MINUTES OF REGULAR MEETING OF

THE INSTITUTE FOR ADVANCED STUDY

October 14, 1941

A regular meeting of the Trustees of the Institute for Advanced Study was held at the Uptown Club, 60 East 42nd Street, New York City, on Tuesday, October 14, 1941.

Present: Messrs. Aydelotte, Edgar S. Bamberger, Louis Bamberger, Flexner, Leidesdorf, Maass, Riefler, Veblen, and Weed.

Absent and excused: Messrs. Carrel, Douglas, Hardin, Rosenwald, Schaap, and Mrs. Fuld.

Mr. Maass presided, expressing his sorrow that he should have been brought to the chair on this occasion by the death of the Chairman, Mr. Houghton.

The minutes of the meeting held May 19, 1941, having been distributed, their reading was dispensed with and they were approved.

In the absence of Mr. Hardin, Chairman of the Finance Committee, Mr. Leidesdorf reported on the financial situation of the Institute. After distributing to the Trustees copies of a detailed report, including a balance sheet as of June 30, 1941, statement of income and expense for the year ended June 30, 1941, and estimated budget for the year ending June 30, 1942, he pointed out that the investments of the Institute, despite some losses on railroad stocks, still have a market value of $7,211,353.87, and that the return on this endowment was satisfactory, having been $332,220.00 for the past year. He expressed the opinion that the Finance Committee had rendered highly creditable service to the Institute, which he, as Treasurer, was happy to acknowledge.

Dr. Aydelotte called attention to Exhibit B of the financial statement, which he said gave the best summary account of income and expense for the year. This exhibit, he pointed out, does not show the excess in certain designated funds, such as the Rockefeller-Bamberger fund for economics, which has a reserve of more than $30,000, and which, if carefully used, may be expected to last five years rather than three years, as originally intended. Leaving out such designated funds, the operation of the budget shows an excess of $7,651.86, which was turned into a deficit of $2,348.14 only by the setting aside of $10,000 for professors' retirement. Despite that provision, the Institute would have today a slight excess of income over expenses if it had not been for the item of net loss of $3,470 on the schedule of rental properties.

Mr. Maass, Chairman of the Committee on Buildings and Grounds, reported that the committee has under consideration the matter of finding some means of relieving the congestion in Fuld Hall, but has as yet no definite report to make.

Mr. Maass, Chairman of the Executive Committee, stated that this committee had held no formal meeting. It had waived notice of meeting and signed a document authorizing the Institute to receive a certain sum from a fund which Mr. Bamberger had established in the name of Jonas D. Bamberger. Mr. Maass moved that the Board ratify the action of the Executive Committee, and, on motion, the resolutions were adopted and ordered to be placed on file, together with an expression of appreciation to Mr. Bamberger for the addition to the funds of the Institute.

The report of the Director was presented, and, on motion, was accepted and ordered to be incorporated in the minutes of the meeting. The report, which appears as an appendix to these minutes, describes the work

of the School of Mathematics. Before beginning his formal report on the School of Mathematics, Dr. Aydelotte commented briefly on the opening of the new academic year. The size of the Institute, he said, is approximately the same as usual, though it seems larger because of the fact that the facilities for work in Fuld Hall are so much better that all members who can do so are eager to work there. Dr. Aydelotte stated that he and Mrs. Aydelotte had already entertained all the members of the Institute at their home and were much impressed with the quality of the group this year.

Dr. Aydelotte said that almost every national fund which grants fellowships for research is represented at the Institute. There are seven Guggenheim Fellows, two National Research Council Fellows, two Fellows of the Rockefeller Foundation in addition to Pauli who is supported by them, one Rosenwald Fellow, one Sheldon Fellow, one Rackham Fellow, two people supported by the Carnegie Corporation, and two others supported by private funds, making a total of nineteen people who are supported at the Institute on grants from outside.

The Institute is taking its part in national defense. The share taken by the mathematicians in this work is noticed in the Director's Report. Members of the School of Humanistic Studies have taken a vigorous part in Greek Relief, in the Committee to Defend America by Aiding the Allies, and in the Fight for Freedom Committee. In addition the Director made certain observations concerning the work of the School of Economics and Politics. The Congress has recently passed a law limiting instalment buying for the duration of the war emergency as a means of preventing inflation. This Bill could not possibly have been as good a Bill as it is had it not been for a series of publications on Consumer Credit issued

by the National Bureau under Mr. Riefler's supervision and guidance. The members of the Research Department of the Federal Reserve Bank who drafted the Bill made constant use of these publications. It will not often happen that the results of research will pass so quickly into public service.

In connection with the work in economic history, Professor Stewart has set one of the members of the Institute, Mr. Jonathan Mitchell, at work on Ambassador Houghton's diary. Mr. Houghton was Ambassador in Berlin when the reparations problem became acute. What he has to say about the problem as seen from Berlin is extraordinarily important. Professor Stewart thinks the diary will be a source book for historians dealing with this period. The Director stated that he had read about one hundred pages of it and had found it fascinating. He was struck with an entry about 1923, in which Mr. Houghton says, talking about conditions in Germany, that if these conditions continue, if the Allies do not modify their restrictions, he feels a dictatorship in Germany will be inevitable.

The Director also mentioned the widespread interest excited by Professor Earle's work on military policy. Professor Earle has drawn up a memorandum describing the work done in his seminar, copies of which were distributed at the meeting.

Dr. Aydelotte stated that he had requested Dr. Flexner to prepare resolutions concerning Mr. Houghton and Dr. Friedenwald, who had passed away since the last meeting of the Board, and he would ask the Secretary to read them. The following resolution concerning Mr. Houghton was read by the Secretary, Mr. Edgar Bamberger, and was unanimously adopted:

The Trustees of the Institute for Advanced Study have heard with deep sorrow of the sudden passing away of their beloved Chairman, Mr. Alanson B. Houghton. Mr. Houghton was among the very first to whom the plan of the Institute was communicated, and he perceived at once its significance and importance. A graduate of Harvard and of the Universities of Göttingen and Paris, who after distinguished service in Congress, had been a wise and far-seeing Ambassador to Germany and to Great Britain, Mr. Houghton knew, as few others knew, the great weight of responsibility for the extension of learning that henceforth rested upon American scientists and scholars. He approved the broad and sympathetic spirit which animated Mr. Bamberger and Mrs. Fuld, the Founders of the Institute, and he never wavered in support of the high standards to which from the very beginning the Institute was permanently and irrevocably committed.

As Chairman of the Board, he was a model of fairness and conscientiousness, and as the years passed by, the Founders and members of the Board developed for him deep feelings of admiration and friendship. He clothed the office with rare dignity. No one who participated in the dedication of Fuld Hall, at which he presided, will ever forget his noble bearing upon that occasion, memorable as it is in the history of higher education in this country. He knew no distinctions of race or religion but had his eye fixed, as did the Founders, upon the achievement of the ends for which the institution was created and in making its opportunities available to gifted men and women whatever their race, creed, or country.

The Trustees and Founders of the Institute extend to Mrs. Houghton and to her children their profound sympathy, and they order that these resolutions shall be communicated in full by the Director to Mrs. Houghton and her family and that they shall be spread upon the minutes of the meeting.

The following resolution concerning Dr. Friedenwald was read by the Secretary and was unanimously adopted:

Dr. Julius Friedenwald was a Trustee of the Institute for Advanced Study from its founding until the day of his death. Closely related by blood to the Founders of the Institute, whose confidence and admiration he had enjoyed all his life, he was also a college-mate of the first Director of the Institute and a warm personal and professional friend from 1884 until his death in the present year.

Dr. Friedenwald stood high in the ranks of the medical profession, and he was probably the outstanding American medical authority in the realm of gastro-intestinal diseases, to which his researches and investigations have made valuable contributions, now practically observed throughout the civilized world. He understood the purpose of the Institute, namely, to carry on research and to train promising investigators from whom important research could be reasonably expected. He was active in the conduct of the Institute through his frequent conferences in private with the Director, who consulted him freely upon many important points of policy. His judgment was sound, his character of the very highest; indeed, in goodness of heart, gentleness, and all the qualities which go to make up the perfect man as well as the superb physician he had in this country no superior.

The Trustees of the Institute extend their profound sympathy to Mrs. Friedenwald and wish to record their high appreciation of the character, intelligence, and goodness of her lamented husband.

Dr. Aydelotte said it was necessary at this time of year to give assurance to the School of Mathematics and the School of Humanistic Studies of a minimum sum for stipends for the following year, in order that selection of members might be begun. He asked Dr. Weed if he, as Chairman of the Budget Committee, would be willing to move that the School of Mathematics be assured of $15,000 and the School of Humanistic Studies of $10,000 for their budgets for the next academic year. Dr. Weed, after inquiring whether these sums were the same as were voted last year and receiving an affirmative reply, moved that the School of Mathematics be assured the sum of $15,000 and the School of Humanistic Studies the sum of $10,000. The motion was seconded and unanimously carried.

There being no further business, the meeting was adjourned.

(Signed) Edgar S. Bamberger,

Secretary

APPENDIX

REPORT OF THE DIRECTOR

October 14, 1941

The School of Mathematics is our oldest department. It began in 1932, while the Schools of Economics and Humanistic Studies were not organized until 1935. Dr. Flexner has explained to the Board his reasons for beginning with this subject and I need not repeat those arguments but wish only to say that they seem to me entirely sound. Since it has been longest in operation, the School of Mathematics illustrates most convincingly the possibilities of the Institute. In the nearly ten years of its work the Institute has admitted more than two hundred and fifty members in this subject and their testimony as to the value to them of their experience, some of which I have myself gathered at first hand, is most satisfactory evidence of the soundness of the plan on which the Institute is based.

The subject is of first-rate importance both in scholarship and in education. Its primary value is as an intellectual discipline and an element in a liberal education. It is, in addition, an indispensable tool for research in all the natural sciences and in the social sciences as well. Mathematics forms an important part of the curriculum of all college and secondary schools. It has been estimated by Professor Birkhoff that American educational institutions spend $6,000,000 per year in the teaching of mathematics alone. As he pointed out to me, anything which we can do to improve teaching and scholarship in so important a subject will more than justify the modest budget of our School.

Dr. Flexner has in previous reports frequently indicated the extent to which he depended upon Professor Veblen's advice in the organization of the School and the selection of professors. I learned accidentally from President Karl Compton of the Massachusetts Institute of Technology that the idea of a research institute of mathematics on a more modest scale had been in Professor Veblen's mind before the Institute for Advanced Study was thought of. The foundation of the Institute and his own appointment to the staff gave Veblen the opportunity to collaborate in carrying out his original idea upon a more generous and adequate scale. The strength of the mathematics faculty of Princeton University offered an additional reason for beginning with this subject in this place. It offered grounds for hope that the two institutions working together might build a mathematical center of world-wide importance.

I think we may say without fear of contradiction that this hope has been realized and that we have in Princeton, including the staff at Princeton University and the Institute for Advanced Study, plus the continual succession of temporary members of the type of

Fubini, Gödel, Siegel, and Pauli, the strongest and most widely interested group of mathematicians existing anywhere at this moment. The only other mathematical center of comparable strength in the United States is Cambridge, Massachusetts, taking Harvard and the Massachusetts Institute of Technology together. The other important centers for mathematical studies in the United States are Chicago, Johns Hopkins, Michigan, and Columbia, no one of which, however, is equal in strength and variety to the groups in Cambridge and Princeton. It is in the public interest and it is best for us that these centers and others like them be built up and strengthened as much as possible, particularly in view of the effect of the present war in destroying work of many of the best European centers for mathematical study.

The great European schools of mathematics of this generation were in Cambridge, Göttingen, Rome, Paris, Moscow, and Warsaw. Of these Göttingen, Rome, Paris, and Warsaw have been completely broken up, while the energies of scholars in Cambridge and Moscow have been absorbed by the war and may be crippled by poverty and confusion for years after the war is ended. During the last decade there has been a most promising development of mathematical studies in Japan, but it is too early as yet to judge either its quality or its permanence.

I have sought opinions as to the importance of our group at Princeton in comparison with these justly famous European centers as they were in their prime. Scholars agree that Princeton compares favorably with any of them at their best in pure mathematics but that other centers were probably better integrated in the direction of applications of mathematics to physics and to other subjects. If and when means are available it will be for the Trustees and Faculty to decide whether a broadening of our mathematics school in this respect is possible or desirable. Scholars are discovering every day new applications of mathematics to other fields of knowledge, and the value of these applications is great not merely to the subject considered but also because of the stimulus which they offer to the development of new branches of mathematical science.

I have from my own experience interesting confirmation of the prestige of the mathematical group at Princeton. For a year or two nearly all the best applicants for Guggenheim Fellowships for research in mathematics have been individuals who either have studied in Princeton or who wished to obtain Fellowships in order to do so. Some of the best American and Canadian Rhodes Scholar mathematicians have also found means to come to the Institute to continue their studies.

It is not easy for those of us whose interests lie in other fields than science to understand in detail the work of our School of Mathematics. Apart from being a highly technical and finely differen-

tiated science, mathematics is also a language, differing radically in grammar and syntax from any other language used by man. Mathematical language is valuable and, indeed, indispensable precisely because it cannot be translated into any other language. For this reason it is possible only to indicate in this report the nature of the work which is being done in Princeton and describe its general tendencies and the spirit and atmosphere in which it is undertaken. Nevertheless, in order to make the record complete I thought it necessary to request from the mathematics faculty summary statements of the work in which each man is at present interested. I reproduce those statements in the language in which they were given to me, for the information of members of the Board who may be able to understand them. If further explanations are called for I regret to say that I must myself decline to be cross-examined and must refer the inquiries to Professor Veblen.

During the last few years Alexander has been working on a presentation of topology from an algebraic-combinatorial point of view. The entire development of topology in the last decade seems to indicate that an important task of generalization and unification can and must be performed in this direction. Work is progressing and it is hoped that eventually a combinatory analogue will be developed to tensor theory which will be applicable to an arbitrary topological space. Certain recent developments in connectivity theory seem to indicate that the desired theory is just around the corner.

Einstein has for the last fifteen years worked on a unification of the theories of relativity and gravitation. This is to be achieved in the form of a general field theory as much as possible in the spirit of the existing general theory of relativity. It is hoped thereby to reach a new understanding of various phenomena which thus far have been described only on an entirely different basis. Outstanding among these is the problem of quanta and those of the electric nature of elementary particles. Many geometrical and field-theoretical avenues had to be explored and while the work is not completed the results obtained so far indicate interesting possibilities. In recent years the collaboration of his assistants, Drs. Bergmann and Bargmann, has proved valuable.

Morse has devoted the major part of the last ten years to the development of a "variational theory in the large." This theory originated for the most part with him, although built on the ancient subject of the calculus of variations. The principal difficulties and major objectives for the theory of simple integrals were developed at Harvard prior to his coming to Princeton and were published in his Colloquium Lectures before the American Mathematical Society. After coming to Princeton the theory was put on a somewhat more abstract basis preparatory to attempting the very difficult extension to multiple integrals. In the last few years this extension has been

achieved. The results obtained have recently been confirmed in part by others working independently or in collaboration with Morse. The general understanding of the scope of the theory was greatly enhanced by the publication of a book on the subject by two German authors shortly before the war. This book consists of expositions of the simpler parts of Morse's papers on the subject prior to 1937. Papers in press include three written jointly by Morse and Charles Tompkins of Princeton University.

Morse has also collaborated with Professor Hedlund of the University of Virginia in giving a proof of new conditions for topological transitivity and has been engaged in writing a joint paper with Professor George Ewing, who was a member of the Institute during the year 1940-1941.

During the last few years von Neumann's interest in mathematics proper has been mainly in the theory of functional operators and the theory of integration in groups. The former subject is closely connected with quantum mechanics, i. e., the form of atomic physics developed since 1926; it also has bearing on various disciplines in pure mathematics, in particular on group theory, algebra, and the theory of higher spaces. He has also worked on the logical and philosophical implications of the indeterministic point of view necessitated by modern quantum physics. Partly in collaboration with Garrett Birkhoff of Harvard, a system of logic based purely on probability and modifying some of the traditional postulates of logic has been developed. It is hoped that this system will be found to do fuller justice to the empirical situation which the new atomic theory has disclosed. In the course of the last year he has also taken up again and continued earlier work on various questions in mathematical economics, in particular in connection with the mathematical theory of production and of the "oligopoly" which is closely connected with the theory of games. Von Neumann and Morgenstern are at present engaged upon a book on mathematical economics, which promises to be stimulating to scholars in both subjects. I have had the privilege of reading some of the non-mathematical parts of this book and have been deeply impressed by the new fields of speculation which are opened up by it.

In his scientific work von Neumann has been closely collaborating with Professors Francis J. Murray of Columbia and Garrett Birkhoff of Harvard, and at Princeton with Drs. Ambrose and Halmos and Professor Kakutani of Osaka. He has been joined in his defense research work by Professor William W. Flexner of Cornell, who spent the past summer in Princeton.

Veblen has been working for several years on a book which will probably be called Spinors in Projective Geometry, in which an attempt will be made to do justice to the various branches of algebra

and geometry as well as theoretical physics, which combine to form this particular body of doctrine. He is collaborating with Dr. Givens and Professor Taub, who were his assistants at the time the work started. Professor Taub returned to the Institute for this year from the University of Washington at Seattle, where he has a permanent position, in order to make this collaboration more effective by personal contact. For the same purpose, both Taub and Givens (the latter until now at Cornell University but going to Northwestern) have worked with Veblen all summer. As a result, the book is now definitely organized and there is good reason to expect that it will appear in the near future. Several other men, including van Stockum (now in the Canadian Air Force) and deWet (now at Cape Town) have worked with Veblen's group on this subject, and particularly on its applications to theoretical physics. In accordance with the general policy of the Institute, all of these men are mature scientists rather than beginners. They came from widely separated parts of the world. Presumably this bringing together of such men to work on a common program for a while and then to depart to their several stations with renewed enthusiasm is about as much as the Institute can profitably attempt to do in mathematics.

Although Weyl cannot and should not be put down as an algebraist only, his major interest in the last years has been in that field, and he has made it a particular subject of his endeavor to see that the two important disciplines of algebra and group theory are adequately represented in the School of Mathematics. He has also attempted to break the ground for number theory, a branch of mathematics which does not seem to have met so far with as much interest in this country as it deserves. A book on The Classical Groups, Their Invariants and Representations, the first in the "Princeton Mathematical Series," for which he enjoyed the close cooperation of such gifted assistants as Richard Brauer and Alfred H. Clifford, and the opening volume of the "Annals of Mathematics Studies," on Algebraic Theory of Numbers, are fruits of his endeavors in this direction. During the present year the theory of reduction under arithmetical equivalence has received much attention because Siegel has just arrived at a wealth of new profound results concerning these problems. Gordon Pall, who came to the Institute as a Canadian Guggenheim Fellow, is writing a book on the subject, and some of Weyl's own latest research has been in this field.

Weyl considers an important part of his mathematical activities to be a seminar on current literature, which this year he continued jointly with Professor Chevalley of Princeton University. The idea is to have the members of the seminar report on recent papers of outstanding interest and thus to counteract the dangerous tendency toward too narrow specialization by covering in the same seminar all fields of mathematics. Next term Weyl hopes to be able to do something in the direction of applied mathematics, particularly in hydro- and aero-dynamics.

The building up of our new mathematical library has required much of Weyl's attention during the last year. He believes we can be justly proud of what has so far been accomplished under difficult circumstances. Much of the credit should go to Weyl's assistant, Alfred Brauer, who is an expert librarian in the field of mathematics and has given as much of his time and energy to this job as he could give without unduly neglecting his own research work.

Aside from their real work with the foundations of mathematics and mathematical physics, with the discovery and development of these principles which give to mathematics deeper harmony as an art and greater power as a science, the members of our School of Mathematics have been active in publications and in national defense. The Institute pays a subsidy each year to support the "Annals of Mathematics," of which Professor von Neumann is one of the editors. Professor Weyl is a member of the editorial board of "The American Journal of Mathematics." Professor Veblen was the leader of a group of scholars who have recently launched the new journal "Mathematics Reviews," which is already felt to supply a need not heretofore filled in giving prompt publication in condensed form to new discoveries. Under the title of the "Princeton Mathematical Series," the Institute joins with Princeton University in the publication of mathematical books of the highest order. Professor Morse is an editor. Morse has also aided in the launching of the newest mathematics venture, "Mathematical Surveys," supplementing other publications with short expository treatises. All the members of our School of Mathematics are on the editorial boards of various international mathematical journals.

Professor von Neumann is chief consultant on ballistics of the War Preparedness Committee of the American Mathematical Society and the Mathematical Association of America, member of the Scientific Advisory Board of the Ballistic Research Laboratory at Aberdeen Proving Ground, and member of one of the sections of the National Defense Research Committee, now part of the Office of Scientific Research and Development. Morse, as President of the American Mathematics Society, has led in the mobilization of American mathematicians for various kinds of expert scientific work for the Army, the Navy, and the defense industries.

The greatest need of the Institute in its relations to mathematics is an increase of funds for stipends to workers. The total amount available each year for this purpose is now considerably less than the amount available during the first years of the Institute. For the last half dozen years we have had at the Institute each year between fifty and sixty candidates for stipends in the School of Mathematics, while the number of stipends which it has been possible to grant has gradually decreased from something over twenty in 1935 and 1936 to about ten at the present time.

Of all the sciences Mathematics is nearest to the arts. I have frequently been assured by mathematicians that the pleasure they get from a fine demonstration is partly aesthetic and that the elaboration of a new chain of mathematical reasoning seems to those who create it to be partly artistic achievement, something like the writing of a poem. It is noteworthy that as between two proofs of a theorem mathematicians will prefer the one which, as they say, is more "elegant," a term which has primarily an aesthetic rather than a logical significance.

It is a striking fact that creative mathematicians think of their subject as an art as well as a science. Perhaps the best analogy is with architecture, which in its highest forms combines use and beauty. Both art and science on the highest level are projects of the creative imagination, and the likenesses between them become more significant than the differences. The curious connection between mathematical and musical ability has been observed since Greek times; it is found more frequently among higher orders of ability than among lower.

Science and art are two methods of apprehending reality which owe their distinctness to the limitations of the human mind, which is unable to grasp the whole significance of an object or event and at the same time see clearly all the details. Those minds which can transcend ordinary limitations can to a greater extent combine the two points of view. Many useful but humdrum scientific workers never rise to the creation of a significant scientific hypothesis, which is a feat of imagination analogous to artistic creation. It has been said that to the mind of God science and art would be one: He apprehends the broad significance of the universe and at the same time understands clearly all its details. It has furthermore been said that the Creator of the universe, whatever else he is, is also a mathematician. Unquestionably all scholars in all fields have their flashes of creative insight when they mold whole systems of knowledge and chains of reasoning into order and symmetry. But it seems as if the very abstractness of his conceptions and the rigor of his thinking give this power to the mathematician in an unusual degree and claim for his subject the position so frequently assigned to it, that of being the mother of the sciences.