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Report on SCAMP 1953

to the

Director

of the

National Security Agency

Submitted by

Stewart S. Cairns

1 September 1953

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Report on SCAMP 1953

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Report on SCAMP 1953

1. Purposes of SCAMP.

The purposes of the project known as SCAMP, which held its first session in the summer of 1952 and its second in the summer of 1953 are

- a. To support research in computational aspects of discrete problems related to the interests of the National Security Agency
- b. To educate a group of competent cleared mathematicians in mathematical problems and techniques applicable or potentially applicable to NSA problems.

Mathematical interpretations of certain practical problems of the NSA are closely inter-related with a number of currently studied research questions in pure mathematics. The relationships are so close that, on the one hand, mathematicians unacquainted with NSA problems may well develop methods contributing to their solutions and, on the other hand, mathematicians working directly for the Agency may achieve results of pure mathematical interest. It was in the hope of capitalizing on this situation that the NSA undertook to sponsor SCAMP. The Agency stands to benefit not only from the immediate products of SCAMP, but also from the creation of a pool of cleared, informed and highly competent mathematicians who may later render valuable service.

Another merit of the SCAMP program is the opportunity for NSA mathematicians to associate professionally with outsiders working on

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related problems. In a recent discussion, Dr. J. Weyl of the ONR drew a contrast between "monastic and secular" mathematics, which fits the present situation much better than the usual dichotomy into "applied and pure" mathematics. To some extent, Agency personnel must lead a monastic life. For the sake of their effectiveness, however, as well as for their personal and professional welfare, it is extremely important to provide for the type of outside collaboration involved in SCAMP, thus lessening the dangers (1) that they will pursue their own Agency research without capitalizing on closely related "secular" mathematics and (2) that their work will be more or less stultified for lack of the stimulation which comes from a wide variety of professional contacts. As already mentioned, the important mathematical problems of the Agency are closely intertwined with unclassified current research. It was therefore possible for the members of SCAMP with incomplete clearances to make valuable contributions to the program, and active cooperation with non-members was found useful in the writing of a paper on finite projective planes by Hoffman, Newman, Straus and Taussky. In connection with the likewise unclassified assignment problem, Mr. De Francesco of the NSA presented a conference paper making use of earlier work by von Neumann and by Gleyzal. This problem is highly relevant to some of the Agency's practical interests. In fact, its solution is employed in one of Tompkins' attacks on the so-called $10 \times 10 \times 70$ problem, and this, in turn, is a direct mathematical interpretation of a type of continuing operational problem vitally important to the Agency. The status of the $10 \times 10 \times 70$ problem is

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further discussed in Section 4 below. These are but a few of the many illustrations which could be cited to reveal the value accruing to the Agency from contacts at SCAMP between NSA personnel and outside mathematicians.

Attention is also called to Appendix V, where open lectures are listed which took place in the Los Angeles area during the SCAMP session and which were closely related to our interests.

2. Background of SCAMP 1953

A fairly detailed account of the first SCAMP symposium is afforded by the "Report on SCAMP to the Director of the Armed Forces Security Agency" (Confidential) submitted by Stewart S. Cairns, 8 September 1952.

On 14 August 1952, the Director of the Armed Forces Security Agency (which has since become the National Security Agency), visited SCAMP and conferred with the available members of the Special Communications Advisory Group, namely: S. S. Cairns, H. P. Robertson and C. B. Tompkins. These three joined in recommending that the Agency sponsor a second SCAMP symposium at the Institute for Numerical Analysis in 1953 and that work be continued there on a reduced scale during the academic year 1952-53, partly in completion of unfinished investigations and partly in preparation for later efforts. These recommendations were accepted.

After inquiring into the availability and willingness to serve of a number of possible chairman for 1953, and after seeking advice from various persons connected with SCAMP, the 1952 chairman, S. S. Cairns,

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recommended that Professor G. A. Hedlund of Yale University be asked to assume the responsibility for 1953. His clearance was not completed until some time during the fall, and, when he was then approached, it turned out that he was unavailable. Accordingly, to avoid the delays resulting from a further search, the 1952 chairman agreed to serve again in 1953.

The work of the chairman has been greatly alleviated, as compared with last year, by the establishment of an executive secretaryship and by the services in that position of Dr. Lowell J. Paige of the UCLA Department of Mathematics.

3. Preparatory work.

The preparation for SCAMP 1953 can be analyzed into the following categories:

- (a) Budgetary negotiations
- (b) Clearance procedures
- (c) Personnel negotiations
- (d) Arrangements for facilities and services on the UCLA campus
- (e) Planning the research program.

These five processes will be separately discussed, although all of them were, of course, simultaneously in progress.

The budget for SCAMP falls into the following parts: (1) Salaries and travel expenses, (2) Computational expenses, (3) Overhead and (4) Miscellaneous. The total allocation for 1953, together with a rough breakdown, was determined in discussions among (1) the Director

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of the National Security Agency and various members of his staff, (2) Dr. John H. Curtiss and Dr. C. B. Tompkins (representing the National Bureau of Standards and the Institute for Numerical Analysis), (3) Dr. Mina Rees of the Office of Naval Research and (4) the chairman of SCAMP. The discussions centered largely about the extent of the computational program, since there was general agreement from the start concerning the other parts of the budget. It was finally agreed that some computations would be prepared in advance at NSA and INA for educational purposes, since many of the participants were relatively unfamiliar with this aspect of the work, and that, for the rest, computations resulting directly from the SCAMP program would be carried out on the spot, except in the case of possible long-range procedures which it might be deemed advantageous to transfer elsewhere. Appendix II contains tabulated budgetary data.

For the record, it should be noted that a number of complications connected with funds arose, even after agreement had been reached on the budget. These complications, which at times appeared to threaten the very existence of SCAMP, or at least its intended location, were largely connected with newly imposed obstacles to the transfer of money between government agencies. There were dangerous delays in the official approval of the necessary transfer, which finally took place just in time, thanks to persistent efforts by personnel of the NSA, the ONR and the Institute for Numerical Analysis. Since the INA is part of the National Bureau of Standards, difficulties were also encountered in

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hiring SCAMP members in various Civil Service categories. Some of these difficulties arose from the need to establish positions in spite of an announced freeze on Civil Service appointments, and some from efforts to arrange for suitable stipends. In order to attract desirable participants from academic institutions, it appears necessary to figure their compensations at a monthly rate of about one-ninth their academic salaries, plus enough to compensate or partly compensate for the summer rental they must pay. In certain cases, this took us out of the highest available Civil Services ratings and necessitated contracts directly with the UCLA. In other cases, negotiations to determine Civil Service salaries involved administrative efforts inappropriate to a two-month research project. Appendix II contains some material relating to these complications.

Clearances presented other problems, some arising from the need for two types of clearance (one for the NSA and one, a loyalty check, for the Commerce Department when Civil Service appointments were used), and others arising from the length of time required for clearance procedures. The double clearances were a source of annoyance both to prospective SCAMP members and to administrative personnel. As for the time element, it was decided, since several months more were available for planning than in 1952, to run the project at a secret level, instead of the confidential level of last year, and to try to secure adequate clearances for all participants before the session. It was, however, necessary to make commitments in several cases before clearance procedures could be completed, since otherwise several of the

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most desirable prospects would have made alternative arrangements for the summer. In the one case where definite clearance difficulties arose in advance of the session, the prospect's salary was carried on the budget because of the commitment, but his services were donated to the INA on open problems not associated with SCAMP, and his office space was in a different building from the SCAMP offices. In the few cases where clearances were still pending when the session started, the participants worked on open problems associated with SCAMP but were, of course, not given access to classified information until their clearances were completed.

With respect to selection of personnel, the chairman drew upon the experience of the previous year and upon the opinions of all those whom it seemed appropriate to consult in preparing a preliminary list of possible participants. He then approached the prospects with an exploratory letter (See Appendix VIII) which, for security reasons, was somewhat vague concerning the ultimate purposes of SCAMP. As soon as a prospect showed definite interest in participating, the responsibility for financial negotiations was taken over by Dr. Lowell Paige, who entered upon a part time Civil Service appointment on 1 Jan. 1953, in order that he might devote the necessary time and energy to preparing for the symposium. Those who finally participated, with the dates of their participation, are listed in Appendix I. A list of those who were approached but, for various reasons, did not eventually join SCAMP is included in Appendix VIII.

During the few months immediately preceding the SCAMP session, the Executive Secretary was occupied not only with personnel matters but also with arrangements for suitable facilities and services on the UCLA campus. This included the securing of office space, a conference room, telephone services, a safe file, various office supplies, a cleared secretary, multilith operator and certain computer personnel. In performing these exacting tasks, Dr. Paige had the cooperation of Professor Magnus Hestenes, chairman of the UCLA Mathematics Department and Dr. C. B. Tompkins, representing the INA.

In 1952, the research centered largely about the existence problem for finite projective planes, although a number of participants occupied themselves with other problems of interest to the sponsor. This restriction of attention was partly a device for concentrating the efforts of the group, in the hope of effecting definite advances in a particular area, and was partly a consequence of the relatively low security level of the symposium, which would have interfered with the motivating of a wider class of problems. With the prospects of running SCAMP 1953 at a security level of secret, one notch higher than in 1952, it became possible to broaden the official interests of the project. The general outlines of the research program were a subject of deliberation, consultation and correspondence from the time that SCAMP 1953 was first suggested. By the spring of 1953, plans had crystallized to the point where a tentative scheduling of lectures and conferences became possible. On 13 June, this scheduling was accomplished at a conference in Washington of Dr. R. A. Leibler (Chief of

the Mathematical Research Division of the NSA), Dr. Mina Rees of the ONR, Dr. C. B. Tompkins of the INA and Dr. S. S. Cairns as chairman of SCAMP. The plans included

- a. The preparation of some relevant computations for the education of the participants.
- b. The scheduling of classified conferences at which NSA personnel might inform the members of SCAMP about certain problems of the Agency, so as to clarify the relationship of the SCAMP program to such problems and to enhance the probability of concrete contributions to their solution.
- c. The scheduling of a series of open lectures on computational methods and equipment.

A useful source of background information for the participants was an expository paper, "Finite Projective Planes", (Appendix III) containing the principal unclassified results of the 1952 symposium. This was distributed in advance of the session.

4. The SCAMP session.

The official dates of the SCAMP session were the months of July and August. Dates of actual participation by the members are given in Appendix I.

The following tabulation reveals the breakdown of the SCAMP membership as far as specialized duties are concerned:

Chairman: S. S. Cairns

Principal representative of the NSA:

1 July - 31 July: R. A. Leibler
3 August - 31 August: H. H. Campaigne

Executive Secretary: L. J. Paige

Supervisors of computing:

C. B. Tompkins
H. F. De Francesco

Advisers on programming and coding:

H. F. De Francesco
A. J. Hoffman
M. Newman
J. J. Wolf

Participants from the NSA not listed above:

J. J. Eachus
W. H. Erskine
O. S. Rothaus
L. W. Tordella

General participants:

A. A. Albert
R. H. Bruck
K. A. Bush
W. R. Church
R. P. Dilworth
A. M. Gleason
R. A. Good
D. W. Hall
M. Hall, Jr.
J. C. Koken
G. Pall
W. A. Pierce
A. E. Roberts, Jr.

Librarian (in charge of files):

L. L. Walters

Secretary:

A. Oates (resigned 31 July).

During the first two weeks of the session, Dr. Mina Rees of the ONR visited SCAMP in order to become familiar with its objectives and activities.

As the work of the project progressed, a number of changes were

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made in the previously planned program. Several dates were shifted, resulting in a concentration of most of the expository lectures toward the beginning of the symposium. The principal change, however, was the omission of a planned series of lectures on engineering aspects of computers, intended to suggest the potentialities of special purpose equipment for particular types of problems. The decision to omit, reached after the session started, was based on (1) the feeling by many members that there was already a sufficiency of scheduled lectures, (2) the relatively small interest of most participants in the technicalities of computing equipment and (3) the fact that a number of speakers would need to be invited from a distance in order to carry out the proposed plan for the few who were interested.

Appendices IV and V give the schedule of conferences and lectures which actually took place, including those planned in advance and some which grew from the work of SCAMP.

The accomplishments of SCAMP are partly revealed by the collection of reports and papers listed in Appendix VI and collected in Appendix VII. A unified exposition of scientific activities and results will be submitted as Appendix IX, which can be adequately prepared only after the accomplishments of the several participants have been carefully studied in relation to the purposes of SCAMP. Professor R. P. Dilworth has agreed to write this account.

It should be emphasized that the work of SCAMP 1953 is not yet complete, especially with regard to those problems which involve machine computation. The programming of these problems was so

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time-consuming that most of them were ready to run on SWAC only towards the end of the session. Hence, most of the money available for computing will be expended between now and June, 1954. The so-called "10 x 10 x 70 problem", should be particularly mentioned, since the rest of this report, appendices included, would otherwise not reveal the effort which has gone into it. As stated in Section 1 above, this problem directly formulates a type of operational problem of continuing concern to the Agency. Dr. C. B. Tompkins, with the aid of assistants, has developed two serious attacks on it and has brought them to a point where the SWAC machine can soon be used. One attack, the "gradient method", was programmed during the SCAMP session by Mr. Henry De Francesco. The other, in which permutations of order ten are systematically tested and can be rejected in large sets, is being programmed by Mr. Jay Wolf.

5. Recommendations for the future.

The two-fold mission of SCAMP, as set forth in Section 1 above, is of such a nature as to suggest a continuing project, since the sponsoring Agency will presumably always be confronted with difficult discrete problems open to computational attack and will therefore continue to benefit from stimulating the interest of research mathematicians in such problems. The experience gained from the first two sessions of SCAMP leads the writer to make the following recommendations:

- I. That further SCAMP sessions be sponsored, primarily as summer projects, but with activities on a smaller scale between sessions, so as to avoid discontinuities in the work and to

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- facilitate preparations for successive summer sessions.
- II. That the National Security Agency, if it accepts Recommendation I, make an early statement of intent, specifying an intended location so that preparations for the next session can be efficiently made.
- III. That the Institute for Numerical Analysis be designated as the intended location for SCAMP, provided suitable arrangements can be effected. The INA is on the campus of the University of California at Los Angeles. Adequate computing equipment is there combined with good quarters and good security facilities. Furthermore, the Los Angeles area has developed into a summer mathematical center, so that NSA mathematicians can benefit from a wide range of professional contacts (see Sec. 1 above), and outside mathematicians can readily be interested in the prospect of becoming members of SCAMP.
- IV. That SCAMP be run on the basis of an ONR contract with UCLA, since the INA is to be transferred to UCLA from the National Bureau of Standards. This will obviate most of the extraneous difficulties detailed in Section 3 above: double clearances, transfer of funds, establishment of Civil Service positions, and determination of salaries.
- V. That a deadline for clearances, 1 April for example, be established, with the understanding that a participant will be led to expect no commitment if the deadline passes

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without his clearance being completed. Even if the future of SCAMP remains doubtful, clearances might well be promptly initiated, say by 15 October, for a list of desirable prospects. A number of such clearances have already been completed or are in progress.

VI. That the administrative organization of SCAMP 1953 be followed, with such improvements as experience may suggest. Among the essential features is the existence of a chairman with deputies for administration and for computing. The first, called the Executive Secretary, should be a member of the host institution and should be active on a part-time basis during the preparatory phases of each session in order (1) to conduct financial negotiations with prospective participants after they have indicated to the chairman an interest in the project and (2) to make arrangements for facilities, supplies and services at the host institution. The deputy for computing, with such assistants as appear necessary, should be responsible for ensuring that problems which involve the use of high speed computing equipment are appropriate and properly prepared. Another essential feature is the representation of the NSA by persons well qualified to clarify its problems and to render advice and assistance to those who are relatively unfamiliar with such problems. The representation of the Agency and the specific contributions of its participants have been extremely valuable during the sessions of 1952 and 1953.

- VII. That Dr. Mina Rees, formerly Director of the Mathematical Sciences Division of the ONR, now Dean of the Faculty at Hunter College, be invited to serve as SCAMP chairman for 1954.
- VIII. That the total budget for the 1954 session be set at \$70,000, as in 1953. This amount has proved adequate but not excessive.

Appendix I

Participants, with dates of participation

Albert, A. A., University of Chicago
1 July - 28 August

Bruck, R. H., University of Wisconsin
1 July - 28 August

Bush, K. A., University of Illinois
1 July - 28 August

Cairns, S. S., University of Illinois
1 July - 28 August

Campaigne, H. H., National Security Agency
3 August - 28 August

Church, W. R., U. S. Navy Postgraduate School
1 July - 21 July

De Francesco, H. F., National Security Agency
17 June - 31 August

Dilworth, R. P., California Institute of Technology
1 July - 28 August

Eachus, J. J., National Security Agency
22 July - 28 July

Erskine, W. H., National Security Agency
27 July - 7 August

Gleason, A. M., Harvard University
1 August - 28 August

Good, R. A., University of Maryland
1 July - 28 August

Hall, D. W., University of Maryland
15 June - 28 August

Hall, Marshall, Jr., Ohio State University
1 July - 23 July

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Hoffman, A. J., National Bureau of Standards
1 July - 28 August

Koken, J. C., University of Illinois
28 July - 28 August

Leibler, R. A., National Security Agency
1 July - 31 July

Newman, Morris, National Bureau of Standards
1 July - 20 August

Oates, Mrs Anne, Institute for Numerical Analysis
1 July - 31 July

Paige, L. J., University of California at Los Angeles
1 July - 28 August

Pall, Gordon, Illinois Institute of Technology
1 July - 28 August

Pierce, W. A., Syracuse University
5 July - 28 August

Rees, Mina, Office of Naval Research
1 July - 19 July

Roberts, A. E., Jr., Engineering Research Associates
23 July - 7 August

Rothaus, O. S., National Security Agency
1 July - 28 August

Tompkins, C. B., Institute for Numerical Analysis
1 July - 28 August (also during preparatory phases)

Tordella, L. W., National Security Agency
1 July - 15 July

Walters, Mrs. Laura L., National Security Agency
30 June - 28 August

Wolf, J. J., Logistics Research Project, George Washington University
17 August - 28 August

Appendix II

Budgetary data

Note regarding financial accounts

Details of actual expenditures during the session are being prepared and should be available for addition to this appendix by 1 October. There will still remain an unexpended balance to be used for computations growing directly from the SCAMP program.

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Appendix III

Expository Material Distributed to Members in Advance of SCAMP 1953

Finite Projective Planes, L. J. Paige and M. Newman, June 1953.

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Appendix IV

List of SCAMP Conferences

- No. 1 On Wired Wheels I. Marshall Hall, Jr., 2 July 1953.
- No. 2 On Wired Wheels II. Marshall Hall, Jr., 3 July 1953.
- No. 3 On Wired Wheels III. Marshall Hall, Jr., 6 July 1953.
- No. 4 Quartic Function Problem. C. B. Tompkins, 8 July 1953.
- No. 5 Problems of NSA. L. W. Tordella, 8 July 1953.
- No. 6 Problems of NSA. L. W. Tordella, 10 July 1953.
- No. 7 Problems of NSA. R. A. Leibler, 15 July 1953.
- No. 8 Problems of NSA. R. A. Leibler, 17 July 1953.
- No. 9 Wired wheel Problem. W. R. Church, 24 July 1953.
- No. 10 The Optimal Assignment Problem. H. F. De Francesco, 27 July 1953.
- No. 11 Problems of NSA. W. H. Erskine, 29 July 1953.
- No. 12 Matrix Projection Methods. A. E. Roberts, Jr., 30 July 1953.
- No. 13 Cyclic Structure Problems. S. S. Cairns, 5 August 1953.
- No. 14 Method for Finding Irreducible Polynomials over a $GF(p)$.
J. C. Koken, 7 August 1953.

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Appendix V

List of Related Lectures

A. INA lectures

1. Programming for discrete variable problems. D. H. Lehmer, 8 July and Emma Lehmer, 13 July
2. Coding for SWAC. E. C. Yowell, 7 July and 9 July.
3. Abelian difference sets. R. H. Bruck, 10 July.
4. Some properties of finite projective planes. Gordon Pall, 13 July.
5. A continuous method in a discrete problem. L. J. Paige, 20 July.
6. Projection methods in discrete problems. A. E. Roberts, Jr., 28 July.
7. A continuous manifold of quasi-solutions to a discrete problem, C. B. Tompkins, 4 August.
8. On proper solutions of the incidence equation for finite projective planes. A. A. Albert, 11 August.

B. American Mathematical Society, Sixth Symposium in Applied Mathematics, held in Santa Monica, 26-28 August 1953.

1. "Application of automatic digital computers to problems with discrete variables", C. B. Tompkins
2. "Computational aspects of certain combinatorial problems", R. H. Bruck
3. "The assignment problem", T. S. Motzkin

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Appendix VI

List of SCAMP Reports and Papers

- Some Theorems on Finite Projective Planes, Gordon Pall, 13 July 1953
- Some Simple Properties of the Incidence Equation, A. A. Albert,
21 July 1953
- A Note on Steiner Triple Systems, R. H. Bruck, 27 July 1953
- Counting by Means of the Trace, A. J. Hoffman, 27 July 1953
- A Set of Conditions to Characterize an Incidence Matrix of a FPP,
Gordon Pall, 28 July 1953
- Third and Fourth Order Rational Orthogonal Matrices with Row and
Column Sums Unity, R. A. Good and D. W. Hall, 31 July 1953
- On a Theorem of Connor, A. J. Hoffman, 5 August 1953
- The Orthogonal Multiplier for Rational Incidence Matrices, R. A. Good
and D. W. Hall, 10 August 1953
- On Proper Solutions of the Incidence Equation (Prepublication Copy),
A. A. Albert, 11 August 1953
- Further Remarks on Correlations, A. J. Hoffman, M. Newman, E. G. Straus
and O. Tausky, 11 August 1953
- Difference Sets in a Finite Group (Prepublication Copy), R. H. Bruck,
19 August 1953
- Coordinate Systems for Finite Planes, W. A. Pierce, 21 August 1953
- On Koken's Method for Checking Irreducibility, A. M. Gleason,
24 August 1953
- Rational Orthogonal Matrices with Row and Column Sums Unity, R. A. Good
and D. W. Hall, 25 August 1953
- Orthogonal Matrices and the Incidence Matrix, K. A. Bush, 25 August 1953
- Mappings, Balanced, Designs, and Orthogonal Arrays, K. A. Bush,
28 August 1953
- Asymptotic Formulas for the Mean and Standard Deviation of the Maximum
of a Sample from a Normal Population, R. P. Dilworth, 28 August 1953

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The following were written independently of SCAMP and were reproduced for the information of participants:

Orthogonal Matrices of Modular Polynomials, J. L. Brenner

Invariants Under Rational Linear Transformations, Chapter 4,
Gordon Pall

The Rational Representation of Numbers, Chapter 6, Gordon Pall

Rational Representation of Forms by Forms, Chapter 7, Gordon Pall

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Appendix VII

Copies of SCAMP Reports and Papers

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Appendix VIII

Miscellaneous Selected Correspondence and Other Records

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Appendix IX

Research Accomplishments of SCAMP

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NSA Participants for SCAMP - 1953

Dr. H. H. Campaigne	NSA-30B	-	1 month
Henry F. De Francesco	34		2 $\frac{1}{2}$ months
Dr. R. A. Leibler	34		1 month
Oscar S. Rothaus	34		2 months
Dr. Louis Tordella	34		2 weeks
Mrs. Laura L. Walters	34		2 $\frac{1}{2}$ months
Dr. J. J. Eachus	30C		2 weeks

Non-NSA Participants for SCAMP - 1953

A. Adrian Albert, University of Chicago
R. H. Bruck, University of Wisconsin
K. A. Bush, University of Illinois
Stewart S. Cairns, (CHAIRMAN), University of Illinois
Randolph Church, U.S. Naval Postgraduate School, Monterey, Calif.
A. H. Clifford, Johns Hopkins University
W. S. Connor,
R. P. Dilworth, California Institute of Technology
A. M. Gleason, Harvard
R. A. Good, University of Maryland
D. W. Hall, University of Maryland
A. J. Hoffman, National Bureau of Standards
V. L. Klee, University of Virginia
J. C. Koken, University of Illinois
Morris Newman, National Bureau of Standards
L. J. Paige, (EXECUTIVE SECRETARY), UCLA
Gordon Pall, Illinois Institute of Technology
A. E. Roberts, Jr., Engineering Research Associates
C. B. Tompkins, Institute for Numerical Analysis, NBS