevent strong coupling to the deeper water-saturated strata, yields of 1-3 kilotons might be possible. Any higher yields will cause cratering or, if placed deep enough to prevent cratering, will have high amplitude signals (m_b 4.5-5.0), which could be detected. Whether all other surface effects associated with the emplacement of devices at such depths in terrains of this type would be removable or preventable is not a seismological matter. A 2 kt explosion in dry alluvium should generate an m_b 3.2-3.5 signal. Since these potential sites are near the southern borders of the U.S.S.R., events of this magnitude could be detected by new stations near, but outside, the borders of the U.S.S.R. Alternatively, these events could be easily detected by a combination of present external capabilities plus a limited number of USO's. Therefore, efforts by the Soviets at evading a CTB by use of available dry alluvium seems extremely unlikely.

⁴ Attachment No. 3.

ATTACHMENT No. 3



MGB, USGS for ARPA, DoD, 1971

U.S.S.R. LOW-COUPLING MEDIA

Senator HUMPHREY. Dr. Foster is our next witness.

Dr. Foster, we welcome you once again. Dr. Foster is Director of Defense Research and Engineering, Department of Defense.

Doctor, you are accompanied by Dr. Stephen Lukasik, Director of Advanced Research Projects Agency, Department of Defense.

Dr. Foster, we welcome your commentary on proposed Senate Resolution 67. Please proceed.

STATEMENT OF DR. JOHN S. FOSTER, JR., DIRECTOR, DEFENSE RESEARCH AND ENGINEERING, DEPARTMENT OF DEFENSE; ACCOMPANIED BY DR. STEPHEN J. LUKASIK, DIRECTOR OF ADVANCED RESEARCH PROJECTS AGENCY, DEPARTMENT OF DEFENSE

Dr. FOSTER. Mr. Chairman, would you care to have me read this brief statement or would you like me to paraphrase it or just ask questions?

Senator HUMPHREY. It is a very brief statement. Why don't you just proceed?

Dr. FOSTER. I would be very pleased to do that, Mr. Chairman and members of the committee.

I am pleased to represent the Department of Defense before this distinguished subcommittee to speak to the proposed Senate Resolution 67. This resolution calls for an immediate moratorium on underground nuclear testing and the acceleration of negotiations with the Soviet Union on a permanent agreement to ban further nuclear testing.

At the outset, let me say that the U.S. policy supports a comprehensive nuclear test ban, adequately verified, in order to limit the escalation and proliferation of nuclear weapons. This has been publicly affirmed in numerous policy statements and is included in the Limited Test Ban Treaty of 1963 and the Nuclear Non-Proliferation Treaty of 1968, to both of which we are a party. The Department of Defense supports those agreements.

I am sure that we all agree that acceptable arms limitation agreements can only be achieved if there is mutual confidence built on adequate objective information that each signatory is abiding by the terms of the agreement, and that none are achieving unilateral advantages at the expense of other signatories in violation of the agreement. Furthermore, we seek to achieve this verification capability through national and international means so that each side can assure itself of the adequacy of the data on which its security must ultimately rest.

The proposed resolution speaks to two circumstances. One is the case of a formal comprehensive test ban treaty where the negotiations provided an opportunity to arrange for such modalities as either side required to secure adequate verification. The other is the case of an informal moratorium which foregoes adequate verification at the outset.

The key issue we must address, therefore, is that of the adequacy of means to verify a ban on underground nuclear testing. To this end, we have funded a major research program to assist us in pursuing

such agreements while at the same time maintaining our national security. I am accompanied today as you indicated, by Dr. Stephen J. Lukasik, Director of the Defense Advanced Research Projects Agency, who is responsible for the research program bearing on the subject of today's hearing.

VERIFICATION ISSUE: SEISMIC TECHNIQUE

The technical questions involved are, as this subcommittee fully recognizes, quite intricate. They were dealt with extensively in hearings before this subcommittee in July of 1971 and later before the Joint Committee on Atomic Energy in October of that year. The status of our understanding of those questions has been published in the proceedings of both hearings; and I will, therefore, state the conclusions of the Department at that time and indicate some of the principal efforts that have been undertaken since then relative to the verification issue.

First, we have determined that we cannot verify a ban on underground testing on the basis of seismic stations on U.S. territory alone. The nature of the seismic signals from underground explosions and the obscuring background noise requires an extensive set of seismic monitoring stations as close as possible to the sites of suspected explosions.

Second, we have studied the differences between the seismic signals from explosions and those from earthquakes and we have found that, while we can distinguish the two in many circumstances, we believe that there will be a significant residuum of seismic signals above some level whose origin we will not be able to establish unambiguously.

And third, we have assessed the possibility of a violator's continuing nuclear weapon developments without the detection or identification of his activities. We find that nuclear explosions at militarily significant yields could be successfully concealed from available national means of verification.

Since reaching these conclusions, the Department of Defense, in cooperation with other interested agencies such as the Atomic Energy Commission and the Arms Control and Disarmament Agency, has continued its research program to attempt to push back the technical frontiers involved in the above conclusions and narrow or, hopefully, eliminate the gap between our capability and our requirement for verification. We have done this by undertaking:

The installation of new seismic instrumentation around the world;
Continuing research on the theoretical understanding of the nature of earthquake and explosion sources;

Continuing empirical studies of the differences between earthquakes, and explosions;

A new and vigorous program to improve the processing of seismic data and its exchange within the international seismic community;

The development of techniques for authenticating seismic data from unmanned stations;

Advanced seismic signal-processing techniques for "seeing through" the attempts of a violator; and

Development of techniques for nonseismic means of verification.

VERIFICATION ISSUE: ONSITE INSPECTION

With the inadequacies inherent in the seismic verification technique, and which are likely to persist in any future seismic system, it is necessary to supplement this technique with other verification modalities. Chief among these is the concept of inspecting of the site of an unidentified seismic event. The required procedures for an onsite inspection would vary greatly, depending on the nature of the ambiguity to be resolved. In the vast number of cases, the seismic event would in fact, be an earthquake, and an examination of the region would either verify that fact or at least turn up no evidence of nuclear testing. After an extensive research program we have found that by far the most effective techniques for such an inspection are visual inspection and radioactive gas samplings.

The fact that several earthquakes per year have seismic characteristics resembling those of explosions gives rise to a second and more serious cause for inspection. Such events represent false alarms and, if unresolved, in the course of time would erode the confidence of the signatories of the treaty.

Another type of false alarm that could be resolved by an onsite inspection is that of the nuclear or nonnuclear nature of clearly established explosive events. It is common to utilize chemical explosions of several kilotons in construction projects. Radioactive gas sampling at or near the site of such an explosion would be particularly helpful in establishing that a nuclear device had not been employed, although other verification procedures could possibly be arranged also.

Finally, there is the possibility that an ambiguous seismic event is a nuclear test and that, despite the most careful attempts at concealment by the violator, the activity has been detected by a monitoring network. An inspection of the site yielding positive evidence, or the mere possibility of such an inspection, would clearly force a resolution of the security issues involved.

Because of the critical role that onsite inspections can play in each of the above examples, we believe they also constitute a major deterrent to a would-be violator of a comprehensive test ban treaty. They are also a necessary adjunct for adequate verification.

DEFENSE DEPARTMENT POSITION ON SENATE RESOLUTION 67

Mr. Chairman, in view of the above, let me summarize the DOD position on Senate Resolution 67:

We believe that adequate verification is an essential requirement for a cessation of nuclear weapon testing;

The present U.S. verification capability is inadequate;

Through international negotiations and also bilateral negotiations with the Soviet Union, we have not yet been successful in obtaining adequate verification capability; and

In our view Senate Resolution 67, by tacitly accepting the Soviet position on national means at the outset, would actually weaken the present U.S. position in attempting to negotiate the required verification capability.

For these reasons, the Department of Defense does not support this Senate resolution. Thank you, Mr. Chairman.

Senator HUMPHREY. Thank you very much.

WITNESS' REFERENCE TO "IMMEDIATE MORATORIUM"

Dr. FOSTER, in your comment you have noted that the resolution calls for an immediate moratorium on underground nuclear testing.

Dr. FOSTER. Yes, sir.

Senator HUMPHREY. And then pending negotiations for an international agreement. As a cosponsor of that resolution I thought it called upon the President to propose an immediate suspension. Do you see any meaningful difference?

Dr. FOSTER. At this stage, Mr. Chairman, it seems to me that the action is in the Senate.

Senator HUMPHREY. Pardon me, would you repeat what you said?

Dr. FOSTER. It seems to me, Mr. Chairman, I was saying the action is in the Senate. The Senate has a resolution.

Senator HUMPHREY. Yes.

Dr. FOSTER. And if the resolution passes, then it is a matter for the President to decide.

Senator CASE. That is not quite the question you asked.

Senator HUMPHREY. The resolution reads: "It is the sense of the Senate that the President of the United States should propose an immediate suspension on underground nuclear testing to remain in effect so long as the Soviet Union abstains from underground testing."

That is rather similar, is it not, to what President Eisenhower did back in the late fifties?

Dr. FOSTER. Yes.

Senator HUMPHREY. And also what President Kennedy did just prior to the Limited Nuclear Test Ban. In fact it goes further than what President Kennedy did because President Kennedy took unilateral action. My question was to the effect that since the resolution reads that the President is requested to propose an immediate suspension, do you see this as a meaningful difference between what your testimony seems to indicate, that the suspension was automatic?

Dr. FOSTER. I was trying to indicate, Mr. Chairman, that at this moment it is not, as I understand it, the sense of the Senate. If it passes it would be the sense of the Senate.

Senator HUMPHREY. For the President to propose.

Dr. FOSTER. Yes, sir.

Senator HUMPHREY. But your statement reads "This resolution calls for an immediate moratorium on underground nuclear testing."

Dr. FOSTER. I believe, Mr. Chairman, that the language is a little too loose and it should be cleaned up.

Senator HUMPHREY. In other words—

Dr. FOSTER. I would be pleased to clean it up.

Senator HUMPHREY. In other words, your testimony—

Dr. FOSTER. I overdraw the situation.

Senator HUMPHREY. Yes, thank, you.

JOINT CHIEFS POSITION REGARDING COMPREHENSIVE TEST BAN

What is the position of the Joint Chiefs in regard to a comprehensive test ban? Does it differ in any way from the statement that you

have made here today? Could you present the specific position of the Joint Chiefs?

Dr. FOSTER. To my knowledge, Mr. Chairman, the Joint Chiefs do not support the Senate Resolution 67. The Joint Chiefs would, of course, abide by any decisions made by the President.

Senator HUMPHREY. Obviously, they would, he is the Commander in Chief.

Dr. FOSTER. That is correct, sir.

Senator HUMPHREY. But I was wondering what their recommendations were. What have the Joint Chiefs recommended to the Department of Defense? Quite obviously the Department of Defense is stating the position of the President, if I am not mistaken.

Dr. FOSTER. That is correct, sir.

Senator HUMPHREY. Yes.

Dr. FOSTER. I do not know of the detailed position of the Joint Chiefs with regard to the President's position.

The Joint Chiefs would be looking at the relatively narrow issue of military capability in the out years that is involved in such a decision. However, the President has to look at a far broader range of issues.

[A position statement by the Joint Chiefs of Staff has been received in classified form and is in the committee files.]

Senator CASE. I am sure that is true, if I may interrupt.

Senator HUMPHREY. Go ahead.

Senator CASE. But the Joint Chiefs don't only have to look at the question of whether we might gain anything. I am sure they have some breadth in their vision.

Dr. FOSTER. Well, certainly, Senator Case, what I indicated was my understanding that the Joint Chiefs do not support this particular resolution—

Senator CASE. I understand.

Dr. FOSTER [continuing]. Discussed here.

Senator HUMPHREY. Do they support a comprehensive test ban?

Dr. FOSTER. That I do not know in detail, Mr. Chairman. I think one of the things that the Joint Chiefs would have to review would be the specifics of a test ban and, in particular, the degree of confidence we would have in the monitoring of such an arrangement. Those have not been spelled out and, consequently, to my knowledge, the Joint Chiefs have not rendered a position.

Senator HUMPHREY. In your testimony you say, "Let me say that the U.S. policy supports a comprehensive nuclear test ban adequately verified in order to limit the escalation and proliferation of nuclear weapons."

My question was not directed toward the resolution as such. The question is: Do the Joint Chiefs support the comprehensive test ban and/or to put it another way, can the subcommittee conclude that the Joint Chiefs see no military requirements that would necessitate delay in achieving a comprehensive test ban?

Senator CASE. Adequately verified.

Senator HUMPHREY. Under the terms of the resolution.

Senator CASE. Yes.

Dr. FOSTER. Let me put the whole thing then in a different light. The position of the President is one of support for a comprehensive

nuclear test ban that is adequately verified. I have stated that the Joint Chiefs support the position of their Commander in Chief.

Senator HUMPHREY. Go ahead, Senator.

Senator CASE. You mean as a general proposition.

Dr. FOSTER. Yes, sir, as a general proposition.

Now, what I tried to carefully point out—

Senator CASE. What we would like to know is whether they would be for this if they were making the decision.

Dr. FOSTER. I think it depends very much, sir, on the details—

Senator CASE. Yes, assuming adequate verification.

Dr. FOSTER [continuing]. Worked out and what one considers adequate verification.

FEELINGS OF JOINT CHIEFS ABOUT COMPREHENSIVE TEST BAN

Senator CASE. Do you have any knowledge as to how they feel about this thing, assuming adequate verification?

Dr. FOSTER. I do know they support the position of the Commander in Chief.

Senator CASE. As a technical matter or as a matter of loyalty to the Commander in Chief?

Dr. FOSTER. They support the President's position, at least in the terms of their understanding of what would constitute adequate verification.

Senator CASE. In other words, they are not trying to stop a comprehensive test ban treaty.

Dr. FOSTER. Not to my knowledge, Senator, no.

Senator CASE. Thank you, Mr. Chairman.

ADEQUATE VERIFICATION SYSTEM

Senator HUMPHREY. What do you think makes up an adequate verification system because I have been hearing for years arguments about an adequate verification system. As was said here a few months ago, there was one time we were talking about 200 of the so-called black boxes stationed inside the Soviet Union. Then we used to argue about how many onsite inspections; you remember when we talked about 18 and 15 and 12 and then we argued about whether we could get by with 5. This language of an adequate verification system is the whole ball game. What is your judgment, Doctor?

Dr. FOSTER. I think you are quite correct, Mr. Chairman. We have argued over a range of conditions. My view is that looking backward we were too naive to be so specific.

Senator HUMPHREY. In the past you mean.

Dr. FOSTER. In the past.

Senator HUMPHREY. Yes.

Dr. FOSTER. It seems to me that perhaps we are doing just the right thing now. We have a vigorous experimental program that I described very briefly in the statement, and I would hope, through that effort, we might understand the situation well enough to be able to come to grips with this issue. It is a very difficult one, and I don't believe it can be resolved by simply deciding which set of numbers the Soviets might accept or not accept. What is at issue here is some risk to our

national security, which we might well be willing to run. The question is one of determining just what degree of verification we might have under some conditions and what risk would be associated with those specific conditions.

SOVIET SUSPICION OF UNITED STATES

Senator HUMPHREY. Wouldn't you presume, too, that the Soviet Union might be a bit suspicious of us?

Dr. FOSTER. I think there is always that situation, Mr. Chairman.

Senator HUMPHREY. We assume that we are right on top of the table here, clean and aboveboard, but when we have seen some of the activities of counterespionage and Central Intelligence Agency, et cetera, it must be that there may be some suspicion in their minds as to whether or not we would be concealing something.

MILITARILY SIGNIFICANT YIELD

What do you consider to be a militarily significant yield? You spoke of the possibility of successful concealment of militarily significant yields from detection by national means of verification.

Dr. FOSTER. In my view, Mr. Chairman, a kiloton is a very significant yield. Now, I will admit there are some cases where a half-kiloton can be very significant or a quarter of a kiloton. But certainly I know from my experience that a kiloton is a very significant yield from a military point of view. Clearly, as one raises the level above that, the number of possibilities that are included grows and so does the significance.

Senator HUMPHREY. Senator Case, do you have any questions?

WILL VERIFICATION ARRANGEMENTS EVER BE ADEQUATE?

Senator CASE. I just wonder how far ahead in time that puts the possibility of any kind of verification arrangements that you might regard as adequate.

Dr. FOSTER. I think, Senator Case—

Senator CASE. Half a kiloton is a little further than anybody can talk about.

Dr. FOSTER. It seems to me, Senator Case, we are really up against two trends here which, in many ways, are quite unfortunate.

Senator CASE. Yes, I know.

Dr. FOSTER. The first trend is that the technology of detection and identification seems to be driving the identification limit to lower and lower values. At the same time, the pursuit of a vigorous underground test ban in support of the safeguards of that treaty has driven up the significance of smaller and smaller yields, and in this issue of cessation of all nuclear testing we are caught between the two.

Senator CASE. Do you think the lines will ever converge or is there no light at the end of the tunnel, to mix a few metaphors?

Dr. FOSTER. Sir, we cannot know.

Senator CASE. Or will there always be light at the end of the tunnel?

Dr. FOSTER. We can't know, but I think there always will be light.

Senator CASE. In other words, we will never get to where we are going.

Dr. FOSTER. I believe that no one can be sure whether there will be means acceptable to both sides that will permit us to so reduce the level at which you cannot identify things as to make it meaningless; and no one can rule out that there may be other factors so strongly in favor of terminating such underground activity that we would not run larger risks in the future. We simply cannot know.

Senator CASE. From the standpoint that you have in mind—and again I am not badgering you at all, but just trying to find out really what is on your mind—if this is your general view, don't you think you are wasting a lot of time even in pretending that you are concerned about developing some kind of a system, because you are not going to do it in your lifetime.

Dr. FOSTER. There is no way we can foresee whether or not it will happen in my lifetime or next year, Senator. I don't believe we are wasting our time or our efforts.

WITNESS' POSITION ON COMPREHENSIVE TREATY, ASSUMING
COMPLETE OPENNESS

Senator CASE. Assuming complete openness, say as much openness as we would be willing to grant to an international inspection system, would you still be against a comprehensive nuclear test ban treaty?

Dr. FOSTER. Well, I would like to think about this a little more, Senator, but it seems to me that, if the Soviet Union and other nations that test were willing to open their countries to inspection, to the degree that the United States might find acceptable, it might well satisfy the criterion for adequate verification.

Senator CASE. Would you be willing to have us open this country to that degree of inspection?

Dr. FOSTER. That involves things which are well beyond my authority and responsibility.

Senator CASE. I am not asking you for your authority now, I am asking for your opinion.

Dr. FOSTER. For what it is worth, yes, I think I would.

Senator CASE. Well, it is something. It starts somewhere.

Dr. FOSTER. Yes.

Senator CASE. And, I take it, your general view is that assuming a treaty or a test ban agreement verified to the degree which you would permit in the United States, such a treaty would not be undesirable.

Dr. FOSTER. Yes, I think so; I agree with you.

Senator CASE. Thank you, Mr. Chairman.

INSPECTION BY SATELLITE

Senator HUMPHREY. Just a few more questions, Dr. Foster, because you are a very well-informed man and highly regarded. You say the most effective techniques for inspection are visual and radioactive gas samplings. Could this kind of inspection be carried out by satellite?

Dr. FOSTER. No, sir; it could not.

Senator HUMPHREY. Not at all.

Dr. FOSTER. All of our national means permit one to narrow down the problem but none seems adequate to take the place of onsite inspections.

Senator HUMPHREY. If I divided that question, could visual inspection be adequately performed by a reconnaissance satellite?

Dr. FOSTER. I believe, Mr. Chairman, that onsite visual inspection is required.

Senator HUMPHREY. It is required.

Dr. FOSTER. Within all other national means there is not adequate capability.

Senator HUMPHREY. Don't we rely on reconnaissance satellite inspection for some very, very important developments that we are trying to monitor within certain parts of the world?

Dr. FOSTER. Mr. Chairman, we rely on our total national means, and, as you well know, within that total national means we find a number of cases where our capability is inadequate.

Senator HUMPHREY. So that your professional judgment is that there is no substitute for onsite inspection.

Dr. FOSTER. That is my judgment, sir; yes.

RADIOACTIVE GAS SAMPLINGS BY AIRPLANE

Senator HUMPHREY. On radioactive gas samplings, we have done this by airplane; have we not?

Dr. FOSTER. Yes, sir; we have.

Senator HUMPHREY. What was the nature of those explosions that we monitored or tested in that way? Were they underground?

Dr. FOSTER. Normally, Mr. Chairman, they are explosions in the atmosphere.

Senator HUMPHREY. In the atmosphere.

Dr. FOSTER. And, as a consequence there are enormous amounts of radioactivity released.

In the case of an underground test, one looks for the seepage of a minute amount by comparison, so it is not possible to do it from aircraft even if one could overfly the site.

Senator HUMPHREY. Yes. All right. I thought we would get your testimony on record on this because there are obviously very different types of explosions at different levels. We have used in the past, as we know, the airplane sampling of radioactive gas to detect chemical composition of a bomb, including its covering. But we are talking now about a comprehensive test ban in which it has to be assumed that someone might practice intricate methods of concealment.

Dr. FOSTER. Yes; that is correct.

LIKELIHOOD OF ANYONE ATTEMPTING VIOLATION OF AGREEMENT

Senator HUMPHREY. The question therefore comes, Would the Soviet Union or the People's Republic of China, or anyone else, run the risk, presuming that a negotiation took place and an agreement were signed, of breaking that agreement through some type of concealment of explosion?

Dr. FOSTER. I do not know.

Senator HUMPHREY. What is your judgment? All of these things are rather subjective.

Dr. FOSTER. I go back, Mr. Chairman, to the situation from 1957 to 1961 when as far as I know, evidence of any Soviet preparations for

the resumption of nuclear tests was totally lacking. In this country, by comparison, there was great concern lest we cause any other nation to feel that we were getting ready to perform nuclear tests. We were taken by surprise. The Soviets tested in the atmosphere without a shred of evidence that we could see that they had prepared for it. So clearly, in this aspect, the two countries are dissimilar. So I think there is really a likelihood that they would attempt a violation.

Senator HUMPHREY. That was not an agreement. That was a unilateral decision by President Eisenhower, at best a gentlemen's agreement, with no binding words and treaty or formal document. Do we have any evidence that the Soviet Union has violated formal agreements that relate to the postwar period of defense?

Dr. FOSTER. I think, Mr. Chairman, that is a question that properly should be directed to Mr. Farley.

Senator HUMPHREY. Do you know of any, since you are a very well respected specialist in the field of nuclear energy?

Dr. FOSTER. I know of no treaties associated with nuclear energy that the Soviets have violated.

HELPLESSNESS OF STANDING COMMISSION TO DETERMINE VIOLATIONS

Senator HUMPHREY. There has been some talk, if you entered into an agreement, about having a standing commission, international body, that could be ready and available, in case there was a complaint or a claim of violation, to move in at once to determine whether or not the violation had taken place. Do you think a standing commission could serve the purpose of forcing resolution of questions that arise? Do you think a standing commission would be helpful?

Dr. FOSTER. I certainly think a standing commission would be very helpful, Mr. Chairman. It would not adequately compensate for onsite inspections.

OTHER AGREEMENTS WITHOUT ONSITE INSPECTION

Senator HUMPHREY. We have a Biological Warfare Convention and a SALT treaty and an agreement, all agreements without onsite inspection. Those are very important treaties. Why do you believe it is necessary in the case of the comprehensive test ban?

Dr. FOSTER. Simply because of the verification issue, Mr. Chairman.

Senator HUMPHREY. You don't believe there is any concern that we should be worried about verification of biological warfare preparation or the ABM treaty, and the limited treaty on offensive nuclear weapons.

Dr. FOSTER. Mr. Chairman, as you know, I have testified in the past that I considered the national means adequate in the case of the SALT I treaty.

BASIS OF DIFFERENTIATION CONCERNING ONSITE INSPECTION

Senator HUMPHREY. You differentiate here. Is that it? What is the basis of your differentiation? I want to get your professional judgment.

Dr. FOSTER. The difference, Mr. Chairman, is simply in the verification capabilities.

ADEQUATE VERIFICATION

Senator HUMPHREY. We have gone over the issue of what you would consider adequate verification. I gather that you have not specified except to say onsite inspection.

Dr. FOSTER Mr Chairman, it seems to me that the number of onsite inspections is tied rather intimately to the number and conditions associated with the remote monitoring stations, and, until one ties those two together in some detail, I don't think it is meaningful to quantify.

CURRENT EFFORTS TO UPGRADE SEISMIC MONITORING NETWORK

Senator HUMPHREY. This brings us to Dr. Lukasik, who is obviously responsible for the research program which is underway on the improvement of verification, seismic technology. Am I correct?

Dr. LUKASIK. That is correct, Mr. Chairman.

Senator HUMPHREY. Would you give us a brief description of the current efforts on the part of your agency and other government agencies to upgrade seismic monitoring networks and how good could the best possible seismic monitoring system be if the latest advances were put to use? In other words, what you now know could be applied with the mechanical instrumentation that is needed.

Dr. LUKASIK. Well, let me first describe what we are doing and then return to the second part of your question. Our research program has, of course, been underway for over 10 years. We have installed seismic stations around the world. We have 116 stations in the so-called worldwide standard seismograph net which is a fundamental contribution to the state of the art.

Senator CASE. Since what time, Doctor?

Dr. LUKASIK. That was a program that started in 1960.

Senator CASE. You mean during that period.

Dr. LUKASIK. During that period of time.

Senator CASE. The reason I ask is that I understand within the last year or so there has been a rather substantial—

Dr. LUKASIK. Yes; I just wanted to put our activity in perspective. We have done a great deal to develop the science of seismic arrays; largely because they have directional characteristics and, hence, enable you to separate the signals from one direction as against signals from another, this is quite fundamental to the whole issue of how many unidentified events you eventually have to deal with.

The array program culminated in the late sixties in the establishment of three large arrays, one in Montana, the large station in Norway that was mentioned earlier today by Mr. Farley, and another large array in Alaska. We have also undertaken a great many automatic signal processing and signal analysis studies, since these stations produce a great deal of information and one must, of course, be able to analyze it sensibly and quickly.

MOST RECENT EFFORTS TO UPGRADE SEISMIC MONITORING

The most recent efforts that you asked about are in a series of programs, one actually going back to 1970, where we installed about 10

stations of very superior long-period capability. As you know from your study of the problem, the matter of surface waves, which are long-period waves and require instrumentation sensitive to them, is crucial to the seismic identification problem. There was a significant improvement in our ability to make instruments of this sort, so we decided to deploy them in order to exploit their possible contribution to improving our ability to identify seismic events.

More recently we have undertaken to install three long-period arrays in three different countries in and near the seismic areas of the Earth; that is where the problem is, where the events that one must distinguish arise. Plans for those installations are underway now.

Senator CASE. Is their location a security matter?

Dr. LUKASIK. We have not completed negotiations with all of the countries involved, so I think it would perhaps be inappropriate to comment further at this time.

In addition, the worldwide standard seismograph net was installed at the inception of our program. Since that time, we have learned a great deal, how to upgrade those stations, how to make them better. They were very good stations when they were installed, better than anything then available; but in 10 years one obviously learns things. Now we are undertaking to upgrade about 15 to 20 of those stations—again, in various countries around the world, largely located in the seismic regions of the Earth. In particular, we are installing improved long-period instruments, because we understand that this really is an important part of the identification problem, both to do the research and eventually to be able to do that identification in a monitoring sense.

Finally, we have been studying the question of unmanned seismic stations, with the intention of developing the technology that might be appropriate to that type of station.

That is the essential nature of our ongoing programs.

WHAT ONE MIGHT DO ULTIMATELY IN SEISMIC MONITORING

Returning to the second part of your question; namely, what might one do ultimately, this is, of course, much more difficult because we are dealing with something that we haven't built and have not worked with; we are dealing with the next step after our current program. We do know, from our theoretical studies of earthquakes and explosions, as well as the growing body of data we are accumulating, that the identification techniques should be available.

We think that earthquakes and explosions actually are different at, for example, magnitude 4.0 and that if we had appropriate instrumentation we should be able to detect those differences.

The issue really is not how well you do in general but under what circumstances you fail to identify seismic events. There are a number of circumstances inherent in the science of seismology and wave propagation in the earth that seem to indicate, as far as we know today, that one simply cannot build a perfect system.

Let me refer to two specific circumstances: In the first place, there is the matter of the mixing of the events. Earthquakes occur frequently above magnitude 4.0 worldwide. There are at least 10,000 earthquakes a year, and they all generate short-period and long-period

waves. Because those wave trains persist for reasonably long periods of time, when you are interested in one particular event, it is quite possible that the waves from another event will arrive at the same time and will confuse the record so you will be unable to read it. Clearly, if you can do signal processing you can improve that situation, and this, in particular, is the reason for arrays. Long-period arrays are especially important in this respect insofar as our program is concerned. But there are times either when two earthquakes occur fairly close together and their wave trains arrive at all seismic stations at about the same time, or because they come from two points not very far separated in space, that the job is very difficult, and there is a limit to the degree to which signal processing can help to sort them out.

Now, just how often that happens and how serious a risk that entails is something that we are determining in our program.

The second circumstance is the problem of uncertainty that we have with us today. It is not clear that it is as fundamental an issue as the mixing problem, but it is something that we do not understand at this time. This is the matter of so-called anomalous events. These were noted in Dr. Foster's statement. There are some earthquakes that look like explosions; that is, their long-period surface-wave amplitudes are more characteristic of explosions than of earthquakes. This can arise from a variety of circumstances, most of which we do not fully understand. These earthquakes are typically shallow-focus, low-magnitude events that are simply poor generators of the long-period waves that we use to make the identification. In that circumstance, when there is a seismic event and we detect it, it will be located and will look like an explosion. Such events are the subject of an important part of our research program: to experimentally measure such events and see whether we can detect anything unusual about them and also to conduct theoretical analyses to understand earthquake mechanisms and see why they occur.

IMPACT OF 1 KILOTON WARHEAD ON RICHTER SCALE

Senator CASE. I don't want to interrupt you, but I have to leave and there is one question I wanted to ask.

Dr. LUKASIK. I was essentially at the end of a long and complicated technical answer.

Senator CASE. We are all interested in what in your judgment is on the impact of, say, a 1 kiloton warhead on the Richter scale. I know you have to qualify your statement as to the type of material and the depth.

Dr. LUKASIK. What is the military significance?

Senator CASE. No, what is the impact measured in terms of the Richter scale of a 1 kiloton warhead, for example.

Dr. LUKASIK. Well, such an event or such a device detonated in hard rock produces about a magnitude 4.0 signal, essentially at the limit of a teleseismic network's detection capability.

Senator CASE. And another material it would be less, I take it.

Dr. LUKASIK. It would be even smaller than that. In a low coupling medium such as tuff, the signal would be roughly a third that of the hard rock seismic signal.

Senator CASE. The depth of the explosion would have some effect?

Dr. LUKASIK. No, for the range of depths at which one would normally drill to emplace a device, the depth has very little effect on the size of the signal.

Senator CASE. This, of course, relates to what Dr. Foster said about the military importance of small explosions.

Dr. LUKASIK. That is correct.

HALF KILOTON IN TERMS OF RICHTER SCALE MEASUREMENT

Senator CASE. What about a half kiloton in terms of the Richter scale measurement?

Dr. LUKASIK. Well, at a half kiloton, even in hard rock, one is generating signals that are below the magnitude 4.0 number that I mentioned, which I think is a reasonable limit to which we can expect a teleseismic network to reliably perform—something in that magnitude range.

Senator CASE. Is this from the standpoint of detection, identification, or both?

Dr. LUKASIK. The problem is that there is a fundamental physical limit here, and that is the matter of earth noise. This is not something that can be pushed to arbitrarily low magnitude because at some point—somewhere below magnitude 4.0, perhaps around magnitude 3.7—there are crustal vibrations, small motions continuously occurring in the Earth, caused by everything from wind and distant earthquakes of small magnitude to cultural noise. At some point, the signals are much smaller than this noise that no amount of signal processing or elaborate seismic instrumentation enables you to monitor a region from stations outside the territorial limits of a large country.

Senator CASE. Half a kiloton is below that, in your opinion?

Dr. LUKASIK. Yes, even in hard rock. If one were to explode a half kiloton in either soft rock like tuff or alluvium, in which the signals are even smaller, the signals just drop out of the picture insofar as monitoring is concerned.

Senator CASE. Thank you.

NOTIFICATION CONCERNING UNDERGROUND TESTING

Senator HUMPHREY. We could ask you many more questions but the time is running along. The thing is that today we have the limited test ban treaty and we are permitted to have underground testing. Do we give notification to anyone when we make underground testing, Dr. Foster?

Dr. FOSTER. Mr. Chairman, we give no notification routinely. For the higher yield events, of course, there is considerable advance notification.

RISK OF TESTING WITH OR WITHOUT TREATY

Senator HUMPHREY. So, therefore, insofar as the amount, insofar as testing is concerned, the risk of testing with the comprehensive test ban treaty, even if the testing was an evasion of the terms of treaty, would be no greater than the risks that are currently present with our legal underground testing, isn't that a fact?

Dr. FOSTER. I think, sir, the question really is only one of potential asymmetry.

Senator HUMPHREY. Would you mind explaining that to a layman a little more precisely?

Dr. FOSTER. Certainly. Ours is a relatively open country.

Senator HUMPHREY. Right.

Dr. FOSTER. The Soviet Union is not. So the concern over verification has to do with the fact that we do not know as much of what is going on in the Soviet Union as they do about ours.

Senator HUMPHREY. Yes, I understand that.

Dr. FOSTER. The whole issue then just turns on verification.

Senator HUMPHREY. But the point is that the Soviet Union could be doing a hundred underground tests a year if they so wished.

Dr. FOSTER. Certainly.

Senator HUMPHREY. There is no treaty that governs underground testing; so there is no way that you could accuse the Soviet Union of violating any agreement. The only thing you can accuse them of is excessive testing. We could be doing exactly the same thing.

Dr. FOSTER. That is right.

Senator HUMPHREY. Now my point is, if the President were to propose an immediate cessation of all testing pending a negotiated agreement that would have binding effect as international law, would he be any worse off than we are presently?

Dr. FOSTER. Yes, sir, I believe we would.

Senator HUMPHREY. Just tell me why.

Dr. FOSTER. We would surely forgo the benefits of underground nuclear testing. The Soviets would forgo some, hopefully some, of their current program. But those crucial ones at low yield or higher yields they may not forgo, that would give them a unilateral advantage.

Senator HUMPHREY. I wanted to pose the question to you to get your views on the record, because, as you know, some people have indicated the proposition that I have just stated. I think it is proper that we get your scientific and professional comment on it.

SHOULD MORE SEISMIC RESEARCH BE DONE?

Just a question that was brought to my attention, Doctor Lukasik. In testimony on the fiscal year 1973 budget, I have been informed that you had said that seismic monitoring funds were being cut because seismic monitoring was a successfully completed area of past emphasis.

What is your position now in support of seismic research? Should more be done if we are serious about moving toward a comprehensive test ban?

Dr. LUKASIK. Well, originally our research program had the job of studying the problems in order to tell the political decisionmakers what the risks were, what the facts were, what was known and what was unknown.

At the time that the fiscal 1973 budget was put together, it was our judgment, in view of the many problems that required study by my agency, that we could afford to do much less in this area. At that time it was our hope that what we had learned about seismic instrumentation could be capitalized on by other people to deploy the sorts of in-

strumentation that were necessary to do monitoring. Along the way, one would at the same time, of course, study the research problems and continue to learn more about them.

At the same time it became clear that there was a great deal of interest in the subject that the answers that had been produced were not adequate as the basis of the kind of national security judgments that were involved; therefore, we were asked to continue our research program.

We pointed out that this would require the deployment of another generation of seismic equipment, the sort of equipment that I was discussing earlier. Therefore, we have continued our work in deploying this instrumentation, intending to learn more about the problem and to resolve further the seismic verification issues.

COMPARATIVE BUDGETS FOR FISCAL YEAR 1974 AND FISCAL YEAR 1973

Senator HUMPHREY. What is your budget estimate for fiscal 1974 as compared to fiscal 1973?

Dr. LUKASIK. We have increased this program by 40 percent. We have gone from \$10 million to \$14 million.

Senator HUMPHREY. Is that for research or is that for the equipment that you are placing about in different parts of the world?

Dr. LUKASIK. That includes both the research instrumentation and the study phase of the research program. The instrumentation amounts to some \$3 or \$4 million.

Senator HUMPHREY. You say about a 40-percent increase in your budget. Is that correct?

Dr. LUKASIK. Yes, in this area of the DARPA program.

Senator HUMPHREY. How much increase in research funds? I want to separate instrumentation, location, placement, all the costs that go into the instrumentation. How much in research?

Dr. LUKASIK. The instrumentation to obtain research data that I discussed is about \$3.4 million, so the remaining research is some \$11 million, the difference between \$14 and \$11 million.

Senator HUMPHREY. How much research funds did you have in fiscal 1973?

Dr. LUKASIK. We had essentially the same level of research funding.

Senator HUMPHREY. How much in salary increases have you had to take on since then?

Dr. LUKASIK. Well, this is all contract research. We don't keep track of specific salary increases.

Senator HUMPHREY. I see.

Dr. LUKASIK. Each year it costs a little more to do the same amount of research. Hopefully one becomes a bit smarter and gets the same amount of research done for each dollar.

Senator HUMPHREY. Hopefully.

IMPORTANCE OF MAINTAINING RATE OF RESEARCH IN SEISMIC AREA

I am very worried about the Federal Government research budget. That is why I am asking you these questions. I think it is terribly important that the rate of research in this area be maintained at a

level that peers into the future, so to speak. I mean so that you can do the kind of things that need to be done. It is one thing to apply the research now, as you are with your instrumentation packages, so to speak. But the same level of research funds for fiscal 1974 is not very encouraging to me.

Dr. LUKASIK. That certainly is a problem of great concern to me also, Mr. Chairman. Where it is particularly difficult is not so much on a year-to-year basis but over the long term, over a 5- or 10-year period in which inflation of costs does constitute a serious erosion of the level of scientific effort that one can apply to any problem.

Senator HUMPHREY. Dr. Foster, will you be testifying before the Appropriations Committee?

Dr. FOSTER. Yes, Mr. Chairman, I will.

Senator HUMPHREY. I know what the ground rules are when a member of the executive branch testifies before these committees, and I don't expect you to break those rules. But in case you are asked a question about the adequacy of research funds, particularly in this seismic area, and in the whole area of monitoring of nuclear explosions. I hope that you will give a professional judgment as well as a OMB judgment. I do not consider OMB to be always professional except as accountants. I know they have a job to do, but I wanted to be sure that we have your professional judgment because I respect it, on the one hand and, second, I think it is going to be very much needed if we are going to proceed even with SALT II. I mean the whole program of SALT II is involved in a lot of things that you are doing.

We are through here. We thank you for your patience and for your participation.

This afternoon at 2:30 the committee will reconvene with Ambassador Harriman, Dr. Scoville, and Dr. Panofsky.

[Whereupon, at 1:00 p.m., the subcommittee was recessed until 2:30 p.m. of the same day.]

AFTERNOON SESSION

Senator MUSKIE. The committee will be in order.

COMMENDATION OF WITNESS

I think it is appropriate that we should begin the afternoon session with a distinguished witness who has been a participant in so many of the great events of our time going back to the time when I was a college student. This man was a key figure in the development of the Limited Test Ban Treaty, and has been close to the issues involved in this whole subject of arms control for a long time.

I have had the privilege and the personal pleasure of being associated with him in ways that permitted me to observe how he operates and how his mind works and how he forms judgments, and I can't think of a man whose observations on subjects of this kind will command more respect from me than Ambassador Harriman. I am delighted that he is able to be here, and that he is ready to testify. I must say that the television cameras missed the best part of the day as far as I am concerned in not staying over from the morning session to the afternoon.

STATEMENT OF HON. W. AVERELL HARRIMAN

Mr. HARRIMAN. Thank you, Mr. Chairman. If I may say so, I want to congratulate you for your part in evolving Senate Resolution 67, and I am grateful for this opportunity to testify in full support of this resolution.

I support it both because it calls for action which I believe to be in the interest of the national security of the United States—the negotiation of a comprehensive nuclear test ban treaty—and because it proposes a sensible way to get negotiations started to arrive at this objective.

REASONS COMPREHENSIVE TEST BAN IN U.S. INTEREST

The reason I believe a comprehensive nuclear test ban to be in the interests of the United States and of world peace is that it will be an effective damper on the ever-existing temptation to develop new weapons systems whether we need them or not—even whether they are dangerous or not. A comprehensive test ban will be a logical followup to the SALT agreements which, while limiting ABM's and restricting the number of certain offensive delivery systems, did not prevent a quality race in weapons systems. A comprehensive test ban would not only reduce vast expenditures on this dangerous arms race but prevent the possibility of such a quality race leading to a breakthrough which could upset the present balance. It would, of course, prevent the fears of the possible development of weapons by the U.S.S.R. suitable for a preemptive first strike—a development which would be dangerously destabilizing. It would have the same effect on the United States, but this would not be a disadvantage since we have stated time and time again that we do not wish to develop weapons systems with this capability.

The negotiation for a comprehensive test ban treaty is necessary for the United States to live up to an international commitment of great importance to the U.S. efforts to obtain wide adherence to the Non-Proliferation Treaty. As this committee is aware, the United States in the Limited Test Ban Treaty, negotiated by President Kennedy, pledged itself to continue negotiations to ban all nuclear weapons test explosions. This commitment was reaffirmed in the Non-Proliferation Treaty, negotiated under President Johnson and ratified by President Nixon. Thus, three administrations have undertaken this commitment.

It is clear that other countries of the world take this commitment of ours quite seriously. I have grave doubts that we can have any success in persuading certain potential nuclear powers to consider seriously the Non-Proliferation Treaty as long as we are conducting an extensive series of underground tests.

REASON GIVEN FOR INABILITY TO REACH AGREEMENT NOW INVALID

For many years—since 1958 in fact—it has been generally accepted that a comprehensive test ban would be in our national interest. The reason given for our inability to reach agreement on a comprehensive test ban has been our inability to obtain agreement on onsite inspection.

once thought necessary to verify such an agreement to prevent violation through clandestine testing underground. Whatever the merits of such a reason 10 to 15 years ago, it is not, in my judgment, valid today. In fact, in my opinion, anyone who continues to give this reason is doing so, is simply doing so, in order to block any chance of a treaty being negotiated, Mr. Chairman.

Everyone knows the Russians will never agree to this. There are many reasons for that, and I can explain it further if you wish, but it is the job of the scientist to find ways and means of being able to identify and to verify, with sufficient chance of success, the possibility of any violation of such a treaty.

Forgive me for being so vigorous but this is something I feel very deeply, Mr. Chairman.

REASONS FOR CHANGE IN POSSIBILITY OF HAVING AGREEMENT

There are two major reasons for the change, the change in the possibility of having an agreement today as against a few years ago. The first reason results from the continued advances in the field of detection and identification of underground nuclear tests by seismic means and other national means of detection. I understand that this committee will have direct testimony on this subject by qualified scientific experts later this afternoon. I will limit my remarks to say that I am advised by scientists whose judgment I have respect for that our national capabilities have advanced to a point where the risks of danger to U.S. security interests by clandestine underground tests by the U.S.S.R. is very limited, in fact practically nonexistent. The tests that might escape detection and identification would be quite small, a relatively small fraction of the Hiroshima bomb and of relatively little importance in their possible effect on the strategic balance. Even with respect to tests of this size, there is sufficient uncertainty so that a potential evader could never be sure that any individual test would not be detected and identified.

The second reason results from the SALT agreements which provide that they will be verified by each side by national technical means, that neither side will interfere with the other national means of verification, that neither side will use deliberate concealment to impede verification, and that a standing commission will be established to consider any suspicion that might arise concerning violation of the agreement. These provisions are helpful in their own right in that they assure that U.S. satellite reconnaissance capability will not be impaired and there is a good deal of evidence to indicate that the satellite reconnaissance achieves more in certain respects than onsite inspection. They are also helpful as a potential model for similar provisions in a comprehensive test ban treaty. While one can always point to a possible residue of uncertainty, and incidentally, there were many of them put forward to the Senate, if you will remember, in opposition to the 1963 Limited Test Ban Agreement, which has now proved to be ridiculous and I am sure there are many of them going to be put before you today in spite of that to point out some inconceivable uncertainties. In my judgment, the risks of undetected violation in the very low yield range have been reduced to a point where they are

outweighed many times over by the gains which would result from the elimination of tests in the higher yield range and would contribute in other important ways to the security of the United States from such a treaty.

PROPOSAL FOR IMMEDIATE SUSPENSION OF UNDERGROUND NUCLEAR TESTS

I find the proposal in Senate Resolution 67 for an immediate suspension of underground nuclear tests so long as the Soviet Union abstains from testing, a practical way of getting negotiations off to a good start. A similar action taken by President Kennedy in 1963 produced just such a result. On June 10, 1963, at American University, President Kennedy, after having announced that high level talks on a nuclear test ban treaty would soon begin in Moscow, made the following statement:

To make clear our good faith and solemn convictions on the matter, I now declare that the United States does not propose to conduct nuclear tests in the atmosphere so long as other states do not do so.

This statement pushed off of dead center nuclear test ban negotiations which had been going on for some 5 years. The Limited Test Ban Treaty was agreed to in Moscow on July 26, 1963, less than 6 weeks later. This treaty truly started the era of negotiations between the United States and the U.S.S.R. The Nonproliferation Treaty, the treaties banning the stationing of nuclear weapons in outer space and on the seabed, and finally the Strategic Arms Limitation Treaties were all made possible by this breakthrough. The world is a safer place for it. In fact, Mr. Chairman, I think it would have been a safer place if we could have had a comprehensive test ban at that time, but there were Senators who made that difficult.

FIRST MAJOR ECOLOGICAL AGREEMENT

We should not forget also that it was the first major ecological agreement. One forgets the fear that people had from the contamination of the atmosphere. It is no longer necessary, for instance, to withhold milk from children in some of the midwestern markets because of radioactive iodine contaminating the feed given the milk cows. This is a field also, Mr. Chairman, in which you have taken such an active leadership. It was the first major ecological agreement, and I hope we will use it, sir, as a guide to your efforts to further agreements in this field.

"BARGAINING CHIP THEORY"

There are people, including some in high positions, who will oppose our suspension of underground tests—even though conditioned upon an exercise of similar restraint by the Soviets—upon the "bargaining chip theory." I put that in quotes. According to this theory any restraint on our part will deprive the Soviets of an incentive to negotiate. According to this theory the only way to persuade the Soviets to negotiate is to act as tough as possible. Announce a massive underground test program, so these theorists say, and the Soviets will come rushing to the bargaining table to try to prevent it happening.

From my experience, I can say without qualification, I can say this is just plain wrong. It completely overlooks the fact that there is a spectrum of official opinion in Moscow—ranging from the hard-liners to those who seek a negotiated accommodation in order to reduce military expenditures for other priorities. In fact, it is very much like the spectrum of official opinion in Washington, although the divergent points of view are expressed differently and the method of resolution is also different. Everytime our hard-liners sound off and demand hard-line positions, they strengthen the hand of the hard-liners in Moscow and pull the rug out from the under those who argue for negotiations. I can say even in Stalin's day during the war, I was conscious of differing views in his Politburo on questions that were still open for policy decisions.

SENATE RESOLUTION 67 INITIATIVE BEST WAY TO GET NEGOTIATIONS STARTED

The proposal in Senate Resolution 67 for the President to take the initiative in suspending underground nuclear tests as long as the Soviet Union shows similar restraint is, in my opinion, the best way to get negotiations started in an auspicious atmosphere. President Kennedy's initiative produced strikingly favorable results a decade ago and with the present atmosphere in Moscow similar action by President Nixon could well do so today.

HOW SOON TO BEGIN NEGOTIATIONS

There are, of course, important subsidiary questions, a number of them. One is how soon to begin negotiations. As far as I am concerned, the sooner the better. We have been discussing the problem for some 15 years and there is now, I believe, no good reason for further delay. In fact, I would hope that it might be the subject of discussions between President Nixon and Secretary Brezhnev at their upcoming meeting. I would even hope that Dr. Kissinger, who is going to Moscow, we are told later this week, would prepare the way. If the two leaders of our two countries could come to a basic agreement the details could be worked out very rapidly. It would be another fine achievement for President Nixon in the international field.

WHERE NEGOTIATIONS SHOULD TAKE PLACE

Another question is where the negotiations should take place. I believe they should be in Moscow as they were in 1963. It was then possible for us to deal directly with Chairman Khrushchev and for Mr. Gromyko, who handled our day to day discussions, to be in touch with the top policymakers every evening. Soviet's decisions were often reached before the next day's meetings. In other words, if we had a disagreement, then Mr. Gromyko would come back the next day with a solution, and in fact he was pressing us for decisions on our part which were more difficult because of the difference in time.

As a result, our negotiations were concluded in less than 2 weeks, Mr. Chairman. They wanted us to get out of town. If you have high level negotiators—we also had a British mission headed by a member

of the government—it is a nuisance to have such high level groups there and they pressed us because they wanted us to get out of town. I would hope if there was a negotiation on a subject such as the comprehensive test ban where the basic considerations are so well understood it could take place in Moscow. For other negotiations such as the present discussion in regard to SALT II, it is another matter. But, on the other hand, I would hope that those negotiations, which are very important, could be pointed up to a few basic differences and then they could be handled on a high level.

CHARACTER OF U.S. DELEGATION

Now, another question is the character of our delegation. I am satisfied that the higher the level the more effective it will be. In obtaining the SALT decisions, I understand that Dr. Kissinger's personal negotiations played a major role in reaching agreement on the most complex subjects. They occurred over a number of months. Also, agreement was finally reached in Moscow, as you well know, between the President and the Soviet leaders.

As Dr. Kissinger so wisely pointed out in his recent Atlantic speech, in negotiations left solely to the experts "inevitable competitiveness . . . will dominate the debate." If you leave it to experts they will never agree, Mr. Chairman. I say that with enormous respect for the experts. These matters have got to be left to the political leaders of our Nation. The expert ought to point out all the difficulties and actual dangers, that is his job, he wouldn't be doing his job unless he did it, but it is for the political leaders to decide where the political, psychological, and other advantages come to our Nation offsetting such risks as there may be.

OTHER SUBSTANTIVE MATTERS TO BE DEALT WITH

There are other substantive matters that will have to be dealt with such as the role of China and the future, if any, of peaceful nuclear explosions. Solutions to these matters can be found if only meaningful negotiations are commenced.

SENATE RESOLUTION 67 SUPPORTED

I wholeheartedly support Senate Resolution 67. I earnestly hope it will be passed by a large majority, thereby encouraging the President to take prompt action in accordance with its wise proposals. A comprehensive test ban treaty could not only save vast expenditures for other urgent national needs but also contribute to substantially a safer world.

WHY RUSSIANS DIDN'T WANT ONSITE INSPECTIONS

Senator MUSKIE. Thank you very much, Ambassador Harriman. It is an excellent statement, particularly in putting in perspective the problems of negotiating with the Russians.

I don't suppose there is any man alive in America today who has had more experience over a longer time than you have had. You offered in the course of your testimony to expand on the question of why the Russians did not want onsite inspection. I wonder if you would expand on that at this time.

Mr. HARRIMAN. I can tell you a little. I had a discussion with Chairman Khrushchev at the time. He had made a proposal for three onsite inspections some 6 months before, which was turned down because we wanted seven. He said he had withdrawn them and when we began to argue about that he said, "Well, nobody will make me believe if you let a cat into the kitchen that he will go for the mouse when he sees a piece of cheese lying close by. The cat will grab the cheese when nobody is looking."

Now they may be psychopathic on the subject of the possibility of subverting their system and of their security, but that is the nature of the whole Soviet system. The Russian Government was always suspicious of foreigners, as you know, throughout history, and the Soviet leaders today are influenced not only by Communist ideology but by Russian psychology. They will never allow onsite inspection in a meaningful way. If one goes into the details of what our experts believe would be necessary—it requires inspection of all kinds and nature and a review of large areas which will never be permitted because they will be suspicious that it will be used to, to use their word, to spy on them for other purposes. And this is unfortunately one of the psychological blocks that we face, and if we want a test ban—comprehensive test ban—I am utterly satisfied it is useless to discuss onsite inspection of a nature that would be meaningful to our experts.

CLOSEST WE CAME IN NUMBERS ON ONSITE INSPECTIONS

Senator MUSKIE. What was the closest we came in numbers on onsite inspection? Was it seven that we required?

Mr. HARRIMAN. Well, Mr. Khrushchev offered in, I think it was, December 1962, three onsite inspections. At that time we said "No, we had to have seven."

Now, with the number of explosions that might have taken place as against earthquakes in certain areas, in which there were a number of earthquakes, we thought seven would be necessary. At the time some of our experts thought three would be adequate because it would give us a spot check which would make the Soviets unwilling to run the risk of detection. But we failed to accept, and Khrushchev withdrew it. He said "We made a mistake in offering three." But then when I saw the details of what our experts would demand in the way of the kind of inspection, I don't remember them all, but the large area over which we would have helicopters range and the number of holes we would have to drill, and that sort of thing, I don't recall it all, I am satisfied they never would have agreed to it.

As I understand it, of the character of onsite inspections was not discussed. The Russians threw out onsite inspection as a principle, but I am satisfied we will never have come to an agreement on what is really needed in the way of onsite inspection.

ADEQUACY OF SATELLITE PHOTOGRAPHY

There will be expert testimony, I expect, later this afternoon. There is not much use in my testifying on it, but I am satisfied that our satellite photography does give us adequate chance of catching any attempt to evade.

Senator MUSKIE. It was our insistence—

Mr. HARRIMAN. You only have to have a real possibility of catching them. You don't have to have a guarantee that you will catch every-one. Experts tell me that one test in this small range will achieve very little. Also through this commission which has been set up, any suspicion that we have can be taken up and we can inquire more and more about it. That is a very important new aspect—that came out, I thought very successfully, in the SALT I treaty.

WHY WERE SEVEN ONSITE INSPECTIONS MORE USEFUL THAN THREE?

Senator MUSKIE. In those terms why were seven so much more useful to us than three at that time? Do you recall that?

Mr. HARRIMAN. I have forgotten how many conceivable earthquakes could have taken place that we could identify at the time, but it was thought seven was the necessary number of inspections in order to be sure to be able to catch enough possible tests. That was a matter of judgment. I think later on some of our people thought we ought to grab the three while we could, but we didn't. We missed that opportunity, if indeed it was an opportunity. I am not sure we ever would have agreed on the terms of onsite inspection.

WERE DETAILS OF ONSITE INSPECTIONS DISCUSSED?

Senator MUSKIE. Did we ever get into details with them on that?

Mr. HARRIMAN. I understand we never discussed the details. We only discussed the theory of onsite inspection. I may be wrong, but I recall being told that we had not discussed the details. When I saw the list of things that we were proposing for onsite inspection, I was surprised that anybody would have thought the Russians would ever agree to such an inspection, and I was satisfied myself that Khrushchev would have withdrawn the three even before he did.

Senator MUSKIE. Well, I wonder if the American people were aware of—

Mr. HARRIMAN. I am not objecting to our experts proposing these but, as a matter of fact, I recall some of the things which they proposed made me wonder whether we would ever really permit the Russians to do that sort of thing on our territory.

Senator MUSKIE. It seems to me—

Mr. HARRIMAN. We went to such extremes that some of us wondered whether the onsite inspection would have been practical for us. I never have had that analyzed, but I have grave doubts whether we would really want to have the Russians have as free a hand at looking at things here.

Senator MUSKIE. As I get the reaction these days among Maine fishermen to Russian fishing fleets off our coast, I can imagine what their reaction might be to Russian inspection teams flying helicopters over the countryside checking on our nuclear posture.

BEST TO CALL A HALT TO ARMS RACE

Mr. HARRIMAN. Well, I know that some people are sincere in not believing a comprehensive test ban is a good thing, that it is best to have

the arms race go on and that our interests are better served if we let our scientists keep ahead of the Russian scientists at vast expenditure.

But I am convinced that it is best for us to call a halt. Our national interests are well protected. In fact the world expects us to do this, Mr. Chairman. We have got to live up to what we said we were going to do to keep world opinion with us. We have three times now in treaties agreed to pursue this and we are not doing it.

Senator MUSKIE. I think that is—

Mr. HARRIMAN. Therefore, I commend most sincerely your resolution, sir, and those Senators on both sides of the aisle who are supporting it.

If we are not sincere in going ahead with a comprehensive test ban, a number of countries are not going to go along, with the nonproliferation agreement.

On the other hand, if we stop testing entirely we have a very different situation in attempting to induce some of these potential nuclear powers in signing up.

READINESS OF RUSSIAN LEADERSHIP TO RESPOND TO INITIATIVE

Senator MUSKIE. Do you believe the Russian leadership is ready to respond to this kind of initiative?

Mr. HARRIMAN. I can only guess that, but I believe they will be. The last time I talked to Mr. Kosygin, a comprehensive test ban was high on his list of priorities. He put nonproliferation down, comprehensive test ban, reduction in our nuclear weapons, and further reduction in our military budgets, incidentally, improvement in our trade relations and improvement in our personal contacts. Since the Soviets have gone ahead with a number of these other matters my guess would be that they would. As far as I am concerned, I think we have basically more to gain than they have because in some of the scientific fields we are ahead of them, and in any event it is worth an honest and sincere try and let the ball be in their lap or the buck be in their lap if they decline.

Senator MUSKIE. If they were to sign—

Mr. HARRIMAN. I can't guarantee it, sir, but I would think that negotiations of this kind carried on discretely to begin with and then openly, might well achieve results that you wish.

POSSIBILITY OF SOVIETS TRYING TO EVADE COMPREHENSIVE TEST BAN

Senator MUSKIE. If they were to sign such a treaty, would you expect them to try to evade a comprehensive test ban?

Mr. HARRIMAN. No; I would not expect them to do it. I would not put it above them to try to do it if there were ways to do it in which they could surely not be caught, but there are so many ways open to have them caught that I would not believe they would try to evade. They have not tried to evade the Limited Test Ban Treaty.

You know it is a popular thing to say the Russians don't ever keep their agreements. Well, an interesting thing in our test ban treaty negotiations, one of the toughest provisions that Gromyko didn't want to agree to was a provision for either side to terminate the agreement. He said the Russian view was that any nation has the right to repudi-

ate any treaty at any time that it is no longer in its interest to carry out. When I said that wasn't our view, he maintained that such an agreement would compromise that principle. We finally found some language that overcame it. He was quite frank about the Soviet position.

However when it is in their interest to carry out an agreement, they do keep them. We have the Austrian State Treaty, as one of the examples. Austria is free today. The Russians don't want to be caught by the world in cheating in such a thing as a test ban of this kind and I don't believe they will attempt to do it. I don't think they would sign the agreement if they didn't intend to keep it.

Senator MUSKIE. Senator Case.

Senator CASE. Governor, it is nice to see you again.

Mr. HARRIMAN. Very glad to see you, sir.

Senator CASE. I always remember how when we first met on a cold spring day up in Schenectady.

Mr. HARRIMAN. I remember very well. You and I agreed, I think we both agreed on what was good for the United States but you thought one gentleman should be the President and I thought another. But on principle, as I recall it, sir, we agreed on the best policies for our Nation.

Senator CASE. That was almost the beginning of your political career; a most distinguished one.

Senator MUSKIE. Thank you very much, Ambassador Harriman. I can't think of more important testimony we have had today and we appreciate your taking the time. It is good to see you looking so well.

Mr. HARRIMAN. Well, I must say I hope you succeed in bringing this resolution to a vote very soon and you have an overwhelming majority.

Senator MUSKIE. We are going to do our best, thank you, sir.

Our next two witnesses are going to appear together, as I understand it. Dr. Panofsky and Dr. Scoville, who are both old friends, have testified before this committee and other committees many times on this subject. You are the experts to whom Governor Harriman made reference. We, as well as he, are looking forward to your enlightenment on the technical aspects of this problem.

**STATEMENT OF DR. WOLFGANG K. H. PANOFSKY, DIRECTOR,
STANFORD LINEAR ACCELERATOR CENTER, STANFORD UNIVERSITY**

Dr. PANOFSKY. Thank you very much, Mr. Chairman.

I appreciate very much the opportunity to present my views to this committee on Senate Resolution 67, dealing with the important problem of transition from the limited Nuclear Test Ban Treaty of 1963 to a fully comprehensive agreement. To avoid any misunderstanding let me state here that I am testifying as a private citizen to whom this problem is of great personal concern and who has long been involved in various capacities related to this question with agencies of the U.S. Government.

My testimony concentrates on technical arguments relating to the feasibility and advisability of reaching a comprehensive nuclear test ban agreement; yet my conclusion will be that there are no purely

technical arguments of great strength either for or against a comprehensive test ban treaty [CTBT].

MILITARY NEED FOR CONTINUED NUCLEAR TESTING

I would like to divide my testimony in a number of sections. First, I would like to talk about the military need for continued nuclear testing.

My first remark is that the arms race is much more decisively affected by nonnuclear developments, both for strategic and tactical warfare, than it is by nuclear developments. While it is therefore difficult to make a case that a complete nuclear test ban treaty would be a major factor in slowing the arms race, a complete nuclear test ban treaty would not be a threat to U.S. security whether or not evaded by the Soviet Union to the limited extent feasible and may in fact be a stabilizing element.

Nuclear weapons technology can justly be described as approaching maturity: Further advances are apt to be refinements of present art rather than genuine innovations. Warheads for strategic missiles have already been developed through several generations of design. While tactical nuclear weapons and nuclear aerial bombs have not been modernized to as large an extent this situation is more a consequence of the low priority assigned to such modernization within the U.S. Government than to limitations in technology.

I would like to emphasize that nuclear weapons testing is not a tool for basic science, that is, for obtaining new facts about nature, but it is a development program trying to improve a product; therefore, one must decide whether the product is worth the price.

The recent nuclear test program has produced moderate advances and useful, but not surprising, data. Notwithstanding the basic limitations on dramatic improvements in nuclear weapons technology, a continuing nuclear explosives test program in the absence of a comprehensive test ban treaty might contain the following elements:

- A. Tests of special emissions from nuclear weapons.
- B. Improvements in survivability of reentry vehicles in a hostile environment.
- C. Improvement in efficiency of nuclear weapons.
- D. Repackaging of nuclear devices for specialized uses.
- E. Improvements in economy in the use of special materials.
- F. Maintenance of the nuclear stockpile and general proof testing.
- G. "Effects" tests to examine vulnerability of military or civilian structures to nuclear weapons effects.
- H. "Plowshare" tests (i.e. peaceful uses of nuclear explosions).

PERFORMANCE OF MISSILES IN ABM ENVIRONMENT

It will be noted that the first two items in this list relate to the performance of missiles in an ABM environment, and, quite apart from the limited intrinsic merit of such improvements, their importance has been greatly reduced by virtue of the SALT I agreement.

STOCKPILE READINESS AND WEAPONS RELIABILITY

Now let me turn to stockpile readiness and weapons reliability. It is of key importance to the security of this Nation and the world that

nuclear stockpiles remain under tight control. Yet until other international security arrangements are formulated which do not involve the potential use of nuclear weapons, stockpiles must remain ready for use. At times the need for nuclear testing has been identified with the requirement of maintenance of the nuclear stockpile and improvements in its security. Since nonnuclear methods are available for this purpose I do not consider this to be a valid reason for opposition to a comprehensive nuclear test ban.

A comprehensive nuclear test ban would certainly reduce the creativity of the weapons laboratories—a circumstance pertaining both to the United States and the U.S.S.R. or other signatories. Extensive computations and laboratory simulation activities, increased emphasis on experimental programs of interest to weapons designers—such as laser-fusion experiments and controlled thermonuclear programs—would do a great deal toward maintaining the vitality of the laboratories.

A primary consequence of a comprehensive nuclear test ban would be some reduction of confidence of the signatories in the predictability of the exact performance of nuclear weapons. In my view this circumstance is on balance beneficial, since it would make nuclear weapons even less useful for first-strike, preemptive purposes. The Congress has heard testimony during the past years about the concerns of some military planners regarding the possibility of a disabling first strike which might be achieved against the U.S. land-based minuteman force by highly accurate enemy MIRV'd missiles; conversely, the Soviets should have at least as large a concern against such a strike from the United States. Many severe technical difficulties make a "first strike" scenario exceedingly implausible; under all circumstances it requires high confidence in near 100-percent reliability of the nuclear weapons system—exceedingly difficult to maintain once a comprehensive nuclear test ban is in force. On the other hand, the function of our nuclear strategic weapons in deterring an attack by an opponent remains unimpaired by the small potential decrease implied by a comprehensive nuclear test ban in the high reliability of their nuclear warheads.

EFFICIENCY OF NUCLEAR WEAPONS

Next, let me talk about efficiency of nuclear weapons. There is little doubt that continued nuclear testing can achieve some limited gains in economy of future nuclear weapons systems, both in terms of economy in use of special materials and what is called the "yield-to-weight ratio," or more colloquially the "bang for the buck." Quite apart from the question whether such improvements pay for the cost of the research and development program to support them in purely economic terms, it is also clear that the deterrent value of our nuclear weapons is extremely insensitive to such improvements. Even if a nuclear weapon attacks a widespread urban target, the damage increases more slowly than the explosive power producing it. If the target is small then the increase in damage produced by an increase in explosive power is even less significant. Therefore the usefulness of weapons of very large explosive power in a deterrent role is quite limited; this has been recognized by U.S. designers a long time ago and for this reason the deliberate choice was made to forgo very large throw

weights in U.S. missiles. The number of warheads in the U.S. arsenal is now greatly in excess of the level needed for inflicting retaliatory damage—either to civilian or military installations—at a level considered “unacceptable” to any opposing nation. The SALT treaty on limiting ABM has assured the penetration of our warheads to enemy targets. Therefore, Mr. Chairman, I would like to emphasize the fact that SALT has made each warhead in our arsenal, made it a great deal more than it used to be before the SALT agreement was signed.

Improvements in yield-to-weight ratio permit more efficient packaging of warheads and penetration aids in a missile warhead, or, alternately permit increases in the explosive power of existing configurations. In particular a comprehensive nuclear test ban might prevent increases in yield of MIRV'd missile systems. This limitation might make attainment of a Soviet MIRV force extremely difficult, if not impossible. I also note that there are strictly physical limits to the attainable yield-to-weight ratio which cannot even in principle be exceeded so that a dramatic breakthrough cannot be expected in this respect.

COMPETITION BETWEEN NONNUCLEAR AND NUCLEAR WEAPONS DEVELOPMENTS

Let me turn to the competition between nonnuclear and nuclear weapons developments.

Improvements in warhead accuracy are much more controlling in determining the destructiveness of a nuclear weapon against a hard target than are increases in explosive yield. Similarly the effect of a nuclear warhead as an ABM interceptor is more directly controlled by its ability to come close to the missile to be intercepted, which in turn is determined by guidance and propulsion of the interceptor, rather than by the nature of the nuclear warhead it carries; this latter conclusion is reinforced by our ignorance of the specific nature of the enemy interceptor to be damaged. May I add again that in the post-SALT I era with its restraints on ABM such considerations have become of greatly decreased importance.

To summarize those last two remarks: In general it is much more important for military application of nuclear weapons that they come close to the target, than that the explosive power which they carry be very large.

I therefore conclude that nonnuclear development rather than nuclear developments are of greatest concern in relation to maintenance of strategic stability and that the strategic balance cannot be critically affected by advances in nuclear weapons technology on either side. There exists no agreement among military analysts as to the usefulness of nuclear weapons in tactical warfare, that is use on the battlefield, and happily tactical nuclear weapons have never been so used. Nevertheless, here also further improvements of tactical nuclear weapons in themselves are not the controlling element whether and how such instruments of war shall be used.

QUESTION OF VERIFICATION OF COMPLIANCE

I will next turn to the question of verification of compliance with the provisions of a test ban treaty; this question has been so much in

focus. There is little question that a CTBT would halt nuclear weapons developments of nations complying with the agreement. Currently we consider the technological status of the U.S.S.R. and the United States of America to be well-matched, although the United States might be ahead in respect to lower yield weapons and has a larger inventory of past test experience. Nonnuclear nations could possibly develop a few very crude nuclear explosives but could not produce efficient weapons or thermonuclear devices without testing. The U.S. Government has frequently reaffirmed its support for an adequately verified CTBT without specifically defining the term. Due to the decreasing significance of nuclear weapons improvements, the risks of evasion are clearly lessened; at the same time the techniques for verification of evasions are improving.

I would like to digress here to point out that clearly what is meant by "adequate verification" should be tailored to the military significance of what we are trying to verify. As Senator Kennedy pointed out this morning, we have set a precedent in the treaty banning biological weapons. Clearly clandestine manufacture of biological weapons cannot be verified by objective means but, nevertheless—and I concur with that decision—the United States has felt it was in the net interest of this country and of humanity to ban them.

Therefore, looking at "adequate verification" as an abstract concept which can be defined without looking at the military significance as to what you are trying to control is simply absurd. I believe the matter of military significance versus ease of verification has to be weighed against one another.

SEISMIC DETECTION AND IDENTIFICATION PROBLEM

Let me next turn to the seismic detection and identification problem.

In view of the foregoing discussion the recent advances in seismology, and detecting and identifying underground explosions are possibly less important toward promoting a CTBT than as scientific achievements in their own right. As you have heard from highly qualified witnesses this morning, Dr. Evernden and Dr. Lukasik, such advances in seismic identification and detection have indeed been impressive. Most important is the fact that the gap between detection and identification has been substantially narrowed in recent years. This means that those seismic events which can be detected at all by the U.S. network can also be classified with fair certainty into explosions and earthquakes with increasing confidence.

Specifically the number of seismic events in the Soviet Union unidentified by the present network at seismic magnitude of, say, 4.5, has become a very small number. Further improvements in the U.S. network can be made if their costs are considered warranted. Moreover the other national technical means of verification, whose legitimacy has been accepted in the SALT agreements, has added to our means of identifying suspected violations beyond that possible by seismic means. As a result the annual number of seismic events of magnitude more than 4.5 remaining unidentified might become less than one and thus the total number of nuclear tests which could be carried out clandestinely underground by the Soviet Union, say at a yield above 20 kilotons, would be very small indeed.

QUESTION OF ONSITE INSPECTION

Let me now turn to the question of onsite inspection.

In dealing with the contentious question of onsite inspections one tends to lose sight of the nature of such an undertaking. Governor Harriman did allude to this situation to some extent. The presumption is that seismic instruments will have detected but not identified a seismic disturbance and that the source of this disturbance has been localized within a certain area of 100 or so square miles within which onsite inspection is to take place. An inspection team is to be dispatched to that area and engage in visual surveillance, either from ground or air, or to engage in such activities as air-sampling to locate possible radioactivity. Clearly such an undertaking has to be limited in scope by the agreement reached, and one might hazard a guess that if a violation had occurred it would be difficult to gain adequate access. At best, onsite inspection would force a violator to test at greater depths. For all these reasons I would conclude that even if access can be secured the incremental value of such an inspection, for instance for radioactivity air sampling toward verifying violation beyond that which can be acquired by other means of collecting information is minimal.

Mr. Chairman, this is a point which is generally overlooked when this matter of onsite inspection is being discussed. If we don't detect the explosion at all, then we have no basis for ever dispatching an inspection team. If we have identified the cause of the seismic signals, then we don't need the inspection. Therefore, this whole question of onsite inspection deals only with a very narrow band of suspected violations and it is a very narrow band which has been greatly narrowed even further by the recent advances in seismology which were discussed this morning by Drs. Evernden and Lukasik.

QUESTION OF DELIBERATE EVASION

Now let me turn to the question of deliberate evasion. Whenever the test ban debate revives nationally, the feasibility of deliberate evasion techniques by complex or contrived means is reintroduced. One should recognize that any means of evasion, however successful technically, still involves a not negligible risk of detection; information leaks, either deliberate or inadvertent, can give clues of evasion attempts involving complex undertakings. Therefore, any attempt at evasion involves a balance of risks, costs, and incentives. Since military incentives for evasion are not large, it would be difficult to see why a nation would sign a comprehensive nuclear test ban with the deliberate intent of then proceeding with evasion.

Moreover, the costs of many of the evasion schemes suggested are very high; I tend to believe that the U.S. security would actually be well served if the Soviets were to dedicate substantial resources to such undertakings as nuclear tests in far outer space involving complex shields, or to tests behind the Moon, or to construction of a big hole rather than to devote those same resources to effective nonnuclear military developments. Moreover, some of the deliberate concealment and evasion schemes such as hiding the nuclear test among aftershocks of natural earthquakes, or detonating nuclear explosions in media of low seismic coupling involve many independent risks of detection such as the appearance of a visible subsidence crater.

Consideration of such artificial means of evasion is fundamentally diversionary from the main argument and would only make sense if a single or a very small number of test explosions would be of dramatic military significance; as discussed above, this is not the case.

Let me summarize the conclusions concerning seismic detection and identification evasion. By citing the advances in seismic detection and flagging in particular the achievements in narrowing the gap between detection and identification I do not mean to imply that evasion has become impossible. It will always remain true that advances in seismology can only lower the size of an explosion which a determined evader could technically conceal. Dr. Foster will always be able to make the statement he did this morning, and I quote, "We believe that there will be a significant residuum of seismic signals above some level whose origin we will not be able to establish unambiguously."

That statement will always remain true, but it will pertain to smaller and smaller explosions each year and it will be a matter of political and military judgment whether such seismic explosions are or are not an acceptable risk. In my view, the decreasing military importance of nuclear weapons developments, whether open or concealed, combined with the advances in verification should make a complete nuclear test ban fully acceptable militarily.

COMPREHENSIVE BAN'S COMPATIBILITY WITH PEACEFUL USES OF NUCLEAR EXPLOSIONS

Let me now discuss very briefly the much discussed issue of the compatibility of a comprehensive nuclear test ban with the problem of peaceful uses of nuclear explosions [PNE].

There exist differences in view, both in the United States and I might add in the Soviet Union, concerning the eventual economic value of peaceful uses of nuclear explosions. However, the U.S. Government has curtailed appropriations for these programs. Essentially all projects which have been proposed for the use of such devices are intended to meet objectives which could also be met by conventional means; therefore, justification of peaceful nuclear explosions has to rest on economic grounds. Ecological damage, radioactive contamination, the need for resettlement of local inhabitants, and other social consequences must be considered. For this reason in the United States [but not in the Soviet Union] the interest in the pursuit of large excavation projects using nuclear explosives has all but disappeared.

However, there is substantial interest in the use of nuclear explosions for stimulation of underground gas and oil reserves, underground gas storage, reclamation of geothermal energy, et cetera. If such projects are to make a significant contribution to the overall economy, underground explosions must be carried out in very large numbers; yet there is considerable doubt that programs requiring hundreds of nuclear explosions per year for their exploitation would be acceptable to the American people.

There are doubts about the compatibility of a comprehensive nuclear test ban with peaceful uses of nuclear explosions, and nonnuclear nations have, in my view, become unduly concerned and, may I add, unduly oversold about the economic disadvantages they would suffer if a comprehensive nuclear test ban would freeze them out from the

benefits of peaceful uses of nuclear explosions. It may be desirable for political reasons to postpone consideration of peaceful uses of nuclear explosions to a later deliberation after a comprehensive nuclear test ban treaty is in existence.

A program of peaceful nuclear explosives, particularly if carried out on a large scale, could be used as a vehicle for evasion of a CTBT for military purposes. As noted above, I normally would not consider even this risk of evasion of a comprehensive nuclear test ban excessive, considering the limited military gains which are in sight. However, the opportunities for evasion which a large-scale program of peaceful nuclear explosions would offer are certainly larger than those which, at least by past standards, the United States has demanded of verification of major arms control agreements.

In principle the opportunities for evasion using nuclear explosions for peaceful purposes can be limited but not eliminated by a variety of control measures such as the requirement for international observers to be present at detonation sites and similar measures. Again, without going into detail, I conclude that without actual inspection of the nuclear device itself—a measure which would certainly be unacceptable to the United States and the Soviet Union—evasion possibilities remain.

ECONOMIC EFFECTS OF COMPREHENSIVE TEST BAN

Let me now turn to the economic effects of a comprehensive nuclear test ban; here I might differ with some of the other witnesses. Nuclear tests currently cost several hundreds of millions of dollars per year. While a comprehensive test ban treaty would stop these direct expenditures, the net saving is less clear. Increased costs would be incurred if programs analogous to the four-point "safeguards" following the 1963 Limited Test Ban Treaty were enacted as a hedge against Soviet evasion or abrogation of a comprehensive nuclear test ban treaty. Moreover, nonnuclear developments and verification systems may grow in response to CTBT. Therefore, strong economic reasons for a comprehensive nuclear test ban are difficult to sustain.

EFFECTS OF NUCLEAR TESTING ON ENVIRONMENT

Let me now turn to the effects of nuclear testing on the environment. In recent times the citizens of this country have justly become more aware of the dangers facing our environment from large man-made disturbances, and consequently much criticism of nuclear testing, including underground testing, has arisen from that source. Dangers considered have been the possible triggering of earthquakes and of tidal waves, the contamination of underground aquifers [meaning underground water carrying strata], and the accidental release of radioactivity accompanying underground testing. It is indeed true that a certain fraction of U.S. underground nuclear explosions have vented, that is released some radioactivity through fissures or access openings; an even larger fraction of Soviet explosions have not been fully contained. In fact, radioactive release, although not a significant health hazard from such venting explosions, has been detectable outside the perimeters of each country and therefore, purely formally, could have

been considered to be a violation of the 1963 Limited Nuclear Test Ban Treaty. I do not consider such occurrences to be either serious or deliberate and it speaks for the improvement in relations between the United States and the Soviet Union that neither side has chosen to challenge these events. Moreover, in spite of the occasional venting from underground nuclear explosions and the atmospheric tests carried out by France and China the total worldwide fallout levels have drastically declined since the signature of the 1963 Limited Nuclear Test Ban Treaty. I would conclude that the environmental risks of underground nuclear explosions, although not totally negligible, can be controlled to levels commensurate with environmental hazards associated with other human activity; therefore the danger of ecological risk in itself cannot be considered to be a persuasive reason for proceeding with a comprehensive nuclear test ban.

SUMMARY

Let me conclude with a very brief summary, Mr. Chairman. The substance of the preceding discussion is that there appear no overriding technical or military issues which argue very strongly for or against a comprehensive nuclear test ban. The technology of nuclear explosives is mature and improvements are limited. Military technology, both tactical and strategic, is paced by nonnuclear rather than by nuclear developments. The leverage of a CTBT on technical grounds alone in slowing the arms race is minimal. The advances in seismic detection, however impressive, have simply decreased the threshold of size of explosion below which detection is not possible and they have narrowed the gap between identification and detection. There is little if any usefulness whatsoever to onsite inspection at the location at which an unidentified seismic event has occurred.

Worldwide fallout has already been dramatically reduced by the Limited Nuclear Test Ban of 1963, and I tend to agree that environmental concerns alone are not a very strong motive for pursuing a comprehensive nuclear test ban, provided, of course, that practices in carrying out underground tests are carefully controlled and hopefully improved. Net economic savings due to a comprehensive nuclear test ban may not be significant.

The primary urgency toward proceeding with a comprehensive nuclear test ban is basically nontechnical and stems from linkage with other arms control agreements. A comprehensive nuclear test ban would serve as a demonstration to the world that the signatories are willing and able to bring a potentially destructive technology under control.

The United States and the Soviet Union have assumed a formal obligation, both in the Limited Test Ban Treaty of 1963 and the Nuclear Nonproliferation Treaty of 1968, to seriously pursue a CTBT. Therefore, to sustain the drive for nonproliferation of nuclear weapons progress on a CTBT appears essential. Moreover, one can hope that signature of a comprehensive nuclear test ban treaty by those who have signed the Limited Test Ban Treaty and those who have signed the Nonproliferation Treaty might exert leverage on those nations who have not as yet signed. At the same time it would be unwise to assume

that all nuclear nations would participate in a CTBT and that all signatories of the Limited Test Ban would sign the Comprehensive Test Ban Treaty. Therefore, demanding this as a precondition would be a destructive move at this time. Similarly, I would oppose linking consideration of a CTBT to the purely bilateral SALT talks. I do believe that serious pursuit of a CTBT by the United States would improve the general climate for future arms control agreements and for this primary reason I support resumed serious negotiation toward a comprehensive nuclear test ban. This concludes my statement.

Senator MUSKIE. Thank you, Dr. Panofsky, for your excellent statement.

I think it might be well if Dr. Scoville presented his statement at this point.

STATEMENT OF DR. HERBERT SCOVILLE, JR., FORMER DEPUTY DIRECTOR, CIA, AND FORMER ASSISTANT DIRECTOR, ARMS CONTROL AND DISARMAMENT AGENCY (ACDA)

Dr. SCOVILLE. Mr. Chairman, it is a great pleasure to be able to appear before this committee again to discuss the subject of a comprehensive test ban treaty. I first worked with this subcommittee on the subject of a nuclear test ban back in the late 1950's when Senator Humphrey was the chairman, and this committee has always played a major part in exploring the issues involving limiting nuclear tests. Since that time, much water has passed under the bridge. We have achieved a treaty banning tests in the atmosphere, outer space and underwater, but unfortunately a ban on underground testing is still in the future. Had we succeeded in banning such tests 10 years ago, we would all be better off today. For this reason, I should like to express my support for Senate Resolution 67 with the hope that its prompt Senate passage would serve as a spark to ignite new efforts toward the achievement of a complete ban on all nuclear tests. The visit of Secretary Brezhnev in June offers a golden opportunity for joint U.S.-U.S.S.R. action to finally halt all nuclear weapons testing for all time.

Now, Mr. Chairman, instead of reading this prepared statement perhaps if this could be put in the record in the interests of time, I could just concentrate on a few points that were emphasized this morning if that is all right.

Senator MUSKIE. I think that would be very helpful, especially since, unfortunately, I am now running up against deadlines.

Dr. SCOVILLE. OK.

Senator MUSKIE. I think that the record would be very usefully served if you would respond to some of the points, especially the technical points that were made this morning. You two gentlemen are in position to do that, and I would like very much to have your responses.

Dr. SCOVILLE. I will just concentrate on one or two things I think seem to have been the thrust of the arguments this morning.

VALUE OF ONSITE INSPECTIONS QUESTIONED

First, it is very significant that both speakers for the administration this morning said and repeated what they have said many times

before, that it is U.S. policy to favor a comprehensive test ban provided that it was adequately verified and they describe adequate verification as onsite inspections. This was supported by Dr. Foster for the Defense Department as well. In other words, he was supporting the U.S. national position in this respect.

Now what does this mean? It means that the U.S. Government and specifically the Defense Department, is satisfied that if we could stop all nuclear testing as of the present time it would not have a serious effect on our security, and that the only drawback to this halt on our part would be fears that somehow or other the Soviets might cheat, and, thereby get a unilateral advantage because we were not testing as well.

It further means that they feel that the added protection that you get from onsite inspections is enough to give us confidence that our security would be protected under these circumstances.

Well, I would submit that the technical evidence just does not support this kind of value for onsite inspections. I think the data that were presented this morning would agree with this conclusion; some of the data was also presented in more detail by these same witnesses before this committee and the Joint Committee on Atomic Energy a year or two ago.

First of all onsite inspections are only allowed or triggered when one detects a seismic event but cannot identify it. Those are the only times in which you can carry on an onsite inspection. Now as a result of improvements in seismology which have been described by the witnesses today and earlier, and Dr. Panofsky stressed this himself, this gap between tests which can be detected but not identified and those which can be identified has now shrunk and only covers a very narrow yield range. There may be some argument exactly what that yield range is today, but it is probably somewhere on the order of a half a kiloton to a few kilotons; it is only in that very narrow yield range that onsite inspections have any value whatsoever. For tests that are below that value you won't detect them and so there is no occasion for onsite inspection. For tests above that value you can identify the events by seismic means alone and don't need them.

Furthermore, we have heard not so much today as in previous testimony, a lot about some of these very fancy evasion schemes such as digging a big hole and exploding a bomb in a big hole. Actually I think Dr. Evernden exploded that kind of myth this morning, but it is still mentioned. Another approach is that you might conduct an explosion under cover of the background seismic noise from a big earthquake somewhere around the world. If you had a test all set to go, maybe once every 6 months there would be a big earthquake and you could, on short notice, set off an explosion and its seismic signals could be lost. But onsite inspections don't do any good against these evasion techniques because they don't provide you the seismic detection signal to trigger an onsite inspection. Thus clearly that kind of an event is not considered sufficiently serious to change or affect our position on a comprehensive test ban.

The reason I mention this is so that some of these, what I think on the whole are red herrings, can be taken out of consideration in making a decision.

Recognizing this narrow yield range over which onsite inspection is applicable, we now have the testimony of Dr. Lukasik, which was again confirmed by Dr. Panofsky just now, that even if you carry out an onsite inspection it is only of marginal value. There are only two techniques which are of any value at all, and Dr. Lukasik has testified that an evader by putting the, particularly these low yield tests for which onsite inspection can be used, at sufficient depths the opportunities for getting radioactive gas to the surface are kept very, very small. Therefore, the chances of an onsite inspection providing any evidence are extremely slight.

WHAT HAS HAPPENED IN OVERALL VERIFICATION SYSTEM SINCE 1962

Now, finally what has happened in the overall verification situation since we first came up with this position for onsite inspections or the last time we changed it in 1962. In those days we didn't have the very extensive unilateral national techniques that we have today, and we didn't have the satellite systems with the kind of capabilities they have today and, perhaps even more importantly, we didn't know what the Soviet reaction would be to our using these as evidence of violations.

We now have the experience of the SALT I agreements which in the verification area are extraordinarily important. We have an agreement by the Soviet Union that national technical verification techniques, will be used, and Secretary Rogers in his presentation of the SALT agreements specifically referred to satellite observation as one of these techniques, so it is clear that the Soviets have agreed to these as legitimate means of verifying arms control agreements.

Furthermore, the Soviet Union has agreed that there will not be any interference with such techniques and, finally, that concealment measures will not be used to try to make these scientific methods inoperative. Perhaps particularly applicable, for the comprehensive test ban they agreed to setting up an international consultative commission to try to settle any questions that might come up about compliance with the treaty.

SALT PROVISIONS WOULD GIVE MORE VERIFICATION ABILITY THAN ONSITE INSPECTIONS

I think that one can make a very strong case that these SALT provisions applied to the comprehensive test ban would give you far more verification capability and far more confidence that the Soviets were not testing than any seven onsite inspections, which has been the U.S. position since 1962. I just don't think that thesis is arguable at all and I have never heard anybody in the Defense Department or anywhere else disagree with this thesis.

For example, Dr. Evernden testified this morning that a system might be built so that by seismic means alone there might be about 10 unidentified events with magnitude greater than 4.0. In other words, of yields, equivalent yields, of one or two kt. Since those 10 events are just natural seismic events, the question was raised wouldn't these provide false alarms. By using satellite observation techniques, I would think that probably at least 9 out of those 10 unidentified

events, and most of these will be low yield in the small kt region, that these would occur in areas where by satellites it would be clearly obvious that no underground test at depths of 3,000, 4,000, or 5,000 feet has ever been conducted. Most of the earthquakes in the Soviet Union occur in completely uninhabited regions in the Kamchatka Peninsula area, in the Tamir mountains; this is where there is just nobody. Any sign of any activity, particularly the kind of activity which would be required to carry out an underground test and get useful results at depths of several thousand feet, would be clearly observable by satellites. I think you would find, if you asked the Defense Department for information on these events they would agree with this conclusion.

I find it very hard to believe that an occasional event per year of 1 or 2 kt is likely to have any serious consequences for our security. Dr. Panofsky has already pointed out really the limited value of tests in the future. We have already gotten essentially to the knee of the development curve and improvement will be limited from now on. A few low yield tests just can't possibly affect our security. The risks from an occasional possible violation are infinitely less than allowing the Soviets to go ahead uncontrolled in testing in the higher yield ranges which they can do now without a treaty.

COMPREHENSIVE BAN USING NATIONAL MEANS OF VERIFICATION SHOULD
BE FAVORED TODAY

So I think from a security point of view it is absolutely clear that if we were in favor of a comprehensive test ban with onsite inspections for the last 10 years we ought today to be in favor of a comprehensive test ban using our national technical means of verification. While I will agree with Dr. Evernden that the idea of having some unmanned, some so-called black boxes, seismic stations in the Soviet Union might give you a little extra confidence, I am not persuaded that this extra confidence is either needed or really that great. While it might be nice to try to persuade the Soviets to have them, I think if we do that it should be absolutely clear they are not necessary; they are only confidence-building measures and by no means should a comprehensive test ban be dependent on getting Soviet agreement to these unmanned stations.

[Dr. Scoville's prepared statement follows:]

STATEMENT OF HERBERT SCOVILLE, JR.

It is a great pleasure to be able to appear before this committee again to discuss the subject of a comprehensive test ban treaty. I first worked with this subcommittee on the subject of a nuclear test ban back in the late 1950's when, under the chairmanship of Senator Humphrey, it played a major part in exploring the issues involved in limiting nuclear tests. Since that time, much water has passed under the bridge. We have achieved a treaty banning tests in the atmosphere, outer space and under water, but unfortunately, underground testing still goes on and at this late date we are still discussing a future ban on underground tests. Had we succeeded in banning such tests ten years ago, we would all be better off today. For this reason, I should like to express my support for Senate Resolution 67 with the hope that it will serve as a spark to ignite new efforts toward the achievement of a complete ban on all nuclear tests. The visit of Secretary Brezhnev in June offers a golden opportunity for joint US-USSR action to finally halt all nuclear weapons testing for all time.

The moment has come for a revision of US policy on a comprehensive test ban treaty. As Philip Farley, Deputy Director of ACDA has testified in previous

years before this committee, US policy has not changed since 1963 despite profound changes in the technical, military and political situation since that time. The requirements for new types of nuclear warheads have been significantly reduced, particularly as a result of SALT I, and our means of verifying an underground test ban have been radically improved. Simultaneously the need to negotiate a comprehensive test ban in order to reduce the probability of the further spread of nuclear weapons to non-nuclear countries is becoming more urgent every day.

VERIFICATION

Previous testimony before this Committee and the Joint Committee on Atomic Energy by representatives of the Defense Department and outside scientific experts has graphically demonstrated the major improvements in the seismic means of verifying a comprehensive test ban treaty. In 1963, we had only relatively crude and ineffective methods of discriminating between earthquakes and explosions. In fact, in those days we were only able to identify a fraction of the natural earthquakes, leaving an appreciable number of seismic events each year which could be either earthquakes or explosions. No firm criteria were available for identifying explosions per se. Now, thanks to the research and analysis sponsored by ARPA and other DOD agencies under the direction of such experts as Drs. Lukasik and Evernden, we have criteria by which explosions can be identified explicitly, and our techniques have been refined to the point that these criteria can be applied to very small events (a few KT or less). While the detection and identification threshold might be somewhat higher for explosions in low coupling media such as dry alluvium, it is most unlikely that this type of soil can be found anywhere in the Soviet Union at sufficient depths to avoid producing a subsidence crater which would be immediately obvious to our reconnaissance satellites. Dr. Lukasik testified before the Joint Committee on Atomic Energy on October 27, 1971 (p. 53) that the upper limit in yield which could be tested in a low coupling media without risk to detection was 1 to 2 KT.

The yield range for events which can be detected, but not identified is now very narrow, perhaps somewhere between $\frac{1}{2}$ and a few KT. Even this range will vary from day to day and location to location depending on the seismic noise background at the time of the event so that a would-be evader could not be certain that any specific test would remain unidentified. Therefore, since onsite inspections can only be applied for events which are detected, but not identified, the opportunities for such inspections would at best be very limited. Even if completely effective, they would only provide added confidence within a very narrow range of yields. But, as Dr. Lukasik also testified before the JCAE (p. 65), only two methods of onsite inspection are of much value, and even these can be circumvented by a determined evader. In sum, it is clear that onsite inspections serve almost no useful purpose in verifying a comprehensive test ban treaty. The deterrent value of a technique of such limited applicability would seem inconsequential. Yet, the US position, unchanged since 1963, still states that it supports a comprehensive test ban provided that onsite inspections are included.

Far more important than onsite inspections for verification would be the adoption in a comprehensive test ban treaty of verification provisions similar to those established in the ABM Treaty and the Interim Offensive Weapons Agreement. These legalize the use of national technical means of verification, forbid interference with such national technical means, and ban the use of concealment techniques to circumvent them. Furthermore, the Treaty establishes a Standing Consultative Commission "to consider questions concerning compliance with the obligations assumed and related situations which may be considered ambiguous." Similar provisions would be extremely useful in verifying a comprehensive test ban treaty. A large proportion of the detected, but unidentified seismic events in the Soviet Union occur in completely uninhabited areas such as the Kamchatka Peninsula and the Pamirs. Satellite photography (an agreed national technical means of verification) of the location of these unidentified events would clearly demonstrate the absence of any activity of the kind that would be required for the conduct of a nuclear test thousands of feet underground. It would only be a rare case where clandestine tests could not be ruled out. Under such circumstances, reassurances could be sought through an International Standing Consultative Commission (ISCC) which might be established by the treaty.

Elaborate evasion schemes have also been devised whereby clandestine tests could be carried out so as to avoid detection by seismic means. One of these

involves the conduct of the explosion in a large chamber (300 foot diameter hole for a 10 KT shot) several thousand feet underground. Such concealment techniques would be forbidden by the treaty, and the activities necessary to prepare for such a test would almost certainly be observable from satellites. At the very least, one would be in a position to seek an explanation in the ISCC, and an evader would have a difficult time in providing a reasonable rationale for such activity. Another proposed evasion scheme, hiding the seismic signal from a clandestine explosion in the noise of a large natural earthquake, would also require considerable preparation long in advance of the test. An elaborate seismic net would be needed to trigger the explosion and yet, if the test was of significant size, it would, nevertheless, always be vulnerable to detection by elaborate data analysis techniques or aerial observation. In any case onsite inspection would be of no value against either of these evasion schemes since if successful they would provide no seismic signal to justify the inspection. There is little question that the risks from cheating under a comprehensive test ban treaty with the SALT I verification provisions would be significantly less than the risk from a comprehensive treaty with the 7 onsite inspections per year which has been the US position since 1963.

Verification problems are no longer a reasonable justification for failure to achieve a ban on underground tests. Clandestine tests below the detection threshold, approximately $\frac{1}{2}$ KT, have long been recognized to be of no security significance as is evidenced by the US position in favor of a comprehensive test ban treaty with onsite inspections which cannot be applied below the threshold. For the same reasons, elaborate evasion schemes which would not trigger onsite inspections have apparently never been considered a reasonable threat. Seismic identification techniques have improved to the point that only a few events per year in the low KT yield range and a rare event above about 5 KT cannot be identified. Tests of new strategic warheads such as those used in MIRVs would almost certainly be detected, and the military significance of a few clandestine low yield tests is negligible. The SALT I verification procedures would provide significant added assurance that cheating in the low yield range or by evasion techniques would not involve a security risk.

SECURITY IMPLICATIONS OF A TEST BAN

As a result of SALT I the incentives for further nuclear weapons testing have been drastically reduced. Since 1963, more than 80 percent of all our tests have been related to strategic weapons, but now the ABM Treaty has virtually eliminated any further need for new designs. Since only 100 ABM interceptors are allowed at each of two sites, there is certainly no need to have new ABM warheads, or for effects tests to determine the vulnerability or reentry vehicles to nuclear explosions. No improvements in ABM warheads can possibly make these admittedly inadequate systems effective. Our Spartans and Sprints already have satisfactory warheads and even if these were to be replaced by other types of interceptors, which would be a terrible waste of resources, nuclear weapons designs that would serve the purpose are already available.

The ABM Treaty also eliminates the need for new warheads for offensive weapons since no longer do these need to be improved in order to insure overwhelming a Soviet ABM. We already have satisfactory designs for our MIRV warheads for the Minuteman and Poseidon missiles and, even if a replacement system were deployed to satisfy some presently unforeseeable need, no new nuclear warhead would be needed. If we were to seek to acquire a capability to destroy the Soviet ICBM force, a move which would be destabilizing and only serve to stimulate the arms race, we would not need to develop a new warhead. Potential improvements in missile accuracy are far more important for this purpose than any potential increases in yield to weight ratios. We already have weapons which can destroy a small number of such hard targets as ICBM silos or command posts provided we are willing to expend on each target several warheads out of our stockpile of thousands.

A comprehensive test ban treaty might, however, have a greater effect on Soviet counterforce capabilities. Because of the large size of their re-entry vehicles, they have never had a requirement for a warhead with the dimensions needed for a small highly accurate MIRV system which could threaten our entire Minuteman force. They may need more tests to develop such a warhead. Therefore, a comprehensive test ban could give us added confidence that the

Russians were not seeking a first strike capability and thus be an important contribution to US security and strategic stability.

Recently, in the aftermath of SALT I, some officials have referred to the need for developing a new generation of tactical nuclear weapons. But the US already has on the shelf a wide variety of designs for such battlefield weapons ranging from those that can be carried by the infantry with yields of tens of tons to missile warheads and bombs with yields as high as a megaton. Even with more than 7,000 nuclear weapons of many different types in the European theater, we have no rational plan for their use since the risks of escalation and the resultant nuclear devastation of Europe and even the US are extraordinarily high. New weapons will not solve this dilemma.

While some improvement in weapons design will always be possible, it is hard to make the case that they are essential for our security or warrant the cost of replacement of existing models. Even without a ban on testing, no priority has been given to "modernizing" these weapons. It has recently been argued that our forces need small yield limited effects weapons which do not produce fallout and use neutron kill in order to increase the credibility of the nuclear deterrent because of the greater likelihood that they might be used in an actual conflict. This is, of course, a step in the wrong direction. Our allies are not interested in becoming the locale for a nuclear war which the US and the Soviet Union might wage at their expense; they only wish to deter Soviet aggression by making its risks unacceptable to the Russians. The US, in turn, should not be in favor of any policy which increases the likelihood of even limited nuclear conflict because of the danger that it might escalate and destroy our society.

In any case, if the military or political circumstances required, we can avoid fallout by exploding our existing weapons above the ground. Furthermore, we already have available very low yield weapons for which the neutron effects predominate over all others so there is no need to develop a whole new class of weapons for this purpose. However, I question the military utility of a weapon which relies on nuclear radiation to affect manpower since a large fraction of casualties will not occur instantaneously, but lingeringly days or weeks later—hardly a desirable characteristic for a battlefield weapon. Only those soldiers who receive an overwhelming superlethal exposure will be unable to continue using their weapons for an appreciable time.

Finally, an argument has been made that we need to continue nuclear testing in order to check the reliability of our stockpiled weapons. However, Dr. Walske, Assistant to the Secretary of Defense for Atomic Energy, indicated that, at least as of the time of the hearings before this subcommittee in July 1971, nuclear tests had never been conducted with stockpiled weapons solely for the purpose of checking reliability. He also said at that time that uncertainty in reliability could be beneficial by serving as an added factor in deterring the first use of nuclear weapons because nearly one hundred percent reliability would be required to consider initiating nuclear war. Reliability is of lesser importance for deterrent or second strike weapons since no aggressor can count on surviving nuclear retaliation even from weapons of uncertain reliability. Therefore, a test ban which prevented both the US and USSR from checking reliability would reinforce the present state of mutual deterrence which President Nixon strengthened through the ABM Treaty.

In summary, in the aftermath of SALT I, the needs for further nuclear testing have drastically decreased. A complete ban on all tests is likely to be more restrictive on the Soviet Union than on the US and should improve the stability of our mutual deterrent posture. The small risks which might now result from clandestine testing under the lowered detection and identification threshold have little security significance and are more than overbalanced by the gains from preventing all tests in the higher yield ranges.

In view of these factors, President Nixon should seek General Secretary Brezhnev's agreement when they meet in June to the tabling at the Conference Committee on Disarmament in Geneva of a draft treaty or an amendment to the Limited Test Ban Treaty of 1963 which banned underground tests and contained verification provisions similar to those included in the ABM Treaty signed in Moscow. While the treaty is being negotiated, President Nixon should declare an immediate suspension of underground nuclear testing by the United States for as long as the Soviet Union reciprocates. This would not involve any risk to US security, would be a demonstration to all countries that the US was at least

prepared to bring to a halt the neverending qualitative nuclear arms race and would be an important move, as was President Kennedy's American University speech, toward the early conclusion of a formal treaty.

NECESSARY AMOUNT OF CHEATING FOR NEW BREAKTHROUGH

Senator MUSKIE. How much testing of this cheating variety would be necessary to lay the basis for development of new nuclear technologies? Is it conceivable that one test would be sufficient or significant? Of course, Dr. Panofsky takes the position that no surprises are likely in any case. But looking back, how much cheating would have to be involved to trigger any real nuclear development, new breakthrough?

Dr. PANOFSKY. It depends on what you mean by breakthrough. As an example, if one wished to make an occasional check on devices in the stockpile, whether they are still in good condition, a single test would be very useful. However, for that purpose, as I testified, other means are available that do not require nuclear tests.

Senator MUSKIE. That kind of cheating would not be militarily significant.

Dr. PANOFSKY. It would be if you attempt to find a military improvement, but it would not be decisive or critical.

But given a free hand one might well wish to continue testing and, after all, given a free hand the Soviets are indeed testing. But I cannot conceive of any kind of nuclear test program underground at this point which deserves the term "breakthrough" which you use.

Dr. SCOVILLE. Can I just comment?

Senator MUSKIE. Yes, please.

Dr. SCOVILLE. It seems to me that one of the major worries we always have is Soviet development of some kind of a MIRV system or strategic system which would permit a first strike.

Now, it seems to me just inconceivable by cheating the Soviets could develop a strategic warhead of the yield range which to be really useful must be higher than 10 or 20 kt, it must be someplace up in the 50 kt's or above. I think a test, or tests, since actually a single test wouldn't do it, which would have any serious security effect would clearly be detectable. We would identify it and know immediately it was a violation. It is a long way from an occasional test of one kt to having a weapon which you would be willing to deploy and would be a real weapon able to threaten our Minuteman force.

U.S. KNOWLEDGE OF STATUS OF SOVIET MIRV DEVELOPMENT

Senator MUSKIE. As a matter of fact, you mentioned MIRV testing. Don't our military people feel pretty sure they are on top of Russian developments in this field wholly on the basis of our national means of inspection of what they are doing?

Dr. SCOVILLE. That is true of the testing of the MIRV delivery vehicle itself. Now as far as the warhead for it we don't know the status of Soviet development of a warhead since now that tests are carried out underground one does not know the details.

On the other hand—

Senator MUSKIE. You know testing is going on.

Dr. SCOVILLE. We know testing is going on, but you don't know whether it was a MIRV warhead or exactly what its characteristics

are. On the other hand, the Soviet missiles so far have never had any requirement for a small high yield warhead, a warhead with small dimensions also, which will be required for a MIRV system which would have the accuracy and the number of MIRV's to threaten our Minuteman. Now it is possible they have developed a warhead for this purpose even though they have had no requirement for it. On the other hand, I think there is a distant possibility that they would still need more nuclear tests in order to have this capability, certainly to have as good a capability as they perhaps would need to have if they were going to be a threat.

So in a sense it seems to me in this particular area a comprehensive test ban could actually be a real boon to our security because it would prevent the Soviets from acquiring such a capability or certainly make it much more difficult.

NATURE OF ONSITE INSPECTION

Senator MUSKIE. What is the nature of an onsite inspection? What kinds of techniques? How much activity? How much personnel or how many ground areas would be involved? Can you envision what it would be like?

Dr. SCOVILLE. Well, I think what one is talking about today, although I am not sure they have gone into a lot of detail on the specifics of it recently, is probably a lot less extensive than the kind of inspection that Governor Harriman was talking about earlier. Back in 1963 one was really talking about large numbers of people staying for a long time, helicopter flights all over the place. At the present day there are just two techniques one talks about, one is radioactive gas sampling in which you would go in and collect gas samples and see if they contained radioactive Krypton. The other thing would just go in and carry out visual inspection on the ground. If you have detected a seismic event in an area that contained a mine you might go in the area and poke around to see if you might find evidence of a nuclear explosion or preparation for one. Both of these kinds of things probably can't be done by satellite, although looking for activity, human activity, can be done by satellite very satisfactorily. That is one reason why the satellite collection would be very useful.

COMPREHENSIVE BAN'S EFFECT ON PEACEFUL EXPLOSIONS

Senator MUSKIE. I have a question I was asked to put in behalf of Senator Haskell. I think it has already been covered by testimony, but I will put his specific question to you so you can respond to it on the record. Dr. Scoville, what would be the effect of a proposed comprehensive test ban on such peaceful explosions as Rio Blanco, which is designed to stimulate natural gas.

Dr. SCOVILLE. Well, both Dr. Panofsky and Mr. Farley addressed the problem of peaceful nuclear explorations earlier. It is clear peaceful nuclear explosions present problems for test ban because the verification difficulties are very extreme. I think Mr. Farley's proposal this morning was probably a good one. If you can't work out details for how these could be carried out under a test ban, one would stop these peaceful explosions for a few years while one tried to develop

schemes for adequate verification. I would approve of his proposal in that connection.

In connection with the problem which I think Senator Haskell is worried about, which is the Rio Blanco test, which is scheduled for Colorado in the near future, that particular test only involves three nuclear explosives. On the other hand that particular test is only the first step down a long road of many nuclear explosions before you have even feasibility determined. The AEC has stated in their environmental statement that perhaps as many as 300 nuclear explosives would have to be fired off before one would even know whether the method was technically feasible and it was worth building a pipeline. To get useful gas in the Rio Blanco area a thousand nuclear explosives may be needed. This is the very kind of point that was being referred to by Dr. Panofsky this afternoon. I personally think that one is just whistling when one talks about firing off a thousand underground nuclear explosives in a small area of Colorado. This is more than we have tested in all the time so far, more underground; even the 300 for feasibility is more than we have done in our whole weapons program in the whole 10 years since the test ban treaty.

Dr. PANOFSKY. May I respond to that?

Senator MUSKIE. Yes.

Dr. PANOFSKY. I think whether a comprehensive nuclear test ban is or is not compatible with the kind of activity as the Rio Blanco tests depends on the standards of verification. I mean if we use the kind of standards of verification which Dr. Foster talks about, including the requirement for onsite inspection for essentially all suspected events, then clearly such activities are incompatible with a comprehensive test ban. If one is willing to negotiate some system where you have observers at the point of detonation or other missions for which there are several proposals, mechanisms might be found to make a comprehensive nuclear test ban compatible with peaceful nuclear explosions. But again I believe that this is a false obstacle to be raised in opposition to a test ban because the economic benefits are so remote and the likelihood that any country in the world will accept the kind of ecological insults which a thousand explosions will involve are so remote that I think there is plenty of time to negotiate provisions for permitting peaceful uses of nuclear explosions as a separate amendment or addition to a preexisting comprehensive nuclear test ban.

COMMENDATION OF WITNESSES

Senator MUSKIE. I wish I had the time to continue but I have another appointment. I would like to express my appreciation to both of you, especially for your sitting through this morning's hearings so that you could give us the benefit of your reaction and respond to the arguments made in opposition to this resolution. We need those arguments.

Thank you both very, very much.

[Whereupon, at 4:05 p.m. the subcommittee adjourned subject to the call of the Chair.]

APPENDIX

STATEMENT BY SENATOR CHARLES MCC. MATHIAS, JR. (R.-Md.) BEFORE THE SUBCOMMITTEE ON ARMS CONTROL, INTERNATIONAL LAW AND ORGANIZATION OF THE SENATE FOREIGN RELATIONS COMMITTEE IN SUPPORT OF SENATE RESOLUTION 67 CALLING UPON THE PRESIDENT TO PROMOTE NEGOTIATIONS FOR A COMPREHENSIVE TEST BAN TREATY, TUESDAY, MAY 1, 1973

I am happy to be able to testify in support of Senate Resolution 67, of which I am a co-sponsor. Senate Resolution 67 represents a fusion of various previous resolutions on a comprehensive test ban treaty presented to the Congress during the past year and a half. The resolution is a very modest one, but it seems to me to represent a proposal for a significant arms control effort. It entails no risks and could do much to strengthen world security by lessening the danger of a nuclear war. In essence, this resolution calls for a mutual moratorium by the United States and the Soviet Union. In addition, it urges the administration to make a proposal to the Soviet Union and other nations for a permanent treaty to ban all nuclear tests.

Most of the witnesses who will testify today testified last year. During the past year, very little has changed, except for the very important fact that there is more authoritative scientific information which indicates that on-site inspection is no longer a necessary requirement. In fact on-site inspection is a less reliable means of verification than the improved seismic means of detection now available.

These hearings will address the question as to what will be lost to the United States security by a comprehensive test ban. On the basis of available evidence, it is my view that very little will be lost. As Dr. Panofsky pointed out last year and in his testimony this year, nuclear weapons technology is at a mature stage of development. The refinements to be gained by further testimony are of marginal significance. It should be admitted, however, that a continued nuclear test program could produce some changes in nuclear weapons technology, particularly in the efficiency and economy of nuclear devices, but in my view these changes do not warrant holding up a complete test ban.

It should also be borne in mind that a comprehensive test ban will not of itself yield significant arms control benefits. It will be significant only in the context of successful SALT talks, and a more extensive application of the nuclear non-proliferation treaty. In saying this, I do not wish to diminish the importance of making an effort to achieve a comprehensive test ban. A comprehensive test ban would constitute an important step in limiting the nuclear arms race and would be an aid in preventing the use of nuclear weapons in war.

I would hope that the administration would initiate with the Soviet Union negotiations on a comprehensive test ban as soon as possible. The Disarmament Conference at Geneva offers a good place to begin the negotiations. In fact, when President Nixon meets with Mr. Brezhnev in June, that might be an appropriate occasion to raise the issue.

The United States is obligated under the provision of the Nuclear Nonproliferation Treaty to undertake further arms control efforts. This pledge was reiterated in the joint statement issued by the United States and the Soviet Union in Moscow at the signing of the SALT Treaty and the Interim Agreement in May 1972.

The Arms Control and Disarmament Agency does not have the responsibility in the SALT II talks that it had under SALT I, so it seems to me that ACDA is now in a good position to carry out preparations leading to a comprehensive test ban.

This modest step of calling upon the United States and the Soviet Union to begin a mutual effort to bring about a complete test ban is a practical and worthy one. It is my hope that hearings on this Resolution, which are to take place today, will assist in bringing about that desirable end.

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., May 30, 1973.

HON. EDMUND S. MUSKIE,
Chairman, Subcommittee on Arms Control, International Law, and Organization,
Committee on Foreign Relations, U.S. Senate.

DEAR SENATOR MUSKIE: The Atomic Energy Commission appreciates the opportunity provided by your letter of May 11, 1973, to provide comments on Senate Resolution 67 for the record of the Subcommittee's hearing on May 1, 1973. We are pleased to submit the enclosed comments for that purpose.

Sincerely,

(Signed) DIXY LEE RAY, *Chairman*.

U.S. ATOMIC ENERGY COMMISSION COMMENTS ON SENATE RESOLUTION 67

United States policy is to support the achievements of a comprehensive nuclear test ban that is adequately verified. This policy has been publicly affirmed in numerous policy statements as well as by U.S. agreement to the Limited Test Ban Treaty of 1963 and the Nuclear Non-Proliferation Treaty of 1968.

The Atomic Energy Commission supports this policy. Nevertheless, the AEC has certain reservations with respect to S. Res. 67. The potential political and national security benefits that might result from a total cessation of nuclear testing have been covered by others before the Subcommittee. The AEC wishes to stress that these potential benefits would be obtained only if any arrangement for cessation of nuclear testing was broadly adhered to and was truly effective in stopping nuclear tests. If that were not the case, there would be significant drawbacks associated with a cessation of U.S. nuclear testing that would need to be seriously considered.

Expert witnesses before this Subcommittee have already provided technical information with respect to the effectiveness of existing verification techniques. The AEC desires to emphasize that, while the capability to detect and identify nuclear tests has improved, the military significance of low yield nuclear tests has also increased. The public record of the U.S. nuclear testing program indicates that over half of the announced tests have explosive yields of less than 20 KT. Underground nuclear tests below this level are the most difficult to detect and identify using even the most advanced verification techniques currently available. Yet nuclear tests at these lower levels provide much of the fundamental knowledge required for a nuclear weapons development program.

In view of existing practical limitations on seismic monitoring systems, on-site inspection should be an integral part of any nuclear test cessation. On-site inspections intrinsically provide the greatest possibility for establishing that a suspicious seismic event is nuclear. They also provide an open procedure enabling all participants to verify to their own satisfaction that the nuclear test cessation is observed; they are necessary for assuring compliance and consequent confidence in the basic arrangement.

There are several drawbacks to the proposed moratorium approach that need to be considered.

1. A bilateral moratorium probably would not be any more effective in restraining third countries from nuclear testing than existing treaties. A moratorium would be far less effective than a formal comprehensive test ban treaty in furthering the goal of non-proliferation.

2. Such a moratorium would not include the safeguards that should be included in a formal treaty and would therefore be less desirable than a comprehensive test ban treaty. Without accepted or established criteria for ascertaining if a violation of the moratorium had occurred, there would be no effective basis for challenging a suspicious occurrence. Such an informal arrangement, which could be breached without significant penalties, could lead to suspicion and instability. In addition, if one country was able to test clandestinely while the other observed the moratorium, then a decisive advantage might accrue to the country doing the testing.

3. A U.S.-Soviet Union moratorium could be construed as U.S. acceptance of the Soviet Union position that national means are adequate for verification of a nuclear test ban. Hence, efforts in later negotiations to include verification measures in the context of a comprehensive test ban treaty could be seriously hampered. Moreover, there would be less incentive for the Soviet Union to negotiate a comprehensive test ban treaty once such a moratorium was in effect.

4. Past experience of the U.S. with a nuclear test moratorium (1958-1961) was not satisfactory. The U.S. was taken by surprise when the Soviet Union, after extensive undetected preparation, resumed testing with an elaborate test series.

As emphasized earlier, the potential benefits of a cessation of nuclear testing would be obtained only if an arrangement for complete cessation of nuclear testing was broadly adhered to and was truly effective in stopping nuclear weapons testing. In the absence of an adequately verified formal agreement the U.S. has been pursuing a path toward highly advanced technology in nuclear warheads. Quite early in the history of the strategic missile program it became apparent that overall system cost effectiveness could be increased by pushing the state-of-the-art toward the development of light, efficient warheads thus permitting smaller and less expensive but more effective and reliable weapon systems. This path of advanced technology is not one to be abandoned lightly and certainly not without adequate assurances that national security will not be degraded.

There are some unique advantages associated with nuclear testing. For example, nuclear testing provides an opportunity to study and evaluate nuclear effects. An understanding of nuclear effects is essential in the effort to reduce the collateral damage associated with nuclear weapons and to check and evaluate the effectiveness of warheads. Nuclear testing also provides continuing confirmation of the reliability of the U.S. stockpile of nuclear warheads. Such reliability becomes all the more essential in view of limitations resulting from SALT. The AEC believes this reliability cannot be achieved with the same degree of confidence through even unlimited non-nuclear testing or rebuilding of warheads.

Nuclear weapon technology should not be viewed as mature and lacking in areas to investigate. There are advances in the national security field which, in the absence of an adequately verified comprehensive test ban treaty, should be investigated. For example, precision guided munitions open a new field for nuclear development. Such munitions coupled with low-yield nuclear warheads designed for minimum collateral damage have the potential of significantly enhancing the deterrent impact of tactical nuclear forces. In addition, one of the growing concerns in the nuclear weapons area is related to improving the ability to prevent the use of a stolen or captured weapon by an unauthorized party. While there are some methods at hand now, the AEC is developing several even more effective ways of accomplishing this end. Some of these techniques require nuclear testing in order to verify their compatibility with nuclear weapon designs.

It is not clear whether, in advocating a permanent treaty to ban all nuclear tests, S. Res. 67 was intended to include peaceful nuclear explosive tests and/or peaceful nuclear explosion applications. Both contained underground engineering applications and excavations with nuclear explosions have technical, economic, and in some cases, environmental advantages over conventional practice. The U.S. has an energy shortage. Production of natural gas and petroleum from oil shale, as well as creation of underground storage space for these commodities using peaceful nuclear explosions, may help ease that shortage.

The U.S. technology base in peaceful nuclear explosions can be employed domestically, as in the recent Rio Blanco natural gas production experiment, and internationally as an aid to non-nuclear weapon states and lesser developed countries which may anticipate the availability of this assistance pursuant to the non-proliferation treaty. Thus, full consideration needs to be given to working out arrangements including safeguards for accommodating peaceful nuclear explosions under a comprehensive test ban treaty.

The AEC has studied possible safeguards which could be effectively employed to insure that peaceful nuclear explosion applications are not being used as a cover for weapon tests and will discuss these with the Subcommittee if that is desired.

In conclusion, the AEC is not in favor of Senate Resolution 67 because it calls for initiatives by the U.S. which do not appear to be justified in view of the tech-

nical and political considerations discussed above. In the absence of a comprehensive nuclear test ban treaty adequately verified, the AEC believes there are compelling reasons for the U.S. to continue with a nuclear weapon development program.

TASK FORCE FOR THE NUCLEAR TEST BAN,
Washington, D.C., May 8, 1973.

Senator J. W. FULBRIGHT,
*Chairman, Senate Foreign Relations Committee, Senate Office Building,
Washington, D.C.*

DEAR SENATOR FULBRIGHT: It is important, I believe, that the enclosed material is brought to your attention, in connection with the scheduled hearings on the appointments of new officers for the Arms Control and Disarmament Agency.

The material, which is being submitted in my individual capacity and not on behalf of the Task Force for the Nuclear Test Ban, summarizes recently disclosed evidence on the role of the U-2 affair in the collapse of the 1960 "summit" meeting. This evidence has been uncovered since the Senate hearings on this subject in the spring of 1960. As you will recall, it was expected an arms control measure, the test ban treaty, would be concluded at the 1960 meeting.

The coming hearings on the confirmation of Fred Ikle and Amron Katz to positions in the Arms Control and Disarmament Agency should provide an opportunity to discuss the current U.S. position on the comprehensive test ban. As you know, the Arms Control Subcommittee held a day of hearings on this issue on May 1, at which both Senator Kennedy and Ambassador Averell Harriman urged that the test ban should be included on the agenda of the "summit" meeting now scheduled for June. However, government witnesses made clear that the Nixon administration still supports the demand for on-site inspection of a test ban agreement—a condition which has prevented conclusion of this treaty for over a decade.

I hope you will find the information in the enclosed piece relevant background for your questions on test ban policies at the hearings.

With best wishes,
Sincerely,

(Mrs.) JOSEPHINE POMERANCE.

A NUCLEAR TEST BAN AT THE SUMMIT?

(By Jo Pomerance)

"The unwarranted influence of the military industrial complex", as President Eisenhower predicted, has reached into significant areas of the nation's resources as well as into its foreign policy. The inability of Congress so far to make substantial cuts in the defense budget, or to completely halt hostilities in Indochina are manifestations of the continuing sickness of the body politic. This infection stems, in great part, from the power acquired by the vast defense establishment, including the intelligence community, developed in the nuclear era.

Most recently the hard liners have initiated a reorganization of the Arms Control and Disarmament Agency, reportedly directed at a reduction of the Agency's influence. The task of protecting the nation from nuclear attack, against which there is clearly no effective resistance, has seemingly made defense an end in itself. Indeed the perpetuation of the deterrence program has become so vital to many of the administration's policy makers, and to the business and military interests which are involved that the end seems to justify the means. Either for patriotic motives as they see them, or merely to preserve status or income, the leading hard liners have often misrepresented the facts and deceived the public in their efforts to promote the defense establishment, sacrificing opportunities for peaceful settlement and arms control agreements in the process.

Concurrent with the attempt to reduce the status of the Disarmament Agency, for example, the administration has insisted on maintaining policies which prevented a test ban agreement for over a decade. Although most of the nation's leading scientists now argue that a test ban agreement can be verified by national means alone without endangering security, the administration continues to demand on-site inspection—a condition the Russians will never accept.

This government position, is only the most recent indication of official inflexibility on this test ban question. Over the years, the officials administering the

testing project have been stubbornly determined to continue testing. They have done this even though experts claimed a test ban agreement could be concluded with the Russians without loss of security and even though no further advantage could be gained by additional tests. The question arises: how has this controversial program been perpetuated?

The one incident which perhaps more than any other insured the continuation of testing was the collapse of the "summit" meeting in 1960 as the result of the crash of an American U-2 spy plane over the U.S.S.R. Although questions were raised at the time about the motives for government policy decisions in the affair, two Senate hearings were unable to find satisfactory explanations for the U-2 flight or for the confusion among American diplomats when the plane was captured. Today it is particularly timely to review this episode, not only because in the intervening years new evidence has become available, but because there may shortly be another summit—this one between President Nixon and Soviet party leader Brezhnev, where the test ban is again expected to be high on the agenda.

Briefly, the facts are these. Preparations for a summit meeting between President Eisenhower and Premier Khrushchev at which it was hoped some of the pressing international problems would be solved, were begun in 1959. Secretary of State Herter expected "an interim agreement for Berlin" might be possible and that the "disarmament deadlock" might be broken, most probably through a ban on nuclear testing.¹ At the Geneva test ban negotiations, Ambassador Wadsworth of the U.S. and Ambassador Michael Wright of the U.K. were both convinced that the Russians wanted the test ban agreement and that adequate preparations had been made on the terms of the treaty. They were apprehensive, however, since they had not received new instructions for months. Rumors were circulating that John A. McCone, Chairman of the U.S. Atomic Energy Commission, the agency responsible for the testing program, had asked the President to break off the talks.² Rumors of McCone's strong opposition to the test ban were confirmed about a month before the scheduled summit meeting, in a column by Joseph Alsop on April 4th in the New York Herald Tribune. McCone's general thesis, Alsop reported, was that a test ban could not be adequately verified and that further testing was essential to security. Commenting on a speech by McCone outlining these views, Alsop wrote: "These are the appalling facts to have to face at the present stage of American policy making. With the summit conference just around the corner, the American government stands virtually committed to the wholly inadequate Geneva detection system . . . In the circumstances" he continued, "one must admire the moderate way Chairman McCone has pressed on President Eisenhower the case for the go slow approach to the voluntary moratorium on tests." Here, Alsop seems to imply that stronger action is needed. It is not known whether McCone took additional action to prevent the test ban. It is known that subsequently his conclusions on this question were shown to be completely false. Nevertheless, the A.E.C., the agency he represented, continued opposition to the test ban.

Officials in another government agency were also disturbed by the prospect of the summit conference. David Wise and Thomas Ross, writing in "The U-2 Affair," report that within the CIA, which ran the U-2 espionage program, and in the intelligence community in general, "there was an uneasy feeling as the summit approached that a detente might be reached in Paris . . . An international rapprochement, followed by Eisenhower's trip to Russia, would make further flights politically impossible in the foreseeable future . . . There was a strong desire therefore to get one last mission in under the wire."³ As a consequence, despite the fact there had been suspension of flights in the past at sensitive periods,⁴ a U-2 flight over the U.S.S.R. to obtain further information on missile installations was authorized for May 1, just two weeks before the summit. The pilot was Francis Gary Powers who has since reported his experiences in "Operation Overflight," a book which the CIA, under the Chairmanship of McCone, succeeded in suppressing from 1961 until 1969. In his book Powers reports that before May 1st, the overflights had been drastically reduced for a period of about two years. Although some other surveillance missions had been scheduled,

¹ Ross, Thomas B., and Wise, David, *The U-2 Affair*. Random House, Inc., New York, 1962, pp. 141, 263.

² Interviews with Ambassadors James Wadsworth and Michael Wright, Geneva, May 1960.

³ Ross and White, op. cit., p. 265.

⁴ *Ibid.*, p. 176.

"Months would pass without one," he writes. "Then suddenly, after a long pause, two flights were scheduled for the same month, April 1960."⁵ Is it probable as Wise and Ross report, that these flights were ordered at the time of the summit because they were so essential, if all flights had already been virtually suspended for a two year period? Certainly Powers' account raises questions as to the credibility of the official reason for the May 1st overflight.

Powers also reported he was unusually nervous during the flight because, instead of his customary plane, he was assigned one flown over the night before from Lockheed, where it had been sent for repairs. It was "known as 'a dog,' never having flown exactly right. . . . No sooner was one malfunction corrected than another appeared. Its current idiosyncrasy was one of the fuel tanks which wouldn't feed all of the fuel. But not all the time, just occasionally."⁶ Moreover, in a recent interview with Paul Jacobs, a Los Angeles writer, Powers said he has since discovered his own plane was not disabled as he was told. Doesn't it seem extraordinary that, at so sensitive a period, a plane which is obviously accident-prone should be assigned to fly over the Soviet Union? Here again, Powers seems to be questioning the motive for the overflight.

Powers took off from Peshawar, Pakistan, flying at about 68,000 ft. to escape Soviet fighter planes and anti-aircraft missiles. Above Sverdlovsk the plane crashed, and Powers parachuted safely to the ground where he was arrested and taken to the Soviet authorities. Later at his trial, and at the Senate hearings, Powers testified he was sure nothing hit his aircraft.⁷ The plane, he thought, was disabled by an internal explosion or by a shock wave from a near miss by a Russian anti-aircraft rocket. Although the official Soviet story was that Powers had been hit by a single rocket, even the Communist press questioned this version. At the operating level of the U-2, Soviet height-finding radar was still judged to be ineffective.

On May 7, Khrushchev announced from the Kremlin that the pilot, Powers, had been captured, concluding: "I am prepared to grant that the President had no knowledge of a flight being dispatched to the Soviet Union and failing to return. But it should alert us still more . . . when the militarists begin to run the show . . . the result can well be disastrous." A few hours later, the President's press secretary, James Hagerty, announced to newsmen that the U.S. would resume nuclear testing, under Project Vela, to improve its ability to detect such blasts. The reporters gained the impression the tests could involve nuclear weapons. Wise and Ross comment, "Because the announcement of renewed U.S. atomic testing came a few hours after Khrushchev's speech, it was inevitable that the two became linked in many minds as a bellicose United States answer to the spy plane charges."⁸

The rest of the story, is, of course, history. Khrushchev was furious that a U.S. spy plane should have been authorized just prior to the summit when a climate of trust was so essential. The Americans made matters worse by their response to the Soviet accusations. Wise and Ross comment on the American handling of the crisis this way: "By lying, when it could have remained silent, by admitting it had lied, by disclaiming Presidential responsibility, and then admitting Presidential responsibility, and finally by implying the flights would continue, the United States made it impossible for the summit to take place." Is it probable that seasoned diplomats would become so confused they would make this succession of errors?

The President, who Powers states was never adequately informed of the circumstances of the flight,⁹ tried to take an independent stand from his advisors. He finally announced at the conference table in Paris that he had called off the U-2 flights. Khrushchev had demanded this pledge as a condition for attending the summit. He could not do otherwise and remain Premier of the U.S.S.R. When the pledge came, however, it was too late, and Khrushchev left Paris.

The Senate investigation by the Foreign Relations Committee was held entirely in executive session between May 27 and June 2, 1960. The CIA testi-

⁵ Powers, Francis Gary, *Operation Overnight*. Holt, Rhinehart and Winston, Inc., New York, 1970, p. 69.

⁶ *Ibid.*, p. 76.

⁷ *Ibid.*, p. 322.

⁸ Ross and Wise, *op. cit.*, p. 100.

⁹ Powers, Francis Gary, *op. cit.*, p. 352.

mony was expurgated by CIA officials before the record was released to the press according to the statement on the flyleaf. Even with all the secrecy, the disaster was not fully explained. Few Committee members asked questions about the crucial points in the affair. The Committee did confirm that the decision to send the U-2 was not made by top officials. President Eisenhower merely authorized a group of flights without any thought that one might be close to the summit, nor was he reminded of this significant point when his approval of the plan was requested. Richard Bissell, Deputy Director of the CIA made all the arrangements.

The Committee seemed concerned that government moves had helped to make the U.S. image sufficiently belligerent to hasten the collapse of the summit. They pressed witnesses particularly on two points: first, how did Vice-President Nixon happen to state on television on May 14 that the flights would continue when the President had given the order to halt them on May 12? Moreover, since there didn't seem to be any emergency, why did Secretary of Defense Gates order a world-wide alert of U.S. forces at the moment it appeared Khrushchev might reconsider his decision to leave Paris?¹⁰

The disaster at the summit ruined hopes for an early easing of the international climate and postponed a comprehensive test ban treaty for years. It is possible to conclude from the evidence presented here, much of it only now assembled together, that mere negligence was not the cause of the tragedy, but that persons and/or agencies planned to prevent the detente which could have resulted from the summit. Commenting on similar U.S. intelligence missions which have had an extraordinary impact on history, Peter Dale Scott writes, "The Pueblo crisis needs to be understood. . . . There are too many indications that many alleged 'errors' and 'coincidences' on the American side without which the incident would not have occurred; were in fact not errors and coincidences but part of an enduring pattern of artificially produced provocations and/or 'crises' the recurrence of which has contributed to the increasing militarization of American foreign policy since the all-too comparable U-2 incident of 1960."¹¹ In a new book on the CIA, C. Fletcher Prouty suggests a plot against the peace: "If by any chance the thought had occurred to the four men who launched it that the failure of this relatively unimportant flight would completely wreck and vitiate all of the hopes and plans of the Eisenhower Crusade for Peace, they could not have chosen a more effective method or time to have done it. The very fact that what was done could have been done so easily according to a sinister plan, not an accident or Soviet act, serves only to fuel the thought that it might have been done on purpose. Such a simple thing as failure to supply the plane with sufficient hydrogen for the flight could have resulted, just as it did, in the certain flame-out of the engine and the subsequent failure of the mission—or the success of the mission—depending upon the secret intent of those who dispatched it."¹² Prouty goes on to say the flight was "launched and directed by a small cell of inner elite"—by four men, whose names he does not reveal.

Today, a new campaign for the test ban is being initiated with the introduction of Senate Resolution 67 on February 20, 1973, and another summit meeting is scheduled in late June. Evidence that the public has been completely misled in recent years by the A.E.C. and the Pentagon about the the necessity for on-site inspection for adequate surveillance of a test ban agreement have already been presented at Senate hearings. The new disclosures assembled here indicating the 1960 summit meeting may have been sabotaged in part to prevent the test ban agreement, are also important to an evaluation of the government's position on this arms control measure. The evidence could be exploded further at additional hearings at which John McCone, Francis Gary Powers and Fletcher Prouty would be among the witnesses who would be asked to provide whatever information they might possess. If at all possible, it would seem the Senate Foreign Relations Committee, which is empowered to oversee government operations in this area, should have the facts.

¹⁰ Events Incident to the Summit Conference, Senate Foreign Relations Committee Hearings, May 27, June 1 and 2, 1960.

¹¹ Scott, Peter Dale, *The War Conspiracy*, Bobbs-Merrill Co., Inc., New York, 1972, p. 112.

¹² Prouty, L. Fletcher, *The Secret Team*, Prentice-Hall, Inc., Englewood Cliffs, N.J. 1973, pp. 354-5.

THE RIPON SOCIETY,
Washington, D.C., April 26, 1973.

HON. CHARLES MCC. MATHIAS,
U.S. Senate,
Washington, D.C.

DEAR SENATOR MATHIAS: As a principal co-sponsor of S. Res. 67, you are no doubt aware of The Ripon Society's past support for attempts to encourage negotiations for a comprehensive nuclear test ban treaty.

Last year, in response to a resolution similar to S. Res. 67, Ripon urged the Administration to actively promote negotiations leading to a test ban treaty. In our statement, a copy of which is enclosed, we observed "that a more propitious time for agreement upon such a treaty may not easily be found again."

A year has passed since we issued our statement, and we are not any closer to negotiating a test ban treaty. Therefore, on behalf of The Ripon Society, I want to reiterate our strong support for a comprehensive nuclear test ban treaty.

We wish you and your colleagues every success in your efforts to secure Senate passage of S. Res. 67.

Sincerely,

MICHAEL F. MACLEOD,
National Director.

Enclosure.

STATEMENT BY THE RIPON SOCIETY

A renewed willingness to actively pursue the negotiation of a comprehensive nuclear test treaty would be in keeping with the best of the foreign policies of the Nixon Administration. A successful treaty would be an important complement to a SALT agreement, and a significant item in the list of initiatives which this administration has undertaken, to reshape the Soviet-U.S. relationship, and even in some respects, the structure of world order.

Such a position is possible and in fact easy, for Mr. Nixon to take. Modern seismic technology can detect and identify all but the trivially smallest seismic events, hence the traditional American position that any agreement must include provisions for on-site inspection, can safely be jettisoned, or at a minimum, substantially modified.

A number of benefits are likely to accrue from a comprehensive test ban treaty. Perhaps the most significant, is that it would act as a substantial brake upon the development of new weapons systems and hence upon the arms race. An important point here is that this brake would be applied at the final development and engineering stages and hence would not necessarily inhibit the early stages of research much, if at all.

Beyond its impact upon the U.S.-Soviet Arms Race, a comprehensive test ban treaty could well serve to bring additional nations to ratify the non-proliferation treaty of 1968, and perhaps even serve to inhibit the atmospheric testing of France and China.

A third benefit of substantial significance is the elimination of the environmental risks inherent in continued underground testing. Among these are the accidental venting of radioactive debris into the atmosphere, which has occurred frequently enough to cause substantial concern; the possible contamination of underground water and/or surrounding earth, which can find its way into rivers and streams and thereby raise radiation levels over broad areas; and finally the not insubstantial risk of triggering earthquakes in some areas.

The costs to United States national security are very small or nonexistent. The warhead stockpile is enormous, the technology is highly sophisticated. It is extremely unlikely that any pressing need to test substantially new warhead technology could be warranted in the foreseeable future, and a working agreement might well preclude that need indefinitely. Furthermore, such treaties can be written with an escape clause, as was the 1963 Limited Test Ban Treaty, whereby pressing dangers to the "supreme national interest" can allow for the abrogation of the treaty.

Beyond arguments over the merits of a comprehensive test ban, it is also important to realize that a more propitious time for agreement upon such a treaty may not easily be found again.

The strategic parity between the United States and the Soviet Union may well make the Soviets more likely to agree to such a treaty, than they have been on such matters in the past.

We would therefore strongly urge the Administration to initiate active efforts to reach agreement on a comprehensive Test Ban Treaty, as an important and logical part of its foreign and national security policy.

LETTERS AND ARTICLES SUBMITTED BY SENATOR EDWARD M. KENNEDY REGARDING
SENATE RESOLUTION 67

THE ARMS CONTROL ASSOCIATION,
Washington, D.C. April 27, 1973.

HON. EDWARD M. KENNEDY,
*U.S. Senate,
Washington, D.C.*

DEAR SENATOR KENNEDY: I am grateful for your kind invitation to comment on Senate Resolution 67, calling for a Comprehensive Test Ban Treaty, combined with an immediate suspension of all United States underground testing for so long as the Soviet Union similarly abstains.

I enthusiastically and unreservedly endorse the Resolution. As Director of the Arms Control and Disarmament Agency from 1961 to 1969, as Chairman of the Arms Control Association for the past two years, and as a citizen who has long been concerned about the needless, costly, and dangerous continuation of the nuclear weapons race, I have always viewed the achievement of a Comprehensive Test Ban Treaty as an arms control measure of the first priority. I believe that an immediate end to nuclear testing by the United States and the Soviet Union, even if others do not at once follow suit, is very much in our security interest, and that continued testing is an unwarranted inhibition to progress in SALT and to the durability of the Non-Proliferation Treaty. It provides continued and embarrassing evidence of a lack of commitment to the solemn treaty undertaking we made, both in the 1963 Limited Test Ban Treaty and in the Non-Proliferation Treaty, to continue to work for an agreement banning all nuclear testing. Although adequate verification of a CTB once required on-site inspection, nuclear test detection and identification technology is now such that we can enter safely into a test ban agreement using existing national means of verification without on-site inspection. The SALT I agreement contains important precedents in this regard. Finally, I applaud the intent of the Resolution to facilitate the conclusion of an early agreement by the immediate suspension of nuclear testing in advance of a formal agreement for so long as the Soviet Union does likewise.

In the remarks that follow I will elaborate on some of the foregoing observations, although it is with a sense that much of what will follow has been said many times before, by myself, by others who have labored in the arms control field with me over the years, and by the many dedicated lawmakers like yourself who have worked to make the world a little safer.

In my view the Resolution provides sound basis for the speedy completion of some long unfinished business.

I commend you and the co-sponsors of this Resolution for your initiative.

Sincerely,

WILLIAM C. FOSTER,
Chairman.

INTERNATIONAL UNION, UNITED AUTOMOBILE, AEROSPACE &
AGRICULTURAL WORKERS OF AMERICA—UAW,
Washington, D.C., April 23, 1973.

HON. EDWARD M. KENNEDY,
*U.S. Senate, Russell Senate Office Building,
Washington, D.C.*

DEAR SENATOR KENNEDY: The UAW strongly endorses the Senate Comprehensive Nuclear Test Ban Resolution and urges all Senators to support it.

The resolution requests the President to propose "an immediate suspension on underground nuclear testing, to remain in effect so long as the Soviet Union

abstains from underground testing," and calls upon him to "set forth promptly a new proposal to the government of the USSR and other nations for a permanent treaty to ban all nuclear tests."

The UAW has long advocated a complete, rather than a partial nuclear test ban. In the words of our 1970 Constitutional Convention Resolution on Peace and Disarmament:

"No less important to the development of a peaceful world is the attainment of a comprehensive test ban treaty between the United States and the Soviet Union. Underground nuclear testing, while resulting in no significant nuclear fallout, does contribute to the further refinement of MIRV and ABM capabilities, and thus adds an extra spurt to the race for first-strike superiority. Only a successful conclusion to SALT can, in our judgment, avoid this race for first-strike superiority."

Much has happened since this resolution was passed to confirm our then-high hopes for peace. A decisive Senate vote in favor of a comprehensive test ban, will, we believe, continue the already strong forward movement towards a stable and lasting peace in the world.

Sincerely,

LEONARD WOODCOCK,
President, International Union, UAW.

U.S. SENATE,
Washington, D.C., April 30, 1973.

HON. EDMUND S. MUSKIE,
*Chairman, Subcommittee on Arms Control, International Law and Organization,
Senate Committee on Foreign Relations, Washington, D.C.*

DEAR MR. CHAIRMAN: Although I did not wish to burden the Subcommittee by coming before you a second time in support of our comprehensive nuclear test ban resolution, I hope a word for the record will be in order.

Developments since 1963, when the United States first committed itself to "achieve the discontinuance of all test explosions of nuclear weapons for all time," make it more logical than ever that we pursue such an objective. Technology has vastly improved our means of detection and verification; the SALT accords of 1972 have placed quantitative limitations on offensive and defensive strategic weapons; the time is ripe for a next step which would bring to a halt a major phase of the qualitative aspect of the nuclear arms race.

A favorable Senate vote on this Resolution would continue the momentum in the arms control field. I earnestly request early Committee consideration.

Thank you very much.

Sincerely,

PHILIP A. HART.

UNIVERSITY OF CALIFORNIA,
La Jolla, Calif., March 15, 1973.

Senator EDWARD M. KENNEDY,
*U.S. Senate,
Washington, D.C.*

DEAR SENATOR KENNEDY: I have read the resolution which you introduced and the arguments which you put forward. Needless to say, I am very much in favor of all efforts to stop this crazy competition between two great countries who have no reason to undertake any kind of war, especially involving atomic weapons. Surely the leaders of two countries should understand that any attempt to initiate an atomic war would be disastrous in the extreme. I have been fearing that some accident will occur and a weapon of some kind will land in our country or in the U.S.S.R., triggering off an enormous exchange of atomic weapons. All efforts that can be made to come to an understanding with the Soviet Union in regard to this matter are of great importance, and I must say that I greatly admire your efforts in attempting to accomplish this.

I wish I could get over the feeling that the Russians are exceedingly tricky, and I greatly deplore their lack of publicity in regard to what they are doing. I do hope that the United States does not play a similar game, but, at the same

time, I hope our negotiators are careful in view of the secretive character of our opponent. Possibly we give them the same impression. I would hope not.

Many thanks for your letter, and I would be glad to have you keep me informed of all moves of this kind.

With best regards,

Sincerely,

HAROLD C. UREY.

UNIVERSITY OF CALIFORNIA,
Berkeley, Calif., May 8, 1973.

Senator EDWARD M. KENNEDY,
U.S. Senate,
Washington.

DEAR SENATOR KENNEDY: Thank you for sending me your May 1 statement supporting a comprehensive Test Ban Treaty (CTB).

I thoroughly approve and applaud your statement.

Sincerely,

OWEN CHAMBERLAIN,
Professor of Physics.

P.S. Any help I give would probably be channeled through the Federation of American Scientists (Washington office).

MASSACHUSETTS INSTITUTE OF TECHNOLOGY,
LABORATORY FOR NUCLEAR SCIENCE,
Cambridge, Mass., March 9, 1973.

Senator EDWARD M. KENNEDY,
Senate Office Building,
Washington D.C.

DEAR SENATOR KENNEDY: I was very pleased to hear of the introduction, by you and some 30 of your colleagues, of the resolution calling on the President to propose to the Soviet Union an immediate suspension of underground nuclear testing, to remain in effect as long as the Soviet Union abstains from testing.

I believe this is one of the most important measures of arms control on the international agenda. Not only will the cessation of underground testing place an effective inhibition on the race for qualitative improvements in nuclear armaments, thereby enhancing the prospects for fruitful results in the next stage of SALT, but it is perhaps the most useful immediate step that we and the Russians can take to promote adherence to the Non-Proliferation Treaty by the technologically advanced nations that have still not ratified it.

I sincerely commend your initiative in this matter. With best wishes,

Sincerely yours,

BERNARD T. FELD,
Professor of Physics.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY,
Cambridge, Mass., March 19, 1973.

Hon. EDWARD M. KENNEDY,
U.S. Senate,
Washington, D.C.

DEAR SENATOR KENNEDY: Thank you for sending me a copy of your recent (February 20) statement on a comprehensive nuclear test ban treaty, and for soliciting my comments and endorsement.

I concur wholeheartedly with your arguments and am most pleased to endorse the effort.

I wish you well with it.

Sincerely yours,

G. W. RATHJENS.

THE JOHNS HOPKINS UNIVERSITY SCHOOL OF MEDICINE,
THE JOHNS HOPKINS HOSPITAL,
Baltimore, Md., March 12, 1973.

Senator EDWARD M. KENNEDY,
U.S. Senate,
Washington, D.C.

DEAR SENATOR KENNEDY: Thank you for sending me your resolution urging a comprehensive test ban treaty. As long as unrestricted research and development of nuclear weapons continue, the danger of a holocaust does not diminish and international tensions will remain high. A comprehensive test ban seems the only feasible way at the moment for beginning to achieve some stability and, thereby, taking the first significant step toward removing the growing threat to human survival posed by the nuclear arms race. Therefore, I strongly support the resolution.

Sincerely,

JEROME D. FRANK, M.D.,
Professor of Psychiatry.

THE LEAGUE OF WOMEN VOTERS OF THE UNITED STATES,
Washington, D.C., March 14, 1973.

HON. J. WILLIAM FULBRIGHT,
Chairman, Senate Committee on Foreign Relations,
U.S. Senate,
Washington, D.C.

DEAR SENATOR FULBRIGHT: Over the years the League of Women Voters has backed various arms control measures under its position supporting international agreements aimed at reducing the risks of war. We have endorsed U.S. ratification of the Nuclear Nonproliferation Treaty, the Geneva Protocol on chemical-biological warfare and the treaty to ban nuclear weapons from the seabed.

Consistent with our past support we now wish to be recorded in favor of S. Res. 67, which proposes an immediate suspension on underground nuclear testing and prompt negotiation with the Soviet Union and other nations for a permanent treaty to ban all Nuclear tests.

League support of efforts to reduce the risk of war evolves from an historic League belief that nations must find means other than war to solve world problems. Changing political balances, emerging areas of mutual interest between the major powers, technical advances in the detection of nuclear blasts, and the development of new weapons systems encourage constant conferences on the various phases of disarmament and arms control. Any agreement reached, however, must include safeguards for U.S. national security and the domestic economy. It is generally held that disarmament is a step-by-step process and that any measure to reduce the risk of war is a step of value, not only in itself but also in creating an atmosphere of mutual confidence in which a disarmed world is possible.

We believe that extension of the partial Test Ban Treaty to include underground testing would be an essential step toward ending the nuclear arms race. It would encourage adherence to the nonproliferation treaty by many potential nuclear powers which are reluctant to forgo nuclear weapons development while testing by the nuclear super powers goes on. It would protect our environment from the venting of radioactive materials, contamination of underground waters and other dangers of nuclear testing.

The League of Women Voters supports U.S. initiatives to negotiate a comprehensive test ban treaty and supports these proposals as vital prerequisites to national security and world peace.

Sincerely,

Mrs. BRUCE B. BENSON,
President.

UNIVERSITY OF CALIFORNIA, SAN DIEGO,
La Jolla, Calif., March 5, 1973.

HON. EDWARD M. KENNEDY,
U.S. Senate,
Washington, D.C.

DEAR SENATOR KENNEDY: Thanks for your letter of February 27, which enclosed a copy of your February 20 statement on a Comprehensive Test Ban. I

am personally delighted by your actions in the matter and strongly endorse them.

Enclosed please find a copy of an article on the subject published in last November's *Scientific American*.

There are some other elements of the Qualitative Arms Race which deserve attention also. Some of these, especially those relating to ASW, have been discussed recently by Pete Scoville and by Kosta Tsipis (at MIT). Some others are discussed in a paper of mine to be published shortly in the *Bulletin of the Atomic Scientists*; I'll send a copy along as soon as it is available.

Sincerely,

HERBERT F. YORK.

[From the *Scientific American*, November 1972]

THE GREAT TEST-BAN DEBATE—THE TREND OF EVENTS IN WEAPONRY AND IN ARMS CONTROL TEND TO REFUTE ARGUMENTS PRESENTED A DECADE AGO AGAINST A LIMITED NUCLEAR-TEST BAN AND TO INDICATE THAT THE TIME MAY BE RIPE FOR A COMPREHENSIVE TEST BAN

(By Herbert F. York)

The modest but significant progress toward the control of nuclear weapons that has been made during the past nine years has brought to the fore the question that was raised in the first place: Is the time ripe for a treaty prohibiting all tests of nuclear weapons? Indeed, both the limited-test-ban treaty of 1963 and the nonproliferation treaty of 1968 contain clauses obligating the signatories to seek to achieve a treaty establishing a comprehensive ban. The issue is therefore being debated again, as it was when Jerome B. Wiesner and I discussed the subject in these pages in October, 1964. This time, however, it is possible to employ hindsight to sharpen foresight, because most of the arguments being made against a comprehensive test ban now are essentially the same as the ones that were put forward in the long debate preceding the adoption of the limited test ban. An examination of how those arguments look in the light of experience will help to supply a basis for estimating how much weight they should be given in the present debate.

The questions involved are of two general types. One type has to do with the means for monitoring a test ban to ensure that the signatories are complying with the treaty. That subject was recently reviewed in these pages [see "Extending the Nuclear-Test Ban," by Henry R. Myers; *SCIENTIFIC AMERICAN*, January]. The other type has to do with the potential effects of a test ban on the national security of the parties to a treaty or any other agreement. I shall limit my discussion to questions of this type.

In the debates of a decade and more ago (from 1957 to 1963, to be more precise) the national-security matters most frequently raised by people who opposed or seriously questioned the test ban came under the following general headings: anti-ballistic-missile (ABM) systems, weapons effects, pure fusion bombs, improvement of the yield-to-weight ratio of nuclear weapons and new knowledge, possibly involving military surprises. Let us review the arguments and the subsequent developments under each heading.

In the early 1960's claims were made by Russian officials that the U.S.S.R. had solved the problem of intercepting and destroying incoming ballistic missiles. Not long afterward U.S. intelligence activity discovered that the Russians were indeed beginning to deploy an ABM system. Moreover, the extensive series of nuclear tests conducted by the Russians during 1961 and 1962 had included explosions at altitudes that would be of interest to designers of an ABM system. The U.S. had also conducted a number of high-altitude tests, leading certain scientists and military officials to assert that this country had enough knowledge to design an ABM system. Secretary of Defense Robert S. McNamara and other high officials did not agree, however, and so no ABM-system deployment was then authorized in this country.

Opponents of a test ban contended that the reason for the difference between the Russian decision to deploy and the U.S. decision not to deploy must be that the Russians knew something we did not know. They suggested that this something had been discovered during the Russian test series. Some opponents went on to speculate that the reason the Russians were now willing to consider a test ban was that they had learned some essential secret and saw the test ban as a way of preventing the U.S. from learning it.

For example, the physicist Edward Teller said: "I think there is a disparity in knowledge, and the disparity of knowledge today means a disparity of power tomorrow. . . . I believe that, because they have acquired this knowledge, they don't need any more atmospheric tests, and I believe that is why Khrushchev is willing to sign the treaty at present." Senator Strom Thurmond said: "All it will take to put the Soviets in a dominant nuclear position is two things: one, enough time to build up a stockpile of the already perfected Red antimissile missile, which will render our huge arsenal of ICBM's [intercontinental ballistic missiles] useless, and second, ratification of the test-ban treaty that will prevent the United States from high-altitude tests necessary for completion of our own Nike X antimissile-missile program, thereby leaving America defenseless against Red missiles."

When pressed for details, the opponents of the test ban commonly referred to several matters on which, they said, insufficient information existed, at least in the U.S. One matter was the blackout phenomenon, in which a nuclear explosion at high altitude produces a large volume of ionized air that is for a time opaque to radar. There were also allusions to certain long-range "kill" mechanisms that would work against incoming warheads. Here it was argued that tests were needed in order to design defensive warheads that would produce such effects and offensive warheads that would survive the effects.

On the other side of the argument it was contended that the U.S.S.R. had not gained any special advantage due to some private knowledge about high-altitude effects. Harold Brown, who was then Director of Defense Research and Engineering, said: "I feel rather strongly that they [the Russians] are not substantially ahead of us." He added that it was not a defect in nuclear knowledge that had prevented the U.S. from deploying ABM systems but rather that "the U.S. decided not to deploy the Nike Zeus because its effectiveness was inadequate against U.S. penetration aids . . . and we assume the same would be true of the Soviet penetration-aid capability." The U.S. Joint Chiefs of Staff said that "development of the U.S. [ABM] system does not depend on atmospheric testing and hence this treaty will not significantly influence any imbalance that may exist."

What have subsequent events revealed about these claims and predictions? The Russian ABM program proceeded erratically from the base described in 1963. After several periods of delay that indicated indecision and uncertainty, the Moscow ABM system (now called the Galosh system) was reported early this year to have fewer than 100 ABM vehicles ready for launching. The system was generally judged to be quite inadequate for coping with an attack against it by U.S. missiles. Russian ABM installations that had at one time been reported around Leningrad and Tallinn either were dismantled or turned out to have a different purpose. Nothing that has happened since the test-ban debate has confirmed the notion that the U.S.S.R. knew something the U.S. did not know. Indeed, the Russian decision to deploy the Galosh system seems to have been due to a poor understanding of just how easy it is to penetrate systems of that type and size.

On the U.S. side the development of an ABM system continued through the 1960's at a level of about \$500 million per year. The system slowly evolved, as did the political situation both domestically and internationally. Finally, near the end of the Johnson Administration, a decision was made to deploy an ABM system called Sentinel around certain cities. The main reason given was that it would provide protection against a prospective Chinese missile force.

After considerable public reaction this decision was rescinded, and a deployment of the same equipment under a new name (Safeguard) was proposed by the Nixon Administration. The Senate accepted the proposal after a long debate about the effectiveness of the system and the problems being met in developing it. In the entire debate developments in nuclear weaponry were never cited as having a crucial role in the various decisions concerning deployment. The serious questions that were raised about the feasibility of the system all had to do with such matters as the computers, the radar and the problems posed by decoys and MIRV's (multiple independently targetable reentry vehicles). When nuclear problems such as blackout were mentioned, it was only peripherally and never as constituting a major problem.

None of this proves that nuclear-weapons development and weapons-effect research are entirely irrelevant to ABM development, but it does indicate that recent research and development in this field have been far from essential. Apparently any lack of perfection in weapons can be overcome in the design of other

parts of the system. Moreover, as the ABM program has shifted from Sentinel to Safeguard and now to the site-defense system (sometimes called Hardsite), the emphasis has shifted from interception at great distances and high altitudes to interception near the target at relatively low altitudes, where the phenomena to be dealt with are much better known.

I turn now to weapons effects. During the years when nuclear weapons were tested aboveground, the basic effects—blast, radiation, fallout—that kill, injure and destroy were studied in great detail. These are the weapons effects that matter; the entire concept of deterrence, which all sides cite as the main reason for maintaining nuclear forces, is based wholly on the threat of unacceptable levels of death and destruction through these effects. For decades the phenomenology of these effects has been known with a precision that far exceeds the practical use of the information.

In addition to these basic phenomena one hears of a few other more exotic effects that are of technical interest in connection with certain duels between nuclear weapons. Uncertainties about such effects are sometimes raised as an issue in test-ban debates. Among the effects are "TREE" and "EMP."

TREE stands for transient radiation effects on electronics. It is an old problem that has become relatively more important as more complex devices have been introduced into nuclear-weapons systems. It is also mainly of interest in connection with duels in outer space, where there is nothing to attenuate radiation, which therefore would far outreach other effects such as blast.

EMP stands for electromagnetic pulse. It refers to the fact that a nuclear explosion produces a large electromagnetic field, which in turn can induce large electric currents in conductors at substantial distances. Such currents, if nothing is done about them, can sometimes produce destructive effects in insufficiently protected equipment.

Some of the people who work on nuclear weapons have envisioned an attack in which an enemy explodes a series of warheads high over U.S. missile fields, producing a series of TREE and EMP phenomena (or other long-range effects) timed in such a way that the U.S. could not launch its missiles while the barrage continued. (The tactic is known as "pin-down.")

It is impossible to believe that real political or military leaders would consider such an effort in the face of the variety and dispersion of retaliatory weapons that could be employed. Even so, the claim that further research was needed on this matter was advanced in the early 1960's as an argument against the test ban. (At the time the argument was largely conducted behind the curtain of secrecy that surrounds much military activity; public discussion of the issue became possible only later.)

All the more exotic effects were observed before the partial test ban went into effect. They were not as thoroughly studied as the basic effects, however, and in addition certain new forms of interaction between these phenomena and specific weapons systems have been found since 1963. At first it was thought that it would be difficult to learn more about the exotic effects in underground explosions, and that possibility was raised as an argument against the partial test ban. Later it turned out that a good deal can be learned about the effects from underground testing and by other means. In 1968 Vice-Admiral Lloyd M. Mustin, director of the Defense Atomic Support Agency, reported to Congress: "We think we have the interaction of threats with these two systems [Minuteman and Polaris] well understood and identified and very carefully developed and sophisticated countermeasures far advanced."

In sum, no really new phenomena produced by the explosion of nuclear weapons has been discovered in about 15 years, and there is no good reason to expect that any will be forthcoming. In those years the U.S. has refined its knowledge of the effects of specific systems and in specific environmental situations. Even at that level of detail we have long since passed the point of diminishing returns. The remaining uncertainties are small compared with the other uncertainties about any nuclear attack: the kind, number, yield and accuracy of the weapons; the targets selected; the timing, the relation to other attacks or to political moves, and so on. These are the uncertainties that will dominate the thinking of any statesman who may one day be considering the use of nuclear weapons. No doubt there is more to be learned about weapons effects, but the matter is largely of interest to specialists, and concern about it should have no bearing on important political questions such as whether or not to ban further nuclear tests.

Pure-fusion bombs and bombs with a high ratio of fusion to fission (also called neutron bombs) were seen in the late 1950's as offering a number of advantages, and the need to develop them was therefore raised as an argument against a test ban. Teller, for example, was reported to have said to a Republican committee on nuclear testing in 1963: "We have started the development of clean and cheap nuclear explosives. We need more tests to complete this development. Clean and cheap nuclear explosives are needed for battlefield use, for peaceful applications and for missile defense." John A. Wheeler of Princeton University was reported as telling the same group: "As a physicist and specialist on nuclear fission I see a decisive loss to national security from a test ban. It will prevent us from developing a technology of pure hydrogen devices free of fission fallout. . . . The new technology will have important peacetime applications in mining and earth-moving and will revolutionize ground warfare. . . . It is unconscionable to renounce for the free world a revolutionary device which others will then make without our knowledge."

On the other side, William C. Foster, director of the U.S. Arms Control and Disarmament Agency, said that the expert advice he had received was that pure-fusion weapons would not be of great advantage. The reason, he said, was that "they would constitute primarily a cheaper substitute for the explosive components in our already large stockpile of nuclear weapons."

How did matters turn out? The pure-fusion bomb remains undeveloped, and responsible people no longer talk much about it as being the basis of a new revolution in weaponry. When officials of the Department of Defense and the Atomic Energy Commission present arguments for continued testing now, they do not rate the need for fission-free bombs any higher than the need for other and more orthodox modifications and improvements.

A pure-fusion explosion may yet be achieved as a result of all the effort that has been expended. It would be a technological accomplishment, but the likelihood that it would have any large military or political value seems small. The basic fact is that the nuclear capability of the major nuclear powers is already supersaturated in the sense that it can produce more varieties of death, destruction and horror than anyone can seriously contemplate seeking to inflict.

It was also stated during the debate preceding the test ban of 1963 that further improvement in the yield-to-weight ratio of nuclear weapons was in prospect and that certain other improvements and modifications were both possible and necessary. Among them were decreased vulnerability to nearby nuclear explosions and increased safety of weapons. Substantial progress has indeed been made along these lines since 1963. The important question, however, is: How important and how relevant has the progress been?

The Poseidon missile provides a basis for discussion. It is more advanced than its predecessor, the Polaris A-3, in many ways. It is bigger, it can carry a larger payload a longer distance and it has improved accuracy. Moreover, its payload is of the MIRV type: each missile launches a "bus," which has on board a large number of reentry missiles, each of which can be accurately and independently targeted. None of these advances depended on nuclear tests.

M. Carl Walske, Jr., assistant to the Secretary of Defense for Atomic Energy, recently stated that the warhead for the Poseidon MIRV was developed after the limited test ban went into effect, and he argued that if the ban had been comprehensive, nothing like the present Poseidon MIRV could have been developed. I believe his statement is highly misleading. If a pre-1963 warhead such as the one for the Polaris A-3 had been adapted for the Poseidon, the Poseidon MIRV would have had either lower multiplicity (fewer independent missiles) or a shorter range, but it could have had a higher total yield.

Presumably the new Poseidon warhead has been further modified so as to reduce its vulnerability to attempts to intercept it. These modifications apparently resulted in a reduction of the yield-to-weight ratio. In any case such modifications were superfluous, since the basic multiple-warhead feature is in itself the most effective means for penetrating anti-ballistic-missile defenses of the kind that now exist. It does so simply by overwhelming the defense with larger numbers. The only requirement is that the individual warheads be hardened enough and separated enough so that one interceptor must be launched for each reentry vehicle. An A-3 warhead on a MIRV bus of the Poseidon type would easily satisfy this requirement.

Defense penetrability beyond what could be achieved in 1963 is needed only against an ABM defense consisting of very large numbers of relatively sophis-

cated interceptors. No such defense now exists—nor, I believe, is there any serious prospect of one in the foreseeable future. To say^o the least, deployment of the post-1963 Poseidon warhead is premature.

It is small wonder that the concern over surprises and new knowledge persists. One need only recall the early years of nuclear development to realize that surprises and new knowledge abounded at that time. The phenomenon of nuclear fission was discovered in 1938. The first nuclear-test device was exploded only seven years later, which was also the first (and so far the only) time that nuclear bombs were employed in warfare. In terms of energy output those bombs were 1,000 times larger than the biggest chemical bombs.

Seven years later the first thermonuclear device was exploded. It was 1,000 times as large in output of energy as the first atomic bombs. Both of these huge technological steps can be characterized as breakthroughs, and they had major political and military consequences. No such huge gains in yield were made thereafter, but during the next seven years fundamentally important factors such as yield-to-weight ratio continued to improve radically. By 1960 the yield-to-weight ratio of fission bombs was two orders of magnitude (100 times) larger than it had been at the beginning. Means also had been found for both reducing the size and increasing the yield-to-weight ratio of thermonuclear weapons, again by order-of-magnitude amounts.

As a result of such developments many people came to believe politically significant technological breakthroughs had become the norm for nuclear technology. One thus finds many leaders in the field emphasizing the likelihood and importance of further technological surprises and arguing that no bars should be raised against obtaining new knowledge. In 1963, questioning the limited-test-ban treaty, John S. Foster, Jr., then director of the Lawrence Radiation Laboratory (he is now director of defense research and engineering in the Department of Defense), said: "We are involved in a field of technology that is not fully understood, nor its applications, and hence new experiments frequently bring surprises." Teller said a ban would "prohibit future science" and was "directed against knowledge." In 1961 Representative Chet Holifield, then chairman of the Joint Committee on Atomic Energy, expressed concern about "the ultimate general effect on weapons technology of a continuing test ban," which would "inevitably stifle developments undreamed of at the present time." He added: "Concepts are now being considered by our scientists which could be as revolutionary as the H-bomb [was] in 1949." General Curtis E. LeMay, as Chief of Staff of the U.S. Air Force in 1963, said: "We are just at the beginning of our investigations into the nuclear-weapons field."

On the other side, proponents of a test ban expressed doubt about the importance of specific potential breakthroughs and saw as unlikely the possibility that any such development would upset the balance of power. William Foster of the disarmament agency, supporting the limited test ban, suggested that nuclear science was maturing. "The point of diminishing returns in improving weight-yield ratios is fast approaching," he said.

At the time of the debate on the partial test ban the issue of surprises and new knowledge was still difficult to resolve. On the one hand there was the record of a remarkable series of discoveries, technological advances and politically significant applications. On the other hand no further breakthroughs were then in sight, with the possible exception of the pure-fusion bomb, and of that many experts said it would be technologically novel but without great political or military significance.

Now, however, it seems to me that this issue has been resolved. Nuclear weapons have been further refined, and there is greater understanding of the details of certain effects, but no new knowledge or surprises remotely similar in kind or importance to those of the first two nuclear decades have been reported or claimed. Moreover, the nuclear arsenal is so large and varied that the significance of new inventions is small in any case. Compared with the danger of further proliferation of nuclear weapons, the danger that the U.S. will be overwhelmed by an unsuspected breakthrough seems vanishingly small.

Let us turn now to the arguments that were made in 1963 and earlier in support of the limited test ban. Five principal points were made and can be set forth here in quotation of participants: (1) "A nuclear test ban treaty would constitute a significant step in the direction of slackening the arms race" (Dean Rusk). (2) It would preserve for a "longer period our present nuclear advantage" (William Foster). (3) "The treaty will curb the pollution of the atmos-

where" (President Kennedy). (4) It would create a political climate in which "new opportunities for further steps toward turning the arms race downward might well be more within the realm of possibility than at present" (Rusk). (5) "A nuclear test ban would constitute a significant first step in achieving control over the further spread of nuclear weapons" (Foster).

Each of the statements also amounted to a prediction. Let us see how the predictions stand up in 1972. The limited test ban probably did slow down the arms race between the U.S. and the U.S.S.R., but it cannot be considered to have been outstandingly successful in this respect. It probably has severely limited the further development of very large thermonuclear weapons, but the rate of nuclear testing has continued at about the same level—although the tests are now underground.

Similarly, the treaty does not appear to have done much to preserve the "nuclear advantage" of the U.S. Since the treaty was signed, the U.S.S.R. has achieved rough parity with the U.S. in strategic weapons. In any event, the degree of "overkill" in the nuclear capability of both countries is such that further technological advances would make little political or military difference.

The treaty has been quite effective in curbing radioactive pollution of the atmosphere. Although France and China have continued to conduct nuclear tests in the atmosphere, the tests are far less frequent than was the case when the U.S. and the U.S.S.R. were conducting them. Moreover, without the treaty there would be no hope of persuading those nations and other potential nuclear powers to accept similar restraints. Meanwhile, in the absence of a comprehensive test ban such hazards as underground contamination, earthquakes and leakage of radioactive substances into the atmosphere remain possible.

The record of the treaty in creating an environment that made further moves toward arms control possible is excellent. The treaty has been followed by agreements to prohibit nuclear weapons in space (1967), make Latin America a non-nuclear zone (1967), bar further proliferation of nuclear weapons (1968), rule out the seabed for the emplacement of nuclear weapons (1971) and prohibit the use of biological weapons (1972). One might also cite the "hot line" agreements of 1963 and 1971 and the recent strategic-arms-limitation talks (SALT) that resulted in agreement by the U.S. and the U.S.S.R. to put ceilings on their offensive and defensive missiles.

One should also recognize, however, that many of the treaties are peripheral to the main problem and in effect prohibit actions that no nation particularly wanted to undertake anyway. The British disarmament expert Philip J. Noel-Baker, reviewing the results of the 1959 treaty that demilitarized Antarctica, commented that "while disarming Antarctica, we put 7,000 nuclear weapons in Europe; we should have disarmed Europe and put those weapons in Antarctica." Nonetheless, all the agreements are steps in the right direction, and collectively they add up to something significant. Moreover, they help to make arms-control and disarmament measures seem more feasible.

Probably the most important result of the limited test ban has been its contribution to inhibiting the further proliferation of nuclear weapons. Since the treaty was signed, only China has begun testing weapons, and the Chinese program to develop nuclear weapons had been set in motion long before 1963. The cause was greatly aided by the nonproliferation treaty, which now has some 70 signatories in addition to the original adherents (the U.S., the United Kingdom and the U.S.S.R.). It also seems evident that the treaty has deterred nonsigners from testing.

Indeed, the most important reason for moving now toward a comprehensive ban on testing nuclear weapons is that it would strengthen and reinforce the non-proliferation treaty. The present situation contains elements of hypocrisy and unfairness, since the two major nuclear powers are trying to persuade other nations that nuclear weapons are unnecessary while at the same time both are conducting test programs.

To sum up, a decade of hindsight on the debates preceding the limited-test-ban treaty of 1963 suggests the following main conclusions:

1. The predictions of major surprises and ominous developments were wrong. There has been no "third revolution" in nuclear weapons. The atmospheric tests before 1963 and the underground tests since then have not produced a solution to the problem of developing an ABM system that would be likely to have more than limited success.

2. On the other hand, the passage of time has confirmed the more moderate claims that there was substantial progress to be made in improving the yield-

to-weight ratio, hardening weapons against interception, making better fits to new delivery systems and so on. The questions to be asked, however, are how progress in these areas has affected the nuclear balance and whether such technical progress is politically significant. The answers seem to be that, if anything, continued testing has further degraded whatever nuclear advantage the U.S. still had in 1963 and that the political significance of nuclear weapons is derived from the huge numbers of such weapons rather than from their technical sophistication.

3. The limited test ban has not done much to slow the main arms race between the two superpowers. The reason is the limited nature of the agreement. A comprehensive ban in 1963 probably would have done much more.

4. On the other hand, the limited ban has accomplished several of the most important objectives that were set for it. In ascending order of importance they are cleaner air, the establishment of a political climate conducive to much additional progress in arms control and disarmament and the distinct slowing of the spread of nuclear weapons.

On balance, therefore, the limited test ban can be described as a success. Clearly, however, it needs to be extended to prohibit underground testing. A comprehensive treaty may now be within grasp; we must reach for it while we can.

CORNELL UNIVERSITY,
PROGRAM ON SCIENCE, TECHNOLOGY AND SOCIETY,
Ithaca, N.Y., March 2, 1973.

Senator EDWARD M. KENNEDY,
Senate Office Building,
Washington, D.C.

DEAR SENATOR KENNEDY: I strongly support your February 20 resolution which calls on President Nixon to propose to the U.S.S.R. an immediate suspension of underground testing and which urges the President to present a new proposal for the conclusion of a comprehensive Nuclear Test Ban Treaty. The securing of a comprehensive test ban treaty would be a strong additional step in curbing the arms race. It would establish the U.S. and the U.S.S.R. as leaders in an attempt to slow down the development of nuclear weapons. It would aid in wide acceptance of the nuclear non-proliferation treaty. Finally, and not trivially, it would save a good deal of money.

My personal judgment is that there is considerable sentiment within the U.S.S.R. for a test ban treaty so that a positive U.S. initiative would have a real chance of bringing forth a positive response from the U.S.S.R. I deeply hope your resolution receives favorable Senate response and stimulates the President into action.

Sincerely yours,

F. A. LONG.

SANE,
A CITIZENS' ORGANIZATION FOR A SANE WORLD,
Washington, D.C., March 29, 1973.

Senator EDWARD M. KENNEDY,
Old Senate Office Building,
Washington, D.C.
(Attention of Mark Schneider).

DEAR SENATOR KENNEDY: I am writing to express the full support of SANE for S. Res. 67. As you well know, our organization was established in 1957 to seek a complete end to nuclear testing in all environments. The Limited Test Ban of 1963 was a long step in the right direction, but the goal was not fully achieved. As a concession to the weapons developers (perhaps in both countries), underground tests were excluded from that treaty.

It is long past time to consummate a comprehensive nuclear test ban. As of mid-1972, the United States had deployed 5,900 strategic nuclear warheads, the Soviet Union, 2,200 ("Peace, National Security, and the SALT Agreements," Bureau of Public Affairs, U.S. Department of State, August 1, 1972).

Since each of these warheads can destroy a city, we now have the power to destroy the 219 major Soviet cities 13 times over, if only half the warheads reach their targets in case of war.

Moreover, the same State Department document informs us that, by 1977, the United States will have 9,800 strategic nuclear weapons and the Soviet Union will

have almost 4,000—under the terms of the SALT Agreement! By then we will be able to destroy the major Soviet cities 22 times over, if only half the warheads reach their target.

From any point of view, this is insanity.

We look forward to working with you on behalf of S. Res. 67.

Sincerely,

SANFORD GOTTLIEB,
Executive Director.

[News Release]

BUREAU OF PUBLIC AFFAIRS,
DEPARTMENT OF STATE,
OFFICE OF MEDIA SERVICE,
August 1, 1972.

PEACE, NATIONAL SECURITY, AND THE SALT AGREEMENTS

Since World War II, the United States and the Soviet Union combined have produced nearly \$20 trillion in gross national product—approximately \$15 trillion in the United States and more than \$4 trillion in the Soviet Union. Of this amount, more than \$2 trillion has been spent on defense (approximately \$1.3 trillion by the United States, and an estimated \$1 trillion by the Soviet Union).

If the two societies continue to grow as projected to the end of the century, and if both continue to spend the same proportion of GNP on defense, the two countries together, by the year 2,000 A.D., could spend another \$5 trillion or more to maintain national security.

In both countries there are other pressing needs for capital, and both countries have long recognized a mutual advantage in first stabilizing the level of spending and ultimately moving to the stage where both countries can safely scale it down.

When President Nixon and General Secretary Brezhnev signed the SALT agreements in Moscow, May 26, 1972, the first stage was completed. Agreement was reached to limit ABMs to very low levels, including a commitment not to build a nationwide ABM defense or the base for such a defense. Both sides thus forego a defense against retaliation, and, in effect, have agreed to maintain mutual deterrence.

Agreement was also reached to stabilize the level of strategic offensive missiles for five years, giving both sides an opportunity to proceed to the second stage of negotiations in which further limitations and controls will be pursued.

The freeze on strategic offensive missiles leaves the Soviet Union with more missile launchers and the United States with more warheads and bombers. (See Missile Balance Sheet below.) A great many factors were balanced off on both sides, but the most important consideration—probably the factor that made the Interim Agreement feasible—is the recognition (given concrete form in the ABM Treaty) that with any conceivable or current or future deployment of nuclear weapons, neither side can expect to attack the other without receiving a retaliatory strike that would destroy the attacker as a modern nation-state. Out of this fact grows the assurance of national security for both sides. This, in turn, now makes it possible to negotiate additional mutual limitations—hopefully including reductions of forces on both sides.

However, if the United States were to make unilaterally a substantial reduction in strategic strength, the other side might lose incentive to continue at the bargaining table. Similarly, if either side were somehow able to make a substantial jump in its strategic forces, we can only anticipate that the other side would undertake to redress the balance.

President Nixon said in his Foreign Policy Report of February 1971 that any Soviet attempt to obtain a large advantage "would spark an arms race which would, in the end, prove pointless." The President added that "both sides would almost surely commit the necessary resources to maintain a balance."

The Interim Agreement limits for up to five years the numbers of intercontinental ballistic missiles (ICBM), and submarine-launched ballistic missiles (SLBM) for the Soviet Union and the United States. Some might argue that the Soviet Union gained an advantage because it is permitted larger total numbers of ICBM launchers, SLBM launchers, and modern ballistic missile submarines.

However, it is also argued that the United States gained an advantage because no current U.S. offensive arms program is limited whereas limitations are placed the three most active Soviet programs. Furthermore, although the Soviet Union will have more missile launchers, the United States has a considerable lead in numbers of warheads and intercontinental bombers, and in qualitative factors—including weapon dependability and general weapons sophistication—which are not limited by the agreements.

The central fact is that both sides find advantages in the limitations. We have reached levels where neither side can start a nuclear war without triggering its own destruction. There are simply too many launchers, too many warheads that would survive a surprise attack.

More importantly, both sides can benefit enormously from additional strategic arms limitations. An important process has, however, been started. Both the United States and the USSR are investing in this process, and we expect will want to preserve the investment and build upon it. It is not a question of "winning" or "losing". Both sides—and the world—gain from what has been achieved without compromising the basic security interests of any nation.

ECONOMICS

The long-range effect of the arms race on the economics of the United States and the Soviet Union is difficult to gauge precisely, but it is obviously enormous. The United States is currently spending about eight percent of GNP on defense—approximately \$80 billion in FY 1972. The Soviet Union is spending in the range of 11–14 percent of GNP—some \$45–60 billion in 1972, depending on the method of evaluating the cost. As noted above, if both countries were to continue to spend at these levels of GNP to the end of the century, the aggregate defense costs for the United States and the Soviet Union combined might total more than \$5 trillion.

Both countries find defense spending a substantial burden on the economy, but the effect probably is more serious in the Soviet Union, because the high level of defense spending is believed to reduce substantially the available growth capital badly needed for expansion of the Soviet economy.

Efforts to compare the Soviet defense burden with that of the United States are difficult because neither the costs nor the distribution of GNP in the two countries are comparable. What is clear is that given the economic resources of the Soviet Union and its relatively lower level of economic development, the arms race places a comparatively greater burden upon the Soviet economy than on the U.S. economy. Therefore, in economic terms the Soviet Union has even greater reason than the United States to develop meaningful weapons controls through negotiation.

The SALT agreements are an important step toward achievement of the kinds of controls that over time can substantially reduce expenditures on both sides, although the goal has not been reached in the initial stage. The agreements signed in Moscow do, however, provide the foundation for negotiations which will, hopefully, lead to important cuts in the level of defense spending on both sides.

Both the United States and the USSR could well continue to spend at approximately current levels while negotiating additional limitations, with the funds devoted chiefly to qualitative improvements. One of our goals will be to avoid this.

MISSILE BALANCE SHEET

ICBM launchers: Current strength: U.S. 1,054; USSR 1,618. The United States has no new ICBM construction program underway; the Soviet Union has been building new ICBMs. Without the agreement, if recent construction rates were continued for five years, the United States would still have 1,054 ICBMs and the Soviet Union, which has been building at a rate of up to 250 a year, could have more than 2,800 land-based ICBMs. Under SALT both sides are frozen at current levels.

SLBM launchers: The United States currently has 656 Polaris and Poseidon missile launchers; the Soviet Union has approximately 650–700 SLBM's. The United States has no missile submarines under construction; the Soviet Union has an on-going program of some eight new submarines a year. Without SALT, in five years the United States missile-launching submarines would not have in-

creased, while the Soviet total could have risen to 80 or 90. With SALT, the United States has the right to increase to up to 44 submarines. The Soviet Union may add modern ballistic missile submarines up to the number of 62 operational, but only provided that they retire 209 older land-based missiles and 30 older SLBM launchers. This would leave the USSR with no more than 950 modern SLBM launchers.

Total ICBMs and SLBMs consistent with the terms of the agreement: United States, 1,170; USSR, 2,419. Warheads: The difference in numbers of missiles is offset by the kinds of warheads they can carry. Currently, with the new MIRV warheads, the U.S. strategic missiles and heavy bombers carry 5,900 nuclear warheads; the Soviet missiles and heavy bombers carry an estimated 2,200 warheads. The Interim Agreement sets no limit on the number of warheads for either side, and both of these figures could rise substantially in five years. The implication of the warhead figures are enormous. They mean that currently, in the event of a surprise nuclear attack, if half of the U.S. strategic capability was wiped out, the United States could still strike more than 2,500 separate targets in the Soviet Union. This reinforces the recognition on both sides that there can be no winner in a nuclear war. The U.S. expects to continue to hold a substantial warhead lead during the Interim Agreement, sufficient to more than compensate for the numerical edge the Soviet Union has in missile launchers. The number of U.S. independently targetable warheads is planned nearly to double in the next five years, and will remain far ahead of the Soviet total.

Megatonnage: The agreement does not limit megatonnage as such. Both sides are free to make warheads as large or as small as they wish. On the average, Soviet Missile warheads are larger than U.S. warheads. It should be noted, however, that the radius of damage does not increase proportionate to the increase in yield. If the explosive power is doubled, the radius of damage increases by approximately one-third. Moreover, accuracy is more important than yield.

BUSINESS EXECUTIVES MOVE,
March 6, 1973.

Re Comprehensive Test Ban Resolution S.R. 67

Senator EDWARD M. KENNEDY,
Senate Office Building,
Washington, D.C.

DEAR SENATOR KENNEDY: On behalf of BEM I am writing in support of S.R. 67.

The greatest dangers of our country are from within rather than from without. Money should be spent for domestic priorities rather than for the building of increasingly sophisticated weapons. Otherwise the unrest in our own population may lead to suppression of freedoms and opportunities which are the best part of the American heritage.

It is futile and wasteful to develop weapons of more terrible destructive power when the weapons we have are so powerful that threats to use them, either expressed or implied, have lost much of their credibility.

BEM is not a pacifist group but we are opposed to the militarization of our society and to spending for weapons which tend to destabilize the international situation.

We hope you will be successful in getting the Senate to vote in favor of S.R. 67.

Sincerely,

HENRY E. NILES,
Chairman.

WORLD FEDERALISTS, USA,
Washington, D.C., March 12, 1973.

Senator EDWARD M. KENNEDY,
Old Senate Office Building,
Washington, D.C.

DEAR SENATOR KENNEDY: I am writing to commend you for introducing S. Res. 67, calling on the President to promote negotiations for a comprehensive test ban treaty.

Our organization would like to go on record as endorsing the philosophy embodied in this resolution and would like to be of every assistance possible in expediting its passage. Please let us know how and what we can do to help.

Sincerely,

LUTHER H. EVANS, *President*,
(Dictated by Dr. Evans but signed in his absence.)

SOCIETY FOR SOCIAL RESPONSIBILITY IN SCIENCE,
March 8, 1973.

HON. EDWARD M. KENNEDY,
U.S. Senate,
Washington, D.C.

DEAR SENATOR KENNEDY: We are heartily in favor of SR 67 and strongly support your effort to see that it is passed.

Sincerely,

J. MALVERN BENJAMIN, JR.,
Vice-President.

CHURCH OF THE BRETHREN,
Elgin, Ill., April 19, 1973.

HON. EDWARD M. KENNEDY,
U.S. Senate,
Washington, D.C.

DEAR SENATOR KENNEDY: Since the advent of atomic weapons the Church of the Brethren has spoken through its Annual Conference regarding its concern for the abandonment of the testing of nuclear weapons. We have recognized the inherent danger of these weapons, not only in their destructive potential, but realize that they also cause a threat to mankind because of their ability to contaminate this planet on which we live and the air which we breathe. Therefore, through the Annual Conference we have called "upon the Government of the United States to take the lead in permanent abandonment of such tests." My denomination throughout its history has counselled its members not to participate in the military and to renounce the way of violence perpetuated by the military way of life and an obsession for military solutions to seemingly every international conflict. Again and again the church has spoken through its Annual Conference regarding disarmament, nuclear testing, the terror of modern weapons and other related issues.

Therefore, we are encouraged that a Senate Resolution has been introduced calling for an immediate suspension of underground nuclear testing and urging the President to set forth a new proposal to the USSR and other nations for a permanent treaty to ban all nuclear tests. At this point we want to register our support for this resolution, wish you well in this effort, and request your suggestions and guidance as to how we can be of further assistance as this matter is dealt with in the two Houses of Congress.

Sincerely,

H. LAMAR GIBBLE,
Peace and International Affairs Consultant.

BOARD OF MISSIONS OF THE UNITED METHODIST CHURCH,
 WOMEN'S DIVISION,
Washington, D.C., April 3, 1973.

HON. EDWARD M. KENNEDY,
U.S. Senate,
Washington, D.C.

DEAR SENATOR KENNEDY: The Women's Division, Board of Global Ministries, United Methodist Church heartily endorses and strongly urges passage of S. Res. 67 in favor of a comprehensive test ban. Your speech and the following colloquy between you and Senator Humphrey as recorded in the Congressional Record of Feb. 20, 1973 outlined very well the need for a comprehensive test ban.

There are many values in a CTB: the significant slow down in the arms race, the psychological effect on other countries to stop the development of nuclear weapons, a hopefully diminishing danger of a nuclear holocaust. The problem of verification and the argument that potential new scientific advances would be inhibited by a testing ban have been effectively shown to be of little import.

It is very important that a comprehensive test ban be initiated. Passage of S. Res. 67 provides an impetus to this quest for peace.

Sincerely,

JOYCE HAMLIN,
Secretary for Legislative Affairs.

UNITED PRESBYTERIAN WASHINGTON OFFICE,
Washington, D.C., April 3, 1973.

HON. EDWARD M. KENNEDY,
U.S. Senate,
Washington, D.C.

DEAR SENATOR KENNEDY: The General Assembly of the United Presbyterian Church in 1971 urged "renewed and realistic efforts to negotiate a comprehensive nuclear weapons test ban, and further urges that consideration also be given to the cessation of peaceful nuclear explosions as well; unless it can be shown to a responsible international group that their benefits clearly outweigh their potential ecological risks and that opportunities for further weapons testing under the guise of peaceful explosions can be foreclosed."

We therefore believe your Senate Resolution 67 calling on the President to declare a moratorium on underground nuclear testing and to negotiate with the U.S.S.R. a treaty to stop underground testing, to be an important step toward the achievement of the comprehensive test ban which our General Assembly supports.

We commend you for the introduction of this Resolution and endorse it wholeheartedly with the hope that the Senate and House will speedily approve it.

Warmest personal regards.

Sincerely,

JOSIAH BEEMAN,
Director.

THE NETWORK STAFF,
Washington, D.C., April 12, 1973.

Senator EDWARD KENNEDY,
Senate Office Building,
Washington, D.C.

DEAR SENATOR KENNEDY: It is in line with the goals of NETWORK, a national task force of religious women working for social justice, to endorse your call for a comprehensive ban on nuclear tests. We fully support Senate Resolution 67 and urge its passage and rapid implementation.

When we negotiated the partial test ban in 1963 there was good reason for hesitation in including underground tests in the ban since appropriate means to insure compliance were not available. That is not the case at present since the SALT accords of 1972 have established precedents for arms control verification procedures and the technology to implement these is fully adequate to the task.

The present international climate of cooperation is one that should be furthered in every possible way and a comprehensive test ban is an excellent step in that direction.

Moreover, both the U.S. and the U.S.S.R. have many domestic needs that would profit from the release of valuable resources now spent in the nuclear arms race. We can not afford to neglect them any longer in an irrational preoccupation with building newer and better weapons of destruction that are clearly unnecessary.

We, therefore, are in full accord 1. with the call for an immediate suspension on our part of underground nuclear testing to remain in effect as long as the Soviet Union abstains from underground testing and 2. prompt action to set forth new proposals to the U.S.S.R. and other nations for a permanent treaty to ban all nuclear tests.

Sincerely yours,

Sister MARGARET HOHMAN, S.C.N.,
Network Staff.

BOARD OF CHRISTIAN EDUCATION,
Richmond, Va., March 27, 1973.

HON. EDWARD M. KENNEDY,
U.S. Senate,
Washington, D.C.

DEAR SENATOR KENNEDY: I am writing to express support for Senate Resolution 67 calling on the President to promote negotiations for a comprehensive test ban treaty.

The 109th General Assembly of the Presbyterian Church in the United States, the highest judicatory of our denomination, adopted a resolution at its meeting in 1969 in which it expressed "appreciation of our government's ratification of

the nuclear non-proliferation treaty, urge(d) strong citizen support of the treaty, and call(ed) for the development of a more comprehensive nuclear ban."

Senate Resolution 67 is clearly consistent with this appeal of the church.

Sincerely yours,

GEORGE A. CHAUNCEY,
Director, Office of Church and Society.

JOINT WASHINGTON OFFICE FOR SOCIAL CONCERN,
Washington, D.C., March 29, 1973.

HON. EDWARD M. KENNEDY,
*Old Senate Office Building,
Washington, D.C.*

DEAR SENATOR KENNEDY: We are delighted that you are again this year co-sponsoring the Senate Resolution for a Comprehensive Nuclear Test Ban Treaty.

We hope that you will press for speedy action in the Senate on S. Res. 67 and clean up the unfinished business which began with the partial test ban treaty achieved by President Kennedy in the last year of his service in the White House.

We think a ban on underground testing is more necessary than ever in view of the Rio Blanco test to be undertaken soon in Colorado by the Atomic Energy Commission.

The organizations in this Office have had a long commitment to disarmament and the reduction of nuclear radiation hazards. I am enclosing a copy of our March newsletter in which you will note that one of our priorities this year is the comprehensive nuclear test ban.

Sincerely yours,

ROBERT E. JONES,
Executive Director.

UNITED CHURCH OF CHRIST,
COUNCIL FOR CHRISTIAN SOCIAL ACTION,
Washington, D.C., March 5, 1973.

HON. EDWARD M. KENNEDY,
*U.S. Senate, Senate Office Building,
Washington, D.C.*

DEAR SENATOR KENNEDY: We wish to offer our encouragement and support for a Senate Resolution that would ask President Nixon to propose an immediate suspension of underground nuclear testing.

We remember that when the ban for testing above the ground was finally approved in 1963, there was apprehension by our more cautious citizens on the possible dangers in this limitation. Experience has shown that their fears were not justified. The ceasing of atmospheric testing reduced the tremendous hazard for deadly pollution and also was an indication of goodwill and the possibility of agreement to limit arms. The 1963 treaty thus was a step leading toward the alleviation of tensions and the accords that are now being developed with countries previously regarded as our enemies.

Time has now passed to where another treaty completing the ban on nuclear testing will be another step in our progress for peace. Furthermore, the tremendous developments in our technology include great improvements in our ability to detect nuclear bomb tests. The fear in 1963 that underground tests would go undetected is not justified in 1973.

With the arguments against nuclear bans thus diminished and the desirability of further progress in international friendship enhanced, we believe it is timely for the Senate to pass this resolution.

Sincerely yours,

TILFORD E. DUDLEY,
Director, Washington Office.

McMURRY COLLEGE,
Abilene, Tex., March 12, 1973.

Mr. MARK SCHNEIDER,
U.S. Senate,
Washington, D.C.

(Attention of Senator Kennedy.)

DEAR MR. SCHNEIDER: On March 12, 1973, the Congress of the Student Association of McMurry College unanimously approved and endorsed the proposal for a Comprehensive Nuclear Test Ban.

If we may be of further assistance in this matter, please contact us.

Sincerely yours,

GARY P. PATTON, *President.*

NATIONAL WOMEN'S CONFERENCE OF THE AMERICAN ETHICAL UNION,
New York, N.Y., February 15, 1973.

Mr. MARK SCHNEIDER,
U.S. Senate,
Washington, D.C.

(Attention of Senator Edward M. Kennedy.)

DEAR MR. SCHNEIDER: The National Women's Conference of the American Ethical Union endorses the Comprehensive Nuclear Test Ban Resolution and supports the effort to secure support from the Soviet Union and other nations for a permanent treaty to ban all nuclear tests.

We are pleased that some of our Senators have co-sponsored such a Resolution and will do all we can to encourage support for it.

We feel that it's most important at this time to begin to reduce the amounts of money budgeted and used for military purposes and that it is important to protect our environment from the dangers of nuclear testing.

Sincerely yours,

ROSE L. WALKER,
(Mrs. Harold L.)
N.W.C. Rep. to U.N.

AMERICAN ETHICAL UNION,
New York, N.Y., February 15, 1973.

Mr. MARK SCHNEIDER,
(Attention of Senator Edward M. Kennedy).
U.S. Senate, Washington, D.C.

DEAR SIR: The American Ethical Union strongly endorses the Comprehensive Nuclear Test Ban Resolution and we urge that you use your efforts to secure strong support for this resolution.

We feel it is important that the United States follow through in its commitment in previous treaties (Partial Test Ban—'63 and Non-Proliferation—'68) to negotiate a comprehensive test ban treaty and that it propose to the Soviet Union that it too help secure a treaty to ban *all* nuclear tests.

Sincerely yours,

MAY H. WEIS.

CHRISTIAN CHURCH,
Indianapolis, Ind., March 5, 1973.

Senator EDWARD M. KENNEDY,
Senate Office Building,
Washington, D.C.

DEAR SENATOR KENNEDY: I have noted with interest that you have introduced Senate Resolution 67 in support of a comprehensive test ban treaty. It is indeed heartening to know that this major concern of all mankind is receiving such serious attention. The Christian Churches (Disciples of Christ) have over the years specifically supported a ban on nuclear testing. Resolutions passed by our Assembly in 1959 and 1971 and reaffirmed since then support this objective.

Therefore, it is my hope that you will be successful in bringing Senate Resolution 67 to a favorable vote in the Senate. If there is any way in which we can be of assistance to you, please let me know.

Cordially,

ROBERT A. FANGMEIER,
Director, International Affairs.

RELIGIOUS ACTION CENTER,
UNION OF AMERICAN HEBREW CONGREGATIONS,
Washington, D.C., March 8, 1973.

HON. EDWARD M. KENNEDY,
U.S. Senate,
Washington, D.C.

(Attention: Mr. Mark Schneider).

DEAR SENATOR KENNEDY: We strongly endorse and support the Comprehensive Nuclear Test Ban Resolution (S. Res. 67) which you are sponsoring in the Senate that would ask President Nixon to propose an immediate ban on nuclear testing and urging a new proposal to the Soviet Union and other nations for a permanent treaty to ban all nuclear tests.

For many years, acting out of moral, religious and social concern, the Union of American Hebrew Congregations, through policies adopted by its General Assemblies and its Board of Trustees, has sought to alleviate the danger to the health, peace and safety of the world that is directly related to the continued development of nuclear and thermonuclear weapons. You might be interested in a brief chronology of positions taken by the UAHC over the past fourteen years:

1959—Opposed resumption of atmospheric nuclear testing.

1961—Supported President Kennedy in his decision to resist resumption of atmospheric nuclear testing.

1963—Supported the Nuclear Test Ban treaty.

1965—Warned against continued proliferation of nuclear weapons.

1968—Supported strengthened Arms Control and Disarmament Agency and urged negotiations to end the proliferation of dangerous weapons.

1969—Opposed ABM, supported renunciation of germ warfare and nerve gases, and supported the objectives of the SALT negotiations.

So, we have a long history that supports the position that you are espousing in your proposed resolution. We ought to recall now that the fears expressed by those who hesitated to support the Test Ban Treaty in 1963 turned out to be groundless and the world achieved more safety than danger from that pact. Now, with reference to underground testing, it is clear that new technology of verification makes it as feasible and desirable, as it has long been necessary, that the end of nuclear testing finally become a reality.

Kindest personal regards.

Sincerely,

MARVIN BRAITERMAN.

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