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GENERAL REPORT

THE PROBLEM OF INSPECTION FOR DISARMAMENT

WORKABLE SYSTEMS of inspection can be designed to ensure compliance with international disarmament agreements.[1] That is the principal finding of this investigation of the feasibility of designing an inspection system for disarmament. The range of workable inspection extends from particular objectives, such as halting nuclear-bomb and missiles testing, to the wider objective of halting production and testing of both the weapons of mass destruction and the instruments for their delivery.

The Meaning of Workability

The workability of an inspection system refers to its ability to make an effort at evading disarmament agreements extremely difficult. It is possible to design and operate systems of control which would give substantial assurance that evasions of various types of agreements on disarmament could not be carried out successfully. It is not possible, however, to design and operate a system by which perfect compliance with international disarmament agreements could be guaranteed. Let it be clear at the outset that perfection cannot be guaranteed here, nor in any natural or social phenomenon. Indeed, foolproof and flawless reliability in inspection for disarmament is not only unattainable; it is not necessary for workability.

1The term "disarmament" as here used includes partial as well as total elimination of specified weapons systems. It thus includes both "arms limitation," as used by some to imply partial arms reduction and "total disarmament."

Both the capabilities and the limitations of inspection for disarmament are discussed in this report. The strong points of inspection systems are more than sufficient, in the judgment of this writer, to form the basis for an optimistic estimate of workability. Stated in another way: the gains that could be obtained for the security of humankind by the relaxation of the arms race are so substantial as to be well worth the risks of successful evasion that may be involved in concluding disarmament agreements.

Partial and Extensive Disarmament

The workability of inspection for disarmament need not be handled as an all-or-nothing problem. There are many alternative inspection techniques of immediate as well as long-range interest. The results of this study cover a wide range of possibilities—from inspection for nuclear-bomb and missiles tests, to extensive inspection of the production of large-scale missiles.

An inspection system for these purposes must satisfy both technical and allied conditions. The strictly technical features define the kinds of critical points in arms production and testing to which access is essential and which lend themselves to surveillance. The allied aspects refer to the legal status, powers, and administrative requirements of an international inspection agency. An inspection system for disarmament must take account of the technical possibilities for inspection at strategic points in the mining, processing, manufacturing, storing, and deployment of the products to be controlled. It must also take account of the technical possibilities of evasion at each stage. Once the technical possibilities for evasion and for inspection are defined, the legal and administrative prerequisites for a reliable control system can be stated.

The problem of the workability of an inspection system must be subdivided. What things shall be inspected? What conditions, other than strictly technical ones, must be taken into account in the design of the inspection system? Is it possible to give 100 percent guarantees against evasion of an international agreement? If that is not possible, what then is the meaning of workable inspection? Finally, who shall carry out such an inspection system and what are the requirements of its operation? Each of these questions will be dealt with here.

Broadly, this report formulates critical problems as to the feasibility of inspection for disarmament, and gives an estimate of what is possible. This book is not a detailed statement of the procedures to be used by an

international inspectorate. Nor have the writers attempted an exhaustive treatment of all weapons possibilities. In order to make this study both possible and useful, the writers have focused upon weapons and problems whose importance is clearly central.

The emphasis on missiles, for example, and the absence of treatment of conventional planes, should not be taken to mean that the latter are judged as unimportant militarily. Indeed, such "conventional" weapons would certainly fall within the scope of an extensive disarmament effort for reduction of all armaments.

The Scope of Inspection

The design of an inspection system is closely affected by the type of disarmament agreement that is to be implemented. In carrying out this study, it has been assumed that an international agreement for extensive disarmament is urgently desired, and that the agreement is politically feasible, if the signatories can satisfy themselves that it is technically feasible to monitor against evasion. An extensive disarmament agreement is taken to mean one that prohibits the production of all major military materiel. Such an extensive objective has been assumed here for two reasons. First, it involves many of the gravest difficulties, and is therefore a way of testing the capabilities and limitations of inspection under severe conditions. Second, within the broad framework there will be found particular aspects which can become the basis for agreements of more limited scope.

For any disarmament agreement there arises the problem: How can the parties to this agreement be assured that evasion of the agreement is not occurring in any of the participating countries? Toward this end it is assumed that some international organization would be charged with administering the inspection for disarmament and that such an agency would be afforded ample means for employing staffs of the quality and size needed for this work.

The Steps in Disarmament

There is, of course, another major aspect of the disarmament problem: What sequence of steps could be taken to attain full disarmament and the inspection system that is appropriate for that purpose? That problem is essentially one of political policy, for which technical feasibility of each step in the sequence must be considered. The selection and the timing of such a sequence of moves involves political problems of tactics and negotiation that are not within the scope of this report.[2]

The formulation of political plans, however, requires an estimate of technical capability. That technical estimate is the center-point of this study.

The United States as the Inspection Area

The United States, which includes a large population and an intricate array of production facilities and transportation and communication networks, has been selected as the model area for inspection purposes. It is assumed here that all countries entering into an international disarmament agreement would be subject to the same degree and conditions of inspection as the United States. There is another reason for the selection of the United States as the model area. It is reasonable to assume that information about the kind of inspection system that would be feasible for the U.S. would provide the best basis for public discussion among the American people as to the kind of inspection system they would consider proposing to the entire world.

2 On this phase of the disarmament problem, see the following publications which have appeared since the Second World War:

U.S. Department of State, *The International Control of Atomic Energy* (Washington, D.C., U.S. Govt. Print. Off., 1947); U.S. Department of State, *A. Report on the International Control of Atomic Energy* (Washington, D.C., U.S. Govt. Print. Off., March 16, 1946); William T. R. Fox, *The Struggle for Atomic Control* (New York, Public Affairs Committee, 1947); William T. R. Fox, "International Control of Atomic Weapons," in Bernard Brodie, ed., *The Absolute Weapon* (New York, Harcourt, 1946); extensive materials on the political and technical aspects of armament (and disarmament) in the *Bulletin of the Atomic Scientists;* U.S. Senate, Committee on Foreign Relations, Subcommittee on Disarmament, *Hearings on Control and Reduction of Armaments,* convening January 25, 1956 (the same Subcommittee was responsible for a series of studies on aspects of disarmament—see especially the volume *Disarmament and Security, a Collection of Documents, 1919-1955;* the Staff Studies of this Committee include unusually interesting materials on the technical inspection and political aspects of disarmament. In Staff Study No. 1 (p. 7) there is a list of Mr. Stassen's task forces to inquire into various aspects of inspection. No reports of these studies have ever been published. Staff Study No. 3 includes a discussion of the evolving policies of the USSR with respect to inspection and control (pp. 20-21). Staff Study No. 8 includes political estimates of Soviet attitudes toward inspection [pp. 7-9]); Jerome H. Spingarn, *Is Disarmament Possible?* (New York, Public Affairs Pamphlet, 1956); Foreign Economic Administration, Enemy Branch, *A Program for German Economic and Industrial Disarmament* (A Study Submitted to the Subcommittee on War Mobilization of the Committee on Military Affairs, U. S. Senate, April 1946, 79th Congress, 2nd Session, 377 pp., Appendix, pp. 379-660); G. Clark and L. B. Sohn, *World Peace Through World Law* (Cambridge, Harvard Univ. Press, 1958); National Planning Association, *1970 Without Arms Control* (Washington, D.C., 1958); Philip Noel-Baker, *The Arms Race* (London, Atlantic, Stevens, 1958).

Many aspects of an inspection process are bound to be similar among countries. However, differences in style of industrial organization and management can require appropriate adjustment of inspection methods. In the Soviet sphere, for example, there are no autonomous organizations of industrial workers, and there has been rather widespread and long-standing indoctrination in keeping information and activities secret. There are no published data for industry in the USSR that compare with the very detailed information available in the United States from such sources as the U.S. Bureau of the Census and from ordinary trade publications and directories. Inspection systems would also take into account international differences in the product and marketing organization of industry.

Weapons for Inspection

What classes of activity should be covered by an inspection system? The relevant weapons and allied devices are those which could be used for massive destruction and domination of large population areas. Accordingly, police weapons and allied small arms are excluded from this study, for these are no longer the decisive means of military combat among large countries. Heavy weapons of a "conventional" type, like tanks, artillery and vehicles of all kinds, are certainly an integral part of any plan for the conquest of a large population area. Even if such weapons were not utilized for striking a paralyzing blow, they would certainly be vital to a conquering power for carrying out extensive policing operations. Nevertheless, such weapons, in order to be strategically useful among large countries, need to be produced in very large quantities, that is, by the thousands. Owing to the sheer mass of metal which must be moved and processed in order to carry out production of tanks, artillery pieces, trucks, etc., inspection of this class of arms does not offer critical difficulties. Even within the extensive industrial complex of the United States, there are a fairly limited number of plants, for example, capable of mass-producing the large engines that are required for heavy military vehicles. The operations of such plants could be readily supervised and the movement of large tonnages of steel and other key raw materials required for these weapons could be readily monitored. Therefore, this class of conventional weapons, though important, is not regarded as central for the purpose of this study.

Next in importance are surface vessels and submarines. These units.

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while necessary both for purposes of general transportation and as weapons carriers, are produced under very special conditions that would facilitate any inspection operation. Ships and submarines are very large units which must be assembled at or near a seaboard. Because of their sheer size, and the large number of men required to assemble them, the production of ships and submarines is an operation that does not present great difficulties for control by inspection.

Finally, there is the class of weapons which includes airplanes and missiles. For the foreseeable future, missiles represent by far the most potent class of instruments of large-scale destruction. Moreover, airplane design has been evolving so as to approximate the characteristics of missiles. Accordingly, the production of large-scale missiles has been the central area for this investigation. Indeed, the development of missiles technologies since the beginning of this study—January, 1957—has confirmed the reasonableness of this estimate. Therefore, in this investigation we have attempted to define workability of inspection for disarmament in terms of techniques that have both very general applicability as well as particular relevance to the various aspects of the production of large-scale missiles. The possibilities of biological warfare have also been treated, for such weapons have special qualities of destructiveness and cheapness of production.

Inspection Strength Through Multiple Approach

In this investigation an effort has been made to apply several techniques to the question of control of particular armament activities. Thus, the detection of nuclear explosions can be effected by measuring sound waves carried in the air, seismic waves carried in the earth, visible light from the bomb flash, and radioactivity that is released.

Every type of inspection technique has its limitations. Therefore, for this investigation, emphasis is placed on the use of multiple approaches to a given inspection problem. The logic of this method is that the limitation of one technique is not the same as that of another. As a result, multiple approaches reinforce each other. It must be emphasized, however, that the ability of an inspection agency to follow up suspicious evidence is an essential condition for the success of any method of inspection for disarmament.

Publicly Available Knowledge as the Basis for Investigation

This study of inspection for disarmament has utilized publicly available information only. No attempt has been made to obtain access to any secret or otherwise "classified" information. This has naturally limited the kinds of detailed information that were available for this investigation. For example, the second part of this report includes two papers on critical components of the guidance systems needed for large guided missiles. In preparing these technical papers, none of the writers utilized any of the body of "classified" information which might pertain to the analysis. Nevertheless, the broad characteristics of such equipment are well recorded in the published literature, and many critical characteristics of such equipment can be inferred from the purpose which the equipment must serve. Thus, the difficulty of inspecting the production of airborne computers can be inferred from the fact that such computers perform functions comparable to those performed by the electronic computers widely in use in many offices, factories, and laboratories, and that the types of components needed to build both kinds of equipment are readily available in most well-equipped radio components supply stores. Thus, it would be difficult to tell by inventories of these stores which components were to be used for which purpose.

In the case of the precision gyroscopes and accelerometers needed for missiles, it could be inferred from the published literature that this equipment, in order to be useful in long-range missiles, must be able to operate with extremely high accuracy. The exactness to which the mechanical parts must be machined requires metal-working equipment of hitherto unknown precision for quantity production. The special metal-working equipment can be produced hi only a limited number of factories and must be utilized under very special conditions. In this case, the writers, through a diagnosis of such conditions, could point to a number of critical, strategic areas for effective inspection, even though they could not themselves examine the equipment in question.

In the opinion of this writer, lack of access to classified information and total reliance on publicly available information has probably given the analysis a conservative bias. In other words, more access and more knowledge might have revealed more strategic control points for inspection. There is also a possibility that access to all existing information might disclose technological alternatives which by-pass points that are now designated as useful for inspection. Since complex weapons systems depend upon an integrated production of many distinctive components, evasion, to be successful, would have to occur at many points simultaneously, while inspection, to be reliable, need operate at few of these points only.

This study defines possibilities and problems of inspection for disarmament. It indicates certain leading characteristics and problems of such a process. The detailed design of an inspection system would probably be consistent with the results indicated here, but would also be based upon more extensive analysis of the relevant technologies than was needed for this study of the feasibility of inspection for disarmament.

Inspecting a Changing Technology

Rapid enlargement of possibilities has become a characteristic feature of all technologies, military technology included. Therefore, an inspection system that is designed with an eye to the weapons of the present will not necessarily be appropriate a few years later. At this writing it is clear, for example, that there are alternative types of missiles, and alternative types of engines and fuels, all of which could be used to propel destructive missiles over long distances and at high velocities. Indeed, the fact that there are alternative available methods for achieving given effects is one of the general features of industrial technologies that are built on extensive scientific bases.

Clearly, then, the evaluation of the feasibility of inspection set forth here is not intended to be serviceable at all times and under all conditions. Rather, the design of an effective inspection system would have to be constantly revised in accordance with the growing body of basic scientific knowledge and its possible application to military technologies.

Objectives of an Inspection System

What is the critical act of evasion which an inspection system at this stage of military technology should be designed to prevent?

It is estimated that between 200 and 400[3] large missiles could be used to devastate effectively any one of the larger land areas of the earth. In this usage, "to devastate" means to destroy some or all major population centers as well as critical industrial facilities. The dimensions of this objective are indicated by the following data.

3 It is assumed here that only about half the missiles launched could actually reach their target areas, owing to missile failure and possible interception.

The unit production cost for an intercontinental ballistic missile in the United States amounts to about $2,000,000 under conditions of quantity output. This estimate excludes the cost of research and development, capital investment, and the warhead. The smaller, intermediate range missiles are estimated to cost about $1,000,000 each.[4] One may estimate the average cost of a man-hour of labor for this production, including the overhead costs charged to such labor, as amounting to about $5.00 an hour. In these terms an intercontinental missile requires about 400,000 man-hours of labor for its production—directly, and indirectly in the form of labor that is included in the costs of raw materials, components, power, and the like. On this basis we may say that if one man-year includes 2,000 hours, the production of 200 to 400 large missiles would require between 40,000 and 80,000 man-years. Other information indicates that ballistic missiles of the intermediate and intercontinental range include 20,000 to 30,000 parts which are handled in 6,000 to 10,000 subassemblies.[5] Even allowing for considerable error in these estimates, it is evident that the production of these missiles hi the indicated quantities is an industrial task of large magnitude.

These estimates indicate the order of magnitude of the effort that would be required to evade an international disarmament agreement which explicitly forbade the further production of large missiles for military purposes.

Under what conditions could such an evasion attempt occur? Let it be assumed that the major governments of the earth join in a disarmament agreement which includes an inspection system. It is assumed, for the purpose of this investigation, that within one country, a group of men, including some highly placed military personnel, develop the opinion that the politicians who concluded such an agreement were in fact leading the country along a dangerous path by opening it to treacherous attack from an enemy. A group so minded, or interested in preparing a deadly blow against another power, decides that, despite the agreement, it must attempt the production and emplacement of the indicated number of missiles. Such a group would then proceed to organize the clandestine production of components of a given missile design, perhaps with the private approval of government officials, and would organize the effort to assemble and emplace such missiles. Another

4 *American Machinist,* December 30, 1957, p. 59.
5 *American Machinist,* February 24, 1958, p. 87.

possibility would be a direct effort by a government to evade an inspection system.

Such an effort, in order to be strategically meaningful, would have to be carried out within the space of about two years. The required production effort would probably require not less than two years, and the calculation of danger, which underlies such an effort, would require a minimum of delay in attaining the secret armaments objective. There is also the possibility, of course, that an attempt might be made to accomplish this objective from an already existing stockpile of missiles, part of which could be secured from public view before an international inspection scheme went into effect. This question will be discussed below, in the section on Inventory Validation.

Finally, it should be noted that there are other types of weapons which could have deadly effect over a large area, and which do not require the massive industrial effort that is necessary in the case of the large missile. Special attention must be given, in this connection, to the possibilities of biological warfare methods. Accordingly, critical aspects of these methods are dealt with in one of the technical memoranda included in this report.

An inspection system would have to be able to cope with efforts to produce weapons in clandestine ways, and also with the problem of hidden inventories of arms produced before the inspection system was begun.

The maximum objective of an inspection scheme is to make any secret effort to evade disarmament agreements so extraordinarily difficult as to be virtually impossible.

Method of Investigation

The enormous range of knowledge that must be taken into account in exploring the problem of feasibility of inspection requires the cooperation of specialists in a wide range of fields. Such cooperation was obtained for this investigation and the resulting group of technical papers, dealing with critical aspects of the inspection problem, is presented following this report. The range of subject matter comprehended here, however broad in scope, should not be understood to define the boundaries of knowledge that are, in fact, involved. Rather, the subjects covered by these technical papers are representative. These fields of knowledge are not only critical in themselves, but also an important

sample of the knowledge and technique that would have to be reviewed and utilized.

In addition, two memoranda prepared for this report deal with the art of the clandestine organization of production, which includes training personnel for the use of weapons, and the transportation and storage of weapons. This report emphasizes the problems of inspection of missiles and their components. It is likely, however, as pointed out above, that the problems of inspection for production of masses of "conventional" heavy weapons would be less intricate. Therefore, if there is a bias here owing to the emphasis on missiles, it is probably in the direction of the more difficult parts of the total area of arms inspection.

The reader should not infer, however, that the writer is thereby implying that any of these methods is sufficiently effective, separately, for coping with the inspection problem.

Evasion Teams

In order to test the effectiveness (and the weaknesses) of the proposed inspection methods, three Evasion Teams were organized. These teams were charged with devising schemes for evading an inspection system. Their imaginative reports are also given in this book.

GENERAL INSPECTION METHODS

Six general methods of inspection are evaluated in this report. They are general because the techniques are not specific to any particular class of weapon. These methods include aerial inspection, inspection of governmental budgets, detection of bomb testing, detection of missile testing, radiation inspection, and checking on scientific personnel. Another method, inspection by the people, is discussed below.[6]

Aerial Inspection

In his paper on "Capabilities and Limitations of Aerial Inspection," Mr. Walter J. Levison has dealt particularly with the capability

6Inspection of military plans, records, and the like is not included in this analysis, which has been focused on problems of controlling production—wherever possible by methods that do not depend on records and statements of groups like the military. It is difficult to conceive of a serious evasion effort which does not involve the collaboration (willing or unwilling) of the professional military men.

of aerial inspection for detecting large military forces, especially those of a conventional character. Thus, he indicates that "ground details as small as one foot in dimension may be analyzed, or huge urban areas, industrial installations, and transportation systems may be encompassed on one photograph." He further indicates that, notwithstanding the limitations of present-day aerial reconnaissance methods, their capabilities for detecting massive industrial installations and large concentrations of troops are substantial.

For the present purpose primary attention must be given, however, to the relation of aerial reconnaissance methods to inspection for preparation of intercontinental ballistic missiles. Mr. Levison's analysis gives particular attention to the very great difficulty of detecting such missiles once they have been produced and placed in position, possibly in camouflaged sites. He indicates that "the task of identifying underground launching sites may be compared to the task of discerning manhole covers from 50,000 feet in the air." And finally, "whereas aerial inspection would serve an important function today, while weapons' delivery systems still consist of conventional aircraft, it will be of almost no value once the intercontinental ballistic missile becomes a part of the military arsenal." Thus, while the capabilities of aerial reconnaissance for locating large military installations, industrial plants, and transportation systems are indeed extensive, the best methods of aerial reconnaissance could hardly cope with camouflaged missile emplacements already in existence. Nor could such methods locate missiles that are in position aboard submarines, merchant vessels, or space satellites. Therefore, it is reasonable to infer that the usefulness of aerial reconnaissance with respect to missiles extends mainly to indicating where they are being produced, but not to detecting their presence once they have been produced and artfully concealed.

Government Budgets

Professor Burkhead's analysis of the feasibility of monitoring budgeting activities and auditing expenditures in government accounts indicates that this mode of inspection possesses major built-in weaknesses. Existing practice permits some types of appropriations to be expended at the discretion of administrators. In other circumstances budgeted funds may be transferred among accounts, and the outlays for certain activities may be concealed by distribution, in whole or in

part, of the amounts in budget accounts bearing unrelated titles. In the federal budget of the United States, Professor Burkhead estimates that the particular allocation of amounts up to $100,000,000 is and can be readily concealed from view by such means. Larger amounts could also be concealed, although with increasing difficulty. It is important to note that such possibilities for concealment characterize the relatively open and published budget of the United States government. Such possibilities could very well be multiplied in the case of governmental budgets operating where there are multiple security restrictions over the entire budgeting system.

The estimated direct cost of manufacturing 200 to 400 large ballistic missiles, amounting to $400 to $800 million over a two-year period, is an item which could be feasibly concealed within a governmental budget system comparable to that of the United Nations.

However, this is not the only conclusion to be drawn from a study of military budget accounting as a means of inspection. In 1933, the League of Nations published a most elaborate technical report in two volumes on the possibilities for monitoring armaments budgets. This subject was examined intensively by a distinguished international group which drew upon technical talent in many countries. The group reported that, with the use of specified methods, substantial control over military outlays could be established. The recommended methods included: a Model Statement of accounts to standardize accounting in all countries; reconciliation between the Model Statement and prevailing budget categories; necessary methods of supervision and control.[7]

The proposed methods of accounting were tested in terms of the military budgets of various countries. The Commission recommended the system as a workable device for monitoring the actual, in relation to agreed, military budgets.

Bomb Testing

The development of an expanding variety of weapons delivery systems utilizing nuclear explosives has required extensive programs of bomb testing. The problem of Professor Orear's paper is: With the application of present methods for monitoring nuclear explosions, are

' League of Nations, Conference for the Reduction and Limitation of Armaments, National Defense Expenditure Commission, *Report of the Technical Committee* (Geneva: League of Nations, Disarmament, 1933. *IX.* 3, Vols. I, II.)

secret bomb tests possible? The answer to this question is clearly in the negative, provided that monitoring stations are within 300 miles of the blasts, and the bombs appreciably larger than the "blockbusters" of the Second World War. Available techniques for monitoring the atmosphere can account for explosions which discharge large quantities of radioactive waste into the air. Acoustic wave detection is best for atmospheric explosions. Also, the light flash can be seen for several hundred miles. Underwater explosions produce radioactive discharge or seismic disturbances of measurable proportions.

There remains the problem posed by attempts to blanket underground nuclear explosions by setting off test explosions of this kind so that they coincide with natural earthquakes. The state of the art of seismic measurement, however, has become capable of differentiating between natural and man-created phenomena of this type, again assuming a network of 300-mile stations. Therefore, reports Professor Orear, a relatively modest network of monitoring stations could readily carry out continuous and even automatic monitoring for nuclear blasts within the largest land areas of the earth. These stations could be unmanned and automatically operated, if necessary. The maps appended to Professor Orear's paper are suggestive in this respect.

The workability of inspection in this sphere is significant not only in its own right, but also as a possible area of initial agreement for disarmament among the major governments.

Scientific Personnel

The employment of large numbers of engineers and scientists is one of the characteristic features of both the development and production of modern weapons. This fact can be utilized for inspection purposes in several ways. The presence of people in certain occupations can be a signal to check further on a given locality, industrial plant, or laboratory. Registers of technical personnel and alumni lists of technical schools can be sampled in order to discover what are the activities of people in certain crucial occupations.

RADIATION INSPECTION

The various types of industrial plants which can produce fissionable materials for atomic warheads also produce radiation that is dangerous for public health. As a result, there has already been a sub-

stantial development of techniques and organizations for monitoring radiation in countries which operate plants or processes that involve atomic fission.

These facts are of special interest here, for detailed inspection for public health purposes of the amount of radiation produced, and of its effect on people in nearby contact, necessarily includes inspection of the major plants that would be inspected for disarmament purposes. That presents an opportunity for implementing inspection for disarmament, in some measure, through the activity of already-operating organizations in various countries.

Professor Penrose has outlined the need for control of sources of radiation as a public health measure. Such steps have already been extensively considered in several countries.[8] Available methods for monitoring the exposure of individuals who are subject to special risk are apparently capable of coping with the problem of measuring exposure in order to limit the hazards of overexposure. An effort to control exposure to radiation would involve registration, together with some sort of periodic inspection, of hospitals, industrial plants, research laboratories, and military establishments where X rays or radioactive materials are regularly used. Professor Penrose points out that the basis for this and similar recommendations is that from a strictly medical point of view any unnecessary exposure to radiation of individuals or of the population as a whole is to be deprecated.

Radiation Inspection and Clandestine Manufacture of Fissionable Materials

The latter part of Professor Penrose's paper calls attention to the possible use of medical knowledge as an aid in the detection of clandestine manufacture of fissionable atomic materials. Two classes of data may be utilized here: the known damaging effects from radiation exposure, and the evidence that protective devices against radiation have been or are being used.

Short-term effects of heavy radiation exposure involve the occurrence of drastic symptoms that are readily recognizable. Hospitals and medical men generally could be on the alert for such symptoms. Long-term physiological effects are less useful here, since they may not be

8 See the report of the Atomic Energy Commission: *Radiation Safety and Major Activities in the Atomic Energy Programs* (Washington, D.C.: U.S. Govt. Print Off., January, 1957).

observed until years after exposure. Professor Penrose indicates various marked, short-run symptoms of radiation overdose which may be monitored by hospitals as indicators of radiation exposure.

The development of industrial, military, and medical applications of radioactive materials has led to the extensive development and utilization of techniques for the control of radiation exposure. For the purposes of inspection for disarmament, knowledge of such techniques, and information as to how they have been utilized, serves to indicate the location of such operations. Relevant types of indicators of such activities include: utilization of special clothing and protective devices, the regular wearing and Inspection of film badges by the workers, the use of pocket monitoring instruments and, finally, regular blood counts at about quarterly intervals for the working personnel. The usefulness of this mode of Inspection is limited, however, by the fact that such devices are also used rather widely in medical, biological, and physical research laboratories. Medical care can be given without public knowledge, especially if an evasion effort is shielded from an inspectorate by wide public support, or is operated by a technically diversified, disciplined organization of a military or quasi-military type, or both. (See the papers by Rivlin and Gumbel.)

The weight of evidence favors the operation of extensive inspection of radiation sources, from a public health standpoint. This consideration is important for implementing possible International agreements on inspection for disarmament. Inspection both for public health purposes and for disarmament would need to include close monitoring of all the facilities that could be sources of explosive fissionable materials.

GUIDED MISSILES

Guided missiles and kindred types of piloted craft have become, and in the foreseeable future will continue to be, a primary form of delivery system for weapons of mass destruction. Accordingly, considerable attention has been given in this study to the various aspects of guided missiles. In each case the question asked is a similar one: What is the feasibility of imposing an inspection system on the production of each of these components? In detail, this question must be translated: What are the possible strategic points, in the form of materials or processes, manpower, or the like, which could be seized upon for inspection control? Primary attention has been given to the larger missiles of the intercontinental ballistic type. The subjects considered here include: production of fissionable materials for warheads, guidance systems, air frames, power plants, and fuels.

Production of Materials for Atomic Warheads

From the vantage point of broad experience in chemical engineering, Professor James H. Boyd has assessed the feasibility of preventing the theft, for clandestine production purposes, of fissionable materials from the relevant processing plants or reactors. The evidence at hand indicates that it is possible to establish tight material controls over the relevant plants and operations.

Professor Boyd also indicates that fissionable materials, usable in atomic warheads, could conceivably be stolen from major processing plants which produce such materials, or from uranium- or thorium-fueled power reactors. Human failure could be the main weakness in the relevant control systems. In the chemical plants which process uranium for explosive use, it is possible to measure process input and output within an error of a few percent.[9] Also, the chemical processing requires large amounts of conventional chemicals. Chemical separation of uranium 235 requires elaborate plants the cost of which is about $1 billion.

The reworking of reactor fuel elements, however, presents a critical inspection point. Periodically, it is necessary to withdraw fuel elements and reprocess the metal in order to eliminate fission products which "poison" the productive fission reactions. Professor Boyd underscores the fact that "the theft of plutonium or uranium 233 after radioactive waste separation appears the most vulnerable point in a nuclear power operation. This is the critical inspection point." It should be noted, however, that limitations on accountability of inputs and outputs in the relevant processing operations do not necessarily mean ease of evasion. Thus, expert opinion indicates that the difficulties in the separation of plutonium from used reactor elements leads to small percentages of

9To be sure, the political significance of any given percentage is a function of the state of disarmament within which this occurs. Also, it is entirely conceivable that access to the full technological information on the relevant processes would permit far greater precision of control than is indicated by the data available to the writers of this study.

loss at various points in the processing. These same difficulties, however, also restrict any attempt to salvage such "lost" materials for secret arms use.

The problem of control over warhead materials affords an interesting example of the complications produced by advances in science and technology. Competent opinion holds that the newly developed methods for possible control of fusion processes for power generation would also produce quantities of plutonium, a material which can be used for nuclear explosions. The fusion process may also involve relatively modest capital outlays as compared with the enormous plants constructed in the United States, England, and Russia for plutonium production. As a result, the possibility of producing plutonium could come within the reach of a large number of countries. This is a good example of why any system of inspection for disarmament needs to remain flexible in the choice of critical control points.

Electronic Guidance Systems

A central point of the paper by Professor John Walsh is that electronic elements of missile guidance systems can be produced from components which may be purchased in the well-equipped radio components shops in American cities. This estimate of the matter does not exclude the possibility that certain components of missiles may indeed be of a special type, and therefore useful as inspection control points. If that is the case, however, it is not publicly known. Moreover, the available knowledge does indicate the feasibility of alternative types of guidance systems. That fact multiplies the inspection problem. The difficulties involved here are suggested by the attempt to answer the question: Would it be possible to recognize the manufacture of computers for air-borne use within a plant which manufactures computers for general industrial and scientific purposes? Recent trends in computer design have emphasized extensive utilization of transistors, standardized subassemblies, and compact construction of entire units. The effect of these design features is to render the computers built for non-air-borne purposes more like the air-borne types in these respects than hitherto. These developments, however, do not exclude the possibility that full access to the relevant knowledge would indeed enable an inspection team to differentiate the air-borne type of computer from others at certain critical points in their assembly. Such data, however,

are not available to this study. Accordingly, this writer prefers to proceed on the conservative assumption based on available knowledge, which is that the electronic elements of large guided missile systems do not offer readily recognizable critical elements for inspection purposes.

Precision Gyroscopes and Accelerometers

In order to control the flight path of a missile, the guidance system must be given constant information about the position and direction of the missile in relation to the earth. This information is given to the guidance system by precision gyroscopes and accelerometers which inform the guidance computer about "which way is up" and about variation in direction. In order to carry out these functions for a long-range guided missile, the gyroscopes and accelerometers must be built to accuracies hitherto unattainable for quantity-produced machines. Professor Eugene Avallone has examined crucial elements of the production of these instruments. He finds that in order to produce and test these units certain components must be produced to accuracies of millionths of an inch. Such precision requirements have been reported in the literature. They may also be inferred from estimates of the tolerable error in the guidance equipment, in terms of the effect of such error on the accuracy of the missile.

Professor Avallone finds that the production of high-precision gears and bearings, for example, requires metal-working equipment of hitherto unknown precision. Such equipment is found in rather few plants and it must be utilized under very special conditions; for example, critical machines must be placed on seismic mounts so as to isolate them from surrounding vibrations. Moreover, the components produced by such machines must be handled meticulously in dust-free atmospheres, and must be assembled and tested by means of machines that are specially constructed for these purposes.

Altogether, the unusual precision requirements of missile guidance equipment make necessary a series of production elements, including special metal-working equipment, special testing machines, special plant conditions, and specially skilled and trained work forces—all of which are unique to the production of this class of equipment. These characteristics are the more striking since gyroscopes, for instance, are produced for other types of guidance systems as well—for example, in the "automatic pilot" equipment that is widely used in commercial airplanes. A substantial number of plants which can produce this latter class of equipment exists, in contrast to the limited number of facilities capable of producing the unusually precise units needed for missile guidance purposes.

While the production of precision gyroscopes and accelerometers appears to offer several useful strategic points for disarmament inspection, it is possible that these units could in due course become conventional equipment—even for general aircraft use, for example, if much more precise guidance of commercial aircraft were called for.

Air Frames

Large guided missiles, as well as high-performance piloted aircraft, require air frames which have unique characteristics of strength, heat resistance, and ability to withstand vibration. In his paper, Professor Bruno Boley indicates that in order to produce air frames with the requisite characteristics, high-temperature alloys with high strength-to-weight ratio must be utilized. The production of these alloys requires the use of materials, some of which have been in short supply, such as titanium, niobium, vanadium, zirconium, rhenium, beryllium, and tantalum. Furthermore, the production of the requisite shapes for air frames has raised special problems of shaping large sections of alloyed metals to precise dimensions. While the methods employed in this shaping process are frequently special, it is a fact that, hitherto, once such methods have been introduced in the air frame production plants, they are frequently instituted rapidly in a wide range of other industries which can utilize such techniques.

The air frames for long-range ballistic missiles require designs which utilize such techniques.

These air frames require distinctive designs. These include accommodation to structural problems of kinetic heating, of atmospheric exit and re-entry, and of vibration and stability. The designs of ballistic missiles, which are made in an effort to meet these requirements, are themselves thereby earmarked as appropriate elements for inspection purposes. Moreover, structural design for ballistic missiles has typically focused on minimum requirements for satisfying conditions of a single use. Therefore, Professor Boley points out, inspection of the structural analysis pertaining to an airplane or a missile should reveal such design considerations. In his opinion, no single item in air frame

production would be sufficient as a single critical element to reveal easily an attempt at illicit manufacture. Nevertheless, in his estimate, attention to the details cited above, in combination, yields useful information for the detection of possible clandestine production.

Propulsion Systems

The availability of alternative propulsion systems is a leading characteristic of the power plants for high-performance aircraft or large missiles. Professor Henry Burlage, Jr., indicates that the development of such power plants would probably afford important strategic areas for inspection purposes. However, if an effort at clandestine production were to involve utilization of an already proved design, this area of inspection could not be relied upon as useful. In the case of the turbo-jet engine, for example, many of the components are traditionally supplied by subcontractors, while the prime contractors carry out what is mainly an assembly and test function. In the case of the ram-jet propulsion systems, the manufacture of components does not appear to offer clearly defined points for inspection since many of the parts involved are essentially non-precision in character.

Liquid fueled rocket engines offer a number of possibly appropriate inspection points. These include special pumps and turbines for the propulsion system (implying light weight), capable of handling extremely low temperature and/or highly corrosive materials; special valves, able to withstand similar conditions; special heat resistant materials like ceramic oxides, graphite, cermets, processes involving coatings of chromium-nickel, and other combinations of heat-resistant alloy materials; special types of equipment, including light-weight, high-capacity refrigeration units, and the like.

The solid-propellant rocket has been extensively developed for military purposes. Professor Burlage indicates that this engine seems to be a difficult one over which to exercise inspection, owing to the essential simplicity of the unit and the possibility that the components might be manufactured by a considerable number of firms.

Professor Burlage also indicates that certain classes of indirect specialty items and processes involved in the manufacture of propulsion systems might be useful inspection points—the apparatus and methods used to produce extremely small holes of great uniformity. He estimates, however, that such techniques might be utilized in industries far removed from the manufacture of air-borne propulsion systems.

Altogether, in the opinion of Professor Burlage, the true strategic type of inspection point is difficult if not impossible to establish in the propulsion systems industry. Instead, a variety of possible inspection points is suggested, and stress is laid on the importance of each being open to review on the basis of developing technological alternatives.

Fuels

In his paper reviewing long-range missile propellants, Professor Charles J. Marsel explains why, in the main, fuels do not offer likely areas for disarmament inspection. Liquid fuels, as well as many solid fuels for rocket purposes, have been produced primarily from materials that are available in great abundance and are utilized as common articles of commerce—such as combinations of liquid oxygen-gasoline, liquid oxygen-alcohol, and concentrated nitric acid-gasoline. Similar considerations apply to the solid fuels, which can be produced from common chemicals like glycerine and nitro-cellulose. Since such materials and others used in association with them in solid fuel propellants are common chemicals of commerce, it would be extremely difficult, in Professor Marsel's opinion, to detect their diversion into possible clandestine missile applications.

Finally, there is the class of so-called "exotic" ultra high energy-to-weight fuels which require the utilization of chemicals such as dimethyl-hydrazine and the high-energy class of boranes. Such materials have been utilized uniquely as high-energy fuels. Accordingly, this class of materials constitutes possible inspection points for monitoring purposes.

Detection of High-Altitude Missile Tests

At this writing, long-range missiles are being intensively developed in several countries. One of the possible aspects of international disarmament agreements is a prohibition of the development of missiles for military purposes. For this purpose it would be useful to have highly reliable methods for detecting missile tests, which form a critical aspect of their development and production.

The paper by Dr. D. G. Brennan sets forth the basis for a rather reliable system for detecting tests of long-range, high-altitude missiles. Radar instruments of moderate requirements at a network of stations

could monitor such launchings on a world-wide basis. Indeed, the spacing requirements between such stations are such that this equipment could probably be combined with the instruments for bomb-test detection that are recommended by Professor Orear. If Orear's stations were used as a base line to be supplemented for the purpose of detecting missile tests, the result would be a radar network more closely spaced than would be necessary according to Dr. Brennan's estimates. By these methods it would be virtually impossible to carry out secret launchings of long-range, rocket-launched missiles, or of space vehicles. The same radar network would supplement the bomb-testing detection methods indicated by Professor Orear, by detecting the vehicles used for mounting bomb tests at high altitudes.

Finally, it is significant that the proposed equipment for detecting missiles could also be made to serve the needs of world-wide monitoring of aircraft for the purpose of air traffic control.

From the viewpoint of capability of inspection, the components of large guided missiles clearly offer a variety of possibilities. The reader's attention will now be turned to another class of weapons—those involved in biological warfare.

BIOLOGICAL WARFARE

While public attention has been focused primarily on the destructive power of long-range guided missiles, sustained research and development has been carried out on another class of weapons whose destructive power may very well be as extensive as that of nuclear explosives. The public record on biological warfare reveals that the major countries of the earth have operated, during the last decades, substantial secret laboratories for the development and testing of biological warfare methods, including the development of chemical, bacterial, and viral agents for attacking human beings directly, or for affecting human life indirectly through attacking plants or animals.

Professor Vincent Groupe points out that the research and development phase of biological warfare involves the utilization of methods, equipment, and personnel altogether similar to those utilized for medical and basic biological researches. Because of this, it is difficult to identify laboratories working on biological warfare methods on the basis of such gross indicators as the main equipment being used.

Other aspects of biological warfare technique offer different possibilities. Thus, the large-scale production of virulent organisms would require equipment and operating techniques whose features could not be inferred from the experience of small-scale laboratory bench experiments. Special equipment, facilities, and techniques are needed for safe handling of masses of virulent material. Further, the handling of virulent material also involves problems of disposal of such material as waste. This would call for special, large-scale, incinerator units and other sterilization equipment whose construction, presence, and operation also constitute a relevant inspection point.

Dr. Groupe also indicates that extensive tests under field conditions are needed to test biological weapons for destructive effect. Large operations are involved and extensive measures would have to be taken to prevent the spread of pathogenic organisms outside of proving grounds. Therefore, it may be inferred that the existence of large, specially guarded areas, and extraordinary precautions for the exclusion of outside persons constitute appropriate inspection points.

Unfortunately, analysis of a sampling of the working materials of a biological laboratory, to detect whether or not it was engaged in biological warfare research, could easily result in a false conclusion. Thus, negative test results would normally be taken to indicate the absence of a given bacterium, virus, or fungus and would "clear" a particular laboratory. But highly virulent pathogens are almost invariably cultivated on culture medium specifically developed for that particular substrain, and the lack of knowledge of that medium would result in failure to detect that pathogen.

The available knowledge certainly does not exclude the possibility that some biological warfare weapons could be developed, even in a small country with relatively limited laboratory and manufacturing facilities, to serve as a "poor man's atom bomb."[10]

The weapons of biological warfare, in the opinion of this writer, should be given continuing and close attention from a disarmament standpoint. The capabilities of biological weapons have been underplayed as against the more spectacular aspects of nuclear weapons and long-range missiles.

10 Some of the men who have been engaged in biological warfare research have attempted to sound an alarm to the general public concerning the potency of such weapons. Dr. Theodor Rosebury, in his volume *Peace or Pestilence* (New York: McGraw-Hill, 1949), has estimated the destructive potentialities of biological warfare weapons. Rosebury has drawn extensively on the published literature in this field.

METHODS OF CLANDESTINE PRODUCTION

An important aspect of the feasibility of inspection for disarmament is an assessment of the possibility and efficiency of clandestine industrial production methods. Accordingly, an effort was made to discover the characteristics of successful clandestine weapons production. Two papers were prepared to record such experience. One deals with the experience of Germany under the Weimar Republic. The second paper is based primarily on the experience of the Jewish underground army during British rule in Palestine.

The papers prepared by Professor Gumbel and Lieutenant Colonel Rivlin both reflect the critical conditions for the successful operation of clandestine industrial production of weapons. These conditions may be summarized as follows:

A. A group of men exists which is prepared to carry out the clandestine production even at the cost of considerable personal sacrifice and risk. These men have strong allegiance to a guiding ideal.

B. The central working group is backed by a substantial part of a population, including a government or quasi-government, which backs up the operating groups and shields them from the inspecting authorities.

C. The operators of the clandestine production system learn how to simulate appearances that will seem to be ordinary and innocent in the eyes of the inspectors.

In the case of Palestine, a population under alien rule backed a secret army and its armament system. These operated with a high degree of success despite determined efforts, especially after the Second World War, to stop illegal arms production. The Palestine record is made significant for the present study owing to the fact that the inspectorate—in this case the British army, police, and Civil Service—represent a highly experienced, intelligent, resourceful and well-equipped inspecting body. Its members were able to carry out systematic and extensive inspection on roads, at airports, and at seaports. They were also able to carry out house-to-house searches under curfew conditions.

The arms produced included small arms, as well as small automatic weapons, and grenades. The largest weapons produced locally were three-inch mortars, as well as mortar shells. Illegal transportation into the country included heavier weapons.

An intelligent, skilled inspectorate did not discover more than one percent of the illegal arms produced in that small country or imported from abroad. Moreover, this inspectorate, operating in a relatively small land area, was unable to stop shipments of arms, first small- and then large-scale (truckloads), within the country. The inspectorate was unable to stop the operation of a fairly extensive network of workshops, whose staffs ranged from a handful to over a hundred workers, which kept a constant flow of small arms moving to the illegal army.[11]

A network of factories, storage areas, and transport systems, labor supply, internal security, and financial control, as well as modest research efforts for the design of weapons, were all organized on an underground basis. Headquarters were operated in camouflaged premises, whose appearance was that of ordinary business offices.

An on-the-spot check by this writer yielded an abundance of testimony from former operators of the clandestine production system. Over a period of about twenty years an elaborate body of technique was developed to handle problems ranging all the way from organization methods to ways of camouflaging truckload shipments of weapons.

Training in the use of weapons, communications, and transportation among arms plants and military units were all artfully organized. Underlying the success of ingenious devices for simulation, there was the strong popular backing for the clandestine army and its arms production. The strength of public support for the illegal army is contained in the following datum:

While it is not excluded that there were some agents of the inspecting government inside the clandestine organization (Hagana), this writer was advised that no proven case of such an agent was known to the leaders of the underground.

As a result of strong public backing for the clandestine army, the inspectorate was confronted with a virtually impenetrable social solidarity against which devices of technical inspection were of little avail.

In Weimar Germany the operators of the illegal armament system were surrounded by a population that was itself partly hostile to their

11 It may be noted that the task of the British was somewhat different from the objective of an international inspectorate. The British were trying to locate a production system, whose existence was at least suspected. That knowledge, however, was not necessarily sufficient to prove a case. Presumably, an international inspectorate would have to gather enough information to prove or disprove violation. From an international political viewpoint, of course, suspicion could be important in its own right.

endeavor. In addition, they had to cope with the inspection efforts of varying intensity that were exerted by the commissions of the Allied military powers.

Notwithstanding the substantial differences in locale and surrounding conditions, the data available to this writer indicate that the three major conditions for the successful operation of clandestine industrial production were operative in Weimar Germany. An inner core of men was moved by nationalist fervor to carry out the operation of illegal rearmament. These inner groups were backed by at least a substantial portion of the general population, and any assistance that was given to the inspectorate of the Allied military powers was popularly viewed as an act of betrayal. Finally, apart from the extensive armament production carried out in Russia and elsewhere on Germany's behalf, there were fairly extensive efforts for the production of armaments in Germany by clandestine means. This involved the use of varied devices of concealment, including partly camouflaged "open" factories in which arms production comprised but a part of the work. There were also underground units, physically concealed from the view of possible inspectors. Moreover, ingenious devices were developed for storing arms that were illegally produced. These included underground inventories and storage of arms components in hollow walls of buildings, as well as storage of arms in "floating inventories." A "floating inventory" consisted of a packaged unit of weapons that was kept in motion through the freight system from one shipping point to another. Thereby the freight transportation system became a mobile "warehouse" for clandestine military materials.[12]

Industrial Secrecy and Clandestine Production

There is another mode of clandestine production, so commonplace and ordinary that it is never designated as such. That is the practice of organizing production so that the people working, for example, on parts of a machine or process do not know the nature of the product—the whole machine, or the end-product—of a production process. Such practices are widely known in ordinary industrial and commercial activities.

The prevailing acceptability of such practices could be utilized

12 It has been suggested that "floating factories" are also conceivable. Commercial-type vessels might carry ordinary cargo, as well as a working industrial plant, or a secret arms inventory.

by the operators of a possible clandestine production organization for armaments. Indeed, the famous Manhattan Project of the Second World War, which secretly organized atom bomb production in the United States, involved extensive application of this technique. Broadly then, the prevalence of security systems in ordinary production (a kind of normal "underground") offers an opportunity for possible application to efforts to evade an inspection system.[13]

The Critical Role of Government

In the case of Weimar Germany and the Jewish community under the British mandate, the illegal arms production was directed and shielded in each case by a governmental body. In the case of Germany, as Professor Gumbel points out, the government of the country organized the clandestine operation under its auspices. In the case of the Jews in Palestine (under the British mandate), the governmental body consisted of the "shadow government" to which the Jewish population gave strong allegiance. This "shadow government," whose legal instrumentality was in the Jewish Agency for Palestine, included the directorate of the illegal Jewish army.

In the judgment of Professor Gumbel, complicity of a government or of part of a government is a necessary condition for the operation of extensive illegal arms production. The facts of the case in Weimar Germany and Palestine bear out his contention.

Certain characteristics of the armed forces of a country are also important factors. Thus, the possibility of evasion is facilitated by a national tradition which makes the military a large, autonomous community of weapons producers or weapons possessors. The existence of such a "state within a state" would be a threat to a system of disarmament at the very outset.

The efficiency of the techniques of clandestine industrial production is critically important for assessing the feasibility of inspection for disarmament. The largest part of the public discussion concerning inspection for disarmament has focused on various aspects of physical inspection, including inspection of transportation facilities, inspection of military installations, and the like. Given the necessary conditions

13 This indicates the importance of the requirement by the inspection agency that all participating governments submit a list of locations and facilities in which there is activity which, whatever the reason, is regarded as confidential to the government.

cited above, it should be possible to evade, with substantial success, monitoring systems over production whose control points are the products, raw materials, production equipment, work-in-process, and the like—while not relying on securing information from the people doing the work. (Note, however, the important cases of inspection feasibility for nuclear bomb testing and for high-altitude missiles testing.) The implications of this conclusion will be developed in the sections, "Strengths and Weaknesses of Inspection Methods" and "'Inspection by the People.'"

INVENTORY VALIDATION

Secret stores of arms, set up before extensive inspection is begun, are a possible device for evasion of a disarmament agreement.

An international inspectorate might ask each of the governments which have signed an inspection agreement to declare their holdings and the locations of certain critical military items as of the first day of an inspection scheme. Let it be assumed that such declarations are duly submitted to the inspectorate. One of the most difficult problems confronting an international inspectorate would be that of verifying the correctness of the declared statements. Here the key problem is: Are there additional quantities of the indicated materials available elsewhere? Could these quantities be large enough to make a significant difference with respect to the military prowess of the country in question?

This type of problem might be expressed in terms of certain missile components. Then the question could become: Is the declared inventory of atomic warheads accurate? Is it possible that additional atomic warheads, beyond those formally declared, have been secreted in concealed stockpiles in order to provide destructive power for a potential clandestine missile striking force? Similar questions could be formulated for other missile components.

A brief discussion of various approaches to this type of problem will indicate its characteristics, and the difficulties that are involved.

If the relevant classes of military hardware include costly items, then it may be assumed that, in the normal course of events, detailed records have been kept to account for their production, receipt, and transfer. Moreover, such military material is normally serial-numbered.

An example of the requirements of military routines may be found by examining the relevant regulations of the United States Army covering property accountability.[14] If large military organizations operate rather similarly in these respects, then one would expect to find regularly operated detailed procedures to provide accountability for costly military equipment.

Nevertheless, the existence of such regular procedures does not exclude the possibility of attempts at wholesale double bookkeeping, and forgeries of production records, serial numbers, inventory records, and the like. To be sure, there are various problems involved in carrying out such forgery. Thus, there is a requirement for consistency which may well be difficult under conditions where property undergoes many transfers. Also, there are ways of testing the alteration of records and the age of papers and inks. Still, reliance on methods of records checking does not afford a firm basis for verifying the correctness of a declared inventory.

Estimating Past Output of Industrial Plants

Another approach to the problem of verifying inventory declarations is available through the technique of relating the output of an industrial plant during an observation period to a number of particular physical inputs used in production. An equation may thus be derived which relates inputs to output. Earlier records of some physical inputs -say, water or electric power—could be entered into the equation to estimate earlier levels of production. Such a method involves, among

"A reading of AR 735-5 discloses the detailed requirements for record-keeping involved in standard U.S. Army practice. Additional details will be found in the following list of published Army Regulations available from the U.S. Government Printing Office.

No.	*Title*	*Date*
AR 735-2	Transfer for Property Accountability and Responsibility	9 June 1955
C 2, 3		
AR 735-3	Receipt, Shipment and Issue of Property	17 Nov. 1954
C 2		
AR 735-5	General Principles and Policies	20 Dec. 1954
C 1,2,3,4		
AR 735-7-1	Property Procedures	27 May 1953
AR 735-11	Accounting for Lost, Damaged or Destroyed Property	6 Apr. 1956
C 1		
AR 735-18	Disposition of Army Property Records	28 Sep. 1956
AR 735-60	FIA, General Principles and Policies	4 Jan. 1955
C 2		
AR 735-71	Accounting Policies—Industrial Property	2 Mar. 1956

others, the assumption of similarity in the production system through the period reviewed. The preferred input elements for this purpose should be of a sort that are routinely, perhaps even automatically, recorded during the course of industrial plant operation. Accordingly, the problem was formulated: Is it possible to estimate the past output of an industrial plant on the basis of measured relations between input and output of the particular plant during a limited period of time? If that were possible within the limits of acceptable error, then estimates of past production could be compared with the inventory declarations, made by governments which have signed a disarmament agreement.

An effort was made to carry out an experiment to test the feasibility of measurement and estimation along these lines. The work was done in a midwestern (U.S.) plant manufacturing a precision motor-driven product. The management of the firm gave generous cooperation in this experiment, which is reported in the paper by Professors Derman and Klein.

The report of this effort in estimating past industrial production indicates that the error involved could very well be larger than the tolerable error for checking the accuracy of a declaration of stockpiled weapons.

There are other conceivable pitfalls in such techniques, as indicated by Professors Derman and Klein. Thus, if an unrecorded but steady proportion of finished products were regularly withdrawn from a plant over a long period of time, it would be difficult to detect either that fact, or the magnitude of withdrawal, by the type of statistical technique used. Another source of error in such analyses stems from the instability of production systems. Thus, in the plant that was available to the writers for this experiment in estimation of past output, there has been a sustained growth in labor productivity during the period reviewed. This effect resulted from many detailed changes in the method of production, a feature that is found in virtually every industrial plant of size.

During recent years various writers have called attention to the problem of concealed inventories. Thus, if the production of atomic warheads had long proceeded on a large scale, and if methods of accountability of materials allowed for even a small percentage of error, that percent, applied to a large output, could leave dangerous quantities of fissionable materials unaccounted for. There is thus real danger of a pre-inspection head start in any area of production that is important militarily.

The available knowledge of production systems does not afford a clear basis for a check on past output through the analysis of factory input-output relations. Nor can various routine records be regarded as a firm basis for monitoring—owing to possibilities of unrecorded withdrawals from production or forgery of records.

The Labor Force Factor

All of the critical armaments production has another aspect which contains possibilities for control by inspection. The 20,000 to 30,000 components contained in large missiles must be fabricated, tested, assembled, packed, loaded, transported, unloaded, and stored. All of this activity necessarily requires the participation of many thousands of people, which leads to the problem: How can the manpower factor in arms production be turned to account for discovering current production as well as concealed inventories of weapons? One aspect of this question is the monitoring of scientific personnel. Appropriate sampling methods can be applied here to check on the current use of people with talents that are critical for weapons development and production. Another aspect of the manpower factor in arms production is the problem of how the inspectorate could benefit from the information that is in the hands of the arms producers. This question will be considered in the section, " 'Inspection by the People.' "

STRENGTHS AND WEAKNESSES OF INSPECTION METHODS

The central problem of this section will be to assess the capabilities and limitations of the various inspection methods reviewed thus far. In the light of this assessment an effort will be made to define the requirements for compensating for indicated areas of weakness in various inspection methods.

Area of Inspection Strength

The very size of a clandestine production project involving 200 to 400 large missiles is a strong point, favoring an inspection effort. The estimated number of man-years required to produce these units ranges from forty to eighty thousand. Other elements of the production problem include the variety and the high levels of technical skills necessary to carry out the production task. Clearly, the assembly of these skills at a central point, or their orderly integration at widely dispersed locations, involves a large-scale production effort. Such a production effort is attended by very many problems when carried out normally, openly, and without complications arising from an effort to evade an inspectorate.

Under conditions of clandestine operations, the problems of integrating large work forces, assembling materials, equipment, and the like, would call for extraordinary feats of organized ingenuity and highly disciplined group secrecy.

A related aspect of the production problem is the sheer size of the product itself. The Redstone Guided Missile of the U.S. Army is announced as a unit 63 feet long. The power plant and fuel tanks account for 34 feet, and the control system and warhead for 29 feet. The missile has been reported to be divided into these two units for purposes of over-the-road shipments to launching sites for test areas.[15] Another indication of the size of the production facilities for the manufacture of large-scale missiles is given in a recently published photograph of a new missiles plant on the outskirts of San Diego, California. It is described as a $40 million industrial plant.[16]

Clearly, any clandestine effort to reproduce industrial plants of this size, either in central locations, or in decentralized form, would involve unusual feats of construction and organization. Thus, an effort to assemble critical types of machinery for such production would involve almost insuperable difficulties if certain machine-producing plants were closely monitored by an inspecting group.

Aerial inspection methods have considerable strength for monitoring the kinds of preparations for invasion that require the massing of thousands of men and vehicles.

The clandestine production of atomic warhead materials might be attempted by way of the refueling operations of power reactors. Such units, however, could be subjected to close inspection control.

The mechanical components of large missile guidance systems offer important strategic opportunities for inspection purposes. The same can be said for certain aspects of air frame production. The

15 *American Machinist,* November 4, 1957, p. 173.
16 *American Machinist,* January 13, 1958, p. 153.

rocket motors that are used in large missiles suggest certain possible critical points. Finally, successful clandestine testing of major nuclear explosives is probably impossible.

The testing of high-altitude missiles and of nuclear warheads can both be placed under effective control by monitoring the relevant physical phenomena with appropriate measuring instruments. The reliability of the monitoring techniques for these purposes make them appropriate as areas of agreement for the early stages of international disarmament agreements.

The preparation of materials for biological warfare may be monitored, owing to the specialized character of the equipment and staffs that are required for such work. The staffs must Include highly trained bacteriologists, virologists, and the like, and they would require an array of special equipment for handling masses of virulent material, even at the experimental level. An intelligent statistical sampling plan could be used to inspect the relevant laboratories and Industrial plants.

The Strength of Combination

The total strength of an inspection system would necessarily depend upon a many-sided approach to the inspection objective. Each method of inspection has its limitations. The limitations of each method, however, are not in the same areas, or of the same degree. Therefore, a many-sided approach to the detection of clandestine production has a cumulative strength that is not revealed in any one method viewed in isolation. Thus, aerial inspection could yield certain Indicators which need ground follow-up. A report of a suspicious accident would be followed by a demand for access to the premises and the people involved. Characteristics of a budget system, themselves uncertain in meaning, become useful if it is possible to follow them up by appropriate inquiries. The general point Involved here is formulated by Professor Boley in his paper: "It is ... unrealistic to hope to find a single item to be used as a sole criterion of clandestine operations. It is rather necessary to search ... a number of separate components for possible adverse evidence, final proof of malpractice being provided by the weight of accumulated discoveries."

These elements of strength on the side of an inspection system oriented towards inspecting materiel must be contrasted with the weaknesses that apparently inhere in such an inspection system.

Weakness of Inspection Methods

There is no escaping the fact that several technical papers disclose gaps in inspection feasibility.

Aerial surveillance methods are definitely useful, but not for locating already existing mounted missiles, ready for firing in well-concealed positions. Budget controls for individual countries may not be regarded as reliable devices because of the possibilities for large-scale concealment of end uses of funds. There are alternative kinds of electronic guidance systems. Also, such systems can often be built from readily available components.

Fuels and rocket motors do not appear to offer crucial inspection points owing to the variety of possible fuels and the alternatives available for rocket propulsion in this very fast developing area of technology. This estimate may prove to be overly conservative if, for example, future rockets require special high-energy fuels that utilize materials uniquely appropriate for this purpose.

In the absence of a major development in the relevant techniques, it is necessary to conclude that the problem of validating a declared Inventory of past production, on the basis of materials accounting, remains substantially unsolved. Indeed, the prospect that there may be concealed inventories of weapons, while governments are dominated by an "evasion mentality," may lead to international agreements, at least at the earlier stages of disarmament, which control production but permit and register caches of arms.

There are also problems resulting from the methods of clandestine production. The possibilities of this class of techniques must be treated with the greatest respect in assessing the feasibility of an inspection system. The types of techniques which have been reviewed above are reinforced under certain patterns of working. Thus, in many sectors of American industry, it is common for people to work on projects, the end use of which they do not know. Frequently such knowledge is withheld from the people working on a project as a matter of policy by a given management. Nevertheless, where there is a tradition of producing machine elements to be used in equipment of unknown performance, that pattern of working fits in neatly with the requirements of clandestine production activities.

Finally, it is necessary to call attention to the range of powers in the hands of a modern government which can be used to facilitate clandestine industrial production desired by that government. The data reviewed in the cases of Germany and Palestine are illustrative of a situation in which strong ideological commitments of large parts of the population could be drawn upon by the government. It is also necessary to take into account the circumstances where a government uses terrorist methods in relation to its population as a regular policy. Under these circumstances no ideology possesses independent force. Such a government could conceivably compel compliance with or nondisclosure of a clandestine production activity, even in the face of bad feeling and resentment in the population toward such a program.

In this assessment of limitations of inspection, a most conservative view has been taken. The fact is that each of the difficult areas for inspection could nevertheless be subjected to monitoring on a sampling basis. Such methods, if properly designed and executed, could operate as major deterrents of clandestine operations in each of the areas where particular, critical check points of a limited number are difficult to specify. Professor Herbert Solomon's paper on sampling methods for use in inspection for disarmament demonstrates some of the reasonable possibilities of such methods.

"INSPECTION BY THE PEOPLE": MOBILIZATION OF PUBLIC SUPPORT

A method is needed to compensate for weaknesses in inspection techniques which are traceable to capabilities of clandestine production organization and the availability of many technological alternatives for achieving a given result. Limitations of these kinds are inherent in an inspection system which places primary emphasis on the inspection of physical things. The writer suggests the following design for coping with this problem.

There is a common feature of any organized production effort to evade a disarmament inspection system, and that is the participation of a large number of people. This has been characteristic of previously successful clandestine production operations. The participation of many thousands of people hi the direct production tasks would certainly be a necessary feature of any attempt to produce a few hundred large ballistic missiles on a clandestine basis, for example. The same condition is necessary in any attempt to produce "conventional" armaments in large numbers. Many people would also be required to emplace secret

weapons systems or to create secret inventories of arms during the early stages of international disarmament agreements. Because of the number of people required, defection by even one man from a clandestine effort would reveal its existence and disclose aspects of its character.

Another feature of the manpower requirement for clandestine production would be the diversity of occupations whose participation would be essential. The technical skills needed to produce and to operate large scale missiles cover almost the whole spectrum of skilled industrial, technical, and scientific occupations.[17]

From this viewpoint the problem may be posed: How can the manpower requirements for a major clandestine production effort be used to strengthen the possibilities of inspection for disarmament?

Inspection by the people is a method that would serve this purpose. In addition to the specific monitoring activities of the inspectorate, it would be invaluable to have a randomly distributed network of inspection that is based upon public support for inspection for disarmament. Such public support could reinforce the work of the inspectorate and could help to undercut evasion efforts that require substantial organizations and widespread production systems. The operation of effective world-wide inspection by the people would be facilitated if the disarmament agreements included provisions which made it a duty, an explicit obligation, of the citizens of participating countries to report violations to the international inspectorate.

In order to implement inspection by the people it would be necessary to establish regular channels of communication to and from the population.

Communication to the Population

The channel to the population would extend from the international inspecting organization and could consist of agreements to make available minimum amounts of radio and television time, newspaper space, and the like. Members of the inspectorate could participate in the work of universities and similar institutions of the country where they are stationed.

17 It should be noted that the armed forces of large countries now include a substantial part of the technical skills of civilian society at large. These men in the military are under a kind of disciplined control that could be used in an attempt to operate a secret production system under an inspection agreement.

The central theme of the inspectorate's communication to the population would be that the international agreement is mankind's shield against mutual extermination and that a violation of this agreement is thereby a crime against humanity. The development of an understanding of this message would secure the commitment of populations to these ideas, and would thereby supplement the formal agreements among governments.

Education along such lines, carried out on a world-wide basis, could very well have the effect of making untenable the position of any government, or group of officials, found guilty of violating the disarmament agreement.

It has been suggested that the degree of success of inspection by the people would probably depend on the success of communication and education in encouraging more openness of personal expression in various countries, so that public opinion would indeed be a factor for governments to reckon with.

An additional feature of such international agreement would be provisions for guaranteeing the security of people who cooperate with the inspectorate. This means, for example, that people who report on clandestine industrial production to the inspectorate must be guaranteed, automatically, the protection of the inspectorate. This could very well include provisions for facilitating the movement of people between countries, as well as provisions for affording temporary local security of persons. Violation of the agreement might very well have to be handled within legal systems set up outside existing national frameworks. The design of the alternatively possible judicial and allied legal aspects of punishment for violation requires detailed analysis by the legal profession.

Apart from clear-cut violations of an agreement, there may be problems of defining enforceable standards of official uncooperativeness. To be sure, the very possibility of such problems may be affected by the changes in political atmosphere that could result from the gradual introduction of steps toward disarmament.

Communication from the Population

Open channels of communication from the population to the inspecting organization are critically important.

The inspectorate would request the population to report to it any

evidence of activity in violation of the disarmament agreement. For this purpose it would be necessary to establish and maintain a channel of communication to the inspectorate which would lend itself to constant inspection for reliability. The postal system, for example, might be well suited in this respect. The postal system could be subjected to constant tests by the inspecting organization. It would be possible to mail letters and packages in a constant stream from various parts of the country, addressed to the publicly announced address of the inspectorate in the capital city. Any evidence of tampering with or nondelivery of mail so posted would alert the inspectorate to some form of clandestine activity against the inspecting organization. Use should be made of the chemistry of inks, papers, and adhesives in coping with the problems of devising appropriate envelopes or other containers for the test mail.

In public statements the inspectorate would elaborate on the kinds of things which constitute indicators of clandestine activity. These would include: the production of materiel; the operation of certain processes; the utilization of certain machines; the production of components to particular kinds of dimensional tolerances (as for precision gyroscopes), or for certain strength and temperature requirements (missile *air* frames). The attention of the population would also be called to such possibilities as the use of workshops in educational institutions for the production of military components, or the camouflaging of research laboratories. Accidents of certain kinds would be evidence of clandestine activity.

The burden of the present argument is that in order to cement an agreement among governments it is invaluable to develop understanding and allegiances that cross national boundaries. Widespread allegiance to ideals of peaceful living and humanitarian methods would undermine the nationalist appeals of any major effort to evade a world-wide disarmament agreement.

Only a few of the numerous parts of an evasion effort would have to be discovered. Therefore, the readiness of rather few people to disclose secret rearmament would be a most powerful adjunct to the work of an international inspectorate which could follow up its findings to check on evasion attempts. Similarly, the knowledge that such disclosure is possible would be a deterrent, in some measure, to clandestine arms production.

Public Opinion on Inspection by the People

Owing to the possible importance of inspection by the people, an extensive effort was carried out on behalf of this study by Professor William Evan of Columbia University, to discover the attitude of the population in several major countries to this question. National surveys of public opinion were made in six major countries, mainly by Dr. George Gallup's American Institute of Public Opinion and its affiliates in other countries.

Three major questions elicited extremely interesting and Important responses.

To the question, "Would you favor or oppose setting up a world-wide organization which would make sure, *by regular inspection,* that *no* nation, including Russia and the United States, makes hydrogen bombs, atom bombs, and missiles?" replies of the following percentages of the population were in favor:

United States	70 percent
Great Britain	72 percent
France	85 percent
West Germany	92 percent
India	78 percent
Japan	91 percent

To the question, "If this inspection organization were set up, would you favor or oppose making it each person's *duly* to report any attempt to secretly make atom bombs, hydrogen bombs, and missiles?" replies of the following percentages of the population were in favor:

United States	73 percent
Great Britain	54 percent
France	74 percent
West Germany	86 percent
India	71 percent
Japan	80 percent

To the question, "If you, yourself, knew that someone in (name of country) was secretly attempting to make forbidden weapons, would you report this to the office of the world-wide inspection organization in this country?" replies of the following percentages of the population were in favor:

United States	80 percent
Great Britain	50 percent
France	63 percent
West Germany	73 percent
India	63 percent
Japan	83 percent

The full report of this work, and the names of cooperating organizations in each country, are given by Professor Evan. At this point, it will suffice to examine the main results, showing the proportion of the people in each country who responded favorably to the key questions.

A majority of the people in each of the six countries polled favors inspection for disarmament, and declares itself prepared to cooperate within a setup of inspection by the people. This statistical summary is of greater interest when certain details of Professor Evan's paper are examined, such as the tabulations of opinion according to occupational groups and political allegiances.

The response of scientists and professional engineers is of special interest because of the critical importance of their work for the design and production of intricate weapons. Taken together, from all six countries, scientists and engineers favored the proposals in the opinion poll more strongly than the population as a whole.

What is the meaning of such opinion data for predicting the possible behavior of people? It is not possible to predict that the same proportions of people would, in the future, actually act in the way that they now say they would. Nevertheless, if the proportion who would act were even half of those who now favor inspection by the people, that would still be a source of massive support against clandestine military activities. Seen in another way, the poll data show that in the six countries there exists the kind of extensive public backing for reporting attempts at evasion of disarmament which could have frustrated the clandestine military activity in Weimar Germany and in Palestine (see the papers by Gumbel and Rivlin).

The Soviet Sphere

No comparable data on public attitudes are available for the USSR and its allied countries. Indeed, it is altogether possible, in the judgment of this writer, that the interpretation of such expressions of opinion, difficult as they are in the West, would be incomparably more difficult within the framework of the Soviet system. The conduct of such polls, and especially the ability to make inferences from them about political behavior, involves certain assumptions about a society. These assumptions include the following: that the people are prepared and able to express their own, individual opinions about public, political matters; that political matters are regarded as an open and appropriate sphere of individual action and initiative; that politics is not a government monopoly; that it is conceivable for people to dissent from and actively criticize their governments; that individuals may dissent from government on public policy matters without fear of serious reprisal.

The available information on the Soviet system indicates that such conditions exist, at best, to only a rather limited degree. If that should continue to be so, then the process of inspection for disarmament in such countries could not rely on important assistance from inspection by the people and would have to be based almost entirely upon monitoring by the inspectorate.

Nevertheless, it may be that the presence of an international inspectorate in such countries might open up possibilities for public support of disarmament. Indeed, the repeated invitation for cooperation by means of inspection by the people could very well be a factor in generating an environment in which such cooperation could become a reality.

In the judgment of this writer, inspection by the people, to the extent that it is workable, could be a bulwark of strength in support of technical inspection, filling its gaps and giving all people mutual assurance against violation of a disarmament agreement. Under such conditions, the limitations of inspection of materiel would no longer restrict the efficiency of inspection for disarmament.

SOME IMPLICATIONS FOR CHARACTERISTICS OF THE INSPECTION ORGANIZATION

The characteristics of an efficient inspection system for disarmament suggest certain of the powers of an inspectorate, as well as the characteristics of the inspection staff—its organization and the development of its function.

Powers of the Inspection Agency

The inspection agency must have unrestricted access to places and to people in order to make determinations of possible violations of disarmament agreements. The need for such powers derives clearly from three conditions: the impossibility of predicting the technological alternatives which may be developed for armaments purposes, the difficulty of anticipating the precise means which might be devised for implementing an effort for clandestine production organization, and the possibility of getting maximal inspection strength only through the use of mutually reinforcing methods.

A good example of the consequences from new technologies may be seen in the problem of missile delivery. It has been suggested that submarines may be efficient vehicles for delivering medium range missiles to within a few miles of their target areas. Moreover, it is suggested that such missiles mounted on submarines could very well be fired under water, thereby rendering the problem of detection extremely difficult.[18] Sustained technological change would be an inevitable condition surrounding the operation of an inspection system. As a result, the inspection methods appropriate to any one technology would have to be revised. Under such conditions the inspectorate must have opportunity for flexibility in determining the kinds of places and persons whose Inspection becomes relevant. The papers on techniques of clandestine production suggest that a range of methods can be utilized for these purposes. Moreover, the literature of this field discloses that a virtually unlimited variety of devices can be invented by determined, ingenious people.

The operation of an international inspection agency with unrestricted access would, of course, lead to various legal problems involving governmental, personal, and property rights. These matters have been given extensive treatment in a companion study by Professor Louis Henkin on *Arms Control and Inspection in American Law* (Legislative Drafting Research Fund, Columbia University), in press at this writing.

The code of general law and detailed rules of an inspection organization would have to be well defined. From the vantage point of the

18 *New York Times,* January 26, 1958, Section I, p. 37. This article, analyzing the possibility of submarine and missile combinations, was written by Sir Philip Joubert, a retired Air Chief Marshal of the Royal Air Force.

present study, it may be said that such a legal code would have to be consistent with the requirements of an effective inspection system. This would include, for example, the right of unrestricted access for inspection.

Beyond that sphere, the designers of such a legal code would have to cope with such problems as: drawing clear dividing lines between what is permitted and what is illicit; who shall make such determinations—the inspectorate, the member states, international courts, etc.; determination of whether responsibility for violation shall be individual or collective (i.e., the problem of individual responsibility of government officials). In order to adapt an inspection system to changing technology, it may be necessary to agree on ways of handling new weapons devices that may be developed. A strong case, for example, may be made for specifying that power to redefine what is illicit activity should reside with the international authority. Otherwise, a given country might attempt to define inspection points in terms of a particular (perhaps soon obsolete) technology. These and allied problems require extensive study and the formulation of alternative solutions that would serve the progressive introduction of disarmament and the allied inspection process.

The Problem of Commercial Secrets

Industrial managements have sometimes called attention to the problem of preserving commercial process secrets under an extensive inspection system. There is evidence, however, that industrial technical eminence is based not on the holding of particular bits of information, but rather on the ability to produce new knowledge. Thus, the operation of substantial research facilities rather than the possession of certain technical "secrets" has become the keystone to the maintenance of industrial technological distinction. Nevertheless, the problem remains: How to adjust the pattern of commercial secrecy to the operation of a disarmament inspectorate.

To be sure, another class of interests is also involved: the protection of commercial information. For this purpose, however, one must rely on the characteristics of the international inspectorate and the checks on inappropriate activity which could be built into an international organization carrying out inspection for disarmament.

Characteristics of Personnel for an Inspection Organization

The staff of an inspection organization must be drawn from many countries. Inspection groups of a multinational character would have the effect not only of giving political reassurance in many cases, but also of supplying a necessary ingredient for making many types of clandestine evasion exceedingly difficult. Thus, the evidence available to this writer indicates that many techniques of clandestine armament production have depended on the ability to adjust behavior so as to suit the expectation of the inspectorate.

In one case a small arms-producing operation was located in the midst of a leather tannery which consistently produced a normal odor so obnoxious to the inspecting officers that they would not think of entering the premises. The same principle has been utilized repeatedly. Broadly, the point is that an appearance of normality, according to the criteria of one culture, will not have the same force when viewed from the standpoint of another pattern of living.

The personnel of the inspectorate must consist of men of substantial technical competence; they must be well paid, given tenure, and accorded prestige for their work.

Part of the inspectorate could be a permanent staff, part of it a rotating staff. Furthermore, the location of inspectors in various countries could be varied on the basis of random selection, within the limits of assuring a certain minimal degree of international representation in each country.

For people who come from various technical occupations, participation in the international inspection organization could be made into a professional opportunity as well, even though their main work would be the operation of a system of technical monitoring. Access to, and participation in, activities of their profession could be arranged in any country in which they were stationed. The inspection organization could arrange for the use of laboratories and other facilities by its scientific personnel in the various countries. The inspectorate could also operate its own research facilities, if deemed necessary, for the sustained training of its own staff, or to carry out special research. Such arrangements would help to secure the services of high-caliber people in the relevant fields of knowledge and technique. This activity would also facilitate the international exchange of scientific personnel and understanding.

Certain areas of technological development would be of special interest to an international inspectorate, including, for example, researches leading to the improved accuracy and reliability of many classes of measuring and controlling instruments, and the development of new methods and techniques for various detection functions.

An international inspectorate for disarmament must be composed of people who would act vigorously, pursuing their work with enthusiasm and imagination. In all the industrialized countries of the world there are substantial numbers of people with special competence for this purpose.

It should be possible to recruit a first-rate staff to carry out the functions of the inspectorate. Various opinions to the contrary were offered to this writer. In order to gauge the condition in this sphere, a questionnaire was sent to all professors and instructors in the Faculties of Pure Science, Engineering, and Political Science of Columbia University. More than half of those solicited replied to the questionnaire. The following were the main responses.

*POLL OF COLUMBIA UNIVERSITY FACULTY ON AVAILABILITY FOR INTERNATIONAL INSPECTION FOR DISARMAMENT SERVICE **

	Percent Answering Yes
Would you consider a two-year appointment to an international inspectorate?	68
Do you think your colleagues in other schools would consider a two-year term?	65
Would you be prepared to be a permanent member of such an international inspectorate?	16

* This poll was taken in March, 1958.

The reasonable inference to be made from the Columbia University faculty poll is that highly trained men in many fields of knowledge at American universities would be prepared to consider tours of duty on an international inspectorate for controlling disarmament. In this writer's estimate, men in industrial and government employment would be even more readily available for these functions.

Manpower Requirements for Inspection

To estimate, however conservatively, the number of people needed for various kinds of inspection for disarmament, a set of staff estimates has been prepared for major inspection methods. These estimates are for field technical staff, and are based on the United States as the area for inspection. Administrative staffs are not included.

The inspection areas included here are of two types: those requiring 100 percent inspection (an inspection staff at each plant), like nuclear reactors; and those which could be monitored by means of sampling inspection. The paper by Professor Herbert Solomon indicates a workable method for designing a scheme of sampling for this purpose.

ESTIMATES OF THE NUMBER OF PEOPLE NEEDED FOR POSSIBLE ASPECTS OF INSPECTION FOR DISARMAMENT WITHIN THE UNITED STATES

Type of Inspection	*Field Staff*
Aerial Inspection (Assuming 3 million square mile area. Including air crew, maintenance, and photo-interpreters.)	550-750
Stations for Monitoring Nuclear Bomb Testing (15 stations: field and analytical staff)	225
Stations for Monitoring High-Altitude Missile Tests (15 stations: field and analytical staff)	180
Nuclear Reactors (300, including experimental and planned)	600-1,500
Fissionable Materials-Producing Plants (6 plants)	300-2,400
Uranium (and Vanadium) Mines and mills (637 in 1954)	1,200
Aircraft Assembly Plants (72 in 1954)	700-1,400
Aircraft Engines and Parts Plants (234 in 1954)	2,400-5,000
Aircraft Flight Instruments Plants (129 in 1954)	1,300-2,600
Radio and Radar Plants (225 in 1954)	2,250-4,500
Ordnance and Accessories Plants (493 in 1954)	5,000-10,000
Explosives Plants (74 in 1954)	750-1,500

Note: These estimates were constructed on the following bases: for aerial inspection and bomb and missile testing, the authors estimated the field staffs required for 24-hour functioning; checks on reactors could be maintained by as few as 2 to 5 men per reactor, depending on the need for 24-hour monitoring; in the fissionable materials plants, the range is due to readiness to rely on instrument monitoring vs. major reliance on human controllers; mines and mills could be covered by an average of about 2 men to each mill or mine; the various critical factories for missiles, aircraft, and explosives could be monitored by an average of 10 to 20 men per plant. Such estimates give an order of magnitude. They would be revised in accordance with detailed operating requirements of an international inspectorate.

Sampling inspection could be made in the following areas:

Biological laboratories
Metal-working plants
U.S. government accounting
Scientific manpower

The areas for 100 percent inspection include aerial inspection, and stations for monitoring nuclear bomb tests and high altitude missile tests. It should be noted that these types of inspection, as well as the control of nuclear reactors and plants producing fissionable materials, could be carried out, in the United States, with staffs of modest size.

Organizational Characteristics of an International Inspectorate

Flexibility in methods and the adaptability of organization to the requirement of new technological conditions are key elements of the organizational design of an international inspection agency. Inflexible administrative routines and the conservatism that accompanies a vested occupational interest in particular methods are mortal dangers for the effectiveness of an international inspectorate. Therefore, the organization of such an agency must include built-in features for the review, evaluation, and modification of structure, departmental functions, and preferred techniques.

To be sure, the performance of an intricate function like international inspection for disarmament requires the solution of a host of political, organizational, administrative, and economic problems, apart from those noted above. These involve, for example: the size and composition of the staff, conditions of payment and tenure, problems of securing international representation, and the relationship of such an organization to the United Nations and to international bodies like the Red Cross.

Evolution of an Inspection Function

Once the technical characteristics of various inspection techniques have been indicated, it is necessary to cope with the problem of "phasing-in," or introducing, various inspection techniques. This is preeminently a policy problem requiring the solution of a range of intricate political and economic problems.

The planned evolution of an inspection function to meet public policy requirements might be facilitated by appropriate analyses of the characteristics and effects of various inspection techniques. For example, inspection methods could be analyzed by ranking them according to criteria like the impersonality of the method (inspection of things vs. people) and the costliness of the operation (staff and equipment that would be needed). Similarly, alternative inspection systems could be diagnosed according to classes of effects—for example: impact on the sovereignty of national government,[19] residual capabilities for secret arming under a given inspection system, and the extent of occupational and economic reconversion that would be caused by the given degree of disarmament.[20] These and related aspects of an evolving inspection scheme require thorough analysis.

Undoubtedly one of the difficult political problems of inspection is finding ways to begin. Of the methods that are reviewed in this report, three suggest themselves as especially interesting in this respect: radiation inspection, monitoring nuclear explosions, and monitoring for high-altitude missile tests.

Inspection of plants that produce fissionable materials is a crucial feature of enforcement of a disarmament agreement. It is likely that close inspection of these, for public health purposes, will be progressively intensified. The several networks of radiation inspection established in major countries for public health objectives may lend themselves readily to serve the objectives of inspection for disarmament as well.

The technical workability of inspection for bomb testing and for high-altitude missile testing is especially important for initiating disarmament programs. The monitoring operations for these purposes could be carried out without the more politically sensitive activities that are essential for control over production.

19 See Henkin, *Arms Control and Inspection in American Law.*

20 In the United States in 1956, about 15 percent of the labor force was engaged in work on military orders. The national defense budgets financed 30 percent of all scientific research and development in the nation as a whole and 37 percent of all research and development in all industrial firms. In 1953-54 the Defense Department and the Atomic Energy Commission sponsored 40 percent of all research expenditures by American universities. These estimates are based upon statistics in: U. S. Bureau of the Census, *Statistical Abstract of the United States* (78th ed., Washington, D. C., 1957), pp. 197, 238, 367, 495; National Science Foundation, *Science and Engineering in American Industry* (Washington, D. C., 1956), p. 17; and National Science Foundation, *Reviews of Data on Research and Development* (March, 1957), pp. 2, 3.

EVASION TEAMS

Evasion of disarmament means an attempt to violate an international agreement made by a group, inside or outside a government that formally accepts the agreement. Evasion by a government or a part of a government is the more serious possibility, in the judgment of this writer. An evasion effort could be prompted by mistrust and the fearful conviction that a country is unsafe without this—either for international bargaining or for carrying out a surprise military stroke, in an unrelenting drive for power over other countries. Such possibilities must be taken into account here because of two factors: first, the history of mutual distrust among the major governments, and, secondly, the influence of this distrust as a guide for both domestic and foreign policies.

In order to test the efficacy of the inspection systems outlined here for partial and extensive disarmament agreements, three Evasion Teams were organized. Each of these teams was given the same Terms of Reference and charged with formulating a strategic plan for evading the inspection system. Each team was somewhat different from the others in its occupational composition, and each group functioned independently. Moreover, no military men or other governmental officials were included. The Terms of Reference, as well as the reports of the Evasion Teams, are given in this book.

These reports contain material that may very well dismay many people. They are included here as a realistic demonstration of what imaginative, technically trained men can do in this sphere, even in a short span of time. Accordingly, the possibilities of organizing highly destructive, clandestine operations, as shown here, must be regarded as only an approximation of what the full-time military professionals of various countries have probably been able to devise. Finally, the writer wishes to point out that the main technological possibilities outlined by the Evasion Teams have been publicly announced at various times. Thus, on April 12, 1958, *The New York Times* reported (on its first page) the successful firing of missiles by the Navy from under water. The fixed underwater missile system suggested by Evasion Team B is one application of this general technique for launching missiles.

The Possibilities for Evasion

Clandestine production of intricate weapons was regarded as a most difficult task by the Evasion Teams, even when ingenious modes of operation are utilized. This confirmed the prior estimate of this investigation. The concealment of arms during the period of introduction of disarmament was singled out by Evasion Team B as the method most likely to succeed. This writer agrees with that estimate.

Successful evasion for arms production, however, requires more than technical feasibility. It needs an "evasion mentality" among its principal operators. This includes: first, an ideology which requires evasion of disarmament; second, the view that the design, production, and utilization of weapons of great destructiveness is natural, reasonable, thinkable, and even laudable. The latter point is critically important, for it pinpoints, in the judgment of this writer, the area of greatest delicacy for the observance or evasion of disarmament agreements. Able men, moved by an evasion mentality, might attempt such a clandestine armaments effort as is indicated, for example, in the report of the Evasion Teams.

As long as an "evasion mentality" dominates a sufficient part of a population, there is danger of evasion of disarmament through one of the great array of technological possibilities. It is also reasonable to assume that as mass destruction is understood more and more widely as an unthinkable, unnatural act, there is bound to be greater security for mankind.[21]

Dr. Alberta B. Szalita, in her comments on psychological aspects of disarmament, calls attention to the possibilities of strengthening the potentials in human personality which would run counter to an evasion mentality: for self-preservation as against self-destructiveness, for peaceful living as against warlike behavior. In her paper, Dr. Szalita also underscores the crucial role of such attitudes among scientists. Due to the central importance of their work in laying the bases for new technologies, more control by scientists over the use of their work, and the fostering of ideals of peacefulness among scientists, could have special value for mankind.

21 It has been suggested to the writer that it might be useful for some international agency to monitor ideologies and public political discussion and opinion in a nation as an indicator of efforts to generate an evasion mentality. Such efforts could be an alarm signal to the inspectorate.

It is altogether possible that, as indicated by Evasion Team B, clandestine arms systems can be fully emplaced during a period of phasing-in of disarmament agreements. An international inspectorate could certainly use every reasonable device, including, for example, checks on rockets for scientific use, to prevent someone from slipping in a warhead.

Successful inspection, like successful evasion, requires more than technical feasibility. In the judgment of this writer, the final line of defense against evasion will be a condition of society in which such acts are widely regarded as unnatural and unthinkable. Even if some deadly weapons systems could be operated by as few as six men (see the report of Evasion Team B), those men could not make a military campaign; that would need the collaboration of at least a segment of a population. In this respect, the presence or absence of an "evasion mentality" could play an important part.

Toward the end-in-view of diminishing or discouraging an evasion mentality, the early implementation of even partial steps for disarmament and international inspection is of the greatest importance. For every measure that relieves international tension and limits the fever of an arms race also limits the conditions that produce an evasion mentality. Stated differently: the introduction of particular disarmament measures in regard to highly destructive weapons, with reliable inspection, is bound to have a feed-back effect in reducing the pressures that lead to clandestine armament preparations. Thereby, conditions of mutual international assurance of compliance with disarmament agreements are unproved.

SUMMARY: CONDITIONS OF WORKABLE INSPECTION FOR DISARMAMENT

The major objective of this investigation is to estimate the technical feasibility of inspection methods for administering international disarmament agreements. For this reason an attempt was made, for analytic purposes, to gauge the possibilities for enforcing a disarmament agreement of wide scope, including the restriction of arms production.

The main finding of this report is that it is possible to define systems of inspection which would ensure compliance with a wide

variety of disarmament agreements. Such monitoring systems can be major deterrents to attempts at clandestine evasion, and are, in that sense, workable systems of inspection. *The range of workability extends from agreements of limited scope to comprehensive disarmament projects which would require rather extensive monitoring.*

The possibility for establishing highly effective physical controls over nuclear bomb testing and high-altitude missiles testing indicates the usefulness of these measures as ways of initiating international agreements on disarmament.

The efficiency of materiel inspection methods for ensuring compliance with a disarmament agreement are limited by three factors: the availability of technological alternatives (like biological warfare in place of atomic bombs) by which given inspection points could be by-passed, methods of clandestine production organization, and the possibility of concealment of weapons during the period of introduction of inspection for disarmament.

The techniques for evasion which can be found in these areas are likely to be applied most extensively when government complicity fosters and is fostered by an "evasion mentality" which gives social sanction to evasion of disarmament agreements. From this standpoint, the greatest safety for mankind is to be obtained from the earliest, even if partial, disarmament agreements—which would serve to reduce international tensions. Such effects would facilitate, in turn, the extension of the scope and the workability of disarmament agreements, and their appropriate inspection methods.

AN INTERNATIONAL PUBLIC OPINION POLL ON DISARMAMENT AND "INSPECTION BY THE PEOPLE": A STUDY OF ATTITUDES TOWARD SUPRANATIONALISM 1

by William M. Evan

[Note: To counteract efforts to evade a disarmament agreement, various methods of inspection are needed. One method recommended by this book, "Inspection by the People," takes advantage of the fact that every major evasion effort requires & large number of man-hours in many occupations. It is, therefore, critical to have an indication of public attitudes toward inspection for disarmament and an estimate of the readiness of a cross section of the population to oppose clandestine armament.—Editor.]

INTRODUCTION

INNOVATIONS in science are now generally valued, whereas in other social institutions they are often depreciated. And yet cultural and social innovations deemed Utopian in one epoch may become part of social reality in another. The proposal advanced by Professor Seymour Melman to include "Inspection by the People"[2] as part of a disarmament inspection system entails a cultural and a social innovation. If methods of *physical* inspection do not afford adequate safeguards against evasion of an international disarmament agreement, then the suggestion to com-

1 The writer is indebted to Professor Paul F. Lazarsfeld for valuable comments and criticisms.

2 See his General Report, pp. 38-44.

William M. Evan is Assistant Professor of Sociology at Columbia University. His major research fields are sociology of law and industrial sociology. He has designed and conducted various sociological surveys.

plement them with a *social* inspection system, namely, "Inspection by the People," assumes special significance.

According to this proposal, an international agreement would make it the legal duty of the citizens of all signatory countries to report evidence of violations in their country to an international inspection authority. Such an agreement implies that nations would relinquish a measure of sovereignty in favor of an inclusive and transcending collectivity of the nation-states of the world or of mankind for the purpose of preserving peace. The *cultural* innovation of the proposal for "Inspection by the People" lies in the acknowledgment that for the purpose of securing peace, loyalty to a supranational entity or to mankind is a higher value than loyalty to nation. The *social* innovation lies in implementing this value by devising open, two-way channels of communication[3] between the peoples of the signatory countries and the international inspection authority. Such an international agency would necessarily create new social relationships and new rights, privileges, and immunities, as well as new duties, for the peoples of the countries which are parties to the disarmament agreement.

Present obstacles—of a political, economic, legal and cultural character—to a system of "Inspection by the People" are, of course, numerous and formidable. This paper is not, however, concerned with a general analysis of these impediments. Rather, it is a study of one possible obstacle: the climate of opinion regarding the proposed innovation in international law as it relates to disarmament.

In polling public opinion on disarmament and "Inspection by the People," the assumption was made that attitudes or latent views toward supranationalism were being explored. A supranational, as distinct from an international, orientation to world affairs acknowledges that individual citizens—not merely governments—have rights and duties with respect to an entity transcending the nation.

With reference to these considerations, this paper seeks to answer two questions: (1) What is the current climate of opinion regarding disarmament and "Inspection by the People" in selected countries? and (2) What are some sociological and social-psychological factors associated with opinions about disarmament and "Inspection by the People" in these selected countries?

To answer these questions, a specially designed poll was conducted

3 *Ibid.*

in six nations: the United States, Great Britain, France, West Germany, India, and Japan. Samples of respondents were personally interviewed from March 7 to March 13, 1958, by the staffs of the American Institute of Public Opinion and its affiliates[4] in Great Britain, France, West Germany, and India. In Japan, the Research Department of the national newspaper, *Yomiuri*, conducted the poll from March 13 to March 29,1958.[5]

THE FINDINGS

In order to measure attitudes toward disarmament and "Inspection by the People," the following three questions were asked:

1. Would you favor or oppose setting up a world-wide organization which would make sure—*by regular inspections*—that *no* nation, including Russia and the United States, makes atom bombs, hydrogen bombs and missiles?
2. If this inspection organization were set up, would you favor or oppose making it each person's *duty* to report any attempt to secretly make atom bombs, hydrogen bombs and missiles?
3. If you, yourself, knew that someone in (name of country) was attempting to secretly make forbidden weapons, would you report this to the office of the world-wide inspection organization in this country?

The first question refers to a somewhat abstract proposal for disarmament, which presumably evokes attitudes toward peace. Since it demands little from the respondent in the way of a sacrifice of values, it was anticipated that a relatively high proportion would express approval. In contrast, Question 2 involves a concrete proposal which imposes a unique legal duty on all citizens to participate in the enforcement of a disarmament agreement. Thus it does potentially entail the sacrifice of one or more values by requiring a citizen to report damaging evidence against a friend, a neighbor, or his own government. Hence an appreciably lower proportion of favorable responses was expected. This is even more true of Question 3, since it asks the respondent if

4 British Institute of Public Opinion, Institut Francais d'Opinion Publique, Emnid, Institut fur Markt- und Meinungsforschung, Indian Institute of Public Opinion, Ltd.

5 For information regarding the validity of the poll data, see Appendix: The Strengths and Weaknesses of the Poll Data.

he personally would accept the duty of reporting to a world-wide inspection organization any evidence of violations in his own country, thus raising a potential conflict of values between loyalty to nation and loyalty to a supranational or "trans-national" body. Consequently, it was anticipated that the favorable response to this question would be even smaller than that to Question 2.

In short, it was expected that the aggregate responses for a country would have a monotonically declining pattern from Question 1 to Question *3*. Moreover, it was expected that those who answered Question *3* positively would be more likely to answer Question 1 positively than those whose answers to Question *3* were negative. Conversely, those answering Question 1 positively would be more likely to answer Question *3* positively than those answering Question 1 in the negative. Otherwise put, it was hypothesized that the three questions measuring attitudes toward disarmament and "Inspection by the People" are interrelated.

National Climates of Opinion

In view of the above set of expectations, the over-all results of the poll in the six nations, as shown in Table 1, are indeed striking. The high level of affirmative responses to all three questions in all six nations underscores the widespread support for a system of disarmament inspection in general and "Inspection by the People" in particular. To the extent that favorable public opinion regarding a disarmament agreement is a necessary condition for its workability, the findings suggest that "Inspection by the People" is not considered as visionary a proposal as one might have thought.

How shall we interpret this overwhelmingly positive response to the three questions in all six countries? What meaning did respondents read into the questions, and what meaning may we read out of their answers?

One interpretation is that Question 1 presents a proposal manifestly concerned with ensuring peace, a proposal which has been debated in the United Nations for over a decade. Questions 2 and *3* raise a novel and hypothetical proposal. The high level of approval may be taken as a measure of readiness to participate personally in implementing a disarmament agreement.

TABLE 1

Opinions about Disarmament Inspection in Six Selected Nations

Questions	*United States* (N:1,610) %	*Great Britain* (N:1,000) %	*France* (N:287) %	*India** (N:250) %	*West Germany* (N:282) %	*Japan* (N:20 %
Would you favor or oppose setting up a world-wide organization which would make sure—by *regular inspections*—that *no* nation, including Russia and the United States, makes atom bombs, hydrogen bombs, and missiles?						
Favor	70	72	85	78	92	91
Oppose	16	10	6	1	1	8
No Opinion and No Answer	14	18	9	21	7	1
If this inspection organization were set up, would you favor or oppose making it each person's *duty* to report any attempt to secretly make atom bombs, hydrogen bombs, and missiles?						
Favor	73	54	74	71	86	80
Oppose	11	15	13	2	4	16
No Opinion and No Answer	16	31	13	27	10	4
If you, yourself, knew that someone in (name of country) was attempting to secretly make forbidden weapons, would you report this to the office of the world-wide inspection organization in this country?						
Yes	80	50	63	63	73	83
No	6	17	18	6	11	5
No Opinion and No Answer	14	33	19	31	16	12

* See the Appendix for a statement of the limitations of the sample

TABLE 2

Opinions about Disarmament Inspection in Two Validation Groups

	Group of Federation of American Scientists (N:32)	*Group of American Legionnaires* (N:76)
Percent in favor of inspection for disarmament	97	53
2. Percent in favor of making it each person's duty to report violations	78	59
3. Percent who would personally report violations to world-wide inspection organization	84	59

Another facet of this interpretation is that these questions are uncovering a possibly higher receptivity to supranationalism than is generally assumed to exist in a world rife with conflicting nationalisms. To ascertain whether these questions are being interpreted along the dimension of nationalism-supranationalism, it was decided to validate the meaning of the questions for the United States sample on two contrasting "known" groups for the purpose of establishing upper and lower limits of a supranational orientation.6

It was assumed that the Federation of American Scientists, which for over ten years has publicly advocated international control of atomic weapons, would score fairly high on a national-supranational scale. At the other end of this hypothetical continuum might stand the American Legion, with its emphasis on military preparedness, national security, and patriotism. The opinions of two groups of members from New York City branches of these organizations were obtained.[7] As shown in Table 2, the response patterns of these groups are indeed different. Whereas 97 percent of the group of members of the Federation of American Scientists approve of Question 1 and 84 percent approve of Question 3, 53 percent of the group of American Legion members are in favor of Question 1 and 59 percent are in favor of Question 3. The relatively high level of favorable responses of the group of American Legion

6 The writer wishes to express his gratitude to Professor Eugene Litwak of Columbia University for the suggestion that a validation procedure be used.

7 The respondents for this validation study were selected groups rather than samples, because of the assumed homogeneity in the attitudes of the members of these organizations.

members to Questions 2 and 3 would suggest that supranationalism is not necessarily a dominant meaning given by respondents to these questions. Confronted with an unfamiliar or unstructured situation, people tend to turn to familiar concepts in an effort to structure the situation. Thus, when presented with Questions 2 and 3, respondents may have had recourse to familiar concepts, such as general ideas of peace or of doing one's legal duty, since these conceptions represent widespread values in modern societies.

It is, nevertheless, reasonable to assume that respondents who answer all three questions—which as predicted are interrelated—positively, would have a more pronounced supranational orientation than those answering only two or less questions positively. If we construct such a disarmament inspection score, ranging from zero to three points, the distribution of scores for F.A.S. and the Legion is indeed different: 78 percent of the respondents affiliated with the F.A.S. have a score of three, i.e., are positive on all three questions, as compared with 34 percent of the group of Legionnaires. These two proportions, as Table 3 shows, represent the upper and lower boundaries for the distribution of disarmament inspection scores in all six countries.

A second unanticipated feature of the over-all poll results in Table 1 is that the predicted monotonic decline in response patterns is generally borne out, with the notable exception of the United States, where the pattern of response is completely reversed: 70 percent are in favor of Question 1; 73 percent are *in* favor of Question 2; and 80 percent answer question 3 in the affirmative.

TABLE 3

Comparison of High Disarmament Inspection Scores among Six Selected Nations and Two Validation Groups

Nation	*Percent Who Have a High Disarmament Inspection Score (who answer all 3 questions positively)*
Japan	72
West Germany	71
India	60
France	57
United States	56
Great Britain	44
Validation Group	
Federation of American Scientists	78
American Legion	34

A clue to the reason for the reversal is provided by the spontaneous verbatim comments of some of the respondents. A recurrent justification for opposing the proposal for the disarmament inspection system in Question 1 is that "Russians couldn't be trusted." The comments offered in support of Question 3 have as their major theme obedience to law, e.g., "If it's a law, it's a citizen's duty to report"; "Law should be obeyed"; "It would be our duty as a citizen"; "Should obey the law of the land." A strong commitment to law-abidingness as a value emerges, which is not nearly so pronounced in the spontaneous comments of respondents in the other countries. James Bryce's observation about America in the nineteenth century may well apply to America in the twentieth century: "Feeling the law to be its own work, the people is disposed to obey the law" and ". . . Americans are specially eager to claim [credit for] being a law-abiding community."[8]

Although the verbatim comments throw some light on the anomalous pattern of responses in the United States, how may we account for the over-all national differences in attitudes toward disarmament and "Inspection by the People"? As shown in Table 3, Japan has the highest positive score on disarmament inspection, Germany is second, India is third, France is fourth, the United States is fifth, and Great Britain is sixth. This rank order of favorable attitudes toward disarmament is largely explainable either in terms of the military experiences of these countries in the Second World War or their present military position. As militarily vanquished countries, Japan and Germany may be particularly interested in maintaining peace. Japan's memory of Hiroshima is still fresh and radioactive fall-out from nuclear tests by both the Soviet Union and the United States has been provoking anxiety. Germany's vulnerability to invasion by the Soviet Union in the event of another war may be a contributing factor to the German interest in disarmament. At the opposite end of the rank order is Great Britain, a victorious country whose possession of nuclear weapons may afford a measure of subjective—apart from objective—security against the outbreak of another world war. France and India are in an intermediate position in the rank order, the former possibly because of its deteriorating military and political fortunes, the latter because of its neutralist position politically and militarily. The United States, although a victorious country and an atomic power, occupies a position closer to France than to Great Britain.

8 Bryce, *The American Commonwealth* (London: Macmillan, 1888), III, 340.

This is due to the high proportion of positive responses to Question 3, which is discussed above in terms of the value of law-abidingness.

In the absence of other poll data to check the validity of these interpretations of the rank order of attitudes toward disarmament inspection, they would be at best merely plausible. However, one question was included in this poll on the assumption that it was a determinant of responses to the three disarmament inspection questions. This question measures the degree of anxiety about the likelihood of a world war in which nuclear weapons would be employed. It reads as follows: "How worried are you about the chance of a world war breaking out in which atom bombs and hydrogen bombs would be used—very worried, fairly worried, or not worried at all?"

TABLE 4

Comparison of Rank Order of Six Selected Nations on High Disarmament Inspection Scores and on Perception of Threat of War

Nation	*Rank Order on High Disarmament Inspection Scores*	*Rank Order on "Very Worried" about War*
Japan	1	1
West Germany	2	4
India	3	2
France	4	3
United States	5	6
Great Britain	6	5

The rank order of the countries on the proportion of respondents who say they are "very worried" is as follows: Japan is first, India is second, France is third, Germany is fourth, Britain is fifth, and the United States is sixth. It is evident, as Table 4 makes clear, that this order closely corresponds to the previous order on high disarmament inspection scores. Japan, which ranks high on favorableness toward disarmament inspection, also ranks high on the perception of threat of a world war; and Great Britain, which ranks low on favorableness toward disarmament inspection, also ranks low on the perception of threat of a world war.

Sociological Factors Associated with Attitudes Toward Disarmament

Apart from the social-psychological variable of the perception of threat of a world war, what is the relation of such sociological variables *as* occupation, sex, education, etc.—which locate people in different segments of the social structure—to attitudes toward disarmament and "Inspection by the People"? On theoretical grounds we should expect some of these variables to be related to attitudes toward disarmament inspection. However, since the six countries differ substantially in their systems of beliefs and patterns of social relationships, the effect of a particular variable on attitudes toward disarmament would not necessarily be uniform in all countries.

Of the seven social background questions asked in the poll, space permits an analysis of but three: sex, occupation, and party affiliation or vote in the last election. With respect to the first of these variables, sex differences in opinions about disarmament inspection are negligible in the United States and Great Britain (see Table 5), where it may be

TABLE 5

Willingness to Report Violations and High Disarmament Inspection Scores among Men and Women in Six Selected Nations

	WILLING TO REPORT VIOLATIONS				HAVE A HIGH DISARMAMENT INSPECTION SCORE			
	Men		*Women*		*Men*		*Women*	
Nation	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*
United States	78	(781)	82	(821)	57	(781)	56	(821)
Great Britain	52	(470)	48	(530)	46	(470)	43	(530)
France	67	(131)	60	(156)	63	(131)	51	(156)
West Germany	77	(127)	69	(155)	75	(127)	67	(155)
India	69	(189)	44	(61)	66	(189)	37	(61)
Japan	79	(102)	88	(98)	66	(102)	78	(98)

surmised that the sexes have moved farthest toward a position of relative social equality and a consequent convergence in opinions pertaining to various spheres of life. In France, Germany, and India, sex is correlated with attitudes toward inspection, with a higher proportion of males than females expressing readiness to report violations and having a high disarmament inspection score. This difference may be due to a more traditional relationship between the sexes in these countries; occupying a subordinate position in the family and in other areas of life, the woman is discouraged from venturing new opinions. The reluctance to express an opinion on a controversial issue is reflected in the higher proportion of "don't know" answers to Question 3 among women than among men in these countries. In Japan, on the other hand, a higher proportion of women than men approve of reporting violations and have a high disarmament inspection score. This is probably due to the fact that family obligations are more likely to take precedence over traditional, militaristic, and nationalistic obligations among women than among men.

The second sociological variable to be considered, occupation, is commonly found to correlate with social, political, and economic opinions. With the exception of France and Japan, a higher proportion of nonmanual workers than of manual workers is willing to report violations and has a high disarmament inspection score (see Table 6). This may

TABLE 6

Willingness to Report Violations and High Disarmament Inspection Scores among Manual and Nonmanual Workers in Six Selected Nations

	WILLING TO REPORT VIOLATIONS				HAVE A HIGH DISARMAMENT INSPECTION SCORE			
	Manual Workers		*Nonmanual Workers*		*Manual Workers*		*Nonmanual Workers*	
Nation	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*
United States	78	(888)	83	(514)	55	(888)	59	(514)
Great Britain	47	(520)	54	(349)	41	(520)	47	(349)
France	65	(131)	62	(154)	59	(131)	55	(154)
West Germany	71	(147)	75	(95)	68	(147)	74	(95)
India	59	(97)	67	(138)	56	(97)	64	(138)
Japan	92	(47)	81	(153)	81	(47)	69	(153)

very well be due to such occupationally correlated factors as education and level of information, particularly with respect to the possible hazards of nuclear radiation. The reversal of this relationship in Japan may be accounted for by the fact that more than one half of the manual workers in the Japanese sample are fishermen—an occupational group which may be especially aware of the dangers of radioactive fall-out. In France the reversal is probably due to the differential impact of the leftist parties on manual and nonmanual workers.[9]

The attitudes of two specific occupational groups, engineers and scientists, toward disarmament inspection are particularly crucial, since these groups not only have access to the production and testing of nuclear weapons, as do other occupations, but they also possess specialized knowledge which would enable them to identify clandestine production in violation of an international disarmament agreement. Hence, their disposition to comply with the duty to report violations is of great significance to the question of the feasibility of a disarmament inspection

9 See footnote 10 below.

TABLE 9

Willingness to Report Violations and High Disarmament Inspection Scores by Perception of Threat of World War in Six Selected Nations

Nation	WILLING TO REPORT VIOLATIONS						HAVE A HIGH DISARMAMENT INSPECTION SCORE					
	Very Worried		*Fairly Worried*		*Not at All Worried*		*Very Worried*		*Fairly Worried*		*Not at All Worried*	
	%	N	%	N	%	N	%	N	%	N	%	N
United States	85	(228)	81	(675)	80	(658)	62	(228)	61	(675)	53	(658)
Great Britain	62	(154)	53	(387)	49	(345)	57	(54)	49	(387)	41	(345)
France	70	(142)	65	(76)	51	(45)	65	(142)	58	(76)	47	(45)
West Germany	79	(131)	75	(99)	68	(33)	79	(131)	74	(99)	64	(33)
India	82	(143)	64	(52)	36[a]	(11)	79	(143)	56	(52)	36[a]	(11)
Japan	87	(139)	79	(57)	25[a]	(4)	80	(139)	56	(57)	25[a]	(4)

[a] The N is too small for meaningful statistical inferences. However, the percentages are shown for general comparative purposes.

In contrast to the three sociological variables which correlate differently with attitudes toward disarmament in the six countries, the social-psychological variable of perception of threat of war correlates uniformly in all countries: the greater the degree of "worry" about a world war, the higher the proportion of respondents who are willing to report violations and the higher the proportion of respondents who have a high disarmament inspection score (see Table 9). This finding suggests that the fear of nuclear war may prove to be a powerful force making for supranationalism.

CONCLUSIONS

The public opinion poll discussed above yields the surprising finding that at the present time the majority in all six countries supports the proposal for a disarmament agreement with a system of "Inspection by the People." Does this result provide us with a reliable prediction as to how people would behave if such an agreement were actually reached, and if an inspection system were established? This raises the general and critical question of the relation between attitudes and behavior or verbal behavior in the present and nonverbal behavior in the future.[11]

Among the conditions making for a close correlation between attitude and behavior are the strength and importance of the attitudes expressed. The greater the strength and importance to a respondent of an opinion, the greater the likelihood that the opinion is predictive of his behavior. In the case of the disarmament questions of this poll, two (Questions *2* and 3) are fairly novel and hypothetical in character. Hence, we might conservatively infer that the strength and importance of the opinions expressed about them are relatively low. If this were so, we could not confidently take the high disarmament inspection scores as predictive of what people are likely to do in the event that an international agreement is reached, obligating citizens to report violations to an international inspection authority.

On the other hand, two factors argue in favor of the possible predictiveness of the attitudes reported in this paper, assuming, of course, that these attitudes are maintained in the future. First, the

11 Cf. Patricia L. Kendall and Paul F. Lazarsfeld, "Problems of Survey Analysis," in Robert K. Merton and Paul F. Lazarsfeld, eds., *Continuities in Social Research: Studies in the Scope and Method of "The American Soldier"* (Glencoe, Illinois, Free Press, 1950), pp. 179-82.

public opinion poll results in conjunction with the responses of the validation groups suggest that underlying the opinions expressed is a commitment to the values of peace and supranationalism. This indicates that the peoples of the countries that are parties to a disarmament agreement would probably comply with the provision to participate in a system of "Inspection by the People"—at least in the six countries in which the poll was conducted. Moreover, if we suppose that a clandestine system of production of nuclear weapons, or the practice of other large-scale evasions, requires a strong nationalistic orientation of a large segment of the population, then it is reasonable to predict that an effort to evade the agreement would not enjoy popular support in these countries.

A second consideration which enhances the prospects of action in line with expressed opinions is the fact that law generally legitimizes the commission or omission of an act. Since an international disarmament agreement would have the force of law in the signatory countries, it would encourage and facilitate the translation of favorable opinions about "Inspection by the People" into action. Following the establishment of such an agreement, the level of support for disarmament and "Inspection by the People"—barring government efforts to undermine the agreement—may even exceed that found in this poll. Such a response may be anticipated because of the finding by social scientists that after the enactment of a law there tends to be an increase of public opinion favorable to the law in question.[12]

Another important result of this poll is that the variation in national climates of opinion regarding disarmament inspection within the six countries is correlated with the perception of threat of war. This helps to account for differences in favorable attitudes toward disarmament inspection. It suggests that if the fear of war increases, favorable attitudes towards disarmament and "Inspection by the People" will increase unless they are counterbalanced by an effort to achieve collective military security.

Yet another important finding is the relationship between occupation and attitudes toward disarmament: engineers and scientists, two strategic occupational groups, express more willingness to comply with

12 .Cf. Paul F. Lazarsfeld, "Public Opinion and the Classical Tradition." *Public Opinion Quarterly,* XXI (1957): 46-47; Hadley Cantril, *Gauging Public Opinion* (Princeton, N. J., Princeton University Press, 1944), p. 228.

a disarmament inspection agreement than non-engineers and non-scientists.

Finally, in an effort to explain the unexpected reversal in the pattern of responses to the three disarmament questions in the United States poll, it was found that obedience to law is highly valued by many respondents. Although commitment to the value of law-abidingness may vary from one country to another, it is highly probable that, like the value of peace, it too transcends national boundaries. Commitment to the values of peace and law-abidingness is a potential basis for the participation of individual citizens of the nations of the world in a new social institution: "Inspection by the People."

APPENDIX: THE STRENGTHS AND WEAKNESSES OF THE POLL DATA

The first and most apparent limitation of the poll data of this study is the number of countries included and the status of those excluded. Of the ninety-odd independent nation-states in the world, six, to be sure, is a tiny proportion. However, limited financial resources made it impossible to increase the sample of nations. Especially regrettable is the omission of the Soviet Union and its allied countries in Eastern Europe and Asia, due primarily to the problem of inaccessibility of the peoples of these countries. On the other hand, the six countries included in the poll are among the major political forces in the world.

Another limitation of the poll data pertains to the sample size and sample design. Again because of the limited financial resources of this study, rather small national samples were selected in four of the countries.[13] The smallness of the sample does not necessarily lead to non-representativeness—providing the sample is designed properly. However, small samples, regardless of sample design, have the disadvantage not only of increasing sampling variance, but also of limiting the statistical analysis because of the dwindling of cases when sample subgroups are compared.

The sample design employed differed in the six countries. In Germany, France, and Great Britain, quota samples were drawn from among

13 The sample sizes are as follows: 200 in Japan, 250 in India, 282 in West Germany, 287 in France, 1,000 in Great Britain, and 1,610 in the United States. The statistical-minded reader will realize that the size of the sample depends not on the size of the population but rather on the desired level of precision.

TABLE 10

Percentage Comparison of Sample and Population Characteristics of the Six Selected Nations*

Characteristics	UNITED STATES Sample	UNITED STATES Population	GREAT BRITAIN Sample	GREAT BRITAIN Population	FRANCE Sample	FRANCE Population	WEST GERMANY Sample	WEST GERMANY Population	INDIA Sample	INDIA Population	JAPAN Sample	JAPAN Population
Sex												
Male	48.5	47.8	47.0	48.1	45.6	48.3	45.0	47.1	76.0	51.4	51.0	49.1
Female	51.5	52.2	53.0	51.9	54.4	51.7	55.0	52.9	24.0	48.6	49.0	50.9
Age												
Under 30[a]	15.3	18.2	25.6	23.6	62.4[b]	23.4	20.5	20.8	22.8	32.6	34.5	31.2
30–49	46.6	44.1	43.6	37.8		35.3	40.2	39.1	56.4	44.4	45.5	40.8
50 and over	38.1	37.7	30.8	38.6	37.6	41.3	39.3	40.1	20.8	23.0	20.0	28.0

[a] The minimum age of the poll respondents in the six countries is as follows: the United States, 21; Great Britain, 16; France, 18; West Germany, 20; India, 20; Japan, 20.

[b] Poll data on age were pre-coded in categories which overlap with those used in this table.

* Source: For the United States, U.S. Bureau of the Census, *Current Population Reports: Population Estimates,* December 18, 1957, Series P-25, No. 170, Table 3. The remaining figures come from the U.N. *Demographic Yearbook,* 1956 and 1957 (forthcoming). Those for Great Britain, France, and Japan are 1956 estimates, that for West Germany is a 1955 estimate, and that for India is from the 1951 census.

sampling units—ranging from 52 in France to 80 in Great Britain—distributed throughout the country. This method of sampling predetermines the selection of the categories of respondents to be interviewed so as to represent correct proportions of the adult population according to such background characteristics as age, sex, occupation, region, etc. A quota sample was also employed in Japan in six cities and their surrounding rural areas, representing the nine regions into which the country is divided.

In India, a probability sample was drawn from electoral registers; however, the poll was confined to five areas in which the Indian Institute of Public Opinion has interviewing staffs. The sampling areas comprise two states out of a total of fourteen—Uttar Pradesh and West Bengal—and one of the six territories, Delhi. The combined population of the sampling areas is approximately one fourth of the population of India.

In the United States, a modified probability sample was drawn by dividing the country into twenty-six regions and subdividing these areas down to the block level in the larger cities, groups of blocks in smaller cities and towns, and segments of townships in rural areas. Within these blocks and segments, 160 interviewers were given a preselected starting point and required to follow a given direction in their selection of households. The choice of respondent within a household was controlled by a systematic but not probability procedure and by male-female quota assignments.

In each of the six nations an attempt was made to draw a representative sample. The success with which this was accomplished differs from country to country, as can be seen in Table 10, which compares the samples and populations on two available characteristics—age and sex. In the United States, Great Britain, France, and West Germany, the samples appear to be fairly representative. In India, women are grossly underrepresented, due to the fact that relatively few women appear in the electoral registers from which the sample was drawn. In Japan, apart from the underrepresentation of the fifty-and-over age group, less educated, rural, and manual worker groups are underrepresented. For example, 43 percent of the sample are college graduates.

The third limitation of the data has to do more with difficulties of interpreting the results than with the generalizability and validity of the data. Once again because of the limited financial resources, only four opinion questions and seven social background questions were asked.

Thus, we are dealing with a poll rather than a survey, which normally consists not only of a large battery of questions, including items designed to test anticipated interpretations of the data, but also of questions varying in degree of directness and seeking to ascertain not only what opinions people hold but the strength and importance of the opinions expressed.

Notwithstanding these limitations, the body of data presented here is highly relevant for the problems with which this book is concerned. It also unquestionably provides a more reliable guide to action than common sense, guesswork, or intuition.