Meeting of the ODM Science Advisory Committee with President Eisenhower and Arthur S. Flemming, Director of the Office of Defense Mobilization. Standing (*left to right*): Emanuel R. Piore, Oliver E. Buckley, Alan T. Waterman, James B. Fisk, Detlev W. Bronk, Bruce S. Old, J. R. Killian, Jr., David Z. Beckler, Robert F. Bacher, Jerrold R. Zacharias, Charles C. Lauritsen. Seated (*left to right*): Arthur S. Flemming; President Eisenhower; Lee A. DuBridge, Chairman; I. I Rabi. *Photo by Abbie Rowe, courtesy National Park Service.*

4
SCIENCE ADVICE BEFORE *SPUTNIK*

Science has been a formative factor in making both the federal government and the American mind what they are today. The relation of the government to science has been a meeting point of American political practice and the nation's intellectual life. This conjunction has been continuous from 1787 onward and has interacted with both contributors. On the one hand, American democracy's very essence has been influenced by the presence of science. On the other, the institutions that harbored and fostered science in America would have been different, and much poorer, without the efforts of the government spread over many decades.[1]

A. Hunter Dupree

PAST PRESIDENTIAL ACTIONS IN SUPPORT OF SCIENCE

When we contemplate today's vast and intricate government structure for science and its diverse vitalities, we are inspired to understand the forces, many of them familiar, that created it.

The Founding Fathers were intellectuals who perceived the symbiotic relationship between natural science and political democracy, between knowledge and power. There was the towering figure of Franklin, an inventor and scientist of great repute, an apostle of the Enlightenment, and a major influence in shaping the alliance between government and science. There was Washington, one-time surveyor, as president advocate of a national university and of improved agricultural methods. There was the philosopher-statesman Jefferson, versed in many aspects of science and vigorous in putting it to work for the nation. And there was John Quincy Adams, who combined politics with an evangelical zeal for the advancement of science. Along with Washington, such men as Madison, Jefferson, Adams, and others advocated a national university, understanding as they did the importance of knowledge in a republic. Their dream was shattered by narrow interpretations of the states'-rights doctrine, but the rational spirit of their visions helped shape the American mind.

All these early presidents were active in initiating governmental institutions related to science, a number of which had to be

APPENDIX 4

INTRODUCTION TO OUTER SPACE

STATEMENT BY THE PRESIDENT

In connection with a study of space science and technology made at my request, the President's Science Advisory Committee, of which Dr. James R. Killian is Chairman, has prepared a brief "Introduction to Outer Space" for the nontechnical reader.

This is not science fiction. This is a sober, realistic presentation prepared by leading scientists.

I have found this statement so informative and interesting that I wish to share it with all the people of America and indeed with all the people of the earth. I hope that it can be widely disseminated by all news media for it clarifies many aspects of space and space technology in a way which can be helpful to all people as the United States proceeds with its peaceful program in space science and exploration. Every person has the opportunity to share through understanding in the adventures which lie ahead.

This statement of the Science Advisory Committee makes clear the opportunities which a developing space technology can provide to extend man's knowledge of the earth, the solar system, and the universe. These opportunities reinforce my conviction that we and other nations have a great responsibility to promote the peaceful use of space and to utilize the new knowledge obtainable from space science and technology for the benefit of all mankind.

Dwight D. Eisenhower

The White House
26 March 1958

AN EXPLANATORY STATEMENT PREPARED BY THE PRESIDENT'S SCIENCE ADVISORY COMMITTEE

What are the principal reasons for undertaking a national space program? What can we expect to gain from space science and exploration? What are the scientific laws and facts and the technological means which it would be helpful to know and understand in reaching sound policy decisions for a United States space program and its management by the Federal Government? This statement seeks to provide brief and introductory answers to these questions.

It is useful to distinguish among four factors which give importance, urgency, and inevitability to the advancement of space technology.

The first of these factors is the compelling urge of man to explore and to discover, the thrust of curiosity that leads men to try to go where no one has gone before. Most of the surface of the earth has now been explored and men now turn to the exploration of outer space as their next objective.

Second, there is the defense objective for the development of space technology. We wish to be sure that space is not used to endanger our security. If space is to be used for military purposes, we must be prepared to use space to defend ourselves.

Third, there is the factor of national prestige. To be strong and bold in space technology will enhance the prestige of the United States among the peoples of the world and create added confidence in our scientific, technological, industrial, and military strength.

Fourth, space technology affords new opportunities for scientific observation and experiment which will add to our knowledge and understanding of the earth, the solar system, and the universe.

The determination of what our space program should be must take into consideration all four of these objectives. While this statement deals mainly with the use of space for scientific inquiry, we fully recognize the importance of the other three objectives.

In fact it has been the military quest for ultra long-range rockets that has provided man with new machinery so powerful that it can readily put satellites in orbit, and, before long, send instruments out to explore the moon and nearby planets. In this way, what was at first a purely military enterprise has opened up an exciting era of exploration that few men, even a decade ago, dreamed would come in this century.

WHY SATELLITES STAY UP

The basic laws governing satellites and space flight are fascinating in their own right. And while they have been well known to scientists ever since Newton, they may still seem a little puzzling and unreal to many of us. Our children, however, will understand them quite well.

We all know that the harder you throw a stone the farther it will travel before falling to earth. If you could imagine your strength so fantastically multiplied that you could throw a stone at a speed of 15,000 m.p.h., it would travel a great distance. It would, in fact, easily cross the Atlantic Ocean before the earth's gravity pulled it down. Now imagine being able to throw the stone just a little faster, say about 18,000 m.p.h., what would happen then?

The stone would again cross the ocean, but this time it would travel much further than it did before. It would travel so far that it would overshoot the earth, so to speak, and keep falling until it was back where it started. Since in this imaginary example there is no atmospheric resistance to slow the stone down, it would still be travelling at the original speed, 18,000 m.p.h., when it had got back to its starting point. So around the earth it goes again. From the stone's point of view, it is continuously falling, except that its very slight downward arc exactly matches the curvature of the earth, and so it stays aloft—or as the scientist would say, "in orbit"—indefinitely.

Since the earth has an atmosphere, of course, neither stones nor satellites can be sent whizzing around the earth at tree-top level. Satellites must first be lifted beyond the reach of atmospheric resistance. It is absence of atmospheric resistance plus speed that makes the satellite possible. It may seem odd that weight or mass has nothing to do with a satellite's orbit. If a feather were released from a 10-ton satellite, the two would stay together, following the same path in the airless void. There is, however, a slight vestige of atmosphere even a few hundred miles above the earth, and its resistance will cause the feather to spiral inward toward the earth sooner than the satellite. It is atmospheric resistance, however slight, that has set limits on the life of all satellites launched to date. Beyond a few hundred miles the remaining trace of atmosphere fades away so rapidly that tomorrow's satellites should stay aloft thousands of years, and, perhaps, indefinitely. The higher the satellite, incidentally, the less speed it needs to stay in orbit once it gets there (thus, the moon's speed is only a little more than 2,000 m.p.h.), but to launch a satellite toward a more distant orbit requires a higher initial speed and greater expenditure of energy.

THE THRUST INTO SPACE

Rocket engineers rate rockets not in horsepower, but in thrust. Thrust is just another name for push, and it is expressed in pounds of force. The rocket gets its thrust or push by exhausting material backward. It is this thrust that lifts the rocket off the earth and accelerates it, making it move faster and faster.

As everyone knows, it is more difficult to accelerate an automobile than a baby carriage. To place satellites weighing 1,000 to 2,000 pounds in orbit requires a first-stage rocket engine, or engines, having a thrust in the neighborhood of 200,000 to 400,000 pounds. Rocket engines able to supply this thrust have been under development for some time. For launching a satellite, or other space vehicle, the rocket engineer divides his rockets into two, three, or more stages, which can be dropped one after the other in flight, thus reducing the total weight that must be accelerated to the final velocity desired. (In other words, it is a great waste of energy to lift one huge fuel tank into orbit when the tank can be divided into smaller tanks—each packaged in its own stage with its own rocket motor—that can be left behind as they become empty.)

To launch some of the present satellites has required rockets weighing up to 1,000 times the weight of the satellite itself. But it will be possible to reduce takeoff weights until they are only 50 to 100 times that of the satellite. The rocket's high ratio of gross weight to payload follows from a fundamental limitation in the exhaust velocities that can be achieved by chemical propellants.

If we want to send up not a satellite but a device that will reach the moon, we need a larger rocket relative to its payload in order that the final stage can be accelerated to about 25,000 m.p.h. This speed, called the "escape velocity," is the speed with which a projectile must be thrown to escape altogether from the gravitational pull of the earth. If a rocket fired at the moon is to use as little fuel as possible, it must attain the escape velocity very near the beginning of its trip. After this peak speed is reached, the rocket will be gradually slowed down by the earth's pull, but it will still move fast enough to reach the moon in 2 or 3 days.

THE MOON AS A GOAL

Moon exploration will involve three distinct levels of difficulty. The first would be a simple shot at the moon, ending either in a "hard" landing or a circling of the moon. Next in difficulty would be a "soft" landing. And most difficult of all would be a "soft" landing followed by a safe return to earth.

The payload for a simple moon shot might be a small instrument carrier similar to a satellite. For the more difficult "soft" landing, the carrier would have to include, as part of its payload, a "retrorocket" (a *de*celerating rocket) to provide braking action, since the moon has no atmosphere that could serve as a cushion.

To carry out the most difficult feat, a round trip to the moon, will require that the initial payload include not only "retro-rockets" but rockets to take off again from the moon. Equipment will also be required aboard to get the payload through the atmosphere and safely back to earth. To land a man on the moon and get him home safely again will require a very big rocket engine indeed—one with a thrust in the neighborhood of one or two million pounds. While nuclear power may prove superior to chemical fuels in engines of multi-million-pound thrust, even the atom will provide no short cut to space exploration.

Sending a small instrument carrier to Mars, although not requiring much more initial propulsion than a simple moon shot, would take a much longer travel time (8 months or more), and the problems of navigation and final guidance are formidable.

A MESSAGE FROM MARS

Fortunately, the exploration of the moon and nearby planets need not be held up for lack of rocket engines big enough to send men and instrument carriers out into space and home again. Much that scientists wish to learn from satellites and space voyages into the solar system can be gathered by instruments and transmitted back to earth. This transmission, it turns out, is relatively easy with today's rugged and tiny electronic equipment.

For example, a transmitter with a power of just one or two watts can easily radio information from the moon to the earth. And messages from Mars, on the average some 50 million to 100 million miles away at the time the rocket would arrive, can be transmitted to earth with less power than that used by most commercial broadcasting stations. In some ways, indeed, it appears that it will be easier to send a clear radio message between Mars and earth than between New York and Tokyo.

This all leads up to an important point about space exploration. The cost of transporting men and material through space will be extremely high, but the cost and difficulty of sending *information* through space will be comparatively low.

WILL THE RESULTS JUSTIFY THE COSTS?

Since the rocket power plants for space exploration are already in existence or being developed for military need, the cost of additional scientific research, using these rockets, need not be exorbitant. Still, the cost will not be small, either. This raises an important question that scientists and the general public (which will pay the bill) both must face: Since there are still so many unanswered scientific questions and problems all around us on earth, why should we start asking new questions and seeking out new problems in space? How can the results possibly justify the cost?

Scientific research, of course, has never been amenable to rigorous cost accounting in advance. Nor, for that matter, has exploration of any sort. But if we have learned one lesson, it is that research and exploration have a remarkable way of paying off—quite apart from the fact that they demonstrate that man is alive and insatiably curious. And we all

feel richer for knowing what explorers and scientists have learned about the universe in which we live.

It is in these terms that we must measure the value of launching satellites and sending rockets into space. These ventures may have practical utility, some of which will be noted later. But the scientific questions come first.

THE VIEW FROM A SATELLITE

Here are some of the things that scientists say can be done with the new satellites and other space mechanisms. A satellite in orbit can do three things: (1) It can sample the strange new environment through which it moves; (2) it can look down and see the earth as it has never been seen before; and (3) it can look out into the universe and record information that can never reach the earth's surface because of the intervening atmosphere.

The satellite's immediate environment at the edge of space is empty only by earthly standards. Actually, "empty" space is rich in energy, radiation, and fast-moving particles of great variety. Here we will be exploring the active medium, a kind of electrified plasma, dominated by the sun, through which our earth moves. Scientists have indirect evidence that there are vast systems of magnetic fields and electric currents that are connected somehow with the outward flow of charged material from the sun. These fields and currents the satellites will be able to measure for the first time. Also for the first time, the satellites will give us a detailed three-dimensional picture of the earth's gravity and its magnetic field.

Physicists are anxious to run one crucial and fairly simple gravity experiment as soon as possible. This experiment will test an important prediction made by Einstein's General Theory of Relativity, namely that a clock will run faster as the gravitational field around it is reduced. If one of the fantastically accurate clocks, using atomic frequencies, were placed in a satellite and should run faster than its counterpart on earth, another of Einstein's great and daring predictions would be confirmed. (This is not the same as the prediction that any moving clock will appear to a stationary observer to lose time—a prediction that physicists already regard as well confirmed.)

There are also some special questions about cosmic rays which can be settled only by detecting the rays before they shatter themselves against the earth's atmosphere. And, of course, animals carried in satellites will begin to answer the question: What is the effect of weightlessness on physiological and psychological functions? (Gravity is not felt inside a satellite because the earth's pull is precisely balanced by centrifugal force. This is just another way of saying that bodies inside a satellite behave exactly as they would inside a freely falling elevator.)

The satellite that will turn its attention downward holds great promise for meteorology and the eventual improvement of weather forecasting. Present weather stations on land and sea can keep only about 10 percent of the atmosphere under surveillance. Two or three weather satellites could make a cloud inventory of the whole globe every few hours. From this inventory meteorologists believe they could spot large storms (including hurricanes) in their early stages and chart their direction of movement with much more accuracy than at present. Other instruments in the satellites will measure for the first time how much solar energy is falling upon the earth's atmosphere and how much is reflected and radiated back into space by clouds, oceans, the continents, and by the great polar ice fields.

It is not generally appreciated that the earth has to send back into space, over the long run, exactly as much heat energy as it receives from the sun. If this were not so the earth would either heat up or cool off. But there is an excess of income over outgo in the tropical regions, and an excess of outgo over income in the polar regions. This imbalance has to be continuously rectified by the activity of the earth's atmosphere which we call weather.

By looking at the atmosphere from the outside, satellites will provide the first real accounting of the energy imbalances, and their consequent tensions, all around the globe. With the insight gained from such studies, meteorologists hope they may improve long-range forecasting of world weather trends.

Finally, there are the satellites that will look not just around or down, but out into space. Carrying ordinary telescopes as well as special instruments for recording X-rays, ultraviolet, and other radiations, these satellites cannot fail to reveal new sights forever hidden from observers who are bound to the earth. What these sights will be, no one can tell. But scientists know that a large part of all stellar radiation lies in the ultraviolet region of the spectrum, and this is totally blocked by the earth's atmosphere. Also blocked are other very long wavelengths of "light" of the kind usually referred to as radio waves. Some of these get through the so-called "radio window" in the atmosphere and can be detected by radio telescopes, but scientists would like a look at the still longer waves that cannot penetrate to earth.

Even those light signals that now reach the earth can be recorded with brilliant new clarity by satellite telescopes. All existing photographs of the moon and nearby planets are smeared by the same turbulence of the atmosphere that makes the stars twinkle. Up above the atmosphere the twinkling will stop and we should be able to see for the first time what Mars really looks like. And we shall want a really sharp view before launching the first rocket to Mars.

A CLOSE-UP OF THE MOON

While these satellite observations are in progress, other rockets will be striking out for the moon with other kinds of instruments. Photographs of the back or hidden side of the moon may prove quite unexciting, or they may reveal some spectacular new feature now unguessed. Of greater scientific interest is the question whether or not the moon has a magnetic field. Since no one knows for sure why the earth has such a field, the presence or absence of one on the moon should throw some light on the mystery.

But what scientists would most like to learn from a close-up study of the moon is something of its origin and history. Was it originally molten? Does it now have a fluid core, similar to the earth's? And just what is the nature of the lunar surface? The answer to these and many other questions should shed light, directly or indirectly, on the origin and history of the earth and the surrounding solar system.

While the moon is believed to be devoid of life, even the simplest and most primitive, this cannot be taken for granted. Some scientists have suggested that small particles with the properties of life—germs or spores—could exist in space and could have drifted on to the moon. If we are to test this intriguing hypothesis we must be careful not to contaminate the moon's surface, in the biological sense, beforehand. There are strong scientific reasons, too, for avoiding radioactive contamination of the moon until its naturally acquired radioactivity can be measured.

. . . AND ON TO MARS

The nearest planets to earth are Mars and Venus. We know quite enough about Mars to suspect that it may support some form of life. To land instrument carriers on Mars and Venus will be easier, in one respect, than achieving a "soft" landing on the moon. The reason is that both planets have atmospheres that can be used to cushion the final approach. These atmospheres might also be used to support balloons equipped to carry out both meteorological soundings and a general photo survey of surface features. The Venusian atmosphere, of course, consists of what appears to be a dense layer of clouds so that its surface has never been seen at all from earth.

Remotely controlled scientific expeditions to the moon and nearby planets could absorb the energies of scientists for many decades. Since man is such an adventurous creature, there will undoubtedly come a time when he can no longer resist going out and seeing for himself. It would be foolish to try to predict today just when this moment will arrive. It might not arrive in this century, or it might come within one or two decades. So much will depend on how rapidly we want to expand

and accelerate our program. According to one rough estimate it might require a total investment of about a couple of billion dollars, spent over a number of years, to equip ourselves to land a man on the moon and to return him safely to earth.

THE SATELLITE RADIO NETWORK

Meanwhile, back at earth, satellites will be entering into the everyday affairs of men. Not only will they be aiding the meteorologists, but they could surely—and rather quickly—be pressed into service for expanding world-wide communications, including intercontinental television.

At present all trans-oceanic communication is by cable (which is costly to install) or by shortwave radio (which is easily disrupted by solar storms). Television cannot practically be beamed more than a few hundred miles because the wavelengths needed to carry it will not bend around the earth and will not bounce off the region of the atmosphere known as the ionosphere. To solve this knotty problem, satellites may be the thing, for they can serve as high-flying radio relay stations. Several suitably equipped and properly spaced satellites would be able to receive TV signals from any point on the globe and to relay them directly—or perhaps via a second satellite—to any other point. Powered with solar batteries, these relay stations in space should be able to keep working for many years.

MILITARY APPLICATIONS OF SPACE TECHNOLOGY

The development of military rockets has provided the technological base for space exploration. It will probably continue to do so, because of the commanding military importance of the ballistic missile. The subject of ballistic missiles lies outside our present discussion. We ask instead, putting missiles aside, what other military applications of space technology can we see ahead?

There are important, foreseeable, military uses for space vehicles. These lie, broadly speaking in the fields of *communication* and *reconnaissance*. To this we could add meteorology, for the possible advances in meteorological science which have already been described would have military implications. The use of satellites for radio relay links has also been described, and it does not take much imagination to foresee uses of such techniques in long range military operations.

The reconnaissance capabilities of a satellite are due, of course, to its position high above the earth and the fact that its orbit carries it in a predictable way over much of the globe. Its disadvantage is its necessarily great distance, 200 miles or more, from the surface. A highly magnifying camera or telescope is needed to picture the earth's surface in even moderate detail. To the human eye, from 200 miles away, a football stadium would be a barely distinguishable speck. A telescopic camera can do a good deal better, depending on its size and complexity. It is certainly feasible to obtain reconnaissance information with a fairly elaborate instrument, information which could be relayed back to the earth by radio.

Much has been written about space as a future theater of war, raising such suggestions as satellite bombers, military bases on the moon, and so on. For the most part, even the more sober proposals do not hold up well on close examination or appear to be achievable at an early date. Granted that they will become technologically possible, most of these schemes, nevertheless, appear to be clumsy and ineffective ways of doing a job. Take one example, the satellite as a bomb carrier. A satellite cannot simply drop a bomb. An object released from a satellite doesn't fall. So there is no special advantage in being over the target. Indeed, the only way to "drop" a bomb directly down from a satellite is to carry out aboard the satellite a rocket launching of the magnitude required for an intercontinental missile. A better scheme is to give the weapon to be launched from the satellite a small push, after which it will spiral in gradually. But that means launching it from a moving platform halfway around the world, with every disadvantage compared to a missile base on the ground. In short, the earth would appear to be, after all, the best weapons carrier.

This is only one example; each idea has to be judged on its own merits. There may well be important military applications for space vehicles which we cannot now foresee, and developments in space technology which open up quite novel possibilities. The history of science and technology reminds us sharply of the limitations of our vision. Our road to future strength is the achievement of scientific insight and technical skill by vigorous participation in these new explorations. In this setting, our appropriate military strength will grow naturally and surely.

SPACE TIMETABLE

Thus we see that satellites and space vehicles can carry out a great variety of scientific missions, and a number of military ones as well.

Indeed, the scientific opportunities are so numerous and so inviting that scientists from many countries will certainly want to participate. Perhaps the International Geophysical Year will suggest a model for the international exploration of space in the years and decades to come.

The timetable below suggests the approximate order in which some of the scientific and technical objectives mentioned in this review may be attained.

The timetable is not broken down into years, since there is yet too much uncertainty about the scale of the effort that will be made. The timetable simply lists various types of space investigations and goals under three broad headings: Early, Later, Still Later.

Scientific Objectives

Early
1. Physics
2. Geophysics
3. Meteorology
4. Minimal Moon Contact
5. Experimental Communications
6. Space Physiology

Later
1. Astronomy
2. Extensive Communications
3. Biology
4. Scientific Lunar Investigation
5. Minimal Planetary Contact
6. Human Flight in Orbit

Still Later
1. Automated Lunar Exploration
2. Automated Planetary Exploration
3. Human Lunar Exploration and Return

And Much Later Still
Human Planetary Exploration

In conclusion, we venture two observations. Research in outer space affords new opportunities in science, but it does not diminish the importance of science on earth. Many of the secrets of the universe will be fathomed in laboratories on earth, and the progress of our science and technology and the welfare of the Nation require that our regular scientific programs go forward without loss of pace, in fact at an increased pace. It would not be in the national interest to exploit space science at the cost of weakening our efforts in other scientific endeavors. This need not happen if we plan our national program for space science and technology as part of a balanced national effort in all science and technology.

Our second observation is prompted by technical considerations. For the present, the rocketry and other equipment used in space technology must usually be employed at the very limit of its capacity. This means that failures of equipment and uncertainties of schedule are to be expected. It therefore appears wise to be cautious and modest in our

predictions and pronouncements about future space activities—and quietly bold in our execution.

Dr. James R. Killian, Jr., *Chairman*, Dr. Robert F. Bacher, Dr. William O. Baker, Dr. Lloyd V. Berkner, Dr. Hans A. Bethe, Dr. Detlev W. Bronk, Dr. James H. Doolittle, Dr. James B. Fisk, Dr. Caryl P. Haskins, Dr. George B. Kistiakowsky, Dr. Edwin H. Land, Dr. Edward M. Purcell, Dr. Isidor I. Rabi, Dr. H. P. Robertson, Dr. Paul A. Weiss, Dr. Jerome B. Wiesner, Dr. Herbert York, Dr. Jerrold R. Zacharias.

ism" and go on to demonstrate leadership in human affairs—the capacity to use and shape technology as a powerful instrument for enhancing the quality of our society and for contributing to the solution of the great human problems of our time. This emphasis on broadening engineering education anticipated the current development of new programs in engineering schools to prepare engineers more effectively for dealing with sociotechnical problems and for helping to participate effectively in national policy making with respect to such problems as urban affairs, improvement of the environment, and technology assessment.

The report was also prophetic in its anticipation of today's emphasis on equal opportunity for women. "Women constitute an enormous potential resource for research, scholarship, and teaching which we have not even begun to tap. We should begin conscious efforts to assist them to make contributions."

In this sampling of the wide-ranging observations and recommendations of the DuBridge report, I would note particularly the great emphasis it gave to curriculum reform, to the importance of scholars' in the universities joining with teachers in precollege schools in developing modern curricula, and to the great need for teacher training for handling the new curricula. This emphasis is not surprising. One of the members of the PSAC panel which prepared the report was Professor Jerrold Zacharias, an innovative physicist at MIT, who took pioneering leadership in the curriculum reform movement for science instruction. In 1956, Professor Zacharias came to me in my capacity as president of MIT with a memorandum he had written on the need for improving the teaching of science in high schools and on the possibility of using first-rate films as teaching aids to improve science teaching. This memorandum was the beginning of what later became the Physical Sciences Study Committee, a panel of leading physicists in the universities which addressed itself to thinking through what a modern high-school curriculum in physics should be, and then to the arduous labor of preparing such a curriculum with the necessary textbooks, films, laboratory equipment, collateral readings, and other aids. This was to grow

into a major enterprise commanding support from private foundations, but principally from the National Science Foundation and, in total, representing an expenditure of more than $6,000,000—a modest amount when one computes the cost per student instructed by this PSSC course in physics. This course was to have worldwide impact, and it became the flagship of a whole group of efforts that brought together scholars in the universities with outstanding teachers in secondary schools to prepare modern content and improve teaching aids for courses in chemistry, biology, mathematics, and other subjects. This curriculum reform movement was to have its impact on the improvement of college curricula and on the development of new courses in the social sciences. It led to the establishment of a new kind of educational institution, a nonprofit corporation known as Educational Services, Inc., which became a vehicle for bringing together scholars and teachers to engage in the development of new teaching materials. It is now known as the Education Development Center, Inc., and is still engaged in curriculum development in science, mathematics, and social science, here and abroad.

The PSAC report with the endorsement of President Eisenhower certainly helped to further this curriculum reform movement and to encourage federal agencies such as the National Science Foundation and the U.S. Office of Education to make funds available for the improvement of education.

In his statement accompanying the publication of the report by the White House, President Eisenhower expressed the hope that it would stimulate a wider understanding of the importance of excellence in our educational system. "One subject discussed in the report warrants special emphasis," he said. "The importance of raising the standing of our teachers in their communities. Higher salaries are a first requirement, but we need also to recognize the great importance of what teachers do and to accord them the encouragement, understanding and recognition which would help to make the teaching profession attractive to increasing numbers of first-rate people." The *New York Times* gave was quoted as saying, "without the guidance of the Lord, could have been right as much as I was."[5]

The air force fought just as hard as the army for the space assignment. The atmosphere and outer space were a continuum, it maintained with considerable logic, and it already was well advanced with an intercontinental ballistic missile program and had under its jurisdiction all the authorized *military* space programs.[6] The air force, after a number of failures, was also to achieve the first successful launch of a *military* satellite, the *Discoverer*.

This was an impressive case, but it might have been stronger if the air force had suppressed some of its own special brand of fantasies about space. Its top-ranking officers freely predicted that the next war would unquestionably be fought with space weapons, and some of the smaller air force fry had visions of space wars and dropping bombs from satellites. The air force, however, did not take the extreme view of Medaris that its ongoing missile program would be a technological fallout from its space program.

It is strange now to recall the fantasies that *Sputnik* inspired in the minds of many able military officers. It cast a spell that caused otherwise rational commanders really to become romantic about space. No sir, they were not going to fight the next war with the weapons of the last war; the world was going to be controlled from the high ground of space. (Lyndon Johnson also took this view.) And they were convinced that their service, be it army or air force, was best qualified to develop the exotic technology that would be needed for space warfare—and for civilian use, too. In recalling these conflicts and fantasies, I also recognize that most of these star-struck officers were also motivated by a laudable concern for the defense of the nation. I cannot say the same for some parts of the aerospace press which outrageously conjured up even wilder fantasies and scare talk, usually in the interest of circulation and advertising from the aerospace industry.

To cope with this fierce competition within the department of defense, Secretary McElroy created a new agency within his office to undertake advanced research and development apart from the three services. The Advanced Research Projects Agency (ARPA) had been recommended to the secretary by an informal advisory committee of astute industrialists in which Charles Thomas, onetime chief executive officer of the Monsanto Company and sometime member of the ODM Science Advisory Committee, played a leading role, with me coming up fast in close support. It proved to be one of the most valuable organizational inventions of the period. My enthusiasm for it led me to recommend Dr. York to be chief scientist of ARPA, although he would be a great loss to my group. He talked with me at length about the job, and I encouraged him to accept Secretary McElroy's invitation to take the post.

The secretary saw another function for this central DOD agency. He indicated that ARPA was to centralize the DOD's space programs and he hoped that it would reduce the rivalry among the services. This centralization of space in the DOD drew bitter opposition from the air force and the cacophony increased. In announcing plans for ARPA, McElroy had also indicated that ARPA stood ready to work with any civilian space agency that might be established or even to manage the civilian as well as the military space programs. The establishment of ARPA was a fine idea for the DOD, but this tentative and self-serving offer to give it the responsibility for the nation's space program was ill timed. Several days before ARPA was formally launched, Eisenhower had announced that he had asked PSAC to recommend an organization to manage the national space program.

Among the other organizational possibilities was the Atomic Energy Commission, which had been urged by the Congressional Joint Committee to add space to its responsibilities, a proposal endorsed by the Federation of American Scientists. There were premature visions of atomic-propelled rockets and other fantasies involving the use of nuclear power, but perhaps in the distant future nuclear-propelled space vehicles will be needed. Still another organizational arrangement was proposed by senators Humphrey, McClellan, and Yarborough, who introduced a bill to create a department of science, which would include a ble, and strong to pass five thousand miles safely out of and then back into the earth's atmosphere. When aluminum was advocated, von Neumann rejected this metal, explaining in his humorous, delightful, foreign way: 'Ah, no, no, aluminum is too flabby.'"[24]

Christofilos was in good form that day he appeared before PSAC. A coworker had once remarked, "Did you ever see two Paris taxi drivers in an argument? Well, Nick could play the part of one of them without any trouble at all." It was this meeting that led PSAC to convene a group of representatives of the scientific and defense communities to consider the desirability of such an experiment. The conclusions were favorable, and PSAC recommended that the great experiment be undertaken. Apparently for security purposes the president preferred not to have the matter discussed at an NSC meeting. I presented the PSAC recommendation to him on 1 May 1958, and he made the decision himself that the experiment be undertaken.

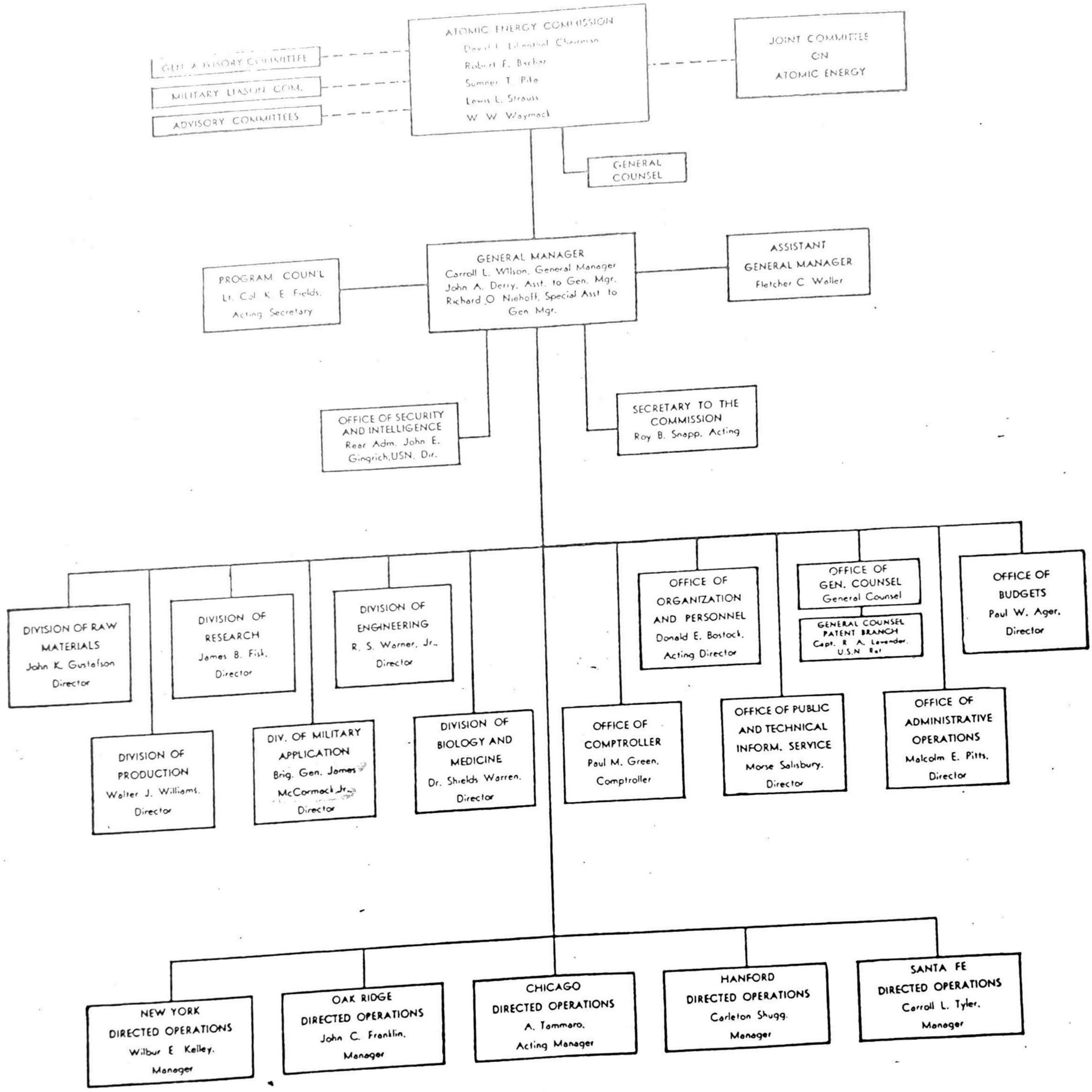
Obviously the test would require immense resources and facilities involving both the Atomic Energy Commission and the Department of Defense and a group of other organizations. As finally organized, the operational and technological management of the project was vested in the new Advanced Research Projects Agency (ARPA) of the DOD. The nuclear explosives would be provided by the AEC, the *Explorer* rocket by the Army Center in Huntsville, and the navy would provide the task force. The Air Force Special Weapons Center undertook the preparation of a series of high-altitude sounding rockets for the study of the lower fringes of the expected effect at altitudes of about 500 miles utilizing a five-stage solid propellant rocket vehicle that had been developed by the NACA. The Air Force Cambridge Research Center and the Stanford Research Institute developed, located, and prepared to operate a variety of equipment at suitable ground stations and aboard aircraft and ships. In his capacity as chief scientist of ARPA, Dr. York directed the program and provided a link with the Science Advisory Committee. The navy was entrusted with the execution of the experiment.

The whole program was under great pressure to meet deadlines, particularly the deadline for the voluntary one-year cessation of nuclear tests that the United States had committed itself to as of 31 October 1958. Staggering in scale and complexity, it was a beautifully managed and highly successful experiment from beginning to end. Three rockets were launched from the rolling, pitching deck of the *Norton Sound*, and all three were successful in delivering the nuclear test devices. Although thousands of people were involved, the tests were conducted in almost perfect secrecy—I say "almost" because Hanson Baldwin of the *New York Times* had advance knowledge of the experiment, but the *Times* responsibly published nothing about it until 19 March 1959, when it broke the story, with the science parts written by Walter Sullivan. The tests had been conducted in September 1958.

Once the tests had been conducted, a great debate within government developed as to what kind of public announcement should be made, if any. There was a tricky question involved relating to the International Geophysical Year because some of the data-gathering facilities that were employed were IGY facilities, and there was a general IGY commitment to publish the data from work done under the program.

While recognizing that there were important military uses for the data yielded by the experiment and that this information should be kept secret, nevertheless there were strong convictions in PSAC that the experiment should be made public and such results as could appropriately be published should be made available for the benefit of the scientific community. I think it was appropriate that the execution of the experiment at the time it took place and its results analyzed should not have been announced, because there were certain features of the experiment in which it was important that information be gathered about the extent to which it might have been observed by the Soviets. The matter, however, was taken out of the hands of the government by publication in the *New York Times*, displayed with a front-page splash: "U.S. Atom Blasts 300 Miles Up. Mar Radar, Snag Missile Plan; Called 'Greatest Experiment.'" Walter Sulli-

U.S. ATOMIC ENERGY COMMISSION



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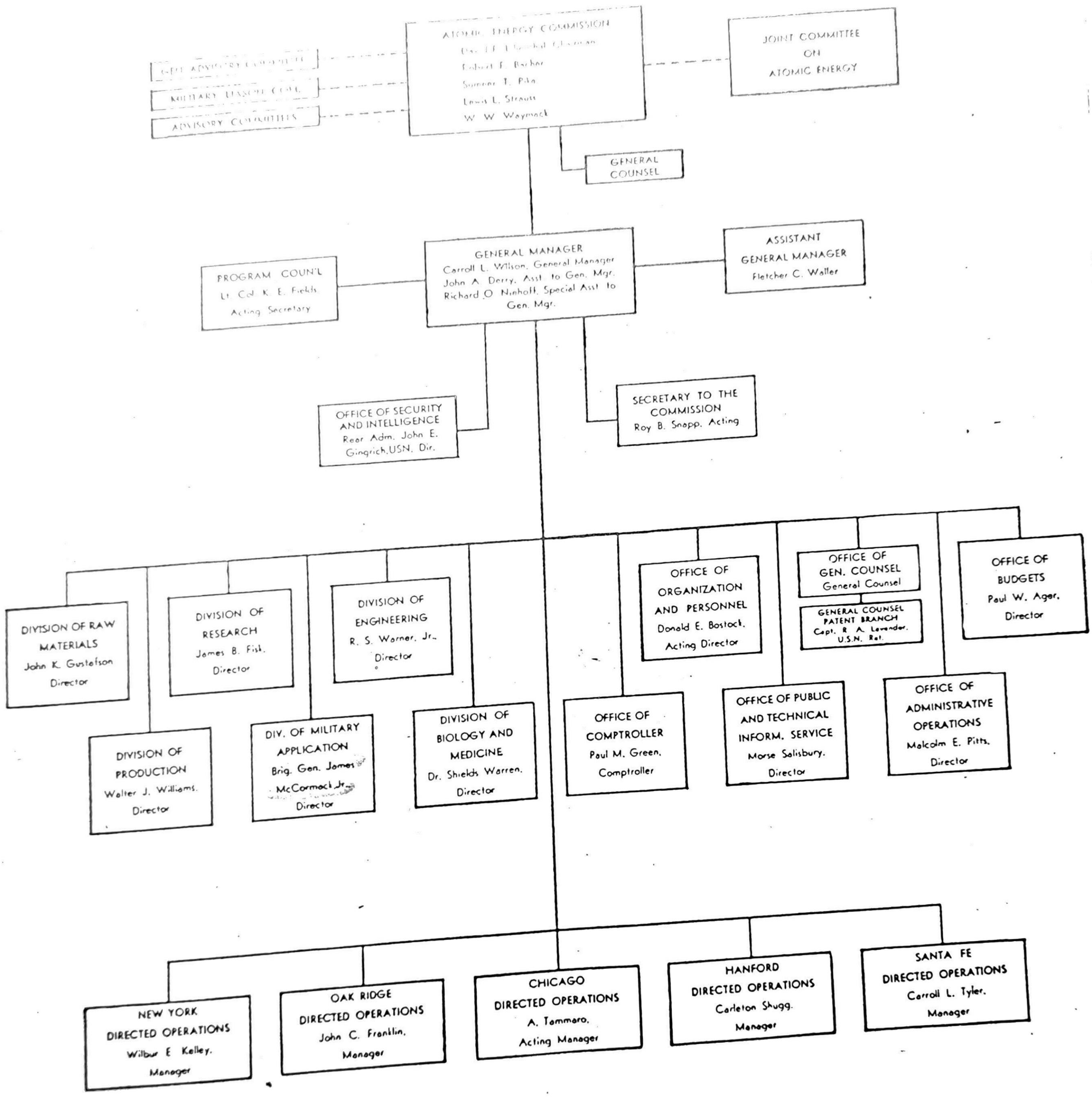
U.S. ATOMIC ENERGY COMMISSION



STANDARD FORM NO. 64

13

Office Memorandum • UNITED STATES GOVERNMENT

TO: DR. MACHLE

FROM: H. L. BOWERS

Declassified by 058375
date 20 APR 1977

DATE: 31 March 1949

SUBJECT: NOTES AND COMMENTS ON "UNIDENTIFIED AERIAL OBJECTS" - PROJECT SIGN

The sighting of unconventional objects can be broken down into the following:

1. Objects identified as conventional aircraft.

2. Weather and atmospheric sounding balloons.

3. Natural phenomena:

   a. Astrophysical (meteors, comets, planetoids).

   b. Electromagnetical (ball lightning, St. Elmo's Fire, phosphorescence, corona, etc.).

4. Hoax.

5. Unexplained.

CIA/OSI
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Of the unexplained objects there are the following possibilities:

a. Natural terrestrial phenomena:

   (1) Meteorological (ball lightning).
   (2) Some type of an animal.
   (3) Hallucinatory or psychological origin.

b. Man-made terrestrial phenomena:

   (1) Advanced type of aircraft.

c. Extra-terrestrial objects:

   (1) Meteors.
   (2) Animals.
   (3) Space ships.

Studies on the various possibilities have been made by Dr. Langmuir of GE, Dr. Valley of MIT, Dr. Lipp of Project Rand, Dr. Hynek of Ohio State and Aero Medical Lab.

That the objects are from outer space or are an advanced aircraft of a foreign power is a possibility, but the above group have concluded that it is highly improbable.

1

 [redacted]

In discussion of this subject with Mr. Deyarmond at Wright Patterson Air Force Base, he seemed to think, and I agree, that the "flying discs" will turn out to be another "sea serpent". However, since there is even a remote possibility that they may be interplanetary or foreign aircraft, it is necessary to investigate each sighting.

[redacted]

Washington—Drive to hold down defense spending is not expected to affect the Advanced Research Project Agency's Project Defender, in which exploratory research and development is being conducted in the field of ICBM defense techniques and penetration aids for U.S. missiles (see p. 72). Defense Dept. is expected to seek $125 million for this effort in Fiscal 1965—the approximate amount appropriated for the current fiscal year.

ARPA will, however, concentrate on cutting back or abandoning programs that show little promise, so it may apply the funds to new projects. One program that has already been abandoned for lack of promise is the Bambi concept of ICBM defense (AW Oct. 21, p. 23), which involves the use of satellite-borne interceptor missiles.

"While the Bambi concept might have been technically possible, the reliability required was many orders of magnitude beyond what we can hope to obtain in the foreseeable future," according to Dr. Charles Herzfeld, ARPA's deputy director.

Approximately half of the Project Defender budget is expected to be spent in the effort to gain more knowledge of the re-entry characteristics of different types of warheads through measurement of their aerodynamic performance, their radiation in the optical, infrared wavelengths and their radar target characteristics at different frequencies, broadly termed "signatures."

The re-entry physics program "has been particularly productive during the past year," according to Dr. Herzfeld. "We are gaining important new knowledge from almost every shot we make." Because of the large amount of re-entry signature data obtained during the past year, where formerly there was almost a void, there will be increased emphasis during the coming year on analysis of this data and developing theories that will permit more basic understanding and future extrapolation without the need for so many expensive test shots.

Where previously there was some Army impatience with the re-entry physics program in its eagerness to push ahead with production of the Nike Zeus anti-ICBM missile, today there is universal agreement that the research effort has paid off handsomely in greatly increased understanding of the ICBM defense problem, according to Herzfeld. Equally important, it has provided invaluable knowledge for the development of devices and techniques to improve the ability of our own ICBMs to penetrate an enemy missile defense system, he said.

Program to investigate technical and economic feasibility of a relatively simple ICBM defense system designed to protect hardened underground missile sites and vital command centers, known as Hardpoint, still is under study by the Rand Corp. and Columbia University (AW Jan. 7, 1963, p. 34). No definitive conclusion has yet been reached as to whether such a defense would be sufficiently effective and inexpensive to warrant its adoption, or whether the funds could better be spent to build additional missiles. Present estimates indicate Hardpoint defense cost would be quite high, but the final answer depends in part upon the future advances that can be expected in technology, particularly in high-acceleration defensive missiles.

Boeing currently holds an ARPA contract for feasibility studies on the Hibex very-high-acceleration defensive missile. Contract calls for Boeing to build full-size experimental models for flight test during the coming year. Boeing's choice of a company to develop the fast-burn solid-propellant booster is expected to be announced very soon.

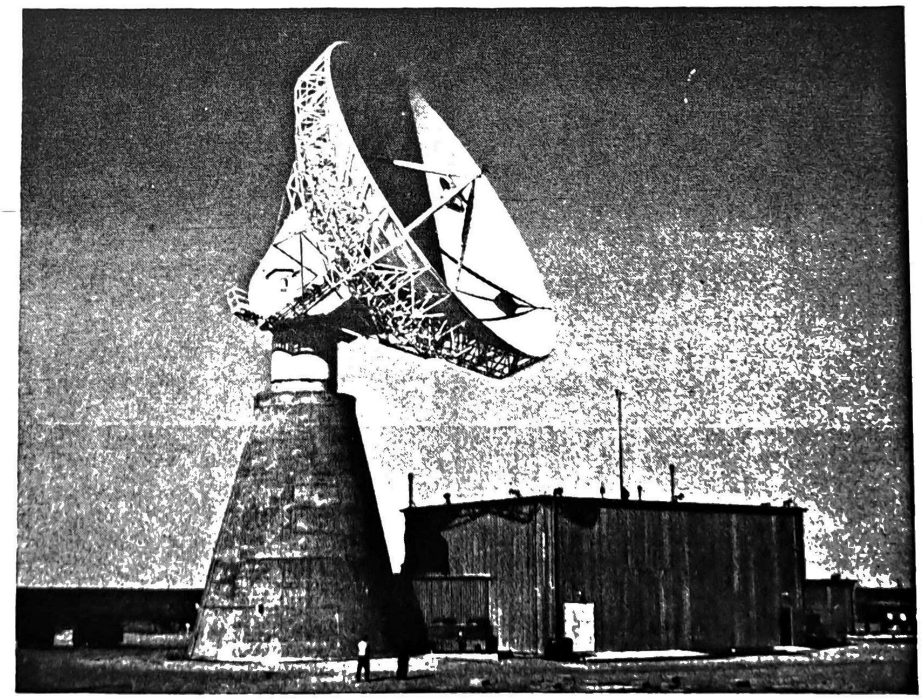
ARPA's research program in propellant chemistry has reached the point that the agency believes it should be transferred to one of the military services to accelerate application of new propellants to weapon systems, according to Dr. R. L. Sproull, ARPA's director. The agency has been spending about $23 million annually on this effort, or roughly 10% of its total budget. Sproull came to ARPA last fall from Cornell University.

About half of Project Defender's current budget is being spent on the re-entry physics program, including research in penetration aids. The Pacific Range Electromagnetic Signature Study —PRESS—now is in full operation at Kwajalein Atoll. The facility includes the Tradex radar, built by Radio Corp. of America, an extremely high-power equipment that operates both at UHF (425 mc.) and L-band (1,320 mc.) frequencies.

Recently, the ARPA Measurements Radar (Amrad), built by Raytheon, has become operational at the White Sands Missile Range.

The remaining 50% of the Project Defender budget is being spent to develop new types of radar techniques that have possible application to ICBM detection and defense. This includes, for example, new techniques for electronically scanning radar beams.

ARPA also is supporting research in optical masers (lasers) under Project Defender. While lasers "are an exciting new technology, and certainly an important one, we have a very long row to hoe before they may play a role in ICBM defense," one ARPA spokesman said.



AMRAD RADAR, developed by Raytheon for Advanced Research Projects Agency's Project Defender ICBM defense program, is installed at White Sands Missile Range to make precision radar cross-section and Doppler shift re-entry measurements on Athena and other targets. Radar uses a 60-ft. antenna and a 10-megawatt peak-power transmitter.

PANAMA:

Death at the Track

Col. José Antonio Remón, 46-year-old President of Panama, was a great sports lover. He never missed a ball game, a fight or a horse race if he could help it. This Sunday, as he did whenever he could spare the time, he dropped in at Juan Franco racetrack—for the last time.

After the races were over and the crowd had filed out, the President and his party lingered in the brightly-lighted presidential enclosure. Suddenly there was a burst of sub-machinegun fire from the darkened infield. The President fell with a bullet in his right side. He was rushed to Santo Tomás hospital, where the announcement came shortly after 9:32 P.M.: "The President is dead." Foreign Minister José Ramón Guizado took over the presidency at once.

During the night in a series of raids police arrested more than twenty suspects including former President Arnulfo Arias. He had been removed from office in 1951 by Remón's police forces following a bloody palace battle.

"Chichi" Remón, as chief of the National Police—Panama has no army—had been his country's strong man and President-maker since 1947. After four Presidents had moved into and out of office in rapid and disorderly succession, he reluctantly decided to run himself and was elected easily—and honestly—in 1953.

He proved to be one of Panama's ablest and most honest Presidents. He was a good friend of the U.S., a bitter foe of Communism, and a stabilizing influence in the sensitive area around the Panama Canal.

Remón's last official accomplishment was a diplomatic triumph, when he negotiated a new Panama Canal treaty with the U.S. on terms markedly favorable to Panama.

CANADA:

A Bouncing Economy

The Canadian story of the year in 1954 was covered in the financial sections of the newspapers. It was the story of how this country of 15 million people pulled through last year's "inventory recession" with only a slight pause in its progress from a raw, undeveloped land to a strong, industrial nation.

The 1954 picture wasn't unrelievedly bright; the post-Korea recession did hurt Canada. There were 50 per cent more business failures, 4.3 per cent of the working force was unemployed as compared with 2.6 per cent the year before, national savings were down, and many plus signs in the 1953 economic indices changed to minuses in 1954. Foreign trade declined, too.

But in spite of higher unemployment and business vicissitudes, the country's over-all income increased slightly: People with jobs were getting higher wages, and slightly lower taxes meant more spendable pay. Third-quarter figures on the gross national product, about which economists had worried earlier in the year, showed Canadians producing goods and services at a rate of $23.8 billion a year, only 2 per cent less than the record $24.3 billion total in 1953.

If 1954 wasn't as good as the peak year of 1953, it was better (as in the U.S.) than any other. On the whole, the outlook was far from depressing, Trade and Commerce Minister C.D. Howe admitted in his year-end review.

Howe listed some reasons for the 1954 slowdown: (1) Many businessmen unloaded goods they had stockpiled during the Korean crisis. (2) International competition was getting sharper. (3) The brief recession in the U.S. had a depressing effect on Canadian exports.

But the chief reason was lower farm output, caused by the failure of the wheat crop. Wheat production totaled less than 300 million bushels, the smallest since 1943 and less than half the record harvest of 1953. Farm cash income was down 13 per cent.

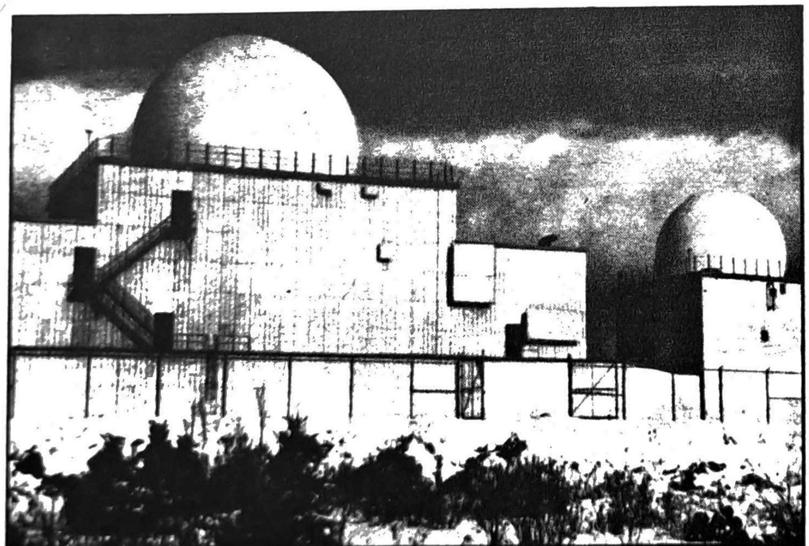
The dip in business last year was notable because it was so limited in extent, according to Gordon R. Ball, president of the Bank of Montreal. Present conditions, he said in his annual report, contain the ingredients for gradual resumption of normal growth.

Among these conditions: A sharply growing exploitation of natural resources; the establishment of new and diversified manufacturing industries; and a population that is increasing at a rate approaching 3 per cent a year.

There are signs that last year's downturn in foreign trade has about run its course. In November, commodity exports and imports both increased substantially over the figures for preceding months and for November 1953. Wheat orders are mounting; the market for base metals has improved; and conditions in the important American market, which absorbs just over 60 per cent of Canada's exports, are generally firmer. The overseas demand for raw and processed materials is stronger and is expected to improve.

Foreign capital, especially U.S. dollars, is still being attracted to Canada. Close to 500 million U.S. dollars sought investment opportunities in Canada last year, bringing the total American investment to about $9 billion and helping to maintain the Canadian dollar at a premium.

Most experts would probably agree with Howe that Canada in 1955 will bounce out of an economic decline but that there will still be some trouble spots.



Associated Press

Watchdog of the North: Sensitive instruments in the rubber-coated domes of radar stations like this are the first line of Canadian-U.S. defense against transpolar attack. Eventually there will be three lines. The Pinetree system, already operating, is an umbrella over southern Ontario and Quebec and certain western Canadian cities. The mid-Canada line, now being built by the Canadians, stretches above the settled areas. The U.S. will spend a billion dollars (with Canadian contributions) on a Distant Early Warning (DEW) line through the Canadian Arctic. The DEW line will be a "McGill Fence," cheaper, more efficient, and more automatic than ordinary radar. Some of the stations will be on ice islands in the Arctic Ocean.

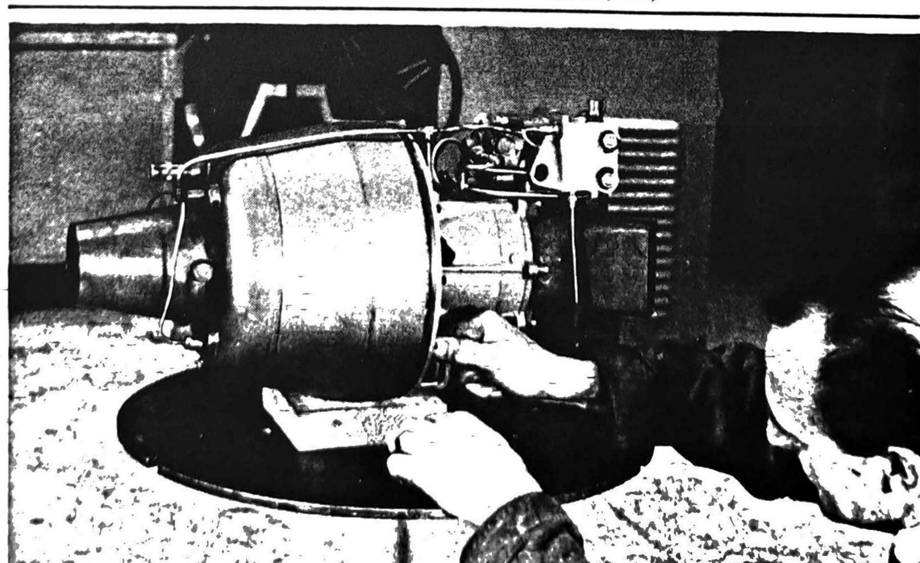
Military Research, Development Contractors

(Top 500-Fiscal 1967)

Rank	Name of Contractor and Location	Thousands of Dollars
	U.S. Business Companies	
1	Lockheed Aircraft Corp.	708,779
	Huntsville, Ala.	667
	Burbank, Calif.	10,869
	Edwards AFB, Calif.	14
	Guadalupe, Calif.	10,663
	Lompoc, Calif.	12,605
	Los Angeles, Calif.	43—
	Mountain View, Calif.	254
	Ontario, Calif.	105
	Palmdale, Calif.	550
	Palo Alto, Calif.	1,796
	Redlands, Calif.	1,480
	San Diego, Calif.	97
	Sunnyvale, Calif.	403,054
	Van Nuys, Calif.	27,656
	Cocoa Beach, Fla.	5,689
	Marietta, Ga.	217,474
	Las Vegas, Nev.	6,930
	Edison, N. J.	115
	Metuchen, N. J.	2,344
	Plainfield, N. J.	3,302
	Watchung, N. J.	53
	West Long Branch, N. J.	447
	Holloman AFB, N. J.	100
	White Sands MS, N. M.	2,018
	Langley AFB, Va.	178
	Norfolk, Va.	362
2	General Dynamics Corp.	461,130
	Lompoc, Calif.	11,044
	Pomona, Calif.	61,766
	San Diego, Calif.	76,919
	Fenwick, Conn.	4,500
	Groton, Conn.	8,027
	Cape Kennedy, Fla.	105
	Cocoa Beach, Fla.	60—
	Orlando, Fla.	51
	Bethesda, Md.	57
	Patuxent River, Md.	30
	Quincy, Mass.	5,490
	Las Vegas, Nev.	159
	White Sands MS, N. M.	1,433
	Rochester, N. Y.	11,583
	Daingerfield, Tex.	2,367
	Fort Worth, Tex.	277,619
	Camp McCoy, Wis.	40
3	General Electric Co.	439,090
	T T Pac	39
	United Kingdom	209
	Phoenix, Ariz.	214
	Pleasanton, Calif.	710
	San Jose, Calif.	24
	Santa Barbara, Calif.	4,723
	Bloomfield, Conn.	92
	Bridgeport, Conn.	139
	Washington, D. C.	785
	Daytona Beach, Fla.	399
	Gainesville, Fla.	40
	Owensboro, Ky.	546
	Chesapeake Beach, Md.	21
	Boston, Mass.	505
	Lynn, Mass.	20
	Pittsfield, Mass.	46,922
	West Lynn, Mass.	5,546
	White Sands MS, N. M.	1,372
	Auburn, N. Y.	36
	Ballston Spa, N. Y.	250
	Binghamton, N. Y.	18
	Johnson City, N. Y.	1,646
	Schenectady, N. Y.	23,590
	Stockbridge, N. Y.	555
	Syracuse, N. Y.	26,953
	Utica, N. Y.	18,823
	Cincinnati, Ohio	111,668
	Evendale, Ohio	36,944
	Oklahoma City, Okla.	12
	King of Prussia, Pa.	32,369
	Philadelphia, Pa.	98,681
	Valley Forge, Pa.	21,086
	Burlington, Vt.	4,153
4	Western Electric Co. Inc.	413,974
	T T Pac	138
	Lompoc, Calif.	1,247
	Point Mugu, Calif.	3,569
	Redondo Beach, Calif.	1,986
	Santa Monica, Calif.	39,127
	Orlando, Fla.	66,110
	Bedford, Mass.	50,938
	St. Paul, Minn.	16,132
	Fallon, Nev.	11
	Kearny, N. J.	12
	Whippany, N. J.	80,670
	Las Cruces, N. M.	623
	White Sands MS, N. M.	1,464
	New York, N. Y.	55,301
	Syracuse, N. Y.	23,675
	Burlington, N. C.	68,958
	Greensboro, N. C.	1,200
	Winston-Salem, N. C.	2,813
5	McDonnell Douglas Corp.	236,826
	Johnstn	30
	Huntington Beach, Calif.	107,028
	Lompoc, Calif.	19,669
	Long Beach, Calif.	3,659
	Los Angeles, Calif.	94
	Newport Beach, Calif.	211
	Santa Monica, Calif.	28,463
	Torrance, Calif.	129
	Cape Kennedy, Fla.	126
	Cocoa Beach, Fla.	14—
	Titusville, Fla.	8,816
	Robertson, Mo.	185
	St. Louis, Mo.	58,301
	Tulsa, Okla.	10,031
	Johnsville, Pa.	98
6	North American Rockwell Corp.	236,165
	Anaheim, Calif.	135,178
	Canoga Park, Calif.	15,005
	China Lake, Calif.	300
	Downey, Calif.	2,552
	El Segundo, Calif.	451
	Los Angeles, Calif.	32,103
	San Clemente Is., Calif.	20
	San Diego, Calif.	102
	Torrance, Calif.	35
	Eglin AFB, Fla.	58
	Patuxent River, Md.	31
	Neosho, Mo.	9,075
	Cloudcroft, N. M.	150
	White Sands MS, N. M.	54
	Columbus, Ohio	41,590
	Tulsa, Okla.	302
	Johnsville, Pa.	11
	McGregor, Tex.	877—
	Quantico, Va.	25
7	Boeing Co.	220,320
	Huntsville, Ala.	378
	Wichita, Kan.	4,146
	Las Vegas, Nev.	207
	Collingdale, Pa.	16
	Morton, Pa.	3,604
	Renton, Wash.	1,884
	Seattle, Wash.	210,085
8	Hughes Aircraft Co.	165,909
	Foreign	200—
	Tucson, Ariz.	203
	Canoga Park, Calif.	3,414
	China Lake, Calif.	25
	Culver City, Calif.	128,628
	El Segundo, Calif.	1,092
	Fullerton, Calif.	26,395
	Goleta, Calif.	150—
	Los Angeles, Calif.	4,965
	Malibu, Calif.	1,062
	Newport Beach, Calif.	42
	San Diego, Calif.	80
	Torrance, Calif.	165
	Dayton, Ohio	188
9	Martin Marietta Corp.	155,821
	China Lake, Calif.	19
	Lompoc, Calif.	10
	Los Angeles, Calif.	32
	Point Mugu, Calif.	28
	Denver, Colo.	82,949
	Littleton, Colo.	2,571—

(Continued on p. 75)

Note: Dollar total followed by a minus sign (—) indicates contract cancellations in excess of new awards.



Rover Jet Designed for Belgian Drone

Prototype Rover T.J.-125 turbojet, designed to power the Belgian Epervier unmanned surveillance drone, weighs 43 lb. The 114-lb.-thrust engine is a derivative of the Rover 2S/150A used as an auxiliary power unit in aircraft and ground effect machines. It has a pressure ratio of 3.9, a mass flow of 2.05 lb./sec. and a turbine entry temperature of 1,185K.

DOD Lists Biggest Research Contractors

The following tabulation by the Office of the Secretary of Defense lists 500 military prime contractors according to the net value of awards of $10,000 or more for experimental, developmental, test and research (EDTR) work during Fiscal 1963. The list is arranged in three sections. Section one includes 377 U. S. business firms; section two lists 119 educational institutions, government agencies and other non-profit institutions; four foreign contractors comprise section three.

A portion of section one appears in this issue. The remainder of the list of 377 firms, along with sections two and three, will appear in a subsequent issue. Of the 500 contractors on the Fiscal 1963 list, 125 were contractors who did not appear on the Fiscal 1962 list. Of the 377 business firms on the current list (identified by asterisk), 118 were small business firms. These are denoted by an S after the location.

In addition to the 500 listed contractors, 1,339 other contractors received prime contract awards of $10,000 or more for EDTR work during Fiscal 1963, making a total of 1,839 contractors in all.

This Fiscal 1963 edition of the list was reproduced from accounting machine tabulations. Because of machine limitations, non-standard abbreviations have been used in some cases. Other changes in presentation:

- **Instead of a single entry** and location for each contractor, this report shows all locations where the prime contractor was expected to perform the work.
- **Contractors were formerly** ranked separately in each section, so that there was a number one business firm and a number one non-profit institution. In this report, contractors in all sections are ranked in a single sequence. Omission of a number indicates contractor with that rank is in another section.
- **Foreign firms** have been listed in a separate section, instead of being included in the section with government agencies and non-profit institutions.

RANK	CONTRACTOR NAME AND LOCATION		(000)
1	Lockheed Aircraft Corp.		547,824*
	Burbank	Calif.	5,227
	Lompoc	Calif.	89
	Los Angeles	Calif.	249
	Maywood	Calif.	17 —
	Palmdale	Calif.	136
	Palo Alto	Calif.	722
	Redlands	Calif.	3,021
	Sunnyvale	Calif.	536,692
	Cocoa Beach	Fla.	47
	Marietta	Ga.	1,034
	Metuchen	N. J.	23
	Plainfield	N. J.	323
	Clark	N. J.	264
	Wright Patterson	Ohio	14
2	General Dynamics Corp.		519,314*
	Lompoc	Calif.	22,995
	Pomona	Calif.	63,952
	San Diego	Calif.	337,546
	Groton	Conn.	1,724
	Cocoa Beach	Fla.	11,263
	Rochester	N. Y.	5,338
	Johnsville	Pa.	21
	Daingerfield	Tex.	5,334
	Fort Worth	Tex.	71,048
	Camp McCoy	Wis.	93
3	Martin Marietta Corp.		457,891*
	Tucson	Ariz.	114,613
	Chico	Calif.	2,600
	Lompoc	Calif.	19,220
	Denver	Colo.	99,187
	Littleton	Colo.	141,553
	Cocoa	Fla.	24
	Orlando	Fla.	15,282
	Wichita	Kan.	31
	Baltimore	Md.	53,294
	Middle River	Md.	1,910
	Fort Monmouth	N. J.	20
	Wright Patterson	Ohio	150
	Rapid City	S. D.	10,007
4	North American Aviation Inc.		394,373*
	Anaheim	Calif.	15,832
	Burbank	Calif.	59
	Canoga Park	Calif.	36,331
	Downey	Calif.	162,776
	El Segundo	Calif.	39
	Inglewood	Calif.	98
	Los Angeles	Calif.	174,395
	Neosho	Mo.	977
	Reno	Nev.	1,112
	Columbus	Ohio	1,621
	McGregor	Tex.	1,133
5	Boeing Co.		363,701*
	Lompoc	Calif.	14,877
	Santa Maria	Calif.	3,200
	Cocoa Beach	Fla.	40
	Wichita	Kan.	8,707
	Knob Noster	Mo.	860
	Great Falls	Mont.	3,006
	Minot	N. D.	1,160
	Morton	Pa.	822
	Rapid City	S. D.	77
	Renton	Wash.	53
	Seattle	Wash.	329,509
	Cheyenne	Wyo.	1,390
6	Western Electric Co.		273,959*
	Lompoc	Calif.	574
	Santa Monica	Calif.	77,186
	Cocoa Beach	Fla.	943
	Orlando	Fla.	2,368
	Kearny	N. J.	303
	Monmouth	N. J.	10,568
	Murray Hill	N. J.	692
	Whippany	N. J.	133,738
	Las Cruces	N. M.	418
	Whippany	N. J.	190
	New York	N. Y.	8,773
	Burlington	N. C.	32,099
	Winston Salem	N. C.	4,639
	Allentown	Pa.	52*
		T. T. Pac.	1,416
7	General Electric Co.		255,792*
	Huntsville	Ala.	22-
	Phoenix	Ariz.	99-
	Laytonville	Calif.	92
	Lompoc	Calif.	3,506
	Los Angeles	Calif.	136
	Palo Alto	Calif.	579
	Pleasanton	Calif.	793
	San Jose	Calif.	285
	Santa Barbara	Calif.	2,720
	Washington	D. C.	143
	Daytona Beach	Fla.	78
	Owensboro	Ky.	454
	Baltimore	Md.	25
	Bethesda	Md.	100
	Fitchburg	Mass.	40
	Holyoke	Mass.	113
	Lynn	Mass.	1,533
	Pittsfield	Mass.	11,434
	West Lynn	Mass.	8,536
	Ballston Spa	N. Y.	16
	Buffalo	N. Y.	42
	Ithaca	N. Y.	922
	Johnston City	N. Y.	1,694
	Schenectady	N. Y.	31,283
	Syracuse	N. Y.	44,477
	Utica	N. Y.	3,758
	Cincinnati	Ohio	11,898
	Evendale	Ohio	7,101
	W. P. A. F. B.	Ohio	148
	Oklahoma City	Okla.	911
	Erie	Pa.	363
	King of Prussia	Pa.	271
	Philadelphia	Pa.	110,436
	Pittsburgh	Pa.	450
	Valley Forge	Pa.	1,137
	Irmo	S. Car	79
	Burlington	Vt.	4,509
	Lynchburg	Va.	5,714
	Roanoke	Va.	16
	Waynesboro	Va.	21
		B. W. Ind.	100
8	Aerojet General Corp.		202,177*
	Yuma	Ariz.	677
	Azusa	Calif.	38,711
	Downey	Calif.	10,356
	El Monte	Calif.	76
	Sacramento	Calif.	150,953
	Valparaiso	Fla.	1,404
9	Douglas Aircraft Co. Inc.		159,471*
	El Segundo	Calif.	495
	Lompoc	Calif.	21,645
	Long Beach	Calif.	1,920
	Santa Monica	Calif.	131,267
	Torrance	Calif.	369
	Cocoa Beach	Fla.	623
	Charlotte	N. Car	328
	Tulsa	Okla.	2,824
10	Sperry Rand Corp.		134,195*
	Phoenix	Ariz.	1,573
	Edwards	Calif.	198
	San Diego	Calif.	78
	San Francisco	Calif.	30
	New London	Conn.	1,494
	South Norwalk	Conn.	41-
	Waterbury	Conn.	16
	Clearwater	Fla.	705
	Cocoa Beach	Fla.	140
	Gainesville	Fla.	86
	Oldsmar	Fla.	422
	Bedford	Mass.	24
	Sudbury	Mass.	50
	Detroit	Mich.	59
	St. Paul	Minn.	21,524
	Fort Monmouth	N. J.	32
	Alamogordo	N. M.	27
	Carle Place	N. Y.	271
	Garden City	N. Y.	179
	Great Neck	N. Y.	56,764
	Ilion	N. Y.	327
	Long Island City	N. Y.	4,200
	Syosset	N. Y.	43,009
	Tulsa	Okla.	17
	Blue Bell	Pa.	279
	Philadelphia	Pa.	39
	Salt Lake City	Utah	1,667
	Charlottesville	Va.	1,026
11	Hercules Powder Co.		132,722*
	Wilmington	Del.	19,748
	Kenvil	N. J.	32
	Port Ewen	N. Y.	31
	Bacchus	Utah	3,000
	Magna	Utah	79,515
	Rocket Center	W. Va.	30,396
12	Westinghouse Electric Corp.		130,952*
	Newbury Park	Calif.	327
	Sunnyvale	Calif.	31,023
	Washington	D. C.	501
	Baltimore	Md.	29,335
	Elkridge	Md.	370
	Winthrop	Mass.	31
	Detroit	Mich.	97
	Bloomfield	N. J.	50
	Red Bank	N. J.	43

RANK	CONTRACTOR NAME AND LOCATION		(000)
	Buffalo	N. Y.	30
	Elmira	N. Y.	601
	Horseheads	N. Y.	127
	Dayton	Ohio	269
	Lima	Ohio	474
	Blairsville	Pa.	170
	Cheswick	Pa.	62
	Large	Pa.	82
	East Pittsburg	Pa.	18
	Forrest Hill	Pa.	40
	Lester	Pa.	124
	Philadelphia	Pa.	50
	Pittsburgh	Pa.	65,985
	Sharon	Pa.	116
	Trafford	Pa.	366
	Youngwood	Pa.	661
13	Pan American World Airways Inc.		121,215*
	Tucson	Ariz.	9,705
	Cocoa Beach	Fla.	109,836
		Can.	1,674
14	Radio Corp. of America		111,389*
	Fort Huachuca	Ariz.	83
	Tucson	Ariz.	102
	Pasadena	Calif.	320
	Van Nuys	Calif.	1,564
	Washington	D. C.	1,502
	Cocoa Beach	Fla.	36
	Bethesda	Md.	1,768
	Fort Meade	Md.	265
	Burlington	Mass.	25,557
	Winthrop	Mass.	180
	Camden	N. J.	30,746
	Harrison	N. J.	1,659
	Moorestown	N. J.	26,652
	Morristown	N. J.	450
	Princeton	N. J.	12,447
	Somerville	N. J.	463
	New York	N. Y.	4,329
	Croydon	Pa.	63
	Lancaster	Pa.	1,447
	Philadelphia	Pa.	1,642
	Alexandria	Va.	114
15	Avco Corp.		104,692*
	New London	Conn.	26
	Stratford	Conn.	25,026
	Connersville	Ind.	21
	Richmond	Ind.	1,784
	Everett	Mass.	5,431
	Lowel	Mass.	16
	Wilmington	Mass.	71,195
	Winthrop	Mass.	90

RANK	CONTRACTOR NAME AND LOCATION		(000)
	Cincinnati	Ohio	730
	Evendale	Ohio	60
	Tulsa	Okla.	78
	Williamsport	Pa.	235
16	General Motors Corp.		86,819*
	El Segundo	Calif.	29
	Goleta	Calif.	1,554
	Santa Barbara	Calif.	295
	Panama City	Fla.	30
	Anderson	Ind.	283
	Indianapolis	Ind.	6,057
	Kokomo	Ind.	397
	Detroit	Mich.	219
	Flint	Mich.	54
	Milford	Mich.	76
	Pontiac	Mich.	88
	Warren	Mich.	346
	Cleveland	Ohio	17,627
	Hudson	Ohio	27
	Milwaukee	Wis.	57,477
	Oak Creek	Wis.	2,260
17	Hughes Aircraft Co.		80,044*
	Fort Huachuca	Ariz.	68
	Tucson	Ariz.	121
	Culver City	Calif.	65,871
	El Segundo	Calif.	131
	Fullerton	Calif.	9,160
	Inglewood	Calif.	152
	Los Angeles	Calif.	3,225
	Malibu	Calif.	874
	Newport Beach	Calif.	191
	Oceanside	Calif.	202
	Floyd	N. Y.	49
19	Sylvania Electric Products Inc.		71,331*
	Mountain View	Calif.	29,153
	Needham Height	Mass.	3,941
	Waltham	Mass.	15,448
	Woburn	Mass.	201
	Ann Arbor	Mich.	12
	La Cruces	N. M.	245
	Buffalo	N. Y.	22,268
	Towanda	Pa.	63
22	International Telephone/Tel. Co.		65,334*
	Lompoc	Calif.	3,864
	San Fernando	Calif.	710
	Chicago	Ill.	5,149
	Fort Wayne	Ind.	271
	Topeka	Kan.	70
	Lincoln	Neb.	31
	Omaha	Neb.	67

RANK	CONTRACTOR NAME AND LOCATION		(000
	Clifton	N. J.	1
	Nutley	N. J.	10,61
	Paramus	N. J.	44,07
	Roswell	N. M.	10
	Altus	Okla.	25
	Spokane	Wash.	4
	Cheyenne	Wyo.	8
23	Thiokol Chemical Corp.		62,34
	Huntsville	Ala.	5,76
	Los Angeles	Calif.	2
	Baltimore	Md.	7
	Elkton	Md.	1,41
	Denville	N. J.	6,44
	Trenton	N. J.	26
	Bristol	Pa.	18
	Brigham City	Utah	47,95
	Logan	Utah	1
24	United Aircraft Corp.		57,03
	Edwards A. F. B.	Calif.	2,57
	San Diego	Calif.	26
	Sunnyvale	Calif.	53
	Broad Brook	Conn.	5
	East Hartford	Conn.	37,75
	Hartford	Conn.	2,96
	Middletown	Conn.	4
	Norwalk	Conn.	50
	Stratford	Conn.	10,32
	Windsor Locks	Conn.	88
	West Palm Beach	Fla.	1,03
	Fort Benning	Ga.	10
25	Bendix Corp		53,11
	Edwards	Calif.	3
	Los Angeles	Calif.	1
	North Hollywood	Calif.	2,81
	Sylmar	Calif	2
	Van Nuys	Calif	48
	Mishawaka	Ind.	11,20
	South Bend	Ind.	4
	Davenport	Iowa	14
	Baltimore	Md.	14,42
	Towson	Md.	7,29
	Ann Arbor	Mich.	10,26
	Detroit	Mich.	50
	Southfield	Mich	83
	Eatontown	N. J.	12
	Teterboro	N. J.	3,52
	Sidney	N. Y.	19
	York	Pa.	69
		Can.	49
26	Ford Motor Co.		53,05