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DEDICATION OF NEW 140-FOOT RADIO TELESCOPE AT THE NATIONAL RADIO ASTRONOMY OBSERVATORY, GREEN BANK, WEST VIRGINIA

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REMARKS OF DR. LELAND J. HAWORTH DIRECTOR, NATIONAL SCIENCE FOUNDATION

It is always an agreeable experience to participate in the dedication of a new scientific research facility. To me this occasion is more than usually gratifying. I say this because I was personally and rather intimately involved with some of the growing pains associated with the planning and developmental stages of the project, as Director of the Brookhaven National Laboratory and as vice president and president, rather briefly, of Associated Universities, Inc.

The 140-foot radio telescope which is the center of our attention today brings a significant additional research capability to the National Radio Astronomy Observatory, and introduces a new potential for exploring the nature of the universe. Even to the eye of a casual observer, the instrument represents a major engineering achievement. The base contains 5,700 tons of concrete and 170 tons of steel resting on solid rock 30 feet below the ground. The moving parts total more than 2,600 tons. It is the largest equatorially-mounted radio telescope in the world, and the most precise instrument of its kind in existence.

But for me, this instrument and the occasion of its dedication serve to rekindle memories of the devotion to duty and perseverance of people who guided the project through some rough waters, who gave unselfishly of their time, their talents, and their loyalty in doing all the things necessary to get the job done.

I am speaking now of people like Max Small who helped us build facilities at Brookhaven, and who then moved over to head the project staff for the National Radio Astronomy Observatory. I am speaking of people like Jerry Tape, a wartime colleague at MIT and close associate at Brookhaven, who played a crucial role as vice president and president of Associated Universities. And I. I. Rabi, Ted Reynolds, Dick Emberson, Charles Dunbar, and Lou Burchill and many others of that earlier period and later to whom I would now like to express a hearty "well done."

The ground rules covering dedication ceremonies are weighted in favor of the speaker. By tradition he is entitled to assume that among his listeners there is at least one individual who knows nothing whatever of the circumstances, but who is waiting eagerly to be informed. On the basis of this assumption, the speaker is then free to say at least some things that may be familiar to many members of his audience and know that he will be forgiven.

With this apology I should like to point out the interesting way in which the achievement we are celebrating resulted from several separate, though parallel and often overlapping developments that had their genesis in World War II. Let me speak first of radio astronomy itself.

Radio astronomy is a new branch of a very old science. In the single generation since Karl Jansky announced his first findings, we have witnessed revolutionary changes in our way of life which can be attributed to the fruits of science. We have moved into the age of jet-air travel, manned orbiting satellites, and space probes capable of traveling to Mars and beyond. On the more mundane level, television sets and automatic dishwashers now rank right along with the kitchen stove as essential items of household equipment.

But here at Green Bank, as at the other 20 or so radio astronomy installations in the United States, we have rather a good illustration of how the feedback from technology, the fruit of science, can be applied, in turn, to fostering and promoting the further development of science.

When Karl Jansky presented his original paper on mysterious extra-terrestrial electrical signals to the International Scientific Radio Union in 1932, there was no immediate great stir of interest in the scientific community. The optical astronomers were busy with their own affairs, and the implications for physicists, chemists, and mathematicians in Jansky's findings were as yet unseen. As a matter of fact, the various scientific disciplines in those times were still living pretty much in separate households. In some cases, professionally speaking, there was hardly even a nodding acquaintance. Besides, while Jansky was a physicist, the problems of radio static upon which he had been working for Bell Telephone Laboratories seemed more related to engineering than to science.

In any event, except for some follow-on work by Grote Reber in the later 1930s, Jansky's fundamental discovery lay dormant for about 15 years. An important contributor to the revival of interest was the same phenomenon that has had so much impact on every aspect of our lives, the explosive scientific and technical developments that grew out of World War II. The electronic arts mushroomed, bringing much more highly sensitive radio and radar receivers, -- especially at the higher frequencies, new types of and much larger antennas, electronic computers, and many other electronic wonders. It is not surprising that numerous people began to realize that here were the means for effectively exploring the nature and sources of Jansky's mysterious astronomical signals.

The United States has always done well in optical observational astronomy. The discoveries from which the present general picture of the Universe has emerged have largely come from observatories in this country. This came about because a few inspired and imaginative men in the first half of this century secured the private funds to build the large telescopes which enabled us to reach our present position in astrophysics.

With so many other irons in the postwar fire, we were frankly late in entering the field of radio astronomy, and the first large telescopes and antenna arrays were built in Australia, England, and the Netherlands.

First serious efforts in radio astronomy in the United States took place in the early 1950s, with modest projects at the Naval Research Laboratory and at Cornell University. A radio astronomy project at Harvard, started in 1953, produced the first Ph. D. s in the new specialty, but even by 1956 we had only about 20 professional radio astronomers in the country, and about 20 graduate students doing research in the subject.

In the early 1950s the scientific community began to make concerted efforts to study the growing needs in the field. An especially crying need was for more and larger, highly-sophisticated equipment. Much of that equipment would be so expensive in money and technical manpower that it could be provided only in small numbers--sometimes only singly--even with substantial increases in the support from the Federal Government. But it was rightly deemed essential that the most advanced equipment be available to the best radio astronomers, wherever based, and that it would not be in the national interest for them to be concentrated in one or even a few places.

This situation was strikingly similar to that in the nuclear sciences as World War II was ending some years earlier. At that time far-sighted scientists foresaw the fact that advancements resulting from nuclear research would result in the need for large and complicated equipment such as nuclear reactors, large accelerators and special laboratories whose construction and operation would involve vast expenditures in money and human effort and whose effective utilization could be accomplished only by the cooperative efforts of large groups of scientists working in many fields. Consequently, in contrast to the pre-war period, much of the more advanced research in the nuclear and related fields would be beyond the scope of most universities and other private institutions and would have to be conducted in large, specialized centers. It was, however, essential both to the effective advancement of science and to the health and vigor of the traditional institutions that they continue to participate in such advanced fields. Thus was conceived the idea of national cooperative laboratories in which the requisite equipment would be provided for use not only by the resident staff but also by the scientific community at large.

Encouraged by General Leslie Groves, then still head of the Manhattan District, and backed by their individual universities, scientists in several of the leading northeastern universities developed the idea of such a laboratory, to be financed by the Government but operated by a private organization. In keeping with the concept of cooperative research it was deemed logical to provide cooperative management. Thus were born the first federally-supported cooperative laboratory, Brookhaven, and the first multiple-university sponsored non-profit research organization, Associated Universities, Inc. which operates it. The Atomic Energy Commission, established about the same time, has financed the Laboratory through a long-term contract with AUI.

The concept of cooperative research was also applied, in varying degrees to others of the Commission's research centers, notably at the Argonne and Oak Ridge National Laboratories and the Lawrence Radiation Laboratory at Berkeley.

With the passage of time the worth of this concept was strikingly demonstrated. For example, a great bulk of our most advanced research in high energy physics has been conducted at these national centers. Literally thousands of university scientists have participated. The National Laboratories have also been vital to most of the research involving nuclear reactors, again with much university participation. Relatively less importantly, the cooperative aspects of the work has extended to many other areas of both the physical and biological sciences.

In their deliberations of the early fifties, those interested in radio astronomy, recognizing the applicability of the national laboratory concept, suggested to the Government the creation of a national observatory for radio astronomy.

The agency to which they turned, the National Science Foundation, itself results from new concepts growing out of World War II. In his report to the President--"Science, the Endless Frontier," made in 1945, Vannevar Bush had forcefully pointed out that not only would the applications of science become of increasing importance to the people and hence to the Federal Government, but also it was essential that basic science grow and flourish, both as the underpinning for technology and for its cultural and intellectual values. From his suggestions ultimately came the National Science Foundation Act of 1950, establishing the Foundation and charging it with the nourishment and support of basic science and science education. This charge is unique among those of government agencies in that whereas all others support science in pursuit of specific practical missions, the NSF supports science in order that science itself be strong and that we are liberally endowed with capable scientists and engineers. It has strong organizational ties to the scientific and academic communities; indeed it is governed by a Board drawn from that and other sectors of the public at large. I need not say that this concept and its fulfillment have been vital to the progress of basic science and of science education in this country.

The Foundation accepted the idea for a national observatory and set about its establishment. Associated Universities, Incorporated was invited to develop and operate the new institution. After considerable research the present site was chosen and a national radio astronomy observatory was established in 1956. My good friend, Lloyd V. Berkner, at that time President of Associated Universities and himself scientifically interested in atmospheric physics and astronomy, was a moving force in all of these activities.

Thus we see the coming together to produce a remarkably fruitful result the various separate post-war developments of which I spoke--the electronic advances that made modern radio astronomy possible, the concept of the national cooperative laboratory, the concept of a consortium of universities working together to achieve a national scientific goal, the concept of a Government agency devoted to science itself and guided by knowledgeable members of the public at large. I hope you will pardon me for saying that I take great pride in having at various stages partaken in each of these developments.

During its short lifetime the Observatory has made great progress under its successive directors, Dr. Berkner, Dr. Otto Struve and Dr. David Heeschen. Starting with modest equipment, including the 85-foot telescope which was wisely installed at a very early date, it has progressed to have the largest movable telescope in the world, the 300-foot reflector, and now the great fully-steerable and highly-precise telescope we are dedicating today. Excellent auxiliary equipment has been designed and fabricated, very significant scientific results have been achieved.

At this point, I would like to say that the NSF's pride in the accomplishments at Green Bank is equalled by its pride in the Kitt Peak National Observatory, built on the same concepts and operated by another university consortium, Associated

Universities for Research in Astronomy. We look forward to increasing cooperation between these two observatories which will undoubtedly be heightened by the millimeter wave telescope which the NRAO will establish on Kitt Peak.

While these developments have been unfolding, progress in optical astronomy, in astrophysics in general, and in our knowledge of the universe at large has been truly amazing. Such discoveries as that of quasers have astonished the scientific world and intrigued the general public. The great advances made in observational techniques and in scientific results have helped to bring about a resurgence of interest in the subject of astronomy. It is fitting that this be so. The world owes a great debt to astronomy in both the scientific and the general sense.

In the remainder of this talk let me trace for you some of the historical trends and natural inter-connections which have led to the current interlocking relationship of science and technology -- and to point out the great importance of re-consolidating the House of Intellect so that presumed or real cultural gaps between science and other crucially important areas of human activity can be bridged once more.

In the early days of western culture, there was no distinction made between the sciences as they were then known and other intellectual pursuits of man. Indeed the physical sciences were long known as natural philosophy. Science and technology were not closely interlocked as they are today. Development of tools, conveyances, and other appurtenances of everyday life was conducted by craftsmen and lowly inventors. The natural philosophers, or scientists, lived on a plane apart, and it would have been beneath the dignity of most such intellectuals to turn their talents to utilitarian uses.

Of course there were a few exceptions to the pattern. For example, since man lived by the seasons, kings and emperors supported large astronomical projects to insure that the calendar was accurate, so that the advent of spring could be predicted precisely and the crops planted accordingly.

Even in this early period, however, with science and what we now call technology so far apart, science gradually began to have an effect on the way man viewed himself in relationship to the universe. The great discoveries, the transforming changes brought about by the intellectuals, were slow in making an impact on society. The impact was delayed by the character of the social structure, which was not simply inimical to progress but incapable of comprehending the idea. The whole idea of progress -- the concept that conditions of life can be improved as time goes on -- is relatively new. Peasants of the Middle Ages did not look forward to any marked improvement in their circumstances within their lifetime or the lifetime of their children. Elements of society with the power to initiate or encourage change were quite content with the status quo. The seasons and the years came and went, and the conditions of life at one springtime were essentially the same as those of the preceding ones. Modest changes in craftsmanship and simple inventions were slow to be adopted. Human progress was almost imperceptible so that most people were unaware of any improvement from one generation to the next.

Although unrecognized by the people as a whole, the ideas and progress of science were to change their circumstances. The theories of Copernicus published in 1543 constituted one of the great transforming ideas. His assertion that the earth was not the center of the universe -- as most men supposed -- cast doubt on a belief that had been accepted for countless centuries without reservation. Galileo, nearly a hun dred years later, confirmed and expanded the Copernican Theory that the sun was the center of the planetary system inhabited by man. Galileo, as history tells us, was not acclaimed by his contemporaries. After defying an edict of the church against "holding or defending" the Copernican Theory that his telescopes had verified, he was arrested by the Roman Inquisition and, under threat of torture, was forced permanently to recant. But the seeds of change had been planted. Scholars such as Newton and Kepler followed in turn to build on the work of their predecessors and -- slowly at first -- mankind began to question his relationship with the world around him.

A major early and continuing result was the contribution of the new mode of thinking to the unfettering of the human mind. Even religion has been basically affected. Galileo's theories have long been accepted by all but the most backward. It is heartwarming and an example of my point that a few months ago Pope Paul VI, the first of that name since Galileo was condemned, displayed again his own greatness by formally praising Galileo as one of the "great spirits" of "immortal memory".

Even at the beginning of the Industrial Revolution, there was little communion between science and what we call technology although there were occasional bridges connecting the two. Technology was based largely on the application of various forms of non-biological energy through increasingly complex machines to accomplish tasks that had formerly been done by man himself or by beasts of burden. As time went on, human ingenuity and improvements derived from experience gradually increased the range of possibilities. But for a long time, new developments continued to be largely the result of invention based on observation and on knowledge that was familiar, qualitatively at least, even to relatively untrained minds. Most advances into the unknown were empirical in nature, and usually occurred in gradual steps.

Gradually, beginning in the last century, some of the inventors -- importantly among them Edison -- began to find ways of applying to practical objectives the findings of the scientists then studying the laws of nature in a basic way.

As more people became active in research over the years, things began to change, slowly at first and then with greater and greater rapidity. Today the pace of change is almost beyond our capacity to keep abreast. Unlike the situation earlier, we now find our lives intimately affected by scientific applications, meaning applications derived directly from scientific research as distinct from technological innovations based on generally known fundamentals.

For decades now there has been an increasingly close and symbiotic relationship developing between science and technology. New discoveries in science open up new vistas in application, In turn, these practical developments often make possible the construction of new tools of research which are of great significance to the progress of science.

All this is as it should be. But the world must not forget the other side of science -- that it has a dual nature. On the one hand it has an enormous intellectual, cultural and educational value, something it shares with other forms of knowledge, with literature and the arts; on the other hand it is the foundation on which rests all of our technological advances. I am reminded of a remark often attributed to Michael Faraday, although at times to Benjamin Franklin. According to the Faraday version, he once demonstrated his first electromagnetic induction equipment to someone who asked, "Of what use is it?" and Faraday replied "Of what use is a new-born baby?" Now this is usually interpreted to mean that his device, like a new-born baby, might grow up to be useful to society, as indeed it did. But I believe there is a second meaning, namely, that a new-born baby is wonderful and useful in itself. When we go down the street and see a little child smiling and gurgling and laughing, and we smile in sympathy and are attracted to that child, it is not because we think it will grow up to become something useful in the world. It is because that child is something highly worthwhile in its own right; and so is basic science.

There has unfortunately been another change. For many centuries, as I have said, science was an integral part of the broad spectrum of advanced knowledge. There was no separation between science and the humanities; they were intellectually indistinguishable as branches of scholarship. But in recent times -- beginning at some point in the 19th century which is difficult to pinpoint accurately -- two related things have been happening. Science has been somewhat pushed away -- or has pulled itself away, depending on one's point of view -- from the arts and "the other humanities."

This is unfortunate, for science is not inhumane, and it is easily demonstrated that the life of the human race has been enriched by the ideas of science, as well as the material benefits which science has made possible. In a deeply meaningful sense, science is one of the humanities.

In placing science and the humanities in separate compartments, so to speak, those who do so frequently overlook the many ways in which science impinges on the mind of man in the same manner as music, literature, and art. Let me illustrate by a personal experience.

Some two years ago I spoke on a scientific subject to an annual "Alumni Institute" at Indiana University. In my talk I alluded to the intellectual and cultural values of basic scientific research. I pointed out that the objective of the fundamental scientist is an understanding of nature without regard to possible practical application. His reward is one of the mind and of the spirit rather than of material things.

Later in the evening, an artist on the faculty gave a very interesting illustrated talk on what interests and inspires the artist. Quoting from my talk, he concluded, with some surprise, that the artist and the basic scientist are not so far apart as is generally supposed, that their objective and their rewards are much the same. I thoroughly agree. It seems to me that the only basic difference is that the scientist seeks to learn and understand the intrinsic beauties found in nature's laws, which are immutable, whereas the artist is free to create beauty by combining nature with his own imagination.

Acknowledging that the scientist and the artist both derive pleasure and satisfaction from their creative efforts, we might well then ask: "What of the spectators?" Many will view -- and some will understand at least in part -- the artist's work. On the other hand, there is a fairly widespread belief that science can be "viewed and understood" only by the initiated few. I disagree. Science can be made understandable, but not easily. It is necessary for scientists and educators -- including the special kind of educators who are engaged in writing stories for newspapers and magazines and scripts for television commentators -- to work together to insure that the advances of science, its great and truly wondrous spirit of adventure and conquest, are conveyed at least to some extent to the public.

It is also important that the public learn to understand the scientists themselves, that they are simply highly educated men working in a specialized field. Today there is no question as to the skill, capability, efficiency and natural endowment of American scientists and engineers. The public is proud of the remarkable achievements they have made. Their successes have instilled in the average citizen a feeling that scientists and engineers can accomplish almost any technical result.

This image of the scientist is, of course, exaggerated. But it is important that we continue to take advantage of our great opportunities in science, for it is certain that this is the best way to improve our lot in life and to maintain our security.

This will entail increased public investment in science and its applications, and I would be the first to say that it is not fair to ask the public to pay taxes for what it does not and cannot understand. But one does not have to be an astronomer to understand in reasonable detail what is exciting and important about the discovery of quasers, those super-super bright objects radiating fantastic amounts of energy as they recede from us at speeds almost beyond imagining and on the outskirts of the observable. Can we ever put such objects to use? Of course not. Is their discovery nonetheless significant? Of course it is. And it takes no more specialized knowledge to understand and become impressed by this discovery -- this accomplishment of man's intellect -- than it does to learn about the scaling of Mount Everest and to share vicariously the joy of accomplishment with those who first accomplished this feat. The point is that those who speak for science -- the communicators -- must make the information available to the audience in palatable and digestible form.

Clearly the leadership of our society as a whole needs to work hard to bring back together the areas of activity we nowadays commonly call the humanities and the sciences. At the same time, we should also address ourselves to the task of making certain that we have in fact this time erected the House of Intellect in complete and inclusive form. Two centuries ago it excluded the technology of the day. As we bridge the gap that is today said to exist between the humanities and science, we will be doing only part of the job if we perchance fail to make sure that technology also is made part of the intellectual family.

A distinguished scientist and past president of the American Association for the Advancement of Science, Chauncey Leake, envisions an intellectual partnership in coping with the need for understanding. "When the sciences and the humanities," he points out, "are used like the two eyes of man's remarkable bifocal vision, we can expect that we shall be able to discern much wiser policy decisions at the various social levels than we can when these two major dimensions of human experience are isolated from each other."

This mutual understanding can be achieved only by movement from both directions. The humanist who scorns -- as some do -- the usefulness of science is wrong. The practical man who scorns intellectual and cultural values is also wrong. In both cases their vision is too circumscribed.

In years gone by, it was not uncommon to hear the claim that science is inimical to the welfare of human society. There are still a few among us who would turn back the clock to an Arcadian era when life was simpler. This sentimental but misguided nostalgia for oil lamps, outdoor plumbing, and germs in the milk helps account for sporadic outbursts of reaction we have witnessed in the United States from time to time. In spite of such small pockets of resistance to progress, it is certain that in the absolute sense man is today closer to meeting his fundamental needs and satisfying his less fundamental wants than ever before. Moreover, science has brought to thoughtful men and women the realization that man can put an end to existing ills and make the planet on which we live a better habitat for the human race.

We must bear in mind that useful work, good health, and survival are not guaranteed in nature. Millions of unfortunate people are still wholly occupied with the desperate effort to obtain enough food to hold body and soul together. Such things as productive jobs, medical services, and the thousand and one characteristics of a highly developed society are man-made. Here in the United States it has been demonstrated that science in concert with other intellectual elements can alter the social and economic balance of a nation, providing a fuller opportunity for personal fulfillment and the pursuit of happiness.

Clearly, science and scientists have changed the world. They have created untold opportunities for good, and enormous potentialities for evil. As a result of their efforts, we enjoy longer and healthier lives; we have such conveniences and tools as abundant electricity in the home, safe and speedy surface and air transportation, nuclear reactors propelling surface and sub-surface ocean-going vessels; instantaneous communication, including live television to and from Europe via orbiting satellites; space vehicles traveling millions of miles to inspect the planets and relay their observations back to earth; giant accelerators probing deep into the sub-nuclear world; ultra-high-speed computers solving complex problems in science, in business, and in many other spheres.

Scientific advances over the fairly recent past have brought with them a sweeping egalitarian influence here in the United States. Although the process is by no means complete, we are approaching more closely to a classless society than any nation since the beginning of the end of feudalism. The gap between the rich and the poor has become progressively narrower as the standard of living for all people has been raised. Judy O'Grady and the colonel's lady patronize the same hairdresser and occupy adjacent seats at the theater. The banker, once an aloof and unapproachable ogre, has become a friendly corner merchant. This dramatic improvement in the standard of living can be directly attributed to science and the benefits it has bestowed. I do not need to remind you that wide class distinctions -- the chasm that yawns between the rich and the poor -- is a major source of the many problems of undeveloped countries.

But science has also made possible intercontinental ballistic missiles with nuclear warheads, world-ranging submarines armed with similar weapons, and a wide variety of death-dealing devices making use of biological and chemical agents. These levels of technological sophistication have been achieved in a world whose inhabitants are not all intellectually mature. The world is still "growing up," and growing up can be dangerous. Throughout the centuries history has shown us that the human race never moves forward uniformly; hence increasing scientific knowledge brings both opportunity and danger. Only by the most arduous efforts can opportunity be strengthened and danger lessened.

In connection with this potential for good or evil, let me here draw an analogy between science and another of man's great intellectual achievements. No one would seriously dispute the inherent value of an expressive and versatile language. It is an essential element of civilized society. Without a good command of language, no man can realize his full potential either culturally or professionally. But language, too, can be used for differing purposes. It is the basic means of communicating knowledge and ideas. In the hands of some, it has reached sublime cultural and intellectual heights. Wrongly used, it can express evil and obscene thoughts. It can by a Hitler spur men on to base and evil deeds. But it can also be used by a Churchill to inspire others to great and noble sacrifices for the common good.

Thus it is the minds of good or evil men -- who use the magic of language to inspire or debase the souls of others -- which determine whether communication is used to accomplish good or evil in the world.

And so it is also with science, Society as a whole -- including both the scientists and the humanists -- must determine the course of science.. Its application for good or evil inevitably reflects our social morality. What uses we now make of science will demonstrate to future generations the kind of moral values we hold in the 20th century.

I am sure that as we move forward together to achieve our common goals astronomy will continue to be enormously important. It is one of the vital contributors to our understanding of the universe about us; it has profound intellectual and cultural depths; it intrigues not only scientists but laymen; its goals are clearly peaceful; they are shared internationally.

I am equally sure that as astronomy continues to move forward an important role will be played by the National Radio Astronomy Observatory and by the great instrument that we dedicate today.