Military Security in a Scientific Age

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THE term *security* is ever present in naval or military affairs. It and its antonym *military intelligence* represent functions that strongly influence the outcome of wars, campaigns, and battles. Military intělligence embraces activities leading to the acquisition of the enemy's military secrets. The maintenance of security, or security in short, represents measures to thwart enemy intelligence. The scope of military intelligence is very wide and varied, since success in total war depends on a variety of factors. The ever-increasing influence of technical developments on the fortunes of a total war, ranging as they do from industrial assets to the actual military weapons, requires a reanalysis of the question of security as understood in classical military practice.

To facilitate discussion, some differentiation and classification of the various types of data required by intelligence must be made. These data may also be assigned an approximate rating in security, indicating the degree of protection required. The use of the current security designations of Top Secret, Secret, Confidential, and Restricted are obvious and need little comment. Perhaps the term *restricted* in relation to *confidential* needs some explanation. In general, restricted information is information that is freely disseminated within say the armed forces or governmental groups, and yet is not for public dissemination, for example, in the press, where it is likely to be misconstrued and misused. It applies, in general, to material falling more in a category capable of political exploitation either by the public or by the enemy than much of the more highly classified material.

It is implied by the words *degree of protection* that high classification requires safeguards which may be more or less onerous and, thus, must lead to delays, to inefficiency, and to consequent adverse effects. Accordingly, classification must be kept at a minimum consistent with safety. This matter is not too often recognized by the responsible security officer in his specialized duties. What is generally less recognized is the continual change and the usual rapid degradation of degree of classification with lapse of time. If efficiency is to be maintained, *declassification* must be as assiduously practiced as is classification. The duration of the classification of any set of data cannot be long. Even long-range planning data should in peacetime be modified so that the original plan is no longer *the* top secret plan after some years. Most other data deteriorate in security value much more rapidly. Thus a time element is introduced into the classification groups with the reasons therefor. The classification of information begins with a division into two broad groups of objectives, primary and secondary.

Primary objectives. The primary objective implies that it exerts a direct influence on action, as contrasted with broader strategic considerations.

1) Military and naval strength as represented in personnel, equipment, and logistic support; reserves of both of these and their geographic disposition. The classification is secret and top secret. It is long range in time with regard to advance plans and short range in time during the dynamic conditions current in war and action.

2) Existing technical devices representing the present and newest weapons or devices, vehicles (planes, ships, tanks), ordnance in general, communications, intelligence, warning equipment, and so forth. These are secret or top secret, but their security value is very short-lived (1 to 2 yr and less), once hostilities start.

3) Tactical employment of vehicles, devices, and weapons; tactical doctrine, evolutions and evaluations of capabilities. These are among the most highly classified data, but the classification is relatively short-lived. It is good for 1 to 2 yr in an alert military force and it is of even shorter life once the tactics are compromised by employment in action.

4) Higher level planning on technical development, strategic theory, and policy as it involves devices primarily projected into the future. This must always be top secret. Since weapons and devices are under study and development for the future, the security will be long-lived. It is doubtful, however, whether even here a given item will remain in its classification for more than 5 yr. The first radar, for example, was maintained in its classification for some 7 or 8 yr. By this time both the British and the Germans independently had essentially the same general device, and the widespread installation, indoctrination, and consequent protection of our ships was definitely delayed by overclassification.

5) Advanced strategic, logistic, and military policy and plans for future wars and campaigns. These are obviously top secret and mostly long-range plans, but again their life should never be indefinite.

6) Communications of all types, including transportation, transmission, reception networks, intelligence, security measures, countermeasures, codes and ciphers, but not including the development of technical devices, fall in this category. Most of these are in the secret and top secret category. Practically all of them are short-lived and, as with codes, the life is very short indeed.

Secondary objectives. These data are of a more geopolitical nature. In general, much of the information is available to the enemy as well. Classification is low since, at most, the information compiled may be of convenience to the enemy. Some of it, such as meteorologic information, degrades over a few hours, some is of longer lived value. Probably the only information of a highly classified nature in this class is the extent of one's own knowledge of the enemy.

* The ideas expressed here are the author's own and in no way represent the views of the Navy or any section thereof.

1) Geographic, hydrographic, topographic, and meteorologic information on one's own and the enemy's terrains comprising the seat of possible or active conflict. Such material, in the main, is open to investigation by general intelligence procedures and, except for very few items, can well remain on the confidential level. Its security life is varied.

2) Information regarding the internal political situation of the opposing countries, public attitude, general national characteristics, loyalty, stamina, morale, susceptibility to hysteria, national health, and so forth. This information is never highly classified and is, perhaps, confidential on matters of short duration—that is, with regard to transient phases.

3) Organization of the opposing governments, chains of authority, procedures and functions bearing on possible conduct of the conflict. Being mostly common knowledge, it is generally of relatively low classification. Such information is also generally of a long-range type and will not degrade rapidly.

4) Industrial and economic potentials, logistics, communications, stockpiling, production, with emphasis on new processes, and transportation. Such information can have aspects that must be more highly classified than the others. Much of this information is of long-range classification, but in terms of 5-yr planning programs, declassification in terms of such intervals is suggested. It must be emphasized that in this country too little attention has been paid to the safeguarding of essential data on new technical and industrial developments and processes. This situation requires immediate action by those responsible for higher level planning.

National Security Policies

For the protection of the afore-mentioned security items on a national basis, there exist two general philosophies on the maintenance of security. The first is the absolute totalitarian maintenance of security involving the exclusion of other nationals and restricted intercourse of one's nationals with other peoples. This might be called the "iron curtain" policy. It was practiced in increasing measure by the German Nazi regime and, in the extreme, is being practiced during peacetime by Russia today. This policy is in some measure utilized by all countries at war. This scheme is exceedingly effective for relatively short-term periods. However, over the years it dooms its users to ultimate failure, especially in the technologic domains. Advance is possible only with the free exchange of ideas. Long confinement leads to intellectual inbreeding and lack of growth. It breeds chauvinism, overconfidence, and self-delusion. It is, furthermore, completely repugnant to free peoples.

The other philosophy is that of a planned and reasonable set of security measures within a free state. The effectiveness of this approach is influenced by several factors. It is much more difficult to develop. It is never entirely secure. It depends on constant analysis of information, classification, and declassification. It depends on patriotic cooperation of individuals and the press. It depends on constant vigilance, not only to apprehend the unreliable, but more so to condition free peoples to security mindedness. It is particularly subject to compromise by careless, inadvertent, and apparently irrelevant disclosure to intelligent and capable enemy agents who, having a clearly defined objective, can piece together information easily obtained from many individuals in a community where movement and speech are unrestricted. On the other hand, it permits healthy growth by stimulating the exchange of ideas so vital to development. It prevents the development of public delusion by practiced governmental deceit so dangerous to national welfare and to a prolonged sound popular morale. It is in keeping with democratic ideals and principles, even though in war there must be restrictions. It is also probable that the damage done by whatever leakages occur is relatively slight and probably much less than that due to the ultimate complete inefficiency of the iron curtain or to the damage done by overclassification and overlong maintenance in a classification.

The Problem Imposed on Security by Science

The United States and its future allies are committed to the second philosophy for the maintenance of security. In this regard, the United States has fought, with relative success, two major wars using classical procedures. However, the increasing dominance of science in warfare is now introducing complications that did not previously exist. The primary purpose of this article is, therefore, to discuss the problems introduced into the classical routine of security by the ever-increasing importance of science and technology in various aspects of the industrial, military, and naval establishments. It must be noted that not only military preeminence but also industrial preëminence is essential to total war, and it is increasingly clear that our past and future enemies have derived material comfort and benefit from our technical industrial advances kindly furnished them. Thus, in the future, industrial as well as military security must be regarded. With regard to security items 1, 5, and 6 in the primary group and 1, 2, 3, and 4 in the secondary group, there is not much, if any, direct influence of the technologic features, and present security doctrine can apply. Thus, discussion will focus chiefly on items 2, 3, and 4 in the primary group—that is, on existing devices and their employment, on planning and development of future devices, and on manufacturing processes of either direct or ultimate military import. In this realm, both the lack of adequate protection and the injudicious use of too-restrictive security regulations can do serious damage; in fact, to some extent Germany's scientific failures in World War II—and she made her full share—can be laid to overcompartmentation and restriction by her security measures.

To understand the problem, it must first be realized that today practically all technologic development depends on *fundamental* science—that is, on highly complicated, specialized scientific knowledge. The age of the *universal* scientist or the *general* inventor, the Rumford, the Franklin, the Alexander Bell, and the

Edison is past. Progress depends on specially trained experts and cooperative effort between highly specialized personnel. Hence, the nation most advanced by eminence in fundamental or basic science is the best endowed for ultimate success. However, science progresses only by freedom of research, by free dissemination of the ideas and results coming from such research, and by the interrelation and correlation of data, interpretations, and methods from many sources. Thus, science flourishes in an environment of free research, free discussion, free movement of personnel, free exchange of ideas, and free and rapid publication and wide dissemination of information. The background of accumulated knowledge and experience makes advance possible. Scientists are trained and steeped in the atmosphere of such freedoms. They are trained in the background, in the traditions, in the procedures, and especially in the doctrine of scientific precision of definition, skepticism, and criticism without which no sound advance can be made. Authoritarianism is repugnant to them. They speak a common language arrived at by free exchange of ideas and mutual agreement. It has taken generations to create the schools and to develop these traditions in the oncoming generations of workers. It takes continuous free intercourse to keep it going. In fact, Russia can well testify to her past stupidity in liquidating the Czarist generation of scientists and learning to her sorrow and detriment that Bolshevik professors of physics and scientists cannot be created in 2 or 5 or 10 yr from the proletariat. Even today Russian science is suffering from these mistakes, and this weakness is again manifesting itself in the appearance of a Lysenkian biology and a Leninist materialistic physics. Thus, science can flourish only in a free atmosphere, unrestricted by authoritarianism or security. Yet in war or during periods of stress, it is clear that science is closely related to vital industrial and military effort and advance, and thus there must be elements of restriction.

Such restrictions are hard to inculcate in the scientists; and patience, reasonable training, and conditioning are required to make them good security risks. That it can be done is demonstrated by the success of efforts in the last war. The scientific personnel of themselves, therefore, pose no great problem. The problem lies in the application of security to science and scientific effort itself. That this science is important to future military success is hardly doubted today. In fact, the danger in this age of the glorification of science lies primarily in the direction of overestimating its importance and, thus, in a feeling of oversecurity derived from it. In this connection, the history of wars shows that science may have been instrumental in the winning of battles, but there is no proof that it has ever *won wars*. In fact, it could be argued that the overreliance on technical devices—the submarine and the aircraft—lost Germany two wars. It is true, however, that new weapons with new tactics have been important factors in deciding battles; witness the longbow at Crécy and the cannon of Gustavus Adolphus, or the success of the *Merrimac* until she encountered a countermeasure in the *Monitor*.

Why weapons have not won wars is not difficult to explain. Wars are exceedingly complex affairs of which the separate battle is only one phase. The winning of a war depends on such things as morale, endurance, the opportunity to fight back, economic resources, and, given time, the development of countermeasures to new devices. There is no weapon—not even the atomic bomb—whose *nature* and *tactical employment* do not permit the development of suitable countermeasures, even though they may be expensive and long in developing.

However, there is no doubt that suitable devices and weapons, as well as the tactics they imply, give an immense and immediate advantage. They can thus be decisive in individual battles or actions; they can save lives and property; and they can hasten victory. Examples of such benefits can be readily drawn from the German submarines in both world wars: gas and tanks in World War I, radar in the Battle of Britain, and for the United States Navy at sea, the proximity fuse both in the Pacific and against the German buzz bombs, magnetic and acoustic mines, and last, but not least, the atomic bomb.

Thus, one must conclude that the use of such devices is imperative, that science is indispensable today for the development of such devices, and that compromises in current security practices must be developed to accommodate science. To see how this may be accomplished, certain none-too-obvious facts about the application of science to warfare must be set forth.

In order to be successful, most of the revolutionary devices, except, of course, many useful but simple gadgets, must involve the following elements: (i) long-range research and development from a scientific concept to relative performance perfection; (ii) mass production and employment; (iii) a completed, satisfactory tactical employment doctrine together with instilling confidence in the device among its users so that the doctrine is properly carried out; (iv) maintenance of security leading to the element of surprise for the enemy.

Failure to achieve one or more of these elements has often doomed a good device. Examples could be drawn in the case of the submarine and the use of gas by the Germans and of the tank by the British in World War I. To my limited knowledge, in World War II there were also several financially costly failures of American devices, owing primarily to lack of perfection and unsatisfactory doctrine, for which the lapse of time does not yet permit specific mention.

Many proposed devices are not developed, no matter how good, for various reasons. Some are developed and released prematurely. Thus, to the four criterions for a successful device, one must add the following considerations which will influence the development and planning of such devices. (i) A device must have a bearing on or use in a phase of a given *planned* campaign or objective or it must be such as to make a *new plan operative*. This restriction places different emphasis on the developments on the opposing combatants as determined by their geographic position and objectives in strategy. (ii) The mass production and development of a major device can unbalance an overburdened wartime industrial program by allocating production priorities away from tried, proved, and vitally needed devices. This is particularly true with a really new, important, but untried weapon. (iii) The experimental production of a few such devices for test purposes in action and to develop doctrine immediately jeopardizes the security of the device and the element of surprise. (iv) Occasionally a need becomes so urgent that a device may be launched in mass production before a suitable doctrine has been developed.

To the average layman who does not understand the elements and responsibilities implied by afore-mentioned items 1, 2, 3, 4, and i, ii, iii, and iv, the condemnation of the "brass hats" for doctrinaire, unimaginative, and unprogressive thinking is easy. This common sort of prejudgment is both uninformed, unfair, and what is worse, detrimental to the war effort. Although mistakes are perhaps made in the direction of conservatism, they are not nearly as bad as those that might have been made in the other direction. For example, had the United States, during World War II, abandoned the building of the Liberty ship in favor of cargo-carrying aircraft, the result would have prolonged the war immeasurably.

First and foremost, any country engaged in total war is straining production in all directions to the limit of manpower and supplies. If the mass production of a new device is required, some other device or weapon suffers. Thus, devices that favor the objectives of the strategic planning for the war are always chosen, and other devices of merit must be put aside until needed. Germany, having no fleet, resorted to research and development of submarines in order to nullify British naval supremacy and to starve Britain. Likewise, Germany resorted to aircraft to attack Britain from the air. When the plane attacks began to fail, she turned to the development of rockets whose range permitted her to reach England without loss of precious aircraft. The United States and Britain had no need of rockets. The United States needed antiaircraft shells for the protection of the fleet against planes of the "Japanese unsinkable aircraft carriers" in the Pacific war and off the coasts of Europe, while the Germans did not seriously need antiaircraft devices until 1943. Thus, the United States developed the VT fuse.

Germany had poor submarine radar because she feared that the use of radar on submarines would disclose their position. The United States and British navies needed radar for their protection and for submarine search. The Germans developed very good infrared detectors and devices for their submarines aircraft, and troops which replaced radar, while the United States and Britain far exceeded Germany in radar perfection. The Germans developed magnetic and acoustic mines at first because they imagined that Britain was very vulnerable and they themselves were fairly immune. Later, to their sorrow, the Germans found that they needed some countermeasures, and magnetic mines did great damage when employed by the British. The United States, apprehensive because of German boastfulness concerning their atomic studies, proceeded to dislocate American war production on a huge gamble to perfect the atomic bomb before Germany. Fortunately American resources were equal to the drain; otherwise the war effort would have suffered. Germany, not having the surplus production available, and long believing herself invincible and scientifically superior, did not push atomic research.

It is believed that enough has been said to illustrate points (i) and (ii) to conclude that the decision to develop a device of major importance is a grave one, open to understanding only by those top-flight planners and their advisors who know the top secret strategic problems and who are in a position to consider the effects on production. It is probable that in the future such matters of policy decision will benefit from the type of analysis yielded by technical operational analysis groups. During World War II, in cases where the suitable scientific talent needed to formulate the necessary statistical evaluations was at hand, the decision arrived at proved to be reasonable, sound, and successful. Small-scale experimental test is in general precluded, although it was possible with the VT fuse at sea. Some of the mistakes that were made in World War II have been, perhaps, embarking on devices in desperation—that is, item (iv)—and releasing them before perfection of the instrument or doctrine and before the proper service introduction could be made. Premature and insufficient mass production was not as glaringly realized in World War II as in World War I.

In light of this review of the questions of the basic policy on the development of new devices, it is seen that once decisions in these matters are reached, planning, research, development, and introduction, as well as doctrine, must be developed in complete security.

Security in Technologic Development and Its Realization

Where does security begin and how can it be achieved? To analyze this, one lists the steps in development and perfection of the devices. They are as follows.

1) The background knowledge of fundamental science containing all the elements, some of them perhaps newly discovered, that enter into a device or weapon. Examples of this are general knowledge of nuclear structure and behavior and of the newly discovered fission leading to the bomb or again fundamental knowledge of thermionic emission and gaseous discharges as well as of optics and electromagnetic theory leading to radar.

2) A form of research that can be termed *basic research*. This is the type of research that was done, for instance, on nuclear fission with an eye to *utilizing it* for the perfection of a bomb, and the study of isotope separation needed for the diffusion and magnetic separators mentioned in the Smyth report. It also comprises the re-

searches on resonant cavities leading to the development of the klystron and the magnetron, or the researches on electron multiplication by surface bombardment in the electron multiplier so essential to television. The basic-research phase requires keen appreciation of the objective, planned scientific attack, collective or cooperative knowledge and effort, and much empirical experimenting, best entitled ''gadgeteering.'' It involves broad practical knowledge and experience.

3) Model design and development. This aspect has two phases: the laboratory, or ''breadboard,'' assembly of the device, and the more streamlined and completed *test model.* These phases determine whether the device, as it is crudely assembled in the laboratory, will work, and consist of making the device into a compact and more proper model for field use, with some consideration of fabrication procedures. It is followed by experimental tests.

4) The perfection of a mass-production model, its actual mass production, inspection, and the fixing of acceptance and test standards.

5) Its issue to the armed forces with tactical and technical instructions, the training of operators, and its evaluation in the field.

6) Field use and further development of the device on the basis of actual use.

As soon as the device has been used in operations, except under unusual circumstances, it must be considered compromised with regard to security in varying degrees. Thus the German magnetic mine was compromised within less than 3 wk in the field. On the other hand, the security of the proximity fuse, by virtue of its character and its use exclusively against aircraft over water, was maintained for nearly 2 yr, until after the Battle of the Bulge, when duds were picked up.

It should be noted that the maintenance of security becomes increasingly more difficult as development progresses from step 1 to step 6, and in step 6 the enemy in general may have all the details of the device except the techniques of manufacture and its technical employment, doctrine, and capabilities. Even the latter will be pretty well known by an alert enemy when the device is mass employed. The enemy can then begin to develop the same device and, what is more, to develop *countermeasures and tactics.* Whether he chooses to develop and use the device depends on his strategic problems at the time. But if the device is *good,* he will *have to develop countermeasures.* Such development can begin as soon as the device is known.

One may then ask, what is the value of security? The answer is primarily in the elements of surprise and time. An important device may require from 2 to 4 yr to perfect and mass-produce. This depends on its complexity and the effort put into it. The atomic bomb required about 4 yr; the proximity fuse required about 2½ yr. The gain, then, is in the element of surprise and in the sole unopposed employment of the device for perhaps 6 mo to 1 yr before countermeasures can be devised and perhaps 2 yr of immunity before the device can be used by the enemy in quantity—provided that the enemy was not already well advanced along the road to development. With this situation well in mind, security measures for the protection of devices must be reanalyzed. Accordingly, the foregoing data provide a basis for considering how security operates at the various steps in development.

1) First and foremost, even in war, pure fundamental research must go on, especially in a prolonged conflict. It is the basis of tomorrow's devices, and unless it goes on, the enemy will discover what one fails to discover, and he then has the advantage. In any case, the results of pure research are common knowledge until the curtain of censorship descends in war. What is known in one country by one scientist is known in another by its scientists, and *the next steps are obvious to all.* In fact, there has hardly been a great recent scientific advance or development that has not been made simultaneously at widely separated places.

The Nobel prize for wave mechanics was shared by three men. Electron diffraction was achieved simultaneously in the United States and Germany. The streamer mechanism of the spark was likewise arrived at simultaneously from different experimental approaches in two countries. Veksler in Russia and McMillan in California discovered the principle of phase stability leading to the synchrotron and frequency-modulated cyclotron independently and nearly contemporaneously. Nuclear fission was on the verge of being discovered in California within 1 or 2 mo of Hahn's discovery in Germany.

Security cannot and must not be applied to pure science. The nearest approach to an application of security restrictions to pure science occurred in 1940 when, on the verge of World War II, all American nuclear research physicists by *voluntary consent* agreed not to publish their work in current journals but to pool all information for the common large group through a common circulating agency. The group was very large and, with the Nazi military successes at their height, circumstances leading to near hysteria perhaps made this procedure pardonable. It probably would have been just as well if only the researches bearing more or less directly on military objectives had been suppressed.

One example of unnecessary restriction on such knowledge during World War II lay in the obstacles placed in the way of scientific workers on a certain project by ignorant but well-intentioned security officers in the matter of the Kerr cell optical shutter. This device, used for the visual study of events in very short time intervals, had been quite widely exploited by physicists throughout the world from about 1930 on. Before 1937 the device had been perfected in techniques, and all details, far beyond the requirements for the application to war devices in the early 1940's, had been published. This classification of the Kerr cell shutter merely hampered the work of the group by imposing cumbersome and onerous restrictions on the workers and by making the acquisition of knowledge from former experts difficult. The mistake in classification in this instance lay in attempting to classify common scientific technique and knowledge. What was really to be classified was the *fact that a certain war device was being perfected and that the Kerr cell was being used as a component part of this device.*

It is not only possible but is often urgent, to issue to public laboratory use information about devices of general application and usefulness, even if they were developed as, and were used in, a component of a highly secret device. If published out of context and with the general uses indicated, other than the secret device in question, the chance that this information will aid the enemy more than one's own scientists working on other projects is remote indeed. This is especially true with regard to the natural restrictions on the international exchange of journals in time of war. What is classified and highly classified is that a given device is being worked on and that it employs certain principles and component devices. Thus, it can be said that, in general, *science should go on, and that it should publish freely in the fundamental field,* scrupulously avoiding mention of possible applicability to military devices. Thus security has basically no concern with this phase, for the chances are that an alert enemy has discovered the same data independently.

This leads to a very important axiom and its obvious corollary. *Science is universal.* All countries have some good scientific men. If the time for a discovery or advance is ripe—that is, if one has it for one's own use—*one can be sure that the enemy also has it if he needs it.* Being secretive about fundamental science results only in deceiving oneself by a feeling of false security. It is best that all nations start from a common basis; then all know where they and their opponents are. This situation leads to a very important corollary doctrine that must always be borne in mind. *Never begin development of a new measure without simultaneously starting to work on a countermeasure.* The chances are that the enemy is as well advanced on the device as one is oneself. The enemy does not have the device only because he thinks he does not need it or is unwilling to dislocate other production for it. Such was the case of magnetic mines in Japan, a country that was preeminent in magnetic studies at the start of the war and had learned of their use from their German allies. In this case, Japan did not have the facilities for production in competition with more urgently needed devices.

To illustrate the importance of countermeasures, American scientists at one point in the war realized that a certain weapon was possible. They began *simultaneous* work on both the *device and its countermeasure.* Security-minded groups in the higher echelons, realizing the very great potency of the weapon and the difficulty in developing a suitable countermeasure, placed the device on the top secret list. Furthermore, they terminated all work on the device *and on its countermeasure* in the fear that the enemy would learn of it from us and use it. The enemy learned of the device from his own scientists at about the same time that it was thought of in the United States. On a certain crucial day in the war, the enemy launched it after all. Under these conditions, there was no countermeasure until 1½ yr later. By this time, the countermeasure was no longer needed. Again there was the story of the magnetic mine. It was developed by Germany for use against Britain, because Germany believed that Britain was more vulnerable, since Britain had sea supremacy, while Germany had air supremacy; Germany developed no countermeasure. This was serious, since as Britain gained air supremacy, German shipping losses from the British-laid mines, with only rudimentary German degaussing, accounted for nearly one-half of her tonnage losses in restricted waters.

There is, perhaps, only one additional statement to add to the foregoing. Techniques following along the same scientific grooves must in general be parallel; note the similarity in early radar techniques developed secretly in three widely separated countries. However, differences arise owing to natural resources and manufacturing processes. Thus, for instance, Germany, having an ample number of good mechanics for a considerable period, actuated her magnetic mines by dip needles of very fine workmanship. The United States, being short on instrument makers but long on radio amateurs and techniques, activated our mines with electronic devices, which the Germans also used later. Such differences are, however, trival and aside from the main argument.

2) When basic research toward the development or proposed development of a weapon begins, security enters and on a high level. Until the results indicate a possible successful solution, the classification may not be more than secret. If, however, the development is essential to any large plan, then the highest degree of safety must be insured from the start. In such a project, the scientific group must be relatively large, since a wide range of technical knowledge may be required. This is especially true since the exchange of ideas with outside workers in these special fields is not possible. A considerable amount of work on component parts can be farmed out to sections in which the workers are ignorant of its ultimate application, thus increasing security.

3) When the working-model phase is reached, the security rating must be placed at the highest level connected with the importance of the device. The device at this stage is known to work, and some of its tactical possibilities and limitations are revealed. At this point, components are fabricated in separate locations, and assembly and tests are centralized in a relatively few, carefully selected personnel.

4) When the device goes into mass production, the security begins to be compromised. Even though production of parts is farmed out, the ultimate assembly line involves many people, and careless and idle gossip begins to leak out. This was clearly indicated in the advance information that the British had of the V-1 and V-2 weapons. They knew of the perfection of *a* device. They knew of its general character. They

knew that it would be launched from a far shore. They may have been able to guess the principle on which it worked. They did not know its exact forms. They did not know its tactical qualities or to what extent it could be mass-launched. They did not know how to produce it. They did know approximately when it could be expected. Such information might have *initiated research* for making such a device had the British seen the need for it. The knowledge they had could not aid them in *devising* direct countermeasures. It did permit them to hinder the work by bombing the *suspected* launching sites and, at an earlier time, to bomb Peenemunde where the project was being developed. Both of these pseudo-countermeasures certainly embarrassed and delayed the Germans and possibly prevented a catastrophe to Britain. It is seen here that the security leak in phases 3 and 4 on the German V weapons did lead to some sort of countermeasures and to a possible early start on development of a similar weapon had the British been so minded.

5) and (6) Real compromise comes, and in the V-bomb case came, with the issue to the field and field use. Once the bombs began to fall, even though often only pieces were recovered, the British rapidly learned how they were made, how they operated, and how they could be countered, if at all. The same applied to the homing submarine torpedo, the guided aerial torpedo, and the magnetic mine. Once the homing submarine torpedo and the guided aerial torpedo were used, they were recognized in a short time; countermeasures were readily developed and were in service within a few months. In the case of the magnetic mine, one mine was seen to have been dropped in the second week of operations. It was recovered, giving the show away to the British, and the degaussing cable was used within 6 mo or less. Thus, the only advantages remaining after field use and compromise are the advantage of several months' to a year's use without countermeasures, the advantage of sole use for 1 or 2 yr before the enemy uses the device in quantity, and the knowledge of methods of production—that is, the "technical know-how" and some details of the tactical employment and doctrine. Of these elements in surprise utilization, only the last two items remain in a classified category after field use. For the sake of efficiency then, shortly after use and capture restrictions should be removed on most of the items involved.

It is hoped that, in the foregoing analysis, the scope, significance, and value of technical and scientific contributions to the art of war and their security value has been indicated. A few more words should be added concerning this and other aspects of security in regard to science in warfare. In peacetime, the data on steps 2–5 in the development of new devices obtain. Security is easier to maintain as the tempo of production and development is less. There is no compromise by use, and the security with fewer and more carefully selected career service personnel is better. There is no chance for field evaluation against an enemy and thus no compromise. However, declassification of obsolescent material must be continual as the device changes and evolves. The use of newer devices by the services should be encouraged and extended, and the services should be indoctrinated on older models at some risk of security. Thus, as stated, the Navy radar was of little help to the fleet at the time of Pearl Harbor and shortly thereafter, although it could and should have been "sold" to the fleet by 1939. With this warning, one may leave research development.

Security in Other Applications of Science in Warfare

Science is now entering an entirely different aspect of military service in the guise of "Operational Research." In this work the scientists must have access to the most secret information. These men, chosen for their ability and their discretion, are fortunately few in number, and the top secret security is easy to maintain, because this type of activity falls into the category of the classical security rules governing all operational work.

Finally, science must again enter another field, that of true "Technical Intelligence." During World War I, any competent military or naval career officer versed in the technical branches could serve as a valuable technical intelligence officer. During World War II, the technical intelligence teams were composed of literally scores of experts in all imaginable fields of science and technology. Again, many of these men were no longer regular service officers but reserves and technical civilians. Here again there is danger of security violation by more numbers and lack of training. The danger of compromise is not primarily from loose talk, although this can occasionally happen. The danger lies in the fact that the men, being perforce experts in their field, know *too much about the details of the development of the art in their own country.* If captured, the danger of their innocently or under torture revealing much more information than could be gained from the compromise of a single weapon is great. Thus, such officers should be carefully picked on the basis of discretion and competence but so as not to have *too much dangerous knowledge.* They should be carefully guarded from capture and briefed for their own protection. On this score, read, for example, *Alsos* by S. Goudsmit, [Schuman, New York, 1947]. As we know today, even with Goudsmit's little knowledge of the details of the bomb, his capture by the Germans might have been very embarrassing. A second danger of another kind lies in the briefing of such officers. Probably the two most compromising documents that I saw during the war were *written briefing instructions* to technical intelligence officers—one for an American officer going overseas and the other from Germany to a German intelligence officer. By reading such a list, if it is captured (and the German list was captured), the enemy could, with the utmost clarity, discern the exact extent of technical advance in devices and weapons being used in the area in question of the nation writing the brief. Such briefing should be in the *head* of the intelligence officer and nowhere else. The classification in technical intelligence reports should generally be fairly high, as should all intelligence data. It would be quite advantageous to the enemy to know the extent of one's knowledge of the enemy's devices and how seriously his weapons are compromised. Downgrading of security in such reports will, however, be rapid.

Strategic Planning in a Scientific Age

With the foundation laid by the preceding analysis, it is tempting to extend the scope of this article to draw some vital but obvious conclusions paralleling those concerning the rapid degradation in classification resulting from scientific advance.

To the extent that new weapons and devices influence the outcome of battles and wars, it is clear that the rapid advance of fundamental knowledge must directly affect the development of a nation's strategy and tactics. Thus, to be best prepared, strategic planning, weapons development, fabrication, and stockpiling must keep pace with scientific advance.

It is interesting to note that great strides were made in fundamental research during the years immediately following the last two world conflicts and also during the years between the conflicts. In contrast to this, little fundamental advance occurred during the war years, but enormous technical and industrial advances took place based on the previous fundamental research developments, leaving the residue of useful fundamental scientific knowledge very meager. That is to say, under the stress and exigencies of war, the whole of a nation's manpower and all resources are poured into the exploitation of the fundamental findings of the past to practical and useful applications. Such expenditures are justified by the emergency but would ruin national economy in peacetime. With the expenditure of a nation's best scientific manpower and wealth in the vast coordinated efforts required for influence, mines, proximity fuses, radar, atomic bombs, and so forth, the basic research potential is exploited to its limit, and as noted, at times fabulous practical results may be derived.

In the immediate postwar years, all manner of new devices, mass-produced and accessible at reasonable cost for the subsequent fundamental research work, are at hand for the research scientist. Thus, for example, World War I gave the world the continuous wave oscillator tubes so essential to basic research, as well as reasonable advances in chemical technology. World War II left the physicist inexpensive, fast sweep oscilloscopes, microwave techniques, photomultiplier tubes, many magnetic and acoustic devices and techniques, to say nothing of the nuclear reactor piles and the remarkable wealth of tracer isotopes they yield.

With this pattern in mind, it must next be realized that it is only during a war that weapons development can be prosecuted, politically and economically, to greatest advantage and also it is only during a given conflict that strategic and tactical problems are sufficiently clearly defined to enable *efficient* weapons and devices development. It is only when the aggressor moves and discloses his strategy, weapons, and tactics that the planning to defeat him can properly be undertaken. Doubtless under these conditions the aggressor enjoys an initial advantage, but such advantage of initiative is in all ways on the side of the aggressor who can choose time, place, and means. When the conflict begins, then and only then, can the nonaggressor nation that is richer in scientific potential go into effective action against an adversary who has *frozen* his weapons into production some years before he attacks. Thus the aggressor's weapons are on the obsolescent side once he initiates action, while the nonaggressor can go into production on newer type weapons.

Thus, consequent to the rapid accumulation of fundamental scientific knowledge and techniques in times of peace, great care must be used in deciding to go into the development and production of weapons and a strategy built about them, which may, in the next 5 yr, become obsolete.

Much disappointment and criticism was manifested when the United States entered the Korean conflict and no stockpiles of the promised adequate, new weapons were at hand. Apparently satisfactory aircraft were in production at that time; otherwise, *quite properly,* within 5 yr of World War II, the United States had not gone into production of the half-developed weapons of the future. What actually was lacking in that emergency were the adequate quantities of World War II weapons that had been generously abandoned to the enemy in the former world-wide bases on evacuation. The American scientists, military planners, and manufacturers were not to blame for this situation. The fault, if any, must be laid squarely at the door of the American people who were much more interested in demobilization, disarmament, and economy, over the protests of the administration and Defense Department, than they were in preparing for emergency. It is also possible that too much loose talk by scientists of "push-button" techniques just around the corner may have contributed to this situation.

Perhaps the most striking and tragic mistake in long-range planning in recent history was the development of the Maginot Line. Fresh from the lessons of World War I, France, financially impoverished, built at enormous cost, what, by standards of the immediate postwar period, was to be the impregnable barrier that no enemy could break through—the Maginot Line. The Maginot Line was not even completed when France discovered to her sorrow that it was obsolete and that her security was gone. Less than 8 yr before World War II broke out, a weapon, considered to be a failure as the result of inadequate tests during World War I proved, under General Guderian, to be the device around which the whole strategy of the armored column and mobile warfare was developed. Once this new tactical device and its accompanying air arm were ready, after a year of the "phony war," the new strategy of mobile columns was launched sweeping around and through the obsolete Maginot Line.

It should give this country serious food for thought, with its need for economy and a defensive philosophy during these times of troubled peace, lest it in turn build an excessively costly "Maginot Line" that will be obsolete before it is finished and will so dislocate the economy that more suitable weapons will be lacking. It must further be held in mind that once such a defensive line is begun, the future aggressor will, like Hitler, bend his strategic efforts toward circumventing that line.

Although no specific solution to today's problems of defense can be given, the foregoing considerations might indicate certain reasonable procedures that will be conducive to ultimate victory if conflict is inevitable. These are

1) An intensive support and pursuit of fundamental science so that this nation will remain in the forefront and its stockpile of knowledge will be ahead of all other nations.

2) The training of adequate scientists and engineers so that when the emergency arrives the manpower needed for the development of weapons will be adequate.

3) A reasonable and well-chosen intensive program of basic research keeping up with the exploitation of important advances in fundamental science. Such effort must in considerable measure be monitored on the basis of top-level strategic planning as laid down by competent military authority with the advice of operational research analysts. For the rest, it should follow the free dictates of creative imagination in industry and in the engineering schools of the country. Perhaps in this connection, judging from the published accounts of achievements, the example of the present administration of the Atomic Energy Commission may be cited.

4) An adequate development and stockpiling of the most recent versions of the standard proved weapons and devices with which to equip the forces adequate to immediate defense needs and such additional supplies as would be needed by the reserves in an emergency. It must be clear from the Korean conflict that infantry, machine guns, artllery, tanks, aircraft, mine sweepers, destroyers, aircraft carriers, and so forth, now and in the foreseeable future, will figure largely in any conflict. In addition to development and stockpiling, there must be continued experimentation and improvement of such weapons and others with an eye to emergency production at certain stages of development if sudden conflict make this desirable.

5) A constant study of possible aggressor strategy and tactics in terms of the devices that he might use, together with intensive study and consideration of countermeasures, and their development and production insofar as it is safe to freeze them.

6) Adequate stockpiling of strategic materials.

7) Adequate planning for the conversion of industry from peacetime activities to war production of the newest weapons.

With a corner on the best in scientific personnel and data, with adequate quantities of good conventional weapons, with adequate countermeasures to expected enemy tactics, with an adequate defense establishment in numbers and training of regulars and reserves on the part of a nonaggressor, if an enemy still has the temerity to launch a war, his initial successes will not be devastating, and in the ensuing prolonged struggle the nonaggressor's chances of ultimate success are good. This was eloquently proved in World War II when the American devices put in production from 1944 on showed what science could do. The initial military reverses that faced the United States in 1942 through 1943 came from a serious lack of adequate forces equipped with suitable quantities of conventional weapons resulting from a popular false sense of economy during a period of depression.

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Young men, have confidence in those powerful and safe methods, of which we do not yet know all the secrets. And, whatever your career may be, do not let yourselves become tainted by a deprecating and barren skepticism, do not let yourselves be discouraged by the sadness of certain hours which pass over nations. Live in the serene peace of laboratories and libraries. Say to yourselves first, "What have I done for my instruction?" and as you gradually advance, "What have I done for my country?" until the time comes when you may have the immense happiness of thinking that you have contributed in some way to the progress and to the good of humanity. But whether our efforts are, or not, favored by life, let us be able to say, when we come near the great goal, "I have done what I could."—Louis Pasteur.