



AIR UNIVERSITY REVIEW



ROKAF Academy

THE MILITARY PROFESSION...COMMANDER SELECTION, TRAINING, AND EFFECTIVENESS...REPUBLIC OF KOREA AIR FORCE

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the cover

One of our sister services, the Republic of Korea Air Force, testifies to its concern for professionalism and leadership by its new Air Force Academy. In this issue of *Air University Review*, Major General Chang, Chi Ryang, Vice Chief of Staff, writes of ROKAF, and Honorable Eugene M. Zuckert discusses professionalism in the USAF.

SOME
REFLECTIONS
ON THE
MILITARY
PROFESSION

HONORABLE EUGENE M. ZUCKERT

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FOR MORE than ten of the last twenty years, I have been associated with the Air Force as Special Assistant to the Assistant Secretary of War for Air, as an Assistant Secretary of the Air Force, and most recently as the Secretary. During those years, I've seen Air Force people as a group become truly professional in techniques and skills, and approach what I would consider a high quality of professionalism in their attitudes and outlook.

The contrast between professional standards of the early postwar years and those of today probably has been more striking to me than to most of you, since I was out of the Air Force from 1952 to 1961. Perhaps I had a basis for comparison more clear-cut than did those who were in the service continuously during that critical period. At any rate, my interest in professional development led me to speak and write rather extensively about the Air Force as a profession when I was Secretary.

This article is about professionalism—but not in the usual descriptive or analytical sense. I propose only to set down some observations that may be useful to Air Force people as they continue to think about their profession. One characteristic of professionalism, it seems to me, is self-examination.

What is military professionalism?

The military profession cannot be delineated by any neat, compact definition. It is too big, too heterogeneous in its component functions, too complex in its relationships, too different from any other profession.

It can be described, but that would take a great deal of space, and anyway you who are professionals can do that better than I.

It can be analyzed, but that, I sincerely believe, is a job the professionals ought to do

for themselves. Civilian observers like Samuel Huntington, Morris Janowitz, and Walter Millis, who have written about the military profession, can provide very helpful insights and historical background. I don't believe, however, that any profession can fully understand itself until its members have thought deeply about their common attitudes, responsibilities, ethical and moral codes, and relationships with other elements of society.

The brief statement that follows is not intended to be a description or an analysis. I set it down only to establish a basis of understanding for my concluding observations.

You will recall that in *The Soldier and the State*, Samuel Huntington described the three characteristics of professionalism as *corporateness* (the feeling of belonging to an identifiable group with common ideals and purpose), *responsibility*, and *expertise*.

There are hundreds of different skills—a wide area of expertise—needed in the Air Force. One could argue that there is no such thing as a military profession—that it is merely a collection of different professions and disciplines. This is not true. There is a binding force that makes you part of an identifiable profession. That force is made up of a great many elements which could be grouped under the headings of “corporateness” and “responsibility.”

The items that go to make up corporateness range from such simple things as wearing the same uniform, through the time-honored military virtues of courage, loyalty, integrity, and self-discipline to more complex ideas like duty and sense of mission.

These last two—duty and mission—establish your responsibilities. They define the job you have to do and the spirit in which you carry out that job. They include a stern imperative which, in itself, sets the military profession apart from all others—the total commitment to

place your responsibilities and duty to your country ahead of personal convenience or gain, or life itself.

The military profession would not be what it is if it lacked any one of Huntington's three characteristics:

Without *expertise*, corporateness and responsibility would be ineffective.

Without *corporateness*, expertise and responsibility probably would result in a low order of efficiency.

Without *responsibility*, corporateness and expertise could be a threat to society.

the early years

Now let me go back for a moment to the late 1940's and early 1950's and trace briefly the rise of Air Force professionalism. The great bulk of our officers and airmen of those years had come into the service during World War II. They had been trained very rapidly in the minimum skills and attitudes that were essential to fighting that war. Generally, they became seasoned in combat and in the organization of combat operations, and certainly they were professional in their ability to fly and fight the equipment of that era. But most of those trained between 1942 and 1945 were not professionals as we conceive of the word today.

A great deal of what we now consider the stock-in-trade of a professional force had been provided by the Army, by experts temporarily in uniform, or by civilian specialists—or it didn't exist at all. For example, much of the Army Air Forces administrative support was furnished by Army personnel; our logistic and maintenance effort relied heavily on civilian professionals who had come in "for the duration"; operations analysis was a civilian-dominated field; and sophisticated, mechanized management techniques hadn't been developed.

The difference between the Air Force of the late 1940's and today wasn't only a matter of skills. It was partly attitude. I remember working on an organizational problem with a young Air Force general in 1947 or '48. He obviously would rather have been anywhere else than the Pentagon. Finally, in complete frustration, he banged the desk and shouted,

"Damn it, I joined the Air Force to fly airplanes—not to do this." Well, we all would have agreed that flying airplanes in combat was the payoff, but it was not the sole measure of professional standing for a senior officer. A lot of our people found this out the hard way when first they sat down at the conference table with Army and Navy officers of equal rank.

Then there were the myths that died hard—especially the myth of Air Force omnipotence. A lot of blue-suiters simply refused to believe that there was any war that couldn't be won by air power alone. They knew, and rightly, that air power was then the supreme deterrent to general war; but for the sake of interservice harmony in a professional atmosphere, they might have settled for the equally praiseworthy concept that there was no war which could be won *without* air power.

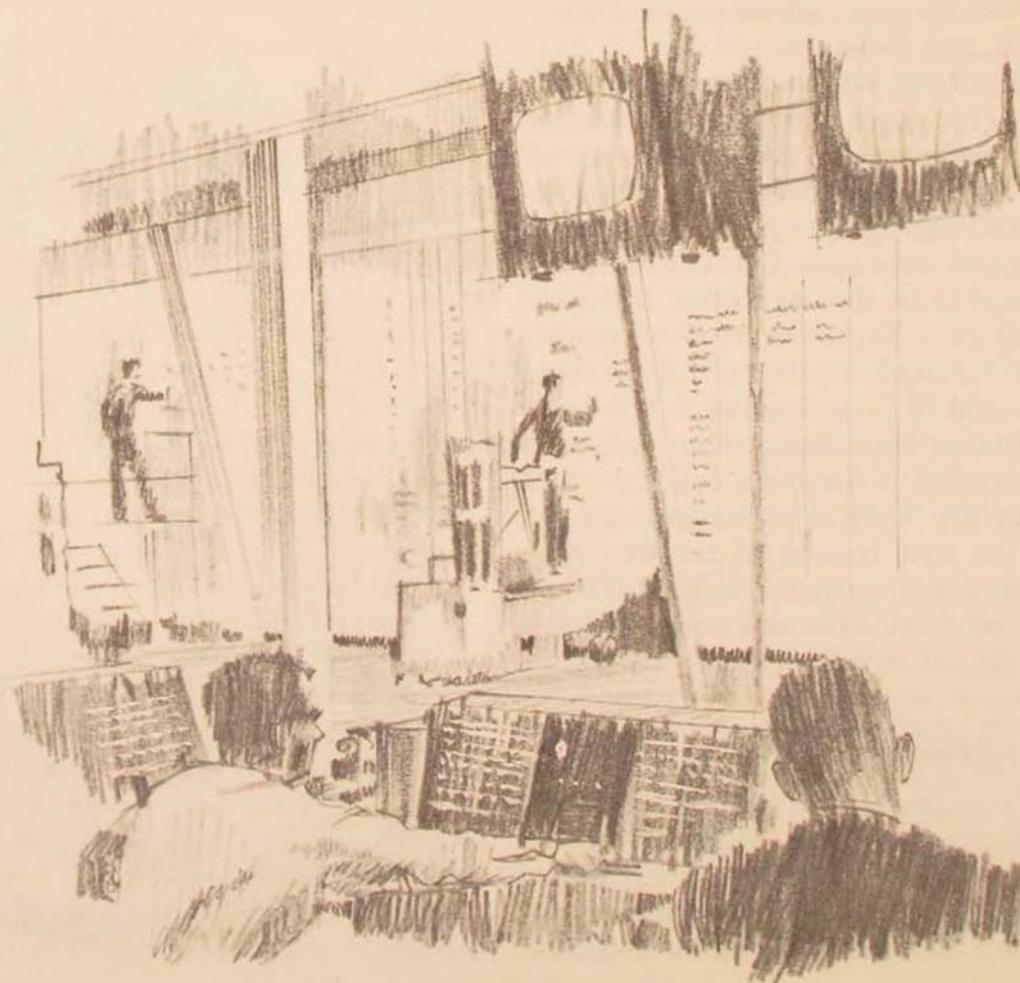
Some also believed there were few if any problems that couldn't be solved with a well-placed bomb. Those were the days of the "preventive war" school—a philosophy not in keeping with national character and probably unrealistic in either military or political terms.

These are random examples to illustrate my point. At any rate, there are exceptions to every generalization when we are talking about an organization of half a million men. Obviously there were exceptions in the Air Force—among the small nucleus of professionals who had been trained before World War II, and among those who came in during the war. If there hadn't been men like Muir Fairchild, Larry Norstad, Tommy White, Curt LeMay, and officers then more junior in responsibilities like J. P. McConnell and Dave Burchinal, the Air Force would not be the professional organization it is today.

Many of them understood not only the strength of air power but also its limitations, not only the unilateral but also the joint and combined use of their forces. Above all, they knew that air power is the most flexible of the military instruments of policy when used properly, that it is most effective when coordinated with all the other elements of national power, and that in the age of nuclear weapons the best victory is one achieved without unnecessary bloodshed.

early months of 1961 passed. It also became more and more clear that some blue-suiters were still approaching top-level problems of national security in terms of the concepts, doctrine, and study methods of the early 1950's. There were too many who took a parochial view of the big problems of planning, programming, and budgeting; who refused to believe that national policy and strategy were what the Administration said they were—not what an element of the armed forces thought they ought to be. I suppose this was a hangover from the ten or more years when we had been the principal guarantor of Free World security and in many ways the favored service. In those years our nuclear monopoly or unquestioned nuclear superiority had made the issues of strategy more clear-cut than they were after the U.S.S.R. achieved nuclear parity.

It took time for some of our old attitudes and outlooks to change; adjusting to new hardware still seems to be easier than adjusting to new ideas and new methods. We had to learn that we just couldn't sell justification of a position on "pure military requirements" or "military judgment" or a mere visceral feeling. A salable position had to be based on sound, objective analysis. We were forced to take a hard look at some of our most revered ideas, particularly in the strategic area, and I think we learned a lot in the process—both substantively and in terms of methodology. We became more objective, more analytical, and more flexible in our view of defense affairs. There is no doubt in my mind that our staff work showed greater improvement between 1961 and 1965 than in any comparable period of Air Force history.



The changes that also took place in the field during those years were, in retrospect, astounding: the advent of operational ICBM's, the transition from liquid- to solid-fuel missiles, a new missile-bomber balance, the YF-12A that could provide tremendously improved manned interceptor capabilities, increased emphasis on tactical air power and conventional weapons, the F-111 which promises a new order of mobility in the tactical area, a dramatic increase in airlift capacity and proficiency, development of special air warfare forces, our work with NASA in space exploration, the introduction of operating space systems.

Air Force progress since 1961 in research and development, management, training, education, and other supporting areas has been just as great as in our combat forces. I'll mention only a few bench marks in these areas: reorganization of our R&D and logistic functions into Air Force Systems Command and Air Force Logistics Command; establishment of the Designated Systems Management Group, which provided for incisive Secretarial and top-level Air Staff review of major weapons projects; an effective cost-reduction program; wide use of programed learning and other advanced educational techniques; reorientation of the Air University programs; development of a relatively large number of people skilled in systems analysis and advanced management techniques.

I am always impressed by the tremendous vitality the Air Force has shown in the past five years. Three years ago, I used to hear the remark that we, newest of the three services, were destined to lead the shortest life of any. The prophets of doom pointed to reduction of our bomber force, the threatened Army take-over of tactical air functions, and a slightly decreased USAF share of the Defense budget, and they predicted that we were not long for this world. I know of no forecast that was ever "busted" worse than that.

It is true that we lost—at least temporarily—some heartbreakers: AMSA, a go-ahead on the IMI, and the cancellation of several programs that don't look as good now as they did a few years ago. But we won some good ones too: the DOD space mission, the MOL, new airlift sys-

tems, a strong position in STRICOM, for example. The Air Force has demonstrated the flexibility of the manned bomber in Viet Nam and proved that we are a really dual-capable force with our effective use of conventional weapons in Southeast Asia. In summary, I think they have been very productive years.

This brief review of Air Force growth and change also illustrates the breadth of Air Force activities. No other military force is equally committed in the scope of its mission—from counterinsurgency through limited war, strategic offensive and defensive tasks, to space. Air Force people serve in nearly a hundred foreign countries and on combined staffs with their counterparts from many allied nations. It takes more than \$18 billion a year to meet these commitments. I can't think of another human activity that matches the Air Force in scope, variety, or complexity. Only the other two military services come even close.

thoughts on the analysis of professionalism

These three words—scope, variety, and complexity—are major factors in making the Air Force profession the most difficult and challenging of any I know. It is also one of the most rewarding. I want to discuss each of these qualifying adjectives in the hope, which I expressed earlier, that my observations may be of use as you think about your profession.

Many of the difficulties are obvious: the skills required to handle very complicated machines, manage vast sums of money, get the right things at the right place on time, direct thousands or hundreds of thousands of people, plan for the uncertain environment that lies ten or more years ahead, and develop machines that stretch science and technology to their limits. These are skills that intelligent, educated men can master.

Then there are the personal and emotional difficulties that not every man can meet or is willing to accept: danger, physical hardship, family separation, discipline, pay that never will match civilian compensation in positions of great responsibility. Those who lack a strong sense of dedication or a realization of the importance of their mission or a love of military

life may find these difficulties unbearable.

Finally, there is a category of difficulties that I would describe as problems of balance. Solving these problems, it seems to me, is one of the real measures of true professionalism. Let me describe some of these problems.

First, the defense of this nation and of the Free World is going to depend for many years on the military stature of the United States. We will have to invest billions upon billions of dollars, scarce skills, and valuable materials in our security. These national resources must be employed responsibly and efficiently, using the best techniques of business management. There will be great emphasis on business practices in the management of defense resources, but the military profession must never become a business or be looked upon as one.

Second, in any profession governed by relatively fixed standards of conduct, there is danger of producing stereotypes. We should strive for diversity within a framework of common understanding. Sometimes the unconventional thinkers—the “wild birds”—have not fared very well in the military. But they are exactly the people most apt to see new opportunities in a world that is unstable in nearly every field of endeavor. Keep the best of them and use their special talents of prophecy, imagination, and intuition.

Third, we must maintain a balance between the relative values we attach to operational skills and to management skills. They are equally essential to the Air Force, but the former has traditionally tended to take precedence over the latter. We have had to put increasing emphasis on administrative skills as a constantly greater degree of expertise is needed to manage defense resources. I might add parenthetically that many of our management improvements since 1947 probably were accelerated by the absence of long-standing tradition in the management area. I add emphatically that management and command of management techniques should not be regarded as a separate type of professionalism, but as an essential of military professionalism.

Fourth, the effectiveness of the Air Force as an instrument for ensuring peace or defending against attack depends on its ability to kill

and destroy more efficiently than any potential enemy. This is a hard thing to say in an age of euphemisms where cemeteries have become “memorial parks” and mortuaries “slumber rooms.” Nevertheless, it is true. You have to preserve a toughness of mind and spirit that is almost unique in this day and age. But at the same time, you have to maintain a respect—a reverence—for humanity and for the works of man. Without this reverence, the military professional could be little different from a gangster.

Fifth, corporateness may become increasingly hard to maintain. To some extent, it may have been weakened by our functional organization and by a tendency—which I believe is disappearing—to think in terms of almost unrelated strategic or tactical or defensive power. Anything which fractionalizes your profession unnecessarily should be regarded with caution.

Perhaps more acute in all the military services—especially in the Air Force which has more than one thousand military occupational specialties—is the possibility that specialization of skills can lead to such close identification with a subprofession that a man may lose his identity with the military profession as a whole. This is particularly true in those areas that are similar or identical to civilian skills—scientific research, personnel management, some kinds of engineering. Many of these areas require advanced education in civilian institutions or duty with civilian organizations. I believe firmly that the military profession should be closely integrated with the civilian elements of our society. I do not believe that the military professional can or should be a mirror image of his fellow citizens in civilian life.

This brings me to my last problem of balance. *Maintain the military mind but let it be a balanced military mind.* Charles Burton Marshall stated the case for the military mind better than I can, in extemporaneous remarks which he made at the National War College in March 1965. This is an excerpt from his remarks:

If there is not a military view of things, then all the other taxpayers and I are not getting our money's worth from the array of institutions set up to inculcate professional aptitude

for the military . . . I think a distinctive set of attitudes is essential to what the profession has to contribute, and I am sure we are going to have to rely on them for a long time. The pride, the lore, the comprehension associated with the specialty are right enough. Without them, it would be hard for the rest of us to find much of a future to count on.

I agree with Mr. Marshall, and I add this note to his remarks. Today the military mind must be somewhere between an essentially civilian outlook and the stereotype of the military mind well known to fiction—dogmatic, inflexible, authoritarian, and narrowly focused on military affairs. It should recognize not only military considerations but also the sociological, political, economic, and technical forces that influence this complicated world.

I think there is little need to dwell on the second adjective I have used to describe the military profession—"challenging." Today your profession stands constantly at the forefront of science and technology. That is one of the great challenges. You also will be challenged by the scale of military affairs. No civilian corporation in this country begins to rival the Air Force in

number of employees, budget, or geographical dispersion. Finally, the problems that the military professional deals with are ultimately concerned with the lives and freedom of millions of people and the security of untold treasure. This is the supreme challenge of your profession.

You will continue to face determined, skillful, and imaginative adversaries in the U.S.S.R. and Communist China. The competition will be tough and the stakes high.

I am convinced that we are at one of the decisive points of history. Whether all the people of the world will one day be free to choose their own way of life; whether the outcome of this great issue is decided peacefully or by war, will be determined in large measure by the quality of our military professionals. You have an unparalleled opportunity to serve your country, and beyond it the cause of peace and freedom throughout the world.

The thoughtful man will find his greatest reward in knowledge that he has served well and constructively not only his own generation but those to come.

Chevy Chase, Maryland



SELECTION AND TRAINING OF COMMANDERS

COLONEL ALMA R. FLAKE

NO ONE doubts the heavy responsibility resting upon the unit commander to lead, to manage, and to exercise his authority in a competent and creative manner so as to accomplish the mission and achieve the policy goals within the bounds of law and regulation. Yet there are no precise published policies as to how officers will be selected for command position or who will select them. Any Air Force commissioned officer, except a chaplain or medical officer, is authorized to exercise command providing he is senior in rank to other qualified officers in the unit and, if the unit is primarily engaged in flying, a rated pilot on flying status. If for any reason the commander departs from the unit, the next senior qualified officer automatically assumes command and inherits all statutory command authority. In rare instances, as when two officers of equal rank are involved or when the senior officer assigned is considered unqualified for reasons other than statutory, higher authority may intervene and designate another officer to assume command.

The succession to command by virtue of rank is a traditional military concept intended to ensure the presence of effective authority under all eventualities. The validity of the concept in view of possible unforeseen events and emergencies is unquestioned. It has, however, some undesirable effects. Since the next senior officer will automatically succeed, there may be little urgency in finding and assigning the officer who is qualified to provide the best leadership over the unit. It is, in fact, unnecessary for any agency to plan in advance to ensure the presence of a commander in each unit. Normally, realization of the critical importance of the position results in a rational selection of a qualified officer to assume command on a permanent basis. Too often, however, the lack of urgency and necessity results in delay in the selection even when loss of a commander has long been forecast. The same factors cause most commands to neglect any advance planning or effort to have a qualified officer identified to replace immediately a commander lost through unforeseen events. The resulting periods of time between permanent commanders are often characterized by a lack of command leadership and direction in the unit.

This article is based on a thesis prepared by the author as a part of his academic work while a student at the Air War College, Air University, Class of 1964.

Air Force Approach to Leadership

"The very fact that you are a commissioned officer marks you as a leader of men." This is the first sentence in the leadership manual used at the Squadron Officer School, Air University. The Air Force's current approach is well expressed and explained in a recent publication:

Rank indicates precedence, command, but it should indicate more—growth in knowledge and understanding of man, functions and operations. As the officer matures in the sense of Air Force experience, as indicated by his rank, he is expected to have a better grasp of the Air Force's overall mission, better insight into its international and national aspects, more flexibility (because of his wider knowledge) in adapting to changing philosophies, concepts and functions, and a greater understanding of what it takes to get the job done right. This philosophy backs the military precedent that rank generally controls command.

Command is implicit in commission: therefore, every officer . . . must always be preparing for command. . . . In this respect, his entire career is a constant challenge. The way he meets the challenge will have a significant effect on his, and the USAF's future.¹

This concept of equal sharing of leadership responsibility and qualification by all officers forms the basis for leadership development in the Air Force. "In leadership training and leadership education, we seem often to work primarily on the assumption that officers have the knowledge they need and the proper skills to become leaders and commanders."² Officer candidate selection procedures are designed to justify this assumption. "We depend upon measurements of potential physical and intellectual abilities to determine those who are to receive officer training."³ The education that the officer candidate receives is heavily oriented, at least verbally, toward leadership. The drill field is now known as the "Leadership Laboratory"; four years of "Air Science Leadership" classroom "affords opportunities for the observation and development of leadership"; and extra-curricular activities "should further develop leadership."⁴ And finally: "An officer is granted a commission because he has real and potential leadership qualities."⁵

This, then, is the basic Air Force system for leadership selection. Since this selection process is based on an "adequacy of natural endowments and special abilities,"⁶ leadership qualification is officially assumed to be a common attribute of all commissioned officers.

The same assumption is not made concerning management ability. The two qualities appear to be completely unrelated in the context of Air Force policy: leadership, a quality possessed by all officers; management, a quality which must be developed in the same sense as a technical skill.⁷ Since management is an inherent responsibility of all Air Force personnel appointed to leadership positions,⁸ the concept for its development may be considered part of the approach to leadership.

The Air Force manager is developed by three factors. First, through participation in a variety of activities, he learns through doing and observing. Second, he receives personal attention and help from his commander, who is always greatly concerned with the development of potential managers. Third, he is allowed to attend certain academic and professional training programs for which the Air Force has established requirements.

A review of the directives and other available publications on the subject reveals that Air Force policy on management development is general and unspecific. Responsibility is so widely dispersed that, in effect, no agency or individual can actually be held responsible. Success of the program would appear to be based on the positive operation of three factors: varied assignment experience, personal participation of commanders, and formal management training.

In summary, the Air Force considers leadership to be a quality possessed by all officers as a result of officer selection and education policies. This concept is in complete harmony with the ancient military traditions of leadership. Management, on the other hand, is an essential quality that officers must develop. These concepts—leadership as a quality possessed and management as a quality to be developed—comprise the basic elements in the Air Force system for selection of leaders and for its management development program.

selection process

The Army estimate of command assignment has been well stated:

A command assignment is the most important assignment that an officer can obtain during his career. The proven ability to command can influence many personnel actions, such as selection to certain high level schools, special assignments, and promotion for those not specialists . . . Command positions at the battalion and regimental level will be filled by those officers whose records have been so outstanding as to indicate they are potential division, corps and army commanders."

The Air Force shares this Army respect for command position, as previously implied in the quotation that "every officer . . . must always be preparing for command" and that in this respect "his entire career is a constant challenge." However, this generally accepted respect for command is not supplemented by any official policy on how commanders will be selected, who will select them, or precisely what qualifications are required of the officer selected. One regulation states: "Officers will be considered for assignment to positions of increasing scope and responsibility when they possess above average capabilities and capacity for growth."¹⁰ No point in time is indicated at which this consideration is to take place; no testing program or other means is cited by which "above average capabilities and capacity for growth" will be determined. Neither is it definite that "positions of increasing scope and responsibility" actually means a command assignment. It may very well mean selection to some other assignment considered important enough that specific qualification is required.

Although officers applying for the graduate science and engineering programs are required to take aptitude tests, no tests of any type are designated to assist in the selection of officers to command. Air Force Manual 35-8 validates the use of personnel testing to determine what career fields people are best suited for, but it contains no reference to tests to determine ability to lead, to manage, or to command. In the *Air Force Statistical Digest, Fiscal Year 1962*, the only official training programs listed which appear to be possibly related to

management are Business Administration and Personnel Management.¹¹ My search of Air Force directives has failed to reveal a definition of any specific training or experience as a mandatory or desirable qualification for selection as a unit commander.

All this indicates the lack of an official policy on the selection of unit commanders and the absence of an official program intended to produce qualified candidates for command assignment. Since there are no definitive policies on the subject, how are unit commanders selected?

In most cases, the next higher commander selects the unit commander. Occasionally, when a unit of relatively greater importance is involved, a higher commander may make the selection. Hopefully, the commander's decision in the matter is concurred in by his staff and by other headquarters in the chain of command, and a well-known, highly competent officer who possesses all the desirable qualifications happily receives the appointment. This optimum result, however, is unusual because of factors bearing upon the selection. Commands are usually too large to enable officers of the middle grades to be well known to the several higher levels of commanders or their staffs. In most cases officers are rotating in and out of the command on a 3- or 4-year basis. Higher commanders move from one assignment to another even more frequently. And further, not all selected officers desire command assignment. Therefore, when a requirement exists to select a unit commander, one of the following conditions can reasonably be expected to exist:

- The appointing commander is newly assigned and personally knows very few of the officers under his jurisdiction. He must resort to recommendations of his staff and/or a review of effectiveness reports to make his decision.

- An appointing commander may restrict his consideration to those few eligible officers whom he personally knows and has confidence in. This eliminates from consideration other officers who well may be the most qualified.

- An appointing commander who has no officer whom he wishes to appoint may allow

succession by seniority to take place, even though the succeeding officer does not have his confidence.

- The officer who is considered best qualified by the appointing commander may successfully decline the appointment for various reasons.

- An officer will be selected solely because his records show that he has previously commanded a unit and has "experience."

Thus, the appointing commander selects, or allows to succeed, the officer who in his personal opinion is the best available in view of all factors bearing upon the problem. The decisive element of the selection is the personal opinion of the appointing commander. The desire of the appointing commander to see the unit well managed and therefore the sincerity of his motivation in making the decision are unquestioned; however, his ability to select the best-qualified officer is doubtful, since his decision is basically a matter of personal opinion, unassisted by any organized system of management development and selection. The problem is even further exacerbated by limitations affecting the selection of unit commanders.

limitations in selection

The size of the Air Force and the large number of officers in the middle grades would indicate a tremendous group from which each commander is individually selected. In actuality, this is not the case. The appointing commander is faced with several limitations which severely reduce the number of officers from which the selection must be made. These limitations tend to parochialize the system, narrow the selection base, and therefore degrade to some degree the quality of the officers selected.

One limiting factor is the requirement for a specific grade, as authorized for the particular unit command position, and for seniority over other assigned personnel of the same grade. Another is the requirement that a rated officer on flying status command a flying unit. The seniority requirement is a traditional military concept, unchanged by modern doctrines and generally accepted as a necessary reality of

military life. The technical requirement of a flying rating is a relatively modern innovation.

The limitations of rank and rating, however, are not the major limiting factors, and both could be strongly defended as valid requirements. The selection system could still be broadly based if other less valid limitations did not exist.

The major limiting factor restricting the appointing commander from selecting the best officer he can find is the absolute lack of priority accorded the action of commander selection. No exceptions from any of the normal personnel assignment directives are granted. An appointing commander must therefore select from the officers under his jurisdiction. To the commander of a division, wing, group, or squadron with deployed detachments, this can often limit the choice to a very few, or even a single officer. If the appointing commander knows of a well-qualified officer, for instance from a command he has just left, he has no legitimate means of requesting his assignment. This policy is, of course, in line with the traditional "rank equals leadership" philosophy: the personnel system will produce an officer of the proper specification to fill the line authorization on the manning document; since he has the rank and rating authorized, he automatically has the leadership called for; therefore, all positions, including command, will always be adequately manned. As long as this philosophy exists, it will defeat efforts to select the best management.

Other restrictions which narrow the selection base are found in normal personnel assignment directives. An officer cannot be transferred until he has completed 18 months on station since his last transfer. This, in effect, precludes the selection of a sizable percentage of officers who may otherwise be under the appointing authority's jurisdiction and ideally qualified. Exceptions to this policy are rare and can be approved only at the highest level. Selection for a command position is not in itself an adequate reason to request an exception. In overseas areas, the prescribed rotation policy is a further restriction. An officer who is within one year of the maximum tour in an area cannot be relocated to take a command. If he has less than two years of theater retainability, this

weighs against his selection because of the generally accepted opinion that a command appointment should be for at least two years' duration. These restrictions are a serious limitation, especially overseas, on the appointing commander's authority to select the best qualified officer for available command positions.

The increasing decline in prestige of the unit command position is another factor that degrades the selection process. This factor, though not the result of official policy nor evident in the pronouncements of responsible officials, causes many eligible officers to evade command assignment. This effect has been brought about by the well-publicized decline in unit command authority, by the recognized absence of an organized system to select the best officers for command positions, and the mediocrity of many of the officers selected under the present inefficient process. Many officers in the middle grades do not consider a unit command assignment as the best, or even a desirable, step toward promotion. It is looked upon as a position where responsibility outweighs authority and where conditions not under the control of the commander may result in failure that will be recorded on the effectiveness report. Although the appointing commander has authority to direct the assignment, there is an understandable reluctance to appoint an officer who does not have a strong desire to command.

results of present practice

There can be little doubt that the unit command position is one of the positions for which the selection of the right man is of critical importance to the effectiveness of the Air Force. Since few basically important actions anywhere in the Air Force escape his final touch, and his final touch is considered the most important,¹² a strong case could be made to support the contention that, collectively, unit command is the most critical of all positions.

Does the existing system produce the right man for the job? Have the officers selected for unit command positions met the challenge brought about by technological and social developments? Has management at unit level increased or decreased Air Force effectiveness?

Precise answers to these questions are impossible to obtain. Certainly the existing system has produced some excellent unit commanders who have successfully met the challenge and have contributed significantly to total effectiveness. It might be claimed that the acknowledged overall increase in Air Force efficiency during the past decade is proof of effective management at unit level. Much more plausible would be attribution of this trend to the dramatic improvements in management initiated at higher levels of command: the standardization of procedures; the establishment of standards of achievement for all activities; the improved distribution of technical skills and vastly improved training programs; more efficient procurement and supply support; better equipment and higher pay for personnel; and perhaps most of all, the extremely close supervision which higher headquarters have exercised over unit accomplishment. The available indicators and my personal experience tend to support the latter conclusion.

One indicative area is in the duration of unit command assignments. If it is granted that stability of command is desirable and that the duration of an individual's assignment is to some degree indicative of success or failure, factual information in this area is useful in judging the effectiveness of the selection system. A survey of the command experience of line-of-the-Air-Force officers in the 1962 class of the Air Command and Staff College revealed some interesting statistics. Of 120 officers who had held squadron command assignments, 54 (45%) were in command for less than one year, 29 (24%) between one and two years, and 37 (31%) two or more years.¹³ Although these figures cannot be directly translated into a ratio of success or failure, they do seem to strongly indict the system. A selection system that fails to produce the right man at the right time in 45% of the appointments can hardly be considered very effective.

The major indictment of the system cannot be obtained from published information. It is strongly indicated, however, by the general dissatisfaction with the system expressed by practically all who comment upon it. Among a multitude of studies by military personnel, it is diffi-

cult to find a defense for any element of the selection system. In my opinion, this dissatisfaction arises from personal observations of many tragic or ludicrous results of appointments to command which are known to the individual officer. These observations from an individual viewpoint are limited to the minor portion of the large Air Force that any one officer personally observes and are to an extent a mixture of fact, rumor, and suspicion. To most, there is a strong feeling that something is wrong with the system. To define the "something" is more difficult. Each individual realizes that his observations are only a fragment of the whole and well may be nontypical.

A statement to the effect that the majority of selections to unit command positions are malassignments will surprise only the very junior, due to his lack of exposure, and possibly the very senior, because of an understandable tendency of intermediate commanders to keep corrective action at their own level. However, whether the circumstances are known or unknown outside the local command, invariably the officers and airmen of the unit involved are acutely aware of them. The cumulative effect of such management failures upon morale and efficiency, though not measurable, is significant.

These failures are not caused by deficiency or neglect on the part of intermediate commanders. They are the result of a deficient management selection system — a system which makes the quality of management selection dependent upon the appointing authority's personal knowledge of his people, backed up by reference to a group of evaluation reports often written by strangers.

New Approach to Air Force Leadership

Writing of military leadership, one well-qualified analyst had this to say:

We have not faced up to the fact that our thinking about leadership, as well as our literature on leadership, is out of joint with the times. We seem to be training and educating on the implicit assumption that past practices are sufficient to produce future leaders. Although

we have been slow to recognize this and even slower to change direction and methods, the force of circumstances insistently demands that we face up to the problem and take steps to solve it.¹⁴

Recommendations contained here are directed only toward the selection and training of Air Force unit commanders. Said another way, these recommendations are aimed at effective selection and training of those officers who will be appointed to management positions at the lowest executive level. If the changes suggested will serve to provide better management at unit level, the effort required for implementation is more than justified. However, any improvement in the development of young leaders will have an upgrading effect on general Air Force leadership and important implications extending far beyond the unit command assignment. For, as one writer has stated, "weaknesses in higher management can be traced to weaknesses in lower management, its major source of recruitment."¹⁵

Before a new approach can be accepted, the old one must be discarded. It is high time the Air Force discarded the outdated, traditional military concept of leadership. The new concept must acknowledge the value of officers who possess a high potential for leadership and management; the Air Force must actively seek them out early in their careers, develop them through training and experience, and, at the right time, appoint them to command positions.

The first step is to abandon the concept that leadership is a responsibility shared equally by all officers. In more recent directives the Air Force has increasingly referred to the need for competent specialists as well as broadly experienced officers qualified for command and managerial positions.¹⁶ Is leadership equally required of each of these types of officers? In a 1962 presentation of the Officer Career Management Program, USAF officials pointed out: "Individuals whose qualifications and desires indicate they can best serve as specialists should be utilized and developed as such."¹⁷ Can these people be utilized and developed as specialists while at the same time taking part in broadening assignments aimed at providing the "largest possible group from

which to select our future leaders as they demonstrate the necessary management skill?"¹⁸ The contradiction is brought about by technology, which created the requirement for specialization, and by tradition, which still proclaims each officer to be inherently a leader of men.

Does the Air Force require from all officers the combination of leadership and management ability necessary for command, and therefore should all officers be expected to develop and be rated upon these qualities? The answer is certainly negative in view of the command positions available versus the number of officers and in view of past records of officer assignment. One study conducted several years ago pointed out that there were approximately 3000 command slots. Of this total, about 2300 called for the grades of captain through lieutenant colonel. At the time there were 83,000 officers serving on active duty in those grades.¹⁹ Simple arithmetic shows the odds against anyone who aspires to command. Even the most successful rated pilot officers have less than a 50 percent chance of achieving a command position at the unit level, and of course they have a decreasing chance thereafter. If an officer is not a rated pilot, his chances of being appointed to a command position are negligible.

The traditional military philosophy — that command is implicit in a commission—clashes harshly with the facts of military life today. An officer no longer needs to command in order to become extremely valuable and gain senior rank. Any officer, regardless of his proficiency, will be well advised not to expect his service to include a command. If he is other than a rated pilot, he would be wise to concentrate primarily on some other more likely career progression and only secondarily on preparing himself for command.

The fact is that command leadership is required of only a minority of the officers who actively serve the Air Force. To require all officers to develop command skills is a wasteful policy. It diffuses the efforts of the many officers whose value lies rather in specialization; it is inevitably frustrating to many officers who are led by the policy to expect to command; and it tends to degrade the respect in which a com-

mander is held by equating his leadership and management capabilities with those supposedly inherent in all other officers of similar rank. Responsibility for command leadership is not shared equally by all officers; it rests entirely on the group who occupy command positions. Training and development for command responsibility should be concentrated on those needed for command positions. Other officers should be trained and developed in the areas of their competence, according to the needs of the Air Force. This will require a new concept of leadership, a concept which will allow for a selection process to differentiate between officers who will be candidates for command and those whose development will be in other fields. Leadership of the type required to take over for a short time in an emergency, or to stop a conflict between two airmen, will remain a responsibility of all officers. But command leadership will become a recognized specialty, to be highly developed in the group of officers actually suited and needed for command positions. This concept is not really new. It was recommended in an extremely high-level report over ten years ago:

A premium must be placed on command and leadership abilities. Accompanying an increase in technocracy within the services, there has been an ever-increasing demand for technical abilities. As a result, many now achieve promotion to responsible positions never placing themselves in a situation where their leadership and command abilities are tested. It must be clearly established that military command and technical astuteness are two separate and distinct fields of endeavor. Both are essential . . .²⁰

If this concept is adopted, if command leadership and management ability are to be considered as an art and a science in themselves, it then follows that individuals with the highest qualifications should be selected for entry into this important field and that a development program should be initiated. Again this is not a new concept. Industry has long placed great emphasis on the selection and training of management candidates. The American Management Association states: "American industry is convinced that the dis-

covery and development of managers is its No. 1 administrative task."²¹

Candidates for command should be selected carefully and given thorough training and experience, just as any other specialist group, to prepare them for command responsibility. This concept, if implemented with effective selection and development programs, will significantly improve management at unit level.

Industry has developed certain basic principles in the recruitment and selection of candidates for management positions. These principles readily lend themselves to Air Force adoption. The discussion below follows accepted industrial practice.²²

definition of qualifications desired

Before an effective selection program can be designed, it is essential that the qualities desired be thoroughly defined. Many of the qualifications, as previously discussed, can easily be defined for selection purposes. However, some of the definitions can only result from top-level Air Force studies and decisions. In writing of the requirement for some basic decisions about leadership, Mr. Oron P. South, formerly of the Air University Aerospace Studies Institute, stated that a better understanding of new military society is required and that

... in order to discover what kind of leaders are most likely to function effectively in it, and how men can be prepared for leadership, it is necessary to:

- (1) Survey the broad areas in which competence is required.
- (2) Develop criteria for the type of competence needed in broad areas, and
- (3) Outline a training and education system that will best develop the competence needed.²³

In the process of developing criteria for leadership qualifications, the Air Force should take a critical look at many of its present policies. The size and organization of units vary greatly, appearing to have evolved by casual incremental modifications to traditional military structures. The authority of some unit command positions, such as the Strategic Air Command tactical squadrons, has been stripped of all management functions, and they appear

to retain no more than administrative responsibility. Increasing criticism of the rated pilot requirement indicates the need for a reconsideration in this area. Since commanders no longer lead massed aircraft in battle, perhaps this requirement should be restricted to only the most highly specialized flying units. Some advocate the placement of military officers possessing scientific competence throughout the command structure of research and engineering activities, stressing the fact that in this area the scientist must make the decisions, while strictly military officers can act only in an advisory capacity.

These are only a few of the many areas in which decisions are required in order to provide full definition of the qualifications required for future Air Force leadership. Initiation of an improved selection program should not be held up pending these decisions. Definitions should be made in the light of already known requirements. These will be sufficient for initiation of an organized selection program that will upgrade unit management capability. Refinements can be added as firm decisions are made.

recruitment

In recruiting, the net should be spread as wide as possible to provide a large number of persons with a variety of qualifications from which management candidates can be selected. Recruiting should aim for as highly educated a group as possible, although no specific type of education should be particularly stressed. In view of the large variety of Air Force management positions, the recruiting effort should begin with those prospects having a broad, liberal education. The present officer recruitment program appears to be adequate to provide a group from which qualified candidates of the desired educational backgrounds can be selected. The Air Force should, of course, attempt to cast the net even wider and continue in its efforts to attract higher-quality graduates.

selection of candidates

With all incoming officers forming the

group from which candidates will be selected, and with desired qualifications defined, methods must be devised to select those officers with the highest potential for leadership. The selection process should comprise all possible means of evaluation. Every care should be taken to see that no one element of the selection process becomes decisive. When the program is initiated, it should be made a matter of importance and given a high priority. All officer candidates should be made aware of the program. It should be added to the mandatory briefing responsibility charged to the unit personnel officer. And finally, it should become a specific responsibility of all commanders in their individual and group counseling of junior officers. A maximum effort should be made to see that every officer is fully informed of the program and its purpose during his first months of military service.

As a first step in constructively reducing the group under consideration and eliminating those not qualified, a statement of minimum qualification should be published. The statement should be designed to eliminate those whose qualifications are for any definable reason considered unsatisfactory. If college graduation is considered an essential requirement, it should be so indicated. Any other qualification considered necessary for success in the military management field, above that required of all officers, should be defined. An officer should be required to meet these minimum qualifications in order to receive further consideration.

As the next step in selection, each officer should be required to indicate whether or not he desires to enter the management field. Desire for selection is necessary for a fully effective program and as a means to further limit the group to be considered.

Personnel Tests. As the best means of reducing the sizable group under consideration and of efficiently eliminating those who do not possess a high degree of the desired qualifications, personnel tests should be developed and administered. Such tests are commonly used in management selection programs by industry. There is general agreement that tests must be designed on the basis of valid criteria and that they should be "designed to supplement other screening methods, not to replace them."²⁴

Tests are also useful in discovering personality problems that have to do with a person's ability to gain the cooperation and respect of the working group. According to one survey, these personality problems are the cause of seven times more management failures than the number that can be attributed to lack of knowledge and proficiency.²⁵

In view of the preponderance of evidence supporting the use of written tests and their widespread use for other purposes by the Air Force, it is difficult to understand why they have not been used in the selection of managers. Appropriate tests should be designed and given at the latest possible time that will enable their being evaluated and considered in the final decision to select or reject the applicant.

Effectiveness Reports. Throughout the period of duty prior to final selection, the officers under consideration should be rated in accordance with current procedures. These ratings should be considered in the final decision as one of the evaluating devices. Because of the well-known and oft-stated deficiencies of the rating systems used by both the military and industry, it is important that the rating not become the only deciding factor in selection.²⁶ Neither should it be given less weight than some other factors considered.

Peer Ratings. At least two personnel studies sponsored by the Air Force and conducted at the Personnel Laboratory, Lackland Air Force Base, Texas, have reported favorably on the validity of peer ratings in predicting later performance. The first study reported that ratings by peers had been shown to be more valid than either ratings by supervisors or references; that the validity increased with the number of peer ratings obtained; that they are one of the most consistent predictors of future job success; and that they had proved to be applicable at any level for any type of group.²⁷ The second study, completed two years later, used both Air Force officer candidates and senior Air Force officers as subjects and found that "the patterns of relationships between personality traits and officer performance were very similar in both groups." They also found ". . . peer ratings on personality traits to be predictive of later per-

formance as second lieutenants in the case of officer candidates, and to be related to concurrent but independent measures of officer performance in the latter group."²⁸

Peer ratings could be easily and economically obtained and should provide an additional useful device in evaluating the individual. These ratings should also be evaluated and given appropriate weight in the final decision to select or reject the applicant.

Personal References. Personal references, specifically related to the applicant's qualifications for management, should be provided by his unit commanders and supervisory officers who have personal knowledge of the applicant's duty performance. A form designed for this specific purpose would facilitate the furnishing of these references to the selecting authority for consideration.

administration of the selection program

Up to now the selection process has been carried out in the field at very little cost or trouble. However, in order to achieve its purpose, the new program must have a central, Air Force-wide authority. Decisions made by this authority will affect the entire Air Force and an officer's total career. Therefore, although all subordinate commands should have full responsibility for implementing the program, no selection authority should be delegated. The administrative body should be a full-time organization, not a committee or board meeting on occasion. Responsibility for all elements of the program—selection, training, etc.—should be charged to the one central authority. The management selection and development officials should have constant access to advice from competent professionals of all disciplines that can contribute to the selection and development process. And finally, decisions on the selection or rejection of individual applicants should result from a balanced consideration of all evaluation devices by a properly constituted board of the highest qualification. The decisions of the board should be considered final, with reconsideration possible only in the most exceptional cases and through an extremely high authority.

At this point the evaluation devices should be in the hands of the administrative authority, who will make and announce the decisions on the basis of an established schedule. During this process the system must be responsive to several factors. The number selected must be based upon anticipated requirements, with a reasonable addition to cover expected attrition during the development phase. The backgrounds of those selected must be taken into account, to ensure the availability of the required number of commanders of appropriate technical and professional competence. Following selection, the central authority will be directly responsible for scheduling selected officers for academic training and providing them in adequate numbers and appropriate areas for assignment to command positions. The authority should also provide guidance as to the assignment policy to be applied to selected candidates when they are neither attending schools nor occupying a command position.

Training and Development

At regularly scheduled intervals, probably annually, the selection of a group of management candidates would be announced. This group should represent the highest basic management qualification available to the Air Force. The system must be designed to take maximum advantage of the time available for the training and development of these potential commanders. The same authorities who agree that leadership and management ability are to some extent inherent traits which cannot be acquired through training or experience also agree on the necessity of providing a training and development process for those who possess the basic qualifications.²⁹ Formal programs are considered of increasing importance because of the rapidly growing complexity facing modern managers.

Imagine any projection of recent trends you like and you are forced to the conclusion that the men who are shortly to exercise authority in the direction of affairs must have a degree of knowledge, intellectual skill, and of competence exceeding anything we have regarded as adequate heretofore.³⁰

That this quotation is equally true of future military leadership is readily apparent.³¹ To meet this challenge, the objective of the training and development program might well be: To provide a degree of knowledge, intellectual skill, and competence adequate to ensure effective Air Force leadership at the unit level.

academic training

An academic program incorporating comprehensive courses on all elements of the science of command management and leadership at unit level should be provided by Air University. Entry should be limited to selected management candidates, and successful completion of the course should be a requirement for retention in the program. The course should include both a general phase, which all management candidates would attend, and a specialist phase to equip candidates for various commands.

In addition to the academic instruction to be provided, the school should make full use of the opportunity to establish the attitude of the individual toward management. "What is needed is not a brilliant exposition by the teacher, but a permanent change or at least a development in the attitude of the student."³² And: "The development of an executive involves the changing of attitudes and the cultivation of habits."³³

While attending leadership school, the student should be subjected to continued evaluation. The school would provide the ideal place to conduct those types of evaluation which are considered valuable but are too difficult or expensive to complete in the field. Evaluation validity could be enhanced by both individual and group interviews, for which industry has developed valid techniques.³⁴ Since the interviews are administered by professionals, they could not easily be accomplished prior to selection. Additional peer ratings should be obtained during this period and a professional evaluation report on each student completed by the faculty.

Academic and personal standards established for the commanders' school should be extremely high. A student not meeting these

standards should be permanently eliminated from the program and the successful one considered to have passed a significant milestone.

assignment policy

Firm guidance in the form of a directed policy will ensure appropriate assignment and distribution of graduates. They should all receive assignments in which they gain useful experience related to the type of command they are qualified to assume. The details of the assignment policy would probably differ, for example, between the officer scientist who will eventually command a laboratory effort and the officer preparing for command of a logistic unit. In each instance the areas of authorized assignment for graduate management candidates must be firmly defined. Certain minimum requirements for broadening experience would probably increase the value of the program; for instance, each candidate to have one year of duty at intermediate headquarters level and a minimum of one year's experience in a position requiring the direct supervision of airmen. He should become familiar with a broad spectrum of military activity, to learn the problems at least and the answers when possible. The details of the assignment policy must be developed for each type of command and rigidly complied with. Waivers from normal personnel policies needed to allow the officer to be shifted in accordance with the command assignment policy should be automatically granted. All assignments would be to a duty responsibility, not merely for orientation.

During this period a commander would be directly responsible for the continued development of those management candidates assigned to his jurisdiction. They will receive primary consideration on all useful additional duty assignments, participate on boards and committees, be made informed assistants in all management matters, and be allowed to participate regularly in such activities as commanders call, staff meetings, unit briefings, and planning councils. These activities would be accomplished in addition to normal assigned duties. Management candidates would be expected to be the most willing and aggressive officers in

the unit. High priority must be given to the candidates' development, the commander to make the allowances necessary to ensure full development. Since these officers will be regularly engaged in activities that may not be within the responsibility of their duty supervisor and their development is a particular responsibility of command, the unit commander would initiate the effectiveness reports and include a mandatory comment indicating the commander's opinion of their capability to assume command.

Each management candidate would be expected to make aggressive effort to advance his experience and capability. The Air Force should provide an information program aimed at keeping candidates interested and informed concerning developments in the management field. Any indication of a decline in interest or performance effectiveness should bring an immediate effort to help the officer overcome the deficiency. If the officer does not react favorably, a factual report would be made to the central authority, which would consider the officer for elimination or direct another action. In this manner those officers who successfully complete the program will be prepared for command.

selection to command

As rapidly as officers selected under this program have reached a satisfactory level of development, they should be appointed to unit command positions. When they are available in sufficient numbers to meet requirements, unit command positions should be assigned only to officers who have successfully completed all requirements of the selection system. This will require that production of candidates be programmed to meet or exceed the total demand. Distribution must consistently provide the candidate to the needing command in advance of the requirement.

To allow the system to achieve optimum results will require elimination of the previously discussed limitations on command appointments, including a blanket waiver from normal personnel assignment policies. All restrictions which interfere with optimum selec-

tion policies must be removed and even present rank requirements considered for modification. Long tradition and certain advantages have led to the general requirement that the commander be the senior officer of the unit. If the management field becomes a recognized specialty and only officers of this field are appointed to command, reconsideration of that requirement may be justified. In line with industry policies, it does not appear essential that the manager be senior to the technicians, the operators, or the supervisors. His authority should be based on legal appointment to command, not on seniority. If removal of rank restrictions would improve management capability at unit level, let us not hesitate to change that policy. All problems affecting the program must be resolved by selecting the course of action that will best contribute to improved management of the unit.

Under this system, selection to command would become an organized, orderly process. Departing commanders would be replaced on a timely basis, even in emergencies, and always with a qualified replacement. The intermediate commander will retain the authority to appoint, but the officer appointed will have been previously selected and prepared by a centrally administered management selection system.

One of the most vitiating factors of the current system is the reliance on individuals to select individuals on the basis of personal judgment. Civilian authorities have long considered selection by this means to be the most ineffective of all systems. To quote one early writer on the subject:

Many corporation executives and others in positions of power are irrational in their attitude toward the selection of men to fill important posts. They operate by their own systems of dead reckoning; they are unobjective, even careless. They follow dark counsels from the depths of their own subconscious, without the slightest suspicion they are doing so.³⁵

A military writer, after researching the subject, makes this conclusion: "Selection on a purely personal basis is the worst method for evaluating potential leaders."³⁶ Personal selection, along with such practices as automatic succession and selection by reference to effectiveness

reports alone, is inefficient and cannot be expected to provide effective leadership in a modern military force.

With these and all other factors considered, a definite timetable of selection actions should be established. To hasten the availability of qualified candidates for command assignment, the program should perhaps initially be open to a wider age group than would be desirable permanently.

THIS ARTICLE has presented an organized approach to the problem of selecting, training, and developing leadership. If accepted, scientific selection and organized development systems will replace the current practice of personal selection and haphazard development. The direct result would be increased effectiveness in the management of Air Force units.

13th Fighter Interceptor Squadron

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WANTED:

College graduates preferably with science or engineering degrees. Age 19-30. Eager to work a minimum of eight hours per day with frequent overtime (payable in psychic income or job satisfaction). Willing to move a minimum of once every four years (with notice) or more frequently (with little or no notice) anywhere in the U.S. or overseas. Good possibility of defense of nationals of other countries at personal risk. Slow promotions in comparison to major competitors. Limited choice of job assignment. Unlimited opportunity for advancement and responsibility (subject to fluctuating quotas) within a hierarchical structure based on seniority.

A NEW ASSESSMENT OF COMMANDER EFFECTIVENESS?

CAPTAIN LYLE D. KAAPKE AND
LIEUTENANT COLONEL RAY W. ALVORD

THE AD above is not a very subtle attempt to describe the negative aspects of an Air Force career. Obviously, no one would write such an ad, with its incongruities and understatements, truths and half-truths. Nor is the appeal for applicants nearly as negative as it could have been. Brigadier General William W. Berg, USAF, Deputy Assistant Secretary (Military Personnel Policy), Department of Defense, has opened a whole new approach to the negative aspects inherent in

a military career under the unique title "fringe liabilities." His list of liabilities includes: no established workday or workweek, high physical standards, job instability and erosion of family life, restrictions on freedom, hazardous occupation, selection up or out, two-career lifetime, marginal living conditions, and duplicate wardrobe.¹

The purpose of this article, however, is not to decry the loss of officer prestige and status as the source of the retention problems that the Air Force has experienced. The literature is becoming saturated with articles of maudlin military self-pity in the style of "Paupers in Uniform" and "We Treat Our Military Shabbily." Even respected civilian advisers have accepted the "swan song" of a supposedly lackluster profession and accentuated and publicized it. A recent report of the Air Training Command Advisory Board asserted:

College undergraduates, and members of society as a whole, no longer consider military careers as significant and challenging professions. The stature of the officer has diminished, the glamour of flying has faded, and the horrors of modern warfare generate similar reactions against anything military. These attitudes are strongest on college campuses.²

Instead of commiserating, we shall pose some vital questions. What factors stimulate officers to seek a career in the Air Force? What action can a commander take to stimulate his best junior officers to seek career status? And, ultimately, what is the Air Force's responsibility to its members to create the type of occupational environment in which positive career stimulus factors really exist?

In the attempt to outline the negative career aspects adequately without slighting their importance, one must consider the following factors. Attacks on fringe benefits, adverse decisions on overpayments and dislocation allowances, loss of combat pay resulting from capture by the enemy, loss of equity in housing because of the closing of bases, low promotion quotas and continuation policies, the persistent battle for a decent wage (with odious comparisons to civil servants), flying requirements and evaluations, budget limitations, certain mission requirements and planning problems, to say

nothing of a "war" in Viet Nam, where men die the same whether their service is entitled military assistance or not—these things all serve to degrade the attractiveness of an Air Force career. Some minor or more mundane (unless you are affected) irritants still exist to stimulate negative attitudes: the requirement for a baccalaureate degree, the struggle (nervous anticipation or anxiety might be more appropriate) for a regular commission, and even the perceived impersonal threat of an unfeeling computer selecting one's next assignment from the Uniform Officer Record.

The question of retention or career motivation at this point might seem rhetorical, for the negative factors seem convincing. Usually something meaningless but sounding very intellectual, playing up the use of popular key words, is interjected at this point. For example: "The *escalation* of personnel problems in the last decade has magnified the problem of retention to the point where it is a manifestation of the attitudes of the larger American culture impinging on the military sub-culture." *The simple uncluttered truth is that 45% of all officers serving a first tour remain beyond their obligated service date* (i.e., beyond the date of completion of the originally obligated tour plus any additional service commitments because of training or educational programs). This statement does not say that 45% of all incoming officers ultimately choose a career in the Air Force but does indicate that 45% are sufficiently motivated or interested to stay beyond the date upon which they might leave. This is truly amazing considering that what has really escalated is our ability to devise and verbalize an apparently unlimited number of negative career factors—not that problems do not exist; we are just becoming more adept at verbalizing them.

The question is not why we cannot attract more career officers but how are we able to attract 45% despite all the negative factors operating in the situation? What could possibly account for this unexpected result? Part of the favorable effect is due to a new approach to the entire problem of career motivation—*participation*. Since World War II, when Lewin, a psychologist, reported the great superiority

of discussion over lecture in changing attitudes, it has been accepted that involvement or participation has many favorable effects in changing attitudes.³ Junior officers are being encouraged to participate in the discussion and solution of career motivation problems. Commanders are stimulating participation through such programs as Junior Officer Councils, Career Motivation Congresses, and various surveys and discussion groups. The concept of participation is somewhat difficult to incorporate into a military organization where discipline and mission accomplishment are primary. However, the concept has been shown to be effective as used in the area of career motivation. Participation, to be an effective technique, must have action or follow-up so that suggestions are acted upon rather than forgotten. Individuals rapidly become disenchanted if they find that there is much discussion and suggestion but no action taken as a result of their participation. Any commander who introduces and encourages participation of junior officers in evaluation of the effect of local policies on career motivation is obligated to take some action on their suggestions. Commanders who feel threatened by the thought of junior officers' evaluating their policies and the commanders' resulting obligation to act on their suggestions forget that participation may have degrees or levels. Keith Davis writing in *Management Review* points out that there are three degrees of participation:

The first is the *mutual-understanding degree*, and its purpose is to help all members understand each other's functions and attitudes so that they will develop better teamwork. They become more self-involved, more creative, and more responsible members. The *advisory degree* is built upon the mutual-understanding degree, because members are hardly ready to give sound advice until they understand the situation. In advisory participation an individual can help make decisions and offer creative suggestions, but he lacks authority to apply his ideas. The leader finally decides the course of action after giving suitable weight to ideas of participants. The *authoritative degree* of participation actually gives the group a degree of power to effect its decision.⁴

The local commander can easily encourage

participation of junior officers in the study of career problems through the use of the advisory degree of participation. This idea is not entirely original, as Headquarters USAF has recently changed the mission of one of its units from the statistical chore of keeping track of various figures on retention to that of a career motivation group to determine the effect of various policies and directives upon the motivation and status of the officer corps. Headquarters is in effect stimulating participation to evaluate the motivational impact of its own policies and directives!

Although participation appears to be worthwhile and effective in its impact upon favorable career attitudes, only limited numbers of officers can take part, and a complete evaluation of the technique is difficult because of the multiplicity of influences, both positive and negative, which occur simultaneously. Also, the fact that the Air Force is retaining 45% of all officers beyond their obligated service date does not mean that those retained are the most highly qualified officers in the total group. Any evaluation of the retention or career motivation program would necessarily have to contain information regarding the *quality* as well as the *quantity* of the officer group retained. It might appear that the quality question could be readily answered, but as yet no ultimate criterion exists to measure it. However, various estimates of the future needs of the Air Force for science and engineering officers exceed the number presently electing to make the Air Force a career.

There are many changes in various indexes which seem, overall, to indicate a broad positive effect of the total factors operating toward a career (one of which is the 45% figure used in the article). One indicator used in the past to estimate positive influence was the total number electing career reserve or regular status. These changes in status are rapidly losing their predictive nature in view of the ease of reversal. The number of resignations has increased as the total number of regular officers has increased, so that the number electing regular status cannot be considered as other than an intermediate indication of career intent. The use of a regular commission as a hedge against

future plans is accepted by many as a fact of Air Force life. The question of quality remains largely unanswered, although it appears that our supply does not match our requirements in certain critical areas such as science and engineering.

The Air Force Systems Command has recently announced that its retention goal is 45% of all science and engineering officers. How can it be done? Evidence suggests that this goal is not at all unrealistic; but how can commands—and, more correctly, commanders exercising commandship rather than just managership—stimulate even greater numbers of selected, career-oriented, young officers to seek career status than we are at present experiencing? There are many methods which are, unlike participation, beyond the control of the commander. A vital key seems to be through greater appeal to job opportunity and job accomplishment.

The authors conducted and analyzed a survey of the career attitudes of 5000 young officers with limited commissioned service.⁷ The analysis of the survey was exceedingly complex, although it did not by any means answer all questions of individual career motivation or intent. One scale that seemed to offer valid and meaningful information on career motivation concerned the importance and possibility of achieving certain rewards or incentives in the Air Force. *Career and noncareer officer groups alike considered many of the rewards to be important, but the disparities occurred in the perception by these groups of the possibility of achieving the rewards as part of an Air Force career.* Career officers perceived a much greater possibility of achieving the following incentives or conditions in the Air Force:

Consistent and intelligent personnel policies

Have a feeling of accomplishment

Be in a competitive situation

Be promoted on the basis of ability

Advance at a fairly rapid rate

Have competent supervisors

Be given recognition for work well done

Do work of which my wife and family can be proud

Have prestige or social status

Keep very busy

Achieve leadership in my field.

Conspicuous by its absence was any significant reference to pay as a major stimulus in career choice. If pay is basically or minimally satisfactory, other incentives such as job accomplishment and career opportunity become much more important. The commander can do little to effect immediate changes in pay or in rank, but he can and must do much to stimulate those below him to feel a sense of worth and accomplishment in what they do. Although there has been much interest and stimulation from the highest level commanders to increase retention, there is evidence that commanders most generally in contact with officers serving initial tours have not been equally effective in stimulating junior officers to seek careers. Some of the most highly qualified and desirable junior officers receive little if any career guidance by supervisors or commanders at the local level. Because of the intense high-level interest, such as that mentioned regarding science and engineering officers in the Air Force Systems Command, methods are being developed for assessing the ability of commanders to stimulate and retain key junior officers.

Industry has long accepted as one of a supervisor's tasks that of counseling and guiding the careers of subordinates so that they are aware of the interest and plans of management for their future utilization. The great numbers of officers commissioned each year since the Korean War have satisfied the Air Force's requirements well, despite a great turnover in personnel. The emphasis *today*, however, is retention not only of a desirable quantity but also of highly qualified officers, despite all the difficulties involved. One cannot deny that the present rate of retention is better than one might reasonably expect, although it is not sufficiently high to allow as wide a choice of career officers as is desired. Although command efforts have been made and some base-level commanders have stimulated career study participation of junior officers, many junior officers still do not receive the career guidance or stimulation necessary to initiate positive

career attitudes. Junior officers, if the salary is perceived as minimally adequate, are influenced more by the possibility of achieving promotion on ability (or job opportunity) in arriving at a career choice than by other factors beyond the scope of the Air Force to supply. In the future commanders will therefore be evaluated more on their ability to retain needed junior officers in career status than they have previously been.

The key to retention, from both a qualitative and quantitative point of view, lies in the ability of the Air Force and every career officer in the Air Force to convince junior officers that the job incentives and rewards they want can be found in the Air Force. The objective, then, must be for every officer to develop the occupational environment which makes these incentives a minimum goal. *We can anticipate little outside assistance in achieving this pur-*

pose. It does seem to be within the capacity of the Air Force, however, to provide for and to emphasize promotion on the basis of ability, work of which one's family can be proud, and similar aspects of its officers' occupation.

Finally, the Air Force through its commanders must work to devise and improve a personnel planning system which will provide greater opportunity on the basis of ability and personnel policies which will be viewed as consistent and intelligent by the officer force. Participation without subsequent action must not result; in other words, action to improve personnel planning, not publicity or indoctrination, is needed. The final result of the effort described—to provide an occupational environment conducive to choosing the Air Force as a career—will be a selective, strong, responsive, and future-oriented Air Force.

6570th Personnel Research Laboratory

Notes

1. "Berg Lists the 'Bad' of Service Life," *Air Force Times*, 17 March 1965.
2. Tenth Report of the Air Training Command Advisory Board, Hq ATC, Randolph AFB, Texas, March 1965, p. 15.
3. K. Lewin, "The Dynamics of Group Action," *Education*

Leadership 1943, ed. Dr. Robert R. Leeper (Washington, D.C.: National Education Association, Vol. I, 1944), pp. 195-200.

4. K. Davis, "Management by Participation," *Management Review*, Vol. 46, No. 2 (February 1957), pp. 69-79.

5. L. Kaapke, E. Tupes, and R. Alvord, "A Multiple-Linear Regression Analysis of Officer Career Attitudes," in press.

The *Air University Review* announces with regret that Major Philip E. Neale, Jr., author of "The VTOL Flight-Test Challenge" which appeared in the September-October 1965 issue of the *Review*, was killed in France on 8 September 1965 while running a USAF evaluation of the Dassault Balzac V-001 VTOL jet-lift research aircraft.

Military Affairs Abroad



THE DEVELOPMENT OF ROKAF AS A MATURE INSTRUMENT OF PEACE

MAJOR GENERAL CHANG, CHI RYANG
Vice Chief of Staff, ROKAF

THE Republic of Korea Air Force (ROKAF) recently celebrated its fifteenth anniversary as an independent air force. Since its inception in 1949, ROKAF has grown and developed into a modern and powerful tactical organization, a sophisticated air arm primarily concerned with maintaining a combat-ready capability. Its story is an impressive one, highlighted by a colorful history and meaningful growth and evolution.

After the conclusion of World War II, seven Korean aviators returned from abroad and prompted the establishment of an air force. As the initial cadre in the creation of this air arm, these senior aviators entered the Korean Army Infantry School on 1 April 1948. They were assigned to the Army Air Corps, which was renamed the Army Air Base Command three months later. The historic beginning of flight training began on 15 September 1948 when 10 L-4 and 10 L-5 aircraft were introduced to the command, which at that time consisted of a flying training unit and a flying base unit.

On 1 October 1949 the Republic of Korea Air Force was officially created when the Air Base Command was separated from the Korean Army. On 14 May 1950, shortly before the outbreak of the Korean War, ROKAF purchased 10 T-6 trainers from Canada with donations from the Korean populace. These aircraft were nicknamed "Keon Kook Ho," which means "Founding of the Nation."

When the North Korean Communists launched their attack on 25 June 1950, the fledgling ROKAF without any fighter aircraft was seriously handicapped. Through the early days of conflict ROKAF pilots displayed unusual courage in weakening the invasion forces. They flew unarmed aircraft on reconnaissance missions and dropped homemade bombs by hand on advancing Communist forces. It was in the midst of such national crisis that ROKAF was supplied with 10 F-51 Mustang fighter aircraft from the United States.

In July 1950 these Mustangs were ferried from Japan to Korea. Major Dean E. Hess, now Colonel,

with 4 officers and 100 airmen arrived shortly thereafter. They formed an organization called the 6146th Air Base Unit, which was given the primary mission of training ROKAF pilots in the use of F-51's. Many ROKAF pilots flew combat missions with only three days of familiarization training at Itazuke AB, Japan. During the three years of hostilities ROKAF flew more than 8000 sorties, and their distinguished record drew numerous praises from other member nations of the United Nations forces. Thirty-nine ROKAF pilots were credited with more than 100 missions each. By July 1953 the ROKAF aircraft inventory had grown to 80 F-51's, which formed the 10th Fighter Wing, and over 14,000 personnel.

On 27 July 1953, after many months of armistice negotiations, a truce was signed at Panmunjom between the North Korean Communists and the United Nations. Under the armistice agreement North and South Korea are separated by a neutral zone or "no-man's land" called the Demilitarized Zone (DMZ), which bisects the Korean peninsula north of the 38th parallel. In the exact center of the DMZ is a demarcation line. Forces of both sides were withdrawn 1½ miles from this line and are there today.

The Communists, in violation of the armistice agreement, have continually strengthened their forces with modern weapons and pose a constant threat from their side of the DMZ. To meet this threat, U.N. forces also equipped themselves with modern weaponry. The armistice agreement is still actively debated and enforced by members of the United Nations Command Military Armistice Commission (UNCMAC), which has its headquarters in Panmunjom. Nearly 500 armistice meetings have been held at Panmunjom between the Commission and Communist representatives of the Korean Peoples Army (KPA) and the Chinese People's Volunteers (CPV).

With the war over and the nation divided and vastly damaged, ROKAF turned its attention to a program of expansion, education, and modernization. Its major goal was the development of a jet tactical air force. With this high objective, budgetary limitations became a primary consideration. Authorities in the Korean government and the United States, under the Military Assistance Program (MAP), soon agreed to support ROKAF's goal of upgraded and modern weaponry and the concurrent training required. On 15 September 1954,

30 combat pilots were sent to the U.S. for jet transition training as a first step in the modernization program. In late 1954 ROKAF personnel were dispatched to the U.S. and Japan for radar operation and jet maintenance training, and in December of the same year jet transition training was transferred to ROKAF along with 10 T-33 trainer aircraft. This led to the formation of the 5th Composite Wing, followed closely by activation of the Air Communications Wing, which integrated all communications activities. In 1956 ROKAF formed its first jet fighter wing, the 10th, followed shortly by establishment of the Technical Training Wing. In February 1957 all F-51's were released from active service when a squadron of F-86F's arrived and were added to the inventory. In July of the same year the aircraft maintenance and supply depots were established. In 1958 the USAF transferred complete control of the aircraft control and warning (ACW) system to ROKAF, and the 11th Fighter Wing was established as more F-86's arrived. Finally, on 1 September 1964, the 1st Fighter Wing was established. (See ROKAF organizational chart of 1 September 1964.)

present ROKAF organization

Within the government framework, ROKAF comes directly under control of the ROK Ministry of National Defense. Operationally, however, ROKAF is subordinate to the Commander, Air Forces Korea, who is also the Commander, USAF 314th Air Division. The Commander AFK is, in turn, subordinate to the Commander in Chief, United Nations Command.

ROKAF is internally broken down into a headquarters and subordinate units, which are divided into tactical and support divisions, the latter including logistics, training, communications, and medical organizations. The tactical fighter wings are structured almost identically along the lines used by USAF Tactical Air Command wings.

mission and functions

Basically, ROKAF has a sixfold mission, to provide air defense, tactical operations, reconnaissance, airlift for ground and air forces, air rescue, and air traffic control. The primary mission is air defense. Within this mission, all bases with jet aircraft

maintain a constant 24-hour alert posture.

In order to accomplish its missions, ROKAF must successfully perform five basic functions: (1) to provide command and administration at an air force level; (2) to plan and conduct the operation of a tactical air force which includes tactical day-fighter, all-weather interceptor, reconnaissance, transport, and rescue aircraft; (3) to conduct both technical and flying training; (4) to maintain a logistical complex which will support a small but

highly dispersed force; and (5) to maintain a highly efficient and flexible ACW complex.

North Korean Air Force

Some basic information on the Communist North Korean Air Force may prove beneficial in our later discussion and interpretation of the current status of the Republic of Korea Air Force.

The NKAFF has a current aircraft strength of



One of ROKAF's early aircraft, the L-5



F-51 Mustangs assembling in formation during the Korean War

approximately 700, divided into jet fighter divisions, a jet bomber regiment, a jet reconnaissance bomber regiment, and other support flying units. Included are about 500 Mig-15's and Mig-17's, a small number of supersonic fighters, less than 100 Il-28 twin-jet light bombers, and approximately 100 miscellaneous support-mission aircraft including jet trainers.

About 20 air bases, including more than 10 capable of conducting combat operations, several reserve bases, and a few civil airports, are maintained. Of a total manpower strength of roughly over 30,000 personnel, more than 1000 are combat pilots. The NCAF air control and warning network consists of its master control center, a local control center, early warning/interceptor control sites, division control centers at fighter division headquarters level, and surveillance and early-warning sites generally deployed along the North Korean coastline.

ROKAF manpower

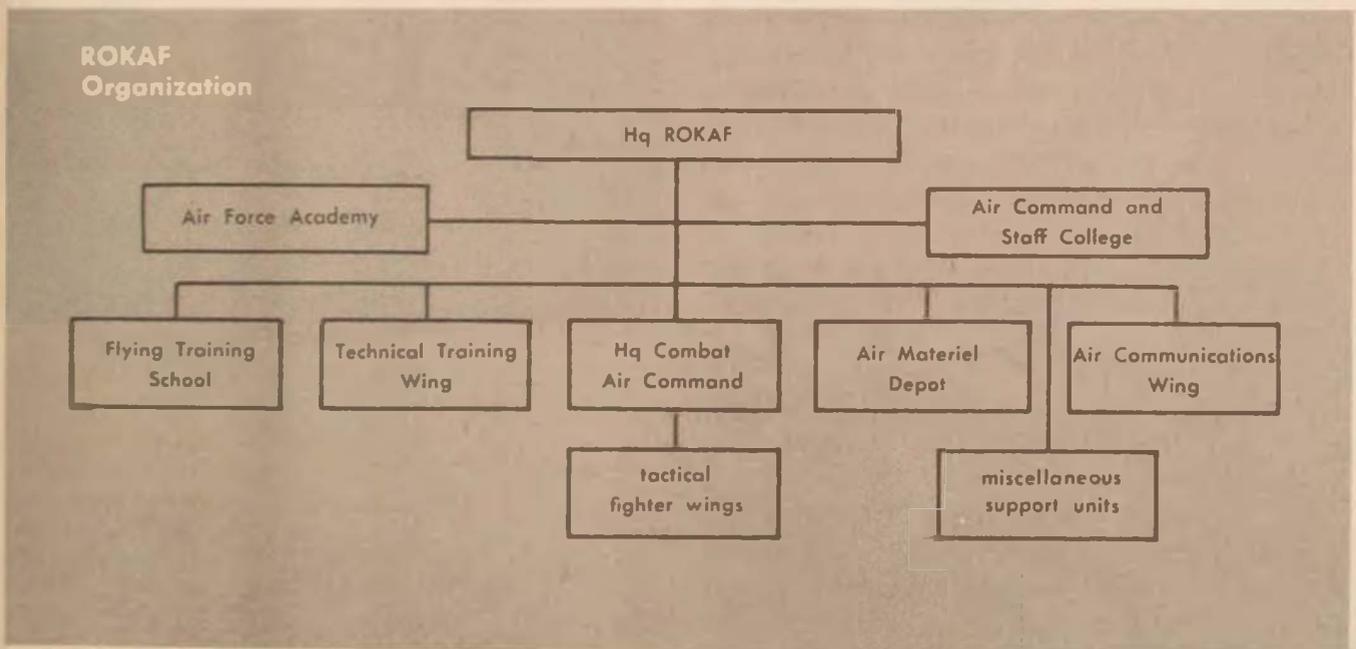
ROKAF maintains a total manpower strength of more than 20,000 active duty personnel, including more than 500 combat pilots and 3000 other officers. Of about 20,000 enlisted personnel, the ratio of airmen to NCO's is almost two to one.

Officers are classified into over 20 different career fields, including seven direct combat support categories such as aircraft maintenance, communications and electronics, and radar control and maintenance. There are approximately 10 miscellaneous support specialties for officers, including personnel, administrative services, comptroller, and supply.

Airmen and NCO personnel are grouped into more than 36 AFSC's, which are divided into two general functions, technical support and general services. Personnel in the tech support function are assigned as specialists in such fields as aircraft maintenance, armament, communications, radar operations and maintenance, weather service, etc. General services enlisted men are assigned to personnel, administrative services, supply, etc.

The minimum service commitment for officers and NCO's is four years; airmen are enlisted for three-year periods with ample opportunity for reenlistment. In certain instances officers and NCO's can voluntarily extend their service commitment by ten years, but they must have served a minimum of four years and must express career desire before becoming eligible for this career type of program.

ROKAF personnel are recompensed under the same pay scale used for all ROK armed services. Compared with military pay scales of the U.S. and



other Western countries, ROK military salaries are exceedingly low, especially in the enlisted ranks. All enlisted personnel below the rank of staff sergeant receive subsistence, quarters, and uniform issue.

Flight pay is divided into three categories: jet aircraft pilot, propeller aircraft pilot, and light aircraft pilot or other crew member. A captain flying F-86's receives \$17 flight pay each month; if he flies a C-46 he receives \$13, and if he flies an L-4 or is a C-46 crew member he is compensated with the equivalent of \$6 monthly. A staff sergeant crew member receives \$3 flight pay monthly.

ROKAF bases and aircraft

Currently ROKAF operates several modern jet bases, and an additional one is nearing completion. A few reserve bases with expansion capabilities and several airfields capable of limited combat operations supplement them. These facilities are primarily maintained for ROKAF's tactical forces; however, they will play an important role in the event U.S. air units should have to respond to resumption of hostilities. The bases are also used for combat cargo and troop carrier operations.

ROKAF is presently equipped with the following types of aircraft, purchased and supported by the Military Assistance Program (MAP): F-86F's, F-86D's, RF-86F's, T-33's, C-46D's, and H-19's. In the spring of 1965 a new fighter aircraft, the F-5A, was added to the inventory. The F-5 is a versatile, twin-engine, supersonic jet fighter supplied through the MAP to Korea and other countries participating with the U.S. in the Mutual Security Program. The present F-86 squadrons, organized into several fighter wings, are outnumbered approximately three to one by the North Korean Air Force.

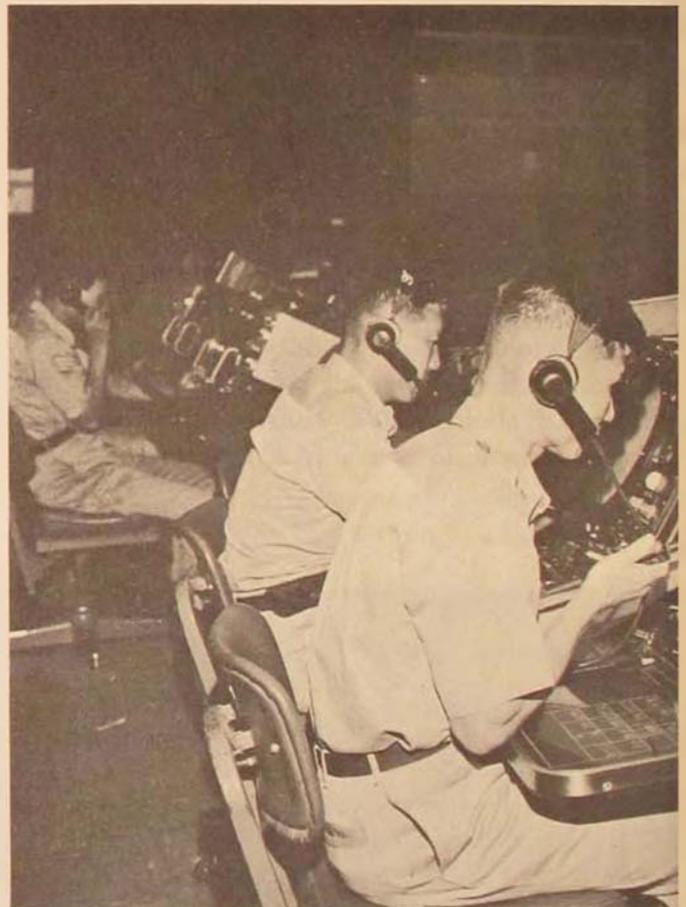
tactical operations

The ROKAF fighter wings, consisting of about three squadrons each, the ACW Wing, the Air Transport Group, the Tactical Reconnaissance Squadron, and a rescue squadron comprise the Combat Air Command located at USAF's Osan Air Base. This command exercises operational control over all elements in the tactical complex. ROKAF follows the dispersal principle wherever possible,

and all fighter squadrons maintain a combat-ready posture. In addition, fighter and flying training squadrons maintain combat-ready capabilities, and even the T-28 squadron is prepared for a secondary "mosquito mission" if necessary.

These fighter wings are organized according to the same principles as USAF tactical wings, including their structure and mission. Tactical squadrons are annually tested in joint USAF/ROKAF air defense exercises. Rapid progress was displayed in

Mission



ROKAF controllers at ACW site

1964 as ROKAF interceptor pilots registered an 81 percent rate of effective neutralization (kill rate) as opposed to a 62 percent rate in 1963.

aircraft in-commission and accident rates

During 1964 ROKAF constantly maintained an aircraft in-commission rate above 75 percent. This figure represents an average for all jet and prop aircraft in the inventory. The rate for jet aircraft has

at times dropped lower than 75 percent because of limited supply of F-86 parts and accessories. Many F-86 parts are in limited production in the U.S., and a few are out of production, making necessary in-country fabrication of parts.

The aircraft accident rate (number of accidents per 100,000 flying hours) for ROKAF is perhaps the best index to their improved flying proficiency. From the 1958 and 1959 rates of 40 and 46 respectively, the rate was drastically reduced to an all-



... ROKAF pilots scrambling at start of a practice alert



... flight of ROKAF F-86D's

... C-46 engine overhaul performed at the ROKAF Air Materiel Depot, Taegu Air Base, Korea



time low of 8.2 in 1962 and leveled off at 15.2 and 11.5 during 1963 and 1964. This sharp improvement can be directly attributed to the increased attention devoted to flying safety through intensive and effective implementation of safety policies. ROKAF's outstanding record of flying safety improvement is even more notable in that total flying time has steadily increased since 1958.

education and training

The education and training program within ROKAF is implemented to maintain the highest degree of combat readiness possible. Within the organizational framework there are three areas of concentration: the Air Technical Training Wing, which also includes basic military training, the Air Force Academy, and the Command and Staff College. Courses are effectively conducted at these institutions with the help of USAF manuals and curriculum guides. Most instructors have become qualified through instructor courses given within the Pacific Air Force or in the U.S.

Perhaps the most progressive military education programs in the Far East are conducted at the Republic of Korea's Air Force Academy and Command and Staff College. The mission of the Academy is to provide each cadet with the knowledge, character, and physical strength essential to his progressive development as a career officer and future air commander. To accomplish its mission, the Academy's organizational structure and curriculum are patterned very closely after those of the USAF Academy. Cadets pursue a four-year curriculum leading to a B.S. degree and a commission as a second lieutenant in ROKAF. There is no flying training in the curriculum; however, each cadet receives ten hours of familiarization flying. Sixty-five percent of all Academy courses are academic in nature, featuring the humanities, social sciences, basic sciences, and applied sciences. The airmanship program makes up the remaining 35 percent, with stress placed upon military studies and physical education.

The Command and Staff College, although located on the Academy campus, is a separate entity. It consists of the Command and Staff Course, Squadron Officers Course, Air Ground Operations School, and Forward Air Controller School. The college conducts limited research on the general

subject of employment of air power and is responsible for the ROKAF Central Library.

logistics

In 1961 the ROKAF aircraft maintenance depot and the supply depot were consolidated to form the Air Materiel Depot (AMD), located at one of ROKAF's bases in the south. This relocation to a modern and complete facility resulted in considerable savings in manpower and overhead. It also provided ROKAF with a depot organization paralleling the traditional USAF organization, but on a much smaller scale.

The AMD is one of the most modern and complete in the Far East and in addition to performing maintenance on aircraft and equipment is the storage point for over 77,000 line items. Highly trained mechanics at this facility have the capability of completely overhauling a variety of aircraft from L-19's and C-46's to the F-86 series. The repair capabilities are so complete that U.S. armed forces aircraft and helicopters are contracted to the depot for maintenance. During 1964 the depot reached a major goal in establishing the capability for major aircraft modification.

Supply activities within ROKAF are rapidly approaching self-sufficiency. In spite of inadequate storage facilities at most installations, a well-

Since introduction of F-5 aircraft into the ROKAF on 30 April 1965, USAF pilots are assisting in transition training at Suwon AB, Korea. The F-5 is replacing the F-86.

ROKAF Academy cadets in parade review formation



organized system is established for requisitioning, receiving, transporting, and distributing supplies. Supply procedures are guided closely by patterns set forth in USAF manuals and standards of inspection. A transceiver system now in operation enables the AMD to requisition via telephone directly to the USAF depot in Sacramento, California.

aircraft control and warning system

As noted earlier, the first and most important mission of ROKAF is air defense. The ROKAF ACW net must function perfectly in conjunction with other defense agencies in the Pacific area for maxi-

imum safety and timely response to enemy attack. ROKAF is an integral part of Far East air defense.

ROKAF ACW sites are scattered throughout the peninsula and on offshore islands. This radar network is capable of early warning and is constantly used in ground-controlled interception exercises. All tactical fighter aircraft are controlled by a master direction center, and the battle staff of the Air Defense Control Center controls all air defense units in Korea within the established rules of engagement. In addition, an air operations center directs ROKAF counterair and interdiction operations and also controls such missions as close air support, aerial reconnaissance, and air rescue.



communications

ROKAF's tactical communications complex presently consists of VHF radio relays operated and maintained by the Eighth U.S. Army and a few troposcatter links and microwave links operated and maintained by ROKAF. The first tropo links and microwave links were completed and turned over to ROKAF in December 1963, and the last link was completed and turned over in July 1964; however, technical advice and assistance in operation and maintenance are being provided by the USAF Advisory Group and MAP.

Concurrent with construction and activation of new radar sites programed, additional troposcatter and microwave communications will be provided in the near future. These additional links will provide a completely integrated ACV point-to-point communications system. It will be operated and maintained by ROKAF, and only one small link will remain on the Eighth U.S. Army's microwave system.

1964: a long step forward

During the calendar year 1964 ROKAF made many notable advancements. Among the most important were the establishment of a new tactical fighter wing and the assumption of operational responsibility for a complete troposcatter communications system.

Through an upgraded and more highly diversified training program, ROKAF developed in-country training in highly sophisticated and technical fields. For example, ROKAF now possesses the capability to train personnel for positions in its new Precision Measurement Equipment Laboratory (PMEL). Previous to 1964 all electronics personnel were trained at USAF bases in Japan.

The year 1964 also marked completion of several long-planned-for facilities: a \$4.5-million runway constructed at an air base in the southern part of the country; a \$2.3-million runway at an air base near Seoul which replaced an older facility; and a complete and modern aeromedical center costing \$323,000. In addition to a large 110-bed hospital with surgical facilities, an X-ray laboratory, and dental clinic, the new facility includes a physio-

logical training building containing a rapid-decompression high-altitude chamber.

Today ROKAF possesses an alert, modern, and progressive tactical force—a force which has been developed despite insufficiencies in budget appropriations received and scarcity of natural resources; a force which is constantly prepared to meet a foe that far outnumbers it both in size and firepower. ROKAF's success in developing this sophisticated air arm would not have been possible without advice and assistance provided by the 6146th Air Force Advisory Group and material and financial support provided by the Military Assistance Program of the United States. However, ROKAF's most stable and cohesive force has been the spirit of its members, intensified by the omnipresent lessons learned from the Korean War. These lessons are ROKAF's heritage, but most members view them as an endowment.

lessons learned from the Korean War

The Korean War provided ROKAF many practical lessons on basic air force doctrine, organization, combat procedures, and techniques of management. It also evoked these two emotional, although vital, axioms:

- Patriotism, passion, and honor of airmanship can overcome inadequate equipment, facilities, and salaries.
- Pride and determination can be the influencing forces when the call of duty requires a twofold mission of flying combat and training sorties concurrently.

Finally, there are two principles that have deeply permeated the attitude of all ROKAF personnel:

- At all times we must seek to apply basic USAF doctrines, which are born of experience, to the operation and management of ROKAF, with appropriate modification as circumstances dictate.
- We must continually advocate the strengthening of ROKAF, within the boundaries of economic conditions, in order to match the growth and power of the North Korean Air Force.

Republic of Korea Air Force

ORGANIZATIONAL INTEGRATION

Key to the Military Application of Computer Technology

COLONEL HAROLD R. JOHNSON

IN THE period since 1950 the use of digital computers within the Air Force has grown from a hazy concept of the potential of the early Whirlwind I computer to a complex of over 500 modern stored-program computer systems. The application of computer technology to the military art within such a short span of time has generated many problems and symptoms of problems that have been extremely difficult to isolate and correct.

In the initial stages of applying computer technology to military problems, the Air Force relied almost entirely upon outside contractors, largely nonprofit, to carry out project management, system design, and programming. For reasons of cost, control, development of military doctrine, and the growing number of applications for computer technology, it is now clear that the Air Force cannot in the future continue to depend upon outside programming talent. The application techniques for this important new element of military command, planning, management, and control must become a part of the generalized military staff skills.

Since 1961 there has been increasing concern at all levels regarding the approach taken to the system planning and programming of military information systems. The Department of Defense and the military departments have sponsored or encouraged a number of studies and investigations into the problem. Most of the studies have been carried out by programming or system-planning organizations that are not a part of the military hierarchy. It is difficult if not impossible for such planning groups to appreciate fully the very high degree of communication and control efficiency that has been built up over thousands of years of military organizational development. The military had a well-established foundation of knowledge in the area of organization and information systems long before modern business realized the importance of organization and administration to effective internal communication and control. In the application of computer technology to military purposes, we must conserve and preserve the foundations of organizational strength that form the base of current military power. Computer technology

hopefully will permit us to build from this base to higher levels of efficiency.

Let us examine the question of military application of computer technology from the viewpoint of organizational integration. In this light, the skills of the data-system designer and programmer are seen as a necessary adjunct of most military staff and command specialties, and the data-processing area as a tool of military management rather than the management system itself. Much more work needs to be done to cast computer technology finally in its proper light vis-à-vis military organization, traditions, and training. There is, however, enough evidence now at hand to point the way towards better approaches to the exploitation of computer technology.

*computer technology: new element
in military command, planning,
management, and control*

During the past ten years there has been an explosive growth in information technology. During this same decade our military establishment has grown to be a 50 billion-dollar-a-year enterprise. Weapons lethality has been increased by orders of magnitude; weapons-delivery times have been reduced by orders of magnitude. Our main adversary has developed his military forces to about the same size and degree of proficiency. Weapons systems have become more and more diverse, yet we still maintain all of the types that were used during World War II. We have added many new types. Weapons systems have become much more complex, automatic, difficult to understand.¹

Beginning about 1950 the U.S. Air Force and the military in general began to see dimly the outlines of a new element of military command, planning, management, and control. The vision grew out of the technical evaluations and projections that were carried out in the early 1950's in connection with the urgent air defense studies that had been launched to find a counter to the Soviet nuclear threat. These studies generated the development of a whole new family of defensive weapons, encompassing the new century series of fighters; surface-to-air missile systems, such as Bomarc and

Nike; and sensor systems, such as the distant early-warning (DEW) line and long-range control radars. It quickly became apparent that a better system of assessing the surveillance picture and managing the air defense resources would be needed to keep pace with the speed and complexity of new weapons.²

The high-speed digital computer, which has provided the basic new element in military information technology, developed as a result of the so-called "Cape Cod" system of semi-automatic air defense tracking and interceptor control. The Whirlwind digital computer proved dramatically that high-speed electronic communication and logic could be applied directly to the highly complex problems associated with air defense.

By 1955, when the pioneering efforts at Cape Cod had been completed, there was a ground swell of planning activity at all levels of the Air Force, directed at finding new applications for computer technology. The general approach during the period that followed is well described by Ruth M. Davis in a recent paper on military information systems design.

The eras can be named so as to be self-explanatory as:

1. The "Hardware" Era: 1953-57
2. The "Damn the User—Full Speed Ahead" Era: 1957-60
3. The "Don't Make a Move Without Calling Everyone" Era: 1960-63

The first era, as the name implies, was dominated by the engineer and the concept that hardware is the key to a successful system. System-development schedules were synonymous with equipment-delivery schedules, and system reliability was ensured by the duplication of equipment. It was the period of nascentcy for the systems analyst, programmer, and systems designer, all of whom suddenly arose around 1957 and started the second era by simultaneously decrying the hardware approach and proclaiming the need for study, analysis, programming, and a well-thought-out system design.

During the second era, operational delivery dates were revised to reflect study, analysis, programming, and documentation times. Most of these endeavors were carried out under the auspices of military technical offices utilizing

the services of industrial system contractors or government-supervised civilian technical groups. The most characteristic feature of this era was the lack of user participation in the design of his systems. During this three-year period, users were occasionally invited to contractors' plants for briefings on the status of their systems; they were informed of changes in operational delivery dates and the like. However, the reins were firmly in the hands of the system designers—both at the administrative and at the production level.

In the third era the user was given more control in the system-design process. In fact, the responsibility for system design was so diffused during this period and the decision-making process involved in system design became so complicated that the system designers were unable to develop the very systems that had been requested for aiding the military in its decision-making process. This diffusion of responsibility has been reflected in the establishment of one organization after another at successive administrative levels, each organization biting off a small chunk of responsibility for system development. Such a trend appears to be a natural outgrowth of a situation in which a new field has overreached itself in its implementation and application of an extremely meager store of accepted and demonstrable concepts and techniques.²

In spite of this rather uncoordinated and hectic evolution, the USAF inventory of stored-program computer systems as of 30 June 1964 was 106 Government-owned systems and 451 leased systems, exclusive of the SAGE and AUTODIN programs.¹ With equipment from the latter two systems included, the total inventory runs very close to 600 major computer systems.

The range of computer applications within the Air Force extends into almost every field of military command and staff activity. Command, personnel, intelligence, logistics, communications, meteorology, transportation, research and development plans, war planning, and a host of other specialized functions all have found application for computer systems. Of the various applications, the material field currently represents the major concentration of effort, 52.7 percent. The remainder is divided among research and development, 13.9 percent; operations and intelligence, 13.2 percent;

finance, 7.2 percent; personnel, 6.4 percent; and others, 6.6 percent. The most challenging application, however, lies in the area of military command and control.

Almost without exception the Air Force has used contract support to accomplish the system designing, programing, and coding necessary to place in operation the computer systems now in inventory. This same pattern has been followed by a large portion of the aerospace and defense industry, and to a degree by the other military departments.³ In the early days of computer technology only a very few scientists and engineers were competent or knowledgeable in the programing art. Computer programing was in a very real sense a research and development undertaking comparable to hardware development. The not-for-profit corporations created by the Air Force originally for SAGE support, and later extended to most other information systems, have provided a valuable bridge into the world of computer-aided military staff and command systems. Now, however, with the beachhead well established, it is essential that the Air Force regroup and create a more efficient and broadly based organizational structure to guide future applications.

the problems of cost and context

Management's growing concern with economic aspects of programming is shared by the Department of Defense (DOD), the customer for large computer programs used in command and control. DOD's Director of Defense Research and Engineering (DDR&E) has established a policy of reviewing the cost of research and development efforts. Apparently, computer programs have been identified specifically by DDR&E as a cost element to be monitored in command and control system development. Similar interest in computer-program costs is being manifested by the Air Force Systems Command, which has initiated studies whose goals are to reduce the costs of computer program production.⁴

The problem of computer programing costs should be viewed from two somewhat diverse

³The U.S. Naval Command Systems Support Activity, Washington, D.C., is a notable exception. The staff of this activity is largely military or career Civil Service.

aspects. In the first instance it is clear that the computer programming and generalized software costs are significantly out of line with the hardware and installation aspects of computer technology. The continuing high cost of the initial programs and of program maintenance is in some ways limiting computer applications and is sharply restricting the flexibility of installed systems. Some data are now becoming available as a result of work being done by Systems Development Corporation⁶ and others,⁷ which give promise of improving management and cost control techniques for computer programming organizations. In general, it appears that the strict application of traditional management practices will go a long way in improving both the cost and quality picture. Adequate work planning, strict control of delegated functions, precise objectives, and control measures are all appearing more frequently as standard management tools in the production of programs.

Perhaps the most important aspect of contract program production is the fact that high costs and loose management have drawn the attention of high officials to a more basic problem, that of context validity in computer programs. By its very nature the computer program is designed to embody to the maximum degree possible the policies and operating procedures of the military commander or unit being served. Experience has shown that the most glaring deficiency in the current contract solution to the programming problem is the nearly impossible task of conveying the military context of command to a programmer who is external to the staff. This fact should have been apparent from the outset, but it has only recently been clearly described as a result of studies by Dr. Fred Thompson:

Neither the various resources available to a commander nor the detailed actions implied by his assigned mission can be provided to him all worked out and in place. He must bring his resources and requirements into a coherent plan; he must develop his context of command. Context development, the development of an acceptable overall view of the situation and a plan of action, involves a number of activities of gathering and organizing information. Primarily, however, it involves the weaving and

reweaving of the plan, the assessment and re-assessment of the situation, the development and testing of alternate courses of action, the assimilation of new evidence, and the resulting evolution both of what should be done and what can be done. The result is the command context through which the commander coordinates his resources in the accomplishment of his mission.⁸

The importance and complexity of the military commander's context seem much more apparent in the light of Dr. Thompson's studies. There have been equally accurate judgments made on this within the military. In considering the problem, Air Force Lieutenant Colonel Rex Jackson of NORAD noted recently:

It is difficult to visualize a situation where complete and undistorted operational parameters, experiences, judgments, weapons characteristics, etc., can be intelligently communicated to a professional programmer through a few interviews and review of documents over a short period of time. This type of cramming can only lead to errors of commission, omission, deduction, and translation. Remember that the perfectly obvious to the trained and experienced operator is completely foreign, hidden or obscure to one who is completely naive in the operations world.⁹

The problem associated with transferring military background and expertise to the computer programmer is not a new one, nor are the symptoms unrecognized. The fact is that for some time the basic difficulty was misdiagnosed and thought to be susceptible to correction through improvements in contractor management technique and other standard measures. The recommendations quoted below are typical of those presented in numerous contract studies.

More standardization of vocabulary to enable comparison of different programming jobs, with special emphasis on activities, resources, requirements, programming tools, program tests, documentation, budgets, and schedules;

Research to improve definition of activities, functions, and products and to qualify the product;

Development of performance measures to help management plan during the course of the work and to permit comparison with other jobs;

Collection of detailed activity and product-related costs data to serve for planning and estimating costs of current changes and new work; and

Development of policies and procedures for applying accumulated knowledge to future programming efforts.¹⁰

While these remedies are all no doubt worthwhile, they fail to identify the root of the problem. The professional skill of the military commander and his staff cannot be transferred to a programmer during a brief interview or by reference to a few SOP's and operational guides. To attempt to do so is to invite a recurrence of the difficulties that have plagued us since the early days of the SAGE program, when, in Colonel Jackson's words, "professional programmers programmed intercept tactics and maneuvers which did not consider the flight characteristics of the aircraft. . . operations and management programs should be written by operations and management trained people."¹¹

the integrated organization

The business manager will have to bring these individual, often diverse, functions into an integrated organized system, with all the parts working toward the common organizational goal. With increasing specialization, size, and complexities, the demands for application of the systems concept to the organizing function have increased rapidly over the past few decades and will be of even greater importance in the future.¹²

During the past 10 to 15 years many abortive efforts have been made to gain the fruits of computer technology via the contract route. All have failed. The Air Force must now face the realization that there is no easy road to the Utopia of the total information system. We must fall back, regroup, draw new strength from our own internal reserves, and proceed towards an integrated Air Force organization that will accommodate both our strong foundation of military experience and the new computer technology. We must continue to remain expert in the human aspects of command, morale, leadership, and military organization. In addition we must learn for ourselves the new skills

that will make it possible to use effectively the capacities for computation, logic, and information storage/retrieval that computer technology can provide.

The initiative and impetus for the integration of computer technology will have to come from within the Air Force. It is our own management problem, and it must be faced and solved internally.

There are clear indications that the complexity of the programming task may decrease drastically with a corresponding increase in computer flexibility within the next decade or so. Mr. W. H. Ware, RAND Corp., Dr. F. B. Thompson, Dr. J. C. R. Licklider, Mr. C. A. Zraket, and many other leaders in the field of military information systems are working toward a whole new concept of computer technology.

This effort may well prove to be the real key to the integrated staff approach. Dr. Fred Thompson outlined the potential in this area as follows:

Can't the staff be given the capabilities of the computer in following the intricate interactions that they see clearly step by step but that are made unmanageable by the multitude of these steps? There already exist general-purpose models that were intentionally built to simulate the context of the staff. However, the staff itself should be given the capability to build and modify such models at will. The notions of recursive building of subroutine on subroutine, of interrogation of computers in English syntax, of multiple access, of direct computer control, and of list-processing techniques for easy file organization are all within our experience. Although there is much work to be done, the ideas of man-computer symbiosis, so lucidly discussed by Licklider, . . . await no technological breakthrough. An integrated capability built around these lines would be of inestimable value to the military staff.¹³

There are probably a great number of organizational innovations that could be applied with success to the problem of integrating computer technology into the Air Force. It is perhaps useful to note some of the more important lessons that have been learned in our experience to date and let these serve as principles for future organizational efforts:

- We must protect and nurture the foundations of organizational efficiency upon which the military hierarchy of today is based.

- We must provide for the direct participation of the commander and the staff in developing and dynamically maintaining the context of command.

- These principles effectively preclude depending upon any outside agency for systems design or programming. They likewise preclude any staff compartmentalization of programming talent within the Air Force.

- The skills of the military information system designer and programmer are a necessary adjunct of most Air Force staff and command specialties. Computer technology is a tool of management rather than a management system in itself.

- The function of programmer—codes should not be confused with that of the system designer and programmer which we have dis-

cussed. The present Air Training Command product in the 68000 career field adequately meets this requirement.

- The military command hierarchy is, by design, redundant, to provide the great flexibility and survivability essential to combat. The integration of computer technology into the organization must take account of this feature.¹⁴

- Computer technology must reinforce the unity and cohesiveness of the military staff rather than fragment and divide it.

- Finally, we must recognize that the integration of computer technology into the organizational structure of the Air Force is a major undertaking that will require priority effort over the next several years. Unfortunately our many false starts in this field have cost us valuable time, and we must now move very quickly if we are to keep reasonable pace with technology.

Industrial College of the Armed Forces

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OBJECTIVES IN FUTURE STRATEGIC WAR

National Military Policy Goals and Controlled Conflict

LIEUTENANT COLONEL HAROLD L. HITCHENS

IN HIS statement before the House Armed Services Committee on the future defense program and the military budget for fiscal year 1966, the Secretary of Defense set forth two strategic objectives of our general nuclear war forces:

- 1) To deter a deliberate nuclear attack upon the United States and its allies by maintaining a clear and convincing capability to inflict unacceptable damage on an attacker, even were that attacker to strike first; 2) In the event such a war should nevertheless occur, to limit damage to our populations and industrial capacities.

The first of these tasks the Secretary designated as "assured destruction," and he defined it as the capability to destroy the aggressor as a viable society—even after a well planned and executed surprise attack on our forces. The other task, "damage limitation," was defined as the capability to reduce the weight of the enemy attack by both offensive and defensive measures and to provide a degree of protection

for the population against the effects of nuclear detonations.

The specific nature of the tasks thus assigned our strategic forces suggests that it might be wise to examine them within the overall framework of our national military policy goals. These goals have developed largely because of the catastrophic potential of modern total war. To make it as unlikely as possible, those interested in our national security have striven to develop all sorts of devices and procedures designed to improve the responsiveness of the military instrument and to enable it to carry out a whole range of national objectives. Among these, deterrence of conflict is probably most important, but if a crisis should develop there will be a great need for ability to provide "multiple options," "controlled responses," "negotiation thresholds," and many others.

These concepts have become the embodiment of our military policy goals, and strategy

and force posture have no other function than to contribute to their attainment. Official documents, speeches, presentations to Congress, and individual policy pronouncements and directives of major figures of the Government clearly indicate that the nation's military resources are to be utilized only in a manner that will demonstrate control, selectivity, limitation, and discrimination.

The terminology describing our military goals was set forth by Air Force Project Forecast in 1963, and in January 1964 the Secretary of the Air Force listed them in terms that stress the concept of control and versatile power:

- *deterrence*
- *arms control*
- *crisis management*
- *multiple options*
- *controlled response*
- *damage limitation*
- *negotiation thresholds*
- *war termination*

In spite of the terminology and intent of these national military policy goals, there is a common tendency to think about only two kinds of conflict—conventional war at the lower end of the spectrum and all-out nuclear war of annihilation at the other end. With respect to the latter, there are few goals that apply, for, by definition, such a conflict is essentially uncontrolled. Only deterrence and damage limitation can be said to be applicable goals in the all-out war situation. Obviously the full range of national military goals cannot be meaningful unless we examine more than the extremes of warfare and develop and maintain a force posture capable of operating across the spectrum of potential conflict.

For example, controlled response is desired, even in a strategic conflict, in spite of the fact that traditionally we have provided for and envisioned very little real control once a strategic conflict is initiated. Similarly, multiple options apply to the provision for many choices for the use of nuclear as well as nonnuclear weapons, and we would seek to arrive at negotiating thresholds and war termination even at intermediate and high levels of intensity that

heretofore have not been regarded as possible stopping points.

The basic conclusion to be drawn from these considerations is that we must have the capability to carry on *controlled strategic war*. All-out nuclear holocaust and conventional war do not suffice as the only options for our national survival. Since each side can (for the time being) devastate the other at the counter-value (city-destroying level), there is every incentive, even in pressing for vital national objectives, to delimit the target system, hold collateral damage to a minimum, and achieve a satisfactory termination without reaching the level of population destruction. The thresholds for negotiation and war termination provided by the capability to carry on controlled strategic war can make it possible to achieve great savings in life and property over the inevitable losses from an all-out war. It is imperative that we provide the means that may enable us to achieve such savings.

implications of mutual deterrence of all-out war

The capability of both the United States and the Soviet Union to destroy the society of the other is probably the most significant factor in the international power struggle today. This capability is by no means guaranteed for the indefinite future, but it seems to be a fact of life for this decade at least. Barring total nuclear disarmament, or significant developments in antisubmarine warfare, anti-ballistic-missile (ABM) defenses, or possibly even more exotic means of negating the city-destroying potential of a major nuclear power, this mutual society-killing capability may be a relatively permanent phenomenon of international life. Although the capability may be mutual in the sense that both sides can generate such destruction to a relatively high degree, it need not and seldom will be precisely symmetrical. Should a war of this type eventuate, there would be an advantage in emerging with a higher percentage of surviving population and industrial capacity than one's adversary, particularly with respect to third powers that might otherwise benefit from a power vacuum resulting from the demise of

the major nuclear powers. Further, if something should alter the fact that *both* sides would incur extreme levels of damage, we would be faced with an entirely different sort of problem.

For the time being, however, we can conclude that both we and the Soviet Union are mutually deterred from being the first to invoke a countervalue strategy. The preservation of a viable "assured destruction" capability that can be held in reserve and employed when necessary in reprisal is the insurance against a breakdown in the mutuality of this type of deterrence.

In addition to mutual deterrence of city-destroying war, there are several other factors that compel us to examine more closely the potential advantages and pitfalls of a variety of contingencies less than all-out war and the possibility of developing usable military options to cope with them. One of these is the strong possibility that, as the fear of escalation to all-out war recedes, the Soviets will become less inhibited in challenging the United States militarily. A second is the potential which intermediate-level military actions have in deterring lower-level aggressions against positions which are locally very difficult to defend—Berlin, Iran, northern Norway, and others. And, third, technological improvements in the military state of the art over the next decade or so, particularly in weapon delivery accuracy leading to dramatic reductions in required yields, may make possible even fairly high-intensity actions, such as strategic attacks on homeland military targets, without triggering the all-out war against cities. Because of these factors, it is incumbent on the United States to develop a strategy and a force posture to provide both deterrence and dominance in conflicts short of all-out thermonuclear war, while preserving an assured capability to destroy the Soviet Union (and the rest of the Communist bloc if necessary) as a continuing deterrent to all-out war.

deterrence in the nuclear age

Without military superiority, there would be little hope of deterring the Communist movement from pursuing its objectives with bold and aggressive military action. Although

military superiority has become an elusive term in an era when the destructive potential of both sides can be measured in large quantities of deliverable megatons, it is important to strive for a better outcome than the enemy can achieve in even the worst case: all-out thermonuclear war.

Effective deterrence requires military superiority at other levels of conflict also — counterinsurgency, small and large-scale conventional wars, theater nuclear wars, limited strategic wars, and so on. The realities of the international balance, however, preclude military superiority at every level. In some areas of the world, particularly some that are contiguous to the Sino-Soviet bloc and in exposed positions such as Berlin, the Communist powers possess local military advantage. The requirement for military superiority obviously does not extend to the extreme of being able to defend against every conceivable military challenge on the precise terms established by the enemy. The resources of the Free World are limited, and it is not necessary to possess this kind of superiority in order to deter effectively at many points along the conflict spectrum.

The key point in designing a strategy and force posture for deterrence throughout the conflict spectrum is this: At any time and at any level of intensity, the enemy must appreciate that he is opposing the U. S. military power *in its entirety*, that we will employ as much of that total power as necessary to achieve the objective for which we are committed. Even when only a small fraction of that power is in the field, it is backed by the total aggregation of U. S. military strength. This precludes the enemy from measuring his risks solely in terms of the amount and kind of force we can put in the field to fight his choice of war.

Military superiority is not measured solely in terms of total megatons or numbers of delivery systems, although these factors can influence the international power balance. Military superiority includes many qualitative factors as well, such as command and control, intelligence, tactics, training, system reliability, responsiveness, accuracy, and versatility. It is closely keyed to national technological superiority.

a viable society, the precise level of destruction required is a matter for careful study. The factors involved include ethnic characteristics, socioeconomic patterns, geographic and demographic relationships, and even historical experiences. Many of these are not susceptible of exact analysis. Further, the problem of damage expectancy is complicated by a lack of knowledge of actual weapon effects against people. Particularly significant are the effects and persistence of radiation, factors of overriding importance in evaluating the fundamental utility of a shelter program. Finally, there is always the danger that a current assured-destruction capability may dissipate; it must therefore be reassessed continually.

Geography and demography are especially significant in the problem of assured destruction; the Soviet Union is a case in point. Some 210 Soviet cities contain all of the nation's critical industries, 74 percent of its total industrial capacity, but only 27.5 percent of its population. Additional increments of population fatalities and industrial destruction require ever increasing megatonnage. The curve tends to flatten out and we are in an area of decreasing marginal utility after these cities have been destroyed. Moreover, the cities contain the industrially skilled population, the educators, government administrators, communications, logistics, and critical industries necessary for the functioning of a modern society. In other words, it is not the percentage of population killed and industrial capacity destroyed per se that matters in assured destruction; it is the percentages of both which represent the level at which the enemy nation would cease to function as a viable society capable of waging war or being a world power economically.

Active and passive defense measures can further complicate planning for assured destruction. An effective ABM system for major cities, a full urban shelter program, and a workable evacuation plan are examples of measures which an adversary can take to protect his society.

Perhaps the most compelling requirement of all for assured destruction is that of survivability of the delivery systems. Assured destruction is a last-resort measure and preferably

would never have to be taken. But if it is taken, it will likely occur late rather than early in the war. Its effectiveness will be directly related to how well the delivery systems have survived the intermediate stages of hostilities.

damage limitation

Damage limitation includes the whole range, offensive as well as defensive, of measures taken to reduce the damage an enemy could inflict on the United States. Among the elements of damage limitation are (1) ability to influence the way the enemy employs his forces; (2) ability to destroy or neutralize forces before they are launched; (3) active defense—destruction of enemy forces after launch; and (4) passive defense — limiting the effects of enemy strikes. The last three factors are direct and visible, and there is a tendency in evaluating damage limitation to concentrate on them and overlook others. Actually, the ultimate in damage limitation is to deter the outbreak of war; failing that, it is to achieve war termination before high levels of damage are generated. If the United States has forces that can fight successfully at intermediate levels and thus prevent conflict from reaching all-out proportions, the result will be far more significant damage limitation than that achieved by variations in the factors normally considered in an examination of large-scale nuclear war only.

The other means of limiting damage can, in the aggregate, have a significant impact on the type and outcome of future wars. One of the most important is to influence the opponent to structure his forces in a way that will minimize their damage-creating potential. The defensive tradition of the Soviet armed forces illustrates the point. The Soviets have always devoted a considerably larger portion of their military budget to defensive forces than we have. Resources so committed are resources that might otherwise have gone toward the development and production of offensive forces, and from our standpoint these are the only Soviet forces capable of damaging the territory of the United States or its allies. We can continue to influence the Soviets to devote a large portion of their resources to defensive

forces by building a variety of offensive systems, each of which poses a different kind of threat to Soviet defenses. This strategy may reduce the resources allocated to the U.S.S.R.'s damage-creating offensive systems.

In influencing the way in which the enemy employs his force, the ultimate aim, of course, is to influence him not to use it at all. Short of that, the management or control of conflict with discriminating military power and usable options will be a better instrument of influence than massive indiscriminate action. Careful attention to the control of collateral damage, the selection of military targets rather than urban centers, maintaining communication with enemy leadership, and the avoidance of unnecessarily provocative actions can all be means of persuading the opponent that it is in our mutual interest to keep the conflict under control.

Direct military action is the most obvious method of limiting damage. The spectrum from offense to defense is essentially continuous, and all measures that contribute to the destruction of enemy military forces, particularly enemy strategic offensive forces, are damage limiting.

The chief damage-limiting role of strategic offensive forces is to deter the enemy from launching an attack on our civilian population and industry. This function has already been described. Although the city-attack degree of violence seems improbable at present, it must be reckoned with; the possibilities of accidental or irrational initiation of conflict at this level or of escalation of lesser conflicts to such a level cannot be overlooked.

The employment of offensive forces for damage limiting in nuclear war below the level of general exchanges involves several factors. Damage avoidance, or limitation of collateral damage in our attacks, is of particular importance. Unless nuclear warfare is controlled and restricted to the specific destruction of military targets, the use of nuclear weapons might remove any incentive opponents would have to refrain from indiscriminate attacks against our civilian population.

Damage avoidance capability is particularly significant where war is being prosecuted within the territory of allies and satellites. In this situation there may be a great need for a

weapon system with both long range and precision delivery. Limited, discrete escalation of the conflict to counter continued aggression could then take place in the form of careful, precise attacks in the territory controlled by the aggressor. The ability to take the war out of allied territory, e.g., the NATO area, and yet keep it below the level of general nuclear attack would be invaluable.

Specific criteria for damage limitation in these circumstances include discriminating attack capability, ability to apply discrete amounts of force with great accuracy, responsiveness to retargeting, an intrawar bomb damage assessment capability, adaptability to reconnaissance-strike functions, and an intrawar capability to gather information bearing on the optimum time for a cessation of hostilities. These requirements point to manned systems as being especially effective in the arena of nuclear warfare below the level of all-out holocaust. With the employment of manned systems and nuclear weapons of very low yields, nuclear wars can be fought at intensity levels lower than massive conventional wars and with less involvement of noncombat population and neutrals. The logistical advantages are obvious.

In this paper, as in most general treatments of the subject, the term "defense" is taken to include all active and passive measures of defense and protection and their associated command and control, warning, and communication systems. All these play an important role in damage limiting.

The utility of defense in all-out thermonuclear war has been questioned, although it is always unwise to think that the technological limitations which apply today are inevitably going to persist into the distant future. Further, defensive forces, even now, have great utility in conflicts at levels other than those involving weapons of mass destruction.

Defensive forces must continue to have a capability to counter enemy aircraft attacks, as well as missile attacks. This is particularly important in view of the present feeling that countervalue attacks are mutually unprofitable. The likelihood of lower levels of warfare therefore exists. Defensive forces for these levels of conflict, as well as for aircraft attacks in general

nuclear war, should have the flexibility that an advanced interceptor system can provide. Not only do interceptors provide the capability to defend areas as compared to the terminal point defense of surface-to-air missiles, but interceptors, possibly of different types, can provide defensive flexibility worldwide — an important factor in the limited wars that are a significant possibility.^o A similar argument applies to missile defense developments. It would be imprudent to consider point defense only, ignoring the flexibility provided by possible identification and destruction of missiles in their boost phase.

A final means of achieving defensive damage limitation is through mitigating the effects of enemy weapons which successfully run the gauntlet of our offensive and active defensive systems. Hardening of facilities and weapon systems, mobility, fallout shelters, and location of military installations remote from population centers are among the many techniques for limiting the effects that the enemy may be trying to achieve with his weapons.

impact of future technology on strategy and force posture

The concept of controlled warfare—conflict management at numerous levels below the holocaust extreme—has been made possible by two principal developments. One is the evolution of mutual deterrence of all-out counter-city war and the effect which this will have toward keeping other conflicts from getting completely out of hand. The other development concerns the unprecedented advances in military technology which are possible in the immediate years ahead. These advances could make it possible for the first time to translate the theory of discriminating and precisely controlled power into military reality.

With the choice of initiating all-out war essentially foreclosed as a viable national policy, both the United States and the Soviet Union will be compelled to search for usable

applications of military power through exploiting the potential of military technology. Although current indications are that the Soviets are developing a force posture emphasizing large-yield weapons and mass destruction, it is unlikely that they will pursue this course beyond the point of diminishing returns. Ultimately, the Soviets must recognize the limited utility of such a force when faced with an assured-destruction retaliatory capability by the United States.

Recent Soviet literature, such as the revised edition of *Military Strategy* edited by Marshal Sokolovsky, indicates that the Soviets are aware of the arguments for and against the controlled conflict strategy even though they currently reject it as a viable strategy for the Soviet Union. Given the relative imbalance in strategic capabilities that exists, it is not surprising that the Soviets do not lend credence to a strategy which they are not yet capable of implementing. To do so would undermine the utility of their current strategy, which is based on the terror aspects of counter-urban weapons. Eventually, however, the Soviets' usual lag in concepts will disappear, and they will catch up with the times, as they have often done in the past.

Among the predicted advances in military technology that are within the reach of both the United States and the Soviet Union, improved accuracy of delivery systems represents perhaps the greatest potential for achieving the practical military reality of controlled response. Improvements over current accuracies could result in dramatic reductions in both the number of weapons and the yields required per target. Ultimately an unambiguous distinction between counter-military and counter-urban targeting may be possible.

Another promising area for technological advancement lies in the related fields of intelligence gathering and command and control systems. These fields provide the physical elements for controlling the use of military power and making it fully responsive to specific political requirements. High-resolution sensors utilizing different phenomena such as radar, infrared, low-light-level optics, visual photography, and electronic emissions will make it possible to

^oThere is another defensive advantage offered by area interceptor defense compared to terminal defense by surface-to-air missiles: interceptor kills of attacking enemy bombers can take place well away from population and industrial centers.

gather a wide range of information at any time of the day or night and in all types of weather. High-speed methods of processing sensor data for dissemination and display and reliable means of transmitting this information will enable decision-makers to base their judgments on timely and accurate knowledge of the situation as it actually is. Survivable and sophisticated command and control systems could present up-to-the-minute status-of-forces information and provide national leadership with a finely scaled system of intraoperation options.

A comment is in order with respect to the impact of military technology on future strategy and force posture. Contrary to some popular belief, the ultimate weapon has not yet been conceived. It is especially hazardous to regard any existing weapon system — even hardened or submarine-based missiles—as the ultimate weapon. A sober review of technological progress leads to the conclusion that, as there always have been in the past, there will be subsequent weapon developments which will negate existing systems. More than at any time in history, military dominance or superiority will be contingent on the relative abilities of the contending powers to marshal their technological resources. ■

FROM THE PRECEDING DISCUSSION, it should be evident that we cannot adequately measure the effectiveness of our strategic offensive and defensive forces if we examine them only from the standpoint of their capability to achieve assured destruction and damage limitation. While these concepts, as currently taken, may be applicable to all-out wars of urban destruction, neither we nor our opponents can be satisfied with such a level of warfare as the only alternative to insurgency and limited conventional conflict. As is indicated by our military goals — “controlled response,” “multiple options,” and others—we require strategic forces that can carry out accurate, discriminating, incremental attacks as part of the carefully controlled response to enemy pressure and aggression.

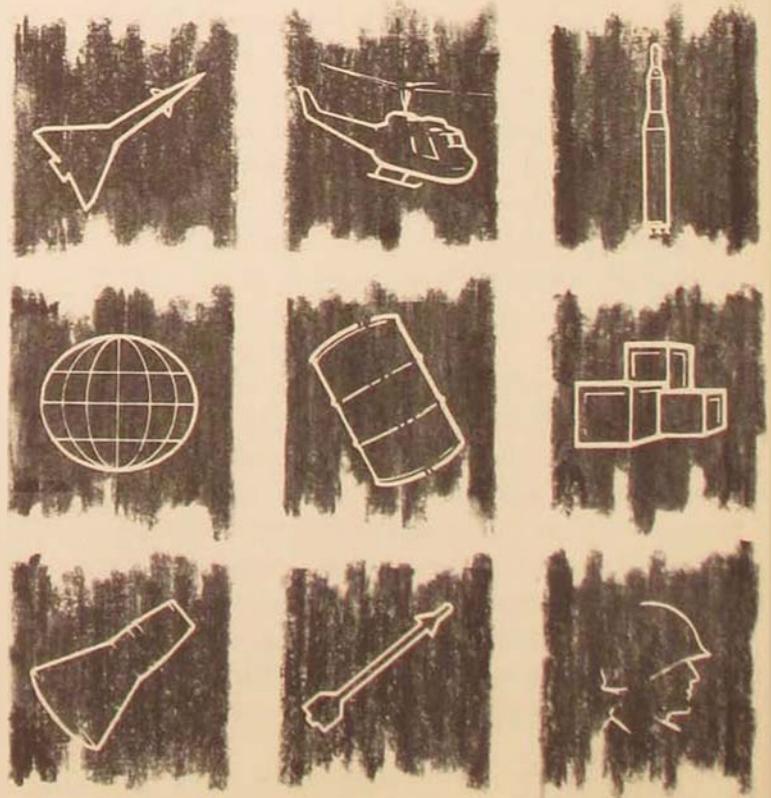
Emphasis on these qualities in our strategic forces will furnish additional resources for the management of crises, provide controlled response to enemy threats at a variety of levels, and enable us to achieve war termination at the lowest practicable level of conflict intensity. The ability to provide such an array of resources—not assured destruction and damage limitation only—will constitute the proper measure of a strategic force for the future.

Arlington, Virginia



MATHEMATICS AND STRATEGY

LIEUTENANT COLONEL JOHN E. MOCK AND SECOND LIEUTENANT WILLARD E. HOBBS, JR.



THE DAY was warm and sunny in Cannae, but impending doom lay heavy over the heads of the Roman legionnaires as they girded for battle. For on that day in 216 B.C. Hannibal skillfully administered one of the most devastating defeats the world has ever witnessed: the Carthaginian force of 42,000 men completely annihilated a Roman army numbering 72,000.

An even more dramatic military victory took place a century earlier. On an October morning in 331 B.C., Alexander the Great with 40,000 infantry and 7000 cavalry troops faced the powerful armies of Darius III, reported to number around 1,000,000. In spite of the great disparity in numbers, the battle of Arbela ended at nightfall with Darius's panic-stricken troops completely routed.

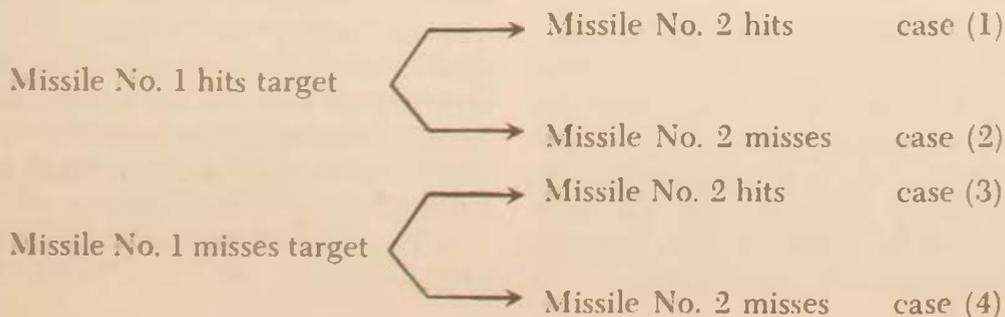
What were the common elements of the successful strategies leading to these fantastic victories? Down through the ages military writers and analysts such as Sun-Tzu, Jomini, Clausewitz, and Von Schlieffen have attempted—with various degrees of success—to dissect the winning strategies in order to develop a set of principles that would lead invariably to victory.

Numerous rules and platitudes have resulted from these studies, all subject in a large measure to personal judgment. The deep-seated hope that perhaps the basic essentials of a winning strategy could be made objective and placed on a scientific-mathematical basis has never been fulfilled. In view of the vagaries of man, weather, and events, this challenging goal will probably never be achieved. Nevertheless, interesting and significant inroads are being made in this problem area today by modern scientists and mathematicians as they continue to develop new fields of research such as operations analysis and game theory.

Anyone who desires to participate in the development and implementation of modern theories of strategy must of necessity be well founded in mathematics. To this end, the curriculum at the U.S. Air Force Academy provides each cadet with a solid foundation in mathematics and offers optional courses in game theory and probability analysis. With an ever increasing number of our officers destined to participate in joint strategy meetings and with civilian scientists at the Department of Defense level, we can no longer afford to neglect the vital role mathematics plays in our military operations. As an illustration of the embarrassment which could arise from a lack of knowledge of basic mathematical concepts, consider the following apocryphal story currently making the rounds. According to the story, a high-ranking officer, when informed that a certain number of missiles would give a 50% probability of destroying certain enemy targets, initiated procurement for twice the number of missiles in the mistaken belief that this would guarantee a 100% probability of destroying the specified targets. Unfortunately, probabilities and life in general (being essentially nonlinear in nature) cannot be dealt with so simply.

How many missiles?

Let us briefly consider the solution to this problem along with a sufficient sampling of other representative problems to indicate the scope of mathematics which pervades our military efforts. The missile-procurement problem succumbs rather nicely to basic probability concepts. If the probability of a single missile's destroying a target is $1/2$, then by the use of two missiles the following equally likely events may occur:



Only in case (4) do both missiles fail to hit the target. The ratio of the number of favorable events to the total number of equiprobable events gives the probability of the occurrence of the event in question. Thus, by the use of two missiles the kill probability has been increased from 50% to 75%, which is still far short of the goal of 100% (which theoretically can never be attained). The reader may find it instructive to prove to himself that if 4 missiles are used kill probability will rise to 93.8%.

Markov chains

Quite often the ubiquitous probabilities that shape both destinies and events are not so clearly exposed as in the preceding example. Consider the following hypothetical situation.

The world situation has rapidly deteriorated; the outbreak of hostilities is imminent. At this point it is necessary for the President to contact all field commanders with respect to implementation of the war plan. In particular, it is necessary to convey a message to the commander of Friji in order to prevent any premature uprising in that small nation which might prove disastrous to the friendly freedom fighters. To reach this last outpost of civilization, the President's message must pass through innumerable relay stations.

The message is to be a simple NO (meaning do not implement war plan) or GO (meaning implement war plan immediately). Now relays being what they are, there is a probability of 1 chance in 1000 that a NO message while passing through a single relay will be erroneously retransmitted as GO and a probability of 2 in 1000 that a GO message will be retransmitted as NO. The question now arises: What is the probability that the commander in Friji will receive correctly the message sent by the President?

The solution depends once again on probabilities, but at a slightly higher level of sophistication. We must first construct a probability matrix, which is nothing more than a square array of numbers in which the elements of the rows (the horizontal elements) are the probabilities of individual events. For our problem this matrix would be written as follows:

		Message Received	
		GO	NO
Message Sent	GO	.998	.002
	NO	.001	.999

The elements in the first row may be interpreted as follows: if the GO message enters a relay, the probability is 998/1000 that it will be transmitted correctly, and the probability is 2/1000 that it will be erroneously retransmitted as NO. The elements of the second row can be interpreted in like manner.

Markov, a noted Russian mathematician, developed a theory to solve this very type of problem. If we generalize the elements of our matrix thus:

		V-1	V-2
H-1	$\frac{1-a}{b}$	$\frac{a}{1-b}$	
H-2	$\frac{1-a}{b}$	$\frac{a}{1-b}$	

the theory of Markov chains tells us that if state H-1 is introduced initially the probabilities of V-1 and V-2, the final states, are given by

$$[P_{V-1}, P_{V-2}] = \left[\frac{b}{a+b}, \frac{a}{a+b} \right]$$

In our present problem, $a = .002$, $b = .001$. Therefore,

$$[P_{GO}, P_{NO}] = [1/3, 2/3],$$

which means that, if the President sends the GO message, the probability is 1/3 that the commander of Friji will receive it correctly, and the probability is 2/3 that in passing through the innumerable relays it will be delivered at the far end as NO. Paradoxically, Markov's theory shows that if the President sends the NO message the probability is still 1/3 that the GO message will be received and 2/3 that the NO message will get through. Thus the message received in that far-off, never-never land of Friji is completely independent of the President's decision and is determined solely by the capriciousness of the relays!

The indications from such an analysis are crystal clear:

- The situation is intolerable.
- The number of relays should be reduced drastically.
- Better relays should be installed.
- Redundancy should be included in the messages so that an error of this type can be readily detected by the recipient, who then can either correct the message based on the redundant information contained therein or query the sender for a retransmission.

These indications are approximately what one might logically derive from a careful review of the problem, even without a detailed mathematical analysis. It is doubtful, however, that the full impact of the paradoxical situation would become apparent without the insight provided by the Markov chain theory. This, then, is but one of many simple illustrations of the manner in which mathematics and operations analysis combine to shed light and provide guidance in military situations.

game theory

Let us now turn our attention to the new and highly controversial field of game theory that began as one of those fascinating diversions in which mathematicians so often become absorbed (and that sometimes turn out to have very practical applications). Much of game theory has been derived from or directly influenced by ideas first expressed by the late John Von Neumann in 1927.

In its simplest form, a game deals with two sets of opposing interests. It is possible, of course, to have three or more conflicting sets of interests involved, as occurred in the three-sided war fought by the Chinese, the Communists, and the Japanese on the Asian continent during World War II. But for the more typical situation, the conflicting parties can generally be divided into two groups, which we shall label *A* and *B*. In the conflicts that we shall consider, the winnings of one group will be the losses of the opposing group. Such games are referred to as zero-sum games inasmuch as the sum of the payoffs to all players, counting winnings positive and losses negative, is zero.

Basic to game theory are the assumptions

that rational, intelligent people are involved and that the sensible object of a player is to win as much as he can, safely, in the face of a skillful opponent who is pursuing a contrary goal. Thus player *A* wishes to use a strategy that will guarantee that the least quantity which he can win is as large as possible, irrespective of the action of *B*. Player *B* on the other hand wishes to pursue a strategy that will minimize his losses regardless of the way *A* plays the game. If *A* departs from his optimum strategy, he does so at the risk of getting less than he might have won, and if *B* departs from his optimum course of action he may lose more than he would otherwise.

strictly determined games

To make the abstract ideas of game theory more concrete, let us consider a simplified problem of ballistic missile defense. Country *A* plans to use ICBM's in an attempt to destroy a target that is protected by Country *B*'s anti-ballistic-missile (ABM) defense system. Country *A* has two options available: the missiles can be sent in on either a "high" or a "low" trajectory. Country *B* has the option of presetting the ABM's to burst either "high" or "low." The payoffs to *A* (which are the losses of *B*) can best be shown in a payoff matrix.

		B (defense)	
		High	Low
A (offense)	High	0	50,000
	Low	210,000	100,000

The elements in the matrix can be interpreted as follows. The payoff to *A* is zero if he uses a "high" trajectory and the defense has preset its missiles to intercept "high." However, if *A* penetrates and detonates "high" while *B* has his defenses set to intercept "low," *A* will receive a payoff of 50,000 units (which might be thousands of dollars of enemy equipment destroyed, number of enemy casualties, or any other physical value representative of the damage sought). Now if *A* penetrates "low" while *B* prepares to intercept "high," *A* achieves a payoff of 210,000 units, whereas if he is intercepted "low" his payoff drops to 100,000 units

(a rather sizable consolation prize produced by destructive force of *B*'s ABM nuclear burst).

The problem to be solved is: What are the optimum strategies and the pay-offs for the opposing forces? Note that if *A* penetrates "high" his minimum payoff is zero, whereas if he penetrates "low," regardless of the strategy of *B*, he is guaranteed a minimum payoff of 100,000 units. Let us now turn our attention to *B*. If *B* attempts to intercept "high" his maximum loss could be 210,000 units, whereas if he intercepts "low" his maximum loss would be 100,000 units, regardless of the action taken by *A*. Thus in this game the largest minimum in either of *A*'s pure strategies (100,000 units) is the lowest maximum loss in either of *B*'s pure strategies. In such a situation we say that a saddle-point exists and the game is strictly determined. Each player should utilize his saddle-point strategy, and the value of the game will be the value of the saddle-point (which in our problem is 100,000). Note carefully that if either player moves away from his optimum strategy he can be hurt. Thus, if *A* shifts from a "low" to a "high" penetration, his payoff falls from 100,000 to 50,000. If *B* shifts from "low" to "high" interception, his losses increase from 100,000 to 210,000 units. Hence both players (if rational) will stick to their optimum strategy. It is apparent that secrecy (or intelligence) is of no particular value to the players. Even if the defense knows the plans of the opposition, there is nothing that can be done (within the framework of the situation described) to reduce the payoff below the saddle-point value.

mixed-strategy games

By developing a more accurate ABM, *B* is able to reduce markedly the yield of the nuclear warhead necessary to guarantee a kill. This one technological advance changes the entire character of the game. The payoff matrix now reads:

		<i>B</i>	
		High	Low
<i>A</i>	High	0	50,000
	Low	210,000	10,000

If we examine this matrix for a saddle-point we find that the larger of the row minimums is not equal to the smaller of the column maximums. The game is no longer strictly determined, and a new concept enters our analysis—the quaint idea of allowing chance to guide our ultimate decision!

Game theory shows that, if there is no single optimum strategy for each player, then there exists an optimum combination of pure strategies. For the general payoff matrix

	<i>B</i> ₁	<i>B</i> ₂
<i>A</i> ₁	<i>a</i>	<i>b</i>
<i>A</i> ₂	<i>c</i>	<i>d</i>

it can be shown that *A*'s optimum strategy is to mix his pure strategies *A*₁ and *A*₂ in the ratio

$$[A_1/A_2] = \frac{(d - c)}{(a - b)}$$

and *B*'s optimum strategy is

$$[B_1/B_2] = \frac{(d - b)}{(a - c)}$$

For our ABM-ICBM duel, the optimum mixed strategies are

$$[A_1/A_2] = [4/1] \text{ and } [B_1/B_2] = [4/21].$$

Game theory would now tell *A* to use some random device (weighted four times as much for *A*₁ as for *A*₂) to select his course of action. Likewise *B* in making his decision should use a chance device (weighted in favor of strategy *B*₂ by a factor of 21/4). *A*'s expectation, i.e., the value he expects to win by using this mixed strategy, can be found by playing his optimum strategy against either of *B*'s pure strategies:

$$E_i = A\text{'s expectation} =$$

$$(\text{probability of } A_1) (\text{probability of } B_1)$$

$$(\text{payoff } A_1-B_1) + (\text{probability of } A_2)$$

$$(\text{probability of } B_1) (\text{payoff } A_2-B_1)$$

$$E_i = (4/5)(1)(0) + (1/5)(1)(210,000) = 42,000 \text{ units}$$

If *B* plays his pure strategy *B*₂, the payoff is

$$E_i = (4/5)(1)(50,000) + (1/5)(1)(10,000) = 42,000 \text{ units}$$

Thus if *A* plays his optimum strategy, his expectation in this game is independent of *B*'s strategy or combination of strategies. (Generally speaking, if either player deviates from his optimum mix, he will suffer. In this particular game, as long as either player stuck to his optimum mix the actions of the opponent were immaterial to the expected payoff.)

At this stage we have encountered one of the more subtle points in elementary game theory. In an actual conflict situation the game generally is played only once. On this basis, why do we choose our course of action as previously outlined? Wouldn't *A* be better off playing his pure strategy A_1 in view of its greater weight in the mixed strategy? The answer is unequivocally no! If life were this simple, *B*, reasoning along the same line with the same information, would arrive at the same conclusion as to *A*'s intended course of action. Therefore *B* would plan on intercepting "high," which would yield *A* a payoff of exactly zero. If *A* is more devious in his thinking, he will recognize the trap that awaits him and on further consideration will use strategy A_2 (since he believes that *B* would not anticipate his using this unfavorable strategy). But *B* was not born yesterday either and realizes that *A*, being an intelligent opponent, would not fall into the trap of playing A_1 . . . etc. Obviously, one has an extremely intricate problem in logic to untangle here, which depends heavily on the character, temperament, and existing moods of the protagonists. In such circumstances game theory shows that the rational approach is to use a chance mechanism, weighted appropriately, to make the decision.

The idea of leaving to chance the determination of such an important decision may seem both frivolous and foolhardy. But before we make up our mind too quickly on this point, consider the following game. Player *A* is to write either the number 0 or 1 on a slip of paper, and *B* is to guess the number. If *B* guesses correctly he wins \$1; if he misses he pays *A* \$1.

		<i>B</i>	
		0	1
<i>A</i>	0	-1	1
	1	1	-1

$$[A_0/A_1] = [1/1] \text{ and } [B_0/B_1] = [1/1].$$

Thus *A* and *B* should play each of their strategies equally in this repetitive game. Now obviously if *A* simply alternates in his choice of 0 and 1, *B* will quickly spot his strategy and will have no difficulty in guessing each number correctly. The rational strategy for *A* is to make his decision on a random basis, giving each of his strategies a 50-50 chance of occurring on any single trial. An appropriate chance device for *A* would be a coin which he could toss, playing 0 if heads turns up or 1 otherwise. (*B* could use the same random device.) Thus there is nothing frivolous or irresponsible in our use of a chance device to determine our choice of action. The chance device is an instrument of our will and not our master.

*Whose game
are we playing?*

A's team of prize scientists has been working intensively for several years and has finally developed a hardened warhead that simply cannot be destroyed by any intercept device. Thinking that he is still playing the same game, *A* fills out his payoff matrix as shown below and realizes that his obvious strategy is A_2 , which completely dominates strategy A_1 .

	B_1	B_2
A_1	50,000	50,000
A_2	210,000	210,000

From *A*'s point of view it is immaterial whether or not the enemy learns his strategy. There is nothing *B* can do to stop *A*'s attack; his strategy appears to be infallible.

B's intelligence received rumors of *A*'s technological breakthrough in sufficient time for *B* to set up an entirely new game structure. Realizing that defeat by *A* would mean the demise of himself and his top leaders, the ruler of *B* had his top scientists devise a true doomsday machine to be automatically detonated if *B* is attacked, splitting the earth in two—a rather unhealthy situation for *A* (as well as *B*). Thus the game actually being played is

	B_1	B_2
A_1	$-\infty$	$-\infty$
A_2	$-\infty$	$-\infty$

If A believes he is still playing the previous game, whereas B 's new game is actually being played, the result will be an utter catastrophe for all. However, unless the leaders of B are obsessed with the idea of joining their ancestors prematurely, their rational course of action will be to convince A of the existence of the doomsday machine and of their unswerving intention to use it. Then A will realize that he has been using the wrong game matrix and will shift to B 's game, with a stalemate the result. A still has the capability of penetrating B 's defenses, but to what avail if B has the power to destroy the world immediately thereafter?

Of what value intelligence?

Each of the games we have considered has a completely different intelligence aspect associated with it. Let us briefly review the situation. If a game has a saddle-point, intelligence is of no particular value to either side. If a saddle-point does not exist, as in the second game, and each side must pick one of several possible strategies, then intelligence becomes extremely valuable. If both sides use a random device to choose their operational strategy at the last possible moment, then intelligence agencies are given an extremely difficult job to perform. In unusual games of the last type we discussed, not only is intelligence desirable, but it is incumbent upon B as a rational act to inform A of the details of his strategy. Thus we see the various degrees of importance which military intelligence plays in our strategic planning.

assessment of payoff values

One of the weak points in the application of game theory to practical situations lies in the assignment of payoff values to the various combinations of strategies. Quite often we can still use game theory if we can at least list the various payoffs in some order of preference.

To illustrate this situation and to touch briefly upon the subject of non-zero-sum games, let us consider the quandary of the wise King Solomon when he was faced with two women, each claiming to be the natural mother of the same child. Gazing around his magnificent palace for a moment, he stalled for time while he tried to recall those lessons in game theory which the grand vizier had just taught him the previous week. Finally he issued his edict: "Ladies, I will give you one minute to decide which one is the true mother of this child. If you both persist in claiming this child as your own, the only rational solution is to split the child in two, giving half to each of you. If you can agree as to the mother of the child, the baby will be returned to its natural mother."

During the tension-filled moment of decision, Solomon ran through his elementary game theory once more to make sure his solution was foolproof. Solomon realized that the two women were not engaged in a simple zero-sum game, for a loss to one woman was not necessarily a gain for the other (for example, if the child were lost to both women). Rather, each woman is playing an individual game against Solomon in which he can be considered an unbiased, disinterested banker who gains or loses in accordance with the payoff of each woman. Thus the payoff matrices would be as follows:

	<i>Solomon</i>			Row
	Statement	Mine	Yours	Min
<i>Real</i>	Mine	a	b	a
<i>Mother</i>	Yours	c	d	c°
Column Max		c°	b	

	<i>Solomon</i>			Row
	Statement	Mine	Yours	Min
<i>Pretender</i>	Mine	e	f	e°
	Yours	g	h	g
Column Max		e°	f	

Solomon realized the futility of trying to assign absolute values to the various payoffs (just as modern game theorists would have some difficulty in assigning a realistic payoff value to the complete destruction of any large American or enemy city). Putting himself in the position of

the real mother, he was quickly able to establish an order of preference for the payoffs, viz., $b > d > c > a$. The reasoning runs as follows: If the real mother claims the child and the pretender admits the truth, she interprets Solomon's edict to mean that she will receive her child (payoff b) and all ends well. She undoubtedly noted that Solomon made no mention of what would happen if both women stated the baby belonged to the other and assigned a zero payoff value to d , assuming that Solomon in his infinite wisdom would set up a new game matrix with different rules if this unlikely eventuality occurred. Both a and c would represent negative payoffs, since she interprets Solomon's decree as meaning she will lose the child in both cases. Of the two payoffs, the former would be her last preference, considering the grisly finality of the decision.

Solomon quickly scans the payoff matrix for a saddle-point, and fortunately for his peace of mind finds one, viz., payoff c . (Note that it is the maximum of the row minimums and simultaneously the minimum of the column maximums.) Therefore, the optimum strategy for the real mother is always to say that the baby belongs to the other woman!

The reader can supply Solomon's reasoning as he quickly assigns the pretender's payoffs in the order $f > h > e > g$. Once again he notes that a saddle-point exists and that the pretender's optimum strategy is always to state, "The baby is mine."

Thus Solomon is not surprised when the moment of decision arrives and one woman states, "It is hers," and the second woman states, "It is mine." Knowing that each woman is playing her optimum strategy, he has no difficulty in returning the child to its rightful mother. The moral of this story is that all is not lost in game theory, even though we cannot assign absolute values to our payoffs, as long as we can list the payoffs in an order of preference.

the future

We have barely scratched the surface of the theory of games. Hopefully, we have not led the reader to expect too much of this brash

infant. It should be emphasized that we have examined only the simpler cases. Many actual conflicts simply do not fall under the province of game theory. As we climb ever higher up the scale of complexity, from games in which each player has many strategies to games in which coalitions are formed, the solutions become increasingly more difficult and may not exist.

Let us return briefly to the ABM-ICBM duel problem (which has been examined in some detail by one of the authors, Lieutenant Hobbs, as an undergraduate thesis problem). This conflict is so complex that it is impossible for either offense or defense to optimize simultaneously all the strategies available. The scientific approach is to subdivide the problem into simpler ones with fewer variables. By optimizing the solutions to each of the subproblems, one can reach qualitative conclusions with respect to the various trade-offs involved. Thus we may choose to optimize the altitude of intercept, neglecting for the moment the fact that the subsequent optimization of the warhead yield will have a significant effect on the choice of the optimum altitude.

In our previous games we dealt only with discrete strategies, e.g., B could intercept either "high" or "low." B could just as well have included a third, intermediate strategy that would lead to a 3×3 game. To give a wider selection of strategies, why not subdivide the intercept range into n regions, thus giving an $n \times n$ game? And why stop there? Why not consider the game in the limit as n becomes increasingly large and we have a continuum of strategies from which to choose? At this point we go from a finite number of payoffs that can be placed in a matrix array to the concept of distributions and integral equations which require for solution such techniques as Lebesgue-Stieltjes integration. This brings us to the frontiers of game theory; moreover, we have reached the point where the basic mathematics background we have assumed the reader to possess will no longer suffice. Let us merely state that in principle many problems of this nature can be solved by the use of some of the basic concepts we have discussed. However, the complexities of simultaneously optimizing many parameters have not yet been satisfactorily resolved.

In conclusion, mathematics, strategy, and game theory are all being brought together to help provide the military commander with a logical and rational approach to making complex decisions. The need for great strategists such as Alexander the Great, Hannibal, Caesar,

Napoleon, and MacArthur will never be eliminated, but new techniques such as these will enable a larger percentage of capable commanders to make better decisions, be it in peace or in war.

United States Air Force Academy

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The Science Frontier



ULTRAPURIFICATION

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IN A classical sense, purification is the removal of extraneous materials from a specific matrix. The term now includes the elimination of physical imperfections from a crystal. Before defining ultrapurification, we should consider four questions. First, for what purpose is purity sought? Here one usually indicates the degree of removal required. Second, what are the methods of purification available to attain the desired degree of purity? The difficulty, complexity, and expense of purification hinge on this consideration. Third, how well can one analyze the purified product? There can be no assurance of purity without accurate, dependable analysis. Finally, what are the consequences of attaining ultrapurity? The effects of trace impurities can best be confirmed by their removal.

What is ultrapurification?

Requirements for purification vary from group to group in the scientific community. The standards

may vary from those of a geologist, who merely requires sufficient separation to identify an ore, to those of a nuclear chemist, who requires separation not only of elements but even of specific isotopes. Between these extremes there are the requirements of inorganic chemists, ceramicists, metallurgists, organic chemists, pharmaceutical chemists, electronic engineers, analytical chemists, solid state scientists, and a multitude of others. Material is prepared for the use of these groups in such a way as to satisfy their ordinary requirements for purity by normal processing and purification techniques.

Ultrapurity results from an extraordinary requirement for purity in which extra purification is mandatory to attain a level beyond that resultant from normal processing and purification. The normal limits of purity range from about 99.9 percent purity for most inorganic reagents. Many pharmaceutical reagents must have impurities removed to the range of one part of impurity per million parts of matrix, which is expressed as 1 ppm.

Metallurgists, too, often have purity requirements in the ppm range. Analytical chemists require standards with impurity levels as low as one part per billion (1 ppb). Designers employing semi-conducting materials such as silicon and germanium normally have requirements for purities in the parts-per-billion range. Furthermore, crystalline perfection is often even more important than chemical perfection for these materials. Study of the electronic structure of metals by cyclotron resonance measurements often requires single crystals having a resistance ratio, $R_{273K}/R_{4.2K}$, of at least 5000. This is a demand which extends even beyond the parts-per-billion range. It is obvious, then, that ultrapurification is a relative term inasmuch as normal standards for one group may exceed the ultrapure requirements of another group. Because of this relative nature of ultrapurity, it is necessary to designate both the material and the purpose for which it is wanted in order to define the limits of ultrapurity. Besides being relative in nature, ultrapurity is also a dynamic term.

Ultrapurification is a term the limits of which will undoubtedly diminish by orders of magnitude as advances are made in techniques for separation of microquantities of impurities from different matrices. The epitome of ultrapurification is preparation of single-crystal, intrinsic material containing no defects. Essentially the task of ultrapurification is to free a material from the effects of imperfections in its structure. These imperfections may be foreign atoms or they may be deviations in the crystal structure. Any deviation of the crystal structure, for example an atom absent from its regular position, can change the properties as significantly as an impurity atom could.

Four specific types of "defects" or "imperfections" are identifiable and must be considered in evaluation of purity: (1) an impurity substituted for a host atom in the lattice, (2) an impurity contained in interstitial space, (3) the movement of an atom from its proper position in the lattice, thereby leaving a vacancy, and (4) a misplaced row of host atoms within the lattice, which is called a dislocation. (See Figure 1.) Such primary imperfections occur in crystals because the ordering forces are not strong enough to exclude them entirely during crystal growth or during subsequent processing. In ultrapure material, any structural imperfections such as vacancies, dislocations, and

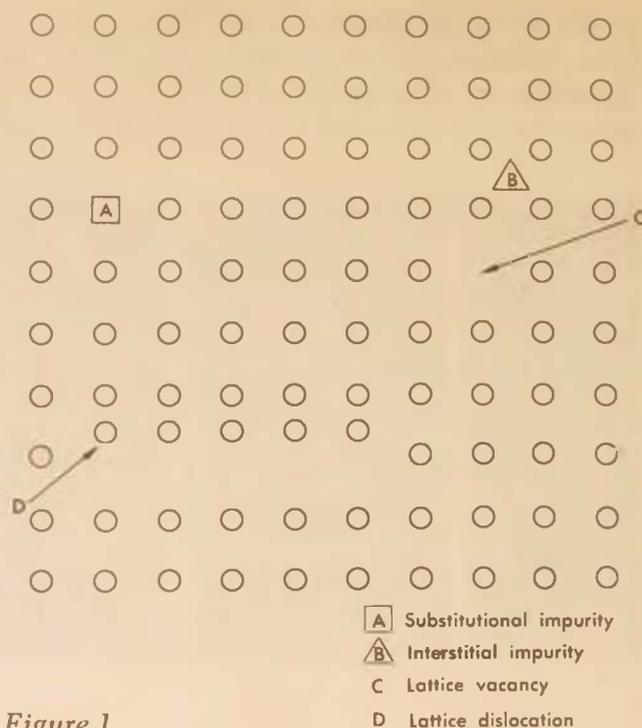


Figure 1

stacking faults play a role comparable to that of impurities. These imperfections are treated in solid state chemistry and physics as solutes in a solvent (the crystal matrix) until thermodynamics requires that the increased concentrations of imperfections be treated as new phases. It is possible to predict reactions between various imperfections and between the imperfections and the matrix itself. This extension of chemical treatment has been carried to the point of writing equilibrium constants for the various reactions and seeking desired effects by applying the Law of Mass Action to these equilibria. Under ordinary conditions thermodynamics imposes certain limitations by demanding the presence of defects. These limitations may be minimized by growing single crystals at high pressures and then studying these crystals at reduced pressures. It is apparent that the atomic arrangement must be considered as well as the presence of foreign atoms.

Although requirements vary with different groups, ultrapurity requires parts per million, or less, of foreign atoms and a minimum of physical imperfections in the matrix. Often, 10^7 lines per square centimeter is given as the upper limit of tolerable dislocations in a metallic matrix. Material

Table I. Relationship of Number of Steps to Purification Achieved

99% A	(Starting Purity)	1% B
% A	Step #	% B
99	0	1
99.5	1	0.5
99.75	2	0.25
99.875	3	0.125
99.938	4	0.062
99.964	5	0.031
99.984	6	0.016
99.992	7	0.008
99.996	8	0.004
99.998	9	0.002
99.999	10	0.001
99.9995	11	0.0005
99.99975	12	0.00025
99.99988	13	0.00012
99.99994	14	0.00006

of such purity rarely is found in nature and must usually be prepared in the laboratory.

The difficulty of obtaining such limits of purity may be appreciated from an inspection of Table I. This table illustrates the number of theoretical steps required to proceed from 99% A containing 1% B to a purity of one part per million of B in A. Each step involves the removal of one-half of all the impurity species B from the matrix A.

It is seen that fourteen separate theoretical steps are required to achieve this degree of removal of impurity. If each of these steps should involve one stage in a continuous process, conditions are favorable for the attainment of this purity. But if this removal is dependent upon several processes, which might involve transfer or handling of the material, the achievement of success is quite doubtful and at best is extremely painstaking.

A feel for the meaning of ultrapurity may result from a glimpse into the microregion of a crystal lattice to reveal the macroconcentration of atoms. Avogadro's number defines the number of molecules in 1 mole of a substance, or the number of atoms in one atomic weight. The value of this constant is 6.02×10^{23} . The density of a material is the weight of one cubic centimeter of the material ex-

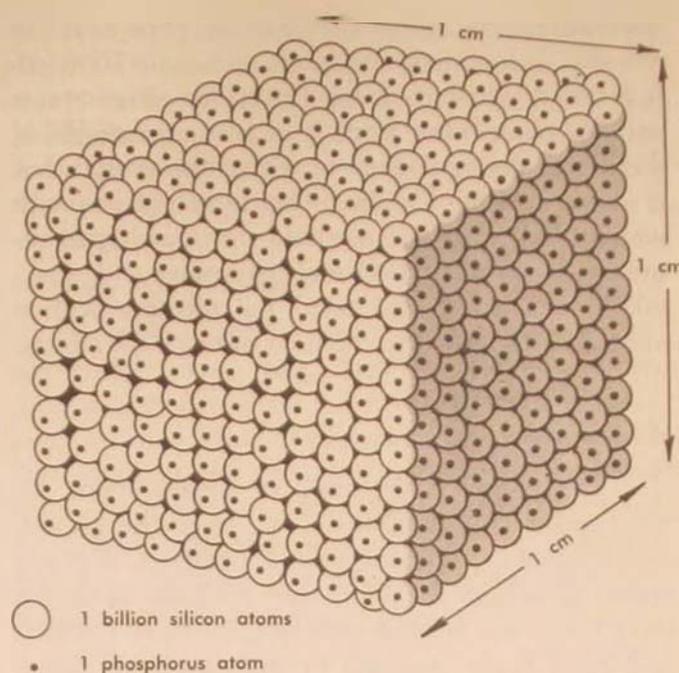


Figure 2. There may be 100,000 billion such sites in a volume of 1 cubic centimeter for a system with a concentration of 1 ppb of phosphorus in silicon.

pressed in grams. For an element, division of the weight of one cubic centimeter of the element by the atomic weight and multiplication by Avogadro's number gives the number of atoms present in one cubic centimeter (1 cc). For example, for silicon, the density is 2.4 g/cc and the atomic weight is 28.06.

To compute the number of atoms in one cubic centimeter of silicon:

$$\frac{2.4}{28.06} \times 6.02 \times 10^{23} \text{ atoms} = .52 \times 10^{23} = 5.2 \times 10^{22} \text{ atoms/cc} \approx 10^{23} \text{ atoms/cc}$$

So, for a concentration of 1 ppb of phosphorus in silicon, there are approximately

$$\frac{10^{23}}{10^9} = 10^{14} \text{ phosphorus atoms/cc of silicon.}$$

That is to say, there is one phosphorus atom for every billion silicon atoms, or there could be 100,000 billion (10^{14}) sites at which there are one billion (10^9) silicon atoms accompanied by one phosphorus atom—all of this contained in a volume of 1 cc. (See Figure 2.)

Now, if the concentration is reduced by two

orders of magnitude to 10^{-11} parts of phosphorus in the silicon, one may say there can not be 1000 billion sites at which there are 100 billion silicon atoms and one phosphorus atom. This is an oversimplified picture of the arrangement within the crystal, but it serves to exemplify the orders of magnitude with which ultrapurity is concerned. Such stringent requirements demand extremely expensive and painstaking efforts. A real need for ultrapurification must be established in order to justify such efforts.

Why ultrapurity?

The common sequence of development for most technological advances has been the growth of a technology following the enunciation of a scientific principle. As significant scientific advances have occurred, related technologies have evolved and have been nurtured by elaboration of these scientific principles. Technology has even served to stimulate more active research designed to exploit these various fundamental laws. In the field of materials, we are faced with an enigma.

Growth of technology is today advancing more rapidly than contemporary basic knowledge of materials should allow. A. D. Franklin in an article in *International Science and Technology* states, ". . . this is a dangerous condition which demands that we acquire with dispatch a high order of control over the resources of nature. Rather than lagging behind the demands of technology, we should be producing materials whose purity is above the level desired. Moreover, we must be able to maintain that standard, even as demands of technology grow." The basis of this gap between technological requirements and scientific knowledge undoubtedly stems from the fact that materials have been used pragmatically for centuries, and a very competent technology has developed as a result. However, this was a technology lacking a scientific foundation from which to acquire sophistication. Only in the last quarter of a century has the philosophy developed that we should be able to create materials consisting of predetermined properties and characteristics. There are two forces striving to advance the standards of materials performance to such extreme limits. These forces are the military demand for uncompromising reliability and industry's search for new materials of unprecedented capabilities. Realization of these goals requires that

we develop an understanding of the properties, the structure, and the interactions of materials.

Most materials are capable of better performance than that attributed to them. The first step needed to make performance equal to theoretical capability is to make these materials in ultrapure form. In their purest state, many materials display marked improvement in physical and chemical properties. The need for materials in ultrapure form is shared by industry and research, each for its own reasons. Obviously the interests of the Department of Defense are involved in both needs.

Industrial needs for ultrapurity are based on the knowledge that certain impurities have harmful effects on mechanical, electrical, magnetic, or chemical characteristics of materials. For example, removal of tin, cadmium, and lead from zinc used for die casting has greatly reduced the embrittling characteristics of the dies. Another example is the discrepancy between theoretical limits of plastic deformation and actual limits as experienced in metals. Calculations show that slippage of whole crystal planes in metals should not occur until energy equivalent to that resulting from several percent of deformation is applied. However, dislocations of rows of atoms cause centers of weakness in the metals, and at these points the uniformity of the lattice is disturbed. Apparent weakness results from the movement of these dislocations through the slip plane at much less than the theoretically tolerable stress. The creation of these dislocations was previously considered inevitable because of accidents of growth during solidification. Recently "whiskers," or very small filamentary crystals, which have practically perfect crystal structures, have been developed by maintaining extremely well-controlled growth conditions. These "whiskers" approach the theoretical strength of metals. Thus, both foreign atoms and crystal imperfections have been recognized as hindrances to materials performance, and the deletion of these imperfections has been undertaken by industry. When a specific industrial need for higher purity is anticipated or uncovered, this need is usually satisfied, and undoubtedly most money spent in the search for ultrapurity falls in this category.

The importance of ultrapurity to research is more difficult to comprehend because it is impossible to anticipate the benefits to be derived from fundamental studies. However, there are certain

relationships between purity and basic research that warrant pursuit. A common and valid reason for researchers' emphasis on purity is "to find out what the true properties of a material are." Depletion of imperfections, as previously described, allows more accurate measurements of a given matrix for melting points, lattice parameters, electronic behavior, thermal conductivity, etc. Novel and previously undetected qualities have been discovered when materials were sufficiently pure. Elimination of impurities that caused brittle films of a second phase in the grain boundaries led to unexpected ductility in chromium. Reduction of the impurity level in iron resulted in a corresponding reduction of the solubility of oxygen and hydrogen in this metal. Recognition of research needs for ultrapurity requires an appreciation of the fact that trace amounts of imperfections can cause faulty conclusions in experiments designed for the study of the solid state.

The observable properties of a solid are determined by the arrangement of the electrons about the nuclei and the resultant binding energies. The tools employed to study this nuclear-electronic framework include measurements of magnetothermal oscillations, cyclotron resonance, Hall effect, and magnetoresonance. Each of these processes is involved with the motion of electrons in the crystal lattice. The paths of these electrons are described as "random diffusion" because of their erratic directions resulting from imperfections and from thermal imbalances. The random effect of these paths is reduced as the imperfections are depleted. Thus, as the crystal becomes more and more perfect, the paths of the electrons become more controlled by the effects of the crystalline fields. It is precisely these effects upon the electrons which are measured by the solid state scientists, and any contribution by random motion decreases the accuracy of their data. The three types of imperfections which interfere with these measurements are structural defects, thermal vibrations, and impurities. The structural defects are reduced by growing nearly perfect single crystals; the thermal vibrations, by conducting the investigations at temperatures near absolute zero; and the impurities are eliminated by removing them bodily from the solid matrix.

This discussion will be restricted to the removal of extraneous materials from a given matrix

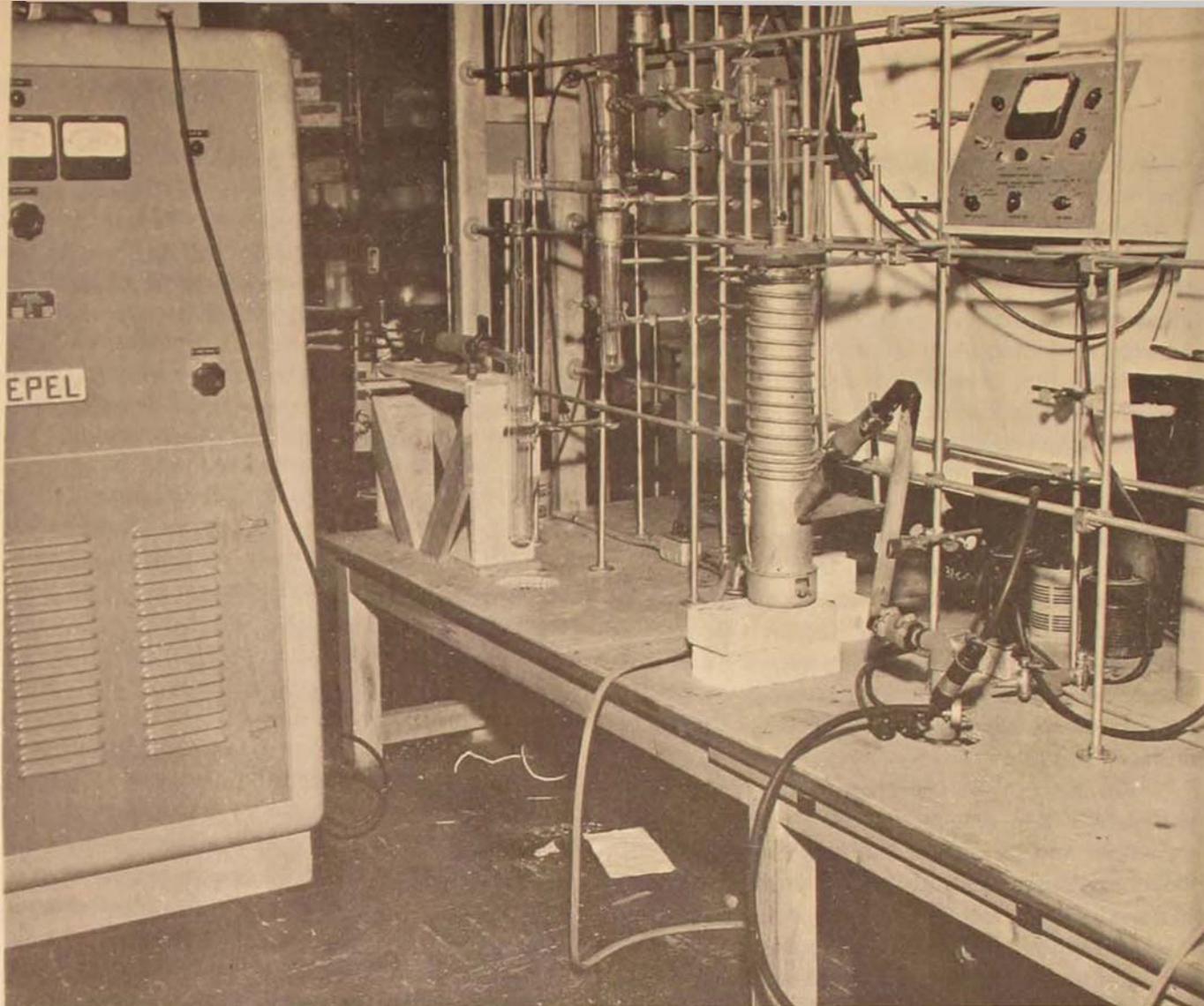
and analytical techniques for confirmation of this purity. The science of crystal growth, which seeks to minimize structural defects, will not be discussed, but it must be remembered that attainment of true ultrapurity hinges on the treatment and preparation of the refined material.

purification techniques

In recent years several new techniques for purification have been proposed and have been applied to a variety of materials. However, there has been a tendency to underestimate the effectiveness of older methods, such as distillation. Most general purification methods employ variations in physical characteristics rather than chemical changes, although specific chemical reactions are useful in certain instances. In the ultrapurification of elemental materials such as boron and silicon, it is usually necessary to convert the element into a compound (intermediate) in order that a purification technique or series of techniques can be applied to it. At least four intermediates were used in the ultrapurification of silicon for semiconductor use: SiH_4 , SiCl_4 , SiI_4 , and HSiCl_3 . Most organic materials having a relatively low molecular weight can be purified directly, as can most metal salts and oxides. The highly complicated organic materials, such as those of interest in biological and pharmaceutical applications, represent a much more difficult problem, and in many instances ultrapurification has not been achieved. Much more work is needed in this area, particularly for the production of materials for research uses.

A variety of the methods presently used in purification procedures will be described, as well as some of the more promising methods that have had only limited application. The methods are divided into groups depending on the physical state or characterization in which the purification is achieved.

Vapor Phase Methods. These techniques rely on differences in vapor pressure between the major components and the impurities. The most useful of these is distillation, in which the equilibrium is between liquid and vapor. This is probably the most efficient and useful of all purification techniques in that it is simple, inexpensive, and effective. Many different types of distillation assemblies are available, from straight unpacked tubes to



Experimental continuous chromatograph for the purification of high-purity intermediates

exceedingly complicated assemblies, such as the Oldershaw column, which allow for better contact between the liquid and vapor. Since better purification is attained for near-equilibrium conditions, a high reflux ratio (ratio of material returning to the column to that taken off) is desirable. Many automatic distilling heads are available for this purpose. An additional advantage of distillation is that the efficiency of the process can be improved (up to a limit) merely by increasing the height or number of plates in the column, thus eliminating the need to transfer the purified material before additional purification can be applied—a procedure that is required in almost all other purification techniques. In addition, distillation can be easily scaled up to produce large amounts of purified materials.

The main disadvantage of distillation is that the material to be purified must be a liquid which is stable to its boiling point. Since most efficient distillation equipment is made of glass (Pyrex), a fairly low boiling point is desirable. Distillation, naturally, can be applied even to high-temperature materials (yttrium, for example), but for them a much less complex and efficient system must be used.

A second purification method involving the vapor phase is sublimation. In this process the starting material and product are solids which are transformed through the vapor, generally without passing through a liquid phase. A solid with a fairly high vapor pressure is needed for this process. The apparatus for this technique is usually quite simple,

often consisting only of a heated portion of a tube where the starting material is placed and a cooled portion of the tube where the vaporized product is condensed. Sublimation may be carried out either in vacuum or in an inert gas stream. The purification, as in distillation, is a function of the difference between the vapor pressure of the principal constituent and that of the impurities; here the matrix material has a higher vapor pressure than the impurities. More refined and efficient sublimers have been constructed. However, since sublimers in general are not as efficient as distillation stills, a wider variation of vapor pressures is necessary in order to achieve a satisfactory degree of purity. The fact that the final product is a solid makes this method generally inapplicable to flow systems. Also, sublimation is usually a single-stage process because of the difficulty of transferring a solid product. In general, this process is applied only where distillation cannot be used.

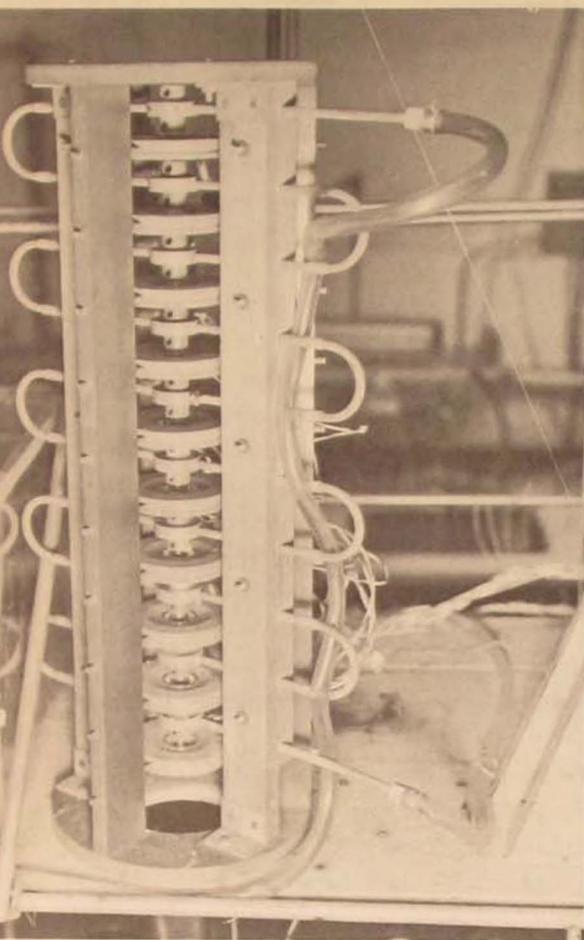
The vacuum melting method is similar in theory to both of the preceding methods, with the exception that the principal component has a lower vapor pressure than the impurities; hence the latter are pulled from the melt into the vapor phase to a greater extent, thus improving the purity of the melt. Of the three vapor methods discussed, it is significant that only distillation is effective in removing impurities with either lower or higher vapor pressure than the major component.

Liquid Phase Methods. Three methods used fall in this category, solvent extraction being probably the least important of the three. In this process a material is dissolved in one liquid phase and agitated in the presence of a second phase, in which the impurities are more soluble than in the first liquid. The major constituent should have a minimum solubility in the second phase. The degree of purity is the ratio of solubilities in the two phases. Several types of continuous countercurrent extractors are available. In spite of this, solvent extraction is of limited use as an ultrapurification procedure for several reasons. To use this method, large amounts of highly purified solvents must be employed because of the limited solubility of many materials. Final separation of the purified material from an occluded solvent can also be a major problem. Selection of the proper solvents adds to the difficulty of the process.

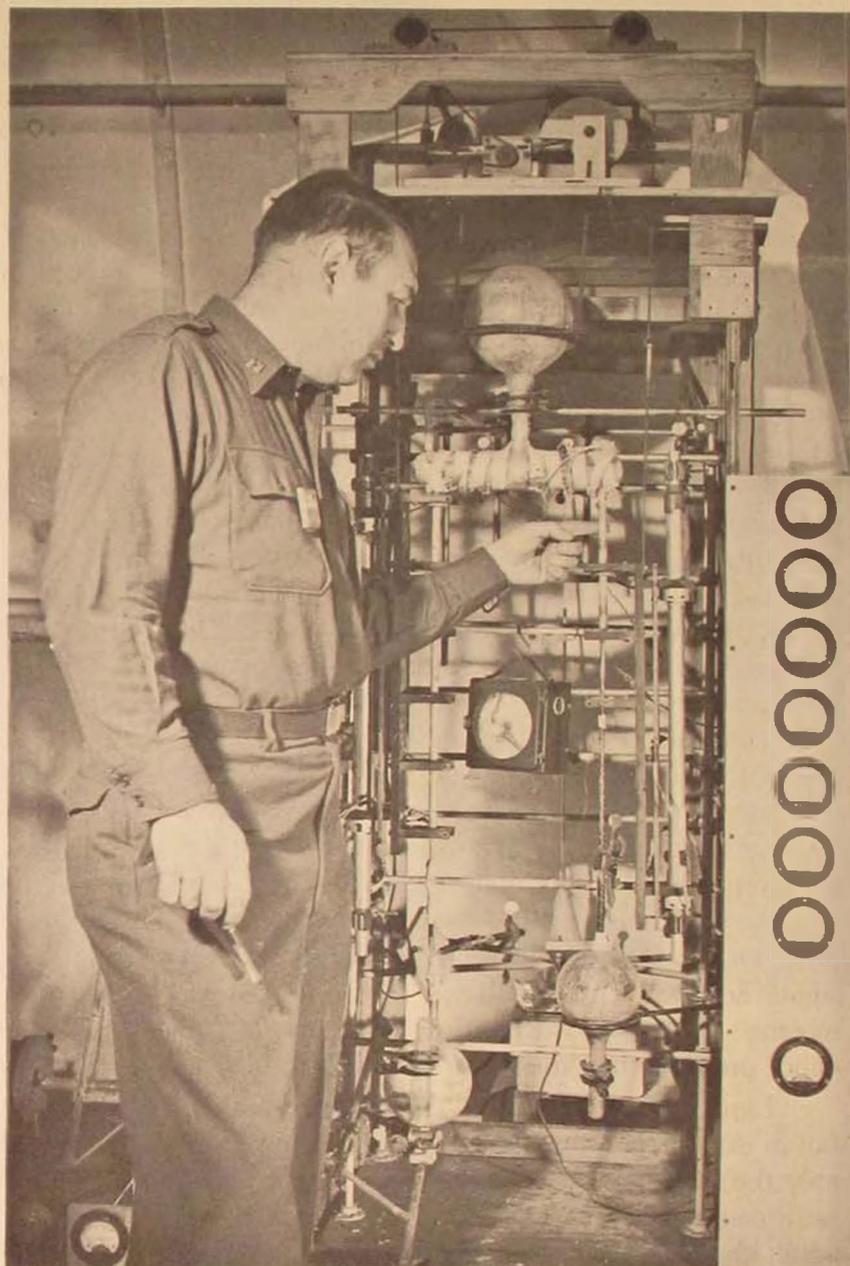
Recrystallization, usually done from an or-

ganic solvent, is a purification method that often has the advantage of producing crystalline material, when this is desired. In order to apply this method, the material must be significantly more soluble in the solvent at elevated temperatures than at lower temperatures. The material to be purified is dissolved in the solvent at an elevated temperature and slowly allowed to cool. On cooling, the product precipitates out of the supersaturated solution, while the impurities remain in the solution. For crystal growth, slow cooling is necessary. Slow cooling is also advantageous for purification, since this allows the crystallization to occur slowly, thus minimizing, but probably not eliminating, the danger of solvent occlusion. Selection of the proper solvent is important here because if the material is soluble in the cold solvent a large percentage of the product will not be recovered.

Zone refining is the most widely used of the liquid phase techniques where high purity is desired. This fairly recent development has been widely described in the literature of ultrapurification. The technique can be applied to any material which has a definite melting point, stability at the melting point, and a fairly low vapor pressure. The principle involved is the difference between the solubility of the impurities in the matrix material when it is in the solid state and when it is in the liquid state. The procedure is quite simple in that a molten zone, or series of molten zones, passes through a solid ingot. Ideally, in most cases, the impurity is more soluble in the liquid phase, which is swept along to the end of the ingot. The opportunity of running any number of molten zones through the ingot is obvious. The procedure is also automated quite simply. Many zone refiners are available, using anything from resistance heaters to electron beams. Float zoning, done in the vertical position, allows zoning to be performed without the use of a container; this is a definite advantage where ultrapurity is desired. Zoning has the disadvantage of being a batch process, although there have been some efforts to produce a continuous system. Also the pure material is often limited to a small portion of the rod, which again limits the useful yield. The process is effective only where impurity solubility in the liquid is about twice that in the solid. As this last factor applies to a majority of impurities, zone refining is applicable to a large number of materials.



Water-cooled vertical zoning apparatus



Laboratory-scale continuous-void zone refiner

Adsorption Techniques. The term "adsorption" may be somewhat too inclusive in this context, since in some of the techniques discussed other criteria, such as trapping or chemical reaction, are also significant. Ion exchange, the first technique of this class, depends on the exchange between ions in a solution to be purified, with different ions contained as part of a resin in a column. Thus, in water purification a resin containing some hydrogen exchanges the hydrogen for the metallic ions in the

water as the water passes through the column. In another application, for rare earths, a copper-loaded resin column is used. Different equilibria are set up between the copper and the various rare earth ions in the solution, causing the rare earths to travel at different rates through the column. This produces relatively pure bands of individual rare earth ions, which can be separated or eluted out from the column. The method is quite effective but requires the use of large amounts of high-purity

solvent and related chemicals, besides being a fairly slow process.

Vapor phase chromatography relies on differential solubility of a major constituent and its impurities in a solvent supported on a large area substrate within a column. Although developed as an analytical tool, it can be a useful preparative tool, particularly for organic materials. Present chromatographs are useful for processing only small amounts of materials, but efforts are being made to scale up the process.

Molecular sieves are applicable to gas purification only. Here a gas is passed through a bed or tube of a solid adsorbent having a large number of very fine micropores in the structure, which allows only gases of small-molecular diameter to pass through, holding back the large-diameter gases. This is quite useful for the purification of hydrogen and helium.

Electrical Methods. Electrolysis, either in aqueous or fused salt solution, is the most important of these purification techniques, but even this method has not gained significant popularity as an ultrapurification procedure. Probably the expense of the process is a factor, although the necessity for pure, unreactive electrodes and solutions may be an additional factor. Fused salts are even more difficult to obtain in a high degree of purity, which limits their application. Electrophoresis, based on the movement of colloidal particles in an electrical field, and electrodialysis, depending partly on diffusion through a membrane under an electric field, are methods which at present are only in the development stage. However, electrodialysis has been used for saline water conversion.

Other Methods. This section deals briefly with certain methods which, although old in principle, have not yet reached the stage where they are widely acceptable. Thermal diffusion methods rely on the difference in diffusivity of materials through a temperature gradient. Either a gas or a liquid solution can be purified by this method. While this method has been somewhat utilized, it is very slow and produces only small amounts of materials.

Clathration involves the use of cage-like chemical compounds (clathrates) to selectively trap certain compounds but not others. The lack of selectivity, as well as the cost of the reagent, limits the usefulness of this technique. Clathration can be considered a part of the larger technique of adduc-

tive crystallization, which embodies the addition of a compound to a melt or solution, forming an adduct with certain compounds in the solution and causing them to precipitate out. Foam fractionation or separation is a technique in which bubbles are passed through a solution, forming a foam. Since some impurities tend to accumulate at a gas-liquid interface, the impurities are swept upward into the foam. Also being investigated is microbiological separation, a technique based on the tendency of certain microbes to react with specific chemicals.

There are certain general considerations involved when any purification technique is to be applied. First, the container presents serious problems wherever ultrapurification is desired. Consideration must be given to the possible reactivity and leaching of both major and minor constituent materials from the container into the purified product. This problem is important because high-purity container materials are almost nonexistent. There is a tendency to attempt to predict the theoretical efficiency of purification procedures by use of available thermodynamic and experimental data. This is a very risky procedure, since often the equilibrium conditions required for thermodynamic calculations are not present in the experimental procedures. An additional factor, the possible interaction between impurities, can complicate the calculations.

A final general problem is that of analysis, which is discussed in the following section.

analytical techniques

As has been pointed out, the characterization of impurity levels in materials has two aspects: one is the more familiar chemical approach, and the other is the concept of physical perfection. In formulating a definition of purity of a material, one must first specify its use. This discussion of analytical methods will be limited to the qualitative and quantitative estimation of trace amounts of chemical impurities in solid materials.

In general, the level of impurities that falls within the realm of trace analysis is the part-per-million range or less. A large number of techniques are useful in trace analysis; however, no single method has been developed at the present time which can provide a complete analysis of all possible impurities. The techniques finally employed



for analysis are based upon a number of considerations, such as sensitivity, speed, coverage, sample size, destructive versus nondestructive methods, bulk versus surface impurities, instrumentation and manpower required, and prerequisite chemical handling. Since a trace is defined in the present context as one part per million or less, it is clear that the single most important quantity is sensitivity. Let us summarize a number of the more important techniques for the analysis of traces of elements in solids.

Emission Spectroscopy. One of the oldest and most universally used methods of impurity detection is emission spectroscopy. A sample is placed in an arc or spark discharge between two electrodes, the atoms are excited, and characteristic radiation of the unknown elements is emitted. This radiation is resolved into its component wavelengths, either by passage through a quartz prism or by refraction from a ruled grating. These wavelengths are usually recorded as lines on a photographic plate; each atom is thus associated with a characteristic group of lines. Usually, two lines are sufficient for a positive qualitative identification;

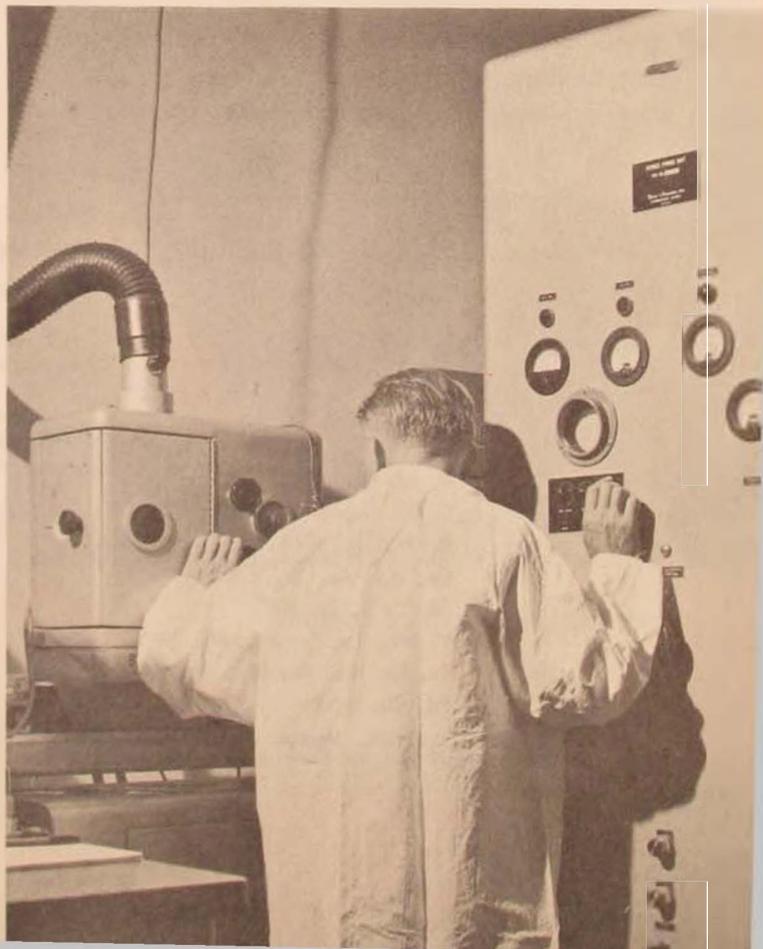
and comparison of the intensity of the lines with known standards enables a quantitative analysis to be made.

Because of its relative simplicity, sensitivity, and ability to provide qualitative information quickly, emission spectroscopy is used widely in both industrial and academic problems. Indeed, for a number of years the sensitivity of the emission spectrograph was considered to be greater than that required by almost any of the technical fields in which it was applied, and the term "spectroscopically pure" was a superlative to indicate near perfection in the achievement of purity. Developments in semiconductor technology have brought about purity requirements that have tempered this view. Depending on the particular impurity and the matrix material, the limit of the concentration sensitivity is about 0.1 ppm.

Emission spectroscopy has a number of advantages. As compared to classical wet analysis, it is more sensitive to trace analysis, nearly free of interferences, more rapid, and, in general, provides additional qualitative information even when used for specific quantitative determinations.

Apparatus used for the decomposition of high-purity intermediates

Analysis by emission spectroscopy



A disadvantage of this method is the requirement for standard emission spectra of all the elements being investigated for comparison purposes, and sometimes these are difficult to obtain. Furthermore the complexity of the spectra produced, when several impurity elements having similar concentrations and atomic numbers are present, makes the analysis somewhat difficult.

For the detection of trace quantities, 10 ppm or less, using existing equipment and techniques, the elements amenable to emission spectrochemical analysis are given in Table II.

As can be seen, some 70 elements can be detected and estimated, the notable exceptions being the halogens, sulfur, selenium, and the inert gases.

Some improvement in the sensitivity can be obtained by the chemical preconcentration of the sample, but this usually involves a risk of contamination.

Mass Spectroscopy. Another important tool in the ultra trace analysis of solids is the mass spectrograph. There are four distinct mass spectroscopic methods of impurity detection: (1) vacuum spark, (2) bombardment, (3) isotropic dilution, and (4) total vaporization.

The vacuum spark method has a broad range of general applicability for solids. In this method, ions are produced by a pulsed high-frequency spark between electrodes of the material to be investigated. After acceleration in an ion gun, the ions produced are separated by passing them

through combined electrostatic and magnetic fields. The relative deflections of the ions are determined by their respective e/m ratios, where e is the charge and m the mass of the ions. The ions having the same e/m ratio can then be focused and detected either by electrical means or on a photographic plate. Since the ion beam is inhomogeneous in energy, a spark source can be used only with a double focusing type of spectrometer.

Samples of convenient size for analysis weigh about 1 mg. Nonconducting solids may be analyzed with sensitivity equal to that of conducting materials by packing them in a conducting tube or by mounting them in thin sections against a conductor. Surface impurities of as little as 0.1 monolayer may be detected by studying the spectrum as a function of time.

The spark method is quite analogous to emission spectroscopy in that it is a general method of analysis; that is, it determines almost all elements in a single experiment. It has the advantage over emission spectra in that, within a factor of about ten, most elements have the same sensitivity. If chemical preconcentration is not used, the sensitivity of mass spectrometry is usually superior to emission spectrometry.

The sensitivity of the method for those substances not normally gaseous is about 0.1 ppm. (See Table III.) Because of the difficulty of ensuring a sufficiently good vacuum and the resulting presence of H_2O , C_nH_m , N_2 , O_2 , etc., in the vacuum

Table II. Applicability of Emission Spectroscopy to Trace Analysis

<i>Applicable</i>	<i>Marginal</i>	<i>Not Applicable</i>
Li, Na, K, Rb, Cs	F, lanthanides* (atomic numbers 51-71)	H, He, Ne, Ar, Kr, Xe
Be, Mg, Ca, Sr, Ba	Actinides (atomic numbers 89-102)	Cl, Br, I, At, Rn
B, Al, Ga, In, Tl		O, S, Se, N
C, Si, Ge, Sn, Pb		
P, As, Sb, Bi, Te		
Cu, Ag, Au, Zn, Cd, Hg		
Sc, Y, Ti, Zr, Hf		
V, Nb, Ta, Cr, Mo, Mn, W		
Re, Fe, Co, Ru, Rh		
Pd, Os, Ir, Pt		

*Note: Recent work indicates that the lower limit of sensitivity for the rare earths is not as poor as once believed.

system, the concentrational sensitivities are poor for such impurities as H_2 , C, N_2 , and O_2 . It has the additional disadvantage that, for quantitative evaluations, prepared standards must be employed.

Radioactivation Analysis. Impurities or trace elements in solid samples may also be determined by activation analysis. Basically, this is a method of making qualitative and quantitative elementary analyses by means of nuclear transmutation. When a material is irradiated by nuclear particles produced in a nuclear reactor, particle accelerator, or some other source, some of the atoms in the material interact with the bombarding particles and are converted into different isotopes of the same element or into isotopes of different elements; the conversion depends on the nature of the bombarded material and the bombarding particles. The radioactivities so produced can be characterized according to the radiation emitted (α , β , γ) as well as by the energies and halflives of these radiations.

Table III. Typical Detection Sensitivities—Solid Spark Source Mass Spectrography

Graphite Matrix

Of 71 detectable elements:

- 41 are detected at 1 ppb or less
(e.g., U, Bi, Eu, Sb)
- 21 are detected at 2 to 10 ppb
(e.g., Ta, Hf, Sn, Mo)
- 3 are detected at 20 to 100 ppb
(e.g., Ge, Ti, Mg)

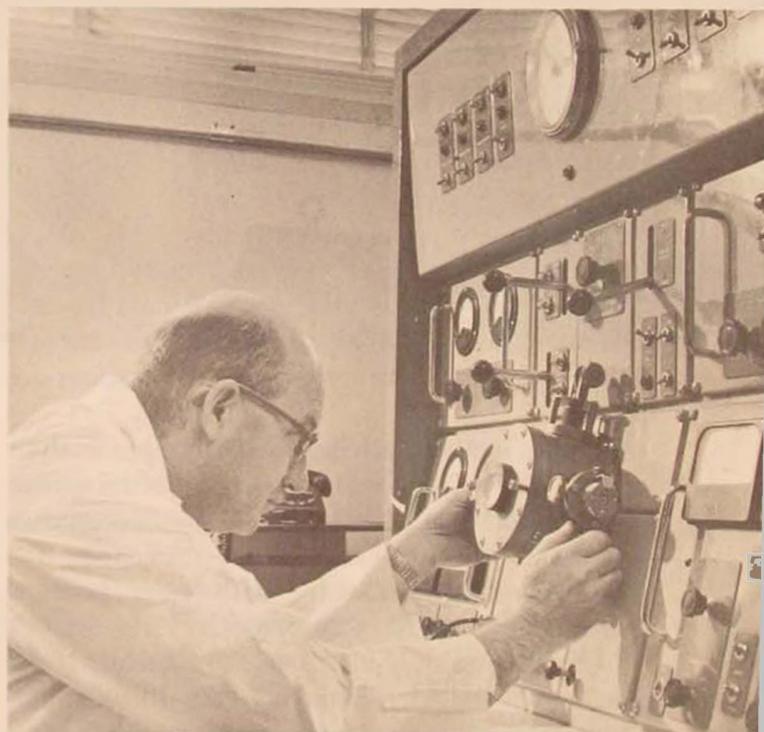
Thus, from a knowledge of the nuclear characteristics, a quantitative assessment of the impurity content is possible.

In practice, the sample is exposed to a flux of activating particles, which may be neutrons, protons, deuterons, tritons, helions, or even high-energy gamma photons. If the particle is of the proper type and energy, some of the atoms will undergo transmutation and become radioactive. The quantity of impurity that is present can then be determined from the decay curves recorded from measurements of the activity.

This technique has a number of advantages.

There is no interference from the matrix; thus sample preparation and handling are greatly simplified. It has a sensitivity range of 0.1 ppm, is essentially a nondestructive technique, and can be very selective, especially when a variety of subatomic particles and detection devices is available. It also can be quite general in its applicability. Thus far, it has been used in determinations for 72 elements with thermal neutron bombardment.

Unfortunately, the determination of an isotope concentration is complicated by uncertainties connected with the irradiation and also by a number of corrections which have to be applied to the counting rate measurements. The situation may be further confused by the activation of different impurity elements, which may necessitate a chemical separation of the stable isotopes. By concentrating a particular element after irradiation, however, we can remove the interfering activities and efficiently count the desired impurity.



Analysis by mass spectroscopy

Table IV. Comparison of Analytical Techniques

<i>Method</i>	<i>Medium Sensitivity</i>	<i>Accuracy (percent)</i>	<i>Elements Determinable</i>	<i>Analysis Time (days)</i>
Radioactivation	0.1 ppm	10	50-70	2-5
Emission spectroscopy	1.0 ppm	25	70	1-3
Mass spectrography	0.01 ppm	100	70-90	1-3

The time required to isolate individual radioelements, in order to achieve maximum sensitivity with the technique, limits its usefulness to the determination of only a few elements in a given analysis. Also, the dependence on a nuclear reactor for maximum sensitivity somewhat restricts its use to that of a research tool.

Table IV gives a comparison of the attainable results with activation analysis, mass spectrography, and emission spectroscopy.

A number of other techniques are useful in trace analysis, but they do not have a wide range of applicability. Flame photometry has been useful in the trace analysis of the alkali and alkaline earth elements, and it has been extended to others. One disadvantage is that the impurities must be present in solution. Also, conventional instruments limit the technique to the determination of one element at a time.

Colorimetry and, in particular, spectrophotometry have been valuable in trace-element analysis. However, the methods are generally time consuming, and the material is subject to contamination and loss when very low concentrations are involved.

X-ray methods are important in trace analysis because they supply information that often cannot be obtained by other methods. X-ray fluorescence is particularly useful, and, where applicable, it is selective and fairly sensitive, with limits for many elements down to 10 to 20 ppm.

Polarography is also a useful method. It depends upon the measurement of the diffusion current corresponding to the deposition of reducible ions from solution at a suitable cathode, such as the dropping mercury electrode. With modern instruments such as the cathode-ray Polarograph and the square wave Polarograph, very small currents can be measured. Since the ions of different elements are reduced at different cathodic poten-

tials, this technique provides a reasonably specific method for the determination of very small quantities of trace materials.

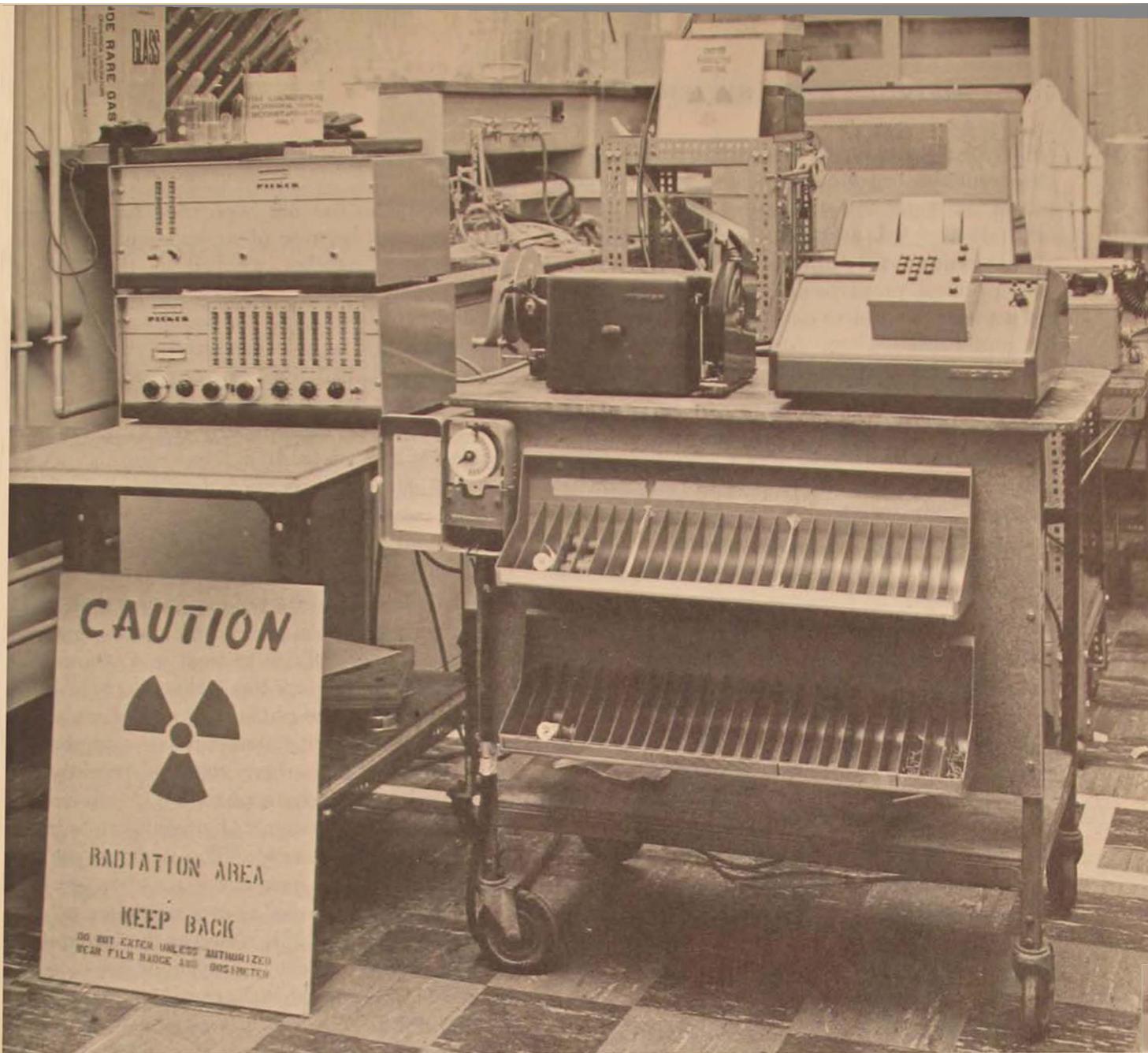
Chromatography is an important tool in many applications of trace analysis. It is useful with all kinds of soluble and volatile substances. Essentially it is a differential-migration method of analysis in which flow of solvent or gas causes the components of a mixture to migrate differentially from a narrow initial zone in a porous, sorptive medium. It has a number of modifications. In spite of its usefulness in trace analysis, this method does not serve directly for the detection or estimation of substances. Its principal service is the resolution of complex mixtures.

In this brief survey of trace-element analysis of solids, only a few of the large number of analytical techniques have been mentioned. Those discussed have demonstrated a general applicability. However, it must be emphasized that no one technique will solve all problems. By the proper use of combinations of techniques, it is possible to advance our knowledge of the properties of high-purity materials and their preparation.

uses of ultrapurity

We shall present now a brief account of some specific examples of ultrapurity so as to draw attention to the kinds of useful results which may be obtained. Examples will be cited to show the role of ultrapurity in biochemistry, elemental metals, alloys, refractories, semiconductors, and research materials.

In Biochemistry. Selenium is directly under sulfur in the periodic table of elements, and as would be expected the physical and chemical properties of the two elements are strikingly similar. Despite this chemical similarity, sulfur and selenium often show a pronounced biological antago-



Computerized monitoring of a purification system

nism to each other. The deleterious effect of selenium has been emphasized in the past; in fact, the laws of several nations require that foods contain "no" selenium.

It has been discovered, however, that selenium does exist in trace amounts in almost all beneficial foods. The aforesaid laws had been enacted prior to the development of analytical techniques sensitive enough to detect such trace amounts. This lack of technique may have been fortunate because in the past 25 years it has been determined that selenium is needed to prevent nutritional deficiencies.

Although selenium in large amounts progress-

es with sulfur in its metabolic channels, evidence shows that it follows its own metabolic route when provided in small, physiological levels. The combination of spectroscopy, radiography, and paper chromatography as analytical tools has enabled investigators to determine that, for normal sheep, selenium is present in kidney and liver tissues at concentrations of 0.25 to 2.25 ppm. In sheep afflicted with a nutritional deficiency, this concentration is reduced by approximately one-half.

The problem resolved itself into determining what end product contained the small amount of selenium. This determination hinged upon the

ability of researchers to remove the selenium species from the organic matrix, the selenium compound being present at a level of less than 1 ppm. Separation of this assimilated selenium presented a real challenge for ultrapurification. The physical and chemical properties of selenium compounds did not lend themselves easily to general techniques for purification. These compounds were usually volatile, and they reacted readily with sulfhydryl groups.

Over a period of years several tons of brewer's yeast, kidney, and casein digest were digested by sulfuric acid hydrolysis. More than four thousand fractions were prepared in the laboratory. These thousands of fractions, when combined, were refractionated, and a selenium compound was extracted.

An ingredient, a selenium organic compound, was separated and identified, but it still has not been isolated from the remainder of the matrix. The compound, called Factor 3, was so named because it became the third known agent required for proper nutrition. The other two factors are vitamin E and L-cystine. Without these three agents a dietary liver necrosis develops.

As a result of these studies on the removal of a trace amount of a specific compound of selenium, the principles of nutrition are today better understood, and nutritional diseases can be more intelligently treated.

In Elementary Metals. As mentioned previously, advances in purification of true metals have not kept pace with those in semiconductor materials. Purities in the range of a part per million are just now being achieved, and the obvious properties being investigated are those which affect the structural worth of these materials. Numerous contradictory data have been published regarding these properties. Without a detailed analysis of these studies, it may be said that the results must be accepted with some reservation. The principal reason for this inconsistency is that one investigator may find the effects of the carbon content on the mechanical properties of a metal while another finds the effects of the hydrogen content, but very likely the other impurity contents are vastly different in the two samples.

It has been found that at 100°C aluminum has a deformation recovery rate of 99.9986% (14 ppm impurity), at least 2000 times as rapid after

cold-working as aluminum of 99.996% (40 ppm impurity).

Chromium has not been used for high-temperature work because of its apparently inherent brittleness. Chromium, purified by the National Bureau of Standards, was further purified by making and decomposing an iodide-intermediate. This highly purified sample exhibited a low nitrogen content which had not been originally achieved. The resultant material exhibited a markedly improved ductility; consequently the exploitation of chromium as a useful high-temperature structural material now depends upon developing an industrial process for preparing the metal in an extremely high purity, especially so far as nitrogen is concerned.

In Alloys. The effect of impurities on the physical, chemical, electrical, and magnetic properties of alloys is very difficult to treat in a quantitative manner. One reason for this is that stoichiometry is not assured, and the phase diagrams of some two- and three-component systems are very complicated.

However, it has been reported recently that superconductivity characteristics are affected by introducing small amounts of zirconium into highly purified niobium stannide. The niobium stannide in a highly purified form has a transition temperature (that is, it changes from a superconductor to a conductor) at 17.82°K. whereas the introduction of 0.75 atomic percent of zirconium enhances the material to the point that the transition temperature is at 17.88°K. Although this is an example of adding a material, it illustrates the effect of an impurity on the electrical and magnetic properties of an alloy. In this example it was desired to find a composition which would produce superconductivity at higher temperatures.

In Refractories. Undoubtedly among the most difficult substances to obtain in a highly purified state are certain kinds of ceramic materials. These materials are stringently defined as inorganic, non-metallic substances. However, semiconducting elements such as silicon and germanium are often considered separately, even though they fall into this class by strict definition. Refractory materials are usually ceramic in nature and are categorized by their difficulty to fuse, reduce, and cold-work, and often by their high heat resistance. Occasionally a nonceramic material apparently displays these traits, as mentioned earlier in the discussion of

chromium. As happens with chromium, ultrapurification often alters the properties of these exceptions.

Few ceramic materials are available with foreign atom concentrations less than 100 to 1000 ppm. The successful operation of a laser or maser depends upon excitation of impurity ions by electromagnetic radiation in a single crystal which serves as a resonant cavity. In the ruby ($\text{Al}_2\text{O}_3:\text{Cr}^{+3}$) laser, it is necessary to prevent an excess of Cr^{+3} ions, which would make it difficult to get the correct organization of excited ions to produce laser transition. Hence, laser operation depends upon preparation of single crystals of host materials with controlled purity and structural perfection.

By a water extraction technique, ammonium alum, the starting material for growth of ruby crystals, was purified to a level of about 50 ppm, boron, calcium, chromium, iron, and manganese being the principal impurities. The use of a prepurified starting material and methyl alcohol as the solvent allowed for the reduction of impurities to about 10 ppm. With this technique all chromium and copper was reduced to less than a-part-per-million concentration, but the yield was only about one-third as high as in water extraction.

With prepurified starting material there is a better possibility of growing ruby crystals doped with ions at the required concentration and with the specified distribution in the host ruby lattice. Such a crystal is needed to provide an efficient laser with minimum line spreading in its spectrum.

In Semiconductor Materials. The story of the growth of the electronics industry from the time of the discovery of the transistor is common knowledge. Certainly the primary impetus for the development of ultrapurification techniques has been the need for semiconductor materials of near intrinsic purity. The manufacture of the multitude of devices by the electronics industry during the past two decades has hinged upon provision of such materials.

Development of the technique of zone melting has been an outstanding advance in the science and technology of materials. This process assured the provision of ultrapure materials and provided for a technique of introducing controlled amounts of impurities into the purified matrices.

The purification of germanium and silicon for use in the semiconductor industry is an example of

the progress achieved through zone melting. By passing molten zones (caused by slowly moving heaters) through the length of an ingot of germanium many times, it is possible to obtain the material in a purity that defies detection of any foreign atoms. This purity range is less than a part per billion of all impurities.

Such purity is approached but not quite achieved in silicon. Because silicon melts at a considerably higher temperature than germanium (1420°C versus 958°C), there is a tendency to leach impurities from the container (usually quartz). Furthermore, certain impurities, chief among which is boron, do not separate from the silicon nearly as efficiently as from the germanium. These problems have been solved by using a technique known as "float zone melting" in which no container is required. At the same time a reagent is introduced in small concentrations to react with the trace boron in the molten zone and convert it into a volatile compound which is immediately boiled off. By such techniques it has been possible to prepare silicon with impurity levels below the part-per-billion range, and these concentrations have been confirmed by neutron activation analysis and by electrical measurements on the bulk material.

In Research Materials. In some respects "research material" is an ill-chosen term because these materials cannot be categorized by characteristic intrinsic properties as can metals, alloys, biochemical agents, semiconductors, etc. In fact, research materials include representatives from each of these categories, and the term specifically refers to a material prepared in such a way as to render it particularly susceptible to measurements for the interpretation of the fundamental structure of matter.

The synergism of materials research is typified by the study of germanium for structural imperfections, such as atomic dislocations. These defects have been revealed in the form of etch pits and interpreted by their effects on the electrical properties of the material. Properties such as ductility, yield strength, plastic deformation, etc., are not of particular significance so far as the use of germanium is concerned, but they are extremely important in structural metals. As mentioned previously, it is impossible to prepare metals with chemical purity sufficient to attribute changes in properties exclusively to physical defects. Germanium can be

prepared with such purity by the zone melting technique. Furthermore the movements, interactions, and changes of the lattice defects in germanium can be detected and traced by the unusual effect of causing large changes in electrical measurements. These measurements are made on the germanium when it is being subjected to controlled external physical stresses. These experiments provide an excellent means for studying the influence of defects on the properties of solids in general.

Germanium purified to a level of 1 ppb or less was subjected to plastic deformation, and the crystals began to yield at stresses less than one-thousandth the theoretical strength of the perfect crystal. The actual dislocation defects in the crystal were made visible by careful etching techniques. Three types of defects noted were surface, edge, and screw dislocations. The motion of dislocations through the crystals was followed both by etching techniques and by the changes in the electrical properties of the germanium. Such electrical properties as Hall effect, lifetime measurements, and mobility of carriers were found to be sensitive to the formation and slippage of the dislocations. It was possible to deduce a theory to explain the source of dislocations, their interactions with other defects, and their effect on the properties of the material. Although these observations were carried out on semiconductor materials, their interpretations can also be applied to metals and other classes of solids. On this basis a theory can be offered to explain the improvement of the properties of metal resulting from metallurgical operations such as cold-working, alloying, annealing, and growth of whiskers. Although these techniques have been a part of materials technology for a long time, they can now be explained quantitatively, and an intelligent estimate of the necessary treatment of new materials can be made.

Several other examples of ultrapurity requirements and effects in research materials follow.

High-purity copper in single crystal form is needed for the study of the fundamental electronic properties of metals. Copper has been used in magneto-resistance studies to determine Fermi surface shapes because the band structure of copper was one of the first to be satisfactorily interpreted and because copper was the first metal for which these measurements offered satisfactory interpretation of the Fermi surface.

As explained earlier, it is necessary to have material as near to intrinsic purity as possible for these studies so as to minimize the "random diffusion" of electrons in the crystal field. Copper for these experiments has been prepared by pulling single crystals from a melt while permitting a small amount of oxygen to remain in the ambient atmosphere. The oxygen evidently reacted with trace amounts of iron and chromium impurities in the melt, thereby preventing their accommodation in the copper crystal as it grew, much as ultrapure silicon is prepared by oxidizing the trace boron. By this technique, copper crystals with resistance ratios of between 4000 and 10,000 have been prepared, as compared to the maximum ratio of 2000 for previous efforts.

With such crystals it has been possible to describe the path and energy of a free electron in solid copper.

Another example of the effect of impurities on a research material is in the effect of radioactive bombardment on solid materials. Relatively low-energy radiation is employed to determine the displacement of atoms from their sites in a lattice or to investigate the effect of radiation on defects in the lattice. Certain impurities, such as carbon in a platinum matrix, lead to faulty interpretation resulting from absorption of the emitted radiation by carbon atoms and their subsequent movement, thereby leaving vacancies behind, or even their colliding with platinum atoms and causing disarray of the crystal lattice. These effects cause a misinterpretation of threshold energies for the specific radiation. The two possible solutions for this problem are to work with higher-energy radiation or to remove the impurities from the matrix. In studies made on platinum foils, the carbon content has been reduced by a factor of about six as a result of vacuum baking.

Work on the semiconducting properties of the organic material phenanthrene has led to the observation of a break in the plot of resistivity against temperature. This discontinuity in resistivity is not observed in the crude material, but as the purity is enhanced by zone refining the discontinuity becomes more apparent. Thermal analysis has demonstrated that the break is not due to a phase change, so it may be attributed to some impurity not removed by the zone melting. The next question to be answered is what the semiconducting tendency

of phenanthrene will be when and if this impurity is isolated and removed. Work is progressing on this problem at the present.

THE PURPOSE of this paper has been to emphasize the significance of ultrapurity in materials research and the critical role of materials research in the technical development of this nation.

The meaning of ultrapurity has been seen to vary with the purpose for which the material is to be used. Requirements run the gamut from inorganic reagents to pharmaceuticals, to structural materials, to electronic materials, and on to research materials. Concentrations of parts per million, or less, are generally indicative of ultrapurity.

Techniques for achievement of this purity usually depend upon one of a few basic principles, and refinements in these classical approaches are still the most dependable and superior methods of separation. Analysis and purification are interdependent; thus advances in the sensitivity and reliability of analytical techniques are required to confirm corresponding advances in the range of purity. The significance of ultrapurity is illustrated by the newly discovered properties of highly refined materials and by the fundamental information pertaining to the structure of materials which has been acquired from the study of ultrapure samples.

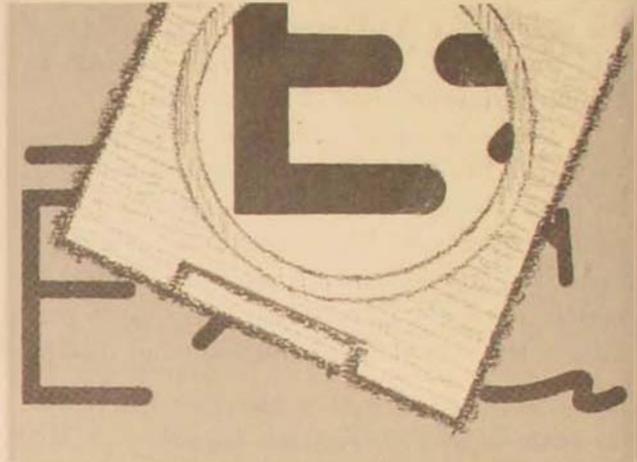
Air Force Cambridge Research Laboratories

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In My Opinion



FLEXIBLE RESPONSE vs. DETERMINED RETALIATION: A CRITIQUE

LIEUTENANT COMMANDER FORREST FORSYTHE, USN

IN THE January-February issue of the *Review* there appeared an article by Major General Dale O. Smith titled "Flexible Response vs. Determined Retaliation." In it General Smith outlined a "philosophy of persuasion" which he called "determined retaliation." This, he suggested, could profitably be substituted for what he called the philosophy of "flexible response" or "graduated deterrence." The ideas presented in the article merit attention and, it seems to me, some criticism.

Since there may be some who do not have access to the issue in which the piece was contained, I feel it necessary to attempt a summary of the General's position. Appreciating the risk in doing this, I can only ask his indulgence and invite his correction if I misstate his point of view.

General Smith's first point was that "massive retaliation" has become a discredited phrase; the terms "graduated deterrence" and "flexible response" have been substituted for it. He suggested

that, in order to avoid the bias associated with the words "massive retaliation," the phrase "determined retaliation" might be used instead. The meaning of "determined retaliation" he illustrated by using a parable concerning two ranches, the Lazy C and the Bar E. The Lazy C represented a state that we would normally think of as an aggressor, since it had begun, without justification, to run cattle on Bar E pastureland and pollute the Bar E water supply. The question he posed concerned the action which should be taken by the Bar E to ensure the integrity of its territory. To answer it he examined the consequences of two alternative courses of action by the Bar E. The first course was to follow a policy of determined retaliation; the second was to follow a policy of flexible response.

In following a policy of determined retaliation the Bar E would take over the Lazy C reservoir with a force large enough to convince the Lazy C that it had both the strength and will to remain

until the Lazy C vacated Bar E pastureland.

The result of this, the General argues, would be that "... if the Lazy C people are *well aware* of our superior strength and wealth, and if our demands do not threaten their *existence* or *prestige*, then only madness would lead the Lazy C to pursue the fight."

If, however, we (the Bar E) followed a policy of flexible response, the action would go something like this: "... we send an unarmed cowhand out to the disputed pastureland and instruct him to drive off the Lazy C cattle." The Lazy C, says the General, will probably then send a man with a gun to drive off our cowhand. We, the next time, send a man with a gun, and the Lazy C responds by sending two gunslingers. We retaliate with three and order them to shoot. The Lazy C brings up four.

"We have," argues General Smith, "encouraged escalation to limited war." The flexible response tactic could bring victory, but the process would have been painful and unnecessarily prolonged.

The General argues that if we have superior strength either strategy—determined retaliation or flexible response—can bring victory. The former is the one recommended by him because it serves "to persuade the Lazy C owners as *soon* as possible with as *little conflict* as possible."

The General then posits "three criteria for effective persuasion." The first is that the initial move by us must be in force in order to demonstrate "our superior strength and our confidence in that superiority." The second is that we must not threaten the "existence" of the enemy but only make it clear that he must vacate our land. Third, we must not "threaten his prestige."

In the General's view a policy of determined retaliation meets these criteria better than one of flexible response. He suggests, therefore, that our national strategy be re-examined on the basis of the three, asking "which strategy leaves us in the most favorable military disposition should our effort at persuasion fail?"

This seems to me a fair statement of General Smith's point of view. He has, of course, advanced arguments to support this view, but I do not believe it to be incumbent upon me to summarize all of them and thereby reargue his case for him. I should hope that my criticism of his position will stimulate readers to return to the original article, in

which his arguments are presented as he thinks best.

The first point to be made is that the General seems to have confused the issue by supposing massive retaliation and flexible response to be contradictory strategies. By doing this he has given to the term "flexible response" a connotation which is not justified. Since he argues that flexible response is not good strategy, it is necessary to sort out the confusion and also to ascribe the proper meaning to the phrase "flexible response."

To advocate a capability for flexible response means simply to advocate the proposition that there are some types of military actions which could be taken against us to which the proper response would not be massive retaliation against the enemy's homeland and military forces. Specifically, to believe in the need for a capability for flexible response is to believe that should Chinese-inspired and -supplied guerrillas infiltrate South Viet Nam, the proper response is *not* to vaporize China. Those who advocate a flexible response capability rightly argue that vaporization of China is a serious step and that any U.S. decision-maker might have some reservations about ordering it. These reservations could, in fact, be grave enough to dictate that it not be so ordered; in which case a prudent man would wish for some other military alternative for combating the infiltration. The existence of alternatives is what constitutes a capability for flexible response.

Although the General implies a contradiction, there is none in a situation in which one possesses a capability both for massive retaliation and for flexible response. The two capabilities, rather than being mutually exclusive, are complementary. In developing a capability for flexible response the United States has been rather careful to retain its capability for massive retaliation, lest that response in some eventuality become the appropriate one. It should be noted that SAC's capability at present is greater than it has ever been. As far as I know, no responsible official has ever suggested that we have no need for our massive retaliation capability. If, as the General suggests, the terms "graduated deterrence" and "flexible response" have been substituted for "massive retaliation," it is only in recognition of the fact that massive retaliation should constitute only one of a number of possible responses.

The General, furthermore, seems to equate flexible response with lack of determination when

he argues that "the 'flexible response' strategy inevitably results in using 'too little too late.'"

In point of fact, it is not at all necessary that flexibility should lead to lack of determination. Given the capability for flexibility, the response chosen can be as determined as is wished. In actuality, the converse of his statement is probably true: Only when options are lacking *need* there be a lack of determination. The wife who owns only an evening gown may hesitate about wearing it to luncheon engagements.

From this it seems reasonable to think that what General Smith is arguing for is only determination in responses. It seems unreasonable that he would wish to sacrifice flexibility and so be forced to unleash SAC's massive retaliation in response to any border crossing.

Assuming this to be the case, it should prove worthwhile to examine his position simply as an argument for determined military response at whatever level is appropriate.

If the logic of his argument is carried to its conclusion, it appears that the General has offered an attractive alternative to the apprehension, anxiety, fear, risk, and burden of international relations. His alternative is, in fact, so attractive that it merits close scrutiny. Its attractiveness becomes apparent if his argument is carried a step or two further than he has chosen to carry it.

He argues, in the Lazy C parable, that if "determined retaliation" is used, "only madness would lead [the aggressors] to pursue the fight." That is, if they are "*well aware* of our superior strength and wealth, and if our demands do not threaten their *existence* or *prestige*," they would have to be mad to pursue the fight.

Presuming that this is true, it must result that no further aggression will take place from the Lazy C. This follows because we must think that the Lazy C people, having correctly appraised the present situation and having acted rationally, rather than as madmen, would also do the same the next time a thirst for aggression arose. Being able to appraise situations correctly and being rational, the Lazy C would recognize that our response would again be determined and would, therefore, desist from any further adventures. By our first determined response we would have achieved, in respect to the Lazy C at least, a condition in which aggressive war was no longer a serious possibility. The

worst that might happen is that the Lazy C would change owners and the new ones, being not so experienced, might have to be taught the lesson again from the same text.

The extreme desirability of this state of affairs is precisely the thing which should engender suspicion of the logic which would supposedly make it possible. It is necessary to ask why, if the problem of aggression can be dealt with so simply, the strategy of determined response has not been adopted long ago.

The reason can be found in the assumptions upon which the logic is based. Many of them are probably valid, but some are not.

The first of those which are not valid is that we, the victims of aggression, are able to decide correctly upon the level of response which is required. We must objectively and dispassionately appraise the seriousness of the aggressor's move, unerringly appraise the strength of his resolve, decide how much force is required to persuade him to yield, and then apply precisely that level of force. This must be done while we at the same time take care that our response does not appear to him to be so great as to threaten his prestige or existence.

The second is that the aggressor must appraise the situation correctly. It must be assumed that he will have the correct facts as a basis for action and, furthermore, that he will then correctly evaluate these facts, recognizing our strength and wealth and recognizing also that our intent is not to threaten his prestige or existence.

Third, it must be assumed that, having correct and sufficient knowledge, he will then act rationally on that knowledge.

All three of these assumptions are manifestly unjustified. This is the root of the difficulty. States are not able to judge what level of response is necessary. Aggressors do not judge situations correctly. Rational action is not the strong suit of a state bent on increasing its territory.

It is quite easy to argue that the Allied Powers should have responded with determination to Hitler's first moves or to the Japanese thrust into Manchuria in 1931. Nevertheless, they did not. It appears undeniable that they "ought" to have done as General Smith suggests. For better or for worse, however, the game of international politics is not played with black and white chessmen. Any number of examples should come easily to mind.

Moreover, at least two conditions are necessary for the success of General Smith's strategy. The first is that we must actually have the capability to make a determined response. While the General sets as a condition the requirement that we possess superior strength and wealth, this is not in all cases the same as possessing a capability for determined retaliation.

While it is obvious that in respect to certain elements of national power the United States is supreme in the world, it is equally obvious that in respect to other elements it is not. It is readily apparent, for example, that the United States is not as well prepared to fight a guerrilla war in Viet Nam as is the Viet Cong. It is not a sufficient answer to say that we could, if we desired, mount a great enough effort of a more conventional sort to defeat decisively the North Vietnamese. I would suggest to whoever makes this answer that he count combat-

ready divisions and aircraft carriers and measure them against our other commitments. The French learned a painful lesson regarding the effort which is required.

The second condition necessary for the success of General Smith's strategy can be set forth quite succinctly. It is merely that the aggressor must refrain from also employing the strategy of determined retaliation.

The sum of these criticisms of the strategy of determined retaliation is, simply, that political man does not act in the way which is necessary for the strategy to succeed. Nations do not demonstrate the constancy of purpose, insight, rationality, and vision upon which the success of the strategy is contingent. If they did, we might not have to concern ourselves with strategies by which to ensure our survival.

Oberammergau, Bavaria

WHAT IS COORDINATION?

COLONEL HORACE W. LANFORD, JR.

THE PURPOSE of this article is to invite attention to the lack of accepted definitions and terminology encountered in the study of theory and practice of management, with particular emphasis upon the concepts of coordination and the resulting impact upon the military manager. I shall highlight some difficulties encountered in systems management in the past because of difficulties encountered in the coordination cycle and point out improvements to be expected through implementation of the Air Force Regulation 375 series. Many system programs were in effect prior to the implementation of the AFR 375 series, so these programs do not operate under its provisions. All new programs initiated since the publication of the 375 series follow these provisions, of course.

Not the least among the problems facing Air Force managers is the concept of coordination. A review of contemporary management literature re-

veals two schools of thought concerning coordination. The greater number of contemporary theorists regard coordination as a vital function of control, to be imposed hierarchically. The other school of thought considers coordination a lateral operation implying agreement or meeting of the minds.

R. C. Davis, one of the foremost contemporary management theorists, identifies two types of coordination—the coordination of thought and the coordination of action. Davis further indicates that the coordination of thought is an element of the planning function and the coordination of action is an element of the control function.¹ I shall further define coordination and control and show that coordination considered as an element of control offers improved management effectiveness for the Air Force.

An important ingredient in effective management is self-analysis. Therefore, one of my objec-

tives is to invite attention to areas of Air Force management philosophy and concepts that are not in agreement with the philosophy and concepts of contemporary management theorists.

Henri Fayol, one of the earliest management theorists to put his philosophy in writing, specifies the major management actions as forecasting and planning, organizing, commanding, coordinating, and controlling.²

The Air Force concept of management actions seems to be based on Fayol's philosophy, as the Air Force specifies five major management actions: planning, organizing, directing, coordinating, and controlling.³ Most readers will concede that "commanding" (Fayol) and "directing" (Air Force) mean the same thing.

Of particular interest in this article is the concept of coordination. Fayol considered coordination as the binding together, unification, and harmonization of all activity and effort. To him, control meant seeing that everything occurred in conformity with established rule and expressed command.

The *theoretical* management philosophy of the Air Force is expressed in Air Force Manual 25-1 dated 15 October 1964. This manual superseded AFM 25-1, 1 September 1954, and AFR 25-1, 13 July 1954. The *systems* management philosophy of the Air Force is expressed in the AFR 375 series.

An attempt is made here to show that Air Force management philosophy appears to be based on the philosophy of early management theorists and appears not to have kept pace with the widely accepted doctrines that have evolved through the philosophies of intervening and contemporary theorists. Harold Koontz and Cyril O'Donnell, well-known contemporary management theorists, propose that the method of achieving coordination is largely horizontal rather than vertical and that people cooperate as a result of understanding each other's tasks. These theorists further state that the line officer's dictum, "coordinate," is both unrealistic and unenforceable. Although they subscribe to the philosophy that coordination is best achieved laterally, they state that control of things is achieved through control of people and that the necessity for synchronizing individual actions arises out of differences in opinion as to how group goals can be reached or conflicts between individual motives and group objectives can be harmonized. It appears that here acceptance of the Davis philosophy

of coordination of thought in the planning function and coordination of action in the control function serves to clarify much of the confusion surrounding the word *coordination*. Koontz and O'Donnell observe that, though some management analysts (including the Air Force) separate coordination as an essential function of the manager, it would seem more appropriate to regard coordination as the essence of managership, for the achievement of harmony of individual effort toward the accomplishment of group goals is the purpose of management. They say that each of the functions of the manager is aimed toward the accomplishment of the objectives of the group.⁴

This last statement cannot be questioned. The important consideration is how best to implement it. As has been suggested, each managerial function is aimed toward the accomplishment of group objectives. The Air Force's five major functions of the manager—planning, organizing, directing, coordinating, and controlling—are also intended to ensure accomplishment of the group objectives. The majority of contemporary theorists tend to reduce the number of major management functions, however. J. R. Beishline combines coordinating with controlling and specifies planning, organizing, commanding, and controlling.⁵ R. C. Davis combines commanding with controlling and specifies planning, organizing, and controlling. The School of Systems and Logistics, Wright-Patterson AFB, Ohio, although having no official position, appears to support the Davis philosophy, and certain course handouts even reduce the number of major management functions to two, planning and controlling, organizing having been combined with the planning function. The present author concurs in the reduction of major management actions to two: planning and controlling. Table I depicts the contemporary trend toward streamlining management actions.

Coordination has thus come to be recognized and accepted by contemporary theorists as a function of control. The Ohio State University management philosophy is making a great impact on the thinking of individual Air Force officers and Civil Service employees through the Ohio State University Extension Center (until September 1964 located on Wright-Patterson Air Force Base and now located close to that base on the new Wright State University campus) and through the School of

Table I. Streamlining Management Actions

<i>Fayol</i>	<i>Air Force</i>	<i>Beishline</i>	<i>Davis</i>	<i>Lanford</i>
Forecasting and Planning	Planning	Planning	Planning	Planning organizing
Organizing	Organizing	Organizing	Organizing	
Commanding	Directing	Commanding	Controlling commanding	Controlling coordinating directing commanding
Coordinating	Coordinating	Controlling coordinating		
Controlling	Controlling			

Systems and Logistics operated by Ohio State University for the Air Force Institute of Technology. R. C. Davis, head of the Management Department of the Ohio State University College of Commerce, has clarified the relationship of control and coordination by defining control as the function of constraining and regulating action in accordance with the requirements of the plan and has stated that coordination of action in accordance with the requirements of the plan is a vital phase of control and is the function of relating activities with respect to time and order of performance.⁶

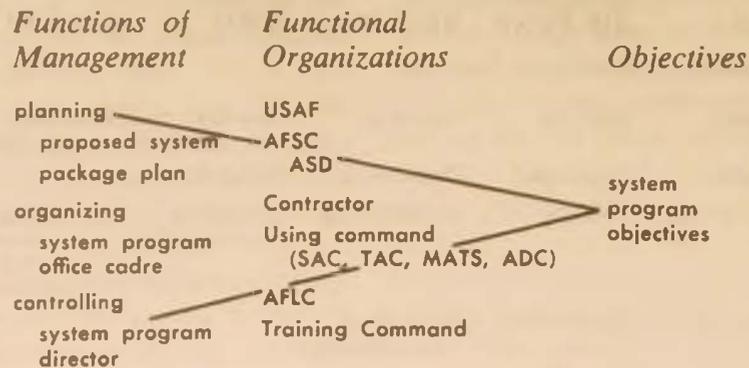
The reader may now ask, why the emphasis on control—and on coordination regarded as an element of control? Control is one of the unquestioned major management actions. The manager, particularly the military manager, must exert control. The importance of control can be clearly shown by the example of one of our military managers, the system program director. The mission of the system program director is to manage (plan, organize, coordinate, control, and direct) the collective actions of participating organizations in planning and executing the system program.⁷ A program is the integrated, time-phased tasks necessary to accomplish a particular purpose. A system program is the accumulation of those portions of Air Force and command programs required to create, deliver, and sustain an operable and supportable system or product.⁸ These definitions are cited to show that systems management must plan and control a program—an *integrated, time-phased* series of tasks to implement a purpose for which the planning function (and coordination of thought in the planning stage) has already been accomplished.

Contemporary theorists have conducted studies which point out the relatively long time and high cost to develop modern military systems and the *relatively* short life expectancy of the system in the inventory.⁹ This situation is, of course, brought about by the rapid technological progress that is characteristic of the present time period. Thus, it is of paramount interest that Air Force managers reduce the time and cost of systems development and increase the length of useful life of systems.

Still another contemporary author focuses attention on the importance of control by stating that the more abstract and dynamic the problems an organization absorbs, the greater part autocratic decisions (by the manager) must play.¹⁰

The example of the system program director as a military manager highlights the difficulties encountered in any philosophy that regards coordination as anything but a vital element of the control function. The system program director is responsible for the major management actions (planning and controlling) to achieve the system program objectives. Consider for a moment the situation portrayed by Table II, which indicates the number of agencies with which the military manager, the system program director, must coordinate. At this point attention is again invited to the fact that preponderance of agreement by contemporary management theorists regards coordination as a function of control, whereas Air Force doctrine regards coordination as one of five major management actions, coequal with control. My view is that, under the presently accepted Air Force doctrine, control is lost (or at least considerably diluted) when the military manager, the system program

Table II. Coordination Elements



director, attempts to secure *agreement* in the methods or timing of actions to achieve the program objectives. Failure to secure agreement results in a compromise, or a continuing series of compromises, to salvage as much of the program objectives as possible. In the past the system program director was therefore placed in the position of the quarterback who was always on the defensive. However, AFR 375-1 now clarifies the apparent paradox:

Representatives of participating organizations, as members of the SPO team, are directed by the SPD, even though they are not in the same chain of command. The "team" represents organizational capabilities, together with the resources, made available throughout the functional structure of the Air Force. A similar, though not as direct, relationship exists between the SSM [system support manager] and individuals within participating organizations once the transition agreement is fulfilled.¹¹

Only time will tell whether the objectives of AFR 375-1 will be achieved.

An examination of AFM 25-1 points up possible reasons for the difficulty that some AF managers have experienced as a consequence of the AF definition of coordination. AFM 25-1 states that the coordinative activity concerned only with elements under the manager's control—i.e., arranging for and getting the right people to do the right things, in the right places, at the right times, and in the right amount to achieve unity of effort within the manager's activity—is inherent in other managerial functions. However, this is the definition accorded *coordination* by contemporary theorists. AFM 25-1 states that references to "coordinating" in the manual mean communicating with activities outside

the manager's jurisdiction and that the manager is to carry out his coordinating function as follows:

- (1) Determine whether and to what extent his operations influence or are influenced by external activities.
- (2) When external activities are affected, communicate with them to:
 - (a) Inform or get information.
 - (b) Secure understanding of common purpose.
 - (c) Obtain required agreements.
 - (d) Get active aid when required.
- (3) Establish ways to resolve conflicts.
- (4) Facilitate future coordinative requirements by maintaining satisfactory relations.

An objective of this article is to advance the suggestion that these activities should properly be *planning* activities. Let's go back to the example of the military manager, the system program director, to demonstrate how other commands—activities *outside* the manager's jurisdiction—are brought into the planning process.

AFSC Manual 375-4 states that the definition phase (the second phase of the life cycle of an AF system: conceptual, definition, acquisition, operational) is designed to produce the detailed plans for the acquisition phase. The responsibility of managing and conducting the definition phase is assigned to the system program office, headed by the system program director. As the managing agency, the SPO must ensure the development and integration of all AF functional planning needed to effect the definition process. AFSCM 375-4 states that normally the agencies supporting the SPO in accomplishing the definition phase are the using command or organization, to provide the plans for

use of the system; AFLC, to provide the plan for the maintenance and logistic support; ATC, to provide the plan for the training of AF personnel; and general system engineering/technical direction contractor or the Air Force in-house Research and Technology Division, to provide the system engineering and technical support.

Very plainly, then, all participating agencies contribute to the planning process. Attention is invited to the fact that these plans are subject to the concurrence of the system program director and are, in fact, prepared under his guidance. The point I am emphasizing is that the planning *has been* fully coordinated and approved by all concerned; the timing of the implementation is the area where difficulty has been experienced in the past.

AFSCM 375-3 states that the system program director is the officer responsible for managing all activities concerned with planning and executing the system program.¹² I have pointed out that each participating command provides the planning necessary in its functional area. Fayol's principle of unity of management states:

There must be *one* manager and *one* plan for all operations which have the same object in view. It is an essential condition for unity of action, for coordination of all one's resources, and for seeing that all efforts are directed towards the same end.¹³ (Italics added.)

AFR 375-1 establishes the broad policy, explains the Air Force principles of system management, and identifies responsibilities and relationships for conducting system programs of the Air Force. This regulation states:

The character of the management task and the degree to which participating organizations exercise their assigned responsibilities change with successive phases in each system life cycle. However, there is only one individual in the field at any one time who assures integration of effort by these participating organizations in achieving system program goals as approved by Hq USAF. This individual is the System Program Director (SPD) until the Acquisition Phase ends, and then the System Support Manager (SSM) until disposition of the system from the inventory. Formal transfer is accomplished in accordance with transition agreements effected between Air Force Sys-

tems Command (AFSC) and Air Force Logistics Command (AFLC).¹⁴

The intent of this discussion is not to get lost in mechanistic approaches to effective management but rather to suggest that some functions of management be relegated to the position of *elements* of certain major unchallenged functions. There is not a one of us to challenge the importance of planning and controlling as major functions of our everyday management activities. My purpose is to suggest, however, that improvements in Air Force management effectiveness can be achieved by relaxation of the present requirement (expressed in AFM 25-1) that *agreement* on a proposed course of action be obtained from organizational elements which are outside the manager's jurisdiction but which influence or are influenced by his operation. The planning activities have ensured coordination of thought. The suggestion offered for consideration is that coordination of action be considered by the Air Force as an element of the very vital function of control.

An objective of this article is to point out a condition that adds to the difficulties of the system program director's duties. Attention has been invited to the basic theory of Air Force management philosophy as expressed in AFM 25-1 dated 15 October 1964. It is suggested that consideration be given to these alternatives: (a) bring AFM 25-1 dated 15 October 1964 into full agreement with AFR 375-1 dated 25 November 1963 or (b) bring AFM 25-1 into full agreement with contemporary management theory, making coordination a subfunction of control, which will then provide the conceptual background (theory) for implementation of the AFR 375 series. The point is that these two guidance documents are contradictory. I do not believe that it is Air Force policy to attempt to deny or hide contradictions but rather, when such a situation is exposed, to research the problem and, if the allegations are proven true, correct the situation.

The Air Force manager, like any other manager, is responsible for planning the course of action to achieve the objectives of the organization or group. This group has been organized around an area of expected results—in our example, the development and acquisition of an Air Force system. The definition phase of the system life cycle is designed to produce a plan, including

the organization necessary to fulfill the plan, and appointment of a manager responsible for its implementation. The system program director in the past has had insufficient control to ensure compliance with the previously coordinated plan of action. The 375 regulations are designed to give the director more control than he has been able to exert in the past.

I believe that serious thought should be given to modifying present Air Force doctrine as expressed in AFM 25-1 to embody the teachings of contemporary theorists. Fayol was the first to write about management doctrine, and he did the management world a tremendous service when he set forth this early management philosophy. His writings served as a departure point for subsequent theorists to confirm or improve upon. The major differences in contemporary philosophy are the emphases placed upon coordination primarily and organization secondarily. Contemporary writers have shown that the control function is certainly a major management action and that coordination, when considered a function of control, adds to the effectiveness of the manager.

Beishline points out that the generally accepted military philosophy of effective coordination requires *agreement* on the part of the parties subject to the coordination, and he recognizes that sometimes one party to the coordination may realize what he *should* do in a given coordination situation, though he may not *want* to do it. He must be convinced of the wisdom of the questioned action. Beishline emphasizes that for effective military coordination, a complete meeting of minds is necessary. Beishline further states that the recognition and development of the function of controlling in military organization and management are not abreast of the progress in business and industry.¹⁵

The dependence of the military manager upon coordination and coordinative methods is readily apparent, as was shown in Table II. Attention is

invited to the varying and different areas of interest—vested interest—of each of the numerous functional agencies. The amount of time the system program director must take away from his management action of controlling to attempt to secure agreement on the wisdom of action from all the functional participants is readily apparent. Fayol's principle of unity of management, previously quoted, offers some relief from this problem.

The Air Force doctrine expressed by AFM 25-1 concerning control and coordination does not appear to subscribe to Fayol's principle of unity of management. AFR 375-1 states that "system management integrates pertinent portions of functional management into a unified approach to achieve the objectives of the system program." Experience has shown that the military manager, the system program director, not covered by 375 series is forced to rely on committees, boards, advisory groups, and acceptance of his recommendations by many levels of superior authority. A survey of system program directors in 1964 showed that at least half of these Air Force managers found a major part of management control was exerted through coordinative methods.¹⁶

An example of such an advisory committee is the Executive Council Management Meeting established by superior authority to consider system program problems that either involve coordination with other system program participants (e.g., the contractor, the using command) or lie outside the system program director's authority. Personal experience of the author and contacts with other system program directors indicate that lack of control by the program director or military manager is a major contributing factor in the application of Executive Council Management Meetings.

The Air Force continues to make significant technological progress. The objective of this article will be met if the reader has his attention focused on the problem area discussed and after serious contemplation takes remedial action.

Aeronautical Systems Division, AFSC

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4. Harold Koontz and Cyril O'Donnell, *Principles of Management* (New York: McGraw-Hill, 1963), p. 38.

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 6. Davis, pp. 19-23.
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 8. Air Force Regulation 375-1, *Management of System Programs*, 25 November 1963, p. 2.
 9. Richard A. Johnson, Fremont E. Kast, James E. Rosenzweig, *The Theory and Management of Systems* (New York: McGraw-Hill, 1963), Figure 10, p. 115.
 10. Adrian M. McDonough, *Information Economics and Management Systems* (New York: McGraw-Hill, 1963), p. 265.

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 12. Air Force Systems Command Manual 375-3, *System Program Office Manual* (Washington: Headquarters AFSC, June 1964), p. 11.
 13. Fayol, p. 79.
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CONTRIBUTORY RETIREMENT?

MAJOR WILLIAM D. CLEMENT

THE PRESENT practice of many military officers, particularly nonregulars, in retiring and then taking employment with the Government in a Civil Service capacity was probably never the intention of Congress in establishing a retirement scheme. It should be stopped immediately. In my opinion, if a person's qualifications and services are required in another branch of the Government, he should be transferred to that branch and eventually retired from Government service from the last branch served in. In order to make this practical, it will probably be necessary to have a contributory retirement system for the military as well as all other branches of the Government.

Using a Civil Service type of contributory retirement system would also solve the problem of separation pay for the armed services. At the present time separation pay (a gratuity) is computed by an arbitrary formula based on length of service. Of course, Civil Service retirement is not completely actuarially funded, but at least it is based on a contributory factor. Under a contributory retirement system a member of the armed services being separated before achieving retirement would be able to withdraw his contribution to the retirement fund in lieu of the gratuity he now receives. If he goes to work for another Government agency his contribution could remain in the fund and be used in an appropriate retirement at a later time.

To give several examples of the types of personnel who could logically be transferred from military service to other Government agencies:

- a. Doctors could be transferred to the Public Health Service or the Veterans Administration.
- b. Electrical, mechanical, and civil engineers

and others could be transferred to the Corps of Engineers, Civil Service-operated depots, Bureau of Ships, etc.

c. Flight controllers and operations personnel might profitably be transferred to the Federal Aviation Agency.

d. Professional career officers might be transferred to the foreign service of the State Department or related diplomatic posts.

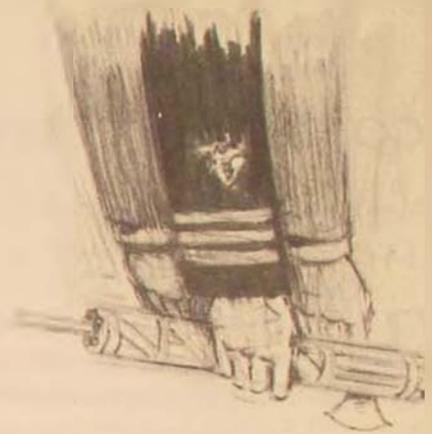
Obviously there are many other possibilities. The criterion should be an actual need for the military man's skill, knowledge, or talents in the job.

Some people will object to the military and Civil Service being so closely similar, since Civil Service personnel do not get transferred involuntarily or so often, nor do they get shot at or stationed on remote duty as do the military. This objection can be accommodated by giving the military "overseas pay" for remote duty and by eliminating the present Civil Service overseas pay.

Many detailed questions and problems will arise, depending on an individual's parochial view. However, I sincerely believe that the principle I am expounding is fundamentally right and any details can be negotiated. I realize that the contributory retirement idea has been proposed for the military before, but I have never heard of it in connection with a transfer to other Government duty. A great advantage to the military is that it would come closer to a guarantee of a pension on retirement. The present near assurance might vanish because of all the talk about "cost of retirements," unless some form of contributory arrangement is worked out and put into effect.

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Books and Ideas



THE ROLE OF THE MILITARY IN LATIN AMERICA

DR. RAYMOND ESTEP

OFTEN unnoticed among the many revolutionary developments in Latin America since World War II has been the new approach by U.S. scholars to study of the area's many economic, political, and social manifestations. Where pre-1945 study, outside the fields of the Spanish and Portuguese languages, was largely limited to a small number of professors of history, political science, and geography and their graduate students, the postwar era has seen the descent on every corner of Latin America of an army of analysts, writers, students, and others. Sustained by grants of private and public funds and loaded down with cameras, tape recorders, and notebooks, they have introduced a new dimension into research that is a far cry from the time-honored activities of their predecessors who confined their efforts to an examination of the dusty archives in Mexico City, Lima, or Seville. From the pens or typewriters of this new generation of writers has flowed a torrent

of studies that go beyond the "who," "what," and "when" in an earnest search for an explanation of the "how" and "why." Economists have analyzed every aspect of the unfortunate influences of one-crop economies. Demographers have painted a gloomy picture of the present and future effects of the population explosion. Cultural and social anthropologists have delved into the mores of Indian, mestizo, mulatto, and Negro villagers from the Rio Grande to Cape Horn. Political scientists have traced the influences at work on public institutions and the administration of government. And sociologists have studied peoples caught up in a world of changing values marked by the rise of new social classes, the rapid increase in urban populations, and the proliferation of peoples newly dependent on a money economy.

Associated with these analysts taking a new look at Latin-American affairs have been a number of historians who have re-examined many facets

of the history of the area in their desire to look behind the bare facts of political history as previously written and provide a sound foundation on which to build an evaluation of what the future holds for the region. Among these historians a number have found a fertile field in the workings of the so-called military mind and the role of the military in the national life of the several countries. Foremost among this group is Professor John J. Johnson of Stanford University, whose first important study of the subject, "The Latin-American Military as a Politically Competing Group in Transitional Society," appeared as a chapter in his edited volume, *The Role of the Military in Underdeveloped Countries* (Princeton, New Jersey: Princeton University Press, 1962). From this analysis he enlarged his scope to encompass a book-length review of the subject in 1964.†

Historians and members of all echelons of government responsible for the making and execution of foreign policy welcome all efforts to shed new light on a region in which revolution and rule by junta and dictator have been commonplace in the century and a half since independence. During this period Bolivia has experienced some 180 revolutions, and not one of the nations has escaped the elevation of at least one ruler by means other than the ballot box. Throughout this century and a half of independence marked by disorder, revolution, and the substitution of the bullet for the ballot, the military has been the chief determining influence in the institutional life of most of the nations, if not in all. The armed forces which enthroned rulers could also dethrone them, as happened to Iturbide in Mexico in the bright morning of independence and to Rojas Pinilla in Colombia and Perón in Argentina in the more recent past. In every decade since the casting off of Spanish rule, military officers or individuals installed by the armed forces have held the reins of government either by election or by seizure of the capitol. The phenomenon of militarism, Johnson says, "has been and is a fact of life in Latin America"; it is with us today and to all appearances will long endure, with military rulers holding forth in El Salvador and Paraguay (by election), Guatemala, Honduras, Brazil, Bolivia,

and Ecuador. (In the last country named, a junta rules.) This picture contrasts with the beginning of the present decade (1955), when the military ruled thirteen nations, represented by such notorious dictators as Perón, Somoza, Rojas Pinilla, Pérez Jiménez, and Batista. Assassins' bullets and revolutions reduced the number of governments under the rule of military dictators to four by 1959. From that low point, heralded by many as the eve of the millennium, the pendulum once again has swung toward the other extreme, with seven nations under military rule and two others (Cuba and Haiti) in the hands of dictators supported by their personal military-like creations (civil militias or constabularies), plus the Dominican Republic in the hands of a U.S.—OAS peace-keeping force.

In preparation for writing this interpretation (he specifically forewarns that it is not a "narrative history") of military-civilian relations in Latin America, Professor Johnson visited six Latin-American nations, interviewed some 500 individuals, both military and civilian, and combed the archives both in the United States and abroad. Throughout his study there runs the dominant theme of "change" in all its manifestations as an influence on society and on the military as he conveys the message that "the attitude of officers toward change and toward emerging groups, rather than toward force and violence and the size of military budgets, will ultimately have the greater effect upon Latin America's position in the world."

Dividing his presentation into three parts, the author devotes the first two to the nineteenth and twentieth century aspects of developments in Spanish America and the third to the political role and public image of the military in Brazil.

Pursuing the central theme of change, the author reveals the effects of professionalization and modernization in the late nineteenth and early twentieth centuries: how compulsory military service (of a sort) became in many countries the alternative to regular standing armies; how the rising cost of new weapons placed the independent *caudillo* at an enormous disadvantage in contests with the national government and thus led to the decline of the *caudillo* as an upsetting political influence

†John J. Johnson, *The Military and Society in Latin America* (Stanford, California: Stanford University Press, 1964, \$7.00), x and 308 pp.

and in turn to the increasing power of the central government; how the introduction of new equipment, with its attendant requirements for more highly trained personnel, influenced sons of the middle sector to enter the armed services and thus effected a change in the social composition of the officer corps; and how these new officers were "better prepared to accommodate themselves to the social-political consequences of economic change than were the landholding elements"—a development which the author declares to have been the most important "in the evolution of the armed forces between 1850 and 1915."

In the period since 1915, an era "of continuing agitational politics" marked by "the continuing willingness of civilians to resort to force, or at least to see violence employed, and their persisting unwillingness to commit themselves to a fixed political way of life," the author avers that the "role of the armed forces has not changed, [but] the attitude of the officers has. . . ." This change in attitude, especially in recent years, reflects in part the social origins of the officers, many of whom at the present time are from the lower sectors; but it is also influenced by the glamor appeal, social prestige, salaries, promotions, retirement plans, and educational opportunities offered by a career in the armed forces.

The oft-condemned intervention by military officers in civilian governmental affairs, which Johnson calls "civil-militarism in politics," is a fact of life today in one form or another in all Spanish-American nations (except Uruguay and Costa Rica), and civilians are equally as responsible for it as the military officers. It will likely continue so long as (1) the military acts as an agent for removing an undesired individual from power (for instance, a Perón or a Rojas Pinilla), (2) violence exists as a "definite feature of the political process," or (3) the armed forces are divided by either interservice or intraservice rivalries.

One of the more significant trends noted in recent years in the evolution of the armed forces has been the tendency on the part of officers to control governments through the exercise of indirect influence rather than through the seizure of direct control. Making this indirect role attractive are the numerous opportunities for serving, usually with added salary, in executive and legislative positions in federal, state, or city governments, in

the diplomatic service, or in state-owned or -managed enterprises.

Where do the modern armed forces stand on such key and often controversial issues as education, industrialization, foreign capital penetration, state intervention in economic development, nationalism, communism, and agrarian reform? Over the last several decades, during which most of the officers have been products of middle-sector economic groups, the military has tended to endorse the same programs as the middle-sector political parties rather than those of the landed elite. This position is expected to change as the new officers from the lower sectors gain in numbers and achieve positions of influence. This group is expected to become more and more receptive to the platforms and programs of the urban left.

How does Spanish America view the military in the modern age? Here the question is answered with many tongues, with the general public more favorably impressed and less critical of the armed forces and their roles in national development than the intelligentsia. By and large, however, the vast majority of Spanish Americans accept the existence of the armed forces and their functioning as a fact of life.

The military officer in Brazil has played a role so different from that of his Spanish-American cousin that the author has chosen to treat him separately in Part III of his study. He devotes considerable space to analyzing "the reasons why the Brazilian armed forces have been able to maintain decisive political influence while avoiding the kind of difficult military-civilian relations [prior to 1964] that have long plagued Brazil's neighbors." Many reasons are advanced to explain why the Brazilian military played a secondary role to the monarchy until 1889 and why, even in the period 1889-1930 when military officers twice ruled the nation, the armed forces, unlike their Spanish-American contemporaries, "avoided any serious confrontation with the civilian leadership" and "managed to create and preserve a relatively favorable image of themselves. . . ." With the revolution of 1930 that brought Getulio Vargas to the presidency in what was to be a 15-year dictatorship, the military, by accident or design, emerged as the "kingmaker" in national politics. Since the termination of the Vargas dictatorship in 1945, the presidents of Brazil have had to depend for their political lives

on the support of a group of officers, a *dispositivo militar*. In playing this role, the military has often in recent years abandoned its earlier traditional position of arbitrating disputes in the civilian body politic and chosen instead "to take public positions on policy conflicts. . . ." In the process the military has become a national agency for destroying the regionalism that historically has divided Brazil; it has become an apostle advocating state intervention in economic development; and it has become the chief agent of nationalism. While the military has traditionally been aligned on the side of conservative elements in national politics, the changing complexion of the officer corps, whose members are increasingly the products of the lower sectors, foretells that a new generation of officers will be more sympathetic to the "demands of the historically oppressed masses." As of the moment, however, the military establishment continues to align itself on the side of the conservatives.

In summing up, Johnson re-emphasizes how the armed forces generally were able to adapt themselves to the shift of power from the traditional landed elite to the urban middle sectors as the latter became the dominant political element. This leads him to conclude that the military will accept the working classes "within a decade or two" and that there is "absolutely nothing in the evolution of the Latin American armed forces to suggest that they can any longer be trusted to be the stronghold of tradition or that they will for much longer 'hold off the mob power of the left.'" He continues, "Those persons in and out of Latin America who fail to appreciate this face a rude awakening, as do those abroad who fail to understand that no group from which potential officers currently are being recruited has close ties with any foreign power." Johnson believes that because of the "force and corruption" that "remain parts of the political process in Latin America" there is a definite place for the armed forces, which have been more responsible than "either the police or the armies raised by ideological parties," and that the military officers who direct governmental agencies "are less corrupt than the civilians" who would otherwise fill the positions they occupy. Over the longer term, how-

ever, he foresees that forces now at work will tend to reduce the military's role in the field of civilian political affairs but that in spite of this limitation the military will always exert an important influence in civilian affairs. Recognizing that the military will continue to exist, he suggests a many-sided program of civic action for converting the armed forces into "more socially constructive institutions."

Pursuing the emphasis on change in his Introduction to another appraisal of Latin America,† Johnson discusses at length the various economic, political, and social implications of such forces as the transformation of traditional value systems, emergence of new power groups, the increasing influence of technology, proliferation of political parties, mass emigration from rural areas, industrialization, demands for agrarian reform, the population explosion, urban growth, and nationalism. He points out, in introducing this volume of essays on social groups, that people rather than institutions will determine, either individually or collectively, whether such forces "will retard or promote social development."

In examining the roles of the peasant, rural laborer, writer, artist, military officer, industrialist, urban worker, and university student, the several writers look at two questions: (1) What are the main problems and aspirations of each group? (2) To what extent are each group's goals realistic in terms of its own capabilities and the national interest?

Of most interest to Air Force personnel and the essay most closely linking this volume with the preceding one is that titled "The Military," which traces the roles of the armed forces as a nation-building force, as an instrument of social integration, and as a force in education. Of especial interest are the sections that describe past and present civic-action accomplishments and projects of the armed forces and examine the role of the military in political affairs. The author's conclusion is significant:

. . . the view of the military as the primary obstacle to political stability and democratic evolution is simplistic. Instability in Latin America

† John J. Johnson (ed.), *Continuity and Change in Latin America* (Stanford, California: Stanford University Press, 1964, \$6.75), xiii and 282 pp.

has been something more basic than transfers of power among the elite by means of *cuarte-lazos* and *pronunciamientos*. . . . In a substantial number of cases, it has been the failure of an incipient democratic system that brought the military into politics. Sometimes civilian leaders have deliberately encouraged or even invited intervention; sometimes political choices have been forced on the military by irreconcilable divisions between civilian factions or the dubious legitimacy of the executive. It can be argued that if regular military forces had been abolished, contending parties and factions would have devised alternative forms of violence to prosecute their interests.

The role and influence of Latin-American university students in national politics, understood by few in the United States, are revealed in an essay that traces the steps by which students acquired their present dominance in university administration. In accomplishing this the author describes curriculums (past and present, and possible future trends), students (as to numbers and family background), campus politics, the "career" student leader, the position of the university graduate in national affairs, and the ideological orientation of students and faculty. He refutes the notion that "students in Latin America engage in political agitation because they see no hope of acquiring wealth or position so long as the present system obtains," pointing out that the "university student is the child of his parents" and that there is some reason for thinking that "the student is at least temporarily a better citizen than his elders."

Other essays examine *the rural peasant*, who constitutes over half of Latin America's 200,000,-

000 people; *rural labor* as an institution and its influence on the economy and society; *the role of the writer* in shaping Latin-American thinking—a fact of tremendous importance in view of the pronounced tendency of writers to adopt or support left-of-center ideologies and causes since World War II; *the role of the artist* (composer, painter, sculptor, architect) in influencing ideological attitudes, with particular emphasis given to Mexican muralists after 1921 and to Brazilian architects since the 1930's; *the industrialist* in terms of origin and opportunity, sense of public responsibility, fear of risk, participation in politics, attitude toward labor, and of family control of industrial empires; and *the urban worker* in terms of origin, concentration in large cities, proportion of the industrial labor force, influence of his needs on city administrators, participation in labor unions, and political influence.

A novel feature of the volume is the comparison of Latin America with Japan in terms of thinking, scholarship, and institutions and in response to nineteenth and twentieth century political and economic influences, presented in the final essay by a British sociologist.

This volume is the best available study of such a wide cross section of thought on so many segments of life in Latin America. Professor Johnson and the other authors reveal the depth of their years of research in pinpointing the significant and in refuting previously accepted truisms. It merits the study of everyone interested in or concerned with things Latin-American.

Aerospace Studies Institute

A PERSPECTIVE LOOK AT OUR AMERICAN MILITARY POLICY

MAJOR JOHN H. SCRIVNER, JR.

AMONG the young nations of the world, the American colonies were singularly fortunate. Geographically, politically, and—not the least—militarily, American settlers found this to be true. It was most advantageous that, time after time, the colonists had their battles fought for them

or saw the fury of the fighting directed elsewhere. This opportune deliverance from foreign conquest was due to a combination of many circumstances, one of the most important of which was the titanic struggle for European and colonial dominance in which England and France were engaged. No one

country dared to challenge either of these world powers without being allied with the other. As a result, the American colonies, even though under the British flag, were able to watch from the sidelines as the two spent their efforts in almost continual struggle for North American empire. When the colonists did become involved, they often found themselves fighting a poorly led, inadequately equipped force that had been siphoned off from the more important European conflict only to keep the American situation in hand, not to force a quick decision. As a result of this disinterest and procrastination on the part of the mother countries, the colonial militia often defeated a foreign force which, given reasonable equality of numbers, equipment, and leaders, would have been vastly superior to their own. Such a fortunate situation, however, was not all to the good for the developing nation.

Gradually the belief grew among the colonists that they were capable of defending themselves and that they could, when necessary, take the offensive with every expectation of success. Taking down the trusty musket from over the fireplace, slinging the powder horn on the shoulder, and marching off to the scene of trouble was sufficient action in the eyes of most colonists to repel any aggression.

Most importantly, American colonists were peace-loving people. Seldom was a thought given to provoking a fight with the mother country. For over a hundred and fifty years after the founding of Plymouth colony, the wars fought by the colonists were wars begun and ended in Europe—and fought principally over European affairs. Life was prosperous and happy under England. The mother country furnished all the protection needed, except on the Indian frontier, and furnished it nearly cost-free as well. Oceans formed an isolating if not completely protective barrier, and the British fleet held off all but a few powers. The forests and mountains added their natural obstacles to foreign invasion. Small wonder, then, that a nonmilitary, peace-loving tradition grew up in the American colonies. Right or wrong, the settlers began to believe that so long as they minded their own business they could look forward to peace and a profit. In the event that they did not mind so well, their fathers and sons, always willing, able, and trained, would spring to their defense and protect their homes from tyrants.

In these early days of political disorganization there was little or no way in which to organize, train, and equip a truly effective fighting force embracing all the colonies. Militia calls were laid upon the colonists and generally were met, but there existed no reliable, overall defensive force. Notwithstanding this fact, and even because of it, the colonists persisted in their belief that father and brother could do the job when the time came to take down the musket.

The desperate straits of the military leaders during the Revolutionary War did little to shake the belief in the growing traditions of isolation, peace, and a let-the-militia-do-it policy of defense. With the victorious conclusion of that war and its aftermath of growing political unity, beliefs grew into accepted custom. They existed in 1812 when a pitifully weak nation, hardly out of swaddling clothes, challenged the most powerful nation on earth. The burning of the White House failed to shock the American people into the realization that the few regulars available were not enough and that the "ever faithful" militia was, at best, a very unreliable backup. It was the victory that counted, if, indeed, a victory it was. To have wrested a *status quo ante bellum* from Great Britain was considered to be a triumph; deserved or undeserved made no difference. Nothing succeeds like success, and the new nation was successful.

Even a superficial analysis of American military strength in the early years of the nineteenth century reveals no practical reason for a single military success. Our Navy had been relegated to coastal patrol duty, and its vessels were fast becoming inadequate for that task, thanks in many respects to that stalwart forefather Thomas Jefferson. Our Army was a small handful of regulars authorized by Congress and then promptly ignored by that parsimonious body when it came to appropriations. Notwithstanding the individual gallantry of these regulars, they were almost completely ineffective in resisting attack, by the Indians or anyone else.

The nation had subscribed wholeheartedly to the militia system, with calls for men levied by a respectful Congress upon powerful and jealous state legislatures. If the men of a state chose not to serve outside the confines of that state, more often than not they did not! As unsatisfactory as this system was, the citizens preferred by far this

method of defending their homeland. The alternative, a sizable standing army, was not in the tradition of the Founding Fathers and had been proven unnecessary in order to obtain victory over otherwise superior powers.

As late as the Civil War, President Lincoln, in embarking upon a war to preserve the Union, was forced to flesh out the scant nucleus of regular troops by calling for volunteers. By this time state boundaries were no longer an obstacle, and in this sense our defense policy was more national in scope. However, short periods of enlistment and militarily inept leaders destroyed much of the effectiveness of brave men. Our military policy at the beginning of the Civil War remained very nearly the same as in the early colonial days. Reasons for change came hard in the face of having nearly doubled our territory at the expense of Mexico less than 13 years before. Mexico had been defeated by a few regulars of fine quality and some individually superior leadership, in spite of the policy of short enlistments of inadequately trained volunteers. If Americans could do all that, then why change a winning formula? A few military people saw that a changing world was to require a change in American military policies, but they were too few to prevail in high councils of indifference.

The end of the Civil War brought a prompt return to peaceful pursuits in which a military establishment had no place. After a brief military occupation of the South, barely enough soldiers were maintained to man the frontier posts against the Indians. The threat of French intervention from Mexico in 1865 dissipated when Napoleon III deserted Maximilian. With it went any reasonable possibility of foreign invasion.

When our "yellow journalism" whipped up a need for armed forces in 1898, there existed in the entire military establishment no more than a handful of officers who had ever commanded anything bigger than a battalion of men at one time. What equipment was available was totally unsuitable for fighting a tropical war. The existent staff organization charged with procuring new materials, food, and supplies was woefully inefficient and, in a few cases, corrupt. Our weapons were antiquated because the Congress had failed to appropriate money for research. Thus well prepared, the United States embarked upon its policy of "jingoist" world expansion. Only the decadence of imperial Spain

saved the United States from abject humiliation. Assistant Secretary of the Navy Theodore Roosevelt had done what little he could for the Navy. As it turned out, the Navy had an admiral in command who was willing to fight. The Army suffered from political inertia plus leadership inefficiency and had no general who knew how to fight a full-scale war.

After the Spanish-American fracas was over, there appeared in Washington a growing awareness of the necessity for overhauling our traditional military policy. It was to be a slow, frustrating process involving such dignitaries as Theodore Roosevelt and Elihu Root, plus the writings of experienced military men like General Emory Upton and Colonel Matthew F. Steele. Despite some remarkable successes in reorganizing the structure of the Army, little headway was made against the real problem, public apathy. The Dick Act of 1903 finally replaced the Militia Act of 1792 and gave us an Army reserve separated into two classes: the poorly trained National Guard in one and the remainder of the able-bodied males, in various stages of training, in the other. It was a step in the right direction, but barely that, and the nemesis of state control remained to haunt military leaders right up to World War I.

Lack of preparedness for World War I on the part of the United States is an embarrassing but well-known fact. Like an adolescent who craves importance but shuns the responsibility that accompanies it, America declared the "war to end all wars" and then went about the work of getting ready to fight it. We were on the winning side, but it was an Allied effort and the major share of any glory goes to Britain and France. In 1919, after a short period of military occupation, the United States reverted to its usual indifference toward the military. The interval between the two World Wars saw a steady decline in American military posture. We sank our fleet in a fit of righteous disarmament fever, ignored the potential of the airplane, and made no effort to modernize our trench-oriented weapons and tactics.

The farsightedness of a few of our between-the-wars military leaders did achieve some technological breakthroughs. These led to the wartime availability of such splendid weapons as the B-17, the aircraft carrier, and the Sherman tank, along with well-developed amphibious warfare tactics.

At the same time planners neglected the need for a long-range fighter plane until heavy casualties forced its development. With the attack on Pearl Harbor, Congress bought time and material with a vast expenditure of dollars so long denied the military forces in peacetime. Millions were spent in haste that could have been better allocated for research and procurement years earlier.

World War II and the chilly atmosphere of incomplete peace that followed did seem to awaken the American people to the necessity of adequate standing forces. It took the Korean "police action," however, to drive home the pragmatic facts. After the Japanese surrender, America had demobilized so fast that our leaders found themselves at the diplomatic bargaining tables with no force adequate to back up their words. Into this vacuum crept the Soviet menace and the condition of "no war—no peace" which is still with us.

A review of our military policy reveals very little for Americans to "view with pride." It is a policy of weakness, inept planning, indifference, and callous abandonment of the responsibility of leadership. Yet it is a policy that, until the age of "limited war," has consistently brought victory. This dichotomy is the substance of a new book, *American Defense Policy in Perspective: From Colonial Times to the Present*.† Professor Raymond G. O'Connor has edited a splendid series of articles and excerpts from classical military writings, past and present, that drives home with the consistency of a jackhammer the theme of lack of preparedness.

The lessons of the past are inescapable, and Professor O'Connor does not sugarcoat the pill. He admirably resists the opportunity to moralize to his reader. He prefers instead to let his selections, plus his brief chapter introductions, do this for him. They do the job magnificently.

General Upton's famous description of the trials of George Washington during the Revolution is familiar to all students of military history. That same familiarity is lost to the general public—the people who most need to become acquainted with it. Colonel Steele's vivid description of the meager American efforts in the War of 1812 evokes amazement now that even the *status quo ante bellum* was achieved.

For each military crisis in our history, one or two writings have been selected that best describe how our policy was formulated and how it was carried out. Only when more current times are reached does the author's choice of writings grow a bit weak. In discussing the overall effects of our World War II policies, he does not, for instance, point up the near failure of our strategic bombing policy as brought out in the Strategic Bombing Survey.

The selections do show the way in which the relatively new concept of "limited warfare" has changed military thinking in recent years. It would appear that the United States has learned its lessons from the past. President Johnson, in his message to Congress on the defense budget in January 1965, closed his remarks by saying, "But all our experience of two centuries reminds us that: 'To be prepared for war is one of the most effectual means of preserving peace.'"

Hopefully the lesson is learned. This truism should have been the basis of American military policy over a century and a half ago. The fact that it was not makes the study of America's defense policy a continuing requirement in the quest for American survival in today's uncertain situations.

United States Air Force Academy

†Raymond G. O'Connor (ed.), *American Defense Policy in Perspective: From Colonial Times to the Present* (New York: John Wiley & Sons, Inc., 1965, \$7.50), 377 pp.

The Contributors



HONORABLE EUGENE M. ZUCKERT was Secretary of the Air Force from 24 January 1961 until his recent resignation. A 1937 graduate of Yale University law school and of the combined law-business course at Harvard and Yale, and a member of the Bar in Connecticut, New York, and the District of Columbia, Mr. Zuckert has practiced law only during breaks in a career devoted almost entirely to public service. He was attorney for the U.S. Securities and Exchange Commission in Washington and New York, 1937-40, then was with the Harvard Graduate School of Business Administration, 1940-44, as instructor in Government/business relations, later as Assistant Professor and Assistant Dean. During this period he was also administrative head of the first advanced management course at Harvard Graduate School, special consultant to the Commanding General, Army Air Forces, in developing statistical controls, instructor in the AAF Statistical Control School at Harvard, and on special assignments at various Air Force bases for the Commanding General. In September 1945, after military service as a LtJG in the Office of the CNO, he became Executive Assistant to the Administrator of the Surplus Property Administration, Stuart Symington. When Mr. Symington became Assistant Secretary of War for Air in February 1946, Mr. Zuckert remained as his Special Assistant; and in September 1947 when Mr. Symington was named the first Secretary of the Air Force, Mr. Zuckert was named Assistant Secretary of the Air Force. Appointed to the U.S. Atomic Energy Commission in January 1952, he served until June 1954, when he retired to work as an atomic energy consultant and attorney. He is the author, with Arnold Kramish, of *Atomic Energy for Your Business*.

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LIEUTENANT COLONEL RAY W. ALVORD (M.A., Stanford University) was Chief, Personnel Evaluation Branch, 6570th Personnel Research Laboratory, AMD, Air Force Systems Command, Lackland AFB, Texas, until his recent assignment to the USAFIT Ph.D. program at Stanford University. Commissioned from AFROTC, he entered active duty in 1950 as a student, Air Tactical School. After graduation he served as an intelligence officer with the 22d Bombardment Wing (SAC) in England, then was assigned to Hq Far East Air Forces in 1952. He completed a USAFIT student tour at Stanford in 1955. Subsequent assignments have been at the Air Force Flight Test Center, Edwards AFB, until 1958; as Assistant Professor of Air Science, Brigham Young University, to 1961; and as student, Air Command and Staff College, 1962.



CAPTAIN LYLE D. KAAPKE (M.A., Baylor University) was a Task Scientist, Personnel Research Laboratory, Lackland AFB, Texas, until his recent assignment to Personnel Plans and Training, Hq Air Force Systems Command, Andrews AFB, Maryland. After completing instructor-navigation training in 1956, he served as an instructor in the FTAF Instructor Training School, James Connally AFB, Texas. In 1956-57 he attended Baylor University under Bootstrap, then returned to Connally as Director, Instructor Training School (FTAF). From 1958 to 1963 at the Air Force Academy he was successively Instructor, Department of Navigation; Instructor, Department of Leadership Studies; and Assistant Professor, Department of Psychology. He was Chief, Testing and Processing Division, Personnel Research Laboratory, 1963-64. Captain Kaapke is a 1958 graduate of the Squadron Officer School.



MAJOR GENERAL CHANG, CHI RYANG, is Vice Chief of Staff, Republic of Korea Air Force. After graduating from the Japanese Military Academy and Japanese Army Aviation School in 1945 and from the ROK Army Academy in 1948, he became Acting Director of Operations, Hq ROKAF, in 1949. Other assignments have been as Deputy Commander, then Commander, 10th Fighter Group, 1953; Air Attaché, Korean Embassy, Washington, D. C., 1954; Director of Personnel, then Director of Operations, Hq ROKAF, 1956; Commander, 11th Fighter Wing, ROKAF, 1958; President, Korea Tungsten Mining Company, 1961; Deputy Chief of Staff, ROKAF, 1962; Vice Chief of Staff, ROKAF, 1963; and Superintendent, Air Force Academy, ROKAF, from 1963 until his present assignment on 1 August 1964. General Chang is a 1949 graduate of the Army Staff College; a 1952 graduate of the Field Officers Course, Air University, USAF; and a 1961 graduate of the ROK National War College.



COLONEL HAROLD R. JOHNSON (M.S., George Washington University) is assigned to duty with the Director of Telecommunications Management, Executive Office of the President. During World War II he served as a combat bombardier with the Eighth Air Force. In 1946 he completed pilot training and then specialized in the research and development and advanced technology of telecommunications. He was with Airways and Air Communications Service, 1946-54. Since that time he has been associated with microwave and tropospheric forward scatter wideband communications. At SHAPE from 1955 to 1958, he participated in the NATO ACE HIGH troposcatter project. As Chief, Plans Branch, Directorate of Telecommunications, Hq USAF, 1958-62, he worked on Dew East, White Alice, BMEWS, most of the Air Force's wideband communications systems, and Telstar. Assigned to the Directorate of Defense Research and Engineering, 1962-64, he was Assistant Director of Technical Support for the National Military Command System. Colonel Johnson, a 1965 graduate of the Industrial College of the Armed Forces, has published numerous technical papers in his field.

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LIEUTENANT COLONEL JOHN E. MOCK (Ph.D., Purdue University) has been an Associate Professor of Mathematics at the George Washington University and at the U.S. Air Force Academy. He has been associated with research and development in propulsion at Wright-Patterson Air Force Base, with air technical intelligence in Germany, and with high-altitude nuclear weapons effects and testing in the Defense Atomic Support Agency. He has published numerous scientific articles and was the recipient of the American Nuclear Society's annual Mark Mills Award in 1960. He has been a consultant in the field of space science to the National Science Foundation, the Institute for Defense Analyses, and several other Government agencies.



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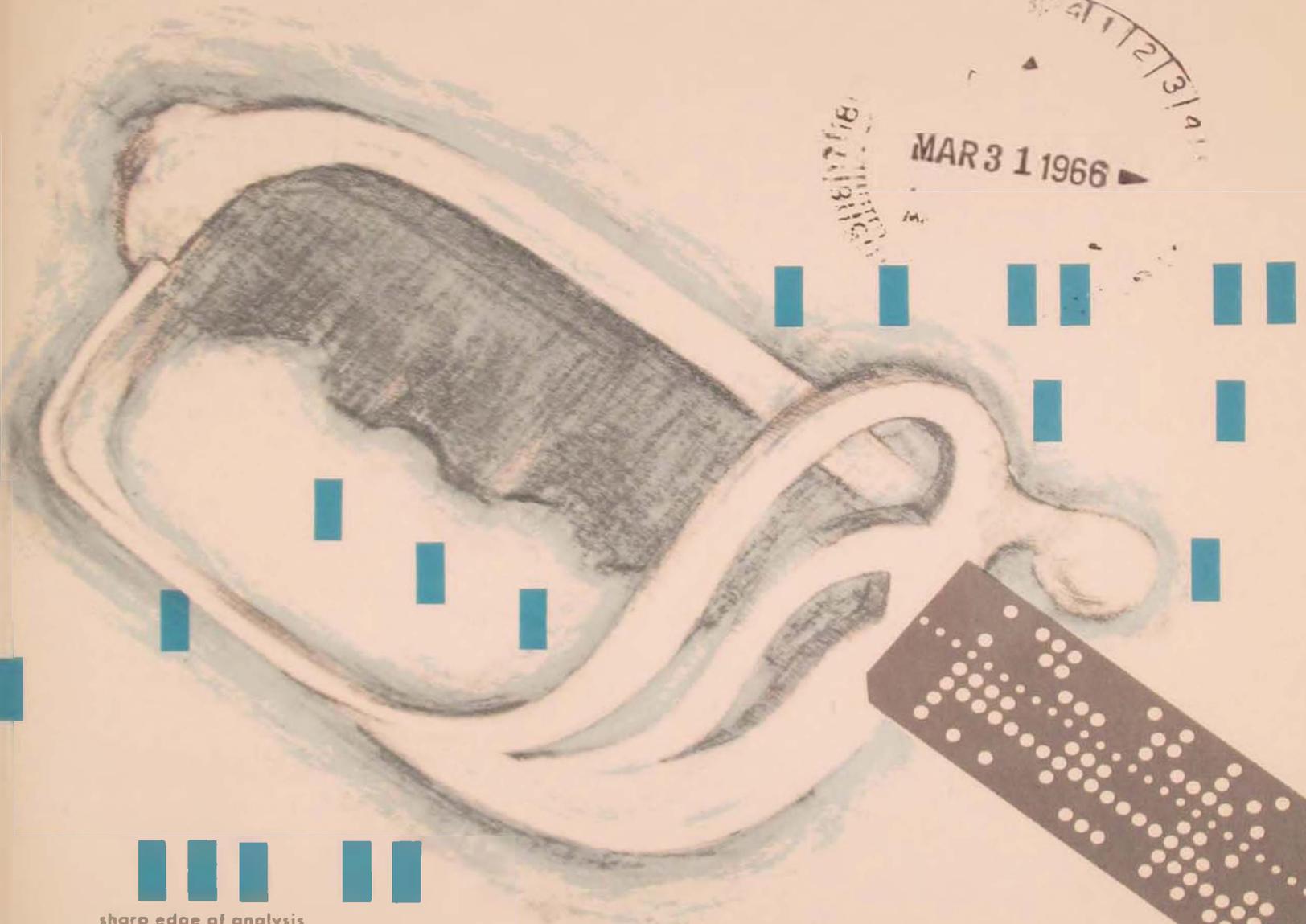


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