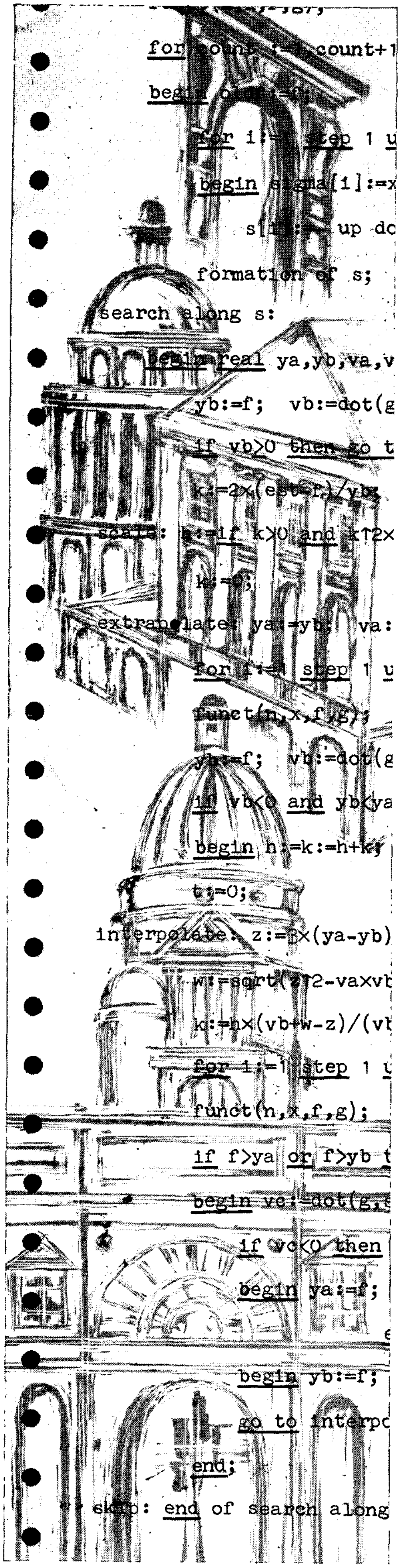

# Computer Capabilities at Western European Universities

By Aaron Finerman*

This report on the author's trip to universities in Western Europe in the summer of 1966 gives brief descriptions of computing activities at each institution visited. Present equipment capabilities vary from moderate to large scale; however, many institutions plan to acquire complex time-shared systems in the near future. In the author's opinion, the state of the art lags behind that on this continent. This lag is attributed to four principal factors: (a) the handicapping organization of academic procedures; (b) the university-government financial relationship; (c) the subordinated organization of the computing facility; (d) the paucity of professional interchange of knowledge. The effects of these constraints are explicated.

## 1. Introduction

During the summer of 1966 I had the fortunate opportunity of visiting colleagues at universities in Western Europe to discuss computing technology in general and time-sharing activities in particular. This paper is a report on some of the impressions gained during the visits.

The most comprehensive "trip" reports in recent years were by Carr et al. [1] and Willis et al. [2] after visits to the Soviet Union in 1959, and by Auerbach [3] after visiting European industrial and academic groups in 1960. These reports contain objective accounts of hardware and software characterizing Russian and European developments. Another early but less comprehensive report by Blachman [4] surveys activities in a large number of Eastern and Western European countries.

More recently the relatively few reports published by Americans mainly have been short articles concentrating on marketing and growth projections (e.g., [5, 6]). Eckert [7], reporting on the shortcomings in Russian computing technology, blames antiquated mass production techniques, communist ideology, and poor analytical methods. The latter finding is in contrast with those in [1, 2] and is also in some contrast with two reports by Feigenbaum [8], indicating either the limitations of impressions based on a short visit, or (which is less likely) extensive, country-wide technological changes occurring in the brief time between visits.

Several short articles by Europeans, that appeared in American periodicals during this period, taken together help explicate the European state of the art (e.g., [9, 10, 11, 12]).

The present report is based on a brief (June 11 to July 17) exposure to relatively few universities (see Section 2). No comment is offered on the industrial situation, which may differ materially from that prevailing in universities. Thus, the sample is limited and the report may not be taken as

* Professor of Engineering and Director of the Computing Center, State University of New York at Stony Brook.

comprehensive reflections on the state of the art in Europe 1966. The report emphasizes service aspects of the computing function, and factors contributing to the differences from the situation on the American continent. As such, the subjective generalizations of Section 3 do not apply equally well to all universities visited,[1] and may not apply at all to any specific university visited.

## 2. Universities Visited or Contacted

Before offering general conclusions, it is worth describing the computing activities at the specific institutions visited or contacted.

*Great Britain*

Imperial College (3500 students) is part of the University of London. The Computing Center, formerly under Electrical Engineering, is now a separate entity. Professor Gill, its Director, will also head the new graduate program in the computing sciences. The Center has an IBM 7090/1401 system which services both the local campus and other British universities. It anticipated acquiring a large computer, such as the CDC 6800 or IBM 360/91, to service other universities and research centers in South England, and has more recently become most interested in time sharing. However, pending clarification of government policy, its future equipment picture is clouded (see Section 3B).

University College of The University of London has approximately the same student population as Imperial College, but is not as heavily oriented toward science and technology. Under the direction of Professor Seaton, it is studying the proper organizational structure of a computing center, but has no center at present. An IBM 360/65 is scheduled for July 1966 delivery, and will be the first 65 in Europe. There are no plans for a curriculum program in the computing sciences, although various academic departments will probably offer a few basic courses.

The University of Edinburgh has no computer of its own; it uses the Imperial College 7090, and has access to an Atlas computer. The Computer Unit, headed by Professor Michaelson, now has a teaching and service function. It may develop into an academic department concentrating on research and education in the computing sciences. The recently established Edinburgh Regional Computing Center, headed by Dr. Thomas, will be located at the university but will be independent of it, reporting to a newly constituted government Computer Board with the university as one of its subscribers. The Regional Center will acquire an English Electric 745, a time-shared system similar to the GE 645 and the IBM 360/67. The University Computer Unit will develop the necessary software. (However the latter aspect had not been formalized at the time of the visit.)

*France*

The Institut Blaise Pascal, Paris, is a research institute in computing technology. Primary emphasis in its current research program is on developing an automatic character-reading machine; its present model requires manual intervention. The institute also provides computing service to the University of Paris and other colleges, and reports directly to a government agency. Its equipment consists of a CDC 3600, two IBM 1401's, and an IBM 704 soon to be replaced by an IBM 360/40. It has no plans for time-shared equipment, feeling that current paging and dynamic relocation concepts may not prove feasible.

The Institut de Programmation, Paris, is affiliated with the Blaise Pascal—by virtue of having the same Director, Professor de Possel—and also with the University of Paris. A teaching and programming research institute, with Dr. Arsac as senior professor, it offers courses for operational-technicians and programmer-analysts. Current enrollment is 160, to be increased shortly to 300 students. It has, and plans, no equipment of its own, but uses the computing facilities of the Blaise Pascal.

The University of Paris at Orsay has a small computer organization servicing the university programs in theoretical, nuclear and high energy physics, under the direction of a three-member committee from the physics researchers. Its UNIVAC 1107 will be replaced shortly by an 1108, with most applications programmed in FORTRAN. The professional staff serve as consultants to the users from the physics group. With installation of the 1108, it is anticipated that a systems programmer will be added to maintain the system and to make use of 1108 multiprogramming capabilities.

*Switzerland*

The Ecole Polytechnique of the University of Lausanne (EPUL) is a Swiss engineering and applied physics institute (2000 students). Its computing organization—in Applied Mathematics, headed by Professor Blanc—has a disk-oriented IBM 7040 servicing EPUL and the University (using the WATFOR system developed at the University of Waterloo). It plans to connect several (1050) terminals to the 7040, allowing for remote computing, as a forerunner to a future time-shared system, which it is currently evaluating. Expansion will probably extend to a 7044, possibly with a peripheral 1401, before going to time sharing. (The 7040 has no peripheral 1401; the thinking is that the peripheral, while increasing the job volume capability, also increases the turnaround time.)

The European Organization for Nuclear Research (CERN) is a multinational organization located in Geneva, performing research similar to the high energy physics program at the Brookhaven National Laboratory in this country. The computing center, directed by Mr. McLeod under Dr. Hines, has a CDC 6600. This services the general research effort and is also used for online control of experimental processes such as the HPD Flying Spot Digitizer. A CDC 3400 (acquired after installation of the 6600 but before it became operational) will be replaced shortly by a CDC 3800 which, in turn, may be replaced by a 6400 at some future date. The center has no current plans for time sharing; priority will be given to improving the remote-console, multiprogramming capabilities of the 6600. It is anticipated that the 6600 will be able to control the HPD and one other experiment (e.g., linear accelerator) simultaneously. It is felt that a small computer can not perform the control function, because of the large storage requirements. Several user departments have installed or ordered such small computers as the SDS 920 and IBM 1800 for online data acquisition; these may be connected to the 6600.

The Eidgenossische Technische Hochschule (ETH) is a federally supported institute of technology located in Zurich (5000 students). The computer center, which had been in the Institute of Applied Mathematics headed by Professor Stiefel, has now been made a separate entity under the direction of Mr. Schai. It has a CDC 1604, servicing the educational and research programs of the ETH, and, shortly, the soon-to-be-established Institute of Data Processing headed by Dr. Engeli. The Center is considering installation of a time-shared system when appropriate.

The University of Zurich has a small computer organization headed by Mr. Bauknecht, under Professor Kunzi. It is acquiring an IBM 360/40, and hopes to incorporate some time-sharing capability in this computer.

*Italy*

The University of Rome (60,000 students, many part time) has a computing group in

---

[1] In fact, cite the following by R. H. Williams from "The Current State of the Computer Field in Britain" [*Computers and Automation* (Sept. 1963), 16]:

"A report on the state of any industry is colored by a certain amount of wishful thinking and the particular position of the individual who is preparing the report.

"Too often in the past, usually intelligent individuals from American universities and other places have visited Europe and in particular Great Britain, and have then returned to the United States with very distorted views on the state of the British computer industry. There is more activity in the development and production of computers in Britain than anywhere else in the world apart from the United States, and how these individuals can ever hope to produce a true report after collecting opinions from a small number of people in a very short space of time has always puzzled us in Britain."

the Institute of Mathematics, headed by Professor Fichera, which operates in close cooperation with the Institute of Physics under Professors Conversi and Amaldi. It has an IBM 7040 (with no peripheral computer) and intends to acquire a time-shared system to service the five major scientific institutes, and possibly engineering. (The School of Engineering has a small GE computer.)

The University of Florence (5000 students) has no major computing capability except for an IBM 1620 in the Solar Astronomical Observatory headed by Professor Righini. A Preparatory Committee, with representatives from the Universities of Bologna and Padua, is studying the establishment of a time-shared regional center (that will probably be located in Bologna) to service universities in the Northwest portion of Italy. The Committee expects to complete the study by the end of 1966 and take some action by early 1967.

*Germany*

The Technical University of Berlin (10,000 students) presently has no computer. The affiliated Hahn Meitner Institute has a Zuse Z22 (see [3, 11]) and a Siemens 2002 (see [3]), in the Mathematics section, headed by Professor Haack; the Institute of Information Processing, headed by Professor Giloi, has an SDS 930, which is used mainly for simulation studies. The university expects to acquire a time-shared system and is now evaluating the GE 645, IBM 360/67 and the Telefunken TR 440. If it acquires a TR 440, it will develop its own software.

*Netherlands*

The Technical University of Delft (9000 students) has a Telefunken TR 4 (see [3, 4]) in its computing center headed by Mr. Wolbers. The Center has recommended acquisition of an IBM 360/67 by early 1968. This recommendation has been accepted by the university and is awaiting government approval.

In general, European university computers are used for the same purposes as on this continent—support of scientific research and education. They do as little administrative data processing as on this continent, but most centers visited expressed an intent to do more work in this field. Aside from CERN, none of the institutions visited was doing much work in online experimental control, and none was doing any work in computer-assisted instruction, two popular research activities in this country.

It should be noted that at all institutions (except Blaise Pascal) discussions were conducted in English. Europeans have a far better knowledge of our language than we of theirs.

## 3. General Impressions

The state of the art at individual European universities varies as widely as in the U.S. At one extreme, there was the computing specialist who indicated that his software effort is in machine language since "higher level languages are not suitable for scientific and engineering applications" (not a verbatim quote). At the other are the several sophisticated computer organizations, especially those in Great Britain (and some which were not visited, such as those in Grenoble, France and Munich, Germany).

Overall, however, the impression is that the state of the art has not progressed as far in Europe as on the American continent. While many universities are planning to acquire complex computing systems, a general naiveté as to the true complexity, limitations and unresolved problems of the machines still prevails.

Several factors contribute to this situation and make its solution difficult:

(A) Organization of academic procedures
(B) University-government relationship
(C) Organization of the computing facility
(D) Professional interchange of information.

### (A) Organization of Academic Procedures

European universities involve a faculty structure quite different from their American counterparts, pre-eminently in the allocation of faculty "chairs." In a Faculty of Science, for example, there is generally only one senior member from each scientific department, say mathematics or physics, who holds a faculty chair. This professor is in completete charge of the teaching and research programs of his department. (In many instances, there exist parallel institutes—such as an Institute of Applied Mathematics—funded by external government or private sources, but affiliated with the university, since the Institute Director also has faculty status. But in any event, only one person from a department and one from an institute are faculty members.) The faculty member may have many expert co-workers; however, since he alone directs the overall effort, it tends to reflect his principal area of interest and thus may result in narrowed channels. (See, for example, Luscher [13] for a description of the West German academic structure.) In the American system, the department chairman administers, rather than directs, his departmental effort. Other members—being faculty themselves, having tenure protection and with independent research funding support in many instances—are co-equals in academic and research matters, and exert considerable influence in the direction of these efforts. (This generalization is not true of all colleges, but does reflect the situation at most leading universities.)

The European practice has two immediate consequences. First, where a professor in the computing field has been appointed, his department (or institute) tends to specialize in a particular field of computing, say languages or simulation, rather than in the comprehensive information processing field. This practice does result in outstanding research achievements. Certainly, European universities are recognized for their contributions to such fields as simulation, numerical analysis and programming languages. (See Salton [14] for a description and comprehensive bibliography of European research in automatic documentation and information processing.) However, within any one university the research activity is directed toward a narrow field of specialization. A comprehensive knowledge of computing—embracing all of its subfields and the numerous applications in scientific and administrative processes—is usually lacking.

Second, in this environment it is quite difficult to initiate an academic effort in a new field—much more so than in the American system. Most European countries have not instituted major academic programs in the computing sciences, e.g., see Gill [15], as is becoming almost traditional in the United States. Aside from Imperial College, University of Edinburgh and Institut de Programmation, few of the universities visited had departments, institutes, or comprehensive curricula in the emerging discipline of computing. Several had isolated courses, generally elementary language courses on Algol (usually) or Fortran (rarely) in an institute of applied mathematics or physics. The absence of academic programs is matched by the lack of training for potential faculty users of computing technology. There has been little emphasis in promoting such "sales" courses. As a result there is limited use of computers (mainly restricted to the department possessing the computer); and the user community which does exist is generally less informed than its counterpart on the American continent.

It is worth noting that many universities are aware of the limitations of this more rigid academic structure, and some are attempting to take corrective steps.

### (B) University-Government Relationship

European universities operate under the control of a government agency, such as the Minister of Education. This does not affect traditional academic and research activities (within normal budgetary constraints).

However, many non-academic policies, particularly those affecting computer acquisition, may be based upon national or political factors rather than professional factors. (This situation is much less prevalent in American universities. Even in the case of public universities, special mechanisms are established specifically to protect against political pressure.)

European countries are experiencing reawakened interests in establishing national computing industries and sponsoring national computer manufacturers. This is seen most clearly in Britain. In 1965 the government requested the Council for Scientific Policy and the University Grants Committee to assess the probable five-year computer needs of universities and of civil research establishments receiving support from government funds. The resulting (1966) report [16] of the Joint Working Group, chaired by Professor B. H. Flowers, is sweeping in scope. In addition to its general recommendations, the Flowers Report refers specifically to each university affected, recommends responsibilities to be assigned to the university (e.g., that it serve as a regional center), indicates specific equipment capabilities required, assesses whether such capabilities can be furnished by English manufacturers, and recommends specific computers accordingly. In accepting the report, the government noted "In considering proposals in the Report for equipment not of British manufacture, the availability of comparable British equipment and the balance of payments, amongst other factors, will be borne in mind" [16]. Subsequently, the report's recommendation for an American-manufactured time-shared system at Edinburgh University was not followed. Instead, the English Electric 745 is to be acquired, and the university Computer Unit is looking forward to the challenge of developing the necessary software. (Some American universities would prefer to profit from the not uniformly felicitous experiences of GE and IBM efforts, by developing their own systems on a computer other than the 645 or 360/67. In such cases, however, the decision would be made by the university, based on professional recommendations.)

By contrast, the U.S. National Science Foundation in 1963 requested the National Academy of Science—National Research Council to perform a similar task to enable federal agencies to develop plans for future support of university computing activities The resulting report [17] of the Committee on Uses of Computers, chaired by Professor J. B. Rosser, was also issued in 1966. Its principal recommendations were to double the 1964 campus computing capacity by 1968, and to place special emphasis on encouraging education and research programs in the computing sciences. The report does not refer to specific universities or computers, except by example. (Unfortunately, the many outstanding qualitative recommendations in this report have not received as much attention as the conservative quantitative recommendations.)

The foregoing observation is not intended as a criticism of the European government-university relationship; it simply indicates the existence of such relationship. (Note that the U.S. has never had to adopt a national policy in computing equipment, but there are numerous instances where the government protects the national interests, by tariff and other devices.) Many (see [9]) will welcome the British government's decision as long overdue, since there are compelling reasons for taking immediate action to develop national industries. However, it is not always necessary or desirable to express nationalism by creating an entire industry. It may be wiser, in selected instances, to import the best equipment and apply national energies to the most effective and advanced utilization of such equipment. (The problems of British government policies in scientific and technological programs is discussed in *Science* [18].) The concern expressed in the present paper is that if, and as, this nationalistic trend spreads across the Continent (as now seems likely in Germany with the time-shared Telefunken 440), some universities will acquire complex computing systems that will require major hardware and software developments before becoming operational. In many cases, these universities simply do not possess the resources or experience to undertake such major efforts, and the very agencies making the decisions may give insufficient attention to furnishing the necessary resources. Consequently, the short-term effect may be a slowing-down of the European efforts, and the anticipated long-term benefits may never be realized.

### (c) Organization of the computing facility

The effects of a highly nationalistic policy are recognized as more severe when it is realized that a well-organized service-oriented computing center is rare in universities on the European continent. This situation results partly from the more rigid academic structure noted above, and partly from the relative newness of large computing systems in European universities. A service facility in a particular department or institute may also serve some portion of the broader university community, but it is primarily staffed for applications in that department. The organizational structure necessary for a dynamic computing center is lacking, the staff is generally small, technological developments are known only in general terms, and the future direction is vague.

This situation is comparable to that which existed in American universities several years ago, when it was customary to establish a small computing facility in a particular department (Mathematics, Physics, or Electrical Engineering, as is now the European practice), and head it by a faculty member with only secondary experience (or interest) in computing. It has been only recently, in many instances, that American universities have recognized the desirability of, and the need for a commitment to a university-wide computing organization, directed by a professional who reports to an official higher than a department chairman.

European universities are now coming to the same realization and are starting to study the necessary changes. The significant difference is that American universities, by and large, came to this realization during the advent of second-generation computing systems. Since then, they have been able to assemble and train well-balanced, professional computing staffs. Furthermore, these efforts have stimulated interest in initiating academic programs in the computing sciences. The academic computing staff, working in conjunction with the service computing staff, has been instrumental in developing balanced service-oriented and research/development programs. (Indeed, these programs sparked the current efforts in time sharing.) Such broad-based organizations are capable of attacking the major problems involved in preparing for and installing a time-shared computing system. Even with this basic structure the efforts will be Herculean and not always successful. (The more cynical will question the optimism of the last statement.)

On the other hand, European computing centers, with narrowly defined responsibilities, are making a quantum jump to large remote-console, multiprogrammed or time-shared systems with university-wide responsibilities; this is of special concern when the implications of the latter responsibilities have not been fully recognized. These centers may face an almost insurmountable task in trying to achieve this jump to systems which require monumental hardware and software development, while having only embryonic (although knowledgeable) computing organizations, and while lacking a comprehensive faculty in the computing sciences.

### (d) Professional interchange of information

The absence of country-wide and European-wide professional conferences is a further handicap. In this country, we take for granted an almost endless succession of such conferences: national conferences—Spring Joint, Fall Joint, ACM, DPMA; user conferences (SHARE and GUIDE attract audiences almost as large as the national conferences); regional conferences (the recent Stony Brook Conference attracted 500 participants); special interest conferences (e.g., design automation, information retrieval, reprogramming); local ACM chapter meetings; mathematical, scientific and engineering conferences; and the variety of peripheral conferences. If budgetary and time constraints were removed, some computing personnel could spend all their waking hours at conferences. As it is, most senior and some junior staff members are able to attend one or more such conferences annually.

While some may (and do) question the quality of many technical presentations, these do afford the participants an understanding of current research and operational developments. (For example, Harwell [19] notes "Although the May IFIP (1965) conference in New York was an international event, the dominant impression for me was the determined effort and progress being made by U.S. researchers and users to resolve the problems of time-sharing and to exploit the opportunities of man-machine interaction.") Of equal importance is the personal interchange among participants, with the corollary opportunity to discuss the problems and proposed solution techniques at similar organizations. (The impetus for time-sharing developments was provided in large measure by conference presentations, demonstrations and discussions.) Further, these conferences draw together people from all elements of the computing society—university, government, industry—with interests ranging from scientific and administrative applications, to programming systems and hardware technology.

The situation is clearly different in Europe where there are significantly fewer conferences and where major national or language barriers exist. While the existence of the latter barriers has been recognized for some time, their removal is still quite remote. Although English seems to be emerging as the dominant language for scientific interchange, there is a natural reluctance on the part of some groups to accept it as such. The absence of professional interchange gives rise to a parochial environment. More than one institution visited wanted to know of developments in other universities which the author has just visited. In more than one institution, plans to acquire conventional equipment were changed after visits to the United States had convinced the visitors (for right or for wrong) that time sharing was the wave of the future.

Willis [2] quotes from a Russian toast ". . . let us scientists continue to exchange information in friendship and in peace." While the latter two ingredients still prevail, the information exchange in Europe is quite muted.

## 4. Closing Comments

Lest the above observations smack of condescension and give a completely erroneous impression, I emphasize that our European colleagues are as perceptive and as committed to excellence as any in this country. In some instances they are aware of the problems they face, and are always most anxious to discuss the experiences of others in effecting solutions. This is reflected in their most gracious hospitality (for which I am indebted) and their penetrating questions. Generally, they are becoming time-sharing enthusiasts although few universities actually have ordered such systems. Hence, they were impressed to learn of the many American universities which are committed to this approach and hope to benefit from this experience. (It may be noted that at times it appeared that time sharing and project MAC were synonymous to most Europeans, and that other efforts were unknown). Unfortunately, however, too few in this country or in Europe recognize that major commitments of resources—intellectual and economic—are necessary to achieve the truly remarkable potential of time sharing.

Auerbach [3] notes ". . . there is no boundary for creative ideas; European laboratories are developing new techniques and products for the world market ranging from peripheral equipment to complete information processing systems."

Salton [14] notes, "It is well known that European work in the design and applications of computing equipment is widely underrated in the United States. . . . Conditions in Europe were found to be neither all black nor all white. Clearly, in quantity at least, the European output cannot compare with the work in this country. On the other hand, a considerable number of interesting developments are taking place."

In this light, perhaps this report's anomalies and inconsistencies reflect the fact that creative and excellent European colleagues are subject to more categories of rigid constraints than we encounter—academic structure, external control, budgetary limitations, language barriers, and the need to convince superiors that changes are necessary. These problems are universal; however, their confluence in the European community makes the solution more difficult.

This report, it should be expressly noted, is not intended to deprecate the state of computing activities in European universities or to belittle the importance of past accomplishments. Rather the observations are offered in the spirit of urging greater attention to understanding the current problems and dedicated emphasis on achieving the necessary solutions.

ACKNOWLEDGMENTS. Here I should like to make explicit my earnest thanks for the unfailing and warm hospitality offered by our European colleagues at every stage of the journey.

I am also indebted to Professor Bernard Galler of the University of Michigan and Professor Thomas Hull of the University of Toronto for their critique of the preliminary draft and their suggested modifications; Dr. Edgar Eichhorn of the Jet Propulsion Laboratory for helping to clarify the European academic process; Mr. Sol Broder of the Stony Brook Computing Center for suggesting a major restructuring of the first draft; and Mr. Lee Revens of the ACM *Computing Reviews* for his invaluable assistance.

RECEIVED SEPTEMBER, 1966

REFERENCES

1. CARR, J. W., PERLIS, A. J., ROBERTSON, J. E. AND SCOTT, N. R. A visit to computation centers in the Soviet Union. *Comm. ACM 2*, 6 (June 1959), 8–20.
2. WARE, W. H. (ED), ALEXANDER, S. N., ARMER, P., ASTRAHAN, M. N., BERS, L., GOODE, H. H., HUSKEY, H. D., AND RUBINOFF, M. Soviet computer technology—1959. *IRE Trans. EC-9* (Mar. 1960), 72–120.
3. AUERBACH, I. L. European electronic data processing—a report on the industry and the state-of-the-art. *Proc. IRE 49* (Jan. 1961), 330–348.
4. BLACHMAN, N. M. The state of digital computer technology in Europe. *Comm. ACM 4*, 6 (June 1961), 256–265.
5. JENNISON, R. E. Foreign EDP. *Datamation* (Jan. 1963).
6. GIBSON, E. D. Data processing around the eastern Mediterranean. *DPMA* (June 1963).
7. ECKERT, J. P. Computers and EDP in Russia today. *DPMA* (Sept. 1963).
8. FEIGENBAUM, E. Soviet cybernetics and computer sciences, 1960. *Comm. ACM 4*, 12 (Dec. 1961), 566–579.
8a. ——. Soviet computer science revisited. Proc. ACM 20th Natl. Conf., August 1965, ACM Publ. P-65, pp. 225–226.
9. WILLIAMS, R. H. The market in Western Europe. *Datamation* (August 1962).
9a. ——. Computers in Britain. *Datamation* (August 1963).
9b. ——. European Computer Marketing Association. *Data Processing* (Oct. 1964).
10. VOGELER, J. G. The market in Western Europe. *Datamation*, (August 1962).
11. SCHUFF, H. K. The use of computers in Western Germany. *Comm. ACM 5*, 12 (Dec. 1962).
12. DE BRUIJN, W. K. Computers and the continent. *Datamation* (Jan. 1964).
13. LUSCHER, E. Physics in West Germany. *Physics Today* (Aug. 1966), 46–54.
14. SALTON, G. Automatic information processing in Western Europe. *Science 144*, 3619 (May 1964), 626–632.
15. GILL, S. Recent computer developments in Great Britain. Proc. ACM 20th Natl. Conf., Aug. 1965, Publ. P-65, pp. 227–228.
16. FLOWERS, B. H., ET AL. A report of a joint working group on computers for research. London, Her Majesty's Stationery Office, Jan. 1966.
17. ROSSER, J. B., ET AL. Digital computer needs in universities and colleges. Publ. 123, Natl. Acad. Sci.—Natl. Res. Council, Washington D. C., 1966.
18. MCELHENY, V. K. Bolder policies for British technology. *Science 152*, 3723 (May 1966), 741–744.
19. HARWELL, J. European's view of IFIP '65. *Datamation* (July 1965).