logical perfection of weapons of mass destruction has an aggravating effect on the international situation. If such testing continues, it can only lead to the gravest consequences, putting the existence of mankind itself in jeopardy.

2. The Government of India remains convinced that it is more imperative than ever that all nuclear and thermo-nuclear tests should cease forthwith and remain suspended pending the urgent conclusion of necessary agreements in this regard.

3. The Government of India considers that this matter should be discussed again and therefore submits for inclusion in the agenda of the seventeenth session of the General Assembly an item entitled “The urgent need for suspension of nuclear and thermo-nuclear tests”.

DOCUMENT A/C.1/873
Letter dated 11 October 1962 from the Permanent Representative of the United States of America to the United Nations addressed to the Secretary-General

[Original text: English]
[12 October 1962]

On the instructions of my Government, I have the honour to transmit the following two memoranda related to the issue of nuclear testing:

1. The “detection” and “identification” of underground nuclear explosions.

2. Technical considerations relevant to a nuclear test ban.

I would be grateful to you if you would have the texts of these memoranda circulated to all Members of the United Nations within a single document and in the order listed above.

(Signed) Adlai E. Stevenson
Permanent Representative of the United States of America to the United Nations

1. THE “DETECTION” AND “IDENTIFICATION” OF UNDERGROUND NUCLEAR EXPLOSIONS

Introduction

1. In the many studies and negotiations for a treaty to ban tests of nuclear weapons, control of underground tests has stood forth as one of the most difficult problems. The reason is that the phenomena associated with underground explosions are very similar to those associated with the numerous small earthquakes which occur all over the world. The problem is not just to detect and locate the occurrence of a seismic event. The difficult aspect is to “identify” the event—in other words to obtain positive verification that a particular event is or is not an underground nuclear explosion.

2. In 1958 this problem was studied in great detail by an international Conference of Experts1 which included both United States and USSR seismologists. This group devised the so-called “Geneva system” of control posts, a network of “detection” stations which was to be installed throughout the world, at distances on land of from 1,000 to 1,700 kilometres from each other. A principal item in each control post was to be a highly sensitive set of seismic detectors. Even with this world-wide network, the Conference of Experts predicted that, although many earthquakes would be positively identified as such by seismic means, no underground nuclear explosions would be positively “identified” in this way. They concluded that for positive “identification”, on-site inspections were essential. A consideration of such inspections has formed a basic part of test ban negotiations ever since.

3. Since 1958 a vigorous programme of research on seismic phenomena has been under way. The hope has been that “detection”, location and “identification” of seismic events could be improved, perhaps even to the point that underground explosions could be “identified”. The discussion which follows summarizes the technical problems involved in seismic “detection” and “identification” and reviews the current state of the art and the prospects for future improvement.

Generation of seismic waves

4. When an underground nuclear explosion or earthquake occurs, great amounts of energy are released. Some of this energy appears in the form of seismic waves which travel outward through the earth. Any event which produces such waves is termed a “seismic event”.

5. The properties of these waves depend upon such factors as the type of explosion or earthquake which generates them, the total energy released, the composition of the medium in which the event takes place, the depth of the event, and the geological conditions in the surrounding area. As the waves travel outward from the source, they are modified by the structure of the earth through which they travel. For instance, they may travel downward only to be reflected by various deep-lying layers within the earth. The over-all result is a complicated set of oscillations which arrive at a “detection” station at different times after the event.

Detection

6. Seismic events can be “detected” at large distances by measuring the motion produced at the earth’s surface. These motions are minute at large distances (as small as one ten-millionth of a centimetre), but sensitive instruments called seismometers, which respond to oscillations in the earth’s surface, are able to detect them.

7. In addition to the oscillations from seismic events, there are continuous slight oscillations of the earth’s surface due to atmospheric disturbances, ocean waves breaking on shorelines, and man-made effects from machine vibrations or vehicular traffic. These small irregular vibrations produce “background noise” which is recorded continuously by all seismometers. Only seismic waves which are stronger than this background noise can be distinguished from the noise.

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1 Conference of Experts to Study the Possibility of Detecting Violations of a Possible Agreement on the Suspension of Nuclear Tests: for report of the Conference, see Official Records of the General Assembly, Thirteenth Session, Annexes, agenda items 64, 70 and 72, document A/3897.
Thus, explosions which take place at great distances from the detection stations, with yields of about 1 kiloton in salt or granite (2 kilotons in tuff and up to about 14 kilotons in alluvium), cannot be detected reliably.

**Location**

8. The location of a seismic event is determined from measured times of arrival of seismic waves at several stations. Where accurate travel times through the region are available and arrival times are obtained at several detection stations surrounding the source, the location can be determined to within a radius of about 10 kilometres.

**Identification**

9. A far more difficult problem than the “detection” and location of seismic events is the problem of “identifying” the nature of the event. The difficulty stems from the fact that nuclear explosions produce wave patterns which are equivalent to and indistinguishable from the patterns caused, in many circumstances, by the numerous earthquakes which occur throughout the world.

10. It has been found possible to “identify” some large earthquakes as earthquakes. However, there is at present no known seismic method by which nuclear explosions and small earthquakes may be positively distinguished. Thus, using presently available “detection” methods, it is possible only to classify underground events into two categories: (i) identified earthquakes; and (ii) unidentified seismic events (earthquakes or explosions).

11. The principal procedure by which large earthquakes are “identified” as earthquakes involves observation at several detection stations of the first motion of the earth when the seismic wave reaches each station. Many of the larger earthquakes are associated with movement of the earth along a fissure or “fault line” in the earth’s crust. For such earthquakes the earth on each side of the fault line slides in opposite directions. The first motion of the resulting seismic wave will thus be outward (“positive”) in some directions and inward (“negative”) in others (figure 1).

![Figure 1. Motion at a fault and resulting “first motion”](image)

Since, as far as is known, the waves from underground explosions never behave in this way, the observation of opposite types of first motion at different detectors positively identifies the event as an earthquake.

12. When an underground explosion occurs, the earth is driven outward from the explosion centre. This outward motion produces seismic waves which are initially symmetrical about the source and so have a first motion which is the same in all directions (figure 2). Therefore all detection stations surrounding a nuclear explosion should “detect” first motion which is initially outward. Unfortunately, some types of earthquakes also give outward first motion in all directions. Because of this, observation of the first motion cannot positively “identify” any seismic event as an explosion.

13. Another factor which interferes with the detection of first motion and can cause it to be an unreliable indicator of earthquakes is the small magnitude of the first oscillation compared to succeeding oscillations (figure 3).

![Figure 2. “First motion” from an explosion](image)

![Figure 3. Representative signal from a seismometer](image)

Because of this, and because of the continuing presence of background noise, the true first motion is frequently lost in the background noise. Thus “identification” of earthquakes using the first-motion criterion is most reliable for large events and when the detection station is near the source.

14. Even though seismic waves are subject to great distortion as they pass through the earth, there may still remain some properties other than the first motion which could identify the source. Several possibilities for providing positive identification of explosions have been suggested on theoretical grounds. However, up until the present time underground explosions have not yielded seismic wave patterns with characteristics which had not been previously observed from earthquakes.

15. Unlike earthquakes, nuclear explosions produce great quantities of heat and electromagnetic radiation, but these are quickly absorbed in the surrounding earth and thus do not reach distant detection stations.

16. The strength of the seismic oscillation cannot be used to identify a nuclear explosion. Typical underground nuclear explosions produce seismic waves of equivalent strength to those generated by many earthquakes. Furthermore, the strength of the emitted wave
does not give a clear indication of the yield since variations in the soil or rock surrounding the explosion or in the size of the cavity in which the bomb is placed can alter the magnitude of the seismic oscillations by factors of several hundred.

17. Most earthquakes occur at depths greater than about 15 kilometres. Some of these can be shown to be deep events by detecting waves which have been reflected from the earth’s surface above. This makes it possible to exclude these deep events from consideration as possible man-made explosions.

On-site inspections

18. Since seismic waves do not permit a positive distinction between nuclear explosions and many earthquakes, it is necessary to conduct inspections at the site of the event to determine whether it was an explosion or an earthquake. During such an inspection the inspectors would search within the area indicated by the seismic instruments for evidence of motion of the earth, such as shifted rocks and torn foliage. Drillings would be made at suspected explosion sites to obtain radio-active debris, which is the only positive means of identifying a nuclear explosion.

Future improvements

19. A vigorous programme of research in seismic detection is currently being carried on by the United States. Some of the more promising approaches involve the use of seismometers placed in deep holes where the background noise is very much reduced, and the use of arrays consisting of large numbers of seismometers at each detection station to reduce the interference from noise. The development of such techniques will increase detection capability and may increase the number of earthquakes which can be identified as earthquakes. Similarly, more detailed studies of the characteristics of seismic wave patterns may increase the capabilities for detection and identification by seismic means. But although a great amount of effort and many millions of dollars have been applied to the problem, there has not been found any scientific technique which would permit the identification of underground nuclear explosions without on-site inspection.

2. Technical considerations relevant to a nuclear test ban

Introduction

1. At his news conference on 1 August 1962, President Kennedy presented a statement relating to the United States position on a treaty which forebade the testing of nuclear weapons. He said: "... we are completing a careful review of the technical problems associated with an effective test ban treaty. This review was stimulated by important new technical assessments. These assessments give promise that we can work towards an internationally supervised system of detection and verification for underground testing which will be simpler and more economical than the system which was contained in the treaty which we tabled in Geneva in April 1961. I must emphasize that these new assessments do not affect the requirements that any system must include provision for on-site inspection of unidentified underground events. It may be that we shall not need as many as we have needed in the past, but we find no justification for the Soviet claim that a test ban treaty can be effective without on-site inspection".

2. The new assessments were based in part on work performed under the auspices of three-year-old Project Vela Uniform, which is a programme designed to enhance man’s knowledge in the field of seismology and from which it was hoped that techniques would be developed to aid in the detection and identification of underground nuclear explosions.

Improvements in seismometry

3. In view of the fact that detection and identification capabilities depend on the signal-to-noise ratio at the seismic stations, a major effort has been devoted to studying and minimizing the effects of seismic noise which is mainly due to earth motion arising from wind, ocean and civilization. One means of increasing the signal-to-noise ratio is through the use of arrays of seismometers. It was expected that an array would provide an improvement proportional to the square root of the number of seismometers in the array. In the case of an array of ten elements, the expected signal-to-noise would therefore be about three times greater than that observed with a single element.

4. These ideas were investigated with a "Geneva type" ten-element array constructed at the Wichita Mountains Seismological Observatory at Fort Sill, Oklahoma. This observatory became operational in October 1960, and it has been demonstrated there that the expectations on array performance were essentially correct for the case in which the signals from all channels of the array were directly summed.

5. Another promising approach to the signal-to-noise problem was the installation of seismometers in deep wells. With an instrument placed at various depths between 150 and 3,000 metres in a hole near Hohart, Oklahoma, there were recorded noise levels which were in general a factor of four or five below those observed at the surface. Data obtained from the operation of another deep well instrument in a 3,000-metre hole outside Dallas, Texas indicate the same order of improvement.

6. A third improvement in instrumentation is the development of a deep ocean seismometer. This instrument will add to the detection and identification capabilities of a seismic network by making it possible to collect data in regions of interest which were heretofore inaccessible.

Coupling effects

7. From the present test series much has been learned concerning the fraction of explosion energy which goes into the seismic signal and how this fraction depends on the medium in which the explosion takes place. Until this series, all United States underground nuclear shots had been fired in Nevada tuff, and in order to gain an understanding of medium effects it was necessary to obtain information from detonations in other media.

8. An analysis of data collected from recent underground tests gives a good indication of the extent of medium effects. From the results it is concluded that, as compared to detonations in tuff, explosions of a given yield produce seismic signals up to 10 times smaller if they occur in alluvium, and 2 to 3 times larger if they occur in salt or granite.

9. However, alluvium may not be as useful for concealment of tests as would be implied by these de-
coupling factors. The requirement that a shot be contained means that it is necessary to conduct tests at a depth which increases with the size of the explosion. Since the depth of alluvial deposits is limited, the advantage of decreased coupling does not exist for high yields. Also, tests in alluvium commonly produce large visible surface depressions which would be difficult to conceal.

10. Present estimates indicate that a decoupling factor on the order of 100-300 might be observed for explosions taking place in large spherical cavities excavated from salt. To achieve this amount of decoupling it is necessary to construct cavities having a volume of 75,000 cubic yards per kiloton of yield. However, partial but substantial decoupling can probably be obtained with smaller holes. In evaluating the feasibility of conducting tests under these conditions consideration must be given to problems associated with cost, concealment of material removed from the hole, and the possibility of using a single cavity for more than one shot.

Transmission properties

11. The structure and amplitudes of seismic waves at great distances from their point of origin depends more on the transmission properties of the medium than on the nature of the seismic event. An examination of the data collected during the recent Nevada test series, from the Sahara event of 1 May 1962, and from the 2 February 1962 Semipalatinsk explosion indicates that geographical factors strongly influence signal amplitudes. This phenomenon implies that care must be taken in discussing amplitude of seismic signal versus distance and in assessing capabilities of individual stations.

Identification problem

12. The most useful auxiliary aid to identification of low magnitude events is the determination of depth of focus, i.e., the distances below the surface of the earthquake's origin. At long range this is accomplished by detecting waves which are reflected from the earth's surface above the earthquake focus. These reflected waves, called pP, follow closely behind the primary P pulse. The time interval between these two waves is roughly proportional to focal depth, although it also has a slight dependence on distance.

13. As the depth of focus decreases the pP pulse arrives more nearly on the tail of the primary P pulse and tends to be lost in the "noise" generated by the primary pulse. The P wave itself tends to become more complicated as the focal depth decreases. This accentuates the problem of separating pP. The increased complication in the P wave from shocks at shallow depths is probably a result of the increased complexity of the earth's structure near the surface.

14. A high proportion of earthquakes which occur well below the crust can probably be identified as "deep" with considerable confidence. Skilled analysis can also find fair to good indications of depth from perhaps one-half of those earthquakes which occur between depths of 15 and 60 kilometres. This form of analysis becomes increasingly subjective as the depth and relative strength of the pP signal decreases. Except for a few quakes with unusually well recorded pP phases, it is probably not possible to write an objective set of rules to follow in conducting this analysis.

15. A second auxiliary aid to identification of small seismic events at long ranges is the identification of the event as a foreshock or aftershock of a large earthquake, which in turn can be shown to be natural by other means. A small event could safely be presumed to be an aftershock if it could be shown from analysis of travel times that it occurred essentially at the same location and shortly after a primary shock. It should also be expected to be accompanied by other small shocks, usually within hours, or at least on a time scale which makes it extremely unlikely that the sources could be explosions. The waveforms of some earthquakes in an aftershock sequence may be identical to (or simply scaled-down versions of) the primary or other large shocks in the sequence. This would add increased confidence to the interpretation.

16. There is a third class of identification aids. These exist in the information carried by the seismic signals. At great distances from the event the most obvious thing to look at is the first motion of the earth. For an explosion, first motion is always compressional (i.e., in the direction away from the event). For most earthquakes first motion compressions are observed in some directions and first motion dilatations in others. However, since some earthquakes appear to give compressional signals in all directions, first motion is not a unique criterion. It permits positive identifications of many earthquakes as earthquakes, but it does not permit positive identification of an explosion as an explosion. Also, since the first motion may have a small amplitude, it is difficult to separate the signal from the background at the instant of arrival unless the ratio of peak signal to noise is large. Present methods of analysis require that this be on the order of 10-20 if first motion is to be determined with certainty.

17. There are other properties of the wave form that might be of use for identification in far zones. These include, for example, signature effects and spectral content. The former is of use for events which occur at the same location. At seismic stations these produce characteristic signals which are recognizable by those experienced in reading seismograms. Several Vela Uniform contractors are looking into the spectral analysis problem but have thus far not come up with significant findings.

Seismicity

18. Studies have been conducted on seismic activity and the relation between earthquake size and explosion yield. A recent discovery of great significance is that there occurs a smaller number—as compared with previous estimates—of earthquakes within the USSR which might be confused with nuclear explosions. The implication of this finding is that a reduced number of on-site inspections will have the same probability of uncovering a clandestine test as would a larger number of inspections if the earthquake frequency was as great as had been believed.

Conclusion

19. By making use of the material in the preceding discussion it is possible to estimate the detection and
identification capabilities of a nationally operated, internationally supervised network of seismic stations. A modest network of high quality seismic stations suitably distributed in the northern hemisphere would have a high capability for detecting explosions, in the Soviet Union or the United States, with yields on the order of 1 kiloton in granite or salt, 2 kilotons in tuff and about 14 kilotons in alluvium. Since progress in identification as distinct from detection has been limited, it is still true that a substantial fraction of the earthquakes occurring in the Soviet Union are indistinguishable from explosions on the basis of seismic records.

DOCUMENT A/C.5/940

Financial implications of the draft resolutions submitted by the First Committee in document A/5279

Note by the Secretary-General

[Original text: English]
[5 November 1962]

1. Under the terms of operative paragraph 7 of draft resolution A contained in document A/5279, the Conference of the Eighteen-Nation Committee on Disarmament would reconvene not later than 12 November 1962 and would report to the General Assembly by 10 December 1962 on the results achieved with regard to the cessation of nuclear weapon tests. It is assumed that for this purpose the Committee would reconvene at the European Office of the United Nations, Geneva, for a period not to exceed four weeks.

2. The First Committee was informed, in accordance with rule 154 of the rules of procedure of the General Assembly, that the adoption of the draft resolution by the General Assembly would give rise to the need for additional credits in 1962 to cover the costs of temporary servicing staff and other related costs. Based on past experience and as indicated by the Secretary-General in his report on the supplementary estimates for the financial year 1962 (A/5223, para. 19 (b)), these costs are estimated at $125,000 per month, or approximately $31,000 per week, for the following items of expenditure:

<table>
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<th>Description</th>
<th>Dollars</th>
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<tbody>
<tr>
<td>(i) Temporary assistance</td>
<td>116,500</td>
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<tr>
<td>(ii) Subsistence of Headquarters staff</td>
<td>2,500</td>
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<tr>
<td>(iii) Overtime</td>
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<tr>
<td>(iv) General expenses</td>
<td>4,000</td>
</tr>
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<td></td>
<td>125,000</td>
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The meetings of this Conference require full services of interpretation, verbatim reporting and translation in four languages. The estimates for temporary assistance would provide for the necessary additional staff to meet such requirements. The estimate for subsistence of staff would provide for five substantive staff members detailed from Headquarters to Geneva. In addition, non-recurring expenses estimated at $20,000 would arise in connexion with travel of both temporary and Headquarters staff.

3. The Sub-Committee on a Treaty for the Discontinuance of Nuclear Weapon Tests, as reported by the Secretary-General in document A/5232 (para. 19 (c)), has remained in session during the period that the Eighteen-Nation Committee has been in recess. Should the Sub-Committee continue in session after the Eighteen-Nation Committee reconvenes, and should it hold meetings simultaneously with the Committee, then further additional expenditures amounting to $17,000 a week would arise in regard to the provision of additional temporary language and conference staff and other servicing requirements. In the past, however, the Committee and the Sub-Committee scheduled their meetings so that they would not meet at the same time.

4. In the event of the adoption by the General Assembly of the draft resolution recommended by the First Committee, and in the absence of definite details concerning the meetings of the Committee and the Sub-Committee, the Secretary-General would request authority to incur expenditures in 1962 not to exceed either $213,000 or $145,000, depending on whether the Conference of the Eighteen-Nation Committee on Disarmament and its Sub-Committee on a Treaty for the Discontinuance of Nuclear Weapon Tests would meet concurrently or otherwise.

5. These estimates were based on the note by the Secretary-General (A/C.5/940), which contained a statement of the financial implications in regard to the draft resolution in question. In paragraph 4 of that note, the Secretary-General undertook to report again on this matter later during the present session when it

DOCUMENT A/C.5/960

Financial implications of General Assembly resolution 1762 (XVII)

Note by the Secretary-General

[Original text: English]
[11 December 1962]

1. In accordance with rule 154 of the rules of procedure of the General Assembly, the Fifth Committee decided, at its 940th meeting on 6 November 1962, to inform the General Assembly that the adoption of the draft resolution contained in document A/5279—which became resolution 1762 (XVII)—would give rise to additional expenditures in 1962 not to exceed either $213,000 or $145,000, depending on whether the Conference of the Eighteen-Nation Committee on