Keynote Address

W. H. Mac WILLIAMS

MY purpose here at this conference is to provide a background, first for meetings like this on subjects dealing with computers, and second, for this particular meeting. My qualifications for keynoting are, I think, as good as those of anyone here: as far as this particular meeting is concerned, I am not now directly engaged in working on computers of the type that we are going to discuss; and the organization that I represent, the Bell Telephone Laboratories, is not in the business of making such computers. So I speak as a relatively innocent bystander.

This meeting, as your Chairman has indicated, is sponsored by the Joint AIEE-IRE Computer Committee, with assistance from the Association for Computing Machinery. It is a direct outgrowth of the successsful meeting a year ago at Atlantic City on electron tubes for computers. The Atlantic City meeting was initiated by Dr. A. L. Samuel as a representative of the Research Development Board, and was co-sponsored by the AIEE and IRE. Several factors were responsible for its success: it was timely; it permitted a thorough discussion of a small number of subjects; it brought together the divergent points of view of the manufacturer and the user; and it lasted long enough for the different points of view to be assimilated. These advantages can be obtained only rarely in the general meetings of the sponsoring societies because their large memberships include so many different interests.

These facts led Professor Brainerd to suggest the formation of the Joint AIEE-IRE Computer Committee, whose members are listed in the front matter of this book, to consider whether more meetings of the Atlantic City type should be held, and if so, on what subjects. We concluded that several subjects demanded attention, among them (1) a review of the useful results obtained from operating high-speed digital computers, (2) a comparison of the logic of these computers, (3) input and output equipment, (4) high-speed memory, and (5) choice of number system.

The first two subjects seemed to us to be the most urgent, and led us to arrange this meeting. We hope that you will tell us whether you too feel that such meetings are desirable, and that you will indicate in a positive way which subjects you consider most important. The start of this meeting is clearly too early to ask for your opinions, but after the meeting is over please let us have your views. We have arranged this meeting for *you*; let us know how you feel about it.

Now let's be more specific about *this* meeting.

A review of life in the field of large-scale digital computers will make it clear how timely this meeting is. Let me point out four phases of life in this field through which you have all passed, more or less together.

The phases were preceded by a period of pioneering, in which a relatively small number of people developed computers such as the ENIAC and the MARK I calculator.

The first phase I have called the future, or building, or talking phase. The common denominator was a remark somewhat like this: "What a wonderful critter our computer is going to be."

The second phase is what might be called the subjunctive, or debugging, or possibly the silent phase. The remarks that people made in this phase were, "It sure would be nice if we could get this thing to work."

The third phase is the present, or working, or bright-look phase, and the remarks that people made at this time were, "Our computer is working now, but we haven't had enough experience to judge it properly."

The fourth I have called the past or getting-results phase. This again is a talking phase, and people tend to say nowadays, "It has been working fine; we are glad we built it, but we wish we had done this and this instead of what we actually did. However, we are going to fix that in our new model, and besides we are going to make it a lot simpler and more reliable."

It is because of this latter phase that we have scheduled this meeting now. Computer people have had enough experience to judge the large machines that they have produced, and it is appropriate to take stock now, before people get too far along on the new round of machines which is being started.

We may now state formally the purpose of this meeting: namely, to assess the adequacy of the designs of present working high-speed digital computers in order to point out the direction in which computer design should go, to make computers best for the jobs that they have been doing and for the jobs that they will have to do.

This is basically an engineering or design objective, but it is clear that it also involves the users in an important way. This is a meeting of both builders and users, all of whom are actively interested in the field. It is a topical meeting because many people are looking around and deciding how to make new machines, for both civil and military purposes.

A sensible assessment of the computers requires a study of their comparative anatomy; that is, a comparison of the logics of their design. Summaries of logic have been included in the indiviual papers.

Published material in this field has been rather sparse. Only a few machines have been well written up in material available to the general public. An important objective of this meeting has been to provide published proceedings that will be available to everyone. Much of the material on detailed subjects such as logic will be presented in abbreviated form, but the written material for the proceedings has not been cut. We have aimed to make the published proceedings a record of the characteristics and usefulness of new operating high-speed computers.

Most of the papers in this meeting are devoted to computers which are now in use. It has been our aim to combine the points of view of the builder and the user. In the case of the UNIVAC, we have papers by both the designer and the user, since they are separate groups. There have been two cases where we have not been able to follow this practice. In the case of the Harvard MARK III calculator, we have information from the user only, since the designer has already spoken at length about this machine. And in the case of the ERA-1101, we have information from the builder only, because the user is not free to talk about his classified applications.

There are three papers on the program that do not relate directly to individual machines.

First, there is a report by one of the most prominent users of computing equipment, which will deal with en-

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gineering applications of computers. This report will be given by Mr. C. R. Strang of the Douglas Aircraft Company.

There also is on the program a paper on the application of transistors to digital computation, since these devices have tremendous possibilities for cutting down power consumption, computer size . . . . I had better stop myself before I give you a sales talk. The paper will be presented by Mr. J. H. Felker.

An important objective of this meeting is to indicate desirable design trends. To assist in this objective and to start general discussion, the last paper will be a summary of the material presented and a forecast of the future of computers, by Mr. J. W. Forrester.

One could say really that we have been optimists to schedule a meeting like this. We feel that in addition to keeping computer engineers employed—in itself a praiseworthy objective—a great deal of worthwhile experience has been obtained from the perhaps $30,000,000 that have been spent so far on large high-speed digital computers. It is important to get the most out of the experience resulting from this large amount of work, so that our new machines can be made as good as possible.

We hope that this meeting will enable you to do just that. Please let us know how you like the meeting and what suggestions you have for other similar meetings.

The UNIVAC System

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Organization of the UNIVAC System

IN March 1951, the first UNIVAC* system formally passed its acceptance tests and was put promptly into operation by the Bureau of the Census. Since the UNIVAC is the first computer which can handle both alphabetic and numerical data to reach full-scale operation so far, its operating record and a review of the types of problems to which it has been applied provide an interesting milestone in the ever-widening field of electronic digital computers.

The organization of the UNIVAC is such that those functions which do not directly require the main computer are performed by separate auxiliary units each having its own power supply. Thus the keyboard to magnetic tape, punched card to magnetic tape and tape to typewritten copy operations are delegated to auxiliary components.

The main computer assembly includes all of those units which are directly concerned with the main or central computer operations. A block diagram of this arrangement is shown in Figure 1. All of the elements shown are contained within the central computer casework except the supervisory control desk (*SC*) and the Uniservos,* to which the lines in the upper right section of the diagram connect.

The supervisory control, in addition to all the necessary control switches and indicator lights, contains an input keyboard. Also cabled to the supervisory control is a typewriter which is operable by the main computer. By means of these two units, limited amounts of information can be inserted or removed either at the will of the operator or by the programmed instructions.

The input-output circuits operate on all data entering or leaving the computer. The input and output synchronizers properly time the incoming or outgoing data for either the Uniservos (tape devices) or the supervisory control devices. The input and output registers (*I* and *O*) are each 60 word (720 characters) temporary storage registers which are intermediate between the main computer and the input-output devices.

The high-speed bus amplifier is a switching central through which all data must pass during transfer between any arithmetic register and the main memory or between the memory and the input-output registers. The arithmetic registers are shown along the bottom of diagram each connected to the high speed bus system.

The *L*-, *F*-, *X*-, and *A*-registers are each of one word or 12-character capacity and are directly concerned with the arithmetic operations. The *V*- and *Y*- registers are of 2- and 10-word capacity, respectively. They are used solely for multiple word transfers within the main memory. Associated with the arithmetic registers are the algebraic adder (*AA*), the comparator (*CP*), and the multiplier quotient counter (*MQC*).

* Registered trade mark.

Addition-Subtraction Instructions

The addition-subtraction operations are performed in conjunction with the comparator since all numerical quantities are absolute magnitudes with an algebraic sign attached. Before either an addition or subtraction is performed, the two quantities, one already in the *A*-register and the other either from the memory or from the *X*-register, depending upon the particular instruction, are compared for magnitude and sign. The adder inputs can then be switched so as always to produce a noncomplemented result for any operation. The choice of adder input arrangement is therefore under the control of the comparator. The comparator also determines the proper sign for the result according to the usual algebraic rules.

One additional function performed by the comparator for addition and subtraction is to control the complementer. This determination is based upon which operation (+, or −) is indicated, and, whether the signs are like or unlike. For a subtract instruction, the sign of the subtrahend is reversed before entering the comparator. The comparator then compares the signs of the quantities in order to

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The UNIVAC System has been an over-all company project and hundreds of people have participated. It is, therefore, difficult to acknowledge the contributions of individuals. However, special mention must be made of the contributions of Mr. H. Lukoff, Mr. E. I. Blumenthal, Mr. L. D. Wilson, and Mr. J. D. Chapline, Jr. To the Census Bureau a great debt of gratitude is owed for their continuous support of this project.