

Mr. Cottrell

# F. A. S. NEWSLETTER

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## PROGRESS IN NUCLEAR TEST DETECTION

The Joint Committee on Atomic Energy held hearings during the week of March 4-8 on technical aspects of detection and identification of nuclear explosions and their relationship to the nuclear test ban. In general, the hearings revealed a considerable advance in detection technology since the last hearings in 1961.

Testimony was presented by various participants in the VELA Program. The most significant technical developments affecting the problem of detecting and identifying underground nuclear explosions appear to have been the following:

1. The number of earthquakes in the USSR which produce signals equivalent to an underground explosion of a given yield has been found to be smaller than previously expected by a factor of 2 or 3.

2. The ability to detect low-yield events from great distances, of the order of several thousand kilometers, has been improved. Distant stations can provide a capability for detecting events of magnitude 4.0 and perhaps even smaller, equivalent to about 2 or 3 kilotons. (There was some discussion during the hearings about the variation of signals produced by explosions in different media. However, by the end of the hearings there appeared to be a consensus that an explosion in any medium of several kilotons yield could be detected at large distances.)

3. Identification techniques have been improved so that it is possible from large distances to identify a substantial fraction of naturally-occurring events. This has been accomplished by using seismometers placed in deep wells or in many-element arrays, thereby reducing the noise level and making the first motion of the signal—the most useful signature of an earthquake—more easily discernible. Techniques for determining the depth of focus of the event have been improved so that many deep earthquakes can be identified. Other techniques involving analysis of the waveforms produced by earthquakes and explosions appear promising but have not yet been fully developed.

The primary change in detection techniques for high-altitude and outer space explosions has been an improvement in the ability to detect over-the-horizon explosions. Two new techniques, the VLF phase method and the earth current method, have contributed to this. The VLF phase method involves a comparison of the phase of a signal received from a distant station with that of a locally-general signal. Since waves in the VLF range (3-30 kc) are reflected by the ionosphere, abrupt changes in the ionosphere produced by nuclear explosions will cause a rapid change in the phase of the

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## THE TEST BAN

Since January, efforts towards a test ban agreement have made continuing headlines of reasons for optimism, pessimism, criticism, and support. Hopes were raised when the U. S. and Soviet Union began new talks (see January Newsletter), especially with the publication of Kennedy-Khrushchev letters in which the Soviet leader reversed his year-long refusal to consider outside inspection in any shape or form. The Kennedy Administration seemed to be making major efforts to seek final compromises on inspection and other issues, and ordered a temporary suspension of U. S. underground weapons tests. After two weeks, the Soviet Union requested suspension of the talks until the reopening of the Geneva Disarmament Conference on February 12; U. S. officials were reported to feel the talks had given no real progress and no real sign that the Soviet Union was seriously seeking solutions. Another pessimistic sign was the Soviet effort to charge the U. S. with "frustrating" agreement after having been offered major concessions to its insistence on "needless" inspections. The Geneva Conference opened on this note, plus sharp Soviet attacks on U. S. overseas bases, plans for weapons-sharing with NATO, and resumption of underground tests. After another two weeks, the U. S. and Soviet Co-Chairmen agreed that the Conference should move on to disarmament questions, temporarily turning test ban issues back to the three nuclear powers as a subcommittee. Meanwhile, the immediate result of the negotiations was to arouse intensive Congressional debate on the Administration's proposals and on the desirability of any test ban agreement.

## ISSUES IN NEGOTIATIONS

The main Soviet offer was to accept an annual quota of "two or three" on-site inspections to verify the nature of suspicious seismic events. While the U. S. had offered last fall to make some reduction of its original proposal of 18-20 inspections, it regarded a quota of three as insufficient insurance, in the light of present knowledge concerning detection and identification of seismic events. In the January talks, the U. S. proposed a quota of 8 to 10; later reports hinted even this figure might be whittled if other verification elements were "foolproof." (W. Post, 2/21.)

Khrushchev's other major proposal concerned verification via the "black box," a system for collecting seismic data which the Soviet Union has recently favored as a solution to the control and inspection impasse, while the U. S. has viewed it cautiously as a supplement to "national" detection systems plus inspections. The gist of this plan is to install in key areas of seismic activity unmanned stations with sealed recording equipment; the equipment and the collection of data would be under some system of international (or "other side") supervision. The Soviet Union suggested three stations in Soviet Asian areas of high seismic activity. During the January talks, the U. S. was reported to want at least 7 to 10 stations, including several in the heart of Western Russia. The U. S. has apparently now prepared detailed ideas for the equipment and supervision of such stations. It is not clear that the negotiations have dealt with details; at Geneva, the Soviet representative recently hinted at objections to "complicated" methods of supervision. (W. Post, 1/20, 2/28.)

It is apparent that these proposals involve other questions besides the prominent one of "the numbers." Although reports of the talks have not given much detail on other points, the U. S. is said to have some new proposals (e.g., "other side" personnel) and to be preparing a revised draft treaty.

## ISSUES IN CONGRESS

In response to the new hopes for at last achieving an agreement to end weapons tests, a group of Republican Congressmen initiated a special review of test and test ban

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### WIESNER TO SPEAK AT FAS APRIL MEETING

The FAS Council will meet on Monday and Tuesday evenings, April 22 and 23, at 7:30 P.M. in the Assembly Room at the Sheraton-Park Hotel, Washington.

Dr. Jerome B. Wiesner, Special Assistant to the President for Science and Technology and Director, Office of Science and Technology, will address a public, FAS-sponsored meeting on Sunday evening, April 21 at 8:30 p.m. in the Cotillion Room, Sheraton-Park Hotel, Washington, D. C. It is hoped that FAS members attending the Physical Society meetings will arrive in time for the lecture on Sunday.

## LETTERS ON THE TEST BAN

The first of the following letters, by Adrian S. Fisher, appeared in the March 4 issue of The Washington Post, in answer to an earlier letter by Sen. Thomas J. Dodd. Senator Dodd's reply to this letter, most of which is reprinted here, appeared in the March 7 issue.

### MR. FISHER'S LETTER

On March 1 your newspaper carried a letter from the senior Senator from Connecticut (Thomas J. Dodd) in which he gave reasons why he believed the present U. S. position in the nuclear test-ban negotiations was unsound. It is with great reluctance that I find myself having to express a disagreement with the Senator, a respected lawmaker and a distinguished public servant. But since it is the firm view of the national security advisers to the President that an effective test-ban treaty is in the national interest and that our position at the negotiations is eminently sound, a few comments should be made with respect to the U. S. position and the points raised in the Senator's letter, as well as in his recent speech in the Senate.

1. The Senator stated that the test-ban policy pursued by both the Eisenhower and Kennedy Administrations "has already cost us our nuclear superiority over the Soviets." The actual situation is quite different. The United States has not lost its nuclear superiority over the U.S.S.R. The trend with unlimited testing, however, in the absence of an agreement will be toward equality in the major nuclear forces between the United States and the U.S.S.R.

2. A test-ban agreement would inhibit nonnuclear powers from obtaining a nuclear weapons capability. The national interest of the United States is served more by a policy of inhibiting the proliferation of nuclear weapons than by a policy of being indifferent to the number of countries that may develop nuclear weapons of their own. A test-ban agreement would not in itself be sufficient to prevent the spread of independent national nuclear capability, but it would be a definite step in the right direction. This question of nonproliferation is one that must be included in any total appraisal of the importance of a test-ban agreement to the United States.

3. The Senator states that if the Soviets continue testing in secret under an agreement and we do not test, "they can confront us with a choice between surrender or annihilation." This is not correct. It is true that if the U.S.S.R. were able to test small devices clandestinely underground for an indefinite period, they could make significant advances in the general field of small nuclear weapons. However, every analysis conducted by the Executive branch in recent years has reached the conclusion that the strategic military balance between the U. S. and the U.S.S.R. could not be altered in any major way by such developments. Furthermore, the risks of detection of a series of such tests would not be ignored by the U.S.S.R. One test would hardly be significant to a nation bent on attempting to gain a military advantage by testing secretly. Such a nation would more likely want to conduct a series of tests, and a series runs a much greater probability of detection than a single test. The risk of undetected cheating would be present under any treaty. The type of treaty prepared by the United States would provide deterrence against Soviet attempts at undetected cheating so that while such a risk must be recognized, on balance the security of the United States would be better served by taking this risk than taking the risk of continued unlimited testing with no agreement.

4. It is contended that the U. S. provisions for inspection and detection are only one-tenth as effective as those in our original proposals because the United States is now proposing fewer detection stations and fewer inspections. The monitoring system now proposed will have at least the same degree of deterrent effect as that contemplated four years ago. The original proposal of an internationally operated system of 180 control posts located in every geographic area of the world was made at a time when we had less knowledge about the detection and identification of underground events and was for a system designed to monitor the entire globe. On the basis of knowledge and experience seismic events in the Soviet Union, we now know that the areas of interest can be monitored by a much smaller system which places primary reliance for the detection of events in the Soviet

Union. This is what we propose.

The original proposal would have required some four to six years to install and the international staff of technicians would have had to have been recruited and in many cases trained from scratch. Under the present proposal the United States would be relying on its own detection system which could begin operating immediately and which would be operated by U. S. and U. K. nationals who are already trained and skilled. This proposal would give the United States both maximum flexibility and maximum control of the detection system.

The previous proposal of the United States would have excluded from inspection underground events below a certain size—roughly, anything below a 20-kiloton explosion detonated in tuff, a relatively soft rock. And, at the same time, the United States would have agreed on a three-year moratorium against conducting tests below this size. The present U. S. proposal would permit the United States to inspect, within the quota, for any underground event that had been detected and had not been positively identified as being an earthquake.

We also now know that the number of earthquakes in the U.S.S.R. is less by a factor of 2½ than we previously believed. This, coupled with our increased knowledge of earthquake identification, means that the number of unidentified underground events for which we might consider inspection, will be very substantially smaller than was assumed a few years ago. Furthermore, our knowledge in these areas is now based on actual observation whereas only a few years ago it was based in large part on uncertain estimates.

5. It is suggested that the United States now is willing to accept the principle that monitoring stations be manned by Russians and that Russians "are to be the judges of whether or not they themselves are cheating." Again, this is not a correct statement. The detection stations on which the United States would rely would be operated or supervised by the U. S. and U. K. and would be outside of the Soviet Union. No Soviet national would judge whether the Soviets are cheating. Automatic recording seismic stations inside the Soviet Union would play a supplementary role only; furthermore, the sealed recording devices which these would contain would be serviced and the records would be picked up by non-Soviet personnel.

6. It is said that we now propose to give the Communist bloc a veto power on the control body of the test-ban organization. No veto on inspection has ever been proposed by the United States, and there is no consideration of proposing such a veto in the future.

7. It is stated that William Foster, Director of the Arms Control and Disarmament Agency, testified in September that there had been no improvement in our verification capability. On the contrary, Mr. Foster testified in September concerning two significant developments which increased our verification capability. The first was a "better capability for long-distance detection of earth tremors caused by nuclear explosions or earthquakes." The second was that "an earlier estimate of the number of tremors from earthquakes in the Soviet Union which might be confused with tremors from nuclear explosions has been shown by actual observations and research to be several times too large. Since there are fewer actual earthquakes which produce tremors similar to those of an explosion, the number of on-site inspections needed to identify the cause of any observed tremors is less." (Hearings before the Senate Preparedness Subcommittee, Sept. 17, 1962, p. 6.)

8. The Senator believes that continued testing is essential to the perfection of the anti-missile missile and to the development of the neutron bomb, and that the nation which first perfects either of these weapons will decisively overturn the balance of power. These contentions were refuted generally in points 1-3 above. Additionally, the perfection of the anti-missile missile does not rest primarily on nuclear weapons testing. It rests on other kinds of activities. Even then, our military experts are of the view that the nation sending a missile to its target will always have the advantage over any foreseeable anti-missile missile defense system. With respect to the neutron bomb, a weapon whose successful development is by no means assured no matter how many tests are made, the chief interest of the United States is to prevent the Soviet Union and other states from acquiring this kind of a weapon. These states are much more likely to be inhibited from developing and producing the neutron bomb under a

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Union upon U. S. national systems located outside the Soviet test-ban agreement than under a situation of unlimited testing.

The United States will continue to persist in its negotiations with the Soviets to achieve an effective treaty. We do this because we firmly believe such an agreement is in the national interest of the United States.

Every person weighing the value and the risks of a test-ban agreement must face squarely the situation in which we reach no agreements and allow testing to go on, unlimited, and see the arms race continue to spiral upward. Those within both the Eisenhower and Kennedy Administrations who have studied these questions and these alternatives thoroughly have concluded that every effort to bring the arms race under control, of which nuclear testing is a part, must be pursued diligently.

I would hope that this letter demonstrates that the kind of test-ban agreement now being negotiated by the United States is one that is in the national interest.

## SENATOR DODD'S REPLY

... For almost two decades, the peace and security of the United States and the free world have rested upon the unchallengeable military power with which our nuclear technology has armed us. All of our honorable efforts toward lasting peace and disarmament through negotiation have failed, each in its turn, because of the calculated deceit and treachery of the Communists. Yet, because of our nuclear technology, we have preserved a form of peace.

Five years ago we began to fritter away our nuclear supremacy. We stopped testing and trusted the Soviets to stop. We halted or hobbled our development of a variety of new, revolutionary weapons. Then we awoke one September morning to find that the Soviets had cheated us again.

When the mushroom clouds of their awesome series of gigantic test shots had faded, we discovered that our precious nuclear supremacy had vanished and we suddenly entered the more perilous age of parity in nuclear technology.

## Testimony Cited

Mr. Fisher disputes this loss of supremacy, but all scientists with access to the facts, from Edward Teller to Hans Bethe, have testified that the Soviets have eliminated our technological lead in the field of strategic nuclear weapons.

We are now asked by the Administration to end all further nuclear development by entering into a treaty with the Soviets to permanently stop all tests. We are asked to do this despite the fact that we are on the threshold of decisive new discoveries, denied us by the previous test ban, discoveries that might restore our lead and dramatically strengthen the security and peace of the free world.

The great question before us is: Does this treaty provide an adequate system of inspection with reasonable assurance that the Soviets are not secretly continuing nuclear tests that can give them the revolutionary weapons denied to us by our observance of the test ban?

I have laboriously pointed out in speeches and letters that there is no assurance; that we have no way of detecting underground tests of a size below several kilotons; that we have no way of detecting test shots in outer space of any size. This has been conceded by Administration witnesses at congressional hearings. It is through hidden tests of these kinds that defy detection that the Soviets could develop a neutron bomb, an anti-missile missile warhead and other decisive weapons.

Mr. Fisher's widely publicized letter purports to answer these statements. But the remarkable fact is that nowhere in his detailed fense of the Administration position is it said that this treaty gives us solid assurance that the Soviets cannot continue tests and develop new weapons while we are immobilized. On the contrary, he confirms my misgivings. He affirms that the proposed treaty does involve the risk of undetected cheating. He affirms that individual tests could go undetected. He concedes that there is only a "probability" that a whole series of tests could be detected, not a certainty, but a probability, which means that there is a possibility that whole series of tests could not be detected. He says we must accept the risk of undetected Soviet cheating because other risks are more dangerous. I challenge this last contention, but before going on to it I want to nail down the fact that the proposed inspection terms do not give us a

guarantee against cheating. This is the cardinal fact to which all other considerations must be subordinate.

## "Reason" Is Given

The reason why the proposed inspection system is inadequate, as I have tried to point out in the past, is that we have made so many retreats and concessions to the Soviets in five years of negotiations that our proposed system of monitoring stations and on-site inspections within the Soviet Union is now a hollow shell.

Mr. Fisher disputes this in two ways: First, he says that improvements in the science of detecting earthquakes and underground explosions have justified a vastly reduced inspection system within the Soviet Union. I dispute this. I say that advances in the science of deception have outraced advances in the science of detection and I point to the fact that it is now possible for the Soviets to test secretly in outer space and to test large weapons underground without any possibility of detection. This situation did not exist five years ago and it makes any gain in earthquake science irrelevant and insignificant by comparison.

Second, he says that it does not matter, anyway, because our reliance is based, not upon monitoring inside the Soviet Union, but upon monitoring stations outside. Here the cardinal principle of American disarmament policy for 16 years goes down the drain. That principle was adequate on-site inspection and control. For 16 years the Soviets have rejected this principle and we now yield to them by saying that our reliance is on a system of outside monitoring and that the token inspection inside the Soviet Union is only "supplemental" and unimportant.

I do not take lightly the efforts of honest men to develop an inspection system that would get around the Soviet road-block against on-site inspections, but I say to the American people: when we consider the vast land expanse of the Communist world, occupying one-fifth of the earth's surface; when we consider the limitless capacity of the Communists for fraud and deceit; when we consider their present capacity for undetectable tests underground and in space; when we consider the unknown possibilities for deception which perverted science will give them in the future, we can not, we must not, entrust our national survival to a treaty which denies us a reasonably foolproof inspection system inside the Soviet Union. We must not entrust the future of freedom to a system of absentee monitoring.

## Called Speculation

I am willing to rest my case against the treaty right here, but for the sake of adequate reply I will take up Mr. Fisher's contentions that a treaty should be ratified which admittedly involves great risk and abandons adequate on-site inspection.

The reasons he advances are in the realm of political and strategic speculation. It is contended that the risks of not signing this treaty are greater than the acknowledged risks of signing it. These greater risks are continued testing by the Soviets and the spread of nuclear technology to other nations. This argument is entirely irrelevant because the proposed treaty does not prevent all testing by the Soviet Union and does not even pretend to prevent the spread of nuclear weaponry to other nations. France and China have already repudiated the negotiations.

I voted for the establishment of the Disarmament Agency because I hoped and still hope that it can lead us to improved systems of detection which will make reliable disarmament treaties possible. I am ready to vote for such treaties and I

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Chairman.....Freeman J. Dyson

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The FAS, founded in 1946, is a national organization of scientists and engineers concerned with the impact of science on national and world affairs.

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policy; early in February, the group issued several papers, including one by Edward Teller, which argued the need for continued development and testing of weapons, and found grave weaknesses in the safeguards being proposed to ensure that a test ban was not being violated. (See Senator Dodd's letter elsewhere in this issue.) The Joint Committee has already held a series of hearings, on the status of the nuclear weapons program and on technical problems of test detection. (See other article on this page.) On March 11, the test ban negotiations were taken up by the Senate Disarmament Subcommittee, led by Senator Hubert H. Humphrey, who has participated in recent Geneva talks and urged the need for quick action if any test ban agreement is to be achieved. While the Senate Preparedness Subcommittee is planning hearings soon on overall disarmament questions, Senator Humphrey has recently proposed that Congress create a new Joint Committee on national security affairs. (W. Post, 2/10, 3/10.)

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say to the Administration: Give us a proposal that does prevent continued Soviet testing and we shall all support it. Give us a proposal that does prevent the spread of nuclear weapons to other nations and we shall all support it. But do not give us a treaty which prevents only the nuclear development of the United States and Great Britain, the principal defenders of freedom in the world.

It is contended by Mr. Fisher that we can risk clandestine Soviet testing because the type of weapons that could be developed will not significantly alter the military balance of power. This argument is accompanied by speculation that it is unlikely that an effective antimissile system or a neutron bomb can be perfected.

**Labeled "Defeatist"**

This reveals a defeatist train of thought which is perhaps the most dangerous element of the Administration proposal. This is a philosophy that rests its hope upon scientific stagnation and thus runs against the grain of human experience. This is a Maginot Line philosophy applied to the nuclear age. This is a philosophy that says "we are going to stop here"—and that "new scientific developments by the other side won't really make any difference." This is a philosophy that says about the neutron bomb what the French once said of the German tank, "it won't make any difference, anyway."

How ridiculous to say that live testing is not essential to the development of the anti-missile missile! You cannot make an automobile without live tests. Does anyone suppose that the most complicated weapon ever attempted can be perfected without testing in its final assembled form?

How blind to say that the neutron bomb would not alter the balance of power. The nation that has it can destroy opposing armies without risk of fallout, or damage to the property of friend or foe. The nation that does not have it will be faced with a choice between surrender or starting an all-out nuclear war.

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received signal. These changes take place in times of the order of 100 microseconds compared to typical onset times for natural events, such as solar flares, of the order of minutes. Similarly, abrupt distortions in the earth's magnetic field caused by nuclear explosions induce currents in the earth that can be detected by very simple equipment—two terminals placed in the earth several thousand feet apart. Another technique utilizing the resonant scattering of sunlight by bomb debris has also been successfully studied.

Franklin A. Long, Assistant Director for Science and Technology of the Arms Control and Disarmament Agency, discussed the implications of these results for the nuclear test ban. Prime consideration is currently being given to a detection system composed almost solely of nationally-owned and -operated detection systems. An International Commission might operate some stations in neutral nations and might supervise automatic recording seismic stations, but the U. S. has proposed that "prime reliance" will be placed on a US-UK operated detection system. Data from these stations would be used to support requests for on-site inspections and, under the "reciprocal inspection" procedure that was suggested, this request would not be subject to veto by the Commission or the country in whose territory the inspection was to occur. The reliance on national stations means that detection of events within the USSR would have to take place outside Soviet territory. ACDA justifies this position on the basis of the results noted above.

The proposed system also envisions the use of automatic recording seismic stations—so-called "black boxes." According to the testimony presented at the hearings, these would actually be large underground vaults which were sealed between visits from Commission personnel. Data from these stations would assist in identifying seismic events; the improvement in identification capability was estimated to range from 15 to 50%.

A central problem that remained was the number of unidentified seismic events and the associated problem of the number of on-site inspections. Data presented at the hearings indicated that about 170 shallow earthquakes above magnitude 4.0 occur each year in the Soviet Union, that 20 of these could be definitely identified by the national system as earthquakes, 75 would give some seismic data indicative of an earthquake, and 75 would remain unidentified by seismic means unless data from the automatic stations or other stations were used. It was pointed out by ACDA that geographic criteria, including remoteness or location in deep water, and information from intelligence sources could reduce the "relative degree of suspicion" of the remainder. On this basis the present U. S. proposal is for 7 on-site inspections each year.

In the age of nuclear warfare you can make only one mistake. So long as this treaty leaves a possibility that the Russians will attain these weapons, we must have them and we must have them first. . . .

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