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# WESTERN UNION

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1032

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DR WICKLIFFE ROSE, PRES INTERNATIONAL EDUCATION BOARD=
61 BROADWAY NEWYORK NY=

GREATLY PLEASED TO RECEIVE YOUR LETTER MILLIKAN BOOKED FOR TWO IMPORTANT EASTERN MEETINGS BOTH OF WHICH MAY BRING VERY NECESSARY FUNDS TO INSTITUTE LATEST DATE HE CAN LEAVE TO ATTEND THEM IS EVENING JUNE NINTH WOULD GREATLY APPRECIATE YOUR ARRIVAL HERE MORNING JUNE NINTH OR SOON AS FEASIBLE THEREAFTER=

GEORGE E HALE.

1032

Form 1228 A

*Charge to the account of* INTERNATIONAL EDUCATION BOARD $

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# WESTERN UNION

NEWCOMB CARLTON, PRESIDENT J. C. WILLEVER, FIRST VICE-PRESIDENT

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*Send the following message, subject to the terms on back hereof, which are hereby agreed to*

June 2, 1928

Doctor George E. Hale
Mount Wilson Observatory
Pasadena
California

Sorry cannot reach Pasadena before eleventh. In Millikan's absence we assume that you with your other associates will be able to carry on.

WICKLIFFE ROSE

PATRONS ARE REQUESTED TO FAVOR THE COMPANY BY CRITICISM AND SUGGESTION CONCERNING ITS SERVICE

1201 S

CLASS OF SERVICE

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A WU 6/6/28

# WESTERN UNION

NEWCOMB CARLTON, PRESIDENT

J. C. WILLEVER, FIRST VICE-PRESIDENT

1232

SIGNS

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**RECEIVED AT 40 BROAD STREET, (CENTRAL CABLE OFFICE,) NEW YORK, N. Y.** ALWAYS OPEN

1928 JUN 6 AM 12 35

SV214 29 NM=PASADENA CALIF 5

DR WICKLIFFE ROSE, INTERNATIONAL EDUCATION BOARD=

61 BROADWAY NEWYORK NY=

VERY GLAD TO SEE YOU HERE JUNE ELEVENTH WE CAN ARRANGE PERFECTLY IN MILLIKANS ABSENCE LET ME KNOW TRAIN AND TIME OF ARRIVAL SO THAT WE MAY MEET YOU=

GEORGE E HALE. Arriving Pasa. 10^20 A.M. June 11

1032

June 6, 1928

Dear Mr. Stokes:

I enclose copy of the revised minute covering the action of the Board with reference to its appropriation to the California Institute of Technology for the telescope. Doctor Rose read this proposed action at a recent meeting of the Executive Committee of the International Education Board at which Doctor Vincent, Mr. Fosdick, Mr. Woods and Mr. Debevoise were present. They were of the opinion that the several points raised during the discussion at the Board meeting are covered in the proposed minute.

Doctor Rose would appreciate your reading it with a view to making any further suggestions that may occur to you. May I hear from you at your early convenience.

Sincerely yours,

W. W. BRIERLEY

Mr. Anson Phelps Stokes
2408 Massachusetts Avenue
Washington, D.C.

WWB:HMN

1032

June 6, 1928

Dear Mr. Young:

I enclose copy of the revised minute covering the action of the Board with reference to its appropriation to the California Institute of Technology for the telescope. Doctor Rose read this proposed action at a recent meeting of the Executive Committee of the International Education Board at which Doctor Vincent, Mr. Fosdick, Mr. Woods and Mr. Debevoise were present. They were of the opinion that the several points raised during the discussion at the Board meeting are covered in the proposed minute.

Doctor Rose would appreciate your reading it with a view to making any further suggestions that may occur to you. May I hear from you at your early convenience.

Sincerely yours,

W. W. BRIERLEY

Mr. Owen D. Young
120 Broadway
New York City

WWB:HMH

1032

June 6, 1928

Dear President Angell:

I enclose copy of the revised minute covering the action of the Board with reference to its appropriation to the California Institute of Technology for the telescope. Doctor Rose read this proposed action at a recent meeting of the Executive Committee of the International Education Board at which Doctor Vincent, Mr. Fosdick, Mr. Woods and Mr. Debevoise were present. They were of the opinion that the several points raised during the discussion at the Board meeting are covered in the proposed minute.

Doctor Rose would appreciate your reading the minute with a view to making any further suggestions that may occur to you. May I hear from you at your early convenience.

Sincerely yours,

W. W. BRIERLEY

President James R. Angell
Yale University
New Haven, Connecticut

WWB:HMN

1032

June 8, 1928

Dear President Angell:

Thank you for your letter of June 7th concerning your feeling with regard to the proposed telescope for the Institute of Technology. Doctor Rose left yesterday for California in connection with this project. When he returns to the office before sailing your letter will be brought to his attention.

Sincerely yours,

W. W. BRIDGEY

President James R. Angell
Yale University
New Haven, Connecticut

WWB:HMN

1032

YALE UNIVERSITY
NEW HAVEN CONNECTICUT

June 7, 1928.

W.W. Brierley, Esq.,
General Education Board,
61 Broadway,
New York City.

Dear Mr. Brierley:

I acknowledge your favor of June 6th with transcript of the revised minute of the International Education Board's action with reference to the new telescope for the California Institute of Technology.

I was not myself particularly keen for the phrasing which was finally adopted, to make the selection of a site contingent upon the advice of a committee of astronomers, the method of appointing which is not indicated. I have, however, no objection to the proposal and I should raise no question about the minute in its present form.

I was frankly solicitous regarding the choice of the site, but, as the whole subject was new to me, I had not canvassed in my mind a suitable method of determining the site and I am not altogether certain what would be the outcome of this present plan. Certainly I have, at the moment, nothing better to suggest.

Believe me,

Yours very truly,

James R. Angell

1032

June 11, 1928

Dear Doctor Stokes:

I am acknowledging your letter of June 8, concerning the resolution in connection with the 200-inch reflecting telescope for the California Institute of Technology. This will be brought to the attention of Doctor Rose upon his return.

Very truly yours,

W. W. BRIERLEY

Doctor Anson Phelps Stokes
2408 Massachusetts Avenue
Washington, D.C.

WWB:MHD

1032

Memorandum re California Institute of Technology, Pasadena, California

June 11, 1928

Monday morning, June 11, Doctor Rose and I arrived at Pasadena, California. We were met at Piso by Doctors Millikan and Noyes of California Institute of Technology, and driven to Pasadena and to Doctor George E. Hale's private laboratory. Here we met: Doctor Hale, Doctor Adams, Director of Mount Wilson, Doctor Merriam, President of Carnegie Institution, and Mr. H. M. Robinson of the Board of Trustees of California Institute of Technology.

We discussed informally the proposed 200-inch telescope. Doctor Rose indicated the status of the action of the International Education Board and stated that the first point to be cleared up was the question of funds necessary to maintain the proposed observatory. Doctor Hale and Doctor Adams agreed that the annual cost based on the present costs of operating Mount Wilson Observatory ($250,000) would be between $100,000 and $150,000. Mr. Robinson stated that, while he would not officially speak for the Trustees, he was sure they would agree to provide these funds up to $150,000 a year. He also stated that he would personally agree to undertake raising the funds necessary for this purpose. We learned later that in this statement given in such a modest way he himself plans to give an annual income of $100,000 for this purpose and later capitalize it. He also agrees to raise this to $150,000 annually if desired.

Doctor Rose then presented the following statement which we had prepared on the train:

200-Inch Reflecting Telescope for California Institute of Technology - Points to be included in Formal Request from the Trustees of California Institute of Technology

I. The International Education Board is to provide funds as needed for:

a) A 200-inch reflecting telescope
b) Site including land and land improvements
c) Observatory and other necessary buildings
d) Auxiliary apparatus
e) Other expenses in connection with making the observatory available for use.

The total funds so provided are not to exceed in the aggregate $6,000,000 and the International Education Board is not expected to provide funds for any other purposes than those here indicated.

II. The California Institute of Technology is to assume full responsibility for building the proposed Observatory and is to provide the necessary funds for operating it after its completion.

III. It is understood that if experience should show at any stage of development that the undertaking cannot be carried to successful completion, no further expenses will be incurred by the California Institute of Technology and no further funds will be provided by the International Education Board.

IV. In transmitting a formal request from the Trustees of California Institute of Technology to the International Education Board for funds to carry out this proposal, it is suggested that the request include:

a) Evidence of cooperation from the Carnegie Institution and the staff of Mount Wilson Observatory.

b) Personnel of:

1. Committee of representative astronomers to consider site
2. Committee on construction of reflectors
3. Committee on design of telescope, buildings, equipment, etc.

c) A budget of estimated expenditures including:

1. Expenses of committees
2. Expenses of experimentation and manufacture of reflectors
3. Expenses of land and land improvements
4. Expenses of buildings and telescope mounting
5. Expenses of other equipment
6. Contingent

Supplemental Information

The formal request from the Trustees of California Institute of Technology will form the basis of the formal pledge of the International Education Board.

After the pledge has been approved, formally executed and accepted the following procedure is suggested:

Upon request from the California Institute of Technology accompanied by full report as to the status of development, the Executive Committee of the International Education Board will consider and appropriate from time to time such funds as may be needed to meet the respective budget items included in the formal request.

After such appropriations are authorized, payments will be made by the International Education Board to the California Institute of Technology upon duly authorized requisition and statement of account.

The intention of this suggested procedure is to provide funds only as expenses are incurred and to enable plans and construction to develop without delay and without expense to the Institute. A full accounting of all expenditures is expected, but approval and payment of bills is the function of the Institute. Advances will be provided as needed.

This was discussed and seemed entirely satisfactory to all present as a basis for a formal letter of application. The principle of furnishing funds as and when needed is also satisfactory. Doctor Hale is prepared to initiate some studies very promptly. He raised the question of securing prompt action from the International Education Board, but we suggested that the Institute advance any funds needed immediately and that the Executive Committee of the International Education Board take appropriate action in the fall.

Doctor Hale then presented the following statement of a proposed scheme of organization:

Astrophysical Observatory of the California Institute of Technology

Proposed Scheme of Organization, Construction, and Operation

Observatory Council

Four members of the Executive Council of the Institute, Messrs. Hale, Millikan, Noyes, and Robinson, to be charged by the Trustees with the expenditure of the Observatory Fund; the selection of building sites; the provision of all necessary roads, water-supply, power-lines, and other requirements; the design, construction, transportation, and erection of instruments, machinery, and buildings; the selection of a scientific and operating staff; and the general policy of research.

The Observatory Council shall appoint an experienced astronomer or physicist as the executive officer of the Observatory, to take direct charge of its design, construction, and operation.

Advisory Committee

Comprising the Director of the Mount Wilson Observatory and other leading astrohomers and physicists, to cooperate with the Observatory Council in the solution of its problems.

Instruments and Buildings

(a) A preliminary study, by a group of the ablest experts, to be made of all promising methods of making telescope mirror discs of large diameter.

(b) If, as now seems probable, such a study should point to the use of fused quartz, the next step would be an experimental test of its possibilities, and the manufacture as soon as feasible of a 200-inch mirror disc.

(c) A simultaneous study, by a group of experienced astronomers, physicists, opticians, instrument makers, and engineers, of the various optical and mechanical questions involved in the design of the telescope and all buildings, instruments, apparatus, and accessories for the observation, registration, and measurement of celestial images, the measurement of photographs, and the laboratory interpretation of results. The preparation of working drawings and the work of construction to follow as soon as circumstances permit.

(d) A simultaneous comparative study, by astronomers, physicists, and meteorologists familiar with the performance of the largest existing instruments, of possible sites for the 200-inch telescope, taking into account not only the clearness and steadiness of the atmosphere at various seasons throughout several years, but with due regard to the special requirements of the telescope, the nature of the problems in view, the efficiency of the observers, and the intimate cooperation of the Mount

Wilson Observatory of the Carnegie Institution of Washington and the Bridge and Gates Laboratories of the California Institute.

(e) The grinding, polishing, and figuring of the large and small mirror discs when ready. Most of this work, like the casting of the 200-inch disc, must be done at the site selected, because of the difficulty of transporting the large disc.

(f) The construction and erection of the telescope mounting, buildings, and accessory apparatus.

Procedure

The design and construction of a 200-inch telescope is a large enterprise, calling for an intimate and effective union of the highest scientific and engineering knowledge and experience. I recommend that the J. G. White Engineering Corporation, of which Mr. Gano Dunn is President, be employed to take general supervision of the work of construction, part of which (including buildings, roads, water-supply, etc.) would be done by their own engineers, while the mounting might be built by Warner & Swasey. In the design of the mounting and dome the combined knowledge of Mr. Francis G. Pease and other members of the Mount Wilson staff and that of Messrs. Gano Dunn, Ambrose Swasey, and other leading authorities should be utilized. If a fused quartz disc is decided upon, Doctor Elihu Thomson of the General Electric Company is prepared to undertake this work. The grinding, polishing, and figuring of the disc should be done by the Mount Wilson opticians, in a building to be erected at the site selected for the telescope.

The simultaneous study of the accessory instruments and apparatus would involve in many cases the cooperation of other agencies. Some of the apparatus could be obtained from dealers in scientific instruments but much of it must be made in the instrument shop of the Astrophysical Laboratory, which should be erected on the campus of the California Institute.

Observing Staff

Toward the end of the construction period, which will necessarily occupy several years, the observing staff should be organized. This should include a director; several observers, assistants, and computers; and research associates, assistants, and fellows appointed for various periods from the staffs of the Mount Wilson Observatory, the California Institute, and other institutions. Provision should also be made for graduate study and research.

It goes without saying that the 200-inch telescope should be employed for investigations beyond the range of other instruments. The prime purpose in view is therefore to supplement the instrumental equipment of the Mount Wilson Observatory and the California Institute in such a way as to provide for the extension of their astronomical and physical researches into fields now inaccessible.

Plan of Cooperation

The chief objects of a plan of cooperation between the Carnegie Institution of Washington and the California Institute should be:

(1) To assure the effective utilization of the knowledge and experience of both institutions in the design, construction, and operation of the proposed Astrophysical Observatory.

(2) To conduct the preparatory studies, as well as the ultimate scheme of research, so that the result will be to aid from outset the current work of both institutions.

The procedure suggested in the preceding pages has been prepared with these objects in mind. It is designed to secure the best possible results without involving the Carnegie Institution of Washington in any expense, or calling for much of the time of its research men, or even of existing shop facilities during the construction period. The study of accessory instruments and methods, which should begin at once, would quickly yield results immediately applicable in current research, and highly advantageous to both institutions. After the completion of the telescope, it goes without saying that the opportunities to be offered to members of both staffs would be invaluable.

Doctor Hale stated that it would take from 18 months to two years to reach a definite conclusion as to site and mentioned two possible sites, one 12 miles and the other 100 miles from Pasadena. We also discussed the question of earthquakes. It was the unanimous conclusion of Hale, Merriam, and Adams that this could be ignored. Doctor Hale even went so far as to state he doubted whether the greatest California earthquake on record could damage an instrument of the proposed dimensions and design.

In his discussion he suggested Doctor Anderson as the executive officer of the proposed observatory during its period of construction, such men as Day of Washington Geo-Physical Laboratory and Elihu Thompson on the committee to consider the problem of reflector construction and design.

The next day we visited the Seismological Laboratory recently built by the Carnegie Institution and saw the equipment and data being compiled. This makes it clear that the Special Committee on Site will have at its disposal a wealth of material on the earth's structure and earth movements never before assembled.

Doctor Rose and I, after completing our conferences, prepared the following letter which was sent to the members of the Board:

June 18, 1928

To the Members of the International Education Board:

At the May 1928 meeting of the International Education Board, resolutionswere adopted approving a proposal by the California Institute of Technology for the construction of an observatory, including a 200-inch telescope and authorizing the Executive Committee to provide funds as needed for this purpose.

At that meeting it was agreed, as the result of discussion, that the resolutions proposed in the docket should be modified in certain details and particularly that they should embody a definite undertaking by the California Institute to provide the necessary funds for the operation of the observatory after its completion.

Officers of the Board visited Pasadena recently for a conference covering all the points discussed at the meeting, Members of the Board of Trustees of the Institute and its executive staff, the President of the Carnegie Institution and the Director of Mt. Wilson Observatory were present. The following is a brief summary of the results of this conference:

1. California Institute is prepared to finance the operation of the observatory after its completion. One of the trustees promptly offered to provide two million dollars endowment for this purpose and assumed the responsibility for an additional million should this be found necessary.

2. California Institute is prepared to assume full responsibility for building the proposed observatory. It is understood that the International Education Board is to make no commitment beyond providing the necessary funds as needed up to a total not to exceed six million dollars. It is also understood that, if experience should show at any stage of development that the undertaking can not be carried to successful completion, no further expenses will be incurred by the Institute and no further funds provided by the International Education Board.

3. California Institute proposes to create a special committee, to be known as the Observatry Council, to have supervision of the undertaking. The Council will appoint a competent scientist as its executive officer.

4. The Council will create a Committee on Site; this committee to be made up of competent scientists and to be reinforced by a group of astronomers - American and foreign - who will serve as consultants. This committee will undertake a study of possible locations, make the necessary tests of atmospheric and other conditions, and will have at its disposal similar studies made in locating the Mt. Wilson observatory, together with accumulated information of this and other observatories and the material now being gathered by the Seismological laboratory at Pasadena, California. It is expected that these studies will require two years for completion after which a recommendation will be made which will combine as far as possible the desirable characteristics of an ideal site.

5. A group similarly constituted and composed of the most competent authorities in the field is to be charged with maturing plans, carrying out experiments and finally producing the necessary disks, including the 200-inch reflector. Here again it is proposed to bring to bear upon this most important feature of the undertaking the best scientific and technical ability to be found in this country and abroad.

6. Still another group will undertake to design the mounting of the great mirror. This is an extremely complex problem and will call for the intimate cooperation of scientists and technicians representing a great variety of ability. This group will have as a starting point the preliminary designs on which Dr. Pease and a group of experts have been working for the past four or five years.

7. In due course the California Institute will make a formal application. This to cover in greater detail than here attempted the important items of the agreement, and to be accompanied by a budget of estimated expenditures. This will be presented to the Executive Committee for consideration, presumably in the early fall.

In the meantime the Institute will give attention to the important question of personnel with a view to starting activities without undue delay. It will also consider plans of organization, of research, of construction and the designing of all necessary accessory equipment, such as interferometers, spectrographs, thermo-couples, etc. In this equipment, as well as in the large instrument, effort will be made to improve upon the best now available.

The discussions at Pasadena emphasized more than ever the international character of the proposed observatory. It is to be a contribution not so much to an institution as to science. In maturing the designs, in all matters of construction and in the use of the completed instrument the undertaking is to call into play the best ability regardless of institutional or national boundary lines.

Very truly,

WICKLIFFE ROSE

Unless objections are made or suggestions received the following resolutions will be incorporated in the minutes of the May meeting:

WHEREAS, The California Institute of Technology, Pasadena, California, presents a proposal to the International Education Board for an appropriation of the funds needed to erect an observatory including a 200-inch reflecting telescope involving the expenditure of approximately $6,000,000; and

WHEREAS, The Trustees of the California Institute of Technology are to assume full responsibility for providing the necessary funds for the upkeep and maintenance of the observatory including the telescope, if constructed; and

WHEREAS, The Carnegie Institution of Washington, D.C., acting in cooperation with the California Institute of Technology approves the proposal and indicates its willingness to assist and cooperate in the undertaking; and

WHEREAS, The staff of the Mount Wilson Observatory, Pasadena, California, under the control of the Carnegie Institution of Washington, is in hearty accord with the proposal and promises cooperation in the program outlined;

THEREFORE, BE IT

RESOLVED, That the International Education Board hereby approves in principle the proposal submitted by the California Institute of Technology, Pasadena, California, to construct, if this should prove feasible, an observatory including a 200-inch reflecting telescope to be situated at such place as may be determined by the Trustees of the California Institute of Technology on the advice of a committee of representative astronomers; and be it further

RESOLVED, That the Executive Committee of the International Education Board be, and it hereby is, empowered in its discretion to commit the Board from time to time to appropriations to the California Institute of Technology, Pasadena, California, of sums not to exceed in the aggregate Six million Dollars ($6,000,000) for the purchase of a site and the construction of an observatory including a 200-inch reflecting telescope with accessories and any and all other expenses incurred in making the observatory available for use, it being understood that the Trustees of the California Institute of Technology will provide the funds required for the operation of the completed observatory; and it being stipulated that commitments by the Executive Committee under this authorization shall not be made more rapidly than developments justify; and be it further

RESOLVED, That a sum not to exceed Six million Dollars ($6,000,000) be, and it hereby is, appropriated to make this action effective, the appropriation to be charged to the principal funds of the Board.

HJT MDB

HJT (H. J. Thorkelson)

1032

# PHELPS-STOKES FUND

101 PARK AVENUE
NEW YORK

I W.R. 6/13/28 WR O

June 8th
1928



Mr. W. W. Brierley
International Education Board
61 Broadway
New York City

Dear Mr. Brierley:

I have your letter of June 6th and greatly appreciate the changes introduced by the Executive Committee in the resolution regarding the 200-inch telescope as discussed at the last meeting of the International Education Board.

The proposed resolutions which I am returning herewith are in the main most satisfactory. I merely suggest for the consideration of Dr. Rose and his associates three additions:

(1) After the word "construct" in the first resolution the words ", if this should prove feasible, ~~and advisable,~~".

(2) Before the words "it being stipulated" in the second resolution the word "and".

(3) At the close of the second resolution instead of the words "more rapidly than experimentation justifies" substitute the words "more rapidly than studies and experimentation justify."

With these minor modifications the resolution has my most complete and hearty endorsement. I repeat my appreciation of the Executive Committee's favorable consideration of the suggestions which I made at their last meeting.

Sincerely yours,

Anson Phelps Stokes

SCIENCE

CALIFORNIA INSTITUTE OF TECHNOLOGY PASADENA CALIFORNIA CONTINUED

WHEREAS, The California Institute of Technology, Pasadena, California, presents a proposal to the International Education Board for an appropriation of the funds needed to erect an observatory including a 200-inch reflecting telescope involving the expenditure of approximately $6,000,000; and

WHEREAS, The Trustees of the California Institute of Technology are to assume full responsibility for providing the necessary funds for the upkeep and maintenance of the observatory including the telescope, if constructed; and

WHEREAS, The Carnegie Institution of Washington, D.C., acting in coöperation with the California Institute of Technology approves the proposal and indicates its willingness to assist and coöperate in the undertaking; and

WHEREAS, The staff of the Mount Wilson Observatory, Pasadena, California, under the control of the Carnegie Institution of Washington, is in hearty accord with the proposal and promises coöperation in the program outlined;

THEREFORE, BE IT

RESOLVED, That the International Education Board hereby approves in principle the proposal submitted by the California Institute of Technology, Pasadena, California, to construct an observatory including a 200-inch reflecting telescope to be situated at such place as may be determined by the Trustees of the California Institute of Technology on the advice of a representative committee of astronomers; and be it further

if this should prove feasible,

RESOLVED, That the Executive Committee of the International Education Board be, and it hereby is, empowered in its discretion to commit the Board from time to time to appropriations to the California Institute of Technology, Pasadena, California, of sums not to exceed in the aggregate Six million Dollars ($6,000,000) for the purchase of a site and the construction of an observatory including a 200-inch reflecting telescope with accessories and any and all other expenses incurred in making the observatory available for use, it being understood that the Trustees of the California Institute of Technology will provide the funds required for the operation of the completed observatory, it being stipulated that commitments by the Executive Committee under this authorization shall not be made more rapidly than experimentation justifies; and be it further

and studies and

Lic Hy 7.

RESOLVED, That a sum not to exceed Six million Dollars ($6,000,000) be, and it hereby is, appropriated to make this action effective, the appropriation to be charged to the principal funds of the Board.

SCIENCE

CALIFORNIA
INSTITUTE
OF
TECHNOLOGY
PASADENA
CALIFORNIA
CONTINUED

1032



University Club,
New York.
April 16, 1928.

Dr. Wickliffe Rose,
President, ~~International~~ General Education Board,
61 Broadway,
New York.

Dear Doctor Rose,

In reply to your request, I beg to summarize briefly the chief arguments favoring the construction of a 200-inch telescope and to outline the procedure in view.

(1) The 100-inch Hooker telescope of the Mount Wilson Observatory has solved many fundamental astronomical and physical problems beyond the reach of our 60-inch reflector, and prepared the way for an attack on still more important problems that demand greater light-gathering power for their solution. Among these outstanding questions are:

(a) The structure of the universe, calling for a more intensive study of the Galaxy, of which our solar system is a minute part, and especially of the vast region of spiral nebulae ("island universes") beyond the Milky Way, where the 100-inch telescope has fixed the distance of the two nearest spiral nebulae at about one million light-years and disclosed their true nature by partially resolving them into stars. It has also revealed hundreds of thousands of more remote spirals, many of which could be analyzed and measured with a larger instrument.

(b) The evolution of spiral nebulae, partially suggested by our recent studies.

(c) The evolution of stars, showing their origin, sequence, and physical and chemical development throughout their life history.

(d) The constitution of matter, since the enormously greater range in mass, temperature, pressure, and density of the heavenly bodies presents opportunities for discovery far beyond the possibilities of laboratory experiment.

Scores of other problems calling for a larger telescope might be mentioned if space permitted.

(2) No method of advancing science is so productive as the development of new and more powerful instruments and methods of research. A larger telescope would not only furnish the necessary gain in light, space-penetration, and photographic resolving power, but permit the application of ideas and devices derived chiefly from the recent fundamental advances in physics and chemistry. These advances, which have suddenly transformed spectroscopy from an empirical into an exact and rational science, would undoubtedly render possible many new discoveries with such an instrument.

(3) The time is also especially opportune because of recent engineering and optical progress, such as the development of fused quartz as a very advantageous substitute for glass, and the proof now available that the atmospheric conditions on Mount Wilson are sufficiently perfect to permit a large increase in aperture to be fully utilized. Hitherto, in the absence of such proof, increases in the size of telescopes have been made at the risk of defeat by atmospheric disturbances.

(4) A study of the optical possibilities, which depend chiefly upon the promise of success in the manufacture of a large quartz disc for the paraboloidal telescope mirror, convinces us that the diameter of this disc should be 200 inches. This would collect nearly four times as much light as the 100-inch telescope (the largest yet constructed), penetrate twice as far into space, and reveal hundreds of millions of stars beyond its range. The shorter relative focal length adopted in our new design and the probable substitution of quartz for glass would greatly increase this gain, which could be still further enhanced by the improvement of photographic plates and accessory apparatus.

(5) The procedure in view involves:

(a) A preliminary study, by a group of the ablest experts, of all promising methods of making telescope mirror discs of large diameter.

(b) If, as now seems probable, such a study should point to the use of fused quartz, the next step would be an experimental test of the possibilities of fused quartz, and the manufacture as soon as feasible of a 200-inch mirror disc. I have already outlined to you the steps in this process, which would be carried on under the personal supervision of Dr. Elihu Thomson of the General Electric Company. Several years would be occupied in this work.

(c) A simultaneous comparative study, by a group of experienced astronomers, physicists, opticians, instrument makers, and engineers, of the various optical and mechanical questions involved in the design of the telescope and all its accessory

apparatus, and the preparation of working drawings for the mounting and dome as soon as the completion of a suitable mirror disc may permit.

(d) A simultaneous comparative study, by astronomers, physicists, and meteorologists familiar with the performance of the largest existing telescopes, of possible sites for the instrument, taking into account not only the clearness and steadiness of the atmosphere at various seasons throughout several years, but with due regard to the special requirements of the telescope, the nature of the problems in view, the efficiency of the observers, and the intimate cooperation of such institutions as the Mount Wilson Observatory and the Bridge and Gates Laboratories of the California Institute.

(e) The grinding, polishing, and figuring of the large and small mirror discs when ready. This work, like the casting of the large disc, must be done at the site selected, because of the difficulty of transporting the large disc.

(f) The construction and erection of the telescope mounting, buildings, and accessory apparatus.

(6) As you have remarked, the most important requirement in the construction and operation of the telescope is the close co-operation of the Mount Wilson Observatory and the California Institute. If your board should decide to provide for the undertaking in accordance with the views expressed by yourself in our recent conferences, the following scheme of organization might be suggested:

(a) A policy committee, consisting of the Director of the Norman Bridge Laboratory of Physics (Dr. Robert A. Millikan), the Director of the Mount Wilson Observatory (Dr. Walter S. Adams), and, if desired, the writer.

(b) A director, chosen with careful consideration of the special knowledge required in the construction and use of the telescope.

(c) A permanent staff of observers, assistants, and computers.

(d) An arrangement providing for the intimate cooperation of the scientific and technical staffs of the Mount Wilson Observatory and the Bridge and Gates Laboratories. This cooperation can now be assured.

(e) The temporary appointment from time to time of research associates, assistants, and fellows from institutions in various parts of the world whose investigations have especially qualified them to make the most efficient possible use of the 200-inch telescope.

It goes without saying that this instrument should be employed for investigations beyond the range of other telescopes. The purpose in view is therefore not to duplicate the instrumental equipment of the Mount Wilson Observatory or other similar institutions, but to provide for the extension of astronomical and physical research into fields now inaccessible.

(7) The best estimate of total cost I am now in a position to offer is six million dollars, to be expended over a considerable period (probably from four to six or more years). This would cover preliminary studies of optical problems, design, and site;

manufacture of mirror discs; optical work; temporary and permanent buildings; tools, machinery, instruments, and apparatus; road to site and expense of transporting building materials, machinery, and instruments; construction and erection of the telescope and its accessories. This estimate, which does not include endowment, is believed to cover the various contingences necessarily to be reckoned with in a large undertaking of this kind.

A more complete statement regarding some of the possibilities of large telescopes may be found in my article in the April number of Harpers Magazine.

Very sincerely yours,

George E. Hale

George E. Hale

Memorandum regarding Mount Wilson Solar Observatory, Pasadena, California - October 1, 1926

Friday afternoon, October 1, 1926, I went with Doctor Adams to the laboratory of the observatory which consists largely of a main building for offices for the fifteen technical members of the staff, an unusual physical laboratory for the experimental reproduction of phenomena associated with the structure of the sun and stars, and an optical department for grinding the lenses used in the work, including the large reflectors now in use at Mount Wilson.

While here I met Doctor Hubble (a friend of Mr. Shepardson) who is devoting his studies to the nebulae, and Doctor VanMaaren who is working on the distances of the stars.

We then took the bus for Mount Wilson, a ride of about two hours. This included a climb of about nine miles on a seven degree road to the top which is about one mile above Pasadena. The construction of this road has involved a large expenditure. It was first designed as a trail and the original apparatus and building material were all brought up by mules. Later the trail was widened for wagons and still later for trucks in order to make possible hauling equipment and materials for the 100-inch reflector.

After dinner at the Inn we listened to an excellent illustrated talk on the work of the Laboratory. I had known something of the structure of the universe of which the solar system is a part, but had not known that this universe in its entirety was probably a

spiral nebula and that there are some 135,000 such nebulae in the heavens, discovered through long time photographs. One such nebula was shown with the statement that it was probably from 850,000 to 1,000,000 light years distant from the earth. With light traveling 186,000 miles a second, or about 7½ times around the earth, it is practically impossible to conceive of a distance light travels in 850,000 years.

We visited the 60-inch reflecting telescope and saw Jupiter and then visited the 100-inch reflecting telescope then being used in making a 100 hour photographic exposure of one of the nebulae. This apparatus is marvelous in its operation, construction, and design. The large lens was ground by the laboratory and is resilvered about twice a year by the staff. The design of the machine and structure were prepared by the staff. The clock mechanism, including the large accurate gear for controlling the movement of the telescope, was built by the staff, and the result of this meant cutting the cost to about one-half the estimates submitted by manufacturing concerns.

The Observatory is open to the public Friday evenings and evidently attracts people from all over the world. The weather on the evening of our visit was very threatening, resulting in an unusually small attendance of about 50. The party included a professor and his wife from Cambridge, England, and a party of nine Japanese.

We spent the night at the "Monastery" (men only), and in the morning saw the solar observatories, the buildings where Michelson of Chicago has been making new determinations of the velocity of light,

and is planning further measurements with a still longer distance. Incidentally Doctor Hale stated that the results of the past summer's work by Doctor Michelson were almost incredible, showing a probable error of only 1 part in 300,000. We also saw the laboratory of Doctor Abbott of the Smithsonian Institute, and the foundations for the new seismological laboratory.

After breakfast we returned to Pasadena where I spent most of the morning with Doctor Anderson. We discussed electro-magnetic waves and he gave a most illuminating statement of the progress in this field from the predictions of Thompson through the verifications of Herz and others, including the contributions of R. W. Wood of Johns Hopkins and others.

This is an excellent illustration of the "great simplifications" that finally emerge after the accumulation of studies of years in apparently unrelated fields. From the minutely short hard cosmic rays, through the scale of "gamma rays," "X-Rays," "ultra violet," "light," "infra-red" and the relatively long rays for radio broadcasting we have one and the same phenomenon; in other words, light and heat are but different manifestations of electro-magnetic waves of different length.

Doctor Anderson and I then visited the Laboratory where he explained his research work in getting unusual temperatures and studying their spectra, thus reproducing phenomena of the heavens and enabling interpretation of the phenomena shown by the spectro photography of the sun, stars, and nebulae.

I then met Doctor Pease who has been responsible for the designs of the various observatories on Mount Wilson. He showed me his plans for a 25 foot reflecting telescope, a machine which with equipment will probably cost some eight millions. This design has been prepared to illustrate the fact that such an apparatus can now be constructed, although the laboratory does not plan such a construction, nor does it have any plans for securing the funds needed.

Altogether my visit to Mount Wilson has impressed me more than I can say with the unusual opportunities that now exist for adding to human knowledge. Here again is a laboratory that far excels that of any educational institution. Doctor Hale and his staff have shown a most daring initiation and conception of possible studies, with results already secured that more than justify the installation and maintenance of this research station. In the design of equipment the staff has shown unusual ability and exceptional skill, coupled with an ingenuity that is very rare and has been most productive.

H. J. Thorkelson

1497

HJT MSD

Memorandum re Mount Wilson Observatory, California - March 26, 1928

Monday, March 26, Doctor Rose and I visited the Mount Wilson Observatory with Director Adams and Doctor Russell of Princeton University. Conditions for observing were so poor that the routine observations planned for the night were abandoned. This afforded an opportunity to use the 100-inch telescope in viewing the moon, Neptune, a double star, a nebula in Orion, and a star cluster. While the conditions of the atmosphere interfered with the vision, still we gained some idea of the design and powers of the instrument.

Doctor Pease was at the Observatory and we discussed at some length his preliminary plans for a 25-foot reflector which he estimates will cost about $12,000,000. Two or three million dollars of this total will probably be needed for endowment. Discussion indicated that while such a glass disc 300 inches in diamter would be impractical, still this disc could easily be made of pyrex with very distinct advantages over glass. Fused quartz, however, would be still better in that its coefficient of expansion is so low the instrument could be used for stellar observations at night and solar observations during the day.

The question of location was also considered and the judgment of of the group seemed to favor a study of this one item by a committee of astronomers. The next question was that of ownership and control. This discussion brought out a number of interesting points. The consensus of opinion seemed to favor independence and freedom for the director, a group of trustees to administer trust funds and secure additional funds from time to time, and an advisory committee of astronomers to assist the Director in mapping a program of studies.

The discussion also brought out some of the weaknesses of university organization and those of the organization of Mount Wilson, and

indicated that further study should be given to these matters before a definite solicitation of funds is inaugurated.

The construction of the proposed telescope will extend the boundaries of knowledge regarding the heavens in enabling studies to be made of nebular structure at one extreme and the moon's surface at the other extreme. It was also shown that such an improved telescope would be more productive than the construction of new telescopes similar to the Hooker 100-inch located at other places on the globe.

In the morning we saw the solar telescope and the plates being made of the sun's surface, the position and movement of sun spots, spectral studies of the sun's atmosphere, etc.

On returning to Pasadena we visited Doctor Hale's private laboratory and saw his spectrohelioscope. We were told that seven portable machines of this type were now being built at the Mount Wilson Laboratory.

Mount Wilson is the center of astro-physical work for the world. The development of the California Institute has benefited the work of Mount Wilson. While this group of scientists have a great program of studies under way, it seems clear that progress in our knowledge of the heavens will be very greatly advanced if in some way the proposed more powerful telescope can be made available.

H. J. Thorkelson

HJT MDB

1032

February 21, 1928.

Dear Doctor Hale:

We are in receipt of your letter of February 14, concerning the possibility of assistance toward the construction of a large telescope mirror, with the view of providing later for the construction of a telescope larger than the present 100-inch Hooker instrument. It is a matter that interests us. We shall be very glad to discuss it with you.

Mr. Thorkelson and I are leaving about the middle of March - the 15th, in fact - for a western trip which ought to bring us to Pasadena on or about the 25th. If you are to be in New York before we leave we shall be glad to see you here. If not, perhaps it may be convenient to meet you at Pasadena, where we can talk matters over on the ground. In any event, we shall be very glad of an opportunity to discuss it with you.

Very sincerely yours,

(signed) Wickliffe Rose

Doctor George E. Hale,
Mount Wilson Observatory,
Pasadena, California.

1032

CARNEGIE INSTITUTION OF WASHINGTON
MOUNT WILSON OBSERVATORY
PASADENA, CALIFORNIA



February 14, 1928

Dr. Wickliffe Rose
President, General Education Board
60 Broadway, New York City.

Dear Dr. Rose:

The progress of recent research, especially in the study of stellar evolution, the nature and development of spiral nebulae, and the constitution and transformations of matter and radiation, has greatly emphasized the importance of large telescopes. In fact, the range of celestial temperatures, densities, masses, and states of matter so enormously transcends that of the physical laboratory that many of the most fundamental advances in physics depend upon the utilization of these conditions. Moreover, we now have definite observational evidence that at such a favorable site as Mount Wilson a large increase in aperture could be made with confidence, whereas we formerly had to risk defeat through atmospheric unsteadiness. I have briefly discussed these matters in an article on "The Possibilities of Large Telescopes", which I have asked the editor to send you as soon as it appears in Harper's Magazine.

May I ask whether the General Education Board would consider the possibility of making a grant to determine how large a telescope mirror it would be feasible and advisable to cast, with the view of providing later for the construction of a telescope considerably outranking the 100-inch Hooker telescope? Naturally, such

a question calls for the discussion of many important matters, but I expect to go east in March and could talk them over with you then.

Two possible methods of procedure have occurred to me. A joint arrangement might be made with the Carnegie Institution of Washington, or the telescope might be given to the National Academy of Sciences and operated under the direction of a committee of astronomers and physicists. I do not believe that the Carnegie Institution is in a position to make a large appropriation for such a purpose, but it could certainly offer the services of experts acquainted with the manufacture of glass and other questions involved. The National Academy could afford a still wider range of technical knowledge, and also give the project a status more nearly resembling that of the Marine Biological Laboratory at Wood's Hole. In any event, the best existing knowledge and experience, both European and American, should be drawn upon in the design and use of the instrument. I am confident that whichever method were adopted, the Carnegie Institution would offer at or near Mount Wilson an admirable site and many other advantages that would greatly decrease the cost of building and operating the telescope. After working for some years in the northern hemisphere, it might be transferred to a favorable site south of the equator.

We have recently had a very satisfactory visit from Morgan, who seemed to be favorably impressed by the prospects for his work at the California Institute.

Trusting that you will find my suggestion of some interest, and that in any case I may see you in March, I am, with kind regards,

Yours very sincerely,

George E. Hale

1032

February 27, 1928.

My dear Doctor Millikan:

I am sorry that I was not in the office when Professor Morgan called, but on returning I saw the correspondence and at Doctor Rose's request sent the telegram of February 21 in reply to your letter of February 16. This telegram reads as follows:

> "Any gifts for biology may be counted as part of the program to be presented at May meeting."

I trust this answers the question you raised. I sincerely hope that you will secure the necessary funds so that the completion of this program may be expedited as rapidly as the initial steps were.

Doctor Rose and I are looking forward with the greatest of pleasure to our visit at Pasadena.

With kind regards,

Yours very truly,

H. J. M.

Doctor R. A. Millikan,
California Institute of Technology,
Pasadena, California.

I H.I.T. 4/12/28 Hg.T. — File



New York, New York - Tuesday, April 10, 1928

Doctor George E. Hale (of Mount Wilson Observatory, Pasadena, California)*

Following up the subject discussed in conference with Doctor Hale on March 14, 1928, no final conclusions were arrived at, but in a rather tentative way Doctor Hale gives the following indications:

1) That if funds were available for the proposed telescope it is probable they should wish to vest ownership of the Observatory in the California Institute of Technology. If this should be done it would work in closest harmony with the Mount Wilson group, with the Institute group in physics and chemistry. This matter the group would like to consider further before final decision.

2) It is pretty clear that if the 300 inch reflector should be decided upon as the definite goal, it would be arrived at by a series of stages, making first a very small reflector and perhaps three or four reflectors being made before undertaking the 300 inch. Of this series a 200 inch would almost certainly be made as a last step in the evolution before undertaking the 300 inch. For this reason it might be advisable to set up the 200 inch as the definite goal to be undertaken at the present time, leaving the question of the 300 inch reflector to be reconsidered after completion of the 200 inch.

3) It would require roughly about $6,000,000 to make and mount the 200 inch reflector with the smaller reflectors that would be made as stages in the development of the larger one. It would probably require an endowment of an additional $2,000,000 to operate the Observatory after completion. It would be feasible to consider financial arrangements in three forms:

(a) Financing merely the reflectors, which would require roughly one-half million dollars;

(b) Financing the reflector and mounting it, with the smaller reflectors, about $6,000,000;

(c) Making and mounting the reflectors and endowing operation, about $8,000,000. In so far as one can estimate roughly, completing a 300 inch reflector, mounting and endowing for operation would cost not less than $15,000,000.

(d) As to methods of procedure, three or four things would have to be done:

(1) First, there is the matter of making the mirror. This is fundamental.

(2) The whole plan of mounting the mirror should be matured with scientific care and calculations. This scheme might be matured while the mirror is being made.

* (Appointment at University Club, 4.30 P.M.)

Doctor Hale (Continued)

(3) Careful study should be made as to definite location. This should be done by a group of scientists, and should be carried out with greatest scientific care, having in mind also the importance of California Institute of Technology and the present Mount Wilson Observatory as factors in the situation.

(4) A definite plan of organization for owning and operating the Observatory should be matured. There are three possible procedures:

a) The proposed Observatory might be given to the Carnegie Institution at Washington, which owns and operates the present Observatory on Mount Wilson;

b) It might be vested in the California Institute of Technology; or

c) It might be vested in a separate board, created for the purpose.

Thursday, April 12, 1928

Doctor George E. Hale, Doctor Robert A. Millikan, and Doctor William A. Noyes of Pasadena
(At University Club 9.45 A.M.)

1) Since our previous interview Doctor Hale had had conference with Doctor J. J. Carty, Mr. Gano Dunn and with Doctor Adams at Pasadena by Long Distance. He, Doctor Noyes and Doctor Millikan had talked the matter over. All were in accord that the objective at the present time should be the 200 inch reflector.

2) All were agreed also that the proposed Observatory should be vested in the Institute of Technology. This was the judgment even of Doctor Carty, who is a member of the board of the Carnegie Institution in Washington.

3) It was agreed by Doctor Hale and his associates also that it might be advisable to undertake at the present time to raise only the fund necessary to produce the series of mirrors and mount them. Doctor Hale's previous estimate for this had been $6,000,000. After talking with Gano Dunn as to increase in prices in work of this character since the War, he thought the cost might run somewhat beyond $6,000,000 - that probably it would be somewhere between $6,000,000 and $7,000,000.

1032

April 13, 1928.

Dear Doctor Hale:

I should appreciate it if you would write me an informal letter about the proposed telescope, in which you make all the essential points concerning the proposal in separate paragraphs as 1, 2, 3, 4, etc.

Very sincerely yours,

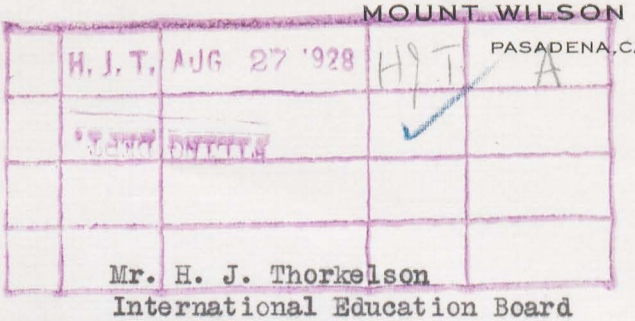
(signed) Wickliffe Rose

Doctor George E. Hale
c/o The University Club
1 West 54th Street
New York, New York

WR/LFA

1032

CARNEGIE INSTITUTION OF WASHINGTON
MOUNT WILSON OBSERVATORY
PASADENA, CALIFORNIA




August 24, 1928

Mr. H. J. Thorkelson
International Education Board
61 Broadway, New York City.

My dear Mr. Thorkelson:

Thank you for your telegram. I have also seen your letter of August 1 to Dr. Millikan, and am sending a brief report regarding the situation, which will be followed as soon as possible by our estimates for six months.

Mirror Disk. The Observatory Council has held several meetings, and has had the aid of Dr. Anderson and the Advisory Committee, enlarged to include Messrs. Adams, Seares, Abbot, Michelson, Russell, Tolman, Epstein, and Bowen. All of these gentlemen are here except Russell and Epstein, and we have had long letters from the former. We have also had advice from Dr. Frederick E. Wright of the Geophysical Laboratory and Dr. Frank E. Ross of the Yerkes Observatory, both of whom are here, and from Dr. W. W. Campbell and Professor Edwin B. Frost, as well as from various members of the staffs of the California Institute and the Mount Wilson Observatory. As there has been unanimous agreement regarding the general design of the telescope and the desirability of using mirror disks of solid fused quartz (not a single person favoring Ritchey's cellular construction), we have requested Dr. Elihu Thomson to proceed at once with his experiments in making and coating a 22-inch quartz disk, to be followed by a larger size (suitable

for use as one of the minor mirrors of the telescope) as soon as possible. Mr. Gerard Swope, President of the General Electric Company, has telegraphed

"General Electric Company will be delighted to do the work on the fused quartz lens under the personal direction of Professor Thomson who is much interested in it at manufacturing cost without any overhead for commercial or administrative expenses",

and both Mr. Swope and Professor Thomson have written us very cordially and enthusiastically to the same effect. We feel very confident that a suitable quartz disk can be made. If there should prove to be insuperable difficulties because of the thickness necessary for a 200-inch mirror, we can almost certainly build it up out of several thinner disks cemented together.

Optical Design of 200-inch Telescope. The underlying principles involved in the design have been extensively studied, especially by Messrs. Anderson, Pease, Seares, and Ross, the last of whom has come out from the Yerkes Observatory for this purpose. It has been decided to adopt the ratio F:3.3, which will mean a tremendous concentration of light and the possibility of photographing extremely faint stars, especially those constituting the spiral nebulae, almost all of which are beyond the reach of the 100-inch telescope. Such a ratio means a comparatively small field of good definition in the principal focus, but Dr. Anderson and Dr. Ross think it probable that Dr. Ross (the best man in the country for such work) can devise a special lens to go in front of the plate and increase the size of the sharp field when this is desirable. (For the faintest stars no lens will be used). Dr. Ross is so much interested in

this problem, and in several other optical devices which may add enormously to the efficiency of the 200-inch telescope, that he is willing to devote most of his time to this work during the next year. We therefore propose that he be employed for this purpose, as Professor Frost has cordially expressed his approval.

Site. We have been fortunate in having the advice of Dr. Charles G. Abbot and of others who have studied the availability of sites in California and Arizona for astronomical purposes. Dr. Charles F. Marvin, Chief of the Weather Bureau, has supplied many meteorological data and agreed to loan us several sets of recording instruments. We have selected and looked at three sites for immediate examination, and systematic astronomical observations are under way at two of them. These are Palomar, about 35 miles inland from Oceanside; Horse Flats, about 15 miles north of Mount Wilson; and Table Mountain, about 25 miles from San Bernardino, where Dr. Abbot has had a station in operation since 1925 for the measurement of the solar radiation. Two or three other points will be examined later. Dr. Anderson has devised a new method of measuring (instead of estimating) the quality of the definition, under a power of 600 diameters, and Mr. Ellerman is now using this method at Palomar. Mr. Robinson, Dr. Anderson and I visited this very remarkable site last Saturday, and were as much impressed with its natural advantages and the extreme purity of the sky as Dr. Adams, Dr. Pease, and other members of our staff have been. All of the observations so far made seem to indicate that it is distinctly better than Mount Wilson for

sharpness of definition, and very greatly superior for purity of the sky. The absence of smoke from any large city and of lights in the valley below are factors of importance. However, a long series of comparative tests, both astronomical and meteorological, will be needed to settle the site question.

Design of Telescope Mounting. Although working drawings should not be made until later, the general design of the mounting must be studied from all angles from the outset. The determination of the ratio of focal length to aperture (F:3.3) and our decision to use a 40-foot Michelson stellar interferometer attached to the upper end of the tube, have defined two of the most important features in the design. In the study of the interferometer problem we have had the benefit of our experience at Mount Wilson, of Dr. Michelson's presence here this summer, and of the advice of Dr. Aitken of the Lick Observatory, a prime authority on double stars. He is convinced that if we can build a 40-foot interferometer which can be rotated in position angle, it will be possible to measure more than a hundred spectroscopic binaries with extreme precision. This would give us for the first time accurate values of the masses and densities of the separate components of many double stars in various stages of development, and contribute in high degree to the solution of the problem of stellar evolution, as well as to many other problems bearon the constitution of matter. (The 50-foot interferometer under construction on Mount Wilson is not suitable for such work, as it cannot be rotated in position angle).

Several other general questions affecting the de-

sign of the mounting have also been settled, but much time must be given to the details, and later to the working drawings.

Photographic Processes. We have taken up with Mr. George Eastman and with Dr. Mees, Director of his Research Laboratory, some fundamental photographic questions. They are keenly interested, and will be delighted to study these problems for us. Some recent discoveries, which indicate that the speed of plates can be increased without decrease in the size of the grain, lead Dr. Mees to believe that an important advance can be made. No other means of increasing the space-penetrating power of the 200-inch telescope is so promising as this. Various other photographic questions, including improved means of sensitizing plates for various parts of the spectrum, should also be investigated.

Auxiliary Instruments. The general study of instruments and devices for receiving, recording, and interpreting celestial images, undertaken in a broad way for the first time in accordance with our plan, is of the greatest importance. The receiving end of a telescope is at least as vital as the light-collecting end, and the only way to make really effective use of a 200-inch mirror is to provide the best possible means of utilizing the light it concentrates.

Our original scheme called for a large machine shop, at least twice the size of the Mount Wilson shop. We have decided, however, to fix the size of the shop chiefly by the requirements of the auxiliary apparatus, which means that tools large enough

to build the 40-foot interferometer and other large auxiliaries will serve our needs. Most of the telescope mounting, which will demand much larger machine tools, can be built by Warner & Swasey, or elsewhere.

As the Mount Wilson shop is used to its full capacity to keep up with the needs of the present Observatory, our first necessity will be a similar shop on the campus of the California Institute. This cannot be in our proposed Astrophysical Laboratory, because of vibration from the planers and other machinery. We therefore wish to put up a one-story building for this purpose as soon as possible, and will include this in the estimates now in preparation. The development of the Mount Wilson Observatory has been chiefly dependent upon the facilities for experiment afforded by its shops, and in the present case our need for such facilities is even greater, because of our general attack upon the problem of highly efficient auxiliary instruments.

The estimates will follow as soon as possible. It will be advantageous to us to know the date of the meeting when fixed, and the action when taken. We have succeeded thus far in keeping the scheme out of the newspapers, but some rumors have reached them in spite of us, and they are keeping quiet through courtesy and in anticipation of definite information, which we have agreed to give them if and when your Executive Committee takes favorable action.

With kind regards,

Yours very sincerely,

George E. Hale

August 27, 1928

My dear Mr. Hale:

Thank you very much for your letter of August 24. As it is customary for the officers to consider first in conference before preparing a statement for the Executive Committee, I will appreciate receiving the estimates you are now preparing as soon as convenient. I am delighted with the report, and will be glad to transmit same to the Executive Committee of the International Education Board.

With kind personal regards, I am

Very truly yours,

H. J. T.

Mr. George E. Hale
Mount Wilson Observatory
Pasadena
California

HJT MVK

1032

CARNEGIE INSTITUTION OF WASHINGTON
MOUNT WILSON OBSERVATORY
PASADENA, CALIFORNIA

A W.R. JUN 18 1928 FILING DEPT. W.R. 6/18/28

June 14, 1928

Dr. Wickliffe Rose
President, International Education Board
61 Broadway, New York City.

Dear Dr. Rose:

It seems to Mr. Robinson and me that as rumors of our project are already floating about, in spite of our best efforts to prevent them, they are almost sure to reach the papers in some distorted or objectionable form unless we forestall them. We have therefore prepared the enclosed statement, which is literally true in all particulars, and suggest that if you approve some form of publication you or Dr. Thorkelson revise it in any way that may seem desirable.

It is a shame to trouble you with this at the very moment of your departure, especially after your long and hurried journey to Pasadena. But I am assuming that you can turn it over to Dr. Thorkelson or someone else, without spending any of your last crowded minutes upon it. Of course no publication will be made if you prefer. Perhaps the references to the work of the telescope should be cut out anyway, but I included them in the hope of heading off the inhabitants of Mars!

You will see that the object in view is not merely to forestall misrepresentation, but to give Anderson and others the necessary freedom in consulting those whose aid will be needed at once. Mr. Robinson says that the Institute can undoubtedly advance

the funds necessary for the summer's work. We expect to present the matter to the trustees very soon.

I hope that we shall ultimately be able to justify in some degree the confidence you have so freely accorded us. We very deeply appreciate your enthusiastic interest and initiative, without which such a project would not have had the slightest chance of success. You may be sure that we shall always be grateful to you and all your associates.

With best wishes for a splendid trip and hoping to see you settled here for a long stay in the not distant future, I am

Yours very cordially,

George E. Hale

POSSIBLE FORM OF ANNOUNCEMENT

The California Institute, having established departments of graduate study and research in mathematics, physics, chemistry, geology, paleontology, and biology, is now taking steps to secure an astrophysical observatory. It is not intended to duplicate but rather to supplement the equipment of the neighboring Mount Wilson Observatory of the Carnegie Institution of Washington, with which the Norman Bridge Laboratory of Physics and the Gates Laboratory of Chemistry of the California Institute have closely cooperated for several years in a joint study of the constitution of matter.

The chief purpose in view is to build and equip a reflecting telescope, with an aperture as great as 200 inches if possible. Such an instrument would be much more powerful than the largest existing telescope, and would penetrate at least twice as far into space. It should reveal hundreds of millions of stars now out of reach, and enlarge our knowledge of the nature, distance, and evolution of the "island universes", shown by recent researches to resemble our own stellar system and to lie beyond its encircling girdle, the Milky Way. It should also add to our understanding of stellar evolution, and aid in the solution of fundamental problems of physics and chemistry. In such a study of the constitution of matter, the enormously greater range in mass, temperature, pressure, and density of the heavenly bodies offer opportunities for discovery far beyond the possibilities of laboratory experiment.

The California Institute has appointed four members of its Executive Council, Messrs. Hale, Millikan, Noyes, and Robinson, to assume general charge of the project. The Carnegie Institution of Washington, through its President, Dr. John C. Merriam, has promised close cooperation, and members of the staff of the Mount Wilson Observatory will assist in the design and construction of the telescope and in its use when completed. An Advisory Committee, consisting of the Director and Assistant Director of the Mount Wilson Observatory, and other leading astronomers and physicists, will aid the Observatory Council of the Institute in determining matters of policy, and many experts in other institutions will be called upon for advice. Through the courtesy of the Carnegie Institution of Washington Dr. J. A. Anderson, a member of the Mount Wilson staff, will serve as executive officer in direct charge of the project. While the necessary funds are being secured, he and his ~~assistants~~ associates will begin a comprehensive study of the many technical questions involved in the design and construction of the observatory.

1032

Form 1258 A

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*Send the following message, subject to the terms on back hereof, which are hereby agreed to*

June 18, 1928

Doctor George E. Hale
Mount Wilson Observatory
Pasadena
California

Your letter June fourteenth received. We approve publication as submitted.

Wickliffe Rose

(Rec'd in files 6/25/28)

1032

200 inch Reflecting Telescope

Points to be included in formal request from the
Trustees of California Institute of Technology

I. The International Education Board is to provide funds as needed for:

(a) a 200 inch reflecting telescope

(b) Site including land and land improvements

(c) Observatory and other necessary buildings

(d) Auxiliary apparatus

(e) Other expenses in connection with making the observatory available for use.

The total funds so provided are not to exceed in the aggregate six million dollars ($6,000,000) and the International Education Board is not expected to provide funds for any other purpose than those here indicated.

II. The California Institute of Technology is to assume full responsibility for building the proposed observatory and is to provide the necessary funds for operating it after its completion.

III. It is understood that if experience should show at any stage of development that the undertaking cannot be carried to successful completion, no further expense will be incurred by the California Institute of Technology and no further funds will be provided by the International Education Board.

IV. In transmitting a formal request from the trustees of California Institute of Technology to the International Education Board, it is suggested that the request include:

(a) Evidence of co-operation from the Carnegie Institution and the staff of the Mt. Wilson Observatory.

(b) Personnel of:

1. Committee of representative astronomers to consider site.

2. Committee on construction of reflectors.

3. Committee on design of telescope, buildings, equipment, etc.

(c) A budget of estimated expenditures including:

1. Expenses of committees

2. Expenses of experimentation and manufacture of reflectors

3. Expenses of land and land improvements

4. Expenses of buildings and telescope mountings

5. Expenses of other equipment

6. Contingent expenses

SUPPLEMENTAL INFORMATION

The formal request from the Trustees of the California Institute of Technology will form the basis of the formal pledge of the International Education Board. After the pledge has been approved, formally executed and accepted the following procedure is suggested.

Upon request from California Institute of Technology accompanied by full report as to the status of development, the executive committee of the International Education Board will consider and appropriate from time to time such funds as may be needed to meet the respective budget items included in the formal request.

After such appropriations are authorized, payments will be made by the International Education Board to the California Institute of Technology upon duly authorized requisition and statement of account.

The intention of this suggested procedure is to provide funds only as expenses are incurred and to enable plans and construction to develop without delay and without expense to the Institute. A full accounting of all expenditures is expected but approval and payment of bills is the function of the Institute. Advances will be provided as needed.

(Original in folder - Eng. 16 - British Astronomical Association)

C
O
P
Y

Carnegie Institution of Washington
MOUNT WILSON OBSERVATORY
Pasadena, California

1632

June 26, 1928

Dr. H. J. Thorkelson
International Education Board
61 Broadway, New York City.

Dear Dr. Thorkelson:

Many thanks for your letter. Kindly return my correspondence with the Astronomer Royal, and let me know to whom the proposed application of the British Astronomical Association, to which he refers in his letter to me, should be addressed.

I think your welcome suggestion is certainly worthy of consideration and I am transmitting it to Dr. Anderson, the Executive Officer in charge of the Observatory project.

We intend to ask official action by the Institute trustees on the formal request to the International Education Board as soon as Mr. Fleming and others return to Pasadena. Meanwhile, several preliminary studies on various phases of the project have been undertaken.

With kindest regards,

Yours very sincerely,

(Signed) GEORGE E. HALE

1032

June 18, 1928

My dear Doctor Hale:

Doctor Rose has left with me some correspondence between you and Sir Frank Dyson of the Royal Observatory, Greenwich, England. If you wish to have this returned, I shall be glad to attend to it.

I know you will pardon a suggestion that has occurred to me. In one of our conferences Doctor Adams mentioned the possibility of using quartz tubes with flattened sides as elements for building up a mirror. Would it not be feasible to draw hexagonal quartz cylinders of a desirable unit size and then by placing these next to each other build up a solid quartz structure for fusing? Feel at perfect liberty to put this suggestion in your wastebasket if you desire.

With kindest regards,

Yours very truly,

H. J. THORKELSON

Doctor George E. Hale
Mount Wilson Observatory
Pasadena, California

HJT MDB

1032

June 27, 1928

Dear Mr. Stokes:

Thank you for your letter of June 19th to Doctor Rose which was received after his departure for Europe. I know that he will be gratified to learn that the proposal for the California Institute of Technology in its revised form has your hearty approval.

Sincerely yours,

W. W. BRIERLEY

Mr. Anson Phelps Stokes
2408 Massachusetts Avenue, N.W.
Washington, D.C.

WWB:HMN

1032

TEL. NORTH 4116



L.F. ANSON PHELPS STOKES
2408 MASSACHUSETTS AVENUE N.W.
WASHINGTON, D.C.

June 19, 1928

Keep together

Dr. Wickliffe Rose
International Education Board
61 Broadway
New York City

Dear Dr. Rose:

Your report of June 18th regarding the proposed new telescope for the California Institute of Technology, and the accompanying votes, are all admirable. I am really perfectly delighted at the result of your conferences and of the further consideration of this important matter by the Executive Committee. You can put me down as heartily favoring the project in the form now presented. I think we shall be on much stronger ground as a result of our discussions, your additional conferences, and the determination to get the advice and cooperation of a broadly selected group of scientists.

Again assuring you of my appreciation of the friendly spirit in which you took my suggestions and criticisms of the form of the original proposal, I am

Sincerely yours,

Anson Phelps Stokes

C.

1032

RBF

Resolutions adopted by the Board of Trustees of the California Institute of Technology on July 5, 1928.

1) That an Observatory Council, consisting of Messrs. Hale, Millikan, Noyes, and Robinson, be and hereby is appointed and empowered to represent and act on behalf of the Trustees in all dealings with the International Education Board or other agencies relating to the provision and operation of an Astrophysical Observatory with large telescope for the California Institute of Technology; to set up and expend an Observatory Fund, which shall be maintained as a separate fund, distinct from all other funds of the Institute; and to have full charge and control of the location, design, construction, and operation of the Observatory in all its departments and relationships.

2) That the attached general plan of procedure, entitled "Astrophysical Observatory of the California Institute of Technology. Proposed Scheme of Organization, Construction, and Operation", be approved, subject to any amendments that may hereafter be adopted by the Observatory Council.

RBF

3) That in consideration of the provision of funds by the International Education Board for the construction of the Observatory by the California Institute of Technology as a part of its plant and equipment, the California Institute of Technology hereby agrees to assume full responsibility for building the Observatory and to provide the necessary funds for operating it after its completion.

4) That the accompanying letter from the Observatory Council to the International Education Board, comprising a formal request on behalf of the California Institute of Technology for six million dollars for a 200-inch reflecting telescope, site including land and land improvements, observatory and other necessary buildings, auxiliary apparatus, and other expenses in connection with making the Observatory available for use, be approved.

5) That the Observatory Council shall set up a regular organization, with a Chairman, Secretary, and other officers, shall hold regular meetings, and shall make reports at least quarterly to this Board.

6) That upon the making of the above grant by the International Education Board, and in accordance with its suggested procedure, payment of same to the California Institute of Technology shall be made from time to time as needed, upon requisition, as construction work proceeds, and the California Institute of Technology shall render to said International Education Board each calendar six months, or more frequently if desired, a full detailed account of all expenditures made on account of such construction.

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I hereby certify that the foregoing is a true copy of resolutions adopted by the Board of Trustees of the California Institute of Technology at a meeting duly called and held at the Institute July 5, 1928.

EDWARD C. BARRETT

Secretary

I. E. B.

1032

AmJ

COOPERATION OF CALIFORNIA INSTITUTE OF TECHNOLOGY AND CARNEGIE INSTITUTION
(From original records)

(See w w diary 4/7/27 with Gifford)

Resolutions adopted by the Board of Trustees of the California Institute of Technology - Signed by Edward C. Barrett, July 5, 1928.

.....

3) That in consideration of the provision of funds by the International Education Board for the construction of the Observatory by the California Institute of Technology as a part of its plant and equipment, the California Institute of Technology hereby agrees to assume full responsibility for building the Observatory and to provide the necessary funds for operating it after its completion.

.....

---

Memorandum re California Institute of Technology - Signed by H. J. Thorkelson, June 11, 1928.

.....

Plan of Cooperation

The chief objects of a plan of cooperation between the Carnegie Institution of Washington and the California Institute should be:

(1) To assure the effective utilization of the knowledge and experience of both institutions in the design, construction, and operation of the proposed Astrophysical Observatory.

.....

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Telegram sent to members of the Executive Committee of the Carnegie Institution of Washington.

Washington, D.C.
May 11, 1928.

Have just received from Doctor Millikan with authority Executive Council and Trustees California Institute cordial invitation to Carnegie Institution Washington to cooperate with California Institute in construction and operation of a great telescope in case funds should become available for such a project STOP With this invitation there is expressed also the purpose of California Institute to offer to Carnegie Institution Washington opportunity for members of the staff of Mount Wilson Observatory to conduct investigations with such a telescope STOP I recommend that Executive Committee Carnegie Institution Washington approve acceptance this offer and express its desire to assist and cooperate in the proposed project STOP Your reply by telegram at earliest convenience will be appreciated.

John C. Merriam

(Unanimous approval received from Executive members voting and constituting a majority).

WESTERN UNION

Washington, D.C.,
MAY 13, 1928.

NIGHT LETTER

DR. R. A. MILLIKAN,
CALIFORNIA INSTITUTE OF TECHNOLOGY,
PASADENA, CALIFORNIA.

EXECUTIVE COMMITTEE CARNEGIE INSTITUTION WASHINGTON HAS HEARTILY APPROVED ACCEPTANCE SUGGESTION OF CALIFORNIA INSTITUTE REGARDING COOPERATION IN CONSTRUCTION AND OPERATION OF A GREATER TELESCOPE IN CASE FUNDS SHOULD BE SECURED FOR CARRYING OUT OF SUCH A PROJECT LETTER FOLLOWS.

J. C. MERRIAM

Charge to:
Carnegie Institution of Washington

---

Washington, D.C.

May 13, 1928.

Dr. R. A. Millikan
California Institute of Technology
Pasadena, California

My dear Millikan:

Following receipt of a telegram from you which presented to Carnegie Institution of Washington the suggestion of cooperation relative to possibility of construction of a greater telescope, I transmitted to the Executive Committee of the Carnegie Institution of Washington the statement approved by the Executive Council and Trustees of California Institute. A copy of the statement as it is in my hands is inclosed herewith.

The Executive Committee of Carnegie Institution of Washington has given its official approval of acceptance of this offer and its expression of the desire to assist and cooperate in the proposed project.

I am by this mail transmitting to Dr. Hale copies of the several documents mentioned, with the statement that within such limits as seem to him proper they might be used in discussion of the greater telescope project.

With my cordial good wishes, I am

Very sincerely yours,

(John C. Merriam)

---

Washington, D.C.

May 13, 1928.

Dr. Wickliffe Rose
61 Broadway
New York, N.Y.

My dear Dr. Rose:

As you have been kind enough to discuss with me recently questions concerning the possibility of a greater telescope, I am taking the liberty of transmitting to you certain data relating to opportunity for cooperation and mutual support in case a plan of this nature is developed.

As bearing upon possibility of relationships between agencies concerned with development of basic aspects of the physical sciences, I know you will be interested to learn that the Carnegie Institution has received through Dr. R. A. Millikan, by authority of the Executive Council and Trustees of the California Institute, a cordial invitation to cooperate with California Institute in construction and operation of a greater telescope in case funds should become available to California Institute for carrying out such a project. The suggestion received from California Institute I have transmitted to the Executive Committee of Carnegie Institution of Washington, which acts for the Institution between sessions of the Board of Trustees, and have recommended that the Committee approve acceptance of this offer and express its desire to assist and cooperate in the proposed project. Through official action the Executive Committee has given its complete and hearty approval of the suggestion presented by California Institute.

In addition to the action just mentioned, a communication has been received from Dr. Adams, Director of Mount Wilson Observatory of the Carnegie Institution, expressing personally and on behalf of the members of the staff their desire to assist and cooperate in the program suggested.

Discussion of the proposed program does not leave room for doubt that, in connection with such a plan concerning a greater telescope as has been discussed, California Institute would be given full assistance and hearty cooperation of the staff of Mount Wilson Observatory, and at the same time it would receive the broader cooperation of Carnegie Institution of Washington as represented by its various departments and activities. In addition to these official and general statements relative to the situation, I may only add that whoever might be interested could depend upon the same kind of intimate cooperation which has characterized the relationships which you and I have maintained through consideration of numerous significant projects in recent years.

With my cordial good wishes, I am

Very sincerely yours,

(John C. Merriam)

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Excerpt from letter to Dr. Wickliffe Rose, dated April 16, 1928, from George E. Hale.

.....

(6) As you have remarked, the most important requirement in the construction and operation of the telescope is the close cooperation of the Mount Wilson Observatory and the California Institute. If your Board should decide to provide for the undertaking in accordance with the view expressed by yourself in our recent conferences, the following scheme of organization might be suggested:

(a) A policy committee, consisting of the Director of the Norman Bridge Laboratory of Physics (Dr. Robert A. Millikan), the Director of the Mount Wilson Observatory (Dr. Walter S. Adams), and, if desired, the writer.

(b) A director, chosen with careful consideration of the special knowledge required in the construction and use of the telescope.

(c) A permanent staff of observers, assistants, and computers.

(d) An arrangement providing for the intimate cooperation of the scientific and technical staffs of the Mount Wilson Observatory and the Bridge and Gates Laboratories. This cooperation can now be assured.

(e) The temporary appointment from time to time of research associates, assistants, and fellows from institutions in various parts of the world whose investigations have especially qualified them to make the most efficient possible use of the 200-inch telescope.

It goes without saying that this instrument should be employed for investigations beyond the range of other telescopes. The purpose in view is therefore not to duplicate the instrumental equipment of the Mount Wilson Observatory or other similar institutions, but to provide for the extension of astronomical and physical research into fields now inaccessible.

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(1/7/37)

D.

1632

MOUNT WILSON OBSERVATORY

Pasadena, California

July 6, 1928

International Education Board
61 Broadway, New York, New York.

Gentlemen:

On behalf of the California Institute of Technology, and in conformity with resolutions adopted by its Board of Trustees on July 5, 1928, we beg to present a formal request for a grant of six million dollars, or so much thereof as may be necessary, to provide funds as needed for:

1) A 200-inch reflecting telescope.

2) Site, including land and land improvements.

3) Observatory and other necessary buildings.

4) Auxiliary apparatus.

5) Other expenses in connection with making the Observatory available for use.

The total funds so provided are not to exceed in the aggregate six million dollars ($6,000,000.) and the International Education Board is not expected to provide funds for any other purposes than those here indicated.

The California Institute of Technology is to assume full responsibility for building the proposed observatory and in accordance with the accompanying resolution of its Trustees, the Institute agrees to provide the funds necessary for operating the observatory after its completion.

It is understood that if experience should show at any stage

of development that the undertaking cannot be carried to successful completion, no further expenses will be incurred by the California Institute of Technology, and no further funds will be provided by the International Education Board.

The Trustees of the Institute appreciate that the International Education Board recognizes the importance of securing the cooperation of the Carnegie Institution of Washington and the Mount Wilson Observatory in this project. They have requested such cooperation, and it has been fully assured by the action of the Executive Committee of the Carnegie Institution of Washington, transmitted on May 13, 1928 by President John C. Merriam to President Wickliffe Rose. Copies of this correspondence, together with copy of a letter from Dr. Walter S. Adams, Director of the Mount Wilson Observatory, indicating his desire for cooperation, are attached.

The general plan of procedure, presented by Mr. Hale to the Trustees of the California Institute and to President Merriam and Dr. Adams of the Carnegie Institution of Washington, is shown in the enclosed memorandum entitled "Astrophysical Observatory of the California Institute of Technology. Proposed Scheme of Organization, Construction, and Operation." This has been approved by the Trustees of the Institute, and by President Merriam and Dr. Adams. The Trustees of the Institute have appointed and fully empowered the Observatory Council as named, and have authorized it to represent them and to act on their behalf in all negotiations with the International Education Board. Dr. J. A. Anderson, a member of the staff of the Mount Wilson Observatory, has been chosen as the Executive Officer of the Astrophysical Observatory during the period

of construction, and arrangements have been made to secure the assistance of other members of the Mount Wilson Observatory staff as needed.

The various Committees chosen to assist the Observatory Council and the Executive Officers, as tentatively selected chiefly in conference with President Rose and Dr. Thorkelson, are as follows:

Advisory Committee ( to meet from time to time with the Observatory Council and assist in the determination of questions of policy):

Dr. Walter S. Adams, Director of the Mount Wilson Observatory.
Professor Frederick H. Seares, Assistant Director of the Mount Wilson Observatory.
Professor Henry Norris Russell of Princeton University.
Dr. Paul S. Epstein of the California Institute.
Dr. Ira S. Bowen of the California Institute.

Committee on Site. The members of the Advisory Committee and

Dr. Charles G. Abbot, Secretary of the Smithsonian Institution.
Dr. Robert G. Aitken, Assistant Director of the Lick Observatory.
Professor Charles F. Marvin, Chief U.S. Weather Bureau.
Dr. W. S. Humphreys, Professor of Meteorological Physics, U.S. Weather Bureau,
and members of the staffs of the Mount Wilson Observatory and the Norman Bridge Laboratory of Physics.

Committee on Mirror Discs. The Advisory Committee and

Dr. Arthur S. Day, Director of the Geophysical Laboratory of the Carnegie Institution of Washington.
Dr. Frederick E. Wright, Geophysical Laboratory of the Carnegie Institution of Washington.
Dr. G. K. Burgess, Director of the Bureau of Standards.
Dr. Elihu Thomson, Director Thomson Research Laboratory, General Electric Company.
Mr. Gano Dunn, President of the J. G. White Engineering Corporation.
Dr. Francis G. Pease, Mount Wilson Observatory.

Committee on Design of Telescope Mounting and Observatory Buildings.

The Advisory Committee and

Mr. Gano Dunn, President of the J.G. White Engineering Corporation.
Dr. Ambrose Swasey, Chairman of the Board, Warner & Swasey Company.
Professor R.R. Martel, California Institute.
Dr. Francis G. Pease, Mount Wilson Observatory,
and other members of the staffs of the Mount Wilson Observatory and the California Institute.

Committee on Auxiliary Apparatus. The Advisory Committee and
Dr. Albert A. Michelson, University of Chicago.
Dr. Charles G. Abbot, Secretary of the Smithsonian Institution.
Dr. Willis R. Whitney, Director Research Laboratory, General Electric Company.
Dr. Frank B. Jewett, President Bell Telephone Laboratories.
Dr. C.E.K. Mees, Director Research Laboratory, Eastman Kodak Company.
Dr. Frederick E. Wright, Geophysical Laboratory, Carnegie Institution of Washington.
Dr. Frank E. Ross, Yerkes Observatory, University of Chicago.
Dr. Joel Stebbins, Director Washburn Observatory, University of Wisconsin,
and members of the staffs of the Mount Wilson Observatory and the California Institute.

Consultants.

Dr. John C. Merriam, President of the Carnegie Institution of Washington.
Dr. Albert A. Michelson, University of Chicago.
General J. J. Carty, Vice President, American Telephone and Telegraph Company.
Mr. Gano Dunn, President, J. G. White Engineering Corporation.
Hon. Sir Charles A. Parsons, London.
M. Charles Fabry, Director General of the Institute of Optics, Paris.
Senator Antonio Garbasso, Director of the Galileo Institute, Florence.
Sir Herbert Jackson, Director of the British Scientific Instrument Research Association, London.
The Director of the Astronomical Department of Carl Zeiss, Jena.
The Director of Repsold & Company, Hamburg.
Professor F. Paschen, Director of the Physico-Technical Institute, Charlottenberg.
Sir Robert Hadfield, London.
Sir Horace Darwin, Director, Cambridge Scientific Instrument Company.

Consultants. (Continued)

Sir Joseph E. Petavel, Director of the National Physical Laboratory, Teddington.
Professor Pieter Zeeman, University of Amsterdam.
Dr. H. F. Newall, Director of the Solar Physics Observatory, Cambridge, England.
Dr. S. J. Plaskett, Director, Dominion Astrophysical Observatory, Victoria.
Dr. George K. Burgess, Director of the Bureau of Standards, Washington.
Dr. W. W. Campbell, Director of the Lick Observatory.
Professor Edwin B. Frost, Director of the Yerkes Observatory.
Professor Frank Schlesinger, Director of the Yale Observatory.
Professor H. D. Curtis, Director of the Allegheny Observatory.
Dr. V. M. Slipher, Director of the Lowell Observatory.
Sir Gilbert Walker, lately Director General of Observatories, India.
* Professor Harlow Shapley, Director of the Harvard Observatory.

Most of the above Consultants have been chosen because of their proficiency in instrument, optical, or engineering design. Other Consultants, including additional astronomers and physicists, will be added later.

In preparing the preliminary budget of estimated expenditures it must be understood, as already explained to President Rose and Dr. Thorkelson, that the figures are necessarily very rough approximations, especially those relating to the manufacture of the large mirrors.

1. Expenses of committees, including cost of travel, salaries of assistants, astronomical and meteorological instruments for simultaneous comparative tests of promising sites, etc. $ 50,000

2. Expenses of experimentation and manufacture of telescope mirrors, including the making of discs of fused quartz (and possibly of Pyrex glass as an alternative) of diameters increasing from 24 inches to 200 inches (all to be used in the Observatory); electric furnaces of various sizes for melting, coating the surface, and annealing quartz discs; transformers and other electrical apparatus; tests of the optical and mechanical properties of the discs; superintendence and skilled labor; optical and testing shop at the mountain site for grinding, polishing, and figuring the 200-inch disc, with all special tools and machinery for this purpose; salaries of opticians; optical

work on smaller mirrors at the Mount Wilson Observatory optical shop (where the necessary grinding machines and other tools are already available); and other expenses involved in the completion of all mirrors required for the 200-inch telescope (including two 60-inch mirrors attached outside the tube for solar work and ultraviolet stellar spectra). $1,150,000

3. Purchase of site, of sufficient area to afford adequate protection from neighboring lights, vibration, etc; construction of road to site; telephone lines; pumping plant and reservoirs for water-supply; powerhouse, transformers, power lines and other electrical equipment; houses and furniture for astronomers, engineers, and other members of staff; fire protection, including fire breaks and machinery; and other expenses of land improvement. 600,000

4. Design, construction, transportation, and erection of telescope mounting and steel building with revolving dome, with all motors, wiring, and standard instrumental attachments and equipment; foundations, piers, and other masonry; and other expenses connected with the completion of buildings for instruments at the mountain site; astrophysical laboratory on the campus of the California Institute, with provision for instrument shop and tools, research rooms, offices for scientific staff and computers, equipment for graduate instruction and research, and adequate facilities for the measurement, reduction and preservation of astronomical and spectroscopic photographs, and the study and interpretation of observational results. $2,700,000

5. Expenses of developing suitable instrumental devices and methods for recording, analyzing, measuring, and interpreting astrophysical phenomena, and the provision of the best forms of spectrographs, gratings, prisms, interferometers, thermocouples, photoelectric cells, radiometers, microphometers, photographic plates and apparatus, measuring machines and other instruments and means of assuring the most efficient use of the 200-inch telescope (most of this apparatus would be attached to the telescope, but some of it would be used in the laboratory for the interpretation of observational results). 400,000

6. Contingent expenses. 1,100,000

Summary of Preliminary Budget

| | | |
|---|---|---|
| 1) | Expenses of committees | $ 50,000 |
| 2) | Expenses of experimentation and manufacture of reflectors | 1,150,000 |
| 3) | Expenses of land and land improvements | 600,000 |
| 4) | Expenses of buildings and telescope mountings | 2,700,000 |
| 5) | Expenses of other equipment | 400,000 |
| 6) | Contingent expenses | 1,100,000 |
| | Total | $6,000,000 |

In preparing this formal request, the suggested outline given us by President Rose has been closely followed.

Very respectfully yours,

(Signed) GEORGE E. HALE
ROBERT A. MILLIKAN
ARTHUR A. NOYES
HENRY M. ROBINSON
Observatory Council.

1032





# THE ROCKEFELLER FOUNDATION



20 RUE DE LA BAUME, PARIS (8)





July 9, 1928

My dear Mr. Arnett:-

I have read the memorandum of June 18th with respect to the negotiations with the authorities of the California Institute of Technology and have examined carefully the proposed form of resolutions to be incorporated in the minutes of the May meeting with respect to the new reflecting telescope. I think the Officers have safeguarded all the points which were raised in the discussion at the May meeting. I am prepared to approve the proposed form of resolutions.

I am sorry to have missed seeing you here. I hope your trip was in every way successful.

Yours sincerely,

George E. Vincent

George E. Vincent.

Mr. Trevor Arnett,
President of the
International Education Board,
61, Broadway,
New York City.

GEV/HK

1032

July 13, 1928

My dear Professor Millikan:

I desire to acknowledge the formal application to the International Education Board dated July 6, 1928, submitted on behalf of the California Institute of Technology, for an appropriation of Six Million Dollars for the construction, equipment, etc. of a 200-inch reflecting telescope.

The officers are now absent for the summer but upon their return in the fall this communication with enclosures will be brought up for further attention.

Sincerely yours,

W. W. BRIERLEY

Professor Robert R. Millikan
Mount Wilson Observatory
Carnegie Institution of Washington
Pasadena, California

WWB:HMN

(Original in folder - Eng. 16 - British Astronomical Assoc.)

COPY

Carnegie Institution of Washington
MOUNT WILSON OBSERVATORY
Pasadena, California

1032

July 14, 1928

Miss Mildred D. Bruen
General Education Board
61 Broadway, New York City.

My dear Miss Bruen:

Please accept Dr. Hale's thanks for your letter of the 9th and the return of the correspondence with Sir Frank Dyson.

Yours very truly,

(Signed) F. LOUISE GIANETTI
Secretary to
Dr. George E. Hale.

1032

July 9, 1928

My dear Doctor Hale:

Your letter of June 26 addressed to Mr. Thorkelson is received while he is away on vacation; it will be brought to his attention on his return to the office.

We are enclosing your correspondence with Sir Frank Dyson as you request. An application for aid from the British Astronomical Association may appropriately be addressed to the International Education Board, Mr. Trevor Arnett, President, 61 Broadway, New York, New York.

Very truly yours,

GENERAL EDUCATION BOARD

By Mildred D. Bruen

Doctor George E. Hale
Mount Wilson Observatory
Pasadena, California

Enc.

MDB

1032

August 1, 1928

My dear Doctor Millikan:

On returning to the office from my vacation I find the paper submitted by your Observatory Council under date of July 6 and acknowledged by Mr. Brierley under date of July 13.

The papers your Council has submitted seem to me in excellent shape and at this time I see no difficulty in presenting the matter formally to the Executive Committee at its next meeting in the fall.

I wish, however, to raise the question as to whether the $50,000 item for "Expenses of Committees" does not represent the only sum needed at this stage. If this is satisfactory we can present to the Executive Committee such a recommendation. Later as developments require, recommendations for other appropriations can be considered.

With kindest personal regards,

Yours very truly,

H. J. THORKELSON

Doctor Robert A. Millikan
Mount Wilson Observatory
Pasadena, California

HJT MDB

1032

August 20, 1928

Dear Doctor Adams:

You probably saw in "Science" an article stating that Professor Ritchie announces that a large telescope was to be built in Arizona near the Grand Canyon. Have you any information regarding this plan? If so, I would like to have it, for I wish to have available at all times all material pertinent to the 200-inch observatory problem.

With kindest regards,

Sincerely yours,

H. J. Thorkelson

Doctor W. S. Adams, Director
Mount Wilson Observatory
Pasadena, California

HJT:KEO

1032

August 22, 1928

Dear Mr. Debevoise:

I am enclosing my first draft of an item to be presented to the Executive Committee of the International Education Board this fall. It relates to the proposed telescope in connection with the California Institute. I think you heard some of the discussion at the meeting and are familiar with the conference which we held at Pasadena following the meeting and with the letter sent by Doctor Rose to the members of the Board on his return from the conference.

You will notice that the resolutions as recorded indicate certain conditions, and I wish in presenting this item to make it clear that the conditions up to the present time are fulfilled by the Trustees of the Institute. This accounts for the lengthy character of the item.

I would greatly appreciate your comments and suggestions on this matter, for this is the largest single appropriation that the Board has dealt with. After the item is prepared in due form, I assumethat Mr. Brierley will consult with

you regarding the form of resolution to be adopted by the Executive Committee.

Appreciating very much your coöperation, I am,

Sincerely yours,

H. J. Thorkelson

Mr. T.M. Debevoise
26 Broadway, New York

HJT:KNO

COPY

(Original in 355, under Thorkelson)
G.E. B. FILES

1032

August 27, 1928

Dear Doctor Rose:

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

I have made my first draft of a memorandum to the Executive Committee of the International Education Board regarding the telescope. Things are moving quite rapidly, excellent committees have been appointed. Mr. Gerard Swope, President of the General Electric Company, has telegraphed

> "General Electric Company will be delighted to do the work on the fused quartz lens under the personal direction of Professor Thomson who is much interested in it at mamufacturing cost without any overhead for commercial or administrative expenses".

Certain decisions have already been reached. One -- the ratio of focal length to apperture (F:3.3) and another -- to use a 40-foot rotating Michelson stellar interferometer. They will get "for the first time accurate values of the masses and densities of the separate components of many double stars in various stages of development". Hale has recently taken up with Mr. George Eastman and Doctor Mees of the Eastman Laboratory some fundamental photographic questions. Recent discoveries indicate that the speed of the plates can be increased without decrease in the size of the grain. We have received a budget (totaling $6,000,000) of estimated expenditures, and expect shortly to receive a budget

of expenditures for the next six months. I hope we can bring this matter up to our Executive Committee very soon. I have submitted to Mr. Debevoise a copy of my first draft.

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

With kind regards, I am

Yours very truly,

H. J. THORKELSON

Doctor Wickliffe Rose
c/o International Education Board
20 Rue de la Baume
Paris, France

HJT MVK

1032

August 29, 1928

My dear Mr. Debevoise;

Thank you very much for your letter of August 28, regarding the California telescope. Doctor Hale is preparing and will soon send us a budget of expenditures for the next six months. His latest letter indicates very considerable progress in settling questions of fundamental importance which will expedite the work of the various committees.

Very truly yours,

H. J. T.

Mr. Thomas M. Debevoise
26 Broadway
New York City

HJT MVK

Lakanuk Club

1032

26 Broadway
New York



HJT 8-29-28

August 28, 1928

Dear Mr Thorkelson

The draft enclosed with your letter of the 22nd of the item on the California Telescope project reads very well and tells a very complete story. You speak of the resolutions as indicating certain conditions. This I suppose means that at the time the resolutions were passed there was some doubt as to the statements contained in the preambles but in form those statements indicate no uncertainty.

Will not the paragraph on page 3 under the title "Actions of Institute Trustees" be complete if it ends with the words "which, in brief."? And is the wording of paragraph (3) at the top of page 4 complete?

The organization set up to handle

the work should be very effective if the Observatory Council is on its job as there is every reason to believe it will be.

I hope you have stood this hard summer well and have had a happy vacation

Sincerely yours
Thomas Nelson Elsom

I shall be expecting to hear from Mr Burley as to the form of resolutions
Yours.

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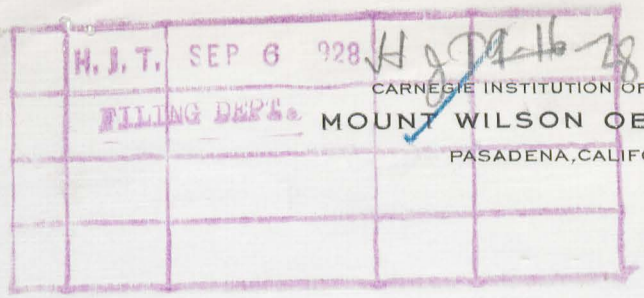


CARNEGIE INSTITUTION OF WASHINGTON
MOUNT WILSON OBSERVATORY
PASADENA, CALIFORNIA

August 29, 1928

Mr. H. J. Thorkelson
Treasurer, International Education Board
61 Broadway, New York City.

My dear Mr. Thorkelson:

In accordance with your request a carefully prepared budget, including expenses to date and estimates for a future period of six months, is submitted herewith by the Observatory Council of the California Institute. The work has advanced more rapidly than we anticipated, resulting in a reduction in some of our estimated expenditures and an earlier need for others. This progress has been due to the following reasons:

(1) The immediate assurance of help in providing an endowment fund by one of our trustees, and the prompt and unanimous ratification of the terms of the formal request to the International Education Board by the Board of the California Institute.

(2) The advance by the Institute of the sum of $25,000., permitting work to be undertaken at once, in harmony with the suggestion made by yourself and Dr. Rose.

(3) The cordial and complete cooperation of the Carnegie Institution of Washington, including President Merriam and the Executive Committee; Director Adams, Dr. Anderson, Dr. Pease, and the rest of the staff of the Mount Wilson Observatory; and Dr. Day and Dr. Wright of the Geophysical Laboratory.

(4) The unanimous agreement of the Observatory Council, its advisory Committee, and all their associates and advisers, as to the desirability

of making the large mirror disk of fused quartz, in accordance with a plan of procedure worked out with Dr. Elihu Thomson and his associates in the spring.

(5) The immediate and cordial agreement of the General Electric Company to permit this work to be done under Dr. Thomson's personal direction at "manufacturing cost without any overhead for commercial or administrative expenses", and its prompt beginning at the Thomson Research Laboratory at West Lynn in July.

(6) The progress of this work, which has been much more rapid than was considered possible last spring, as indicated by their present hope to complete a 60-inch disk and begin on a 100-inch disk before next May.

(7) The fact that all the members of our committee on the disk have come to Pasadena without cost to us, thus saving time and expense.

(8) The fact that Dr. Frank E. Ross of the Yerkes Observatory was willing to come here at once, thus enabling us to settle the general optical design of the telescope in harmony with the hopes of our entire group and to secure his services during the coming year in working out mathematically the details of the design.

(9) The aid of Messrs. Michelson and Aitken in connection with the proposed 40-foot stellar interferometer, now shown definitely to be of the first importance as the largest and heaviest attachment of the telescope and fixing the necessary character of the telescope tube and other features of the design.

(10) The discovery, through comparative astronomical observations by Dr. Anderson's new method of precision, of an easily accessible site decidedly superior to Mount Wilson, and the possibility that a still better site may be found as the result of the tests now in progress.

(11) The fact that by cabling members of the Mount Wilson staff who were attending the meeting of the International Astronomical Union in Leyden, we have been able to secure quickly and at small expense a large amount of special information needed from observatories, laboratories, and opticians in Europe.

In consequence of these and other considerations, we are in a position to proceed at once with various features of the work which might have been expected to come later, and our estimates have been prepared accordingly.

In certain respects the most vital feature of the whole undertaking is the study of auxiliary apparatus and methods. If pushed forward in harmony with the procedure approved by yourself and Dr. Rose, and by all of our group, this plan will quickly yield results serving not only to increase greatly the power of the 200-inch telescope, but also to find immediate application at the Mount Wilson and other observatories and in the Norman Bridge and other laboratories.

Pardon me for continuing this letter by hand. Its completion was delayed in anticipation of Dr. St. John's return from abroad and my secretary is away over Labor Day.

As I have wired you, Dr. St. John's report, after many conferences with astronomers, physicists, and instrument makers in various parts of Europe (following my cabled request) has placed our project in a new and most promising light. The willingness of so experienced a firm as that of Carl Zeiss in Jena, and of Sir Charles Parsons, grandson of Lord Rosse and well-known for his turbines, who bought out the long-established optical firm of Sir Howard Grubb some years ago and has since produced the largest optical work in England, to undertake the manufacture and figuring of a 200 inch telescope mirror, seems to remove all possible doubts of ultimate success. We may thus proceed with a feeling of certainty that is greatly strengthened by our detailed report from Dr. Elihu Thomson, which will be copied and sent you to-morrow. He now expects to have completed a 60 inch disk and be well on his way with a 100 inch disk

by next May, far in advance of his estimates of last spring. As for the possibility of transportation from Europe, neither Zeiss nor Parsons see any difficulty. The latter has shipped a turbine weighing 67 tons to Chicago from the Tyne, its greatest dimension being 17½ ft. He has also sent over a larger machine weighing 80 tons.

As stated in my last letter, our first need is a good instrument-shop, about the size of that of the Mount Wilson Observatory, in which the construction of the equipment of the Astrophysical Laboratory on the Institute campus, and the experimental work required in the development of auxiliary apparatus, may be undertaken as soon as possible. Some small work is being done for us in the Mount Wilson shop, but their own needs, which will continue as long as the Observatory staff and the Research Associates continue to show the originality and ingenuity that have been the making of the Observatory, will prevent them from dealing with our larger jobs. It is planned to train our opticians in the Mount Wilson optical shop and to transfer them to our own optical shop when ready.

Our estimate for the shop will provide for a one story reinforced concrete building, of the best modern design, with pictures for heating, ventilating, lighting, and plumbing, and connections to the nearest outlets from the Institute power plant. We should be in a position to order the machine tools and other equipment within the next few months, at a cost of approximately $50,000. This is about the same as at the Mount Wilson shop, but a closer estimate will be sent later. The vital part played by the Mount Wilson shop in the development of the Observatory is partly indicated in "Ten Years Work of a Mountain Observatory", a copy of which will be sent under separate cover.

I think the enclosed estimates will explain themselves. There is no item for photography, as Mr. Eastman wishes to bear all the expense of the various researches that may greatly increase the photographic efficiency of the 200 inch telescope. We are endeavoring in every case to keep down costs, as illustrated by Mr. Swope's telegram quoted in my last letter. For this reason our estimates sent with the formal request may require considerable changes. It was

necessary to allow for the purchase of a large mountain site and for the construction of expensive roads. But if we should decide on Mount Palomar, the most promising site in view, we shall have the benefit of a splendid road far superior to that on Mount Wilson, while land can be purchased at moderate cost. In this and all other cases, however, our purpose is to spare no effort in getting the best possible results, at as low a cost as may prove feasible.

An early need will be the Astrophysical Laboratory, which will be designed to supplement the Norman Bridge Laboratory and the Observatory Laboratory on Santa Barbara St. A strong committee is at work on its design and estimates will be submitted later.

Kindly wire me regarding the action of the Executive Committee. If favorable, I plan to set a release date one week later and to give a carefully prepared statement to the press, as false rumors are afloat regarding a large new refracting telescope for Mount Wilson. It is not our plan to name the amount of money appropriated.

Very sincerely yours

George E. Hale

Astrophysical Observatory of the California Institute of Technology.

Estimated Expenditures to March 1, 1929 (including those to date).

| | | |
|---|---|---|
| (1) | Dr. Elihu Thomson's work on quartz mirror disks | $75,000. |
| (2) | Optical and mechanical design of 200 inch telescope, including some optical work and experiments | 15,000. |
| (3) | Investigation of sites | 5,000. |
| (4) | Purchase and development of auxiliary instruments | 20,000. |
| (5) | Instrument shop on California Institute campus | 50,000. |
| (6) | Expenses of committees (other than that on site) | 7,000. |
| (7) | Salaries not included above (Anderson, stenographer, computer) | 7,000. |
| | Total | $179,000. |

An item for contingencies would be desirable. 36000

$215,000

George E. Hale

Sept. 3, 1928.

Mr. Thorkelson - This may be of some interest to you. G.S.H.

What new knowledge of the heavens may be expected from a great telescope, more powerful than any now existing?

Advances at the Mount Wilson Observatory of the Carnegie Institution of Washington which followed the construction of its powerful instruments suggest an answer. Some of the outstanding results obtained at Mount Wilson are:

1. Precise determination of the rotation period of the sun (which does not rotate as a solid body) at different distances from the sun's equator and at different levels in the solar atmosphere.

2. Discovery that sun-spots are associated with great whirling vortices in the upper atmosphere of the sun.

3. That sun-spots are centers of powerful magnetic fields, with north poles prevailing in one hemisphere and south poles in the other — the first evidence of magnetism outside the earth — and that the poles reverse at intervals of 11 years, at the beginning of each new cycle of spots.

4. That the sun, like the earth, is a huge magnet with its north and south poles near the poles of its axis of rotation.

5. Identification in the sun of six elements not previously known to occur there, and the discovery of chemical compounds in sun-spots.

6. Measurement of the ultra-violet radiation of the sun over a period of several years, showing that the sun is a variable star, with the largest changes affecting its ultra-violet light.

7. Detailed study in the physical laboratory of the effect of a magnetic field on the spectral lines of different chemical elements (the Zeeman effect) as a means of measuring the strength of the magnetic fields of sun-spots and of the sun's general magnetic field.

8. Laboratory study of the way in which different lines appear in the spectrum of a chemical element as the temperature of the source of light is increased. These data permit the conclusion that sun-spots are regions of relatively low temperature and are of the greatest importance in studying the temperatures of stars; they are also of fundamental importance in learning how the atoms of different elements produce their characteristic spectra.

9. Analysis of the distribution and intensity of the spectral lines of certain elements on the basis of modern atomic theory — the beginnings of a rational theory of spectrum analysis, which already has explained many long-standing puzzles in the spectra of the sun and the stars and thrown much light on the physical characteristics of stars.

(This paragraph needs slight revision)

10. Measurement of the velocities in the line of sight - toward or away from the earth - of approximately 3500 stars, results which have been made the basis for a detailed study of the systematic motions of stars.

11. Discovery of the asymmetry of stellar motions -- that the stars having the highest velocities all move in the same general direction, and, in general, that the motions of stars are not wholly random, but highly systematic, each different class of stars having its own regularities.

12. Accurate measurement of the distance of 250 of the nearer stars, among them several small, faint stars of exceptional importance in determining how the stars are scattered throughout space. Aside from the value of the results for individual stars, these measures are of great importance in perfecting the method of determining the distance of a star from its spectrum.

13. Discovery of the method of spectroscopic parallaxes and determination of the distances of 4000 stars from their spectra. The relative intensity of certain lines in the spectrum tells the intrinsic brightness of the star - its candle power. This, combined with the brightness as seen by the eye, gives the distance. Measures of distance are fundamental for a study of the structure of the stellar system.

14. Confirmation of the giant and dwarf theory of stars - that most classes of stars comprise two groups differing enormously in size and intrinsic brightness.

15. Direct measurement with the interferometer of the diameters of seven giant stars, thus confirming theoretical values found in other ways. The diameter of Antares is nearly 500 times that of the sun. At the other extreme are the dwarfs, some of them having diameters of only a few thousand miles.

16. Proof that the densities of giant stars are astonishingly low, in some cases only a thousandth of the density of air at the earth's surface. The companion of Sirius, on the other hand, with a diameter of about 20,000 miles, has a density of the order of 50,000 times that of water.

17. Perfection of the vacuum thermocouple and measurement of the total radiation of more than a hundred stars.

18. Determination of the temperatures of stars from (a) measures of their colors, (b) comparison of measures of total radiation with radiation in special regions of the spectrum, (c) measures with the radiometer at different points in the spectrum, (d) theoretical relations connecting the temperatures of stars with the intensities of the lines in their spectra.

19. Development of the method of wire explosions, produced by passing a large amount of electrical energy through a fine wire of iron or other suitable metal. The temperatures accompanying the explosion -

about 20,000°C - are the highest ever produced in the laboratory and comparable with those of the hottest stars. The spectrum of the explosion aids in the interpretation of the spectra of stars.

20. Determination of the scale of stellar brightness now adopted as the international standard and measurement of the brightness of about 70,000 faint stars, thus affording an improved determination of the number of stars and their distribution over the sky.

21. Extended study of the structure of the stellar system which strengthens the idea of similarity between our own system and some of the great spiral nebulae.

22. Development of the method for determining the distance of a Cepheid variable star from the interval required for it to complete its variations in light, and derivation of the distances of all known Cepheids and of all globular clusters of stars, thus greatly extending our ideas as to the size of the stellar system.

23. Intensive observation, classification, and study of the nebulae, leading to the conclusion that the diffuse nebulae, like that in Orion, are clouds of dust and gas in our own system shining either with reflected light or with a luminescence stimulated by the radiation of neighboring stars of very high temperature; the spiral and elliptical nebulae, on the other hand, are outside our stellar system, scattered more or less uniformly throughout space, and are to be counted in millions.

24. Discovery in the larger spiral nebulae of new stars, Cepheid variables, diffuse nebulosity, and ordinary giant stars of different spectral types, thus showing that some of the spirals at least are gigantic systems, similar to our own stellar system, situated at distances of the order of a million light years. This points to still greater distances for the smaller spirals and again revolutionizes our ideas as to the extent of the visible universe.

25. Close quantitative verification of the displacement of the lines in the spectrum of a star required by Einstein's theory of relativity, both by observations on the sun and on the companion of Sirius.

26. Repetition of the famous Michelson-Morley experiment with a precision hitherto unattained; the confirmation of the negative result found in the original trials strengthens the foundations of the theory of relativity.

27. Redetermination of the velocity of light by Professor Michelson with greatly increased precision by measurements over a path of 45 miles, longer than any hitherto used.

(Original in GEB files - Ga 12)

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COPY

August 29, 1928

Dear Mr. Arnett:

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Since writing you about the telescope, I have heard from Mr. Hale and apparently things are going much more rapidly than his earlier letters indicated. He is preparing now an estimate of expenditures for the next six months, and I hope we can incorporate this in the item to be presented to the Executive Committee of the International Education Board. Mr. Debevoise has read my first draft and when Brierley returns he will work with him on the form of resolutions.

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With kind regards, I am

Very truly yours,

H. J. THORKELSON

Mr. Trevor Arnett
Grand Beach
Berrien County
Michigan

HJT MVK