PREPARED FOR THE SECRETARY OF STATE'S COMM. cE
ON ATOMIC ENERGY

A REPORT ON THE INTERNATIONAL CONTROL OF ATOMIC ENERGY

FOREWORD BY SECRETARY OF STATE JAMES F. BYRNES and
A PREFACE BY DR. I. I. RABI, Professor of Physics, at Columbia University
and Consultant for the Los Alamos Project.

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By a Board of Consultants: CHESTER I. BARNARD • DR. J. R. OPPENHEIMER
DR. CHARLES A. THOMAS • HARRY A. WINNE • DAVID E. LILIENTHAL, Chairman

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The Acheson-Lilienthal Report
on the International Control of Atomic Energy
Washington, D. C. March 16, 1946

FOREWORD

By The Secretary of State

This "Report on the International Control of Atomic Energy" is in the main the work of a Board of Consultants to the Department of State. The Board carried out its assignment under the general direction of a Committee on Atomic Energy which I set up on January 7, 1946 with Dean Acheson, Under Secretary of State, as Chairman. A letter of transmittal at the beginning of the Report embodies the comments which Mr. Acheson's Committee made on the unanimous findings and recommendations of the Board of Consultants.

In thus transmitting to me the detailed report of the. Board, the Committee emphasizes the Board's observation that the Report is not intended as a final plan but "a place to begin, a foundation on which to build." The Committee also states that it regards the consultants' work as "the most constructive analysis of the question of international control we have seen and a definitely hopeful approach to a solution of the entire problem."

The intensive work which this document reflects and the high qualifications of the men who were concerned with it make it a paper of unusual importance and a suitable starting point for the informed public discussion which is one of the essential factors in developing sound policy. The document is being made public not as a statement of policy but solely as a basis for such discussion.

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INTRODUCTION

The board of consultants met for the first time on January 23rd, conferring briefly with the Secretary of State's Committee on Atomic Energy respecting the board's assignment to study the problem of international control of atomic energy. For more than seven weeks since that time we devoted virtually our entire time and energies to the problem we were directed to study and report upon. We visited the plants and installations at Oak Ridge, Tennessee, and Los Alamos, New Mexico, and spent days consulting with numerous scientists, industrial experts, and geologists, authorities in the technical fields concerned with atomic energy. Since February 25th this board has met almost continuously, developing and writing the following report. Our absorption in this task does not, of course, assure the soundness of the recommendation which is the product of our deliberations. But it is relevant as a measure of how important and urgent we feel it to be that the Government and the people of the United States develop a rational and workable plan, before the already launched international atomic armament race attains such momentum that it cannot be stopped.

We have concluded our deliberations on this most difficult problem, not in a spirit of hopelessness and despair, but with a measure of confidence. It is our conviction that a satisfactory plan can be developed, and that what we here recommend can form the foundation of such a plan. It is worth contrasting the sense of hope and confidence which all of us share today with the feeling which we had at the outset. The vast difficulties of the problem were oppressive, and we early concluded that the most we could do would be to suggest various alternative proposals, indicate their strengths and limitation, but make no recommendations. But as we steeped ourselves in the facts and caught a feeling of the nature of the problem, we became more hopeful. That hopefulness grew not out of any preconceived "solution" but out of a patient and time-consuming analysis and understanding of the facts that throw light on the numerous alternatives that we explored. Five men of widely differing backgrounds and experiences who were far apart at the outset found themselves, at the end of a month's absorption in this problem not only in complete agreement that a plan could be devised but also in agreement on the essentials of a plan. We believe others may have a similar experience if a similar process is followed.

We have described the process whereby we arrived at our recommendation, to make it clear that we did not begin with a preconceived plan. There is this further reason for describing this process. Others would have a similar experience if they were able to go through a period of close study of the alternatives and an absorption in the salient and determining facts. Only then, perhaps, may it be possible to weigh the wisdom of the judgment we have reached, and the possibilities of building upon it.

The plan of the report itself may be briefly described, as an aid in reading it:

In Section I. we examined the reasons that have led to a commitment for the international control of atomic energy and the early proposal for realizing this objective by a system of inspection.

In Section II. the essential characteristics of a workable plan for security are stated, and the considerations that favor the development of a plan are set out. By the time this discussion is concluded, the outlines of a workable plan as we see it are apparent.

In Section III. the essentials of an organization that puts such principles into effect are described.

In Section IV. we consider the problems of the transition period leading from the present to the full operation of the plan.

We have tried to develop a report that will be useful, *not as a final plan, but as a place to begin, a foundation on which to build.* Many questions that at later stages should and must be asked we have not touched upon at all. We recognize that securing the agreement of other nations to such a plan will raise questions the precise contours of which can hardly be drawn in advance of international meetings and negotiation. We have not, of course, undertaken to discuss, much less to try to settle, problems of this character. The newly created Atomic Energy Commission of the United Nations, when its deliberations begin, will deal with many of these in joint discussion. Indeed, this process of joint international discussion is itself an integral part of any program for safeguards and security.

We desire here to express our great indebtedness to the Secretary of the Secretary of State's Committee on Atomic Energy, Mr. Herbert S. Marks, Assistant to the Under Secretary of State, and to the Secretary of this board, Mr. Carroll L. Wilson. They have contributed in many ways to the work of the board. Whatever value our work may prove to have owes a great deal to their acumen, diligence, and high quality of judgment. We wish especially to thank General Groves and his associates in the Manhattan District and the industrial contractors for facilitating our inspection of the installations at Oak Ridge and Los Alamos, and Captain Joseph Volpe, Jr., for his liaison services. We are also indebted to a number of other officers and staff members of the Manhattan Project for their cooperation. As a result of this cooperation we have had unlimited access to the entire range of facts and activities involved in our assignment, and this has been most helpful.

It has not been possible for security reasons to set forth in this report all of the facts which we have taken into account, but we believe that those which are set forth are a sufficient basis for a useful appraisal of our conclusions and recommendations.

WASHINGTON, D. C.
March 16, 1946

A REPORT ON THE INTERNATIONAL CONTROL OF ATOMIC ENERGY

SECTION I

Background of the Problem

This report is a preliminary study of the international control of atomic energy. It has been prepared to contribute to the clarification of the position of the U. S. Representative on the United Nations Commission on atomic energy set up by resolution of the United Nations General Assembly to inquire into all phases of this question.

THE COMMITMENT FOR INTERNATIONAL CONTROL.

We were given as our starting point a political commitment already made by the United States to seek by all reasonable means to bring about international arrangements to prevent the use of atomic energy for destructive purposes and to promote the use of it for the benefit of society. It has not been part of our assignment to make a detailed analysis of the arguments which have led the Government of the United States in concert with other nations to initiate these steps for international action. By way of background, however, it is useful to review some of the main reasons which have influenced the people of the United States and its Government in this course. These reasons were first definitely formulated in the Agreed Declaration of November 15, 1945, issued by the President of the United States and the Prime Ministers of the United Kingdom and Canada. An understanding of the declarations in that document will itself throw considerable light on the criteria by which any specific proposals for international control may be judged.

The Agreed Declaration cites three reasons for seeking international control. This Declaration recognizes that the development of atomic energy, and the application of it in weapons of war, have placed at the disposal of mankind "means of destruction hitherto unknown." The American people have been quick to recognize the really revolutionary character of these weapons, particularly as weapons of strategic bombardment aimed at the destruction of enemy cities and the eradication of their populations. Enough has been said to make unnecessary a repetition of the probable horrors of a war in which atomic weapons were used by both combatants against the cities of their enemy. But it is hardly possible to overestimate the deep impression of horror and concern which insight into these future possibilities has made so widespread.

The second point recognized in the Agreed Declaration is that there can be no adequate military defense against atomic weapons. A great mass of expert testimony is involved in an appreciation of the firmness of this point, but it appears to be accepted without essential reservation, and subject only to an appropriate open-mindedness, about what the remote future of technical developments in the arts of war may bring.

The third point, and again we quote from the Agreed Declaration, is that these are weapons "in the employment of which no single nation can in fact have a monopoly." Of the three, this is perhaps the most controversial. Strong arguments hare been brought forward that the mass of technical and scientific knowledge and experience needed for the successful development of atomic weapons is so great that the results attained in the United States cannot be paralleled by independent work in other nations. Strong arguments have also been put forward that the degree of technical and industrial advancement required for the actual realization of atomic weapons could hardly be found in other parts of the world. These arguments have been met with great and widespread skepticism. It is recognized that the basic science on which the release of atomic energy rests is essentially a world-wide science, and that in fact the principal findings required for the success of this project are well known to competent scientists throughout the world. It is recognized that the industry required and the technology developed for the realization of atomic weapons are the same industry and the same technology which play so essential a part in man's almost universal striving to improve his standard of living and his control of nature. It is further recognized that atomic energy plays so vital a part in contributing to the military power, to the possible economic welfare, and no doubt to the security of a nation, that the incentive to other nations to press their own developments is overwhelming.

Thus the Agreed Declaration bases its policy on the revolutionary increase in the powers of destruction which atomic weapons have injected into warfare, and on the fact that neither countermeasures nor the maintenance of secrecy about our own developments offers any adequate prospect of defense.

There are perhaps other considerations which have contributed to the popular understanding of the necessity for international control, although they do not appear explicitly in the Agreed Declaration. The United States is in a rather special position in any future atomic warfare. Our political institutions, and the historically established reluctance of the United States to take the initiative in aggressive warfare, both would seem to put us at a disadvantage with regard to surprise use of atomic weapons. This suggests that although our present position, in which we have a monopoly of these weapons, may appear strong, this advantage will disappear and the situation may be reversed in a world in which atomic armament is general.

The atomic bomb appeared at the very end of hostilities at a time when men's thoughts were naturally turning to devising methods for the prevention of war. The atomic bomb made it clear that the plan which had been laid at San Francisco for the United Nations Organization would have to be supplemented by a specific control of an instrument of war so terrible that its uncontrolled development would not only intensify the ferocity of warfare, but might directly contribute to the outbreak of war. It is clear, too, that in the solution of this relatively concrete and most urgent problem of protect-

ing mankind from the evils of atomic warfare, there has been created an opportunity for a collaborative approach to a problem which could not otherwise be solved, and the successful international solution of which would contribute immeasurably to the prevention of war and to the strengthening of the United Nations Organization. On the one hand, it seemed unlikely that the United Nations Organization could fulfill its functions without attempting to solve this problem. On the other hand, there was hope and some reason to believe that in attempting to solve it, new patterns of cooperative effort could be established which would be capable of extension to other fields, and which might make a contribution toward the gradual achievement of a greater degree of community among the peoples of the world. Although these more general considerations may appear secondary to the main purposes of this report, they are not irrelevant to it. There is another phrase of the Agreed Declaration which rightly asserts "that the only complete protection for the civilized world from the destructive use of scientific knowledge lies in the prevention of war."

The proposals which we shall make in this report with regard to the international control of atomic energy must of course be evaluated against the background of these considerations which have led to the universal recognition of the need for international control. We must ask ourselves to what extent they would afford security against atomic warfare; to what extent they tend to remove the possibility of atomic weapons as a cause of war; to what extent they establish patterns of cooperation which may form a useful precedent for wider application. We ourselves are satisfied that the proposals in this report provide the basis of a satisfactory answer to these questions.

EARLY IDEAS ON SAFEGUARDS.

So much for the main outline of the political action that led to the setting up of the United Nations Commission on atomic energy. There is a further aspect of the general background that also requires discussion at the outset. When the news of the atomic bomb first came to the world there was an immediate reaction that a weapon of such devastating force must somehow be eliminated from warfare; or to use the common expression, that it must be "outlawed." That efforts to give specific content to a system of security have generally proceeded from this initial assumption is natural enough. But the reasoning runs immediately into this fact: The development of atomic energy for peaceful purposes and the development of atomic energy for bombs are in much of their course interchangeable and interdependent. From this it follows that although nations may agree not to use in bombs the atomic energy developed within their borders the only assurance that a conversion to destructive purposes would not be made would be the pledged word and the good faith of the nation itself. This fact puts an enormous pressure upon national good faith. Indeed it creates suspicion on the part of other nations that their neighbors' pledged word will not be kept. This danger is accentuated

by the unusual characteristics of atomic bombs, namely their devastating effect as a surprise weapon, that is, a weapon secretly developed and used without warning. Fear of such surprise violation of pledged word will surely break down any confidence in the pledged word of rival countries developing atomic energy if the treaty obligations and good faith of the nations are the only assurances upon which to rely.

Such considerations have led to a preoccupation with systems of inspection by an international agency to forestall and detect violations and evasions of international agreements not to use atomic weapons. For it was apparent that without international enforcement no system of security holds any real hope at all.

In our own inquiry into possibilities of a plan for security we began at this point, and studied in some detail the factors which would be involved in an international inspection system supposed to determine whether the activities of individual nations constituted evasions or violations of international outlawry of atomic weapons.

We have concluded unanimously that there is no prospect of security against atomic warfare in a system of international agreements to outlaw such weapons controlled *only* by a system which relies on inspection and similar police-like methods. The reasons supporting this conclusion are *not merely technical,* but primarily the inseparable political, social, and organizational problems involved in enforcing agreements between nations each free to develop atomic energy but only pledged not to use it for bombs. National rivalries in the development of atomic energy readily convertible to destructive purposes are the heart of the difficulty. So long as intrinsically dangerous activities may be carried on by nations, rivalries are inevitable and fears are engendered that place so great a pressure upon a system of international enforcement by police methods that no degree of ingenuity or technical competence could possibly hope to cope with them. We emphasize this fact of national rivalry in respect to intrinsically dangerous aspects of atomic energy because it was this fatal defect in the commonly advanced proposals for outlawry of atomic weapons coupled with a system of inspection that furnished an important clue to us in the development of the plan that we recommend later in this report.

We are convinced that if the production of fissionable materials by national governments (or by private organizations under their control) is permitted, systems of inspection cannot by themselves be made "effective safeguards ... to protect complying states against the hazards of violations and evasions."

It should be emphasized at this point that we do not underestimate the need for inspection as a component, and a vital one, in any system of safeguards—in any system of effective international controls. In reading the remainder of this section it is essential to bear in mind that throughout the succeeding sections of this report we have been concerned with discovering what other measures are required in order that inspection

might be so limited and so simplified that it would be practical and could aid in accomplishing the purposes of security.

The remainder of this section, however, is concerned with outlining the reasons for our conclusion that a system of inspection superimposed on an otherwise uncontrolled exploitation of atomic energy by national governments will not be an adequate safeguard.

THE TECHNICAL PROBLEM OF INSPECTION.

Although, as we have said, a system of inspection cannot be judged on technical grounds alone, an understanding of the technical problem is necessary in order to see what an inspection system would involve. The general purpose of such inspection (that is, inspection as the sole safeguard) would be to assure observance of international agreements according to which certain national activities leading more or less definitely to atomic armament would be renounced, and others which have as their purpose peaceful applications of atomic energy would be permitted. The fact that in much of their course these two types of activity are identical, or nearly identical, makes the problem one of peculiar difficulty.

In our study of the technical factors involved in appraising systems of inspection, we were greatly aided by consultations with the Technical Committee reporting to the War Department on the technical aspects of this problem.* We are indebted to this uniquely qualified group of experts for helpful discussions and for making available to us many of their reports, without which we should doubtless have been very much slower to understand the situation.

As a result of our work with this Committee, we are clear: That every stage in the activity, leading from raw materials to weapon, needs some sort of control, and that this must be exercised on all of the various paths that may lead from one to the other; that at no single point can *external* control of an operation be sufficiently reliable to be an adequate sole safeguard; that there is need for a very extensive and technically highly qualified and varied staff if the job is to be done at all; that the controlling agency must itself be active in research and development, and well informed on what is an essentially living art; and that, for effective control, the controlling organization must be as well and as thoroughly informed about the operations as are the operators themselves. Finally—and this we regard as the decisive consideration—we believe that an examination of these and other necessary preconditions for a successful scheme of inspection will reveal that *they cannot be fulfilled in any organizational arrangements in which the only instrument of control is inspection.*

*Membership of this Technical Committee on Inspection and Control established by the Manhattan District included L. W. Alvarez, R. F. Bacher, L. A. Bliss, S. G. English, A. B. Kinzel, P. Morrison, F. G. Spedding, C. Starr, Col. W. J. Williams, and Manson Benedict, Chairman.

A fundamental objection to an agency charged solely with inspection is that it will inevitably be slow to take into account changes in the science and technology of the field. One cannot look intelligently for a factor of whose principle of design and operation one has never heard. One cannot effectively inspect if the purpose of the operator is to conceal the discoveries by which he hopes to evade inspection. In a field as new and as subject to technical variation and change as this, the controlling agency must be at least as inventive and at least as well informed as any agency which may attempt to evade control.

HUMAN FACTORS IN INSPECTION.

Even more important than the technical difficulties of realizing an adequate system of inspection, against a background of national rivalry in the field of atomic energy or through an organization whose major or whose sole directive is suppressive, are the many human factors which in such an arrangement would tend to destroy the confidence and the cooperation essential to its success. The first of these appears when we ask whether it would in fact be possible to recruit the very large and very highly qualified organization of experts and administrators needed for the work The work itself, which would be largely policing and auditing and attempting to discover evidences of bad faith, would not be attractive to the type of personnel essential for the job. The activity would offer the inspectors a motive pathetically inadequate to their immense and dreary task.

The presence of a large number of "foreigners" necessarily having special privileges and immunities inquiring intimately and generally into industrial and mining operations would be attended by serious social frictions. For adequate inspection the numbers are large. As an example, it has been estimated that for a diffusion plant operated under national auspices, to offer any real hope of guarding against diversion, 300 inspectors would be required. They would have to check not merely accounts and measuring instruments but also individuals personally. Inquiries would need to be made of individuals without regard to rank or general status. Moreover, it would be especially important to check the location and employment of scientists and many technologists, probably including students. Industrial secrets would be at least to some extent open to "prying." The effect of this would vary with countries. It would probably be as obnoxious to Americans as to any others. Its corrosive effect upon the morale and loyalty of the inspecting organization would be serious.

Some of the organizational difficulties involved in intimate inspection "down the line" of one organization by another are known from experiences that are undoubtedly mild compared with what we should anticipate here. The following are illustrative of the political difficulties of practical operation (quite apart from those to be expected in adopting the international system to begin with). Adequate surveillance by inspection

as the sole or primary means of control involves a persistent challenge of the good faith of the nations inspected. If this were confined to relations between the chancellories and general military staffs the difficulty while serious might not be insuperable. But official questioning of the good faith of a nation by concrete action of inspectors among its citizens is another matter and would tend to produce internal as well as external political problems. A somewhat similar problem is involved when a government (or its officials or employees) interferes with the functions of inspectors or molests or threatens them personally, or bribes or coerces them, or *is accused of doing any of these things.* Such incidents could not be avoided.

Some may question whether nations would possess strong incentives to illicit operations, if they actually agreed to forego the production and use of fissionable materials for purposes of war. It is obvious, however, that suspicion by one nation of the good faith of another and the fear engendered thereby are themselves strong incentives for the first to embark on secret illicit operations. The raw materials of atomic energy, potentially valuable for new peacetime purposes and of critical importance for war, are already a matter of extreme competition between nations. The forces growing out of this situation and making for acute rivalry between nations seem to us far more powerful than those which cause the present rivalries with respect to such resources as oil. The efforts that individual states are bound to make to increase their industrial capacity and build a reserve for military potentialities will inevitably undermine any system of safeguards which permits these fundamental causes of rivalry to exist. In short, any system based on outlawing the purely military development of atomic energy and relying solely on inspection for enforcement would at the outset be surrounded by conditions which would destroy the system.

There is much technical information which underlies our belief that inspection can be effective only if it is supplemented by other steps to reduce its scope to manageable proportions, to limit the things that need to be inspected, to simplify their inspection, and to provide a pattern of organization which on the one hand will be of assistance to the controlling agency, and on the other will minimize organizational sources of conflict and the inducements to evasion. Much of this technical information is interwoven with later sections of this report. As the facts on which we base our recommendations for a workable plan of control are discussed, the detailed considerations which led to the conclusion stated in this section will appear more concretely than in the foregoing summary.

SECTION II

Principal Considerations in Developing a System of Safeguards

INTRODUCTION

At the outset of our inquiry we were preoccupied with some way of making an inspection system provide security. This is a preoccupation that is apparently common to most people who have seriously tried to find some answer to the extraordinarily difficult problem presented by the atomic bomb. But as day after day we proceeded with our study of the facts concerning atomic energy, and reflected upon their significance, we were inescapably driven to two conclusions: (a) the facts preclude any reasonable reliance upon inspection as the primary safeguard against violations of conventions prohibiting atomic weapons, yet leaving the exploitation of atomic energy in national hands; (b) the facts suggest quite clearly a reasonable and workable system that may provide security, and even beyond security, foster beneficial and humanitarian uses of atomic energy.

WHAT SHOULD BE THE CHARACTERISTICS OF AN EFFECTIVE SYSTEM OF SAFEGUARDS.

It may be helpful to summarize the characteristics that are desirable and indeed essential to an effective system of safeguards; in other words, the criteria for any adequate plan for security.

a. Such a plan must reduce to manageable proportions the problem of enforcement of an international policy against atomic warfare.

b. It must be a plan that provides unambiguous and reliable danger signals if a nation takes steps that do or may indicate the beginning of atomic warfare. Those danger signals must flash early enough to leave time adequate to permit other nations—alone or in concert—to take appropriate action.

c. The plan must be one that if carried out will provide security; but such that if it fails or the international situation collapses, any nation such as the United States will still be in a relatively secure position, compared to any other nation.

d. To be genuinely effective for security, the plan must be one that is not wholly negative, suppressive, and police-like. We are not dealing simply with a military or scientific problem but with a problem in statecraft and the ways of the human spirit. Therefore the plan must be one that will tend to develop the beneficial possibilities of atomic energy and encourage the growth of fundamental knowledge, stirring the

constructive and imaginative impulses of men rather than merely concentrating on the defensive and negative. It should, in short, be a plan that looks to the promise of man's future well-being as well as to his security.

e. The plan must be able to cope with new dangers that may appear in the further development of this relatively new field. In an organizational sense therefore the plan must have flexibility and be readily capable of extension or contraction.

f. The plan must involve international action and minimize rivalry between nations in the dangerous aspects of atomic development.

The facts we have come to think essential, and the elements of our thinking as we moved toward the plan we herein recommend, are set out in this section, in the form of the considerations that are relevant to an effective program for security, and that have led us to devise what we believe is an adequate plan.

CHAPTER I

The Problem Has Definable Boundaries

This problem of building security against catastrophic use of atomic energy is not one without boundaries. This is important. For if the fact were that tomorrow or a year hence we might reasonably expect atomic energy to be developed from clay or iron or some other common material then it is apparent that the problem of protection against the misuse of energy thus derived would be vastly more difficult. But such is not the case. The only scientific evidence worthy of regard makes it clear that in terms of security uranium is indispensable in the production of fissionable material on a scale large enough to make explosives or power. The significance of this fact for effective international control will appear.

As a first step in our work, we undertook a study, with the help of the qualified members of our group, aimed at an understanding of the well-established principles of nuclear physics upon which, among other things, the conclusion is based that uranium is indispensable as the primary source of atomic energy. These scientific principles are not familiar, but they are capable of being appreciated by laymen. Because the specific content of any system of control will be importantly influenced by the scientific principles and facts, we would emphasize the importance of an appreciation of them. For present purposes, we shall state in greatly simplified terms certain conclusions that are drawn from a full technical account of this subject.

Until 1942 the energy which man had learned to control for his useful purposes derived almost exclusively (except for water, wind, and tidal power) from chemical reactions. For practical purposes, chemical combustion was the main source of energy. This energy is the product of rearrangements of electrons in the periphery of atoms and results from the change in *chemical structure* which occurs in the process of combustion.

"Atomic energy," as that term is popularly used, refers to the energy that results from rearrangements in the structure of atomic nuclei of elements. There are very strong forces which hold such nuclei together and account for their stability. The nature of these forces is not adequately understood, but enough is known about their behavior, not only to make it certain that the energy of an atomic bomb or an atomic power plant comes from the work done by these forces when the structure of atomic nuclei is rearranged, but also to explain one major fact of decisive importance: Only in reactions of very light nuclei, and in reactions of the very heaviest, has there ever been, to the best of our knowledge, any large-scale release of atomic energy. The reasons for this can be given in somewhat oversimplified form.

As to the light nuclei—The forces which hold all nuclear particles together are attractive. When lighter nuclei combine to make heavier ones, and in particular when the

lightest nucleus of all, that of hydrogen, is combined with another light nucleus, these attractive forces release energy. This combination of light elements to form somewhat heavier ones occurs in the stars and of the sun; in the sun effectively what happens is that hydrogen nuclei combine to form the more stable nuclei of helium. Almost all sources of the energy used on earth come to us from the sunlight which this great atomic energy plant provides. But the conditions which make this plant possible are very special, and we do not know how to duplicate them on earth; we may very well never learn to do so. They depend on maintaining matter deep in the interior of the sun at very high temperatures—many millions of degrees. The nuclear reactions themselves provide the energy necessary to keep the matter hot; and it is kept from expanding and cooling by the enormous gravitational forces of attraction which hold the sun together and provide a sort of container in which this temperature and pressure can be maintained. For the foreseeable future the maintenance of such reactions on earth will not be possible; in the immediate future it is certainly not possible.

As to the heaviest nuclei—Although nuclear reactions can be carried out in the laboratory for all nuclei, and although in some cases a given nuclear reaction may release energy even for nuclei of intermediate weight, the properties which make the large-scale release of such energy possible are peculiar, to the very light nuclei and to the very heaviest. And the very heaviest nuclei have a property shared by none of the other elements. These very heavy nuclei generate energy if they can be caused to split into lighter ones; this unique process is called "fission." Perhaps a dozen nuclear species are known which can be made to undergo fission; under more drastic treatment no doubt the list will be extended. But to make atomic energy takes more than the property of fission. The fission process itself must maintain itself or grow in intensity so that once it is started in a few nuclei a chain of reactions will be set up and a large part of the material will become potentially reacting. The agency which initiates this process is the neutron. In fission neutrons are emitted; and in certain nuclei bombardment by neutrons is enough to cause fission.

There are several substances for which this is true, but there is only one substance which occurs in nature with any significant abundance for which it is true—that substance is uranium. Uranium is the only natural substance that can maintain a chain reaction. It is the key to all foreseeable applications of atomic energy.

One may ask why there are so few materials which undergo fission, and why so few of these can maintain a chain reaction. The reason lies in the fact that only the heaviest nuclei are sufficiently highly charged to come apart easily, and that only the most highly charged of all are sufficiently susceptible to fission on neutron bombardment to maintain a chain reaction. It is not to be anticipated that this situation will be invalidated by further scientific discovery.

A word needs to be said about the role of thorium, which is slightly more abundant

than uranium, and for which fission is also not too difficult to induce. Thorium cannot maintain a chain reaction, either itself or in combination with any other natural material than uranium. Nevertheless, it occupies an important position with regard to safeguards. The reason for this is the following: Without uranium, chain reactions are impossible, but with a fairly substantial amount of uranium to begin with and suitably large quantities of thorium a chain reaction can be established to manufacture material which is an atomic explosive and which can also be used for the maintenance of other chain reactions.

Absolute control of uranium would therefore mean adequate safeguard regarding raw materials. Yet, since any substantial leakage of uranium through the system of controls would make possible the exploitation of thorium to produce dangerous amounts of atomic explosive, provisions governing thorium should be incorporated in the system to compensate for possible margins of error in the control of uranium. The coexistence of uranium and thorium in some natural deposits makes this technically attractive.

There can be little hope of devising a successful scheme of control unless the problem can somehow be limited to the immediate future, by arrangements that have a reasonable prospect of validity for the next decade or two, and which contain sufficient flexibility to accommodate themselves to inevitably changing conditions. We believe that a system of control which disregards all materials except uranium and thorium satisfies these conditions. Indeed if a successful system of control can be commenced now, based upon these materials, and if the time should ever come when other materials lend themselves to the same activities, it should in fact be far easier to include them within the system than it will be to set up the initial control system with which we are now concerned.

Because the constituent raw materials of atomic energy can be limited to uranium and thorium, the control problem is further narrowed by the geological conditions under which uranium and thorium are found, and the fact that at present those elements have only restricted commercial significance. Although they are distributed with relative abundance throughout the world, and although it is clear that many sources beyond the known supplies will be discovered, it is apparently the view of the authorities that these elements occur in high concentrations only under very special geologic conditions. This would seem to mean that the areas which need to be surveyed, to which access must be had, and which would ultimately have to be brought under control, are relatively limited.

CHAPTER II

The Adequacy of Present Scientific Knowledge

There can be no question that its dynamic changing quality is one of the dominant features of the present situation in the field of atomic energy. Advances in knowledge must be expected in a constant stream. Does this mean that a system of safeguards is impossible because new knowledge will completely change the nature of the problem from year to year or even month to month? The answer is in the negative.

When the atomic bomb was first used there was a widespread belief that its development involved a few simple, static secrets. As it became possible for people to learn how rapidly ideas and techniques had changed in this field in the last year, and how many further developments the future seemed to have in store, the original opinion was replaced by another: that we knew very little of the possibilities and limitations of this field and that it was so rapidly changing that no account of the present technical situation would have much validity. This view has been expressed both in the preamble to a pending Bill, which indicates that too little is known of the technical facts to provide a firm basis for political action, and in such statements as one attributed to a high official, that it would not be long before we could extract atomic energy from common materials such as clay.

Neither the initial view of a static body of knowledge nor the later one of unpredictably rapid change accurately describes the present situation. As the preceding chapter has shown, there is a great deal that we know about nuclear reactions—know solidly, firmly, and with vast, interrelated experimental checks on the soundness of the description. Novelty will of course appear in scientific discoveries, but it will appear for the most part not as a negation of present knowledge but as the result of new types of physical experience made possible by new methods of physical exploration, and in turn requiring new modes of description. This future experience may have something to do with the basic knowledge involved in release of atomic energy, but there is no basis for believing this, and the chances are against it. There is another type of novelty that lies in ingenious applications of the fundamental facts as they are now known. This does not lessen the importance of the underlying facts and of conclusions which can unambiguously be drawn from them.

For the limited but useful objective of devising a system of control valid for the reasonably foreseeable future, we believe the present knowledge in the field of atomic energy is adequate. We know for example, that uranium occupies a unique role in the production of fissionable substances and that without it atomic explosives cannot be made. We know that there is no evidence whatever that this situation will soon change. We know that a vast scientific and industrial effort is necessary in order to produce atomic bombs. This is not to say that the effort, however vast, cannot be concealed—although

we believe that measures can be taken to reduce this danger. We know that the release of atomic energy does demonstrate the convertibility of mass to energy, but we also know that the familiar example of this physical principle—that the annihilation of a kilogram of any kind of matter is equivalent to all the power consumed in the United States in a period of three months—is a statement of a possibility, the realization of which is so remote that for the purposes of devising a system of safeguards it may be entirely disregarded.

We know, too, that many areas in this field which are now unclear will be clarified by further investigations. Within a few years much more could be learned about atomic explosives. Within a relatively few years the technology of atomic energy power plants will become clearer. It seems likely that before very long we shall have discovered many useful therapeutic and technological applications for the radioactive substances which can be made in the production of fissionable materials. Nor can there be much question that ways will be found to cheapen and simplify the processes involved in the production of the fissionable materials themselves.

But what needs most to be emphasized is that the dynamic quality which has so excited popular interest must be seen in its proper perspective in relation to the general field of scientific knowledge. The prophecies as to future discoveries must not be permitted to obscure the fact that there are at key places throughout the field of knowledge firm anchor points around which it should be possible to construct an effective and adequate system of control.

In this report it is possible for us to do little more than record our own sense of the soundness of this statement. Those who must assume responsibility for political action should test for themselves the correctness of our conclusions. This testing will require an examination of difficult and complicated technical facts, but we are confident that the process is one which other laymen with the appropriate help of experts can readily repeat. We are also confident that unless the effort is made it will be impossible to come to grips with the problem of devising political measures to prevent atomic warfare and to promote the beneficent use of atomic energy.

CHAPTER III

Constructive Applications for Atomic Energy

To "outlaw" atomic energy in all of its forms and enforce such a prohibition by an army of inspectors roaming the earth would overwhelm the capacity and the endurance of men, and provide no security. This conclusion has a further implication in a search for a security system. While suppression is not possible where we are dealing with the quest for knowledge, this thirst to know (that cannot be "policed" out of existence) *can* be used, affirmatively, in the design and building of an effective system of safeguards.

Human history shows that any effort to confine the inquiring human mind, to seek to bar the spirit of inquiry, is doomed to failure. From such efforts comes subversion fraught with terrible consequences: Gestapo, inquisitions, wars. The development of atomic energy is one of a long, long line of discoveries that have their well springs in the urge of men to know more about themselves and their world. Like the jiu jutsu wrestler whose skill consists in making his opponent disable himself with his own thrusts, the designers of a system of safeguards for security should and can utilize for enforcement measures that driving force toward knowledge that is part of man's very nature.

If atomic energy had only one conceivable use—its horrible powers of mass destruction—then the incentive to follow the course of complete prohibition and suppression might be very great. Indeed, it has been responsibly suggested that however attractive may be the potentialities for benefit from atomic energy, they are so powerfully outweighed by the malevolent that our course should be to bury the whole idea, to bury it deep, to forget it, and to make it illegal for anyone to carry on further inquiries or developments in this field.

We have concluded that the beneficial possibilities—some of them are more than possibilities, for they are within close reach of actuality—in the use of atomic energy should be and can be made to aid in the development of a reasonably successful system of security, and the plan we recommend is in part predicated on that idea.

That mankind can confidently look forward to such beneficial uses is a fact that offers a clue of not inconsiderable importance to *the kind of security arrangements* that can be made effective.

The difficulty of recruiting enforcement officers having only a negative and policing function, one of prohibiting, detecting, and suppressing, is obvious. Such a job lacks any dynamic qualities. It does not appeal to the imagination. Its future opportunities are obviously circumscribed. It might draw the kind of man, let us say, who was attracted to prohibition squads in years past. Compare this type of personnel with those who could be expected to enter a system under which it is clear that the constructive possibilities of atomic energy may also be developed. Atomic energy then becomes a

new and creative field in which men may take pride as participants, whatever their particular role. They are in "on the ground floor" of a growing enterprise. Growth, opportunities, future development—these are the characteristics, let us say, of the field of air transport that have made it possible for the airlines to attract a high grade and youthful personnel.

The importance of this fact that atomic energy has beneficial uses as well as destructive uses, in terms of the attraction of personnel in a security organization will, of course, depend upon the functions given to that organization. If the security organization has not only enforcement but also *development functions,* then this consideration of beneficial possibilities becomes a most weighty one.

What are the beneficial possibilities? We have had the benefit of a thoughtful, unpublished report on the technical possibilities now apparent in this field. This report was prepared for the Secretary of War's Interim Committee on Atomic Energy by a panel of scientists who worked with a large additional group of leading scientists in the field.* The conclusions there stated represent an appraisal of these possibilities, that is, in our opinion, challenging and at the same time balanced and restrained.

In introducing its conclusions the report observes that "We are probably no more able to foresee the ultimate fruits of development than were Faraday's contemporaries to understand what would come of the discovery of electro-magnetic induction." It gives a further sense of perspective in emphasizing that "The unique preoccupation of the war years in the use of atomic energy for military weapons . . . has probably retarded our understanding of other applications." We believe that this is equally true at present.

The report discusses two "great fields" for beneficial use, "the development of atomic energy as a controlled source of power" and "the application of radiations and radioactivities to the growth of the sciences and the practical arts." It gives a sober appraisal of each of these possibilities: "It is probable," the report states, "that the exploitation of atomic energy as a tool for research will outweigh the benefits to be derived from the availability of a new source of power." But this new source of power is itself regarded as of great significance, and is thought to be "the most appropriate focal point for the work of the next few years."

> "We have examined in some detail [the report continues] the technical problems of making available heat and power on the scale of present world consumption from controlled nuclear reactors. We see no significant limitations on this development, either in the availability or in the cost of the fundamental active materials. We see characteristic limitations and characteristic

*This panel included A. H. Compton, E. Fermi, E. O. Lawrence, and J. R. Oppenheimer. Their report was prepared in consultation with S. K. Allison, Zay Jeffries, C. C. Lauretsen, I. I. Rabi, C. A. Thomas, H. C. Urey, and with the further help of numerous specialists.

> advantages in atomic power which make us regard it in great measure as a supplement to existing sources, and an incentive to new developments, rather than as a competitor, let us say, to coal or to petroleum products. We see no foundation in current science for the hope that atomic power can be effectively used for light, small portable units such as are required for aircraft and for automotive transportation; but we believe that the development of rather large power units for heat and conversion to electrical energy is a program for the near future; that operating units which will serve to demonstrate the usefulness and limitations of atomic power can be in existence within a few years, and that only the gradual incorporation and adaptation of such units to the specific demands of contemporary economy will involve a protracted development."

Finally, the report takes up the opportunities which have been opened in the field of research by the prospect of a plentiful supply of radioactive substances as byproducts of the manufacture of fissionable materials, a circumstance which it has been said may well be as significant for scientific progress as the ready availability of microscopes for every laboratory.

> "It should be understood [the report says] that work specifically focused on atomic power need not and should not interfere with making available to biology, medicine, chemistry, and physics the radiations and activities characteristic of this field . . . We should not be astonished if the greatest benefit of this program were in fact to lie in therapy for some of the neo-plastic diseases, such as cancer, or in the increased understanding of biological systems or of the realities of the physical world, which will in turn open up new fields of human endeavor."

The full report contains descriptions in more concrete terms of some of these possibilities. We are convinced that in the vigorous exploitation of them lies one of the greatest hopes of developing a successful system of international control.

Under the most favorable conditions, the peril of atomic warfare can be averted only by drawing upon the best human resources of good will, imagination, and ingenuity. All experience teaches that these resources cannot be tapped except by challenging opportunities. One of the most serious dangers to the promotion of effective international action is the danger that our natural preoccupation with the destructive aspects of atomic energy may blind us to its useful aspects. Upon searching investigation, some of the latter may prove illusory. But if the lessons of past scientific and technological progress mean anything, we also know that many of these opportunities will materialize. We believe that only a system of safeguards which is built around these

hopeful prospects can succeed. We have tried throughout this report to make explicit the connection between a system of safeguards and these opportunities.

Important, perhaps even decisive, in the proposals we put forth in this report is the fact that many of the constructive activities required in the development of atomic energy involve no risks of providing a material basis for weapons of war. This aspect of the matter is dealt with in detail in Chapter V of this Section.

CHAPTER IV

The Elimination of International Rivalry

It is clear that uranium and thorium are materials of great strategic importance to nations seeking to establish for themselves a powerful position in the field of atomic energy. The fact that rich sources of such materials occur in a relatively few places in the world, as compared, for example, with oil, creates a competitive situation which might easily produce intolerable tensions in international relations. We believe that so long as nations or their subjects engage in competition in the fields of atomic energy the hazards of atomic warfare are very great indeed. We assume the General Assembly of the United Nations, in setting up an Atomic Energy Commission, had this disturbing fact much in mind.

What is true in respect to the dangers from national competition for uranium is similarly true concerning other phases of the development of atomic energy. Take the case of a controlled reactor, a power pile, producing plutonium. Assume an international agreement barring use of the plutonium in a bomb, but permitting use of the pile for heat or power. No system of inspection, we have concluded, could afford any reasonable security against the diversion of such materials to the purposes of war. If nations may engage in this dangerous field, and only national good faith and international policing stand in the way, *the very existence of the prohibition* against the use of such piles to produce fissionable material suitable for bombs would tend to stimulate and encourage surreptitious evasions. This danger in the situation is attributable to the fact that this potentially hazardous activity is carried on by nations or their citizens.

It has become clear to us that if the element of rivalry between nations were removed by assignment of the intrinsically dangerous phases of the development of atomic energy to an international organization responsible to all peoples, a reliable prospect would be afforded for a system of security. For it is the element of rivalry and the impossibility of policing the resulting competition through inspection alone that make inspection unworkable as a sole means of control. With that factor of international rivalry removed, the problem becomes both hopeful and manageable.

To restate the conclusion: It is essential that a workable system of safeguards remove from individual nations or their citizens the legal right to engage in certain well-defined activities in respect to atomic energy which we believe will be generally agreed to be intrinsically dangerous because they are or could be made steps in the production of atomic bombs. We schematically describe what we regard as intrinsically dangerous steps later in Chapter V. Those activities thus classified as dangerous we conclude are far less dangerous when carried on not by competing nations but by an international organization whose obligation it is to act for all nations. They can, in our opinion, be rendered sufficiently less dangerous to provide an adequate measure of security.

We can illustrate the force of these conclusions in a few simple cases. *(a)* Take the case of uranium ores. If any nation may engage in prospecting for and mining uranium ore, subject to inspection as to the proper, i.e., peaceful use thereof, inspection is a most difficult thing. But if the *only legal ownership and development of uranium ore* is in the hands of an international agency manned by and representing all nations, the problem of detection of evasions is, by a single stroke, reduced tremendously. Indeed, we are persuaded that it is reduced to quite manageable proportions in the light of existing knowledge about uranium ore deposits through the world. For then it would be true that not the purpose of those who mine or possess uranium ore but the mere fact of their mining or possessing it becomes illegal, and national violation is an unambiguous danger signal of warlike purposes. The very opening of a mine by anyone other than the international agency is a "red light" *without more;* it is not necessary to wait for evidence that the product of that mine is going to be misused.

(b) Take another illustration involving the building and operation of a plutonium pile. The product of that operation is a material that can be used for atomic weapons. The product is also useful for power piles. If all such piles are designed and operated exclusively by an international agency, then the building or operation of such a pile or any move in that direction by *any one else* is illegal without respect to the use he says he plans to make of it, and constitutes a plain and simple danger signal calling for action of a preventative character by an international agency.* Nor could there be a clearer sign of danger calling for immediate international action or countermeasures than interference with the operation of an international plant.

We conclude that the international development and operation of potentially and intrinsically dangerous activities in connection with atomic energy would bring the task of security within manageable proportions because of the elimination of the hazards of rivalry between nations. But there is a further advantage to vesting exclusively in an international agency these activities so hazardous to world security. That advantage grows out of the nature of the development of atomic energy itself.

This is a growing and changing field. New advances in technology may be confidently expected. It therefore becomes absolutely essential that any international agency seeking to safeguard the security of the world against warlike uses of atomic energy should be in the very forefront of technical competence in this field. If the international agency is simply a police activity for only negative and repressive functions, inevitably and within a very short period of time the enforcement agency *will not know enough* to be able to recognize new elements of danger, new possibilities of evasion, or the beginnings of a course of development having dangerous and warlike ends in view. There

*In Section III we discuss what would happen if the international organization should fail or an international plutonium plant should be seized by a nation; we shall not digress from the present point to discuss that here.

is a striking example of this. The art of atomic weapons is in its infancy and we are quite ignorant of the possibilities in this field. Such ignorance, such uncertainty of such catastrophic weapons, is itself a source of danger, and its continuation, through the prohibition of further study and development, would in our opinion not only be hard to effect, but would itself be dangerous. Yet the development of atomic weapons can hardly be left to national rivalry.

A further example: The present separation plants for U 235 at Oak Ridge are huge and bulky in the extreme, and use enormous amounts of power. Quite probably this will always be true. But it is not a law of nature. Those in whose hands lies the prevention of atomic warfare must be the first to know and to exploit technical advances in this field.

We have, therefore, concluded that here was an additional reason and a very practical one why a responsibility for the *development* of atomic energy should be vested in the same international agency that has also responsibility for developing and enforcing safeguards against atomic warfare. For unless the international agency was engaged in development activities itself (as, for example, in the design and operation of power piles or in the surveying and exploration of new sources of raw materials) its personnel would not have the power of knowledge or the sensitivity to new developments that would make it a competent and useful protection to the people of the world.

We have therefore reached these two conclusions: *(a)* that only if the dangerous aspects of atomic energy are taken out of national hands and placed in international hands is there any reasonable prospect of devising safeguards against the use of atomic energy for bombs, and *(b)* only if the international agency was engaged in development and operation could it possibly discharge adequately its functions as a safeguarder of the world's future. Such a development function also seems essential in terms of attracting to the international agency the kind of scientists and technicians that this problem requires, recognizing that a mere policing, inspecting or suppressing function would neither attract nor hold them.

CHAPTER V

"Safe" and "Dangerous" Activities

It is true that the internationalization of activities intrinsically dangerous to security reduces the hazards in the way of security and does bring into more manageable form the problems of enforcement and the suppression of atomic weapons. If it were necessary, in such a scheme of safeguards, to vest in an international agency a total monopoly as to all aspects of atomic energy, disadvantages would arise so great as conceivably to make the prospect of effective internationalization itself beyond realization. Such an overall grant of exclusive right to develop, operate, and utilize, conferred upon an international agency, would change many of the industrial and economic practices of this country, for example, and would change them quite disadvantageously.

Such a complete international monopoly would be hard to live under. Its restrictive limitations would chafe, and might in time cause serious loss of support to the security purposes that lay behind the proposal itself. Many of the considerations of complexity, irritation, the engendering of suspicion, the encouragement of deceit that we found militated against a system of safeguards based upon national operation and international inspection would to a lesser degree be repeated by such an all-out proposal for centralization.

This problem need not arise. For there are important areas in the field of atomic energy where there is no need for an international monopoly, and where work may and should be open not exclusively to the international organization, but to private and to national institutions in a quite free manner. These fields are among those of the greatest immediate promise for the beneficial exploitation of atomic energy. They are technically complex and closely related to the central scientific problems. That open and, in some respects, competitive activity is possible in much of the field should go a long way toward insuring contact between the experts of the international organization and those outside it, in industry and in scientific and educational organizations. The same fact should help correct any tendencies that might otherwise develop toward bureaucratic inbreeding and over-centralization, and aid in providing healthy, expanding national and private developments in atomic energy.

The technical facts which underlie the possibility of regarding many developments in the field of atomic energy as safe for national and private exploitation are in themselves rather complex; to the discussion of these we must now turn. These are, of course, activities which without reliance on the conscious determination of the operators, and with a minimum of control and supervision, are physically incapable of contributing to the making of atomic weapons.

A word may be in order about our views on what constitute "dangerous activities"—those that, in our opinion, ought to be subject to an international monopoly. It will be

appreciated at the outset that this distinction between the "safe" and the "dangerous" can be useful without being completely sharp or fixed for all time. In our view, any activity is dangerous which offers a solution either in the actual fact of its physical installation, or by subtle alterations thereof, to one of the three major problems of making atomic weapons:

I. The provision of raw materials,

II. The production in suitable quality and quantity of the fissionable materials plutonium and U 235, and

III. The use of these materials for the making of atomic weapons.

Thus we regard the mining and processing of uranium as a dangerous activity even though it must be supplemented by plants and ordnance establishments if atomic weapons are to result. We regard the facilities for making atomic weapons as dangerous even though some control be exercised over the provision of the fissionable material; and we regard the operation of reactors or separation plants which make the material for bombs or which, by relatively minor operational changes, could make the material for bombs, as dangerous even though they in turn would have to be supplemented by supplies of raw material and by installations for assembling atomic weapons.

We need not regard as dangerous either amounts of material which are small in relation to those needed to make a weapon or installation whose rate of production is small in these terms. A further point which will prove important in establishing the criteria for the safety or danger of an operation is this: U 235 and plutonium can be denatured; such denatured materials do not readily lend themselves to the making of atomic explosives, but they can still be used with no essential loss of effectiveness for the peaceful applications of atomic energy. They can be used in reactors for the generation of power or in reactors useful in research and in the production of radioactive tracers. It is important to understand the sense in which denaturing renders material safer. In the first place, it will make the material unusable by any methods we now know for effective atomic explosives unless steps are taken to remove the denaturants. In the second place, the development of more ingenious methods in the field of atomic explosives which make this material effectively useable is not only dubious, but is certainly not possible without a very major scientific and technical effort.

It is possible, both for U 235 and for plutonium, to remove the denaturant, but doing so calls for rather complex installations which, though not of the scale of those at Oak Ridge or Hanford, nevertheless will require a large effort and, above all, scientific and engineering skill of an appreciable order for their development. It is not without importance to bear in mind that, although as the art now stands denatured materials are unsuitable for bomb manufacture, developments which do not appear to be in principle impossible might alter the situation. This is a good example of the need

for constant reconsideration of the dividing line between what is safe and what is dangerous.

We would, however, propose as criterion that installations using material both denatured and insufficient in quantity for the manufacture of bombs could be regarded as safe, provided the installations did not themselves make large quantities of suitable material. With some safeguards in the form of supervision, installations in which the amounts of material are small, or in which the material is denatured, might also be regarded as safe; but installations using or making large amounts of material not denatured, or not necessarily denatured, we would call dangerous.

Let us see now what we regard as safe activities in this field.

(1) Perhaps the clearest case is the application of radioactive material as tracers in scientific, medical, and technological studies. This is a field in which progress may be expected to be very rapid, and we can see no reason at all for limiting, on grounds of safety, the activities using such tracer materials.

(2) It is easy to design small nuclear reactors which use denatured U 235 or plutonium. These reactors can be operated at a power level low enough to be incapable of producing dangerous quantities of fissionable materials but high enough to provide neutron sources and gamma ray sources of unparalleled intensity. The material in these reactors is neither in quantity nor in quality significant for bomb production; even if one combined the material from many, no practical method of making weapons would be available. On the other hand, reactors of this kind can and almost inevitably will be designed to operate at so low a power level that they cannot be used to produce quantities of fissionable material which are of military significance. Reactors of this general kind have the following important applications:

(a) They may be used to make radioactive materials, and as such may be a supplement, and a valuable supplement, to the more dangerous reactors operating at higher power levels; in particular, they can make useful radioactive materials that last too short a time to permit them to be provided from remote plants.

(b) As a source of radiation, primarily of neutron radiation, such reactors are research tools for physics, for chemistry, and for biology. This may, in fact, be one of the most important applications of the release of atomic energy.

(c) The high intensity of radiation from such reactors will bring about changes in chemical and biological systems which may be of immense practical value, once they have been understood.

(3) More marginal from the standpoint of safety, but nevertheless important, is another case of an operation which we would regard as safe. This is the development of power from the fission of denatured U 235 and plutonium in high power-level reactors.

Such power reactors might operate in the range from 100,000 to 1,000,000 kw. If these fissionable materials are used in installations where there is no additional uranium or thorium, they will not produce further fissionable material. The operation of the reactors will use up the material. If the reactors are suitably designed, a minimum of supervision should make it possible to prevent the substitution of uranium and thorium for the inert structure of the materials of the reactors. In order to convert the material invested in such reactors to atomic weapons, it would be necessary to close down the reactor; to decontaminate the fissionable material of its radioactive fission products; to separate it, in what is a fairly major technical undertaking, from its denaturant; and to establish plants for making atomic weapons. In view of the limited amount of material needed for such a power reactor, and of the spectacular character and difficulty of the steps necessary to divert it, we would regard such power reactors as safe provided there were a minimum of reasonable supervision of their design, construction, and operation. If the material from one such reactor (of a size of practical interest for power production) were diverted, it might be a matter of some two or three years before it could be used to make a small number of atomic weapons.

We attach some importance to reactors of this type because they make it possible in large measure to open up the field of atomic power production to private or national enterprise. It is, in this connection, important to note that the materials required to construct these reactors cannot themselves be produced in installations which we could regard as safe. It is, furthermore, important to note that for every kilowatt generated in safe reactors, about 1 kilowatt must be generated in dangerous ones in which the material was manufactured. Thus if atomic power is in fact developed on a large scale, about half of it will inevitably be an international monopoly, and about a half might be available for competitive exploitation. That is to say, the primary production plants necessary to produce the materials required to construct *safe* power plants will in that process of production produce large amounts of power as a by-product. It is, furthermore, clear that the stockpiling of appreciable quantities of fissionable material suitably denatured, must precede the development of these safe power reactors. We think it fortunate that the actual operation of such reactors will have to await the production of these essential materials, so that there will be time for further study of means by which they may be supervised and their safety insured.

All the above illustrations show that a great part of the field of atomic energy can be opened with relative safety to competitive activity. They also show that the *safe operations are possible only because dangerous ones are being carried out concurrently.* It is not possible to devise an atomic energy program in which safeguards independent of the motivation of the operators preclude the manufacture of material for atomic weapons. But it is possible, once such operations are undertaken on an international basis, to devise others of great value and of living interest in which safety is no longer dependent on the motivation of the operators.

We have enumerated elements of the large field of non-dangerous activities under (1), (2), and (3) above. Among the activities which we would at the present time classify as those dangerous for national exploitation are the following:

(4) Prospecting, mining, and refining of uranium, and, to a lesser extent, thorium.

(5) The enrichment of the isotope 235 by any methods now known to us.

(6) The operation of the various types of reactors for making plutonium, and of separation plants for extracting the plutonium.

(7) Research and development in atomic explosives.

Of these activities, (6), as we have indicated, not only plays an essential part in providing active materials, but involves installations capable of generating power.

It should be added in conclusion that to exclude even safe activities from international operation seems unwise, but these should not be an international monopoly. It would equally be unwise to exclude from knowledge and participation in the dangerous activities experts who are not associated with the international authority. As the next section will show, there are practical means for making this collaboration possible in such a way that security will be promoted rather than impaired. Only a constant reexamination of what is sure to be a rapidly changing technical situation will give us confidence that the line between what is dangerous and what is safe has bees correctly drawn; it will not stay fixed. No international agency of control that is not qualified to make this reexamination can deserve confidence.

SUMMARY

1. If nations or their citizens carry on intrinsically dangerous activities it seems to us that the chances for safeguarding the future are hopeless.

2. If an international agency is given responsibility for the dangerous activities, leaving the non-dangerous open to nations and their citizens and if the international agency is given and carries forward affirmative development responsibility, furthering among other things the beneficial uses of atomic energy and enabling itself to comprehend and therefore detect the misuse of atomic energy, there is good prospect of security.

SECTION III

Security Through International Cooperative Development

INTRODUCTION

In the preceding section of this report we have outlined the course of our thinking in an endeavor to find a solution to the problems thrust upon the nations of the world by the development of the atomic bomb—the problem of how to obtain security against atomic warfare, and relief from the terrible fear which can do so much to engender the very thing feared.

As a result of our thinking and discussions we have concluded that it would be unrealistic to place reliance on a simple agreement among nations to outlaw the use of atomic weapons in war. We have concluded that an attempt to give body to such a system of agreements through international inspection holds no promise of adequate security.

And so we have turned from mere policing and inspection by an international authority to a program of affirmative action, of aggressive development by such a body. This plan we believe holds hope for the solution of the problem of the atomic bomb. We are even sustained by the hope that it may contain seeds which will in time grow into that cooperation between nations which may bring an end to all war.

The program we propose will undoubtedly arouse skepticism when it is first considered. It did among us, but thought and discussion have converted us.

It may seem too idealistic. It seems time we endeavor to bring some of our expressed ideals unto being.

It may seem too radical, too advanced, too much beyond human experience. All these terms apply with peculiar fitness to the atomic bomb.

In considering the plan, as inevitable doubts arise as to its acceptability, one should ask oneself "What are the alternatives?" We have, and we find no tolerable answer.

The following pages contain first a brief summary of the plan we recommend, and then an expansion going into some detail.

Summary of Proposed Plan—The proposal contemplates an internationa1 agency conducting all intrinsically dangerous operations in the nuclear field, with individual nations and their citizens free to conduct, under license and a minimum of inspection, all non-dangerous, or safe, operations.

The international agency might take any one of several forms, as a UNO Commission, or an international corporation or authority. We shall refer to it as Atomic Development Authority. It must have authority to own and lease property; and to carry on mining, manufacturing, research, licensing, inspecting, selling, or any other necessary operations.

This chapter is not an attempt to write a corporate charter for such an international agency. It is the aim, rather, to show that such a charter can be written in workable terms, and that the nature of the organization and its functions will have decisive consequences for world security. We are satisfied that the differences between national and international operations can be exploited to make the problem of atomic energy manageable. This idea, we think, can become as familiar as the fact that the differences between individual enterprise and corporate enterprise have important consequences in the conduct of business.

If we are to do anything constructive in relation to atomic energy it must inevitably be novel and immensely difficult. We think that the weeks that we have spent in analysis of the problem have made it appear somewhat less difficult and somewhat less novel. A succession of such processes will be necessary, each building on the preceding analysis, before even the major ramifications of the problem can be understood and the major questions partially answered. What is chiefly important now is to describe the right course of action in terms sufficiently practical and valid to show that the further exploration is worthwhile.

The proposal contemplates an international agency with exclusive jurisdiction to conduct all intrinsically dangerous operations in the field. This means all activities relating to raw materials, the construction and operation of production plants, and the conduct of research in explosives. The large field of non-dangerous and relatively non-dangerous activities would be left in national hands. These would consist of all activities in the field of research (except on explosives) and the construction and operation of non-dangerous power-producing piles. National activities in these fields would be subject to moderate controls by the international agency, exercised through licensing, rules and regulations, collaboration on design, and the like. The international agency would also maintain inspection facilities to assure that illicit operations were not occurring, primarily in the exploitation of raw materials. It would be a further function of the Atomic Development Authority continually to reexamine the boundary between dangerous and non-dangerous activities. For it must be recognized that although the field is subject to reasonable division, the dividing line is not sharp and may shift from time to time in either direction.

The development agency itself would be truly international in character. Its staff would be recruited on an international basis. Its functions would be such as to attract a calibre of personnel comparable to our own activities in raw materials during the war and

our own primary production and experimental work. It would be set up as one of the subsidiary agencies of the United Nations, but it would have to be created by a convention or charter establishing its policies, functions, and authority in comprehensive terms.

Whatever the formal organization, its integration with national structure would of course be one of the major problems. Measures to assure the proper degree of accountability to the United Nations and to individual nations, measures to assure that individual nations would have ample opportunity to be informed of the agency's activities, measures to make the agency responsive to the changing needs of nations—all these would have to be worked out with extraordinary care and ingenuity. But certainly our experience with business and government institutions, national and international, would afford a wealth of guidance in the development of such measures.

In the actual conduct of its operations the development organization would at all times be governed by a dual purpose, the promotion of the beneficial use of atomic energy and the maintenance of security. We believe that much can be done in a convention or charter to make these purposes concrete and explicit, to draw the line between the dangerous and the non-dangerous, to establish the principles determining the location of stockpiles and plants so that a strategic balance may be maintained among nations, to establish fair and equitable financial policies so that the contributions of nations to, and their receipt of benefits from, the organization will be justly apportioned. The most careful and ingenious definitions will be required in order to accomplish these purposes.

In what follows we shall attempt to develop and expand the foregoing statement of essentials.

We can best visualize the Atomic Development Authority in terms of the answer to these concrete questions:

(1) What will be the functions of the agency; what are the things that it will do?

(2) What kind of organization is necessary to carry out these functions?

(3) How will the organization be related to the United Nations and the individual nations that it will represent?

(4) What policies will guide the agency in determining its manifold actions?

CHAPTER I

Functions of Atomic Development Authority

In the field of raw materials—The first purpose of the agency will be to bring under its complete control world supplies of uranium and thorium. Wherever these materials are found in useful quantities the international agency must own them or control them under effective leasing arrangements. One of its principal tasks will be to conduct continuous surveys so that new deposits will be found and so that the agency will have the most complete knowledge of the world geology of these materials. It will be a further function of the agency constantly to explore new methods for recovering these materials from media in which they are found in small quantities.

In this way there will be no lawful rivalry among nations for these vital raw materials. Through its surveys the agency will be better informed about their geology and extraction than any single nation could possibly be. It will be in a better position to discover whether and where illicit operations might occur than any inspection force could possibly be. This is not to say that there is no risk of illicit operations; any plan, any system of safeguards, involves some risk. The question that must be answered in appraising the dangers is whether the risk is so large that it is better to make no attempt at international control and abandon the world to national atomic armament.

As we have pointed out earlier, if the Atomic Development Authority is the only agency which may lawfully operate in the raw materials field, then any visible operation by others will constitute a danger signal. This situation contrasts vividly with the conditions that would exist if nations agreed to conduct mining operations solely for proper purposes; for surreptitious abuse of such an agreement would be very difficult to detect. It is far easier to discover an operation that should not be going on at all than to determine whether a lawful operation is being conducted in an unlawful manner.

For the purpose of its surveys, the international agency would require access to various nations for its geologists and mining engineers. But the known geology of the critical materials is such that it may be possible to limit the degree of access from the start. And, as explorations proceed and various areas are eliminated it may be hoped that the *need* for access would narrow, rather than expand, but at all times the right of access to any region for re-survey in the light of new knowledge would be necessary.

All the actual mining operations for uranium and thorium would be conducted by the Authority. It would own and operate the refineries for the reduction of the ores to the metal or salt. It would own the stockpiles of these materials and it would sell the by-products, such as vanadium and radium. It would also provide the necessary supplies of uranium and thorium for the present limited commercial uses. All these sales would presumably go through normal commercial channels.

In the field of raw materials as in other activities of the Authority, extremely difficult policy questions, with the most serious social, economic, and political implications, will arise. How shall nations and individuals be compensated for reserves taken over by the Authority? As between several possible mines in different areas, which shall be operated when it is clear that the output of all is not presently required? How can a strategic balance be maintained between nations so that stockpiles of fissionable materials will not become unduly large in one nation and small in another? We do not suggest that these questions are simple but we believe that practical answers can be found. An attempt to suggest an approach to such answers is made later where the general question of policies of the Authority is discussed.

Production Plants—The second major function of the Authority would be the construction and operation of useful types of atomic reactors and separation plants. This means that operations, like those at Hanford and Oak Ridge and their extensions and improvements, would be owned and conducted by the Authority. Reactors for producing denatured plutonium will be large installations and by the nature of the process they will yield large amounts of energy as a byproduct. As the technology of power development by this method expands, ways will be found for utilizing this power both as heat and as electricity. The existing plants are not designed to operate at a sufficiently high temperature for the energy to be used for the generation of electrical power. One of the first research and development problems of the Authority would be to develop designs of reactors such that the energy released would be in form usable for the generation of electric power.

These production plants are intrinsically dangerous operations. Indeed they may be regarded as the most dangerous, for it is through such operations that materials can be produced which are suitable for atomic explosives.

In addition to questions similar to these mentioned in the case of raw materials, many new ones suggest themselves in relation to such production plants. What measures can be taken to assure the minimum degree of danger in design of plants and output? What measures can be taken to assure the minimum danger of diversion? What measures can be taken to assure location of plants that both will permit the disposition of byproduct power and heat in areas where they are most needed and at the same time will maintain a strategic balance between nations so that none may be inspired with fear lest the existence of plants in another would give that nation an advantage if it suddenly developed aggressive intentions? How will the vast amounts of byproduct power be disposed of by an international agency operating geographically within a national economy? Like the questions previously stated, these are not easy to answer. But here again we think that answers can be found and we venture later to suggest a way of going about the process of formulating answers.

Research Activities—We have already referred to the research that the Authority will

conduct to extend the field of knowledge in relation to recoverable raw materials. We have referred to research in power development. There will be many other forms of research in which the Authority will have to engage, relating to simplifying reactors and the like.

Here we desire to emphasize that the field of research in its broadest sense is the field in which the greatest opportunities present themselves for national and private activities. For research in relation to the application of discoveries relating to atomic energy is a great area of work which in the context of the general plan of safeguards herein proposed is non-dangerous. For the reasons already indicated the Authority itself will have to engage in a wide variety of research activities. For example, one of the important things that the Authority will have to do is research in atomic explosives. We are by no means sure that important new discoveries in this field do not lie ahead. Possibly the study of atomic explosives may yield byproducts useful in peaceful activities. But this will not be the main purpose of the Authority's research. Only by preserving its position as the best informed agency will the Authority be able to tell where the line between the intrinsically dangerous and the non-dangerous should be drawn. If it turns out at some time in the future, as a result of new discoveries, that other materials lend themselves to dangerous atomic developments, it is important that the Authority should be the first to know. At that time measures would have to be taken to extend the boundaries of safeguards.

But, as we have said, it seems highly desirable that while conducting its own necessary research the Authority must not discourage but rather must give vigorous encouragement to research in national or private hands. The universities and public technical agencies, industrial enterprises, research institutes, all will have a direct interest in participating in these activities. A good example of the opportunities in this direction is afforded by considering the situation with respect to radioactive isotopes. It will be possible for the Authority to produce these isotopes in primary production plants. The chemical separation and purification of them, however, is an involved industrial process, but involves no threat to security; states or private organizations should be encouraged to go into these activities. But for many purposes it will also be possible to produce these isotopes in small non-dangerous reactors that can be safely operated by nations or private institutions. In the interest of avoiding overexpansion of the international Authority, we think a deliberate effort should be made to encourage the production of isotopes in national hands.

It would be premature, of course, to seek now to draw any hard and fast line between the functions that the Authority should have in producing these isotopes and the functions which ought to be left to nations and their citizens. But it is important to be aware at all times of the necessity for taking advantage of the opportunity for promoting decentralized and diversified national developments and of avoiding unnecessary

concentration of functions in the Authority. The field of research is an area in which the keenest awareness of this problem will be essential when the time comes to draft a charter and when thereafter the time comes for establishing the detailed administrative policies of the Authority.

Up to now we have been dealing with the exclusive proprietary functions of the Atomic Development Authority. Except as to the discussion just concluded we have been describing the things it must do wholly withdrawn from national hands. We turn now to a discussion of functions more regulatory than proprietary in character. These are the functions through which the agency will maintain moderate controls over the activities that will be conducted by nations or private agencies. For convenience we shall refer to these activities as "licensing" functions though we think that various devices besides licensing may in fact be developed to do the job.

Licensing Activities—The uranium and thorium which the Authority mines and the fissionable materials which it produces will remain the property of the Authority. By such ownership the Authority could determine the conditions under which these dangerous materials might be used. Through the lease of such denatured materials to those desiring to build and operate reactors of various non-dangerous kinds, the personnel of the Authority could have access to the establishment in which such material is used. Moreover, through its own research and development activities and through establishing cooperative relationships with research and development laboratories in this field throughout the world, the Authority would be in a position to determine intelligently safe and unsafe designs of reactors for which it might lease its fissionable materials.

In the following paragraphs we shall refer to three of the general types of activities of great importance in the field of atomic energy which, as already indicated, are or can be made sufficiently safe to be carried on by nations under suitable arrangements with the proposed Authority. These types of activity, as we have pointed out earlier, open up a broad field for national and private exploitation of the useful applications of atomic energy. In particular, they will permit broad scope for research and development in this field by nations and private groups within such nations.

One of the first licensing activities of the Authority might be in the field of research reactors for which it would furnish on lease denatured plutonium or U 235. In carrying on such operations, presumably those desiring to build such research reactors would submit their designs to the Authority both for approval and for advice as to improvements, and would obtain a license to build such a reactor and lease of the denatured fissionable material needed for it. There would be a minimum of danger involved in allowing the construction and operation of research reactors not exceeding a prescribed power level. As we have seen, the amounts of fissionable material which might be produced through their use would be so small that for any individual unit, or even for units in one country which might number a dozen or more, there would be no real dan-

ger in terms of producing material sufficient for use in atomic explosives. Presumably the Authority from time to time would send its research personnel, in the dual role of research workers and inspectors, to the laboratories in which these reactors were used, but a minimal inspection would be needed. Moreover, such research reactors would fulfill to a large extent the urgent requirements for further intensive scientific research in this field. Presumably licenses and leases of material would be arranged between the Authority and individual nations so that the Authority would not be dealing directly with private groups within nations.

The Authority would also license and lease in the same manner as described for research reactors the construction and operation of reactors for making radioactive materials. There may well be, as suggested above, a field for the national or private production of such radioactive materials which will require a pile to produce materials for industrial and other peaceful uses. The fissionable materials leased by the Authority would always be in the form of denatured plutonium or U 235.

Within the next few years, the Authority should also be in a position to license the construction and operation of power piles and to furnish on lease denatured plutonium or U 235. The design of such piles would have to be carefully renewed, and the construction perhaps should be inspected by the Authority, to insure that the pile was not readily convertible to a dangerous form. For example, there should be no provision within such piles for the introduction of uranium or thorium. Iron or lead might be required as structural materials and if these were made non-removable, there would be a large factor of safety against abuse. Such power reactors would "burn" the active materials and require replenishing from time to time. The fissionable materials for such power reactors would be derived from the operation of the production plants of the Authority. There is no prospect that for several years such power reactors as described here could be licensed, for the reason that there would not be enough fissionable materials produced in the plants of the Authority. Thus there is a reasonable period during which research and development may proceed both in the laboratories of the Authority and in national and private groups throughout the world, as a result of which much more will be known as to the safe and unsafe features of design prior to the time when decisions will be required.

The questions of policy that arise in relation to the licensing activities of the Authority will likewise require the utmost in ingenuity and resourcefulness for their solution. How shall control be exercised lightly enough to assure the free play of national and private enterprise without risk to security? How shall facilities and materials available for national and private exploitation be allocated and at what cost? How may safe activities, assigned to national hands, be withdrawn if new discoveries show them to be dangerous? Again, we do not minimize the difficulties. We say only that we believe them to be of manageable proportions, and that techniques can be devised to facilitate

solutions.

Inspection Activities—Throughout this report we have recorded our conviction that international agreements to foreswear the military use of atomic weapons cannot be enforced solely by a system of inspection—that they cannot be enforced in a system which leaves the development of essentially dangerous activities in the field of atomic energy in national hands and subject to national rivalry, and, to insure against diversion of these activities to aggressive ends, relies upon supervision by an agency which has no other function. But inspection in a wide variety of forms has its proper place in the operations of the Atomic Development Authority—it has a proper and essential place. Sometimes it may take a form scarcely recognizable as inspection, but that may be regarded as one of the virtues of the proposal.

It may at the outset be useful to recall some of the factors which lead us to believe that as a function of the Atomic Development Authority inspection can be effective. We do not by this wish to suggest that the necessary inspection functions are trivial or that they can be carried out without inventiveness and effort. We do believe that the proposers of this report create a framework within which such inventiveness and such effort can be effective.

In the inspection of declared and legal activities—to be sure that they are really legal—it is of the greatest advantage that the operations can themselves be so conducted as to make this inspection and control easy. The Atomic Development Authority will have the double responsibility of technically effective development, and of safety. It would be in a position to insure that in the plan of operations, in the physical layout, in the system of audits, and in the choice of developments, full weight and full consideration can be given to the ease of detecting and avoiding diversion and evasion. Thus, the Authority may conceivably find it unwise to exploit certain types of deposits because of the difficulties they present to adequate auditing. The Authority may have reason to decide on one or another method of the separation of isotopes because it lends itself more readily to control. In the location of its operations, it will be in a position to take into account political and sociological factors which might make control difficult, or to allow such considerations to influence its choice of operating personnel and procedures. We attach great weight to the importance of unifying at the planning stage the requirements of development and control. We also attach great weight to the far-reaching inseparability of the two functions in the personnel of the development authority.

As we have pointed out repeatedly, the Authority will be aided in the detection of illegal operations by the fact that it is not the motive but the operation which is illegal. Any national or private effort to mine uranium will be illegal; any such stockpiling of thorium will be illegal; the building of any primary reactor or separation plant will be illegal. This circumstance is of very great importance for the following reason: It is true that a thoroughgoing inspection of all phases of the industry of a nation will in general be an

unbearable burden; it is true that a calculated attempt at evasion may, by camouflage or by geographical location, make the specific detection of an illegal operation very much more difficult. But the total effort needed to carry through from the mine to the bomb, a surreptitious program of atomic armament on a scale sufficient to make it a threat or to make it a temptation to evasion, is so vast, and the number of separate difficult undertakings so great, and the special character of many of these undertakings so hard to conceal, that the fact of this effort should be impossible to hide. The fact that it is the existence of the effort rather then a specific purpose or motive or plan which constitutes an evasion and an unmistakable danger signal is to our minds one of the great advantages of the proposals we have outlined.

We have frequently emphasized the related difficulties of providing in an inspection agency personnel with the qualifications necessary for that work, and with enlightened and constantly improving understanding of the technical realities. We believe that these problems can be solved in an Atomic Development Authority to which is entrusted the technical exploration of the field, and in which inspection activities will be carried out in part by the very personnel responsible for the new developments and in part by the men of the same organization, who have access to, and who have an interest.in, the research and development activities of the Authority. We do not wish to overemphasize the advantages that may arise from the free association of the Authority's scientists and experts with those engaged in private or national undertakings, but we believe that if a serious effort is made to cultivate this association it will greatly reduce the chance of evasive national or private action, or of the existence, unknown to the Authority, of technical developments which might constitute a potential danger. As an example of an association which would on technical grounds be most appropriate for the Authority, we may cite the problem of power. The Authority will be engaged in the production of power. It will be engaged in licensing power plants of non-dangerous type for private or national operation. It should take advantage of these associations to be informed about the power requirements which play so large a part in the operation of separation plants.

It will be seen that we do not contemplate any systematic or large-scale inspection activities for the Authority except those directed to the control of raw materials. It is our hope—and we believe it a valid hope—that when the Authority is in full operation it will, through the application of ingenuity to the problem, have obtained a sufficiently complete control over raw materials and the fissionable products so that no elaborate and formal inspection procedures will be needed to supplement it. It is clear that final decision on this matter must take into account the events of the transition period from our present condition to that of the full operation of the Authority. It is also clear that the more rapidly the initial steps leading to the Authority's control of raw materials are taken, the greater the chance of the elimination of the more burdensome forms of inspection.

The geological survey, while in a sense inspection, will be focussed on a world-wide search and survey for the discovery of the essential raw materials. In the conduct of research and development, and through the location of the Authority's laboratories in various parts of the world, the Authority should become cognizant of a wide range of research and development activities in various countries. Therefore, the purpose of inspection would be served in that personnel of the Authority should be currently and intelligently informed regarding national and private research and development activities in this field.

In operating mines, refineries, and primary production plants in various countries, the personnel of the Authority will likewise acquire insight regarding the activities and trends in various countries. In its licensing activities the Authority will maintain contact with the research and development laboratories authorized to use reactors. Exchange of personnel, visits, and even formal inspection, may all be involved.

In licensing power reactors which are somewhat less safe than research reactors, the Authority would send its representatives to inspect or visit these plants at frequent intervals. Such personnel would presumably be trained in the development or engineering branches of the Authority and their primary purpose might well be to furnish engineering services and advice to the operators. The. inspection that would actually result would be far more effective than any direct attempt to inspect.

Under the relations described between the Authority and national or private groups using denatured fissionable material, the inspectors would have a right of access deriving from the terms of the license and lease. Furthermore, if the Authority conducted the operations described, it would have within its organization a unique knowledge of the whole field of atomic energy and the changes in that field, which are almost certain to be rapid if it is developed in a healthy manner. To the extent inspection was required it could be done by competent engineers or scientists who would be far more knowledgeable than those inspected and who could furnish useful aid and advice at the same time.

In the course of its activities, the Authority might acquire information which would cause it to suspect evasions or violations in places to which it did not have the right of access for geological survey or for inspection of installations using leased material. Some means would have to be provided so that the Authority by making out a prima facie case would be granted access to the suspected plant or laboratory. This might be arranged through the presentation of such a request to some international body such as the International Court. If the Court were satisfied with the adequacy of the reasons presented by the Authority, it might then request the nation in which the suspected activities were located to grant access to representatives of the Authority. This seems to us one of the possible means of approach to the limited problem of detection of evasions that would be present even under the Atomic Development proposal. The procedure

seems sufficiently limited in its effect upon national sovereignty to be practical. We recognize that the idea raises a host of questions that would have to be answered before the feasibility and effectiveness of the device could be established but we think it worthy of this further exploration.

CHAPTER II

Organization and Policies of Atomic Development Authority

In the light of the scientific and technological facts and of broad human and political factors, we have undertaken, up to this point, to describe the kind of functions that an Atomic Development Authority would have to be given in order to be effective. In considering the problems of organizational structure and detailed policies for such an authority it is also clear that the facts concerning atomic energy are decidedly pertinent. But as to these problems, there is much relevant experience in the general field of international organization. Obviously the systematic approach necessary for a solution of these problems must draw heavily on that experience.

But there is an important question of timing. It would be premature now to seek definitive answers to many of the questions as to organization and policy. For in order to have validity the answers will have to be the product of international discussion and deliberation rather than any unilateral statement of a detailed plan.

In considering the type of organizational problem involved in setting up an Atomic Development Authority under the United Nations, it should be readily possible to find helpful analogies in other international operations, public and private, and even in national activities. In the course of our discussions numerous questions concerning these matters have naturally occurred to us as they would to anyone studying the international issues created by atomic energy. It has been necessary to reflect intensively on the possible answers to such questions as a means of testing the soundness of our main conclusions. We present here some of the results of our own discussion and reflection, not in the form of a systematic statement but rather for the purpose of illustrating the types of questions that arise and possible answers which occurred to this group.

One of the key problems of course will be the question of personnel. It will be of the essence to recruit that personnel on a truly international basis, giving much weight to geographical and national distribution. It does not seem to us an unreasonable hope that the organization would attract personnel of high quality. For the field of knowledge is one in which the prospects for future development have become an absorbing interest of the entire world. Certainly there is a far better chance that the Authority would attract personnel of a high calibre than that any purely policing organization would do so. At any rate, it is clear that the success of the organization would depend upon the quality of the administrators, geologists, mining experts, engineers, physicists, chemists, and other personnel, and every possible effort must be made to establish the kind of organization that will attract them.

It is not alone necessary for the organization to be thoroughly informed in the field of atomic energy. It will also be necessary for the nations of the world to be thoroughly

informed at all times about the operations of the Authority. There are many ways of assuring this necessary degree of accountability on the part of the Authority to the nations and peoples whose instrument it will be. Some integral organ of the United Nations, perhaps the Security Council itself, will need to serve as the overseeing body for the Authority. But it could do so in ways generally comparable to those employed by congressional appropriations and investigating committees and the Bureau of the Budget in relation to governmental institutions in the United States. Detailed measures would have to be worked out to assure the proper connection between such an overseeing or "accountability" body and the Atomic Development Authority itself. Ways will also have to be worked out to assure that individual nations may maintain enough direct contact with the organization to give them a sense of intimate relations with it. This need will be served in part by the fact that the staff of the organization will be recruited from various nationalities. The operations of the Authority in its licensing activities, where it will be dealing directly with individual states, will also be one of the ways in which this objective is accomplished. For in this field there will be constant collaboration between the Authority and individual states in working out the detailed scientific, technological, and political problems which will cluster around the Authority's licensing activities. None of these matters appears to present insuperable difficulties.

The foregoing is intended merely as a statement of the possibilities for actually creating an organization that will have sound relations with the United Nations and with individual states. These possibilities must be made the subject of further exploration as intensive as that which we have directed to the scientific and technological facts concerning atomic energy itself.

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Until qualified men set themselves the task of actually writing a charter, chapter by chapter, anything said about policies must be merely by way of preface. The actual statement of policy, like the form of organization, will have to grow out of the internationa1 discussions and deliberations.

The fundamentals governing the Atomic Development Authority must of course be those which have been so well stated in the resolution of January 18, 1946 setting up the United Nations Atomic Energy Commission, that is, the strengthening of security and the promotion of the beneficial use of atomic energy. In our report we have adopted as the first principle in the accomplishment of these fundamental objectives the proposition that intrinsically dangerous activities in the field must not be left open to national rivalry but must be placed in truly international hands. To establish the boundaries between international and national action, we have grasped the fortunate

circumstance that a dividing line can be drawn between dangerous and non-dangerous activities. We have emphasized that not the least in the fortunate circumstances that we have observed is the fact that the field of non-dangerous activities is so challenging that it provides an opportunity to avoid such centralization of authority as might make the price of security seem too high. In this connection it is important that a purposeful effort should be made to keep as broad and diversified as possible the field of activities which is left in national and private hands. Every effort must be made to avoid centralizing exclusively in the Authority any more activities than are essential for purposes of security.

These are the kind of basic considerations which we assume the United Nations Atomic Energy Commission would seek to make explicit in its recommendations for the charter of an Atomic Development Authority. Many others can be added to the list. We mention some now which are typical and illustrative and which are drawn from the kind of questions which have arisen in our own discussions.

We would expect that the charter itself should, so far as practicable, define the areas that are clearly dangerous, in which there must be an exclusive international operation, and the areas which now seem clearly non-dangerous, in which there may be national and private operations. One of the most difficult problems will be the creation of charter provisions and administrative machinery governing the manner in which the line will be drawn between safety and danger near the middle of the spectrum of activities where the division becomes less sharp. Another difficult problem will be to provide the means to redefine as either "dangerous" or "safe" when new knowledge shifts the line. In these matters close questions will arise, of course, as to the issues which must be referred for approval to the individual nations, the issues which need only be referred to some organ of the United Nations, like the Security Council, and the issues which can be determined by administrative action of the Atomic Development Authority itself.

In strengthening security, one of the primary considerations will relate to the geographical location of the operations of the Authority and its property. For it can never be forgotten that it is a primary purpose of the Atomic Development Authority to guard against the danger that our hopes for peace may fail, and that adventures of aggression may again be attempted. It will probably be necessary to write into the charter itself a systematic plan governing the location of the operations and property of the Authority so that a strategic balance may be maintained among nations. In this way, protection will be afforded against such eventualities as the complete or partial collapse of the United Nations or the Atomic Development Authority, protection will be afforded against the eventuality of sudden seizure by any one nation of the stockpiles, reduction, refining, and separation plants, and reactors of all types belonging to the Authority.

This will have to be quite a different situation from the one that now prevails. At present with Hanford, Oak Ridge, and Los Alamos situated in the United States, other nations

can find no security against atomic warfare except the security that resides in our own peaceful purposes or the attempt at security that is seen in developing secret atomic enterprises of their own. Other nations which, according to their own outlook, may fear us, can develop a greater sense of security only as the Atomic Development Authority locates similar dangerous operations within their borders. Once such operations and facilities have been established by the Atomic Development Authority and are being operated by that agency within other nations as well as within our own, a balance will have been established. It is not thought that the Atomic Development Authority could protect its plants by military force from the overwhelming power of the nation in which they are situated. Some United Nations military guard may be desirable. But at most, it could be little more than a token. The real protection will lie in the fact that if any nation seizes the plants or the stockpiles that are situated in its territory, other nations will have similar facilities and materials situated within their own borders so that the act of seizure need not place them at a disadvantage.

Various auxiliary devices, in addition to a strategic geographic division of plants and facilities and stockpiles, will also be necessary. Some of these have already been referred to. The design of primary production plants should make them as little dangerous as possible. The stockpiles of materials suitable for the production of bombs should be kept as small as possible consistent with sensible economics and engineering. So far as practicable, stocks should be denatured or kept in low concentrations unsuitable for the production of bombs. In other words, the design and operating procedures should definitely prevent the accumulation of substantial amounts of material quickly convertible into important quantities of explosives.

All these matters must be the subject of the most careful consideration in the writing of the charter itself.

With appropriate world-wide distribution of stockpiles and facilities; with design rendered as little dangerous as possible; with stockpiles of dangerous materials kept at the lowest level consistent with good economics and engineering; there will be no need for a sense of insecurity on the part of any of the major powers. Seizures will afford no immediate tactical advantage. They would in fact be an instantaneous dramatic danger signal, and they would permit, under the conditions stated, a substantial period of time for other nations to take all possible measures of defense. For it should be borne in mind that even if facilities are seized, a year or more would be required after seizure before atomic weapons could be produced in quantities sufficient to have an important influence on the outcome of war. Considering the psychological factors in public opinion, the fixing of danger signals that are clear, simple, and vivid seems to us of utmost importance.

There are other basic problems of only slightly less difficulty which will also need to be dealt with in the international deliberations. These have to do with such matters as

compensation to nations and private agencies for the raw materials which the Authority would take over, they have to do with the problem of initial financing, they have to do with allocations and distribution of the materials and the facilities which the Authority will license or sell to individual nations and, through them, to their citizens. One of the difficult problems in this respect will be the question of priority in establishing non-dangerous power plants within various nations and the relation between these licensed activities and the power-producing activities of the Authority itself. A special word needs to be said on this subject.

The needs of nations for new power resources vary not only with industrial conditions, but also with their proximity to water power, coal, and petroleum. As we have emphasized before, the power supply from fissionable materials is of two entirely distinct kinds. Power will be produced in the very process of operating the production plant which make fissionable materials. These plants are of the dangerous kind which must be owned and operated by the Authority. The decisive consideration in determining the location of such plants will have to be strategic; otherwise the physical balance between nations will be impaired. In other words, the distribution of these plants throughout the world will have to be based primarily on security considerations. But there will still be ample room for an individual nation, once it is decided that such a plant can be located within its borders, to determine where the plant shall be situated in relation to its own economic and social needs. It also appears fair to assume that the charter could provide specifically for the Authority to turn the power over to the nation or its designee at the bus bar of the power plant, thus leaving it to each individual state to determine policy in relation to transmission, distribution, and use, or the Authority might deliver steam to the individual state, leaving all electrical operation in national or private hands as determined by the policies of the particular nation. Problems of price will be difficult, but here again it should be possible to state basic policies in the charter which will give reasonable assurance of fairness in the fixing of cost.

The problem of power producing piles should be somewhat less difficult in the case of the non-dangerous plants. In these, fissionable materials will be denatured. The charter should be able to provide for their allocation of this type of plant in accordance with more conventional economic standards. It might be possible to provide that they should be located on the basis of competitive bids among interested nations. On such a basis, countries with ample power resources in water, coal, or oil wouId limit their bids to those warranted by the costs of alternative sources. Those countries having few or expensive ordinary sources of power might bid higher, but below the cost of other alternatives. In this way the maximum usefulness of fissionable materials with the greatest conservation of other sources of power would be secured.

Many other questions of the same order as those we have discussed can readily be imagined. These are enough to illustrate the nature of the problem.

SECTION IV

The Transition for International Control

When fully in operation, the plan described in the previous section would, in our opinion, provide a great measure of security against surprise attack by atomic weapons. But it will take a considerable time before the plan can be adopted, and once the nations of the world have adopted it, a still further time will be required to put the plan into operation. It is essential to consider what will be the condition of affairs during the necessary period of transition.

In particular we must take note of the nature of the commitment already made for international action in order to determine whether the proposal satisfies the conditions attached to that commitment. In the pronouncements which the United States has made and sponsored in concert with other nations, the commitment for action has always been coupled with the requirement that the process of moving toward the goal of complete international collaboration must be accompanied at each stage by appropriate safeguards. It is the purpose of this section to describe the extent to which the suggested plan will satisfy this requirement.

The period of transition may be broken down into two sub-periods. In the first there will be no Atomic Development Authority. There will be discussions in the Atomic Energy Commission of the United Nations Organization, and as a result of these discussions, proposals will be referred to the United Nations Council and Assembly and to the several nations for further discussion and acceptance. From this process, there will result a charter that has been ratified by the various nations. It is at this stage that the Atomic Development Authority will come into being. All of this will inevitably require time. In the second period, when an Atomic Development Authority is created by the ratification by the several nations of the charter which establishes it, it will have an immense task before it, involving many different fields and many different activities. It would, of course, be possible to leave the ordering and sequence of these activities, or rather of undertaking them, to the discretion of the Authority. It seems far more likely that provisions governing the sequence of steps by which the Authority will come into full operation will be provided in the charter.

Two different kinds of consideration will be involved in setting up the steps of discussion and operation. On the one hand there are, as we shall see, certain indispensable requirements for the *adoption and the success of the plan itself,* which require that certain steps be taken before others can be effective. On the other hand, there is a wide range of schedules all equally compatible with the operability of the plan and *affecting primarily its acceptability* to the several nations. We shall be concerned in this section with outlining the requirements of the plan as to schedule, and pointing out what other elements are not fixed by the plan itself and in the fixing of which quite

new considerations are essential. In other words, we shall attempt to describe those steps which must be undertaken in a particular order if the plan is to become effective at all. We shall also indicate other steps which are a necessary part of bringing the plan into operation, but as to which there is some freedom of choice in determining their sequence. The sequence of the first set of steps is fixed by the plan itself; the sequence of the second set is a matter that will have to be fixed by the negotiation between the nations.

THE POSITION OF THE U. S. DURING THE TRANSITION.

In order to have meaning, the examination of the transition period must take account of the present position of the United States in the field of atomic energy, and that position must be compared with the one that this country would occupy during the period when the plan for international action is being adopted and executed. Today's position must also be compared with the conditions that will prevail when the plan has finally been brought into full operation. We must also consider what our position would be some years hence if we were forced to abandon our present commitment for international action and pursue instead a purely national treatment of the problem.

Today the United States has a monopoly in atomic weapons. We have strategic stockpiles; we have extensive facilities for making the ingredients of atomic bombs and for making the bombs themselves; we have a large group of people skilled in the many arts which have gone into this project; we have experience and know-how obtainable only in the actual practice of making atomic weapons; we have considerable resources of raw material; and we have a broad theoretical knowledge of the field which may appear inadequate in future years, but which enables us to evaluate not only the performance of the past but also what the future is likely to hold.

It is true that some part of our monopoly we hold in common with the United Kingdom and Canada. This applies, principally not to material facilities or to weapons, but to the availability of raw materials, to theoretical knowledge, and to some elements of the know-how.

It has been recognized that this monopoly could not be permanent. There have been valid differences of opinion on the time which it would take other nations to come abreast of our present position, or to surpass it; but it is generally admitted that during the next five to twenty years the situation will have changed profoundly.

International control implies an acceptance from the outset of the fact that our monopoly can not last. It implies substituting for a competitive development of atomic armament a conscious, deliberate, and planned attempt to establish a security system among the nations of the world that would give protection against surprise attack with atomic weapons. Above all, it involves the substituting of developments which are

known to the world for developments by the several nations which might well remain more or less secret, and where the very fact of secrecy would be a constant source of fear, incitement and friction.

Inherent in the adoption of any plan of international control is a probable acceleration—but only acceleration—of the rate at which our present monopoly will inevitably disappear, since our knowledge and our mastery of practical arts, and to some extent our physical installations, must ultimately be made available to an international agency in the process of establishing control.

Let us consider, for example, the plan we recommend in this report. If adopted and executed in good faith, this will have reached a reasonably full degree of operation in a period of years. At that time nearly all the factors making the present position of the United States in relation to atomic energy a preferred one will have been eliminated. For, when the plan is in full operation, no nation will be the legal owner of atomic weapons, of stockpiles of fissionable material or raw materials, or of the plants in which they can be produced. An attempt will have been made to establish a strategic balance in the geographical distribution of the internationally owned plants and stockpiles.

The security which we see in the realization of this plan lies in the fact that it averts the danger of the surprise use of atomic weapons. The seizure by one nation of installations necessary for making atomic weapons would be not only a clear signal of warlike intent, but it would leave other nations in a position either alone or in concert to take counteractions. The plan, of course, has other security purposes, less tangible but none the less important. For in the very fact of cooperative effort among the nations of the world rests the hope we rightly hold for solving the problem of war itself.

It is clear that it would be unwise to undertake a plan based on the proposals which we have put forward unless there were some valid hope that they would be entered into and carried through in good faith; nevertheless, we must provide against the hazard that there may not be such good faith and must ask ourselves this question: What will be the state of affairs should the plan be adopted with the intention of evasion or should evasion be undertaken by any nation during the years when it is being put into effect?

The basis of our present monopoly now lies in two rather different things: knowledge, and physical facilities. The ultimate geographical balance toward which a plan for international control must work will witness the loss of both kinds of monopoly. Knowledge will become general, and facilities will neither in their legal possession nor in their geographical distribution markedly favor any one nation. Although both elements of our present hegemony will thus disappear over a period of years, quite different considerations are involved in the sharing of our knowledge and in the balancing of physical facilities.

THE MATERIAL ASPECTS OF THE TRANSITION.

The transfer of such facilities to international control; the establishment under international control of similar facilities in other nations; the creation of stockpiles; the gradual building up of groups of men skilled in the various necessary arts—these are changes which from their very nature will require time to bring about, and which can, within not too wide limits, be scheduled and controlled. In the discussions within the United Nations Commission leading up to the adoption of the charter for the Authority, and even more in the early planning phases of the Authority's work, there will have to be some disclosure by us of theoretical information. But these discussions and these plans will not essentially alter the present superiority of the United States. They will not move its stockpiles of uranium or of fissionable material or its bombs or its operating plants, and need not alter the operation of these plants. These disclosures of information, now secret, will not create in any other nation the experience and the know-how which are so great a part of our present position of superiority.

No matter what may be the schedule of operations adopted, this situation cannot change overnight under any circumstances. Nevertheless, it is clear that very serious consideration must be given to the scheduling of those physical and legal changes which over a period of years will bring about a balanced international operation. On the one hand, the general principles underlying this scheduling will have to be the subject of negotiation, and the outcome will in one form or another have to be written into the charter. The charter may, for instance, provide that some things should not be done before a specified number of years have elapsed, or before the activities of the Authority, let us say, in the field of raw materials, have reached a certain stage of effectiveness. On the other hand, the Authority itself may by charter provision be given responsibility and discretion in the planning of its activities. It may, for instance, be called upon to certify that it is in satisfactory control of the raw materials situation before it undertakes certain of its other functions.

We are aware of the great importance which attaches to a prudent and reasonable scheduling of the step by step transition from our present position. But this problem is of a fundamentally different kind from those that have been discussed in this report. In this report we have attempted to discover and describe the conditions which, as we view the matter, a workable system of international control would have to satisfy.

The consideration of the steps of transition by which the special position of the United States may be relinquished involves quite other values. The sequence, the ordering, and the timing of these steps may be decisive for the acceptability of the internationa1 controls, but they will not affect its operability. Therefore, they present problems of negotiation between the nations within the UNO in the course of agreeing upon a charter for the Atomic Development Authority. Such problems of negotiation, in our

opinion, are separable from the nature of the objective of the negotiation. They are problems which cannot be solved now, because they depend, among other things, on the motivation of the participating nations, on the political background of the negotiations, and on what may be conceived to be the separate, as opposed to the collective, interests of these nations.

The extent to which special precautions need to be taken to preserve present American advantages must be importantly influenced by the character of the negotiation and by the earnestness which is manifested by the several nations in an attempt to solve the common problems of international control. These questions lie in the domain of highest national policy in international relations.

We are convinced that the first major activities of the Authority must be directed to obtaining cognizance and control over the raw materials situation. This control may of course be subject to limitations, defined in the charter, on the freedom of the Authority in its early operations to alter the national distribution of raw materials. The problems of making a geological survey reliable and not prohibitively difficult are major technical problems. The raw materials control will bring the Authority face to face with the problem of access, which is both a technical and a political problem. It will bring it face to face with the need for establishing its own research agencies and for their coordination with private and national ones. These undertakings are fundamental for the operation of the Authority and to all of its future prospect of success.

There are other things which no doubt the Authority would wish to do at once. Without much delay it should set up laboratories for the study of nuclear physics and the technological problems that it must expect to encounter in its future work. It should attempt to establish suitable forms of liaison and interchange with private and national institutions working on atomic energy or on its applications or on the fundamental sciences which may be involved. In short, the Authority should get started on its research program and in establishing the patterns of its liaison with other agencies for which it will be responsible in the future.

It would be desirable that even in the earliest days the Authority act to permit the use of radioactive tracer materials and those laboratory reactors which use small amounts of denatured active material, and which seem to provide such valuable tools for research in a variety of fields.

The Authority may need to establish, even in its earliest days, planning boards to make studies of the difficult questions of stockpiling, power development, future plant construction; it may need to set up a system for the interim recording and accounting of operations in the field of raw materials, and in the production plants of the United States.

These seem to us reasonable plans for initial operations. All the other operations of

the Authority are certainly subject to scheduling. They may accompany these initial operations, or they may come later. But the control of raw materials is an essential prerequisite for all further progress and it is the first job that the Authority must undertake. It will be a continuing activity, but what we are concerned with is that it should start.

In considering the special position of the United States, there are, as we have seen, the following important components, the discontinuance or transfer of which to the jurisdiction of the Authority will have to be very carefully scheduled by international negotiation: our raw material supplies; the plants at Oak Ridge and Hanford now operating to make atomic explosives; the stockpiles of bombs now in our possession; the stockpiles of undenatured fissionable materials; our atomic bomb plant and laboratory at Los Alamos. Our loss of monopoly in these elements cannot be indefinitely postponed. Some of the things we now have will have to cease; some will have to be transferred to the Authority; some will have to be paralleled by activities elsewhere.

The scheduling will determine the rapidity with which a condition of international balance will replace our present position. Once the plan is fully in operation it will afford a great measure of security against surprise attack; it will provide clear danger signals and give us time, if we take over the available facilities, to prepare for atomic warfare. The significant fact is that at all times during the transition period at least such facilities will continue to be located within the United States. Thus should there be a breakdown in the plan at any time during the transition, we shall be in a favorable position with regard to atomic weapons.

DISCLOSURE OF INFORMATION AS AN ESSENTIAL OF INTERNATIONAL ACTION.

One of the elements in the present monopoly of the United States is knowledge. This ranges all the way from purely theoretical matters to the intimate practical details of know-how. It is generally recognized that the transmission of any part, or all, of this knowledge to another nation could provide the basis for an acceleration of a rival effort to make atomic weapons. Even that part of our knowledge which is theoretical, which can be transmitted by word of mouth, by formula, or by written note is of value in this context. If such knowledge were available to a rival undertaking it would shorten the time needed for the solution of the practical problems of making atomic weapons, by eliminating certain unworkable alternatives, by fixing more definitely design features which depend on this theoretical knowledge, and by making it possible to undertake the various steps of the program more nearly in parallel, rather than in sequence. It is not, in our opinion, possible to give a reliable estimate of how much such revelation would shorten the time needed for a successful rival effort. It is conceivable that it would not be significantly shortened. It is conceivable that it might be shortened by a year or so. For an evaluation on this point depends on information, which is not available to

us, on the detailed plans and policies of such a rival undertaking, as well as on their present state of knowledge. It is, of course, clear that even with all such theoretical knowledge available, a major program, surely lasting many years, is required for the actual production of atomic weapons.

Our monopoly on knowledge cannot be, and should not be, lost at once. Here again there are limitations on the scheduling inherent in the nature of our proposals, and in the nature of the deliberations necessary for their acceptance. But even with the recognition of these limitations, there is a rather wide freedom of choice in the actual scheduling of disclosures. Here considerations of acceptability and of general political background will make a decisive contribution.

It is clear that the information, which this country alone has, can be divided more or less roughly into categories. The acceptance and operation of the plan will require divulging certain categories of this information at successive times. A schedule can outline the point at which this must occur. In particular, there is a limited category of information which should be divulged in the early meetings of the United Nations Commission discussing these problems. There is a more extensive category which must be divulged some years hence after a charter has been adopted and the Atomic Development Authority is ready to start its operations; and there are other categories that may be reserved until the Authority later undertakes some of the subsequent stages of its operations, for instance, those that involve research on weapons. We are convinced that under the plan proposed in this report such scheduling is possible, though it is clear, as we have pointed out, that many factors beyond the scope of this report, and involving the highest considerations of international policy, will be involved in such schedules. We wish to emphasize that it will involve an initial divulging of information, which is justifiable in view of the importance of early progress on the path of international cooperation.

It is true, as the Secretary of State has said, that there is nothing in the Resolution setting up the Atomic Energy Commission that compels the United States to produce information for the use of the United Nations Commission. But the point that needs to be emphasized is that unless we are prepared to provide the information essential to an *understanding* of the problem, the Commission itself cannot even begin the task that has been assigned to it.

Let us examine in a little more detail the nature of the information which is required in the early stages. What is important for the discussions in the United Nations Organization Commission is that the Members and their technical advisors have an understanding of the problem of the international control of atomic energy and of the elements of the proposals that the United States member will put forward. They must be in a position to understand what the prospects for constructive applications of atomic energy are and to appreciate the nature of the safeguards which the plan we here propose

affords. They must be in a position to evaluate alternatives which may arise, and to have insight into the rather complex interrelations of the various activities in this field. Above all they must have a sound enough overall knowledge of the field as a whole to recognize that no relevant or significant matters have been withheld. For the process of reaching common agreement on measures of international control presupposes an adequate community of knowledge of fact. Much of the information which is required for this purpose is already widely known. We are convinced, however, that there are further items now held by us as secret without which the necessary insight will be difficult to obtain. These items are of a theoretical and descriptive nature and have in large part to do with the constructive applications of atomic energy. In our opinion, they are largely qualitative; and they involve almost nothing of know-how.

On the other hand, when the Atomic Development Authority is in existence and undertakes operations in a given field, it must have made available to it all information bearing on that field—practical as well as theoretical. Thus, if the Authority, as its first major undertaking, attempts to obtain control of raw materials, we must be prepared to make available to it *all* knowledge bearing on this problem. This will, of course, be a common obligation on all participating nations. Conversely, should it by charter agreement be determined that research and development in the field of atomic explosives will be undertaken by the Authority only at a late date, the specific technological information relating to such developments would not be required by it in the earlier phases. It is important to bear in mind that before the Authority can undertake some of its functions, such as the construction of reactors or the development of power, it will have to spend some time in planning these activities and in research directed toward them, and that information must be made available early enough to make such planning and research effective.

These are examples of requirements for information by the Atomic Development Authority at certain stages of its progress. In accepting the plan here recommended for international control, the United States will be committed to making available this information at the time, and in the full measure required by the operating necessities. Once the sequence and timing of stages has been fixed by negotiation and agreement between the nations, a minimum rate of disclosure of information will have been fixed by the agreement as well. A too cautious release of information to the Atomic Development Authority might in fact have the effect of preventing it from ever coming to life. For one of the decisive responsibilities of the Authority is the establishment and maintenance of the security of the world against atomic warfare. It must be encouraged to exercise that responsibility, and to obtain for itself the technical mastery that is essential.

We may further clarify the nature of the disclosures required by this board's proposals by a reference to a report. We have had the opportunity to examine in detail a

report of December, 1945, prepared for the Manhattan District by its Committee on Declassification, a committee of seven scientists, including the wartime heads of all the major laboratories of the Project.* This Committee was directed to report on a policy of declassification—that is disclosure—of scientific and technical material now classified as Secret, a policy *which would best promote the national welfare, and protect the national security.* In interpreting its directive the Committee limited itself to a consideration of these objectives *in the absence of any system of international control.* It recommended against declassification at the present time of a very considerable body of technical, technological, industrial, and ordnance information, that is information bearing directly on the manufacture of weapons and the design and operation of production plants. But it recommended the prompt declassification of a large body of scientific fact and of technical information of non-critical nature and wide applicability. It expressed the view that the further declassification of critical items of basic theoretical knowledge would conduce, not only to the national welfare, but to the long-term national security as well—no doubt because of the damaging effect which continued secrecy in these matters could have on our own scientific and technical progress. Corresponding to these distinctions, the Committee divided our secret scientific and technical information into three categories, the first of which it recommended for immediate declassification; the second of which it recommended for eventual declassification in the interests of long-term, national security of the United States; and for the third of which it recommended against declassification in the absence of effective international control. We have tried to see what technical information this board would find essential for the sort of understanding that must be established as a basis for discussion in the UNO Commission, and to compare this with the items listed in the report of the Committee on Declassification. Many of the facts needed are already public; many are included in Class One; the remainder are all in Class Two, and comprise perhaps one-third of the items there listed. It is important again to emphasize that the Declassification Committee's recommendation was aimed at furthering our own long-term national security in the absence of international measures.

We wish to emphasize that the initial disclosures will place in the hands of a nation (should it be acting in bad faith) information which could lead to an acceleration of an atomic armament program. We do not regard this circumstance as in any way peculiar to the plan recommended in this report. It is inherent in the concept of international control. The adoption of any workable scheme of international control may shorten the time during which the United States has a position as favorable as it has today. We cannot be sure of this, but we must be prepared for it.

In this section we have been discussing the problem of transition to international control as it affects the security of the United States. During this transition the United States'

*Membership of this Committee included R. F. Bacher, A. H. Compton, E. O. Lawrence, J. R. Oppenheimer, F. G. Spedding, H. C. Urey, and R. C. Tolman, Chairman.

present position of monopoly may be lost somewhat more rapidly than would be the case without international action. But without such action the monopoly would in time disappear in any event. Should the worst happen and, during the transition period, the entire effort collapse, the United States will at all times be in a favorable position with regard to atomic weapons. This favorable position will depend upon material things; less and less will it rest upon keeping nations and individuals ignorant.

When fully in operation the plan herein proposed can provide a great measure of security against surprise attack. It can do much more than that. It can create deterrents to the initiation of schemes of aggression, and it can establish patterns of cooperation among nations, the extension of which may even contribute to the solution of the problem of war itself. When the plan is in full operation there will no longer be secrets about atomic energy. We believe that this is the firmest basis of security; for in the long term there can be no international control and no international cooperation which does not presuppose an international community of knowledge.

Chester I. Barnard
J. R. Oppenheimer
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David E. Lilienthal, *Chairman*