88[Z].—WERNER BUCHHOLZ, editor, *Planning a Computer System*, McGraw-Hill Book Company, Inc., New York, 1962, xviii + 322 p., 23 cm. Price $9.75.

The conception, design, simulation, operational details, and finally the limitations that must be accepted in the creation of a very large and powerful logical machine, STRETCH, are documented in a satisfyingly complete and thorough manner in this volume of more than 300 pages. Much of the material has appeared in the form of journal articles elsewhere, but this bringing together of the many considerations that entered into this mammoth undertaking provides the serious student of systems design with a compact, concise, and convenient handbook of valuable and workable ideas.

It is strongly recommended that this volume be studied and kept as a shelf reference by any who would be conversant with the latest techniques of computer organization—and this includes programmers as well as logicians. This first group would surely find writing routines for such a magnificently endowed machine a tremendous challenge and stimulating experience. Surely only the truly first-rate members of the profession can accept this challenge and learn to make use of the facilities so carefully provided by the designers.

Project STRETCH, as the book is sub-titled, is a welcome library addition for all of these reasons, and still more so as a volume to record, for easy distribution, the key ideas and developments in a remarkable achievement of a dedicated team.

The book never glosses over difficulty, and with remarkable candor acknowledges wherever design goals could not be met.

Chapter 1 traces the history and gives the design objectives for the project, and gives some indications of how well these were, or were not, met. Chapter 2, entitled Architectural Philosophy, presents a most intelligent approach to satisfying the conflicting needs of a variety of potential users. Chapter 3, entitled System Summary, presents enough of the characteristics of the STRETCH to make it sound like an exciting machine to have at one's disposal. The FORTRAN influence is quite evident.

Chapter 4 begins the detailed technical presentation with a discussion of why "words" are made of variable numbers of "bytes" rather than a fixed length, as is more common. Chapter 5 is a perhaps unnecessary rationalization of the old "bits versus digits" or "binary versus decimal" dichotomy. For the initiated, who are sufficiently computer wise to appreciate Project STRETCH, it is needless to belabor the point. Chapter 6 presents an interesting discussion of the character-set choice, including a fine awareness of the multiple-faceted implications which are not as obvious as those in Chapters 4 and 5. One comes to the conclusion that it is indeed unfortunate that the computer-user, i.e., programmer-expert, will rarely read and appreciate such design-viewpoint computer "biographies" as this, missing the insights into the design procedures, the often difficult choices and elegant solutions which render to them many extra conveniences. Many of these are often taken lightly, ignored, or rarely appreciated and used, in optimizing machine usage. The search for the ultimate, the effort to attain logical perfection, is again illustrated in the discussion in Chapter 7 of the variable-field-length operational feature. Aesthetics and utility meet when it is shown how 16 Boolean connectives were furnished at little more than the price of a "basic set" of four. We have here a

beautiful example of the futility of eliminating an innovation on the basis of its probable cost or utility. How much better to let it be found both valuable and easy by actual trial and usage. What use has been, or will be, made of an evidently powerful Boolean data-handling facility may determine whether whole new areas are to be opened to mechanization or whether it is an essentially superfluous "frill", put in before its time!

The discussions of floating-point arithmetic, and particularly the Noisy Mode in Chapter 8 are of above-average interest to the analyst. Chapter 9 details the machine-language instruction formats, including the relationships to earlier machines and to automatic programming requirements. Chapters 10 and 11 show the complexities and intricacies that arise in attempting to implement the flexibility and speed of STRETCH, with particular reference to program-interrupts, multiprogramming, and indexing.

The general philosophy and some discussion of details of Input-Output Control occupy Chapter 12. Flexibility, speed, simplicity-in-complexity, and refraining from "freezing" the system to today's hardware again pervade this chapter. In Chapter 13 a closer look is taken at Multiprogramming, its needs and advantages. The balancing of features in the supervisory executive routine vis-à-vis hardware is well presented. Chapter 14, the Central Processing Unit, emphasizes the organization of hardware to achieve a performance gain of several orders of magnitude over that achievable by component technology alone; i.e., the effective 0.5 μsec interval of memory access with a 2.1 μsec memory cycle; the simultaneity approach in the Exchange, disk synchronizers, C. P. U. overlapping of up to 11 instructions by use of its sub-computers (Instruction Unit, Look-Ahead, Main Arithmetic Unit with a serial and a parallel unit); strictly binary multiply and divide with subroutines for decimal; multiplexing of every imaginable kind to achieve extreme speeds; retaining accuracy by parity checks with one-bit error correction on transfers and duplication, parity and "casting out three's" on arithmetic. The total hardware to realize this Central Processing Unit includes 170,000 transistors, consumes 21 KW of power, and attains average speeds of 1.5 μsec for Add, 2.7 μsec for Multiply, and 9.9 μsec for Divide.

Chapter 15 focuses in greater detail on the Look-Ahead portion of the Central Processing Unit, describing its behavior in providing maximum computer utilization despite work-load peaks, which cause conflicts between the Arithmetic Unit and Input-Output memory access demands. Despite its very complex overlapping and non-sequential completion of parts of several instructions, the logic must function so as to appear perfectly sequential, to the user who writes the instruction program! The actual configuration and relationships between Look-Ahead complexity, the Arithmetic Unit speeds, and memory unit access restrictions were arrived at with the help of simulations on the IBM 704 and timing comparisons of five typical problem types with the various C. P. U. configurations. Obvious savings of time by giving maximum control of input-output to the Exchange, guessing "no-branch" on conditional transfers, and "forwarding" data from common memory-address references are described. The implications of "yes" on a branch instruction, or any "interrupt", are discussed under the "housecleaning" mode.

A more detailed description of input-output control follows in Chapter 16, devoted to the Exchange, which is a highly specialized, fixed-program computer

with its own 1 μsec memory. Finally, the book concludes with Chapter 17, a discussion of non-arithmetic data processing, i.e., byte streaming through the table look-up, statistical aid, and adjustment units of the 7951 auxiliary computer to the 7030 STRETCH. With tape units furnishing up to 140,000 64-bit words per second, a rate of approximately 3.3 million bytes per second is achieved for merging, sorting, searching, or file maintenance.

In summary, a wealth of information, a candid view of practical solutions to grand concepts, and an insight into the philosophy of large computing machine design are all to be found herein. It is a readable and highly worth-while book for those whose interest in computers extends beyond the "where" and "when" to the "how" and "why" they are what they are!

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89[Z].—S. WINOGRAD & J. D. COWAN, *Reliable Computation in the Presence of Noise*, M. I. T. Press, Cambridge, Massachusetts, 1963, xiv + 112 p., 24 cm. Price $5.00.

Reliable computation in the presence of noise, meaning errors in the machine, is a problem of increasing interest as we come to depend more and more upon computers which we are not in a position to repair immediately.

The authors consider not only the construction of reliable machines from unreliable components, but also the effects of errors in the basic wiring. The treatment is mathematical and reasonably precise as opposed to past speculations by philosophers on these matters.

Behind all the search for a theory to enable us to construct reliable machines is the fascinating fact that we ourselves seem to be constructed with an unreliable nervous system whose individual components seem to die at a surprisingly high rate. We are each of us apparently a living proof that reliable large scale operation can be achieved from unreliable components, and it naturally is of considerable interest to us to learn about possible models of how we might be constructed. The authors wisely refrain from too much premature speculation in this area, but almost every reader will do his own anyway.

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