PALOMAR

June 3, 1948

June 3, 1948

*

Dedication of the Palomar Observatory and the Hale Telescope

*

California Institute of Technology

DEDICATION

Palomar Observatory

June 3, 1948

*

JAMES R. PAGE

Chairman of the Board of Trustees :: California Institute of Technology

PRESIDING:

The dedication of the Palomar Observatory, if it were being held in England, would be accompanied by brilliant pageantry both of the state, with its knights, heralds, pursuivants, kings at arms, admirals and captains, and of the church with its bishops, priests and deacons, crucifers and choirs; and I am sure that we feel the quality of religion in this ceremony. We would hear the choirs chanting in antiphony that great canticle which so delights the choir boys:

Benedicite, omnia opera Domini

O all ye Works of the Lord, bless ye the Lord: *Praise Him and magnify Him forever.*

O ye Angels of the Lord, bless ye the Lord: *Praise Him and magnify Him forever.*

O ye Heavens, bless ye the Lord: *Praise Him and magnify Him forever.*

O ye Waters that be above the firmament, bless ye the Lord: *Praise Him and magnify Him forever.*

O all ye Powers of the Lord, bless ye the Lord: *Praise Him and magnify Him forever.*

O ye Sun and Moon, bless ye the Lord: *Praise Him and magnify Him forever.*

O ye Stars of Heaven, bless ye the Lord: *Praise Him and magnify Him forever.*

O ye Showers and Dew, bless ye the Lord: *Praise Him and magnify Him forever.*

O ye Winds of God, bless ye the Lord: *Praise Him and magnify Him forever.*

O ye Fire and Heat, bless ye the Lord: *Praise Him and magnify Him forever.*

O ye Winter and Summer, bless ye the Lord: *Praise Him and magnify Him forever.*

O ye Dews and Frosts, bless ye the Lord: *Praise Him and magnify Him forever.*

O ye Frost and Cold, bless ye the Lord: *Praise Him and magnify Him forever.*

O ye Ice and Snow, bless ye the Lord: *Praise Him and magnify Him forever.*

O ye Nights and Days, bless ye the Lord: *Praise Him and magnify Him forever.*

O ye Light and Darkness, bless ye the Lord: *Praise Him and magnify Him forever.*

O ye Lightnings and Clouds, bless ye the Lord: *Praise Him and magnify Him forever.*

O let the Earth bless the Lord: *Yea, let it praise Him and magnify Him forever.*

O ye Mountains and Hills, bless ye the Lord: *Praise Him and magnify Him forever.*

O all ye Green Things upon the earth, bless ye the Lord: *Praise Him and magnify Him forever.*

O ye Wells, bless ye the Lord: *Praise Him and magnify Him forever.*

O ye Seas and Floods, bless ye the Lord: *Praise Him and magnify Him forever.*

O ye Whales, and all that move in the waters, bless ye the Lord: *Praise Him and magnify Him forever.*

O all ye Fowls of the air, bless ye the Lord: *Praise Him and magnify Him forever.*

O all ye Beasts and Cattle, bless ye the Lord: *Praise Him and magnify Him forever.*

O ye Children of Men, bless ye the Lord: *Praise Him and magnify Him forever.*

O let Israel bless the Lord: *Praise Him and magnify Him forever.*

O ye Priests of the Lord, bless ye the Lord: *Praise Him and magnify Him forever.*

O ye Servants of the Lord, bless ye the Lord: *Praise Him and magnify Him forever.*

O ye Spirits and Souls of the Righteous, bless ye the Lord: *Praise Him and magnify Him forever.*

O ye holy and humble Men of heart, bless ye the Lord: *Praise Him and magnify Him forever.*

The Board of Trustees of the California Institute of Technology, while they may not be "holy and humble men of heart," feel genuine humility in the presence of so great a gift as has been made by the Rockefeller Boards. It is their resolve to see that this observatory which is entrusted to them is administered and maintained for the benefit of science in the spirit in which it has been given.

It is appropriate that the President of the Rockefeller Foundation, Dr. Raymond B. Fosdick, should open this ceremony, for it is this Foundation and the other Rockefeller Boards that have made the observatory possible. Just twenty years ago the International Education Board pledged $6,000,000 to the California Institute for the construction of the observatory. Later, when the International Education Board was dissolved, the remainder of the $6,000,000 pledge was assumed in 1932 by the General Education Board. Finally, after the delay caused by the war with consequent increased expenses and rising prices, an additional half million dollars to complete the project was required, and this was pledged by the Rockefeller Foundation in 1947.

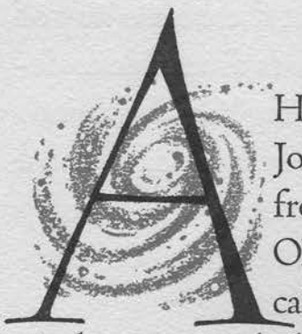
It would have been appropriate for the observatory to be called the Rockefeller Observatory except that the Rockefeller Boards have adopted a policy against the use of their founder's name in this way. However, a plaque recognizing the Rockefeller contributions has been placed in the lobby of this building.

Following a distinguished career in the practice of law and in public service, in 1936 Dr. Fosdick became President of the Rockefeller Foundation and the General Education Board. He will speak to us on "The Challenge of Knowledge."

The Challenge of Knowledge

BY RAYMOND B. FOSDICK

*



A HUNDRED AND FIVE YEARS AGO, John Quincy Adams, 77 years of age, journeyed from his home in Massachusetts to Cincinnati, Ohio, to lay the cornerstone of the Astronomical Observatory. It was a long and fatiguing trip by stagecoach, by canal boat, by steamboat, and part of the way by the newly invented railroad train. Much of Mr. Adams' dedicatory address concerned the neglect of astronomy in the United States. We have been, he said, "so absorbed in the toil of converting the wilderness into a garden," that we have been indifferent to the sciences, and "particularly to the science of astronomy."

To our generation, a hundred years later, the significance of his address lies, perhaps, not so much in what he said—although his comment is historically illuminating—as in what he failed to say. And what he failed to say was what nobody could have foreseen a century ago, because in 1843 there was no evidence that the time might come when the lag between advancing knowledge and social control would threaten the existence of society itself.

Twenty years ago, when the 200-inch telescope project came up before our group in New York, one of the trustees raised an objection. It was in the form of a question—a question which finds an echo everywhere today. "What are we going to do with our new knowledge?" he asked. "Aren't we acquiring more

knowledge than we can assimilate?" The shattering events of the last two decades have underscored the relevancy of his query. Knowledge and destruction have joined in a Grand Alliance that has made the history of our generation a history of deepening horror.

Obviously the difficulty lies in the fact that there is no way of foretelling what particular kind of knowledge is divertible to destructive ends. There is no method of classifying knowledge into safe and unsafe categories. All knowledge has become dangerous. Indeed, knowledge has always been dangerous; for knowledge means power, and power can be used to degrade as well as to ennoble the life of man.

Today, in dedicating this telescope, we are face to face with the problem of the unpredictable consequences of knowledge. We cannot even guess what will come from this mighty instrument, or to what ends the fresh insights which we gain here will be employed. When the giant cyclotron was built at the University of California, nobody was thinking of the atomic bomb. The cyclotron was conceived as an adventure in pure research, as an attempt to advance the boundaries of understanding on a far frontier. It was a symbol of the human hunger for knowledge, an emblem of the unconquerable exploring urge within the mind of man.

And yet that cyclotron contributed materially to the development of one of the phases in the construction of the atomic bomb, just as this telescope may conceivably give us knowledge which, if we so choose, we can employ in the insanity of a final war. Years ago an Oxford professor, working in the field of theoretical mathematics, remarked that he loved his subject because it could never be prostituted to any useful purpose. But he was wrong. There is no segment of knowledge, whether in the physical sciences or the social sciences, whether in medicine or economics

or astrophysics or anthropology, which cannot ultimately be employed to the detriment of mankind if that is what we deliberately elect to do with it. Indeed, I believe that if the social sciences were developed as the physical sciences have been, we might have a weapon which, in unscrupulous hands, would be as deadly as the atomic bomb.

In the face of this dilemma, what is our proper course of action? Do we stop building telescopes? Do we close down our cyclotrons? Do we forbid the extension of knowledge? Do we retreat to some safe, underground existence where we can barricade ourselves against our fears and the unwelcome intrusion of new ideas?

The questions answer themselves. Any attempt to fix boundaries beyond which intellectual adventure shall not be allowed to go, even if it could succeed, would return us to an animal existence in which mere survival was the only goal. The search for truth is, as it always has been, the noblest expression of the human spirit. Man's insatiable desire for knowledge about himself, about his environment and the forces by which he is surrounded, gives life its meaning and purpose, and clothes it with final dignity. We are false to ourselves and to our best instincts only when we turn our backs on truth or close our eyes when it beckons.

And yet we know, deep in our hearts, that knowledge is not enough. This telescope is not enough. The vast enterprise of men that is pushing out the boundaries of knowledge in glorious adventure on a score of frontiers—all this is not enough. Unless we can anchor our knowledge to moral foundations, the ultimate result will be dust and ashes—dust and ashes that will bury the hopes and monuments of men beyond recovery.

The towering enemy of man is not his science but his moral inadequacy. Around the world today, laboratories supported by almost limitless resources are feverishly pushing their research in

the development of physical and bacteriological weapons which overnight could turn this planet into a gigantic slaughterhouse. On what moral basis will the decision be made to use these weapons? What ethical restraints will have developed to curb the hysteria, fright and passion of men against such a blind paroxysm of destruction? For if this final Nemesis overtakes the pretensions of modern man, it will not be his science that has betrayed him, but rather the complete prostration of his moral values. It will not be this telescope and all that it symbolizes that have led him to the doorstep of doom; it will be the impotence and immaturity of his ethical codes.

There is a sense, of course, in which the problem we face is not new. Over scores of centuries, man's progressive accessions of power have always outstripped his capacity for control, and the gap between his morality and the physical force at his disposal has always been uncomfortably wide. But never before have his curiosity and ingenuity led him within the space of a few years to weapons by which he could completely obliterate his own institutions and decimate the planet on which he lives.

This may seem too somber a note to be sounded at the dedication of a mighty instrument whose purpose is in line with man's noblest instincts; but in the twenty years that this telescope has been under construction, the human race has lived through its greatest tragedy. We know now that knowledge is not a gift; it is a challenge. It is not merely an augmentation of facts; it is a test of human character. And our generation is presented with what may well be the final choice between the use of knowledge to build a rational world or its use to arm, for one last, desperate affray, the savage and uncivilized passions of mankind.

And yet I believe that in the crisis which we face, this telescope can furnish our stricken society with some measure of healing

perspective. This great new window to the stars will bring us into touch with those outposts of time and space which have beckoned from immemorial ages. It will bring into fresh focus the mystery of the universe, its order, its beauty, its power. It will dramatize the questions which mankind has always asked and to which no answers have been found, and perhaps can ever be found. Why are we here on this dwarf planet? Are there other planets that have burst into consciousness like our own? Is there an answering intelligence anywhere in space? Is there purpose behind the apparent meaninglessness and incomprehensibility of the universe? What is this divine spark of awareness which we call consciousness? And finally, in the words and spirit of the Psalmist, what is man?

In the face of these supreme mysteries and against this majestic background of space and time, the petty squabbling of nations on this small planet is not only irrelevant but contemptible. Adrift in a cosmos whose shores he cannot even imagine, man spends his energies in fighting with his fellow man over issues which a single look through this telescope would show to be utterly inconsequential.

We need in this sick world the perspective of the astronomer. We need the detachment, the objectivity, the sense of proportion which this great instrument can bring to mankind. This telescope is the lengthened shadow of man at his best. It is man on tiptoe, reaching for relevancy and meaning, tracing with eager finger the outlines of order and law by which his little life is everywhere surrounded. There is nothing which so glorifies the human race, or lends it such dignity and nobility as the gallant and inextinguishable urge to bring this vast illimitable complexity within the range of human understanding. In the last analysis, the mind which encompasses the universe is more marvelous than the universe which encompasses the mind. "Astronomically speaking,"

said the philosopher, "man is completely negligible." To which the psychologist answered: "Astronomically speaking, man is the astronomer."

So we dedicate this instrument today in humbleness of spirit, but in the firm belief that among all the activities and aspirations of man there is no higher peak than this. There is a real sense in which Mount Palomar is Mount Everest.

*

Dr. Max Mason of the California Institute of Technology, a mathematical physicist, has been closely associated with the Palomar Observatory almost from the time of its inception. As President of the Rockefeller Foundation from 1929 to 1936 he was, of course, keenly interested in the Palomar Observatory project. In 1936 he succeeded Dr. George Ellery Hale as Chairman of the Observatory Council, the committee established to supervise and direct the construction of all the observatory instruments and facilities. He has remained in that capacity up to the present time. He will address us on "The 200-inch Telescope--Man and Matter."

Man and Matter

BY MAX MASON

WE DEDICATE today a great tool of science, an instrument of such magnitude and delicacy that many years of effort by many minds and many hands were needed for its construction. The project has been an example of devoted and harmonious cooperation since its inception. This could not have been otherwise, with George Hale as its guiding spirit.

We feel the greatness of the achievement and look forward eagerly to its contributions to our knowledge of the universe. This adventurous and costly project was financed by three Rockefeller Boards whose funds are devoted to "the well being of mankind throughout the world."

I choose that fact for my text. Wherein lies the justification for this participation?

I shall make no apology if you find hope and optimism underlying my brief discussion of this searching question. These are days of deep concern and anxiety for the well being of mankind over the near future. But concern need not, and must not, surrender to pessimism.

Nor shall I make apology for adopting a long range view. It lies in the heart of man to care more for the lives to follow than for his own life.

A promise for the future can be evaluated only through the accomplishments of the past and the trend of the present. It was

only three hundred and fifty years ago that experience and contemplation were brought into proper balance in the search for knowledge. Observation and that accelerated experience we call experiment, reported with punctilious accuracy, were brought into interplay with the broad description we call theory. Theories, which put the facts gained by experience into systematic order, grow and change. In describing, they also predict.

The success of the method in the field of natural science has been great, and the advance of knowledge has proceeded in ever increasing tempo, as new knowledge excites new curiosities. Physics, chemistry and biology developed during the seventeenth and eighteenth centuries, with little except method in common. Even physics, for example, was a group of separate chapters, somewhat drawn together through the aid of mechanics. The nineteenth century saw the triumph and then the failure of mechanics. So powerful had mechanics proved for description of physical behavior that hope persisted in spite of growing difficulty that all physical phenomena, even light, electricity, and magnetism would fall into the frame work.

Then came the revolutionary experiments fifty years ago which initiated the electron theory of matter and the new physics. With startling rapidity new knowledge was met by new theories and new concepts, which in turn accelerated the acquirement of further knowledge. As physics grew in power, basic understandings grew in breadth and simplicity. In revenge for the failure of description of radiation as wave motion in a hypothetical ether came the evidence, as predicted by theory, of common characteristics of matter and radiant energy, of their transformability of one into another, and hence of their essential unity.

At the beginning of this remarkable half century the very wealth of new knowledge gained by experiment seemed overwhelming to

the point of confusion, but human intelligence proved equal to the demands, bringing order out of confusion, and evolving understandings of power and simplicity, and new concepts of sweeping breadth.

The universe is a living unit. Atoms of closely related constitution are in evolution, reacting with radiation, forming aggregates, from molecules to stellar systems, themselves in evolution. In the derivation of these great understandings astronomy and astrophysics, with the whole cosmos as their laboratory, have played a basic role. Vacuum tubes, cloud chambers, cyclotrons and telescopes are full partners in the derivation of knowledge, and will remain so. So rapid is the progress of today that the present triumphs of understanding will seem in a few years but crude and naive beginnings.

So much for the study of the distribution and behavior of the matter which makes up man's environment. Does the great method of science concern itself merely with man's environment? With deep concern we realize that man's greatest problem is not the mastery of his physical environment, but is self-mastery. Another great triumph in understanding points the way. At last it is clear that man is not merely a spectator of his environment—he is a part of it. He is a psycho-biological organism, a product of organic evolution. His body is made of that same matter which forms the physical universe, that same matter following the same regularity of behavior.

During the last few decades, as all sciences have been merging into one, a great century for biology has begun. Biology drives today at basic understandings of the vital processes, using the methods and the knowledge of physics and chemistry. Atomic biology is in rapid growth, illuminating through biochemistry and biophysics the fields of genetics, embryology, physiology,

neuro-physiology and physiological psychology. These studies of the detailed processes which condition physiological and mental behavior join with objective observations of individual and group behavior, psychology, anthropology, sociology. Natural law and regularity of behavior are not restricted to the field of the physical sciences. They exist in the somatic and psychic behavior of man. They apply to the reflexes and their conditioning, to the association of ideas, to learning and the formation of mental action patterns, to the mental disorders produced, for example, by endocrine imbalance or by faulty education.

Is our concept of man belittled because we have learned this? Does it lead us to think of man as merely a machine? Surely not. The inspiration of the painter is freed by a knowledge of the facts pertinent to his art, a knowledge of pigments, brushes and techniques. A musician cannot reach the soul of his audience unless through years of study he has become the master of his technique. Only through knowledge can we advance, through detailed, accurate scientific knowledge, and reach closer to that time when every child born into the world may enjoy his birthright, his right to be formed into a character of as great intelligence, emotional stability and sweetness as is consistent with his heritage.

Science, through its accumulated and ordered knowledge, is the servant of the spirit and intelligence of man. A philosophy of life is to be achieved by that spirit as a great synthesis, the synthesis of knowledge. The greater the knowledge the greater the synthesis.

Even today we can eliminate those residues of medievalism, which heap verbalism upon verbalism. Even today, in our new knowledge of man and the universe lies the power to vitalize and implement the concepts of ethical behavior, to lead to a more realistic philosophy, a deeper reverence, a more dynamic understanding of the brotherhood of man.

With clumsy fingers man has fumbled over the keyboard of a vast organ. He has called forth only a few shy notes, but of a sweetness so piercing that we tremble at the thought of the glorious harmonies to come.

*

Dr. Lee A. DuBridge, President of the California Institute of Technology, has been requested by the Board of Trustees of that institution to make the formal dedication of the telescope and observatory.

The Men of Palomar

BY LEE A. DUBRIDGE

*

IT IS NOT OFTEN in the history of science or of mankind that a group of men and women have such a high privilege as we have here today in dedicating to the service of man this magnificent and significant scientific instrument.

Since long before the dawn of history man has gazed wonderingly and thoughtfully at the heavens. Since the time of Galileo he has been able to study the heavenly bodies ever more searchingly and more precisely with ever larger and more precise instruments. What these instruments have revealed has vastly increased man's understanding of the universe. But each new advance in understanding has raised new questions. A 60-inch telescope raised problems that only a 100-inch instrument could answer. The 100-inch called for a 200-inch. How much farther this quest will lead no one can foretell. But this great telescope before us today marks the culmination of over 200 years of astronomical research. And for generations to come it will be a key instrument in man's search for new knowledge.

It is with great pride that the California Institute of Technology today formally dedicates this great observatory to the service of science and of mankind. We know not what new knowledge will accrue as a result of the work that goes on in coming years on this mountain top. We only know that new knowledge will come which will lead men a few steps farther along the road toward a more perfect understanding of this great universe.

It was almost precisely twenty years ago to the day in May, 1928, that the 200-inch telescope project was assured. But it was long before 1928 that the idea of this great telescope was born in the minds of George Ellery Hale and some of his associates. Indeed, not long after the 100-inch telescope on Mount Wilson was put into successful operation in 1917, Dr. Hale saw that an even larger telescope was both feasible and desirable.

By 1927 Drs. Hale, Adams, Pease, Hubble, and the other members of the staff of Mount Wilson had the broad outlines of a large telescope project in mind and an article outlining the purposes and possibilities of such an instrument was written by Dr. Hale for *Harper's Monthly,* appearing in the spring of 1928. That article did not fix a size for the mirror but mentioned that Dr. Pease had sketched a mount for a mirror 25 feet or 300 inches in diameter.

Before the article appeared, however, Dr. Hale on February 14, 1928 wrote to Dr. Wickliffe Rose, then President of the General Education Board, sending a proof copy of the *Harper's* article and inquiring as to the possible interest of the Rockefeller Boards. He received an encouraging reply and at once went to New York to discuss the matter. Within a few weeks the dream had been reduced to the form of a definite proposal for a 200-inch instrument. On June 12, 1928 Dr. Hale was informed that the International Education Board had voted a grant of six million dollars to the California Institute to finance the project. The Institute in turn had agreed to undertake the project, to cooperate with the Mount Wilson staff and to finance the operation of the observatory after it was complete. Dr. Hale was asked to serve as Chairman of the Observatory Council which was to supervise the whole project, with Dr. Millikan, Dr. A. A. Noyes and Mr. H. M. Robinson as the other members.

And so began what was to become one of man's greatest scientific enterprises. Unfortunately, Dr. Hale did not live to see it completed. But for ten years from 1928 until his death in 1938, Dr. Hale gave all his energy to this task. His vision and his leadership were decisive factors during those critical years, and this great observatory stands today as a monument to that great scientist.

On May 10, 1948, the Board of Trustees of the California Institute of Technology unanimously adopted the following resolution: "The Board of Trustees of the California Institute of Technology hereby resolves that the 200-inch telescope of the Palomar Mountain Observatory shall hereafter be known as

THE HALE TELESCOPE

By this action the Board of Trustees seeks to recognize the great achievements of Dr. George Ellery Hale (1868-1938) who served as Director of the Mount Wilson Observatory from 1904 to 1923, who served as a member of the Board of Trustees of the California Institute from 1907 to 1938, who originated the bold conception of the 200-inch telescope, and whose brilliant leadership made possible its design and construction. As this great instrument probes the secrets of the universe, it is fitting that it should stand also in memory of the great scientist and the great leader who contributed so brilliantly to the science of astronomy and who served so ably his community and his nation.

"The Board of Trustees further directs that a suitable plaque in Dr. Hale's honor be permanently installed in the observatory and that an engrossed certified copy of this resolution be presented to Mrs. Hale."

I am sure that you are all as delighted as I am that Mrs. Hale is here today—and I would like to ask her to step up to the platform.

Mrs. Hale, pursuant to the resolution I have just read, I have the honor to present to you herewith a certified copy of this resolution—and I hereby declare by the authority of the Board of Trustees that this great telescope which is the final realization of the vision of your distinguished husband shall henceforth be known as the Hale Telescope. Pursuant also to this resolution a bronze plaque in honor of Dr. Hale has been placed below his bust in the foyer of this building.

We are deeply grateful, Mrs. Hale, that you and the other members of your family could be with us on this occasion.

The bronze plaque which I have just mentioned will be unveiled during the ceremony. It reads as follows:

"The 200-inch telescope is named in honor of George Ellery Hale whose vision and leadership made it a reality."

A second bronze plaque is also to be unveiled this afternoon. It is placed opposite the stairway to this floor and reads as follows:

"The Hale Telescope and all the equipment of the Observatory were built through funds provided by three Rockefeller Boards: The International Education Board, the General Education Board, and the Rockefeller Foundation."

I have already mentioned that the initial grant was made in 1928 by the International Education Board. When that Board wound up its affairs a few years later its obligation to complete the observatory was assumed by the General Education Board and this Board supplied over $4,000,000 of the $6,000,000 pledge. Finally when the war caused delays and higher costs, the Rockefeller Foundation itself during the past year pledged an additional $550,000 to bring the project to completion. Not all of these funds have yet been spent, for there are many items of auxiliary equipment still to be completed. These, however, can be finished while the telescope itself is in use.

I wish it were possible at this time to pay adequate tribute to all the many men who have contributed to this great enterprise. There are hundreds of them. You have already heard from Max Mason, who in 1936 succeeded Dr. Hale as Chairman of the Observatory Council and who previously had aided and followed the project as President of the Rockefeller Foundation.

But I must pay tribute also to three other men, all of whom have been actively associated with the telescope continuously for these twenty years.

The first is a man whose extraordinary skill and knowledge have been decisive in the successful completion of this instrument; a man who, as Executive Officer of the Observatory Council from 1928 to date, has borne a major responsibility in directing the actual construction—Dr. John A. Anderson. It was his task among others to see that a fifteen-ton disk of pyrex glass which was delivered from the Corning annealing oven to Pasadena in 1936 was ground and polished, tested and polished some more, carefully, painstakingly, day after day, year after year, until it reached a degree of perfection of surface form such that departures were measured in terms of a fraction of a wave-length of light—a few millionths of an inch.

Though this observatory was built officially by the California Institute of Technology it was conceived, planned and largely executed by the staff of the Mount Wilson Observatory. The second man I wish to present was the Director of that observatory from 1923 until his retirement in 1946. He and Dr. Hale worked intimately together during the days when the project was in the formative stage. It was an analysis of the possibilities of a 200-inch instrument which he prepared at the request of Dr. Hale which was decisive in convincing everyone, including the Trustees of the International Education Board, of the practical feasibility

of the project. For twenty years his knowledge and abilities, his unstinting collaboration, his kindly wisdom, have been decisive in the success of the work: Dr. Walter S. Adams.

As I have said, the responsibility for the Palomar project was placed by a combination of circumstances in the hands of the California Institute of Technology. This truly was a momentous decision. Clearly all those concerned must have had supreme confidence in the Institute and its leadership. And well they might, for its leader then and all through the years until 1945 was none other than Robert A. Millikan. No history of this project would be complete without a long section devoted to Dr. Millikan's part in it. He has been a member of the Observatory Council from the beginning. He and Dr. Hale and others discussed the plan exhaustively from the start. He boldly pledged the Institute to assume responsibility for the enterprise including financial responsibility for its operation. This dedication would be incomplete without a salute to him and an acknowledgement of the success of his years of wise leadership.

To these three men I have named and to the multitude of others who made outstanding contributions we all pay tribute today. This observatory stands as a monument to their collective efforts. And it is a living monument. For from this observatory will flow down through the ages the one indestructible thing that mankind achieves—new knowledge, new understanding.

The Board of Trustees of the California Institute of Technology and the Carnegie Institution of Washington some time ago agreed mutually that the Palomar Observatory and the Mount Wilson Observatory should operate cooperatively as one, under single management, with mutual sharing of facilities and staff.

I wish only to emphasize that the California Institute has entered into this cooperative arrangement with greatest enthusiasm.

In dedicating this observatory, we dedicate it as one part of the combined observatories. We pledge ourselves to work in fullest collaboration with the Carnegie Institution as we devote our combined facilities to the service of science. We deeply appreciate the collaboration of Dr. Bush and the other officers and trustees of the Carnegie Institution. We are glad so many of them are able to be with us today. We and they are fully aware that in combining talents and facilities in this way we are creating in southern California the mightiest astronomical center the world has ever seen or is likely ever to see. The California Institute assumes its share in this joint enterprise with pride, but also with humility and a deep sense of our responsibility.

The word "dedicate" in the English language means to set apart by a promise. It is essentially synonymous with consecrate, which means to make holy by a special act. The word has more than a formal or material significance. It carries also a spiritual implication. It is in this sense actually that we do today set aside this temple of learning and promise that it shall be devoted henceforth to deepening man's intellectual and spiritual understanding.

*

The operation of the Palomar Observatory will be carried out under a joint plan of cooperation between the Carnegie Institution of Washington and the California Institute of Technology. This unified plan of operation is a unique accomplishment in the field of astrophysical research, and its consummation owes much to the vision and wisdom of Dr. Vannevar Bush, President of the Carnegie Institution of Washington and Chairman of the Research and Development Board of the National Military Establishment. He will speak on "Two Observatories Operate as One."

Two Observatories Operate as One

BY VANNEVAR BUSH

*

THE OCCASION for which we are met today will probably remain unique for many years to come—we should not expect for a long time indeed to see the equal of the great instrument dedicated today. This event, which brings to bear on the vast mysteries of the skies the most powerful means thus far devised by man, has many connotations. In one way or another, these are all implicit in the subject of which I am to speak,—two observatories operate as one.

In point of fact, these two observatories, Palomar Mountain and Mount Wilson, have actually been operating as one for something over two months already. They have thus been operating in order that while the long task of completing and officially opening the installation which shelters us was being brought to fulfillment, the richly promising adventure of bringing it into full use in a joint unitary scientific program might be getting under way. It is a great truth of science that every ending is a beginning, that each question answered leads to new problems to solve, that each opportunity grasped and utilized engenders fresh and greater opportunities. And this truth has its reflection even in such seemingly down-to-earth and diurnal affairs as the administrative and operational history of observatories.

With the specific detail of the plan of unified operation under which Mount Wilson and Palomar will constitute a single integrated marshaling of equipment and intellectual forces for further advancing astronomy we need not here be concerned. In its broad aspects, the plan means that facilities of each observatory will be brought to bear on those problems for which they are best adapted, that they will be available for those who need them most and can make the best use of their powers. In its broad aspects, then, the plan is a straightforward endeavor to assure that the increase of knowledge shall be aided and expedited to the fullest extent possible through the presence of unique material apparatus to serve the skill and acumen of able scientists. The plan was arrived at only by the most careful consideration and thorough analysis, in full and congenial collaboration. It has the unstinted endorsement of the Boards of Trustees of the California Institute of Technology and the Carnegie Institution of Washington. It assures to the able Director of the Mount Wilson and Palomar Observatories, Dr. Bowen, and to his distinguished colleagues the greatest opportunity for the unhampered devotion of their efforts to the search for knowledge to which they are dedicated.

In the light of the purposes for which we are gathered today, the plan of unified operation is significant as a witness to unity, a witness to that singleness of purpose which is the essential condition of all efforts in which men join their strength, whether intellectual or material. As such a witness, this plan honors many men, and of two in particular, I would say a word. There is truth indeed in Emerson's declaration that "an institution is the lengthened shadow of one man." The institution which I have the honor to represent expresses today as it did now nearly half a century ago the faith of Andrew Carnegie in the beneficence of

knowledge and in the inspiration and incentive which would arise in men of wisdom in response to conditions of freedom and capacity to seek for new knowledge.

So also with George Ellery Hale, for this plan is witness to his early vision and his steadfast loyalty to it, which culminate today as this ceremony marks the formal inauguration of this observatory and the establishment on this and the neighbor mountain of the greatest concentration of astronomical power in the world. These two great observatories that are two and yet one—they also constitute an institution which is the lengthened shadow of one man. It is a happy thing that there should be here today those who remember earlier days when Mr. Carnegie and Dr. Hale joined convictions and enthusiasms in the launching of a great effort whose pioneering has brought us now to the opening of still greater ranges of adventure.

The unity, the singleness of purpose, the faith, and the spirit to which this plan bears witness lie at the heart of any undertaking in which men or institutions associate together. They are hence themselves manifestations of the essential characteristics of science—of the search for truth. The long history of science is a constant record of co-operation, often conscious and designed co-operation, often implicit and accepted simply as such. It is natural that this should be so, for the frontiers of knowledge are vast, and advance along them hence demands that each shall contribute his bit to the aid of others and receive from them in his turn.

Thus the most isolated scholar, the most independent and individualized investigator of a highly specialized field, is nonetheless assured of the encouragement and zest that come from realization that some day, somewhere, some other man will share his knowledge and be benefited thereby.

Thus the raw new neophyte, venturing with trepidation on his

first inquiry as an independent investigator, yet has the reassurance and comfort that grow from recognition that the rich resources of attained knowledge are his to be freely drawn upon and that from colleagues and compeers support and counsel are his for the seeking. There is no paradox in the concept that research depends upon the individual mind and that the individual mind depends upon others. The collaboration of free and independent individuals is the strongest and most precious force in the world, and that collaboration reaches one of its highest expressions in the combination of aspiration and hard work which we know as science.

In no branch of scientific endeavor more than in astronomy should we rightfully anticipate finding at the full this unity of effort, this unity of spirit. In no other discipline—not even, I dare say, in those whose field is life itself—do men confront mystery and challenge of the order of that which looms down upon the astronomer in the long watches of the night. The astronomer knows at first hand, and places all the rest of us in his lasting debt by translating to us, how slight is our Earth, how slight and fleeting are mankind. But more than that, he senses more closely than can we, I think, the majesty which resides in the mind of man because that mind seeks in all its slightness to see, to learn, to understand at least some little part of the mysterious majesty of the universe. No calling brings more sharply into focus the seeming disparity between man and the cosmos. And yet, no calling reflects more steadily the fact, both prideful and humbling at once, that the reaches of the intelligence of man are vast and that his will strives to extend them to encompass even the fabulous reaches beyond the stars. It is in the humility thus engendered that men recognize their individual insufficiency, and recognizing it, join as free spirits in co-operation and collaboration.

Two observatories operate as one, and as they do, they evoke for us the warm memories of past pioneers, they place before us the hearty strength of a present endeavor which seeks in all ways to live up to its heritage and hence to proceed farther and more swiftly on the courses earlier traced, and they hold out to us the promise of inspiring and ennobling achievement in time to come.

They remind us again that the search for truth is indeed hazardous but is worth the risk. The search for truth is the noblest work of man. We can participate in it with courage, and without reservation, as we look forward to a world, in which there will indeed be test and trial, but in which I see no insane suicide of the race, but a world in which the spread of science and its applications will lead us upward, as it has for centuries, not back again to barbarism. We can truly recite again, with new meaning in these modern days, but with no lack of conviction and faith, the old charge "Know the truth and the truth shall make you free."

Dr. Ira S. Bowen is Director of Mt. Wilson and Palomar Observatories. He is in direct charge of the operation of the observatories. Dr. Bowen is a physicist who has made important contributions in the field of spectroscopy. He will speak on the subject, "The Telescope at Work."

The Telescope at Work

BY IRA S. BOWEN

THE HALE TELESCOPE above us is now undergoing its final tests and adjustments preparatory to the start of astronomical operations. It is therefore fitting that we conclude these ceremonies with a brief discussion of the scientific program to which this great instrument has just been dedicated.

Any complete enumeration of the astronomical problems that may be attacked with the aid of the Hale Telescope would read like a general survey of all of the fields of modern astronomy. Thus this instrument is not of a highly specialized design suited for only one purpose or a limited group of purposes. Its essential feature, compared to the most powerful earlier instruments, is a fourfold increase in mirror area and light-gathering power. This greater light grasp should permit us to peer twice as far into space, thereby increasing the volume of space that is open to study by a factor of eight. Stating this in another way, the Hale Telescope should make it possible to study any astronomical body in as much detail as if by some magic we could reduce that body's distance to one-half its present value and continue to investigate it with the best previous equipment. Consequently, with the completion of the Hale Telescope a great new power will be brought to bear on the study of nearly every astronomical problem, whether it be pushing back the extreme limit of the

observable universe or investigating in detail one of the earth's nearest neighbors.

Let us consider just two of the more important of these problems and see how the telescope will be used for their investigation. The first of these is the study of the distant spiral nebulae. One of the great early successes of the 100-inch telescope on Mount Wilson occurred when it was used by Hubble to measure the distance of these nebulae and to prove that each of these objects represents another Milky-Way system. This was followed by studies of the distances and the velocities of the more distant of these nebulae. These investigations led to the concept of the expanding universe and enlarged the dimensions of the measurable universe by a thousand fold. As often occurs, however, these investigations raised more questions than they answered. For example, is the universe really expanding or are the observed effects caused by some curvature of space? Is space uniformly populated with nebulae or do we finally reach a distance beyond which their numbers fall off rapidly? We hope the greatly increased space-penetrating powers of the Hale Telescope will help us to answer some of these problems.

For this type of investigation direct photographs of the nebulae will be made, using the telescope as a huge camera of 55-foot focal length and the great speed of F3.3, as expressed in the language of the camera fan. The role of the camera lens is taken by the 200-inch mirror located at the lower end of the telescope tube. Such a mirror has many advantages over a lens as the main light-gathering element of a telescope. However, it has the one disadvantage that the image of the object to be photographed is formed in the center of the incoming beam of light. In the smaller mirror-type telescopes it has been necessary to place a second mirror in the center of the light beam to reflect this image to the

side of the telescope tube where it is accessible to the observer. The Hale Telescope is the first telescope that utilizes so large a beam of light that a cage of sufficient size to house the astronomer can be placed in the center of the beam without obstructing a substantial fraction of the incoming light. This cage, some six feet in diameter, can easily be seen in the center of the upper end of the telescope. It is in this cage that the photographic plate is placed and that the observer rides during the long exposures required. The observer reaches the cage by means of the prime focus elevator which moves up the side of the shutter opening.

A second type of problem involves the detailed study of the spectrum of the stars of our own galaxy. Even with the Hale Telescope all stars will appear as points and we cannot hope to observe directly any details on their surface. We can, however, pass the light from such a star through a prism or grating of a spectroscope. This spreads the light from the star out into a spectrum showing the characteristic rainbow colors. Such a spectrum is crossed by many dark lines which, when properly interpreted, tell us the temperature, the pressure, the velocity, and the chemical composition of the gases of which the star is made. A knowledge of the exact chemical composition of the stars is becoming of increasing importance since it has been recently established that the energy which causes the sun and stars to shine comes from the same source as that which gives the atomic bomb its tremendous power, namely, the transformation of one chemical element into another. A determination of the relative abundance of the chemical elements in a star, therefore, provides information as to how much fuel remains to keep these atomic fires burning and as to what types of atomic conflagrations may have occurred in the past history of the star.

For investigations of this type the great mirror is used as a

huge condensing lens to concentrate the light from the star on the slit of the spectrograph. For detailed spectroscopic studies, large spectrographs up to 30-feet long, weighing many tons and needing precise thermostatic control will be required. They will therefore be placed in a fixed position in the constant temperature room to the south of the telescope. The light reflected from the main mirror goes to a small convex mirror in the lower part of the cage, then down to a flat diagonal mirror which in turn reflects the light through the polar axis of the telescope to the spectrograph. For these observations the astronomer guides the telescope from a position near the slit of the spectrograph.

Like all astronomical telescopes, this instrument can be rotated about either of two perpendicular axes, thereby permitting it to be pointed at all parts of the sky. Rotation about the declination axis allows it to move north and south. The second, or polar, axis is parallel to the axis of rotation of the earth. By turning the telescope about this axis at the rate of one revolution in twenty-four hours, the telescope can be made to follow the stars as they move from east to west in the sky. Finally, the dome can be rotated to permit the telescope to look out through the shutter-opening in any direction.

*

Dr. Bowen then gave a demonstration of the Hale Telescope, showing the rotation about the two axes and the rotation of the dome, as outlined in his address. This demonstration concluded the dedication program.

When I consider thy heavens,
The work of thy fingers, the moon
And the stars, which thou hast ordained;

What is man, that thou art
mindful of him? And the son of man,
That thou visitest him?

For thou hast made him a little lower than
The angels, and hast crowned him with glory and honor.

—Psalms VIII, 3-5