Meetings and Societies

Physics of Semiconductor Surfaces

Semiconductor surfaces have been the subject of intensive research during the past 5 years because of their intrinsic interest and because they affect the performance of transistors and other semiconductor devices. Progress during recent years was reviewed, and new results were reported, at a Conference on the Physics of Semiconductor Surfaces that was sponsored jointly by the Office of Naval Research, the University of Pennsylvania, and the Lincoln Laboratory of Massachusetts Institute of Technology. The conference was held at the University of Pennsylvania in Philadelphia, 4–6 June 1956. The cochairmen, representing the aforementioned groups, were J. L. Jackson, P. H. Miller, and R. H. Kingston, respectively. Approximately 125 attended, including nine from overseas. While the majority of the participants were physicists, the chemists were well represented and took an active part in the conference. As P. B. Weisz stated in his introductory talk on the subject of adsorption and catalysis, the chemist's approach to surfaces has been mainly through studying the effect of metal and semiconductor surfaces on gas reactions, while the physicist's approach has emphasized the influence of gas ambients on the properties of the solid. It was generally agreed that the conference succeeded in enlightening each group about the other's point of view.

Detailed proceedings of the conference are being published by the University of Pennsylvania Press. This report is intended to be only a summary, but if it is read in connection with a recently published review article [R. H. Kingston, *J. Appl. Phys.* **27**, 101 (1956)] it should convey a reasonably up-to-date picture of the field.

The subject matter and chairmen of the sessions were as follows: "Clean surfaces," J. Bardeen (University of Illinois); "Real surfaces—fast states," H. K. Henisch (University of Reading, United Kingdom); "Real surfaces—slow states," A. F. Gibson (Radar Research Establishment, United Kingdom); "Adsorption and catalysis," P. Aigrain (Ecole Normale Superieure, France); and "Surface oxidation," W. H. Brattain (Bell Telephone Laboratories).

C. Herring (Bell Telephone Laboratories) opened the conference with a review of the theory of surface states. He classified them into states associated with an ideal crystal plane (Tamm and Shockley states) and states associated with isolated surface imperfections. He discussed the density, energy level, capture cross-section, donor or acceptor character, and excited levels of these states. This provided an excellent starting point because the main emphasis of the conference was on surface states.

Since the work of Tamm in 1932, it has been expected that the surface of an ideal crystal would have a high density (10^{15} per square centimeter) of surface states. However, it is difficult to prepare an ideal surface and to keep it clean while making measurements. Low-energy electron diffraction patterns of a germanium surface that is prepared by a high-temperature bakeout show an amorphous structure. In 1954, H. E. Farnsworth, R. E. Schlier, and R. M. Burger (Brown University) prepared germanium surfaces by bombarding with ions of argon and then annealing in high vacuum. These surfaces show a diffraction pattern with all the lines to be expected from a germanium surface. In addition, a set of ½-order lines are present which cannot be attributed to normal germanium sites. R. E. Schlier reported the most recent experimental work of the group and suggested that the extra lines are due to the displacement of germanium surface atoms. This displacement permits the atoms to saturate their bonds. An alternative explanation, offered from the floor, is that there is a half-monolayer of oxygen on the surface. Evidence for this is that a small amount of oxygen admitted to the system changes the diffraction pattern, but subsequent heating at 500°C restores the pattern to its original condition. It is argued that the binding energy of the first half-monolayer of oxygen is much too large for it to be driven off at 500°C; thus, a half-monolayer must have been present before the test oxygen was admitted.

P. Handler (University of Illinois) reviewed recent work at the University of Illinois, Brown University, Harvard University, and Lincoln Laboratory on the electric properties of germanium surfaces prepared by the ion-bombardment technique. From work-function, surface-conductance, field-effect, and photoconductance measurements, a strong case was argued that the states observed were Tamm-Shockley states. This conclusion, however, was not accepted unanimously by those at the conference. Perhaps the most serious objection was the afore-mentioned oxygen reversibility.

R. H. Kingston concluded the morning session with a short review of the important milestones in the study of semiconductor surfaces. (See his review, the aforecited article, for references and discussion.)

The model of a germanium surface which was the basis for the discussion of real surfaces is shown in Fig. 1. The case of a *p*-type surface on an *n*-type crystal has been shown. The space-charge region can be *n*- or *p*-type, depending on the gas ambient, temperature, etch, and so forth. If the space-charge region and crystal are of opposite type, the surface is said to have an inversion layer as shown in Fig. 1. If they are of the same type and the concentration in the space-charge region is greater than it is in the interior, the surface has an accumulation layer; if the carrier concentration on the surface is less than in the crystal, it is called a depletion layer. Conduction is assumed to take place in the space-charge region but not in the oxide layer.

Two general classes of states, interface and outer, are shown in Fig. 1. Electrons and holes make transitions into, and out of, the interface states in times of the order of microseconds to milliseconds, while the times involved for transitions to and from the outer states are of the order of seconds to minutes.

J. R. Schrieffer (University of Illinois) opened the first of the sessions on real surfaces by reviewing and presenting new results of his theory of mobility in the space-charge region. This theory predicts a reduction in mobility of carriers in surface channels due to scattering from the surface. The theory has been confirmed indirectly by field-effect and conductance measurements, but a direct measurement of the surface mobility has not yet been made.

A. Many, E. Harnik, and Y. Margoninski (Hebrew University, Israel) reported measurements of the surface recombination velocity, *s*, in germanium. This quantity is a meaure of the rate at which electrons and holes recombine at the surface, presumably through the interface states. Transverse electric fields were used to vary the height of the surface potential, and consequently *s*. The results indicate that, in some samples, the

Shockley-Read theory with one type of recombination state at the surface describes the data adequately. Other surfaces exhibit a more complex structure, involving two types of states. Analysis of the data shows that the surface states are acceptorlike in both n- and p-type material.

B. H. Schultz (Philips Research Laboratories, Netherlands) reported a theoretical study of storage of injected carriers in surface channels. He concluded that, in low resistivity materials ($\rho < 1$ ohm-cm), measurements of the relaxation time for recombination in thin rods are not suitable for the determination of the surface recombination velocity, unless one takes precautions against surface storage effects.

The field-effect measurement has proved to be useful in studying surface states. An electric field is applied capacitively to the surface, inducing a change in the density of carriers and a measurable change in conductance. A portion of the induced charge is rapidly immobilized in interface states, after which quasi-equilibrium exists for times of the order of seconds to minutes, when further charge is immobilized in the outer states.

P. C. Banbury, G. G. E. Low, and J. D. Nixon (University of Reading, United Kingdom) described field-effect experiments on accumulation-type surfaces of germanium in which the initial decay was studied. From analysis of the data, they find the cross-section for majority carrier capture in interface states to be 10^{-17} to 10^{-16} square centimeter in both n- and p-type material.

W. L. Brown, W. H. Brattain, C. G. B. Garrett, and H. C. Montgomery (Bell Telephone Laboratories) reported field-effect experiments on etched germanium surfaces at frequencies such that quasi-equilibrium with the fast states existed. From analysis of this and capacitance data, the density of interface states is found to be 10^{11} to 10^{12} per square centimeter, per volt near the middle of the band, and somewhat larger at 0.1 electron volt above and below the band center. From analysis of surface photovoltage and surface recombination-velocity measurements, they find the states are acceptors with capture cross-sections of 6×10^{-15} square centimeter and 4×10^{-17} square centimeter for holes and electrons, respectively.

Another important tool in the study of surfaces is the channel effect on transistors. A channel occurs, for example, when a p-type surface develops on the n region of a p-n-p transistor, resulting in an inversion layer as shown in Fig. 1. It is a deleterious result as far as transistor action is concerned because the conductance of the transistor is then mainly due to the surface channel. Such a system, however, provides a sensitive method of studying inversion layers. H. Statz, G. A. de Mars, L. Davis, Jr., and A. Adams, Jr. (Raytheon Manufacturing Company) reported such measurements on silicon and germanium. They find in silicon an interface density of 10^{12} states per square centimeter about 0.45 electron volt below the middle of the gap and another set of density 10^{11} to 10^{12} per square centimeter varying in position between 0.42 and 0.48 electron volt above the middle of the gap. Their results for germanium are similar to those reported by other contributors.

Charge transfer into, and out of, the slow outer states represented in Fig. 1 can be induced by electric fields (d-c field effect) and by light. Such experiments on germanium show that the time decay associated with slow states does not follow a simple exponential law. S. R. Morrison (Minneapolis-Honeywell Corporation) reviewed two methods of interpreting such data, a multiple time-constant system which would result from an inhomogeneous surface, and the Elovitch equation where the transition rates depend on the instantaneous surface potential. He concluded that a combination of the two models is needed to fit the data.

M. Lasser, C. Wysocki, and B. Bernstein (Philco Corporation) reported that the dependence of the slow time constant on the thickness of the oxide layer indicates that the slow states are on the outside of the layer. The time constant shortened appreciably when the dry air ambient was replaced by water vapor.

J. Zemel (Naval Ordnance Laboratory) reported that for lead sulfide films the slow field effect could be described by a single time constant of the order of 10 minutes.

Measurements of slow changes in the work function of gold, germanium, and silicon induced by light and electrostatic fields were reported by G. W. Pratt, Jr., and H. H. Kolm (Lincoln Laboratory). They concluded that the slow changes in work function resulted from charge transfer to and from oxygen traps on the outer surface, in agreement with conclusions reached from field-effect measurements.

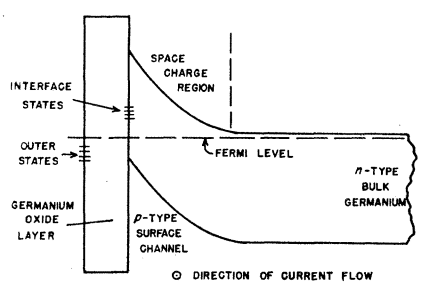

Fig. 1. Energy-level diagram of an inversion-layer-type semiconductor surface.

A. L. McWhorter (Lincoln Laboratory) reviewed theories of $1/f$ noise which consider fluctuations in the rate of charge transfer to and from the slow surface states to be the mechanism of the noise. He concluded that a combination of the multiple time-constant and the Elovitch equation was needed to fit the $1/f$ spectrum over the observed range. R. L. Petritz (Naval Ordnance Laboratory) expressed doubt that this model could explain the large magnitude of noise observed when current flows across oxide layers. He suggested that the $1/f$ noise was related to local barrier-breakdown phenomena.

R. L. Petritz, Frances L. Lummis, H. E. Sorrows and J. F. Woods (Naval Ordnance Laboratory—Woods is now at International Business Machines Corporation, and Sorrows is with the Office of Naval Research) reported surface studies on lead sulfide photoconductive films which indicate that the general model developed for germanium is also applicable to lead sulfide.

W. W. Scanlon (Naval Ordnance Laboratory) presented a new approach to the clean-surface problem. He cleaves lead sulfide crystals in an atmosphere of argon. The cleanness of the surfaces was the subject of considerable discussion.

The session on "Adsorption and catalysis" consisted of an introductory talk by P. B. Weisz (Socony-Mobil Research Laboratory) and papers by K. Hauffe (Farbwerke Höchst, Germany) and G. M. Schwab (Physikalisch-Chemisches Institut, Germany). The idea that semiconducting properties and catalytic properties are correlated presupposes that catalysis has something to do with the electronic state of the solid. Up to 10 years ago such a connection had not been firmly established. While it was clear that some sort of chemisorption had to occur as a preparatory step to catalysis, only conjectures had been made about the nature of the molecule-catalyst bond. Today it is known that in an ample number of reactions the catalytic activation consists of a transfer of electrons from the molecule to the catalyst, or vice versa. Reactions may be divided into two groups: donor reactions in which electrons are transferred to the catalyst and acceptor reactions where the electron transfer is from the catalyst to the molecule. Thus, the task of connecting semiconductor properties to catalytic action reduces to a study of how and to what degree donor reactions are catalyzed by p-type semiconductors, and acceptor reactions by n-type semiconductors. The afore-mentioned speakers presented impressive experimental and theoretical evidence that such a connection does exist.

In the final session, "Surface oxidation," N. Cabrera (University of Vir-

ginia) discussed the basic ideas of the theory of oxidation of metals. He considered first the formation of oxide nuclei, in which case nucleation controls the beginning of the oxidation, and, second, the formation of thin uniform films of oxide everywhere on the metal surface, in which case the controlling factor is the activation energy for diffusion. He emphasized the possible connection of the nucleation process with dislocations.

M. Green (now at the Zenith Corporation), J. Kafalas, and P. H. Robinson (Lincoln Laboratory) reviewed their study of the oxidation of freshly cleaved germanium surfaces. The experiment was to crush a germanium crystal in a small closed system. They find that the extent of oxidation is small, equivalent to about two layers of germanium dioxide. The oxidation is not sensitive to changes in the bulk properties of the germanium [*n* or *p*-type, high (+90°C) or low (−65°C) temperatures], indicating that the bands must be clamped at the surface as would be expected from Tamm states.

J. T. Law and P. S. Meigs (Bell Telephone Laboratories) reported measurements of the oxidation rates of the (110), (111), and (100) etched faces of single germanium crystals. The etched surfaces are initially covered with at least a monolayer of oxygen; thus, no direct comparison of the results of these investigators with those of Green can be made. The rate was measured from 500°C to 700°C as a function of oxygen pressure. From analysis of this and of other workers' data Law and Meigs summarized the present knowledge of the oxidation process as follows: at and above 550°C, the oxidation process is controlled by the diffusion of germanium monoxide away from the surface, and no effect of crystalline orientation is found; between room temperature and 550°C, few data are available, but it is probable that the (110) plane oxidizes more readily than either the (100) or the (111).

At this point, Brattain, the chairman of the session, allowed a half hour for further discussion of the question of clean surfaces. After much discussion had made it clear that a scientific settlement could not be reached, Bardeen suggested that the question be settled by the democratic process—namely, by majority vote!

The conference was concluded with a stimulating summary by J. Bardeen. He was particularly encouraged at the progress being made in determining the cross-sections and distribution in energy of the interface states. He concluded by stating that while the general characteristics of semiconductor surfaces are well established, much remains to be done in further clarifying the nature of the surface states—particularly as to what the states are and how to control them.

The University of Pennsylvania is to be thanked for its hospitality and congratulated on the excellence of the arrangements, which included a memorable banquet.

RICHARD L. PETRITZ
U.S. Naval Ordnance Laboratory, White Oak, Maryland

Meeting Notes

■ A steering committee of some 50 scientists, representing various aspects of biophysical research in this country, has organized a national biophysics conference to take place in Columbus, Ohio, 4–6 Mar. 1957. The conference will encompass studies which employ the approach of physics in biological measurement and theory, at levels of organization from molecules and cells to complex systems and psychophysics.

The program is expected to include 12 invited papers related to different biophysical fields and a large number of contributed papers. Scientists with biophysical interests may write for information on presenting contributed papers to Dr. Herman P. Schwan, School of Medicine, University of Pennsylvania, Philadelphia 4, Pa.

■ Offices of the International Atomic Exposition have been moved from Detroit, Mich., to 304 Architects Building, 117 S. 17 Street, Philadelphia 3, Pa. The next exposition will take place 11–15 Mar. 1957 in Philadelphia's Convention Hall as part of the United States Nuclear Congress, which is being sponsored by the major engineering and scientific societies.

Society Elections

■ American Microscopical Society: pres., R. P. Hall, New York University; 1st v. pres., W. T. Edmondson, University of Washington; 2nd v. pres., F. Frouet, Chicago Museum of Natural History; sec.-editor, G. W. Prescott, Michigan State University; treas., L. O. Nolf, Iowa State University.

■ Xi Sigma Pi (forestry), 1956–58: forester, L. W. R. Jackson, University of Georgia; associate forester, B. F. Grant, University of Georgia; sec.-fiscal agent, J. R. Parker, University of Georgia.

■ Society of General Physiologists: pres., Daniel Mazia, University of California, Berkeley; sec., Abraham M. Shanes, National Institutes of Health, Bethesda, Md.; treas., Irving M. Klotz, Northwestern University. Representatives to the AAAS Council are Rudolf T. Kempton and David R. Goddard.

■ American Society of Human Genetics: pres., Curt Stern, University of California; pres.-elect, William C. Boyd, Boston University; v. pres., Philip Levine, Ortho Research Foundation; sec., Eldon J. Gardner, Utah State Agricultural College; treas., Walter E. Heston, National Cancer Institute.

■ Phycological Society of America: pres., G. F. Papenfuss, University of California, Berkeley; v. pres., L. A. Whitford, North Carolina State College, Raleigh; sec., P. C. Silva, University of Illinois, Urbana; treas., R. C. Starr, Indiana University, Bloomington. Representative to the AAAS Council is Luigi Provasoli.

AAAS Finances: Report for 1955

The Association's financial records are kept in two separate accounts. One—the Operating Account—shows the expenses of running the Association's ordinary, continuing activities and the income that is devoted to those activities; the other —the Investment Account—includes funds that have been given to the Association to endow prizes, to pay the cost of maintaining the membership of emeritus and life members, and to support research.

Operating Account

Operating receipts totaled $602,420.68 during 1955. This income was divided as follows:

Annual dues paid by members	$288,808.62
Extra payments by members who wanted to receive both *Science* and *The Scientific Monthly*	18,927.37
Money transferred from the Investment Account to pay for subscriptions for emeritus and life members	3,330.00
Journal subscriptions from nonmembers	60,625.97
Sales of individual copies of journals	2,476.31
Advertising in *Science*	142,054.25
Advertising in *The Scientific Monthly*	11,615.79
Sale of symposium volumes	24,023.59
Miscellaneous sales, including journal binders, Association emblems, and microcard edition of *Science*	4,351.99
Annual meeting: registration fees, exposition space, advertising in program, and contributions	27,470.61
Income from investment of funds not needed in checking account	13,751.67
Miscellaneous other income	4,984.51
Total	$602,420.68

These receipts amounted to $8744.61 more than the operating expenses. This amount, therefore, was the Association's

surplus for the year. The principal items of expense were:

Printing and editing *Science*	$267,137.80
Printing and editing *The Scientific Monthly*	77,282.85
Editorial Board expenses and honoraria	7,136.20
Cost of selling advertising in the two journals	36,101.46
Printing and editing symposium volumes	21,736.91
Meetings of boards and committees	7,942.44
Contribution to Scientific Manpower Commission	1,000.00
Recruitment of new members	15,223.22
Expenses of the annual meeting	28,905.01
Press service for annual meeting	4,687.22
Allowances ($1 per member) to Pacific, Southwestern and Rocky Mountain, and Alaska Divisions	5,740.00
Expenses of AAAS sections	4,584.05
Administrative staff salaries and general expenses	82,340.77
Building maintenance and rental of temporary quarters during construction of new building	19,586.89
Social security, insurance, and retirement provisions for staff members	10,860.51
Miscellaneous other expenses	3,410.74
Total	$593,676.07

Comparison of 1955 with 1954

Receipts in 1955 were $7971.92 smaller than in 1954. The smaller total was chiefly accounted for by two facts: the Association derived $15,801.27 less income from the 1955 annual meeting in Atlanta than from the 1954 annual meeting in Berkeley; and the 1955 income from rent of the houses owned but not occupied by the Association was $5029.48 smaller in 1955 than in 1954. Early in 1955 those houses were torn down to make way for the new headquarters building.

Operating expenses in 1955 were greater by $27,933.28 than they were in 1954. The largest increases were in the cost of publishing the Association's journals and in the cost of housing the Association's offices. In 1955 we spent $22,703.52 more than in 1954 in editing and printing *Science* and *The Scientific Monthly*. The necessity of renting office space for most of 1955 meant that housing cost $10,354.22 more than it had in 1954.

Balance Sheet

All of the foregoing deals with the operating funds of the Association for the entire year of 1955. At the end of 1955, the Association's balance sheet showed the following assets:

Cash	$ 261,533.37
Money owed to the Association	21,991.41
Money invested in short term and easily convertible securities (for example, U.S. Treasury bills and Building and Loan Association deposits)	408,527.64
Value of real estate owned by the Association	153,297.20
Construction account for new building	479,527.42
Total assets	$1,324,877.04

Offsetting these assets, as they always must in a balance sheet, were liabilities, as listed below:

Accounts payable to others	$ 104,039.31
Unexpended portions of grants from Carnegie Corporation and National Science Foundation	97,283.93
1956 dues received, but for which members had not yet received journals or other services	223,884.14
Subscriptions to 1956 issues of journals	54,059.04
Money earmarked for construction of new building	476,756.79
Unallocated funds, available to the Association for operating expenses, payment on new building, or other purposes	368,853.83
Total liabilities	$1,324,877.04

Grants Received in 1955

Among the liabilities shown above is an item of $97,283.93 which represented the unexpended portions of grants made to the Association during 1955. Expenses, under these grants, were not listed as expenses, nor were the grants listed as income, for the grants represent special projects undertaken by the Association. They are not part of the regular operating funds, even though the purposes for which the grants were received are part of the Association's program of activities; including them in the Operating Account would give a grossly distorted picture of the Association's income and balance for the year. The grants received are briefly accounted for below.

During 1954 and 1955 the Association received grants totaling $24,770.89 to pay the expenses of the International Arid Lands Meetings held in New Mexico in April and May of 1955. The expenses of the meetings totaled exactly the same amount, and the nice balance is explained by the fact that what would otherwise have been a deficit of $1070.89 was canceled by contributions from generous supporters in the area in which the meetings were held. The other contributions to support the meetings were $10,000 from the National Science Foundation, $10,000 from the Rockefeller Foundation, $3000 from UNESCO, and $700 from the Department of State.

The National Science Foundation made three other grants to the Association during 1955. One, of $2820, was to finance a conference on the education of science teachers. The conference cost $1762.82 and the remaining $1057.18 was returned to the National Science Foundation. A second grant, of $2300, was for the purpose of holding a conference on the science training of talented students. The conference cost $1324.41 and the balance of $975.59 was returned to the National Science Foundation.

The other grant from the National Science Foundation was for $23,250 and was given to enable the Association to develop traveling libraries of books about science and scientists that were rotated during the academic year among 66 small high schools scattered throughout the United States. As of 31 December 1955 there remained $8946.70 in this account. This money was retained by the Association for the purpose of paying expenses of the program that had not yet been incurred by the end of 1955.

From the Carnegie Corporation, the Association received $100,000 on 1 July 1955. This amount was the first third of a grant of $300,000 to support the AAAS Science Teaching Improvement Program. Since the program did not get actively under way until September of 1955, there was a substantial balance of $88,337.23 on 31 December.

Members and other friends contributed $32,775.88 to the Association's building fund during 1955.

Not included in this accounting are grants of $10,000 each from the Rockefeller Foundation and the National Science Foundation that were made to the Gordon Research Conferences.

Investment Account

To keep them separated from operating funds and grants for special activities, the Association holds its endowment and investment funds in a separate Investment Account. Although the Association has some leeway in the handling of these funds, ordinarily the income is used and the principal left intact. Disbursements during 1955 were as follows:

Income allocated to Gordon Research Conferences	$1015.36
Newcomb Cleveland prize	1000.00
Socio-psychological essay prize	1000.00
Grants to academies of science to use in support of research	4612.28
Transferred to operating account to pay for journal subscriptions for emeritus and life members	3330.00
Expenses of managing investments	1742.75

The accompanying statement of receipts and disbursements from this account also shows that $273,268.50 was spent for the purchase of securities. All but a small fraction of this amount was derived from the sale of other securities.

At the end of 1955 the Investment Account showed assets of $435,340.03, of which $36,502.75 consisted of endowment for the Gordon Research Conferences and $398,837.28 was for the other purposes mentioned above. The funds in the Investment Account were distributed as follows:

	Book value	*Market value*
Cash	$ 16,334.46	$ 16,334.46
U.S. Government bonds	143,386.51	138,937.00
Other bonds	75,932.25	75,600.00
Preferred stocks	58,908.59	60,375.00
Common stocks	140,778.22	215,763.00
Total	$435,340.03	$507,009.46

Prior to 1955 a larger fraction of this account had been invested in Government securities. During 1955, with the advice of the investment firm of Scudder, Stevens and Clark, the percentage in such securities was reduced while the percentage in corporate bonds and stocks was correspondingly increased.

Auditor's Report

A condensed statement of the Association's finances for 1955, prepared by the auditing firm of G. P. Graham and Company, is published herewith. Balance sheets and statements of receipts and expenditures are given separately for the Operating Account and the Investment Account. The term "Investment Account" has been adopted to replace the older name, "Treasurer's Account," but the auditor's report uses the older name. The portion of the auditor's report published here does not include funds for the Gordon Research Conferences.

DAEL WOLFLE
Executive Officer, AAAS

Washington 5, D.C.
25 May 1956

To the Council of the
American Association for the
Advancement of Science
Washington, D.C.

We have examined the balance sheet of the Operating Fund of the American Association for the Advancement of Science as at 31 December 1955, and the statement of revenue and expenditures for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the accompanying statements present fairly the financial position of the Operating Fund of the American Association for the Advancement of Science as at 31 December 1955, and the results of its operations for the year then ended.

G. P. GRAHAM & COMPANY
By G. R. BOWERS

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE OPERATING FUND
BALANCE SHEET AS AT 31 DECEMBER 1955

Assets

Current assets		
Cash on deposit	$258,033.37	
Imprest funds	3,075.00	
Accounts receivable	21,991.41	
Deposit with airline	425.00	
Investments	408,527.64	$ 692,052.42
Building accounts		
Investments	$ 975.87	
Real estate	153,297.20	
Building construction account	478,551.55	632,824.62
		$1,324,877.04

Liabilities

Current liabilities		
Accounts payable	$104,039.31	
Unexpended balances of grants		
Traveling High-School Science Libraries	8,946.70	
Science Teaching Improvement Program	88,337.23	$ 201,323.24
Deferred income		
Prepaid dues	$223,884.14	
Prepaid journal subscriptions	54,059.04	277,943.18
Building fund		226,756.79
Reserve fund		250,000.00
Unallocated funds		
Balance 1 January 1955	$360,109.22	
Add: Excess of revenue over expenditures	8,744.61	
Balance 31 December 1955		368,853.83
		$1,324,877.04

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE OPERATING FUND
STATEMENT OF REVENUE AND EXPENDITURES FOR THE YEAR ENDED 31 DECEMBER 1955

Revenue			
Dues			$288,808.62
Journals			
Subscriptions			
From Treasurer's accounts (Life, 50-year, and emeritus members)	$ 3,330.00		
Members' special subscriptions	18,927.37		
Nonmembers' subscriptions	60,625.97	$ 82,883.34	
Advertising		153,670.04	
Miscellaneous sales		2,476.31	239,029.69
Publications			
Binders		$ 1,268.53	
Symposium volumes		24,023.59	25,292.12
Atlanta meeting and exhibit			27,470.61
Income from investments			13,751.67
Miscellaneous			8,967.97
			$602,420.68
Expenditures			
Administrative and general expense		$ 82,340.77	
Building expenses		7,539.39	
Rental of temporary offices		12,047.50	
Board of directors		6,800.52	
Other committees		1,141.92	
Allowance to divisions		5,740.00	
Section expense		4,584.05	
Circularization–new members		15,223.22	
Meetings and exhibits		33,592.23	
Journals		387,658.31	
Publications		23,014.87	
Employees' retirement		8,008.13	
Social security		2,852.38	
Miscellaneous		3,132.78	593,676.07
Excess of revenue over expenditures			**$ 8,744.61**

Washington 5, D.C.
25 May 1956

To the Council of the
American Association for the
Advancement of Science
Washington, D.C.

We have examined the balance sheet of the Treasurer's accounts of the American Association for the Advancement of Science as at 31 December 1955, and the statement of cash receipts and disbursements for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as are considered necessary in the circumstances.

In our opinion, the accompanying financial statements present fairly the financial position of the Treasurer's accounts of the American Association for the Advancement of Science as at 31 December 1955, and the cash receipts and disbursements for the year then ended.

G. P. GRAHAM & COMPANY
By G. R. BOWERS

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE TREASURER'S ACCOUNTS
BALANCE SHEET AS AT 31 DECEMBER 1955

Assets

Cash in bank		$ 16,334.46
Securities—at cost		382,502.82
		$398,837.28

Liabilities and Reserves

Liabilities		
Accounts payable	$ 62.00	
Academy grants	2,859.23	
Special academy grants	475.00	$ 3,396.23
Endowment funds		
For research	$174,289.52	
For general purposes	154,798.28	
For special purposes	66,353.25	395,441.05
		$398,837.28

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE TREASURER'S ACCOUNTS
STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS FOR THE YEAR ENDED 31 DECEMBER 1955

Cash balance 1 January 1955		$ 3,343.29
Receipts		
Income from investments	$ 12,368.16	
Redemption and sale of securities	270,606.76	
Life membership fees	4,650.00	
Gifts	2,919.69	
Special academy grants	450.00	
Deceased emeritus life membership fees	900.00	
Transferred to research fund income from UNESCO fellowship fund	8.50	
Refund of advance to Gordon Research Conferences	9,465.45	301,368.56
		$304,711.85
Disbursements		
Income allocated to Gordon Research Conferences	$ 1,015.36	
Securities purchased	273,268.50	
Newcomb Cleveland prize	1,000.00	
Socio-psychological prize	1,000.00	
Academy grants	4,362.28	
Special academy grants	250.00	
Emeritus life membership fees (From Jane M. Smith fund)	1,500.00	
Deceased emeritus life membership fees (To Jane M. Smith fund)	900.00	
Journal subscriptions (Life, 50-year, and emeritus members)	3,330.00	
Expenses	1,742.75	
UNESCO fellowship fund transferred to research fund income	8.50	288,377.39
Cash balance 31 December 1955		$ 16,334.46

Forthcoming Events

November

1–2. Society for Applied Spectroscopy, 11th annual, New York, N.Y. (F. M. Biffen, Johns-Manville Research Center, Manville, N.J.)

1–3. Association of Geology Teachers, annual, Chicago, Ill. (C. E. Prouty, Dept. of Geology, Univ. of Pittsburgh, Pittsburgh 13, Pa.)

5–7. Paleontological Soc., annual, Minneapolis, Minn. (H. B. Whittington, Museum of Comparative Zoology, Harvard Univ., Cambridge, Mass.)

6–15. International Grassland Cong., 7th, Palmerston, New Zealand. (S. H. Saxby, P.O. Box 2298, Wellington, New Zealand.)

7–9. Electrical Techniques in Medicine and Biology, 9th annual conf., New York, N.Y. (E. D. Trout, X-Ray Dept., General Electric Co., Milwaukee 1, Wis.)

7–9. Society of Rheology, annual, Pittsburgh, Pa. (W. R. Willets, Titanium Pigment Corp., 99 Hudson St., New York 13.)

8–9. Canadian High Polymer Forum, 7th, Sarnia, Ont. (M. H. Jones, Ontario Research Foundation, 43 Queen's Park, Toronto 5, Ont.)

8–10. Gerontological Soc., annual, Chicago, Ill. (N. W. Shock, Baltimore City Hospitals, Baltimore 24, Md.)

10. Society for the Scientific Study of Religion, fall meeting, Cambridge, Mass. (R. W. Burhoe, American Acad. of Arts and Sciences, Cambridge 36.)

11–12. American Soc. for the Study of Arteriosclerosis, annual, Chicago, Ill. (R. G. Gould, P.O. Box 1663, Los Alamos, N.M.)

11–17. Cardiology, 5th Inter-American cong. of, Havana, Cuba. (I. Chavez, Calzada de la Piedad 300, Mexico, D.F., Mexico.)

12–14. Association of Military Surgeons of the U.S., annual, Washington, D.C. (S. E. Womeldorph, AMSUS, Suite 718, 1726 Eye St., NW, Washington 6.)

12–15. American Petroleum Inst., 36th annual, Chicago, Ill. (API, 50 W. 50 St., New York 20.)

12–16. American Public Health Assoc., 84th annual, Atlantic City, N.J. (R. M. Atwater, 1790 Broadway, New York 19.)

12–16. American Soc. of Agronomy, annual, Cincinnati, Ohio. (L. G. Monthey, 2702 Monroe St., Madison 5, Wis.)

13–15. Historical Development of Physiological Thought, symposium, Brooklyn, N.Y. (E. Goodwin, State Univ. of New York, College of Medicine, Brooklyn 3.)

14–15. Industrial Hygiene Foundation, 21st annual, Pittsburgh, Pa. (C. R. Walmer, IHF, Mellon Inst., Pittsburgh.)

14–16. Optics and Microwaves, symp., Washington, D.C. (Symp. on Optics and Microwaves, P.O. Box 355, Falls Church, Va.)

14–16. Newer Developments in the Diagnosis and Management of Cancer, symp., Duarte, Calif. (J. Love, Director, Div. of Postgraduate Medical Education, City of Hope Medical Center, Duarte.)

15. Enzymes and Feed, Assoc. of Vitamin Chemists, Chicago, Ill. (M. Freed, Dawe's Laboratories, Inc., 4800 S. Richmond St., Chicago 32.)

15–16. American Philosophical Soc., Philadelphia, Pa. (APA, 104 S. 5 St., Philadelphia 6.)

15–16. Operations Research Soc. of America, 10th natl., San Francisco, Calif. (T. E. Oberbeck, U.S. Naval Post Graduate School, Monterey, Calif.)

15–16. Society of Technical Writers, jointly with Assoc. of Technical Writers and Editors, New York, N.Y. (S. F. Shapiro, STW, P.O. Box 22, Newton Centre 59, Mass.)

15–17. Acoustical Soc. of America, Los Angeles, Calif. (W. Waterfall, ASA, 57 E. 55 St., New York 22.)

18–25. National Meeting of Surgeons, Mexico City, Mexico. (Intern. Acad. of

Proctology, 147–41 Sanford Ave., Flushing, N.Y.)

19–20. Entomological Soc. of America, Eastern Branch, Atlantic City, N.J. (B. F. Driggers, Experiment Station, New Brunswick, N.J.)

21. Arctic Branch, Alaska Div., AAAS, College, Alaska. (Miss C. Juedes, Box 47, College.)

22–23. Calder Hall Nuclear Power Station, conf., London, England. (Secretary, British Nuclear Energy Conference, 1–7 Great George St., London, S.W.1.)

22–3. International Cong. of Industrial Chemistry, 29th, Paris, France. (J. Gerard, Société de Chimie Industrielle, 28, rue Saint-Dominique, Paris VII^{e}.)

23–24. American Mathematical Soc., Evanston, Ill. (E. G. Begle, 207 Leet Oliver Memorial Hall, Yale Univ., New Haven 11, Conn.)

23–24. American Physical Soc., Chicago, Ill. (K. K. Darrow, APS, Columbia Univ., N.Y. 27.)

23–24. American Soc. of Animal Production, annual, Chicago, Ill. (W. M. Beeson, Dept. of Animal Husbandry, Purdue Univ., W. Lafayette, Ind.)

24. American Ethnological Soc., New York, N.Y. (A. G. James, Hunter College, Bronx 68, N.Y.)

25–30. American Rocket Soc., annual, New York, N.Y. (J. J. Harford, ARS, 29 W. 39 St., New York 18.)

25–30. American Soc. of Mechanical Engineers, annual, New York, N.Y. (C. E. Davies, ASME, 29 W. 39 St., New York 18.)

26–28. American Soc. of Refrigerating Engineers, Boston, Mass. (R. C. Cross, ASRE, 234 Fifth Ave., New York 1.)

26–30. Automation Exposition, 3rd intern., New York, N.Y. (TIAE, Richard Rimbach Associates, Inc., 845-A Ridge Ave., Pittsburgh 12, Pa.)

27–30. American Medical Assoc., clinical, Seattle, Wash. (G. F. Lull, AMA, 535 N. Dearborn St., Chicago 10, Ill.)

27–30. National Chemical Exposition, 9th, Cleveland, Ohio. (American Chemical Soc., 1155 16 St., NW, Washington 6.)

28–30. American College of Cardiology, 5th interim, Pittsburgh, Pa. (P. Reichert, ACC, Empire State Bldg., New York, N.Y.)

28–30. International Conf. on Ozone, 1st, Chicago, Ill. (C. E. Thorp, Armour Research Foundation, 35 W. 33 St., Chicago 16.)

30. American Rheumatism Assoc., Bethesda, Md. (E.F. Hartung, 580 Park Ave., New York, N.Y.)

30–1. Oklahoma Acad. of Science, Stillwater. (D. E. Howell, Entomology Dept., Oklahoma A. & M. College, Stillwater.)

30–1. Tennessee Acad. of Science, Murfreesboro. (D. Caplenor, Dept. of Biology, Peabody College, Nashville 4, Tenn.)

December

2. American Acad. of Dental Medicine, 11th mid-annual, New York, N.Y. (A. Reiner, 114–01 201 St., St. Albans 12, N.Y.)

2–7. Radiological Soc. of North America, Inc., annual, Chicago, Ill. (D. S. Childs, 713 E. Genesee St., Syracuse 2, N.Y.)

5–7. Instrumentation Conf., 2nd, Inst. of Radio Engineers, Atlanta, Ga. (M. D. Prince, Engineering Experiment Station, Georgia Inst. of Technology, Atlanta.)

6. Amino Acid Imbalance in Nutrition, Assoc. of Vitamin Chemists, Chicago, Ill. (M. Freed, Dawe's Laboratories, Inc., 4800 S. Richmond St., Chicago 32.)

6–7. American Astronautical Soc., 3rd annual, New York, N.Y. (N. V. Petersen, AAS, 516 Fifth Ave., New York 36.)

6–8. American Phytopathological Soc., annual, Cincinnati, Ohio. (G. S. Pound, Dept. of Plant Pathology, Univ. of Wisconsin, Madison.)

6–9. American Psychoanalytic Assoc., New York, N.Y. (J. N. McVeigh, APA, 36 W. 44 St., New York 36.)

7–8. Association for Research in Nervous and Mental Disease, annual, New York, N.Y. (R. J. Masselink, 710 W. 168 St., New York 32.)

8–11. American Acad. of Optometry, annual, Houston, Tex. (C. C. Koch, 1506 Foshay Tower, Minneapolis 2, Minn.)

9–12. American Inst. of Chemical Engineers, annual, Boston, Mass. (F. J. Van Antwerpen, AICE, 25 W. 45 St., New York 36.)

9–12. American Soc. of Agricultural Engineers, Chicago, Ill. (J. L. Butt, ASAE, St. Joseph, Mich.)

10–12. American Nuclear Soc., winter meeting, Washington, D.C. (ANS, P.O. Box 963, Oak Ridge, Tenn.)

10–12. Eastern Joint Computer Conf., New York, N.Y. (J. R. Weiner, Remington Rand, Inc., 315 Fourth Ave., New York, N.Y.)

13–15. Texas Acad. of Science, annual, Brownwood, Tex. (G. C. Parker, Texas A.&M. College, College Station.)

19. Arctic Branch, Alaska Div., AAAS, College Alaska. (Miss C. Juedes, Box 47, College.)

26–31. American Assoc. for the Advancement of Science, annual, New York, N.Y. (R. L. Taylor, AAAS, 1515 Massachusetts Ave., NW, Washington 5.)

The following 55 meetings are being held in conjunction with the AAAS annual meeting.

AAAS Academy Conference (L. Taylor, West Virginia Univ., Morgantown). 29–30 Dec.

AAAS Cooperative Committee on the Teaching of Science and Mathematics (M. Meister, Bronx High School of Science, New York 68). 27 Dec.

AAAS-Gordon Research Conferences (W. G. Parks, Univ. of Rhode Island, Kingston). 27 Dec.

Alpha Chi Sigma (H. G. Seavey, 30 Church St., Room 340, New York 7). 28 Dec.

Alpha Epsilon Delta (M. L. Moore, 7 Brookside Circle, Bronxville, N.Y.). 29 Dec.

American Assoc. of Clinical Chemists (A. E. Sobel, Jewish Hospital of Brooklyn, Brooklyn 16, N.Y.).

American Assoc. of Hospital Consultants (E. D. Barnett, School of Public Health, Columbia Univ., New York 32.)

American Assoc. of Scientific Workers (R. J. Rutman, 6331 Ross St., Philadelphia 44, Pa.). 29 Dec.

American Astronomical Soc. (J. A. Hynek, Harvard College Observatory, Cambridge 38, Mass.). 26–29 Dec.

American Documentation Inst. (J. Hilsenrath, National Bureau of Standards, Washington 25). 27–29 Dec.

American Educational Research Assoc. (A. G. Wesman, Psychological Corp., 522 Fifth Ave., New York 36). 29 Dec.

American Meteorological Soc. (R. J. Roth, Crop-Hail Insurance Actuarial Assoc., 209 W. Jackson Blvd., Chicago, Ill.). 28 Dec.

American Museum of Natural History (G. Reekie, AMNH, Central Park West at 79 St., New York, N.Y.). 26 Dec.

American Nature Study Soc. (R. L. Weaver, Univ. of Michigan, Ann Arbor). 26–30 Dec.

American Philosophical Assoc., Eastern Div. (J. Wild, Harvard Univ., Cambridge 38, Mass.). 27 Dec.

American Psychiatric Assoc. (B. Pasamanick, Ohio State Univ., Columbus 10). 28–29 Dec.

American Soc. of Hospital Pharmacists (G. E. Archambault, U.S. Public Health Service, Washington 25). 29 Dec.

American Soc. of Range Management (F. G. Renner, Soil Conservation Service, U.S. Dept. of Agriculture, Washington 25). 28 Dec.

American Statistical Assoc. (R. E. Johnson, Western Electric Co., New York 7).

Association for Computing Machinery (J. P. Nash, Univ. of Illinois, Urbana).

Association of American Geographers (P. M. Stern, Conservation Foundation, 30 E. 40 St., New York, N.Y.).

Astronomical League (H. B. Davidson, 812 Park Ave., New York 21.)

Conference on Scientific Editorial Problems (J. G. Adashko, Ford Instrument Co., Long Island City, N.Y.). 26–28 Dec.

Conference on Scientific Manpower (T. J. Mills, National Science Foundation, Washington 25). 26 Dec.

Ecological Soc. of America (M. F. Buell, Rutgers Univ., New Brunswick, N.J.). 26–30 Dec.

Entomological Soc. of America (P. W. Oman, Plant Industry Sta., Beltsville, Md.). 27–30 Dec.

Genetics Soc. of America (A. W. Pollister, Columbia Univ., New York 27). 28 Dec.

History of Science Soc. (Miss P. Kibre, Hunter College, New York, N.Y.). 27–29 Dec.

Institute of Mathematical Statistics (Miss E. Scott, Univ. of California, Berkeley 4).

International Council for Exceptional Children (M. H. Fouracre, Columbia Univ., New York 27). 26 Dec.

International Union for the Study of Social Insects, North American Section (T. C. Schneirla, American Museum of Natural History, Central Park West at 79 St., New York, N.Y.). 26–27 Dec.

Mountain Lake Biological Sta. (B. D. Reynolds, Univ. of Virginia, Charlottesville).

Mycological Soc. of America (L. S. Olive, Columbia Univ., New York 27). 26 Dec.

National Acad. of Economics and Political Science (D. P. Ray, George Washington Univ., Washington, D.C.). 27 Dec.

National Assoc. for Gifted Children (Miss A. F. Isaacs, 409 Clinton Springs Ave., Cincinnati, Ohio).

National Assoc. for Research in Science Teaching (N. Washton, Queens College, Flushing 67, L.I., N.Y.). 27 Dec.

National Assoc. of Biology Teachers (J. Breukelman, State Teachers College, Emporia, Kan.). 26–30 Dec.

National Assoc. of Science Writers (J. E. Pfeiffer, New Hope, Pa.).

National Geographic Soc. (W. R. Gray, NGS, 16 and M Sts., NW, Washington 6). 29 Dec.

National Speleological Soc. (Brother G. Nicholas, LaSalle High School, Cumberland, Md.). 29 Dec.

New York Acad. of Sciences (R. F. Nigrelli, New York Zoological Soc. and M. Kopac, New York Univ., Washington Sq., New York, N.Y.)..29 Dec.

Philosophy of Science Assoc. (C. W. Churchman, Case Inst. of Technology, Cleveland, Ohio). 29–30 Dec.

Pi Gamma Mu (B. H. Williams, Industrial College of the Armed Forces, Washington 25). 26 Dec.

Scientific Research Soc. of America (D. B. Prentice, Yale Univ., New Haven, Conn.). 26–27 Dec.

Sigma Delta Epsilon (C. Chandler, Boyce Thompson Inst. for Plant Research, 1086 N. Broadway, Yonkers 3, N.Y.).

Sigma Pi Sigma (M. W. White, Pennsylvania State Univ., University Park).

Society for the Advancement of Criminology (D. E. J. MacNamara, New York Inst. of Criminology, 2109 Broadway, New York, N.Y.). 29 Dec.

Society for the Advancement of General Systems Theory (L. von Bertalanffy, Mt. Sinai Hospital, Los Angeles 48, Calif.). 29–30 Dec.

Society for the Study of Evolution (H. Lewis, Univ. of California, Los Angeles 24). 27–29 Dec.

Society of General Physiologists (A. Shanes, National Institutes of Health, Bethesda, Md.).

Society of Systematic Zoology (R. E. Blackwelder, Box 500, Victor, N.Y.). 27–30 Dec.

Society of the Sigma Xi (T. T. Holme, Yale Univ., New Haven, Conn.). 27 Dec.

Society of Vertebrate Paleontology, annual (J. T. Gregory, Peabody Museum of Natural History, Yale Univ., New Haven, Conn.). 28–30 Dec.

Torrey Botanical Club (David Keck, New York Botanical Garden, Bronx Park, New York 58). 26–27 Dec.

United Chapters of Phi Beta Kappa (C. Billman, PBK, 1811 Q St., NW, Washington 6). 27 Dec.

27–28. Fluid Mechanics in Chemical Engineering, American Chemical Soc., Lafayette, Ind. (W. E. Ranz, Dept. of Engineering Research, Pennsylvania State Univ., University Park.)

27–28. Linguistic Soc. of America, Philadelphia, Pa. (A. A. Hill, Box 7790, University Sta., Austin 12, Tex.)