ESD ACCESSION LIST
ESTI Call No. 70367
Copy No. 1 of 2 cys.
FILE COPY

ESD-TR-70-204

M69-65

ANNOTATED MICROPROGRAMMING BIBLIOGRAPHY

Microprogramming Group

JULY 1970

Prepared for

DIRECTORATE OF PLANNING AND TECHNOLOGY
ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
L. G. Hanscom Field, Bedford, Massachusetts

ESD RECORD COPY
RETURN TO
SCIENTIFIC & TECHNICAL INFORMATION DIVISION
(ESTI), BUILDING 1211

Project 700A
Prepared by
THE MITRE CORPORATION
Bedford, Massachusetts
Contract F19(628)-68-C-0365

This document has been approved for public release and sale; its distribution is unlimited.

AD0709765

When U.S. Government drawings, specifications, or other data are used for any purpose other than a definitely related government procurement operation, the government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

Do not return this copy. Retain or destroy.

ESD-TR-70-204

M69-65

ANNOTATED MICROPROGRAMMING BIBLIOGRAPHY

Microprogramming Group

JULY 1970

Prepared for

DIRECTORATE OF PLANNING AND TECHNOLOGY
ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
L. G. Hanscom Field, Bedford, Massachusetts

Project 700A
Prepared by
THE MITRE CORPORATION
Bedford, Massachusetts
Contract F19(628)-68-C-0365

This document has been approved for public release and sale; its distribution is unlimited.

FOREWORD

This report was prepared by The MITRE Corporation, Bedford, Massachusetts, under Air Force Contract No. F19(628)-68-C-0365. It carries MITRE Project No. 700A. There is no Air Force System, Project or Task Number assigned. The report is a bibliography which provides an indexed, annotated list of publications related to the field of microprogramming. It covers the period from 1951, when the term was introduced, until the present time.

REVIEW AND APPROVAL

This technical report has been reviewed and is approved.

Robert P. Savoy

Robert P. Savoy
Electronics Engineer
Development Engineering Division
Directorate of Planning & Technology

ABSTRACT

This bibliography provides an indexed, annotated list of publications related to the field of microprogramming, from the introduction of the term in 1951 to the present time.

ACKNOWLEDGEMENT

Documents for this bibliography were collected by Thomas Berschback and Nancy Anschuetz. A number of entries were obtained from the bibliography published by John Douglas, General Electric, Phoenix, in the SICMICRO Newsletter, Vol. 1, No. 2.

After initial review by Thomas Berschback, revisions were made by Robert W. Cornelli, Robert G. Curtis, Barbara J. Huberman and Codie S. Wells.

The KWIC index program used was prepared by William Amory.

Editorial control was exercised by Thomas Berschback throughout most of the preparation process.

TABLE OF CONTENTS

SECTION I

INTRODUCTION

This bibliography provides an indexed, annotated list of publications related to the field of microprogramming, from the introduction of the term in 1951 to the present time.

This bibliography has been winnowed to exclude publications related only to the technological aspects of the memories, whether read-only or read-write, used to implement microprograms.

Section II is the annotated bibliography. Entries are organized alphabetically, by first author. Otherwise unidentified quoted sections are taken from the paper.

Section III contains a computer generated index, which provides access to bibliography entries by:

1. Key words in titles.
2. Authors' names.
3. Date of publication.

SECTION II

BIBLIOGRAPHY

(1)
ALLEN-BABCOCK COMPUTING, INC., "Information outline: Remote-access time-sharing system".

This sales brochure for ABC briefly describes their time-sharing system. Their 360/50 "...has been modified by the attachment of a second Read-only-store (ROS) which contains additional operation codes...performs operations such as list searching, evaluation of PL/I expressions, floating decimal arithmetic, and various utility functions, all of which result in the fastest interpretive system in existence."

(2)
ALLEN, M. W.; PEARCEY, T.; PENNY, J. P.; ROSE, G. A. and SANDERSON, J. G., "CIRRUS, An economical multiprogram computer with microprogram control", *IEEE Transactions on Electronic Computers, Vol. EC-12;* December 1963, pp. 663-671.

Machine: CIRRUS

CIRRUS, constructed in 1963 at the University of Adelaide, Australia, is a general-purpose computer built for test purposes and is not being produced. Some mention is made of microprogramming, but only as a mechanism which allows certain operations to be handled with more efficiency.

(3)
AMDAHL, L. D., "Microprogramming and stored logic", *Datamation, Vol. 10, No. 2;* February 1964, pp. 24-26.

Machines: Thompson Ramo Wooldridge 133 (now the Bunker-Ramo 133),
Packard-Bell 440, Collins 8401

"Microprogrammed computers basically differ from conventional computers in that the equivalent of a single instruction in a conventional computer is often a subroutine (interpreted instruction) in a microprogrammed computer." In such computers a program can be considered a calling sequence. The calling sequences of the machines listed above are described to show how the control sequences are simplified and more flexibility is allowed through the use of microprogramming. The cost of additional execution time is compared with the flexibility provided by microprogramming and the time saved in executing some complex instructions.

(4)
BAILEY, S. J., "Faster computer control with a read-only memory", *Control Engineering, Vol. 14, No. 8;* August 1967, pp. 65-68.

Machine: Interdata 3

This article presents several applications of Interdata 3 computers with special microprograms implemented to achieve significantly improved efficiency. The author claims that the use of read-only memories makes the use of small computers (like the Interdata 3) practical for application to process control problems.

(5)
BASHKOW, T. R.; SASSON, A. and KRONFELD, A., "System design of a FORTRAN machine", *IEEE Transactions on Electronic Computers, Vol. EC-16, No. 4;* August 1967, pp. 485-499.

"The authors suggest an approach to the use of algebraic languages, by means of hardware interpreter. A design is presented for the construction of a machine for the execution of a subset of FORTRAN consisting of arithmetic assignment, GO TO, computed GO TO, arithmetic IF, PAUSE, DO, CONTINUE, unformatted READ and WRITE, END and DIMENSION statements. Although such a machine has not been constructed, the authors make it clear that such construction is feasible. State diagrams are given for some of the most important circuits, and the hardware implementation is given for one of these circuits."

Computing Reviews; January 1968,
#13,542, p. 63.

(6)
BAZERQUE, G.; FERRIE, J. and HUGOT, P., "Micromachine universal structure study oriented to computers simulation", *Preprints of papers presented at IFIP Congress 68, Edinburgh; Booklet D: Hardware I,* pp. D103-D107.

Machine: IBM 360/30

This article, originally in French and only roughly translated, addresses the design of a general-purpose or universal system to simulate any microprogrammed computer. As an example, a simulation of an IBM 360/30 is presented - a convenient choice because both the micromachine and the 360/30 contain 32 bit words. The authors note that the quality of the simulation is greatly enhanced by such matching where possible. The simulation of the 360/30 includes representations of general registers, instruction location counter and core memory, but not the I/O operations.

(7)
BEELITZ, H. R.; LEVY, S. Y.; LINHARDT, R. J. and MILLER, H. S., "System architecture for large-scale integration", *AFIPS Conference Proceedings;* FJCC 1967, pp. 185-200.

Machine: LIMAC

This article describes an approach for simplifying the control structure of a machine which utilizes the benefits of large-scale integration (LSI). "This evolutionary development has gone from conventional machine design first to a one-dimensional functional control partitioning (the register machine) and then to a two-dimensional elementary operation formatted control partitioning (the LIMAC machine)."

The two "dimensions" are: information transfer and data processing execution. Use of this structure "...leads naturally to the elementary operation (EO) format of control (also known as microprogramming)." In LIMAC (Large Integrated Monolithic Array Computer), a machine instruction is executed by performing a sequence of microinstructions. First, the operands are transferred into a function module, then another transfer operation passes the control word into a register to specify the execution.

(8)
BECK, L. and KEELER, F., "The C-8401 data processor", *Datamation, Vol. 5, No. 2;* February 1964, pp. 33-35.

Machine: The Collins Radio C-8401

The C-8401 is "...a stored program, intermediate scale digital computer...a microprogrammed data processor...communications oriented." The 1024 word, 36 bit micro-memory, though non-destructive, "...may be conveniently loaded under operator or program control."

(9)
BENJAMIN, R. I., "The Spectra 70/45 emulator for the RCA 301", *Communications of the ACM, Vol. 8, No. 12;* December 1965, pp. 748-752.

Machine: RCA Spectra 70/45

The author, with startling brevity, discusses the concept of emulation, describes the RCA 301, the RCA Spectra 70/45 and its micromachine and the emulation process as applied to emulating the RCA 301.

"A micro-program simulation (i.e. emulation) is invariably more efficient than a macro-program simulation, since the simulation is being performed at the point of least difference between the computers."

(10)
BILLING, H. and HOPMANN, W., "Mikroprogramm-Steuerwerk", *Elektronische Rundschau Nr. 10;* 1955, pp. 349-359.

This paper, tutorial in nature, describes microprogramming as Wilkes defines it, and discusses read-only memory technology. In the original German.

(11)
BLANKENBAKER, J. V., "Logically micro-programmed computers", *IRE Transactions on Electronic Computers, Vol. EC-9;* June 1960, pp. 103-109.

"Simple computers exploiting the concepts of simulation and microprogramming are described. Logical rather than arithmetic microprogramming operations are employed for generality and greater simplicity. Design techniques are given for computers employing only multiple-bit time delays (i.e. no flip-flops or toggles are used)."

SICMICRO Newsletter, Vol. 1,
No. 2; August 1969, p. 10.

(12)
BORSCHEV, V. B.; VASILEVSKIY, P. L. and KHOMYAKOV, M. V., "A programming micro-language for Ural-4", *Kibernetika, No. 6;* 1966, pp. 47-49 (Russian).

Machine: Ural-4

"The usefulness of developing a programming language for Ural-4 is justified. The following conditions are formulated which must be satisfied by the programming micro-language for Ural-4 and its translator: a substantial reduction of the programmer's work (compared to manual programming); the quality of programs constructed by the translator is not poorer than that of programs written by hand; the training of programmers with a good knowledge of Ural-4 should not exceed several days; the language admits of readjustment, extension, and inclusion in the automatic programming system; translation from other programming languages to the proposed one is simpler than translation to machine language; the work of programming the translator for this language should be minimal. The following basic properties of the microprogramming language for Ural-4 are pointed out: the instruction system coincides with that of Ural-4; the instructions consist of the operation code and certain names -- alphanumeric words -- used for locating the numbers taking part in the operation; symbolic addressing is used; the program can be divided into rows (connected sequences of instructions, joined by a single condition for execution); block programming is applied. An exact description of the language, its syntax, and the translation rules are not given."

G. V. in *Cybernetics Abstracts, No. 9;* 1967.

(13)
BOUTWELL, E. O., Jr., "The PB 440 computer", *Datamation, Vol. 5, No. 2;* February 1964, pp. 30-32.

Machine: PB 440

The PB 440 is described as a microprogrammed computer with two applications: (1) as a control and arithmetic element in real-time systems, and (2) as a high performance calculator for general scientific purposes. The author states that a microprogram is much faster than a conventional subroutine.

Access to the read-only memory in the PB 440 is one microsecond, while the cycle time of the main memory is five microseconds.

(14)
BOUTWELL, E. O., Jr. and HOSKINSON, E. A., "The logical organization of the PB 440 microprogrammable computer", *AFIPS Conference Proceedings;* FJCC 1963, pp. 201-213.

Machine: PB 440

One of the original motivations for designing computers with a microprogramming control feature was to enable the programmer to direct the computer at a lower level of control than was possible with conventional, wired-logic computers. The logical structure of the PB 440, which fulfills this lower-level control requirement, is the topic of this paper.

The paper describes the general characteristics of the computer and also the different types of micro-instructions available. Included in the micro-machine is an automatic instruction counter, the P register.

An early time-saving characteristic, that of being able to initiate a read operation before finishing a restore operation in the main memory, is also introduced with the PB 440.

(15)
BREUER, M. A., "Adaptive computers", *Information and Control, Vol. 11, No. 4;* October 1967, pp. 402-422.

This paper discusses several possibilities for graceful degradation in adaptive computers. Graceful degradation occurs when a computer can continue to function, at some loss of accuracy or speed when a portion of the hardware is malfunctioning.

The author suggests the use of microprogramming: an alternate microprogram, not affected by a particular set of component failures can perform the failing function - at the cost of memory space.

(16)
BRILEY, B. E., "Picoprogramming: A new approach to internal computer control", *AFIPS Conference Proceedings*; FJCC 1965, Part I, pp. 93-98.

Picoprogramming recognizes a "correspondence between the pulse-programming requirements of a control section and the capabilities of a memory element known as MYRA. A MYRA memory is a MYRiAperture ferrite disk which, when accessed, produces sequential trains of logic-level pulses upon 64 or more otherwise isolated wires."

The main advantage of picoprogramming is that no clock is needed because each MYRA disk, as it completes its switching, causes the next instruction to be obeyed.

(17)
BUCKINGHAM, B. R. S.; CARTER, W. C.; CRAWFORD, W. R. and NOWELL, G. A., "The controls automation system", *Sixth Annual Symposium on Switching Circuit Theory and Logical Design;* October 1965, pp. 279-288.

Machines: IBM 360 Systems, Models 40, 50, 65 and 67.

"This paper discusses the specifications, programming implementation, and use of a design automation system that can be used in the development of any computer having read-only storage (ROS) controls.

This system, called the Controls Automation System (CAS), designed concurrently with the IBM System/360 was used in the development of Models 40, 50, 65 and 67. The current version of CAS is used by IBM to aid in the design of all systems with ROS controls.

The newly developed elements of this system are: 1) a programming language for describing the data flow of a machine; 2) a program for translating a variety of microprogramming languages into a common one, and 3) a set of computer programs enabling the machines operation to be simulated on an IBM 7090/1401 computer."

(From the paper)

(18)
CALHOUN, R. C., "Diagnostics at the microprogramming level", *Modern Data, Vol. 2, No. 5;* May 1969, pp. 58-60.

Machine: RCA Spectra 70/35

Diagnostic procedures for the RCA Spectra 70/35 are implemented with a special diagnose instruction, which allows the execution of individual microinstructions ("elementary operations" or "functions") directly from main memory.

Two approaches to diagnostic procedures are discussed, both based on the use of the diagnose.

The first method involves testing at the instruction level until a problem occurs, then switching control over to the diagnose instruction. Major drawbacks to this approach are that: 1) sometimes the incorrect instruction cannot be isolated, and 2) the number of registers and the size of the instruction repertoire makes the number of possibilities to be tested prohibitively large.

The second method is a building block approach, in which testing is accomplished completely at the function level. For example, the transfer bus is tested after assuming the reliability of two registers. Then, if the transfer of information from one register to the other fails, the transfer bus should be at fault. The routine will continue if the transfer information is valid. The aim of the diagnostic routine is to isolate and test as few unknowns as possible at one time to better pinpoint a malfunction.

(19)
CAMPBELL, C. R. and NEILSON, D. A., "Micro-programming the Spectra 70/35", *Datamation, Vol. 12, No. 9;* September 1966, pp. 64-67.

Machine: RCA Spectra 70/35

A concise paper on the advantages of microprogramming in the Spectra 70/35. The 70/35 elementary operations, which include register-to-register and variable operations, are discussed with an example given of the microprogram for the SS format MOVE instruction. This paper emphasizes the practicality of the read-only memory design method for both user and manufacturer.

(20)
CHU, Y., "A higher-order language for describing microprogrammed computers", University of Maryland Computer Science Center, Technical Report 68-78; September 1968.

Mr. Chu defines a microprogram as a series of binary numbers linked together. He has developed an ALGOL-type symbolic language to describe microprograms. This paper introduces the language by describing as an example a serial complement sequence using both normal computer techniques and microprogrammed control.

The difference between sequential logic control and microprogrammed control is (in this particular system) a trade-off between time and flexibility. Normal control in the example requires four elementary operations, microprogramming requires six. However, the latter allows flexibility because each bit in the instruction word can cause one micro-operation to be executed. Because of this opportunity for paralled operations, only three instruction words are actually needed.

Two drawbacks appear in this specific microprogram. Considerable time can be lost in addressing the control memory; and the multiplicity of micro-operations would require very long control words. Trade-offs are possible, but at the cost of the full flexibility of the bit-per-operation concept.

A simulator has been constructed to test this higher-order language and a print-out is provided.

(21)
CONROY, E. D., "Microprogramming", *Preprints of papers presented at 16th National Meeting of the ACM*; Los Angeles, September 5-8, 1961.

Machine: IBM 7950 System

E. D. Conroy defines microprogramming as the "direct control by the programmer of more than one echelon in the hardware hierarchy." Microprogramming allows the programmer direct control over the elementary operations.

Only the abstract and summary of the paper is presented.

(22)
CONROY, E. D. and MEADE, R. M., "A microinstruction system", *Preprints of papers presented at the 16th National Meeting of the ACM*; Los Angeles, September 5-8, 1961.

This paper describes a computer organization in which only the more complex operations (for example, variable length add) exist as instructions. Each such (primary) instruction is followed by some microinstruction words (up to 256) which specify microinstructions (for example, load accumulator with zero) and the conditions which must exist in order for these instructions to be executed. If such a condition arises, the execution of the primary instruction is interrupted to permit execution of the microinstruction depending on the conditions.

In this brief summary, discussion of the technique is omitted.

(23)
CONTI, C. J.; GIBSON, D. H. and PITKOWSKY, S. H., "Structural aspects of the System/360, Model 85", *IBM Systems Journal, Vol. 7, No. 1;* 1968, pp. 2-21.

Machine: IBM 360/85

This paper has as its purpose the introduction of the IBM 360/85, both in design and performance, and assumes knowledge of the IBM 360 system.

The first section deals with the design of the computer, and introduces a high-speed buffer called a cache. The cache provides for more storage space in the main memory by holding those portions of main storage that are currently in use.

(24)
DECISION SYSTEMS, INC., "Interim status report No. 1", TR 517-1; August 11, 1968.

The ideal computer, according to this article, is one that must be able, via microprogramming, to encompass a variety of instruction sets and provide an easy means of switching these sets. Such a system could have the capability of general emulation.

To attain this goal, this interim report studies the standardization of microprogramming techniques and attempts to incorporate these benefits: 1) ease of microprogram preparation and the ability to load a control memory with different microinstructions in the field, 2) designing compilers and check-out systems for the microprogram, 3) create better debugging devices for microprograms, and 4) create an "ideal" logic simulator which analyzes instruction sets before they are committed to hardware.

The theoretical microprocessor would have three major units, each able to function independently. They are an internal processor, a main memory controller, and an I/O controller. Each of these units would be controlled by the read-only control memory. A description of the read-only memory and the planned microinstruction format is also given.

(25)
DREYER, L., "Principles of a two-level memory computer", *Computers and Automation, Vol. 17, No. 5;* May 1968, pp. 40-42.

Machine: Elbit 100

This paper describes the Elbit 100 computer. It argues the merits of a two-level memory computer, one level of which is the normal storage unit, while the other is a read-only memory. A speed increase due to the read-only memory occurs not from faster computing circuits, but from operational instructions built into the hardware for more efficient sequences of orders.

A good schematic diagram of a read-only memory control is included in the article. One memory is a standard random-access core store with a two microsecond cycle time while the other is a microprogrammable read-only store with 400 nanoseconds access time. The Elbit 100 has perhaps the simplest micro-machine of any existing computer.

(26)
EMELYANOV-YAROSLAVSKY, L. B. and TIMOFEEV, A. A., "Microprogram control for digital computers", *Proceedings IFIP Congress 62;* pp. 567-569.

This brief but excellent article provides a description of micro-instructions (the author terms these micro-orders), the information that each micro-instruction must contain, and some of the applications of microprogram control.

The three types of information required are: (1) operational, which controls the execution of a statement; (2) address information, which in some manner contains the address of the next micro-instruction; and (3) time information, which determines the processing time of the micro-instruction.

Under the heading of applications, the author's main point is that microprogram control can execute complex operations more efficiently by enabling the programmer to take into account the special properties of the algorithm, as well as using simpler circuits to generate the control circuit.

Finally, the author hypothesizes that two or more microprogram control computers can work together efficiently.

(27)
FLYNN, M. J. and MACLAREN, M. D., "Microprogramming revisited", *ACM Conference Proceedings;* 1967, pp. 457-464. (Essentially identical to the Argonne National Laboratory internal document Technical Memorandum No. 134, dated 1 June 1967, same title and authors.)

As in many of the better technical papers, the authors early and concisely state their aims:

> It is the objective of this paper to briefly trace the history of the idea (microprogramming) and the difficulties involved with defining or implementing it. In doing this, we first consider the general control problem and instruction formats. Next, storage implementations of the control function are considered and a restricted definition of microprogramming is proposed. This is then evaluated from a technological, architectural and programming point of view. We hope to show that our (demanding) definition of microprogramming is now technologically feasible and attractive from systems consideration.

In addressing these objectives the authors have produced a worthwhile paper.

The development supporting the definition of microprogramming is clear and to the point. Consideration of technological, architectural, and programming implications of this early development is less successful, but still worthy of attention. On occasion the authors resort to designing when they should be stating requirements or categorizing potential properties, but their design sketches hit a nice level of complexity for their presentation purposes. Fired with enthusiasm, Messrs. Flynn and Maclaren are guilty of identifying and discussing only some of the problems and potentials of microprogramming (according to their definition, which assumes a read/write control store).

The problems of microprogramming on the level comtemplated by the authors are those of programming. No observation is made that the control store becomes yet another level to be (dynamically) managed within the hierarchy; rather, specific ad hoc management techniques are presented. Similarly, deadlock potential in a multiprogrammable microprogram is ignored, and protection problems are considered by design sketch rather than by requirement specification.

In perspective, however, the paper is of interest because of its structured, considered approach to some real problems, including some credible comments on the software aspects of microprogramming -- a subject too often completely ignored in the literature.

The references are adequate and supportative, and the general form of presentation satisfactory (in spite of several typographical errors).

(28)
GERACE, G. B., "Microprogrammed control for computing systems", *IEEE Transactions on Electronic Computers, Vol. EC-12;* December 1963, pp. 733-747.

Starting with Wilkes' logical design of a control unit, this paper develops some variations and extensions. Specifically, it deals with problems concerning the conditions intervening at the end of a micro-order to determine the next one, with timing of micro-operations and also time-sharing and multiprogramming.

(29)
GLANTZ, H. T., "A note on microprogramming", *Journal of the ACM, Vol. 3, No. 2;* April 1956, pp. 77-84.

This article, written in August 1955, is an attempt to provide a rough outline of some conditions under which microprogramming might be a useful technique. Two methods of constructing a microprogrammed machine, a plugboard control and an internal relay setting control, are discussed in Section IV of the paper.

Efficiency is touted as the basis for a decision in favor of using micro-operations. The problems encountered in microprogramming are discussed in general from both an engineer's and a programmer's viewpoint.

(30)
GRASSELLI, A., "The design of program-modifiable micro-programmed control units", *IRE Transactions on Electronic Computers, Vol. EC-11;* June 1962, pp. 334-339.

In this paper a design is given for a program-modifiable control unit which does not require the usual high speed control store. A wired-in control memory contains microinstructions stored without repetitions. These are executed by means of words stored in core memory, each word containing the addresses of several microinstructions plus looping information. The logic necessary to sequence these words is quite complicated. Furthermore, the user is restricted to the wired-in microinstructions.

"The author refers to the reviewer's expressed opinion that a program-modifiable microprogram system would probably not justify itself in practice, but suggests that in the area of non-numerical information processing of the 'production' type this may not be so. The case is not, however, argued in detail, and the author soon passes to a description of a proposed method of designing a program-modifiable control unit.

In the conventional microprogramming system a read-only memory is used to hold the program of micro-orders. In the proposed scheme the read-only memory contains the micro-orders arranged in a random order, each order used in the microprogram appearing once only. There is a secondary memory of normal erasable type containing words into which information about the microprogram is packed. These words are processed in order by the sequencing circuits, and each causes a sequence of micro-orders to be extracted from the read-only memory and executed.

The scheme is ingenious but complicated. The author realizes this, and he also draws attention to the other major disadvantage, namely, that the microprogrammer is restricted in his choice of micro-orders to those which are wired into the read-only memory. This might seriously prejudice the main object of the scheme, which is to get closer to ultimate efficiency by being able to choose an order code optimum for the application in hand."

M. V. Wilkes, Cambridge, England,
Computing Reviews; 1963, #4166,
p. 129.

(31)
GREEN, J., "Microprogramming, emulators and programming languages", *Communications of the ACM, Vol. 9, No. 3;* March 1966, pp. 230-232.

"This paper is concerned with the no-man's land between, or common to, machines and languages; the land of soft hardware and hard software. We know the problem of finding a machine in terms of which programming languages can be defined; what of the problem of finding a language in terms of which machines can be defined? There is a need for a metalanguage in which no distinction need be made between hardware and software, between machine and language, so that the gap which exists in practice can be bridged in discussion.

Some confusion to the reader is likely on first reading owing to the fact that the word 'automaton' is incorrectly printed as 'automation' in a number of places."

F. G. Duncan, London, England,
Computing Reviews; September-
October 1966, #10,450, p. 409.

(32)
GREENBERG, M. and WEGBREIT, E., "μ-212: A microprogrammed computer", Unpublished class notes, Eng. 212, Harvard University; May 1968.

Machine: μ-212

This set of class notes for "Engineering 212" presents the detailed design of a microprogrammed computer, the μ-212, which was created to highlight microprogramming aspects. Descriptions of the central processing unit, basic instruction set, and control unit (read-only) are listed. Three appendices are also provided:

1. Hardware drawings
2. Various microinstructions
3. Operation codes

The read-only memory has a 170 nanoseconds cycle time divided into three phases. Period one executes the current microinstruction and loads the control memory address register with the next microinstruction. Period two starts the reading of the new instruction from the address register, and period three places the instruction into the memory buffer register.

The authors claim the novelty of their read-only memory control design, but do not elaborate.

(33)
HAGIWARA, H.; AMO, K.; MATSUSHITA, S. and YAMAUCHI, H., "The KT Pilot computer - A micro-programmed computer with a phototransistor fixed memory", *Proceedings IFIP Congress 62;* pp. 684-687.

Machine: KT Pilot

This paper introduces a computer designed jointly by Kyoto University and Tokyo Shibaura Electric Company Ltd. The system design, circuit elements and physical construction of the computer are briefly described. The order code of the machine is under the control of the programmer.

The fixed memory is unique in that it has been constructed with phototransistors. A punched card template is placed over an array of phototransistors and, by means of projected light, a path in a matrix is either opened or remains closed.

The output of the read-only memory is used to open and close gates (1 gate per bit organization). There are 256 eighty bit words in the ROM.

(34)
HARRAND, Y., "Evolution of microprogramming concepts", *Proceedings 3rd AFCALTI Congress of Computing and Information Processing*; Toulouse, 1963, pp. 187-190.

"The author defines a microprogrammed machine as one that has only those orders wired in that can be done in one machine cycle. Actual executed instructions are built up out of these basic operations. Generally, each 'macro-instruction' is executed as some sort of a hardware subroutine. The paper discusses the advantages of such machines, especially in the case where the user is allowed to design his own hardware subroutine. Of course, this technique is used in the hardware emulators of other machines used in IBM's System/360 machines."

J. E. Denes, Upton, New York,
Computing Reviews; March-April 1966,
#9474, p. 189.

(35)
HAWRYSZKIEWYCZ, I. T., "Microprogrammed control in problem-oriented languages", *IEEE Transactions on Electronic Computers, Vol. EC-16, No. 5;* October 1967, pp. 652-658.

Machine: CIRRUS

The application of microprogramming to problem-oriented languages is described in terms of a simulated analog system on a digital computer. In the system described a problem defined by differential equations is drawn up in the form of an analog diagram. The system allows the machine assembly code to be freely mixed with the analog-oriented source language input in coding the supervisory and interrupt facilities.

(36)
HECKELMAN, R. W., "Self-checking redundant microprograms", *IEEE Computer Group Repository R67-31;* August 1966.

"Quick, comprehensive error detection is a requisite of high reliability."

Hardware solutions are either too expensive or incomplete, while software solutions are both incomplete and result in severely slowed performance.

"If redundant software instructions are implemented as microinstructions, then the speed of checking is greatly increased."

"In this report, redundant algorithms and corresponding microprograms are presented and evaluated for detection of both transient and steady errors in parallel arithmetic and logical operations. The results are quite promising with respect to potential speed of performance, percentage of added hardware, and comprehensiveness of error detection."

(37)
HELLERMAN, L. and HOERNES, G. E., "Control storage use in implementing an associative processor for a time-shared processor", *IEEE Transactions on Computers, Vol. C-17, No. 12;* December 1968, pp. 1144-1151.

Machine: IBM 360/40 (CP-40)

This paper discusses the use of the Associative Memory (AM) used to implement the Cambridge System, a modified 360/40. The Cambridge System allows up to 15 users to time share what appears to each user to be a standard, complete, but slow 360/40. The AM is used for automatic address translation, supporting a paging concept; it is controlled via microprogram.

The AM is functionally described, as are the controlling microprograms.

(38)
HILL, R. H., "Stored logic programming and applications", *Datamation, Vol. 10, No. 2;* February 1964, pp. 36-39.

The author evaluates "...the contributions of stored logic to computer design...from the viewpoint of programming and applications."

He concludes that the techniques have not proved themselves, that "...the developers...found they had put together general purpose devices directly competitive with more conventionally organized computers in any given applications area."

"...Stored logic loses its significance when a stored logic computer is called upon to compile and execute FORTRAN, COBOL, NELIAC, JOVIAL, etc."

"...the future of stored logic as a design technique is somewhat cloudy."

(39)
IBM, "Data processing: Microprogramming PI course", IBM #221-0083.

Machine: IBM System 360

This course is designed to introduce the student to an in-depth study of microprogramming for the IBM System 360 series. It describes the engineering techniques employed in microprogramming, but the primary concern is for the programmer's point of view.

Section I includes an introduction to read-only storage and control points. Section II contains ideas on the microprogram and control file memories. Section III is concerned with Controlled Automated System (CAS) logic diagrams.

(40)
INGALLS, R. A., "Logical design of a microprogrammed special-purpose computer", United States Naval Postgraduate School; December 1966.

Machine: UNIVAC 1830 Avionics Computer

This thesis is a comparison between a conventional computer, the UNIVAC 1830, and an experimental computer similar to the UNIVAC 1830 which uses a microprogrammed control unit.

The first section contains a general outline on the difference between conventional and microprogram control, followed by the test itself. The test results clearly show that the microprogrammed computer is faster; for example, the add operation under microprogramming takes 275 microseconds, while conventional means would take 1016 microseconds. This test, operated under hypothetical conditions, appears to contribute to the theory that microprogramming can contribute to a more efficient computer.

(41)
IVERSON, K. E., "Microprogramming", *A Programming Language,* Chapter 2, John Wiley and Sons, Inc.; New York, 1962, pp. 71-104.

Machine: IBM 7090

This chapter from Iverson's book defines microprogramming to include paper descriptions of a computer's machine language which could be used to bridge the gap between the computer design and the logical circuit designer. Iverson proceeds to describe the 7090 machine language in terms of more elementary operations.

(42)
KAMPE, T. W., "The design of a general-purpose microprogram-controlled computer with elementary structure", *IRE Transactions on Electronic Computers, Vol. EC-9;* June 1960, pp. 208-213.

Machine: SD-2

This paper discusses the logical design of a binary, parallel, real-time computer. A description of the type of machine wanted is followed by the design decisions generated by the description. The contents of the micro-controlled logic generation are discussed, with reasons given for their incorporation into the scheme.

(43)
KLEIN, S. and SCHWARTZ, S., "Model 4200-8200 read-only memory control logic", *Honeywell Computer Journal;* Winter-Spring 1968, pp. 25-33.

"This paper summarizes the principal characteristics and the advantages of the read-only memory (ROM) as a control element in the 4200/8200 processors. The functions of both the address-generator ROM and the arithmetic unit ROM in the Model 8200 are described. Bit steering is discussed as a decoding scheme used to reduce the size of the ROM in the Model 4200." (Author)

Described with facility poor even for a house journal, bit steering is an encoding scheme intended to provide "a method by which one could change the way ROM bits were interpreted without having to rewire the machine." The full flexibility achieved was not what might have been desired. Consider the number of μ-operations which may be explicitly and concurrently mentioned "by (encoded) name" by b bits. On one hand we may associate one bit for each of b μ-operations, allowing concurrent mention of b distinct μ-operations. Alternatively, one might associate a μ-operation with each of the 2^b states uniquely expressable by the b bits, allowing concurrent mention of only one of the 2^b possible μ-operations.

"Bit steering" chooses a middle ground. Given a field of n + b bits, let the n bits select ("steer to") one of 2^n sets of association maps for the b bits. Each association map pairs each of the b bits to one μ-operation. One has the potential of addressing up to 2^n x b μ-operations, b at a time. In practice, the association maps are not mutually exclusive.

(44)
LAWSON, H. W., Jr., "Programming-language-oriented instruction streams", *IEEE Transactions on Computers, Vol. C-17, No. 5;* May 1968, pp. 476-485.

In a fourth generation computer with a changeable control store, microprograms can be used to implement a variety of instruction sets. It then becomes practical to translate a higher level language into some intermediate language which efficiently and conveniently expresses the higher level language, and then interpret the intermediate language by means of a microprogram. Six candidates for this intermediate language are defined. These candidates are then compared and evaluated with respect to conciseness, complexity, dynamic capability and flexibility.

(45)
LEVY, L. S., "State of the Art of Microprogramming", Report No. TOR-469(5710-01)-1, Aerospace Corporation, El Segundo, California; 15 April 1965.

This report covers the history, concept and advantages of microprogramming until 1965. The history is somewhat sketchy and only the fact that Wilkes invented the term is discussed in detail. The concept, again that of Wilkes, is shown to be a dual-matrix control which handles elementary operations.

Microprogramming is described as "a technique for systematizing the design of the central sequencing and control in a digital computer". The incorporation of microprograms in groups of computers is then given, including the Spectra 70 systems and the IBM 360 systems.

The last section of the paper deals with the design features of microprogramming, such as a modifiable order code, a late design freeze, and the improvement of speed. Some reference is given to the microprogram's role in multiprogramming, but this is very sketchy.

(46)
LIVERANCE, H. H., "A System/360 profile -- Read-only storage", IBM Technical Information Exchange #Z77-5170; June 1965.

Machine: IBM 360 Systems

This paper presents a factual, concise and in-depth explanation of the concept of a read-only memory, with particular reference to the read-only memories used in the IBM 360 systems.

The two technologies used at IBM for the read-only storage are: (1) transformer read-only storage (TROS), and (2) capacitor read-only storage (CROS). The fact that these are permanent, but easily replaceable, devices is their advantage over conventional computer devices.

The functions of the ROS program are explained, along with their relationship to the macro-instructions they are executing. The distinction between "interrupt" and "trap" is made explicit. "A Trap is a hardware-initiated asynchronous transfer to some other point in the Microprogram. An Interrupt is a ROS-initiated, asynchronous transfer to some other point in the Macroprogram."

(47)
MATSUSHITA, S., "A microprogrammed communication control unit, the TOSBAC DN-231", *Preprints of papers presented at IFIP Congress 68, Edinburgh; Booklet D: Hardware I,* pp. D108-D112.

Machine: TOSBAC 3400

The TOSBAC DN-231 is a microprogrammed communication control unit designed to provide more efficient passage of I/O information to and from a general computer system. It contains a multiplexor channel controlled by microprograms.

This article provides basic reasons for using microprogramming: 1) decreased software overhead, 2) the flexibility needed to incorporate new control methods and new message formats without changing hardware, 3) easier maintenance, and 4) the ability to use special functions to save trivial software tasks.

A number of special functions are realized by microprograms. One such function provides for automatic data-chaining, concatenating buffers automatically to accept data streams. Another instruction, called POL 0, polls all the lines in a designated range. POL 0 polls only those lines used more frequently. By combining these two instructions, using POL 0 only occasionally, the user can decrease overall polling time.

This article, without going into great detail, points out some of the potential benefits of microprogramming a communication channel.

(48)
McCLURE, R. M. and DAVIS, R. D., "A small microprogrammed computer", IEEE Computer Group Repository R-69-58; 1969.

The paper is primarily a description of the SCC 4700, "...a 16-bit general purpose digital computer that features a microprogrammed control section. The paper gives the details of the microcode sequences. The paper also gives a few of the authors' opinions of the microprogramming technique for computer control sections."

The authors conclude that "microprogramming is not a panacea...microprogramming must be considered as simply another way by which computers can be implemented."

(49)
McCORMACK, M. A.; SCHANSMAN, T. T. and WOMACK, K. K., "1401 compatibility feature on the IBM System/360 Model 30", *Communications of the ACM, Vol. 8, No. 12;* December 1965, pp. 773-776.

Machines: IBM 360/30 and 1401

This paper describes the hardware available for the IBM 360/30 which makes the emulation of an IBM 1401 possible. Special consideration is given to the read-only memory which contains the microprogram to do the emulation. The flexibility allowed through microprogramming in reference to the instruction counter, sense switches and stop routine is discussed, and the author concludes that the inherent flexibility of the read-only storage allows the emulation of an IBM 1401.

(50)
McGEE, W. C., "The TRW-133 computer", *Datamation, Vol. 5, No. 2;* February 1964, pp. 27-29.

Machine: The TRW-133 (BR-133)

"This is a very clear and concise description of a small general-purpose machine that was built with a fairly large set of primitive orders that can be combined into subroutines by the user, and are executed under the control of a sequence of interpreted macro-orders.

The author, in addition to his clear expression, is to be congratulated on his restraint in avoiding the term 'micro-programming'.

The machine was designed for shipboard NTDS usage, at far greater speed, reliability and I/O processing than that of its predecessors designed by the same company. With the exception of the interpretive execution of micro-orders, its memory, logic, and registers are conventional."

Herbert M. Teager, Cambridge, Mass.,
Computing Reviews, Vol. 6, No. 2;
March-April 1965, #7440.

(51)
McGEE, W. C. and PETERSEN, H. E., "Microprogram control for the experimental sciences", *AFIPS Conference Proceedings;* FJCC 1965, pp. 77-91.

Use of microprogrammed control units is suggested for interfacing experimental apparatus or computer peripheral devices with a computer. "...conventional design process is straight forward, it has the inherent disadvantage that it must be repeated for each new configuration...a single design schema which was sufficiently general to accommodate a wide variety of computers and external equipment, and which could be quickly and easily particularized to meet the requirements for specific controllers." The internal design of such a controller is described in great depth.

The IBM 2841 disk, drum, data cell controller is cited as one example, and a microprogram for controlling PEPR, "...a computer-controlled CRT scanner used to automatically measure bubble chamber tracks which have been recorded on film", as another.

(52)
McGEE, W. C. and PETERSEN, H. E., "Microprogramming for data acquisition and control", *IEEE Transactions on Nuclear Science, Vol. NS-12, No. 4;* August 1965, pp. 310-320.

Essentially equivalent to McGEE, W. C. and PETERSEN, H. E., "Microprogram control for the experimental sciences", *AFIPS Conference Proceedings;* FJCC 1965, pp. 77-91.

(53)
MEGGITT, J. E., "A character computer for high-level language interpretation", *IBM Systems Journal, Vol. 3, No. 1;* 1964, pp. 68-78.

This paper discusses the design of an experimental character-processing computer for the interpretive execution of higher-level language programs.

The design specifies a 100 nanosecond instruction cycle for the microprogram instructions stored in a read-only memory, a fast memory for intermediate "scratch pad" computation, and input/output through a conventional computer coupled to a two microsecond main memory.

(54)
MELBOURNE, A. J. and PUGMIRE, J. M., "A small computer for the direct processing of FORTRAN statements", *Computer Journal, Vol. 8;* 1965, pp. 24-27.

On this small, special-purpose computer, FORTRAN programs are compiled and executed. The big difference lies in the microprogramming of both operations.

In the first phase of compilation, statements are entered at an on-line typewriter. Key words (DO, DIMENSION, etc.) require only one key to be depressed - the microprogram echoes the full word. Statements are collected, error-checked and stored in digested form. The second phase completes the compilation process. Expressions are transformed into Reverse Polish form and space is allocated.

Program execution is controlled in the microprogram using an Instruction Stack and a Data Stack. The Instruction Stack provides program control, particularly useful in controlling nested DO statements. The Data Stack is used by the microprograms corresponding to each statement, particularly for function and expression evaluation.

A DEBUG switch allows on-line tracing of the execution of each statement, by the logging of its statement number.

Using a standard FORTRAN compiler on another machine, and hand coding the same machine, the authors conclude that their FORTRAN lies somewhere between the other two techniques in performance.

(55)
MERCER, R. J., "Micro-programming", *Journal of the ACM, Vol. 4;* April 1957, pp. 157-171.

The first section of this article presents a general outlook on the concept of microprogramming, incorporating the work of M. V. Wilkes and H. T. Glantz.

Microprogramming is defined as "...the technique of designing control circuits of an electronic digital computer to formally interpret and execute a given set of machine instructions, Mi, as an equivalent set of sequences of micro-operations, elementary operations that can be executed in one pulse time."

The author gives an example of an adder in a hypothetical microprogram, explains how it works and shows why it would take less time than an ordinary add instruction. The other sections of the paper deal with rather unrelated specific problems.

(56)
MILLER, E. H., "Reliability aspects of the Variable Instruction Computer", *IEEE Transactions on Electronic Computers, Vol. EC-16, No. 5;* October 1967, pp. 596-602.

This article stresses the use of the variable instruction concept to enhance reliability by means of controlled graceful degradation. When a component fails, the set of microprograms which implement the macro-operations dependent on that component are replaced with a new set not so dependent. Processing can then continue, perhaps less efficiently.

Much of the article is descriptive of the logic used to arrive at the VIC design; embedded in this is most of the design itself.

See also Spence, A. L., "Hardware and Software Interactions; A Machine Organization Solution, The Variable Instruction Computer".

(57)
MORRISON, G. E., "Investigation of micro-programming as a technique in the control of digital computing systems", (Thesis), University of California at Berkeley; 1958.

"The micro-program technique produces desired external operations in a digital computing system by sequences of internal operations controlled by a stored program of internal orders called 'micro-orders'. The various 'micro-program' sequences are selected by a second level of command, called 'sequence command'. This evaluation of the technique consists of an investigation of the effect of use on hardware complexity, computing speed, and ease of use.

Investigation of design considerations indicated the choice of a system consisting of an arithmetic section designed to be controllable by micro-orders, a memory which stores the micro-order sequences, a second memory which stores the sequence commands, a third memory which stores the problem data, a unique modified index register system for memory address control, and appropriate buffer and control registers.

It is shown that the arithmetic section could be achieved with no more functional elements than the minimum required in any system for the selected arithmetic operations and computing times. No unusual requirements were found for the problem data and sequence memories other than the need for independent control. Investigation of the micro-program memory indicated that a capacity of 10^6 bits with a speed comparable to the data memory would be desirable.

By investigation of a 'standard' operation and matrix multiplication program, it is found that the micro-program system was significantly faster than a 'typical' conventional system. However, it was about as fast as a conventional system modified to provide more effective subroutine operation with a resulting complexity which was comparable to that of the micro-program system..." (From the abstract)

Computing Reviews, Vol. 9, No. 1;
January 1968, #13,456, pp. 40-41.

No legible copy of this thesis was available for review.

(58)
OPLER, A., "Fourth-generation software: The realignment", *Datamation, Vol. 13, No. 1;* January 1967, pp. 22-24.

This paper deals with the future of computers. Mr. Opler projects that microprograms will be used more frequently. He predicts that fourth-generation hardware will use large-scale integration (LSI) logic specialized by microprogramming. Mr. Opler hypothesizes the speed of three elements in a fourth-generation computer: circuitry (LSI) takes 5 nanoseconds, the micromemory access takes 10 nanoseconds, and main memory access 400 nanoseconds. Therefore, microprogram interpretation of instructions is feasible. He also introduces the term "firmware" to designate microprograms in the control memory. He expects the most important potential of the microprogram to occur with the advent of a slow-write/fast-read memory. This would enable the programmer, via a special set of punch cards, for example, to change the contents of the micromemory, thus permitting him to define his own instruction sets.

(59)
OPLER, A., "New directions in software 1960-1966", *Proceedings of the IEEE, Vol. 54, No. 12;* December 1966, pp. 1757-1763.

Among other topics, the effects of microprogramming and its potential are examined. Designers have begun to study it in depth because several micro-instructions of 10-100 nanoseconds each can be executed in less time than access to the main memory (500-2000 nanoseconds).

The concept of virtual memory with peripheral devices containing more storage is discussed in relation to microprogramming by showing how micro-operations can decrease access time. This is a short but excellent summary of the advantages of microprogramming.

(60)
PATZER, W. J. and VANDLING, G. C., "Systems implications of microprogramming", *Computer Design, Vol. 6, No. 12;* December 1967, pp. 62-66.

This article gives a description of the functions of microprogrammed control and makes a comparison between general-purpose and microprogrammed machines. It dwells on microprogramming from both the engineer's and programmer's viewpoint; and, without going into any depth, does a creditable job. It says that a microprogram may consist of: (1) a fixed sequence of words containing conditional micro-orders; (2) a variable sequence of words containing unconditional micro-orders; or (3) a combination of both.

A hypothetical comparison is drawn in performing a square root with conventional and microprogrammed instructions.

(61)
RAKOCZI, L. L., "The computer-within-a-computer: A fourth generation concept", *Computer Group News;* March 1969, pp. 14-20.

Machines: Standard Computer Corporation IC 3000, 4000, 7000

"The fourth generation computer is a systems-architecture-oriented device which stresses changes in structure, organization and utilization of computer techniques and programming skills." Mr. Rakoczi thus defines his concept of the fourth generation computer. Since fifty per cent of the article is a sales brochure, the convenience of having the only fourth generation computer is obvious.

The division between third and fourth generation computers seems to lie in the <u>use</u> of microprogramming. The microprograms resident in third generation computers are a replacement for controlled logic. They are devices to simplify and organize design procedures and aid in maintenance problems. The microprogram in a fourth generation computer system is in itself an inner computer, designed not only to help the engineer, but also the programmer. The inner computer controls all communication between the functional stations of the system, aiding in efficient subroutine handling.

Perhaps the most sweeping claim made is that the inner computer, along with a process called MINIFLOW, allows for complete emulation. Even the author admits that only one type of computer can be emulated at any given time. No examples are given of the time factor involved if more than one machine is to be emulated during the same process; and no discussion is given as to the effect when the emulated machine has a different length word from the micromachine.

(62)
REBOULOT, M., "Extracteur microprogramme d'information radar", *L'Onde Electrique, Vol. 48, No. 491;* February 1968, pp. 138-140.

Machine: IBM 360/30

EMIR (acronym from the title) is a real-time microprogrammed collector of radar data, apparently implemented using an IBM 360/30 CPU. EMIR also includes communication circuits with the radar, and another, possibly remote, more powerful computer, which might perform functions such as trajectory plotting.

The author defines microprogramming by example of an add operation, and does so classically: each microinstruction, operating in a single cycle time, opens or closes gates which correspond to the bits in the microinstruction.

The 360/30 condenser memory is briefly described, as are the IBM programs for developing microprograms.

The author is most taken with the flexibility which would allow rapid adaptation to new developments in radar technology or usage.

The article appears in the original French.

(63)
ROSE, G. A., "'Intergraphic', A microprogrammed graphical-interface computer", *IEEE Transactions on Electronic Computers, Vol. EC-16, No. 6;* December 1967, pp. 773-784.

Machine: Intergraphic

This paper describes a proposed microprogrammed interface computer to link many (from 13 to 50) general-purpose graphical terminals to a central processor. The digital computer is fast (3-5 nanoseconds for integrated circuitry and 100 nanoseconds access time to the read-only memory) and versatile because of its read-only memory.

The control section comprises a ROM, addressed from a "read" register, a micro-routine link register Q, decoding and timing logic, and a bit-wise programmable register F. One of the microprograms is a small Cartesian vector program with 28 micro-orders.

(64)
ROSEN, S., "Hardware design reflecting software requirements", *AFIPS Conference Proceedings;* FJCC 1968, pp. 1443-1449.

The author introduces microprogramming as one of a number of hardware developments (the first one he lists) which has "contributed to the development and the performance of multiprogramming and multiprocessor operating systems and compiling and translating systems."

A conventional definition is given, and the relation to simulators/emulators is pointed out.

(65)
SCHLAEPPI, H. P., "Microprogrammed computer control", *IBM Technical Disclosure Bulletin, Vol. 5, No. 9;* February 1963, pp. 45-46.

Machine: IBM 360 Series

This short (two page) article describes the use of a special return register along with a counting address register that eliminates the need for an explicit micro-address for each new microinstruction. A description of the execution of a micro-operation in each of four modes follows. The modes are: normal, prepare-return, execute-return and jump. The only mode which requires an explicit micro-address is the jump mode, in which a field of the microinstruction is interpreted as the next micro-address.

(66)
SEMARNE, H. M. and McGEE, W. C., "Stored logic computing", *Preprints of papers presented at the 16th National Meeting of the ACM;* September 5-8, 1961.

A stored logic type of computer is one in which the basic logic expressed by micro-commands is implemented by hardware, and all computer instructions above this building block level are programmed. The authors discuss the merits of the stored logic computer in relation to ease of learning, ease of modification, speed, and versatility, but do not go into much depth.

(67)
SEMARNE, H. M. and PORTER, R. E., "A stored logic computer", *Datamation, Vol. 7, No. 5;* May 1961, pp. 33-36.

Interpretation as a technique leads to performance losses of a factor of 10 to 15. The stored logic concept, say the authors, offers "interpretation without deceleration".

"One may consider computer instruction types as rungs on an 'abstraction ladder' rising from machine language toward natural human language, with distance from the bottom denoting level of abstraction with respect to the computer logic.

The bottom rung of the instruction ladder is held by the primary building-blocks of all types of computer instruction, namely micro-commands which cause the machine to open gates, trigger flip-flops, and perform other useful circuit functions.

In the Stored Logic concept, much of the wired logic which mechanizes the machine-language instructions customarily found in an instruction list is disregarded, and only the basic logic expressed by the micro-commands is implemented by hardware. The logic for any instructions above the micro-command level is stored in the computer memory in the form of a micro-program, i.e., a sequence of micro-commands. Hence, in the Stored Logic concept, any type cf instruction can be made up out of micro-commands and stored in memory access as a macro-instruction. Thus, conventional machine language differs from an interpretive system only by a degree of abstraction..."

(68)
SLOBODYANYUK, T. F., "A Method of Minimizing Microprograms", AFSC Foreign Technology Division, FTD-HT-23-600-67, AD 662 821; 27 July 1967.

This article gives an algorithm for reducing a sequence of elementary micro-operations into a sequence of microinstructions. A microinstruction contains one or more elementary micro-operations, all of which can be performed in parallel. The desired microinstruction sequence attains a maximum speed coupled with a minimal amount of apparatus. The algorithm produces this sequence by doing a backward analysis of the contents of the registers. Experiments showed that in the new sequence the execution time is shortened by 6-12%; its size is 23-29% smaller than the original sequence.

(69)
SPENCE, A. L., "Hardware and Software Ineractions: A Machine Organization Solution, The Variable Instruction Computer", Radio Corporation of America; 23 September 1966.

Machine: RCA VIC

This paper, written during the embryonic stages of the VIC computer development, contains the elementary concepts of the microprogramming involved in it. The high speed memory, with a "scratch-pad" section, consists of two modules, each containing 256 x 38 bit words. On Page 5 is an excellent example of how a macroinstruction (add) is carried out by a sequence of micro-orders. Many reasons for the use of microprogramming are given including flexibility, utility and speed.

See also Miller, E. H., "Reliability Aspects of the Variable Instruction Computer".

(70)
STEVENS, W. Y., "The structure of System/360; part II - system implementations", *IBM Systems Journal, Vol. 3, No. 2;* 1964, pp. 136-143.

Machines: IBM 360/30, 40, 50, 60, 62, 70

This paper discusses the system implementations of the 360 series and measures performances in four areas: 1) main storage, 2) central processing unit, registers and data paths, 3) sequence control, and 4) input-output channels. Each of these is then further categorized into three factors: basic speed, size, and degree of simultaneity.

The read-only storage control is discussed under the major heading of sequence control. Besides listing certain characteristics of the read-only storage in the individual models in the 360 series, the author states, "This microprogram control...is the only method known by which an extensive instruction set may be economically realized in a small system." The IBM 360/60, 62, is presented as proof of this. Originally designed with conventional control logic, the IBM 360/60, 62, was altered for microprogramming control when its instruction set required too many circuit modules.

(71)
STRINGER, J., "Microprogramming and the choice of order code", *Proceedings Symposium on Automatic Digital Computation*; London, 1953, pp. 71-74.

Written in the first stages of the evolution of microprogramming, this paper first overviews the original view of the concept, then questions the choices of order code that could be built into the microprogram.

Most of the article expounds certain advantages that seemed to provide a raison d'etre for microprogramming. These include late design freeze, easier and faster floating-point arithmetic, and more efficient control methods.

This paper is interesting from the standpoint of examining the early endeavours into the field of microprogramming; but it does not introduce the reader into any in-depth concepts.

(72)
STRUGARU, G., "A microprogrammed unit for computer systems", IEEE Computer Group Repository R-69-95; 1969.

"The paper examines the possibilities of utilizing the micro-subprograms...to reduce the number of micro-orders and to increase the flexibility..."

"In new computers there are introduced complex operations which result from the nonarithmetical applications of these, from the automation problems of programming, multiprogramming, etc."

"In this condition of complicating the microprogram, formal synthesis methods must be used and the microprogram minimization becomes essential for design."

(73)
TUCKER, S. G., "Microprogram control for System/360", *IBM Systems Journal, Vol. 6, No. 4;* 1967, pp. 222-241.

Machine: IBM 360 Systems

"This paper describes the kind of microprogram control that has been used in several models of System/360. A microprogramming language, as well as some of the main techniques used in "assembling" and testing microprograms, are discussed. Applications of microprogram control to the design of emulators, to compatibility features, and to special modifications are summarized."

(From the paper)

(74)
VALASSIS, J. G., "Modular computer design with picoprogrammed control", *AFIPS Conference Proceedings;* FJCC 1967.

"This paper describes the use of a multiaperture ferrite device called MYRA, and the use of picoprogramming to build a 16-bit, one microsecond integrated circuit computer. Picoprogramming is described as conceptually comparable to microprogramming but without the need for decoding logic. The MYRA provides the means for picoprogramming.

Organization of the computer, implementation of a microinstruction, operation of the MYRA, and the advantages and disadvantages of the technique are presented.

The paper is complete and well written."

H. Marks, Canoga Park, California,
Computing Reviews, Vol. 9, No. 6;
June 1968, #14,585.

(75)
VAN DER POEL, W. L., "Micro-programming and trickology", *Digital Information Processors; Selected Articles on Problems of Information Processing;* ed. Walter Hoffman; Interscience Publishers, a division of John Wiley and Sons, Inc.; New York, 1962, pp. 269-311.

Machine: ZEBRA

This article discusses the practical limitations of the dissection of macro-instructions into more elementary operations. The ZEBRA computer is used to test this dissection.

The argument that construction of the micro-code is too laborious for the programmer (van der Poel's concept of microprogramming is slightly different from Professor Wilkes' -- he sees it as an easily adjustable elementary machine language) is outweighed by its efficiency, especially in the area of automatic programming.

Mr. van der Poel also defines two concepts: trickology and underwater programming. The generation of pieces of coding in fast registers which are subsequently executed is called underwater programming. Considerable ingenuity is often required to devise the macro-instructions, giving rise to the name trickology for the art of using this tricky programming.

Three-fourths of this article is a description of ZEBRA. The examples and micro-code used are also from this computer. The article may be of some interest to those designing micromachines, or those actively (!) concerned with coding for the ZEBRA computer.

(76)
VANDLING, G. C. and WALDECKER, D. E., "The Microprogram Control Technique for Digital Logic Design", *Computer Design, Vol. 8, No. 8;* August 1969, pp. 44-51.

"Basic concepts of microprogrammed control design, representation of current design practice, and selected design variations are examined as sources of informative value to the logic designer."

(From the paper)

(77)
VOLLBRECHT, J. R., "MIDAS: Microprogramming Design Aid System for RCA Spectra 70/45", Presented at ACM Workshop on Microprogramming, October 7, 1968.

Machine: RCA Spectra 70/45

MIDAS, the Microprogramming Design Aid System, describes a program which performs much of the routine work necessary in developing a useful, effective microprogram.

Designing a microprogram requires "that a set of micro-orders be combined into a set of elementary operations in such a way that 1) the required function is in fact performed, and 2) the execution time is minimized." MIDAS allows the programmer to concentrate on this creative task by permitting him to "see" his microprogram and check it by a simulation process.

MIDAS includes an assembler, a simulator, a program to punch cards by which the read-only memory can be built, and a system to aid in debugging.

(78)
WEBER, H., "A microprogrammed implementation of EULER on IBM System/360 Model 30", *Communications of the ACM, Vol. 10, No. 9;* September 1967, pp. 549-558.

Machine: IBM System/360 Model 30

This article describes an experimental processing system for a higher level language, EULER. The language is processed in two stages. First a microprogrammed compiler translates it into a Reverse Polish String Language. Then this language is interpreted by a microprogram. The experiment was undertaken to show that microprogramming can be used to create more efficient systems than conventional programming systems. This system is predicted to be at least ten times faster than the execution of an ordinary (efficient) machine code compilation.

(79)
WEBER, H., "Microprogramming", *International Summer School on Fundamental Aspects and Current Developments in Computer Science;* August 1969.

In this course, Mr. Weber introduces the microprogram level language by analogy - as ALGOL is to machine language, so machine language is to a microlanguage.

Using several of the System 360 micromachines as examples, Mr. Weber weaves through the classical and later definitions of microprogramming, the types of read-only memory that are used and the possibilities of read-write memories. The 360/30 (2030) and 360/20 Submod 5 (2020-5) are examined in detail.

He also points out that "...a simulator, an interpreter, and the machine hardware performed exactly the same function, namely, to interpret string code. Why was it necessary to invent different names for simulator and interpreter?" "...emulators were announced. Again, a new word for an interpreting mechanism!"

Also, "the ideal processing system for a higher level language would therefore consist of a translator and an interpreter. Both the translator and the interpreter can be written in a microprogram language."

(80)
WILKES, M. V., "The best way to design an automatic calculating machine", *Manchester University Computer Inaugural Conference, Manchester, England;* July 1951, pp. 16-18.

This paper contains the original explanation and definition of the term microprogramming. A micro-operation is one of a series of steps. These steps may include transfers from the store to control or arithmetical registers and transfers from one register to another. The micro-operations can be generated by pulses. These pulses enter a decoding tree, and then are routed to two matrices, one of which executes an instruction, the other sets up the next instruction to be performed.

When introduced, microprogramming's main advantage seemed to Wilkes to be the increase in the degree of reliability in a machine. Reliability had a direct relationship to 1) the amount of equipment of a computer, 2) its complexity, and 3) the degree of repetition of units. Since microprograms can perform many operations with the same set of logic circuitry, it would appear that microprogramming did increase the reliability of a machine.

Since this was the original paper on the subject, the problems of programmer instruction, design, and time consumed are not discussed in detail.

(81)
WILKES, M. V., "Microprogramming", *Proceedings of the EJCC 1959,* pp. 18-20.

This article, written in 1958, gives a very brief outline on the development of microprogramming, including its advantages and potential. A microprogram is defined as "the list of suboperations or micro-operations required to execute all the orders in that order code".

The one outstanding advantage of microprograms is that changes in the order code can be incorporated at a very late date in the building of a computer.

The other new concept of the erasable or "scratch-pad" memory which allows the programmer to invent his own order code is also mentioned.

(82)
WILKES, M. V., "The growth of interest in microprogramming", ACM Workshop on Microprogramming, sponsored by the Association for Computing Machinery in cooperation with The MITRE Corporation, October 7-8, 1968.

Tracing the evolution of microprogramming from its conception in 1951 to the present, M. V. Wilkes examines its original and current uses and theorizes on further potential development.

A helpful explanation of the two current and different definitions of microprogramming are included. The concept of stored logic (a read-write control memory), a technique which allows the programmer to create his own microprograms, is also mentioned.

A history of microprogrammed computers is compiled, with brief comments provided on each referenced article.

Tucker's reasons for the use of microprogramming are summarized. It provides: 1) an economical way for smaller computers to have large instruction sets, 2) an aid to efficient maintenance, 3) the possibility of emulation, and 4) a gain in flexibility for both the programmer and designer.

The current state of the art is discussed in terms of further developments in emulation, software support, and the interpretation of higher-level programming languages.

(83)
WILKES, M. V., "The growth of interest in microprogramming: A literature survey", *Computing Surveys, Vol. 1, No. 3;* September 1969, pp. 139-145.

"The literature is surveyed beginning with the first paper published in 1951. At that time microprogramming was proposed primarily as a means for designing the control unit of an otherwise conventional digital computer, although the possible use of a read/write control memory was noted. The survey reveals the way in which interest has successively developed in the following aspects of the subject: stored logic, the application of microprogramming to the design of a range of computers, emulation, microprogramming in support of software, and read/write control memories. The bibliography includes 55 papers."

(From the paper)

(84)
WILKES, M. V. and STRINGER, J. B., "Microprogramming and the design of the control circuits in an electronic digital computer", *Proceedings of the Cambridge Philosophical Society, Vol. 49, Part 2;* 1953, pp. 230-238.

This article, dated November 18, 1952, describes in clear, concise terminology the structure and advantages of a microprogrammed computer.

Building on his original paper which introduced the concept of microprogramming in 1951, Professor Wilkes defines microprogramming as a method of designing the control circuits of a machine to be logical and yet enabling the order code to be alterable without ad hoc alterations to the circuits. The concept of a micro-control unit is discussed. Branching within the microprogram is shown to be accomplished by the setting of two flip-flops.

```
                                               KWIC INDEX LISTING
                                                                                                      DATE      10/23/69
                                                                                                      TIME      01:42:03

TEXT_____________________________________________________ KEYWORD_AND_TEXT__________________________________________ INDEX____

          25 ENTRIES WERE SUPPRESSED FOR KEYWORD -------> &

           5 ENTRIES WERE SUPPRESSED FOR KEYWORD -------> -

           1 ENTPIES WERE SUPPRESSED FOR KEYWORD -------> --

         177 ENTRIES WERE SUPPRESSED FOR KEYWORD -------> "

          34 ENTRIES WERE SUPPRESSED FOR KEYWORD -------> A

         MCGEE,W & PETERSON,H " MICROPROGRAMMING FOR DATA ACQUISITION AND CONTROL " 1965                            52
                                        BREUER,M  " ADAPTIVE COMPUTERS " 1967                                       15
            VOLLBRECHT,J " MIDAS: MICROPROGRAMMING DESIGN AID SYSTEM FOR RCA SPECTRA 70/45 " 1968                   77

           7 ENTRIES WERE SUPPRESSED FOR KEYWORD -------> AL

CCESS TIME-SHARING SYSTEM "                               ALLEN-BABCOCK COMPUTING, INC " INFORMATION OUTLINE: REMOTE-A     1
PROGRAM COMPUTER WITH MICROPROGRAM CONTROL " 1963         ALLEN,M; PEARCEY,T; PENNY,J ET AL " CIRRUS, ECONOMICAL MULTI     2
                                                          AMDAHL,L " MICROPROGRAMMING AND STORED LOGIC " 1964              3
JTER WITH A PHOTOTRANSISTER FIXED MEMORY " 1962 HAGIWARA,H; AMO,K ET AL " THE KT PILOT COMPUTER - A MICROPROGRAMMED COMP  33

           4 ENTRIES WERE SUPPRESSED FOR KEYWORD -------> AN

           B ENTRIES WERE SUPPRESSED FOR KEYWORD -------> AND

                   HILL,R " STORED LOGIC PROGRAMMING AND APPLICATIONS " 1964                                        38
        BEELITZ,H; LEVY,S; LINHARDT,R & MILLER,H " SYSTEM ARCHITECTURE FOR LARGE SCALE INTEGRATION " 1967            8
                                 LEVY,L " STATE OF THE ART OF MICROPROGRAMMING " 1965                               45
 1958       MORRISON,G " INVESTIGATION OF MICRO-PROGRAMMING AS A TECHNIQUE IN THE CONTROL OF DIGITAL COMPUTING SYSTEMS "  57
            CONTI,C; GIBSON,D & PITKOWSKY,S " STRUCTURAL ASPECTS OF THE SYSTEM/360, MODEL 85 " 1968                 23
                                 MILLER,E " RELIABILITY ASPECTS OF THE VARIABLE INSTRUCTION COMPUTER " 1967         56
   HOERNES,G ET AL " CONTROL STORAGE USE IN IMPLEMENTING AN ASSOCIATIVE PROCESSOR FOR A TIME-SHARED PROCESSOR " 1968   37
 HELLERMAN,L ET AL " CONTROL STORAGE USE IN IMPLEMENTING AN ASSOCIATIVE PROCESSOR FOR A TIME-SHARED PROCESSOR " 1968   37
                                CALHOUN,R " DIAGNOSTICS AT THE MICROPROGRAMMING LEVEL " 1969                        18
                   WILKES,M " THE BEST WAY TO DESIGN AN AUTOMATIC CALCULATING MACHINE " 1951                        80
JCKINGHAM,B; CARTER,W; CRAWFORD,W & NOWELL,G " THE CONTROLS AUTOMATION SYSTEM " 1965                         B       17

 1967                                                     BAILEY,S " FASTER COMPUTER CONTROL WITH A READ-ONLY MEMORY "     4
N MACHINE " 1967                                          BASHKOW,T; SASSON,A & KRONFELD,A " SYSTEM DESIGN OF A FORTRA     5
CTURE STUDY ORIENTED TO COMPUTERS SIMULATION " 1968       BAZERQUE,G; FERRIE,J & HUGOT,P " MICROMACHINE UNIVERSAL STRU     6
                                                          BECK,L & KEELER,F " THE C-8401 DATA PROCESSOR " 1964             7
RE FOR LARGE SCALE INTEGRATION " 1967                     BEELITZ,H; LEVY,S; LINHARDT,R & MILLER,H " SYSTEM ARCHITECTU     8
65                                                        BENJAMIN,R " THE SPECTRA 70/45 EMULATOR FOR THE RCA 301 " 19     9
                                         WILKES,M " THE BEST WAY TO DESIGN AN AUTOMATIC CALCULATING MACHINE " 1951        80
                                                          BILLING,H & HOPMANN,W " MIKROPROGRAMM-STEUERWERK " 1955         10
                                                          BLANKENBAKER,J " LOGICALLY MICRO-PROGRAMMED COMPUTORS " 1960    11
```

```
                                                                                                    DATE      10/23/69
                                                                                                    TIME      01:42:03

TEXT_______________________________________________________ KEYWORD_AND_TEXT_____________________________________________ INDEX____

O-LANGUAGE FOR URAL-4 " 1966                                BORSCHEV,V; VASILEVSKIY,P & KHOMYAKOV,M " A PROGRAMMING MICR      12
B 440 MICROPROGRAMMABLE COMPUTER " 1963                     BOUTWELL,E & HOSKINSON,E " THE LOGICAL ORGANIZATION OF THE P      14
                                                            BOUTWELL,E " THE PB 440 COMPUTER " 1964                           13
                                                            BREUER,M  " ADAPTIVE COMPUTERS " 1967                             15
                                                            BRILEY,B " PRIOPROGRAMMING " 1965                                 16
 AUTOMATION SYSTEM " 1965                                   BUCKINGHAM,B; CARTER,W; CRAWFORD,W & NOWELL,G " THE CONTROLS      17

                                    BECK,L & KEELER,F " THE C-8401 DATA PROCESSOR " 1964                                       7
            WILKES,M " THE BEST WAY TO DESIGN AN AUTOMATIC CALCULATING MACHINE " 1951                                         80
                                                            CALHOUN,R " DIAGNOSTICS AT THE MICROPROGRAMMING LEVEL " 1969      18
" 1966    N A VARIABLE STRUCTURE DIGITAL COMPUTER " 1962    CAMPBELL,C & NEILSON,D " MICROPROGRAMMING THE SPECTRA 70/35       19
STEM " 1965                                  BUCKINGHAM,B; CARTER,W; CRAWFORD,W & NOWELL,G " THE CONTROLS AUTOMATION SY       17
1964                                             MEGGITT,J " A CHARACTER COMPUTER FOR HIGH LEVEL LANGUAGE INTERPRETATION "    53
                     STRINGER,J " MICROPROGRAMMING AND THE CHOICE OF ORDER CODE " 1953                                        71
ED COMPUTERS " 1968                                         CHU,Y " A HIGHER-ORDER LANGUAGE FOR DESCRIBING MICROPROGRAMM      20
STRINGER,J " MICROPROGRAMMING AND THE DESIGN OF THE CONTROL CIRCUITS IN AN ELECTRONIC DIGITAL COMPUTER " 1953WILKES,M &      84
ONTROL " 1963            ALLEN,M; PEARCEY,T; PENNY,J ET AL " CIRRUS, ECONOMICAL MULTIPROGRAM COMPUTER WITH MICROPROGRAM C      2
ONTROL " 1963                 ROSE,G; SANDERSON,J ET AL " CIRRUS, ECONOMICAL MULTIPROGRAM COMPUTER WITH MICROPROGRAM C         2
     STRINGER,J " MICROPROGRAMMING AND THE CHOICE OF ORDER CODE " 1953                                                        71
                        MATSUSHITA,S " A MICROPROGRAMMED COMMUNICATION CONTROL UNIT, THE TOSBAC DN-231 " 1968                 47
              MCCORMACK,M; SCHANSMAN,T & WOMACK,K " 1401 COMPATIBILITY FEATURE ON THE IBM SYSTEM/360 MODEL 30 " 1965          49
 FIXED MEMORY " 1962 HAGIWARA,H; AMO,K ET AL " THE KT PILOT COMPUTER - A MICROPROGRAMMED COMPUTER WITH A PHOTOTRANSISTER       33
 FIXED MEMORY " 1962        YAMAUCHI,H ET AL " THE KT PILOT COMPUTER - A MICROPROGRAMMED COMPUTER WITH A PHOTOTRANSISTOR       33
 FIXED MEMORY " 1962      MATSUSHITA,S ET AL " THE KT PILOT COMPUTER - A MICROPROGRAMMED COMPUTER WITH A PHOTOTRANSISTOR       33
THE DESIGN OF THE CONTROL CIRCUITS IN AN ELECTRONIC DIGITAL COMPUTER " 1953WILKES,M & STRINGER,J " MICROPROGRAMMING AND       84
                    SEMARNE,H & PORTER,R " A STORED LOGIC COMPUTER " 1961                                                     67
 THE SPECTRA 70/35 " 1966    N A VARIABLE STRUCTURE DIGITAL COMPUTER " 1962    CAMPBELL,C & NEILSON,D " MICROPROGRAMMING      19
 " THE LOGICAL ORGANIZATION OF THE PB 440 MICROPROGRAMMABLE COMPUTER " 1963                        BOUTWELL,E & HOSKINSON,E      14
                                   BOUTWELL,E " THE PB 440 COMPUTER " 1964                                                    13
                                     MCGEE,W " THE TRW-133 COMPUTER " 1964                                                    50
LLS,R " LOGICAL DESIGN OF A MICROPROGRAMMED SPECIAL-PURPOSE COMPUTER " 1966                                            INGA   40
; A MACHINE ORGANIZATION SOLUTION, THE VARIABLE INSTRUCTION COMPUTER " 1966SPENCE,A " HARDWARE AND SOFTWARE INTERACTIONS       69
 MILLER,E " RELIABILITY ASPECTS OF THE VARIABLE INSTRUCTION COMPUTER " 1967                                                   56
SE,G " INTERGRAPHIC,' A MICROPROGRAMMED GRAPHICAL-INTERFACE COMPUTER " 1967                                              RO   63
                 DREYER,L " PRINCIPLES OF A TWO-LEVEL MEMORY COMPUTER " 1968                                                  25
                GREENBERG,M & WEGBREIT,E " A MICROPROGRAMMED COMPUTER " 1968                                                  32
               MCCLURE,R & DAVIS,R " A SMALL MICROPROGRAMMED COMPUTER " 1969                                                  48
                            SCHLAEPPI,H " MICROPROGRAMMED COMPUTER CONTROL " 1963                                             65
                                       BAILEY,S " FASTER COMPUTER CONTROL WITH A READ-ONLY MEMORY " 1967                       4
                                    VALASSIS,J " MODULAR COMPUTER DESIGN WITH PICOPROGRAMMED CONTROL " 1967                   74
                                MEGGITT,J " A CHARACTER COMPUTER FOR HIGH LEVEL LANGUAGE INTERPRETATION " 1964                53
965                           MELBOURNE,A & PUGMIRE,J " A SMALL COMPUTER FOR THE DIRECT PROCESSING OF FORTRAN STATEMENTS " 1      54
                         STRUGARU,C " A MICROPROGRAMMED UNIT FOR COMPUTER SYSTEMS " 1969                                      72
,H; AMO,K ET AL " THE KT PILOT COMPUTER - A MICROPROGRAMMED COMPUTER WITH A PHOTOTRANSISTER FIXED MEMORY " 1962 HAGIWARA       33
AMAUCHI,H ET AL " THE KT PILOT COMPUTER - A MICROPROGRAMMED COMPUTER WITH A PHOTOTRANSISTOR FIXED MEMORY " 1962          Y    33
SUSHITA,S ET AL " THE KT PILOT COMPUTER - A MICROPROGRAMMED COMPUTER WITH A PHOTOTRANSISTOR FIXED MEMORY " 1962        MAT    33
T " THE DESIGN OF A GENERAL-PURPOSE MICROPROGRAM-CONTROLLED COMPUTER WITH ELEMENTARY STRUCTURE " 1960             KAMPE,      42
ROSE,G; SANDERSON,J ET AL " CIRRUS, ECONOMICAL MULTIPROGRAM COMPUTER WITH MICROPROGRAM CONTROL " 1963                          2
 PEARCEY,T; PENNY,J ET AL " CIRRUS, ECONOMICAL MULTIPROGRAM COMPUTER WITH MICROPROGRAM CONTROL " 1963           ALLEN,M;       2
69                                         RAKOCZI,L " THE COMPUTER-WITHIN-A-COMPUTER  A FOURTH GENERATION CONCEPT " 19       61
ROSLAVSKY,L & TIMOFEEV,A " MICROPROGRAM CONTROL FOR DIGITAL COMPUTERS " 1962                                   EMELYANOV-YA   26
                                      BREUER,M  " ADAPTIVE COMPUTERS " 1967                                                   15
,Y " A HIGHER-ORDER LANGUAGE FOR DESCRIBING MICROPROGRAMMED COMPUTERS " 1968                                            CHU   20
```

```
                                              KWIC INDEX LISTING
                                                                                                          DATE      10/23/69
                                                                                                          TIME      01:42:03

TEXT                                                          KEYWORD AND TEXT                                               INDEX

 JGOT,P " MICROMACHINE UNIVERSAL STRUCTURE STUDY ORIENTED TO COMPUTERS SIMULATION " 1968          BAZERQUE,G; FERRIE,J & H     6
                           SEMARNE,H & MCGEE,W " STORED LOGIC COMPUTING " 1961                                                 66
   MICRO-PROGRAMMING AS A TECHNIQUE IN THE CONTROL OF DIGITAL COMPUTING SYSTEMS " 1958        MORRISON,G " INVESTIGATION OF    57
                       GERACE,G " MICROPROGRAMMED CONTROL FOR COMPUTING SYSTEMS " 1963                                         28
RING SYSTEM "                                   ALLEN-BABCOCK COMPUTING, INC " INFORMATION OUTLINE: REMOTE-ACCESS TIME-SHA      1
                  BLANKENBAKER,J " LOGICALLY MICRO-PROGRAMMED COMPUTORS " 1960                                                 11
  CZI,L " THE COMPUTER-WITHIN-A-COMPUTER  A FOURTH GENERATION CONCEPT " 1969                                           RAKO    61
                    HARRAND,Y " EVOLUTION OF MICROPROGRAMMING CONCEPTS " 1963                                                  34
                                                              CONROY,E & MEADE,R " A MICROINSTRUCTION SYSTEM " 1961            22
                                                              CONROY,E " MICROPROGRAMMING " 1961                               21
SYSTEM/360, MODEL 85 " 1968                                   CONTI,C; GIBSON,D & PITKOWSKY,S " STRUCTURAL ASPECTS OF THE      23
                       SCHLAEPPI,H " MICROPROGRAMMED COMPUTER CONTROL " 1963                                                   65
   CIRRUS, ECONOMICAL MULTIPROGRAM COMPUTER WITH MICROPROGRAM CONTROL " 1963                    ROSE,G; SANDERSON,J ET AL "     2
   CIRRUS, ECONOMICAL MULTIPROGRAM COMPUTER WITH MICROPROGRAM CONTROL " 1963            ALLEN,M; PEARCEY,T; PENNY,J ET AL "     2
  ,W & PETERSON,H " MICROPROGRAMMING FOR DATA ACQUISITION AND CONTROL " 1965                                          MCGEE    52
   VALASSIS,J " MODULAR COMPUTER DESIGN WITH PICOPROGRAMMED CONTROL " 1967                                                     74
  KES,M & STRINGER,J " MICROPROGRAMMING AND THE DESIGN OF THE CONTROL CIRCUITS IN AN ELECTRONIC DIGITAL COMPUTER " 1953WIL      84
                                   GERACE,G " MICROPROGRAMMED CONTROL FOR COMPUTING SYSTEMS " 1963                             28
          EMELYANOV-YAROSLAVSKY,L & TIMOFEEV,A " MICROPROGRAM CONTROL FOR DIGITAL COMPUTERS " 1962                             26
                                      TUCKER,S " MICROPROGRAM CONTROL FOR SYSTEM/360 " 1967                                    73
                          MCGEE,W & PETERSON,H " MICROPROGRAM CONTROL FOR THE EXPERIMENTAL SCIENCES " 1965                     51
                           HAWRYSZKIEWYCZ,I " MICROPROGRAMMED CONTROL IN PROBLEM-ORIENTED LANGUAGES " 1967                     35
    KLEIN,S & SCHWARTZ,S " MODEL 4200 - 8200 READ-ONLY MEMORY CONTROL LOGIC " 1968                                             43
   " INVESTIGATION OF MICRO-PROGRAMMING AS A TECHNIQUE IN THE CONTROL OF DIGITAL COMPUTING SYSTEMS " 1958        MORRISON,G    57
  FOR A TIME-SHARED PROCESSOR " 1968        HOERNES,G ET AL " CONTROL STORAGE USE IN IMPLEMENTING AN ASSOCIATIVE PROCESSOR     37
  FOR A TIME-SHARED PROCESSOR " 1968      HELLERMAN,L ET AL " CONTROL STORAGE USE IN IMPLEMENTING AN ASSOCIATIVE PROCESSOR     37
                  VANDLING,G & WALDECKER,D " THE MICROPROGRAM CONTROL TECHNIQUE FOR DIGITAL LOGIC DESIGN " 1969                76
               MATSUSHITA,S " A MICROPROGRAMMED COMMUNICATION CONTROL UNIT, THE TOSBAC DN-231 " 1968                            47
 SELLI,A " THE DESIGN OF PROGRAM-MODIFIABLE MICRO-PROGRAMMED CONTROL UNITS " 1962                                      GRAS    30
                                   BAILEY,S " FASTER COMPUTER CONTROL WITH A READ-ONLY MEMORY " 1967                            4
          BUCKINGHAM,B; CARTER,W; CRAWFORD,W & NOWELL,G " THE CONTROLS AUTOMATION SYSTEM " 1965                                17
                   IBM " DATA PROCESSING: MICROPROGRAMMING PI COURSE "                                                         39
5                                     BUCKINGHAM,B; CARTER,W; CRAWFORD,W & NOWELL,G " THE CONTROLS AUTOMATION SYSTEM " 196     17

                       REBOULOT,M " EXTRACTEUR MICROPROGRAMME D' INFORMATION RADAR " 1968                                      62
                  MCGEE,W & PETERSON,H " MICROPROGRAMMING FOR DATA ACQUISITION AND CONTROL " 1965                              52
                                                        IBM " DATA PROCESSING: MICROPROGRAMMING PI COURSE "                    39
                               BECK,L & KEELER,F " THE C-8401 DATA PROCESSOR " 1964                                             7
                                                  MCCLURE,R & DAVIS,R " A SMALL MICROPROGRAMMED COMPUTER " 1969                48
                                                              DECISION SYSTEMS,INC " INTERIM STATUS REPORT NO. 1 " 1968        24
                                                          VAN DER POEL,W " MICRO-PROGRAMMING AND TRICKOLOGY " 1962             75
                          CHU,Y " A HIGHER-ORDER LANGUAGE FOR DESCRIBING MICROPROGRAMMED COMPUTERS " 1968                      20
  ER,D " THE MICROPROGRAM CONTROL TECHNIQUE FOR DIGITAL LOGIC DESIGN " 1969                            VANDLING,G & WALDECK    76
                       VOLLBRECHT,J " MIDAS: MICROPROGRAMMING DESIGN AID SYSTEM FOR RCA SPECTRA 70/45 " 1968                   77
                                   WILKES,M " THE BEST WAY TO DESIGN AN AUTOMATIC CALCULATING MACHINE " 1951                   80
                    BASHKOW,T; SASSON,A & KRUNFELD,A " SYSTEM DESIGN OF A FORTRAN MACHINE " 1967                                5
 WITH ELEMENTARY STRUCTURE " 1960               KAMPE,T " THE DESIGN OF A GENERAL-PURPOSE MICROPROGRAM-CONTROLLED COMPUTER     42
                                          INGALLS,R " LOGICAL DESIGN OF A MICROPROGRAMMED SPECIAL-PURPOSE COMPUTER " 1966      40
" 1962                                      GRASSELLI,A " THE DESIGN OF PROGRAM-MODIFIABLE MICRO-PROGRAMMED CONTROL UNITS      30
UTER " 1953WILKES,M & STRINGER,J " MICROPROGRAMMING AND THE DESIGN OF THE CONTROL CIRCUITS IN AN ELECTRONIC DIGITAL COMP      84
                                           ROSEN,S " HARDWARE DESIGN REFLECTING SOFTWARE REQUIREMENTS " 1968                   64
                                VALASSIS,J " MODULAR COMPUTER DESIGN WITH PICOPROGRAMMED CONTROL " 1967                        74
                                                  CALHOUN,R " DIAGNOSTICS AT THE MICROPROGRAMMING LEVEL " 1969                 18
```

```
                                                   KWIC INDEX LISTING
                                                                                                              DATE      10/23/69
                                                                                                              TIME      01:42:03

TEXT------------------------------------------------------ KEYWORD AND TEXT-------------------------------------------- INDEX--

ING AND THE DESIGN OF THE CONTROL CIRCUITS IN AN ELECTRCNIC DIGITAL COMPUTER " 1953WILKES,M & STRINGER,J " MICROPROGRAMM     84
GRAMMING THE SPECTRA 70/35 " 1966    N A VARIABLE STRUCTURE DIGITAL COMPUTER " 1962    CAMPBELL,C & NEILSON,D " MICROPRO     19
YANOV-YAROSLAVSKY,L & TIMOFEEV,A " MICROPROGRAM CONTROL FOR DIGITAL COMPUTERS " 1962                                EMEL     26
ATION OF MICRO-PROGRAMMING AS A TECHNIQUE IN THE CONTROL OF DIGITAL COMPUTING SYSTEMS " 1958       MORRISON,G " INVESTIG     57
NG,G & WALDECKER,D " THE MICROPROGRAM CONTROL TECHNIQUE FOR DIGITAL LOGIC DESIGN " 1969                           VANDLI     76
         MELBOURNE,A & PUGMIRE,J " A SMALL COMPUTER FOR THE DIRECT PROCESSING OF FORTRAN STATEMENTS " 1965                   54
                                              OPLER,A " NEW DIRECTIONS IN SOFTWARE 1960-1966 " 1966                          59
 " A MICROPROGRAMMED COMMUNICATION CONTROL UNIT, THE TOSBAC DN-231 " 1968                                   MATSUSHITA,S     47
                                                            DREYER,L " PRINCIPLES OF A TWO-LEVEL MEMORY COMPUTER " 1968      25

 1963                    ROSE,G; SANDERSON,J ET AL " CIRRUS, ECONOMICAL MULTIPROGRAM COMPUTER WITH MICROPROGRAM CONTROL "      2
 1963          ALLEN,M; PEARCEY,T; PENNY,J ET AL " CIRRUS, ECONOMICAL MULTIPROGRAM COMPUTER WITH MICROPROGRAM CONTROL "      2
CROPROGRAMMING AND THE DESIGN OF THE CONTROL CIRCUITS IN AN ELECTRONIC DIGITAL COMPUTER " 1953WILKES,M & STRINGER,J " MI    84
 OF A GENERAL-PURPOSE MICROPROGRAM-CONTROLLED COMPUTER WITH ELEMENTARY STRUCTURE " 1960             KAMPE,T " THE DESIGN     42
FOR DIGITAL COMPUTERS " 1962                                EMELYANOV-YAROSLAVSKY,L & TIMOFEEV,A " MICROPROGRAM CONTROL      26
                             BENJAMIN,R " THE SPECTRA 70/45 EMULATOR FOR THE RCA 301 " 1965                                   9
                                GREEN,J " MICROPROGRAMMING, EMULATORS AND PROGRAMMING LANGUAGES " 1966                       31

             7 ENTRIES WERE SUPPRESSED FOR KEYWORD -------> ET

              WEBER,H " A MICROPROGRAMMED IMPLEMENTATION OF EULER ON IBM SYSTEM/360 MODEL 30 " 1967                          78
                                                HARRAND,Y " EVOLUTION OF MICROPROGRAMMING CONCEPTS " 1963                    34
        MCGEE,W & PETERSON,H " MICROPROGRAM CONTROL FOR THE EXPERIMENTAL SCIENCES " 1965                                     51
                                               REBOULOT,M " EXTRACTEUR MICROPROGRAMME D' INFORMATION RADAR " 1968           62

                                                 BAILEY,S " FASTER COMPUTER CONTROL WITH A READ-ONLY MEMORY " 1967            4
   MCCORMACK,M; SCHANSMAN,T & WOMACK,K " 1401 COMPATIBILITY FEATURE ON THE IBM SYSTEM/360 MODEL 30 " 1965                    49
ORIENTED TO COMPUTERS SIMULATION " 1968         BAZERQUE,G; FERRIE,J & HUGOT,P " MICROMACHINE UNIVERSAL STRUCTURE STUDY      6
OMPUTER - A MICROPROGRAMMED COMPUTER WITH A PHOTOTRANSISTOR FIXED MEMORY " 1962        YAMAUCHI,H ET AL " THE KT PILOT C     33
OMPUTER - A MICROPROGRAMMED COMPUTER WITH A PHOTOTRANSISTOR FIXED MEMORY " 1962      MATSUSHITA,S ET AL " THE KT PILOT C     33
OMPUTER - A MICROPROGRAMMED COMPUTER WITH A PHOTOTRANSISTER FIXED MEMORY " 1962 HAGIWARA,H; AMO,K ET AL " THE KT PILOT C     33
                                                            FLYNN,M & MACLAREN,M " MICROPROGRAMMING REVISITED " 1967         27

            16 ENTRIES WERE SUPPRESSED FOR KEYWORD -------> FOR

      BASHKOW,T; SASSON,A & KRONFELD,A " SYSTEM DESIGN OF A FORTRAN MACHINE " 1967                                            5
& PUGMIRE,J " A SMALL COMPUTER FOR THE DIRECT PROCESSING OF FORTRAN STATEMENTS " 1965                        MELBOURNE,A     54
              RAKOCZI,L " THE COMPUTER-WITHIN-A-COMPUTER  A FOURTH GENERATION CONCEPT " 1969                                 61
                                                  OPLER,A " FOURTH-GENERATION SOFTWARE: THE REALIGNMENT " 1967               58

TARY STRUCTURE " 1960             KAMPE,T " THE DESIGN OF A GENERAL-PURPOSE MICROPROGRAM-CONTROLLED COMPUTER WITH ELEMEN     42
      RAKOCZI,L " THE COMPUTER-WITHIN-A-COMPUTER   A FOURTH GENERATION CONCEPT " 1969                                        61
963                                                         GERACE,G " MICROPROGRAMMED CONTROL FOR COMPUTING SYSTEMS " 1     28
D, MODEL 85 " 1968                                 CONTI,C; GIBSON,D & PITKOWSKY,S " STRUCTURAL ASPECTS OF THE SYSTEM/36     23
                                                            GLANTZ,H " A NOTE ON MICROPROGRAMMING " 1956                     29
                  ROSE,G " INTERGRAPHIC,' A MICROPROGRAMMED GRAPHICAL-INTERFACE COMPUTER " 1967                              63
MED CONTROL UNITS " 1962                                    GRASSELLI,A " THE DESIGN OF PROGRAM-MODIFIABLE MICRO-PROGRAM     30
GES " 1966                                                  GREEN,J " MICROPROGRAMMING, EMULATORS AND PROGRAMMING LANGUA     31
                                                            GREENBERG,M & WEGBREIT,E " A MICROPROGRAMMED COMPUTER " 1968     32
                                             WILKES,M " THE GROWTH OF INTEREST IN MICROPROGRAMMING " 1968                    82
" 1969                                       WILKES,M " THE GROWTH OF INTEREST IN MICROPROGRAMMING: A LITERATURE SURVEY      83

GRAMMED COMPUTER WITH A PHOTOTRANSISTER FIXED MEMORY " 1962 HAGIWARA,H; AMO,K ET AL " THE KT PILOT COMPUTER - A MICROPRO     33
```

```
                                          KWIC INDEX LISTING
                                                                                                        DATE     10/23/69
                                                                                                        TIME     DI:42:03

TEXT_________________________________________________________ KEYWORD AND TEXT______________________________________________ INDEX___

OLUTION, THE VARIABLE INSTRUCTI3N COMPUTER " 1966SPENCE,A " HAROWARE AND SOFTWARE INTERACTIONS; A MACHINE ORGANIZATION S      69
                                                  ROSEN,S " HAROWARE DESIGN REFLECTING SOFTWARE REQUIREMENTS " 196B          64
                                                            HARRAND,Y " EVOLUTION OF MICROPROGRAMMING CONCEPTS " 1963          34
ED LANGUAGES " 1967                                         HAWRYSZKIEWYCZ,I " MICROPROGRAMMED CONTROL IN PROBLEM-ORIENT      35
                                                            HECKELMAN,R " SELF-CHECKING REDUNDANT MICROPROGRAMS " 1966       36
SSOCIATIVE PROCESSOR FOR A TIME-SHAREO PR3CESSOR " 196B     HELLERMAN,L ET AL " CONTROL STORAGE USE IN IMPLEMENTING AN A      37
                      MEGGITT,J " A CHARACTOR COMPUTER FCR HIGH LEVEL LANGUAGE INTERPRETATION " 1964                      53
RS " 196B                                         CHU,Y " A HIGHER-OROER LANGUAGE FOR DESCRIBING MICROPROGRAMMED COMPUTE      20
                                                            HILL,R " STORED LOGIC PROGRAMMING AND APPLICATIONS " 1964         3B
OCIATIVE PROCESSOR FOR A TIME-SHARED PROCESSOR " 196B       HOERNES,G ET AL " CONTROL STORAGE USE IN IMPLEMENTING AN ASS      37
                                                BILLING,H & HOPMANN,W " MIKROPROGRAMM-STEUERWERK " 1955                   1D
OGRAMMABLE COMPUTER " 1963                     BOUTWELL,E & HOSKINSON,E " THE LOGICAL ORGANIZATION OF THE PB 44D MICROPR      14
 COMPUTERS SIMULATION " 196B            BAZERQUE,G; FERRIE,J & HUGOT,P " MICROMACHINE UNIVERSAL STRUCTURE STUDY ORIENTED TO       6

                                                            IBM " OATA PROCESSING: MICROPROGRAMMING PI COURSE "               39
 SCHANSMAN,T & WOMACK,K " 14D1 COMPATIBILITY FEATURE ON THE IBM SYSTEM/360 MOOEL 3D " 1965                    MCCORMACK,M;     49
    WEBER,H " A MICROPROGRAMMED IMPLEMENTATION OF EULER CN IBM SYSTEM/360 MODEL 30 " 1967                                     78
                STEVENS,W " THE STRUCTURE OF SYSTEM/360; PART II - SYSTEM IMPLEMENTATIONS " 1964                             7D
                              WEBER,H " A MICROPROGRAMMED IMPLEMENTATION OF EULER ON IBM SYSTEM/36D MODEL 3D " 1967          78
  STEVENS,W " THE STRUCTURE OF SYSTEM/36D; PART II - SYSTEM IMPLEMENTATIONS " 1964                                           7D
ESSOR " 196B      HELLERMAN,L ET AL " CONTROL STORAGE USE IN IMPLEMENTING AN ASSOCIATIVE PROCESSOR FOR A TIME-SHARED PROC      37
ESSOR " 196B        HOERNES,G ET AL " CONTROL STORAGE USE IN IMPLEMENTING AN ASSOCIATIVE PROCESSOR FOR A TIME-SHARED PROC      37
                              PATZER,W & VANDLING,G " SYSTEMS IMPLICATIONS OF MICROPROGRAMMING " 1967                        60

          B ENTRIES WERE SUPPRESSED FOR KEYWORD -------> IN

 "                              ALLEN-BABCOCK COMPUTING, INC " INFORMATION OUTLINE: REMOTE-ACCESS TIME-SHARING SYSTEM         1
                               ALLEN-BABCOCK COMPUTING, INC " INFORMATION OUTLINE: REMOTE-ACCESS TIME-SHARING SYSTEM "        1
                    REBOULOT,M " EXTRACTEUR MICROPROGRAMME D' INFORMATION RADAR " 196B                                       62
OSE COMPUTER " 1966                                         INGALLS,R " LOGICAL DESIGN OF A MICROPROGRAMMED SPECIAL-PURP      4D
INTERACTIONS; A MACHINE ORGANIZATION SOLUTION, THE VARIABLE INSTRUCTION COMPUTER " 1966SPENCE,A " HARDWARE AND SOFTWARE      69
             MILLER,E " RELIABILITY ASPECTS OF THE VARIABLE INSTRUCTION COMPUTER " 1967                                      56
                 LAWSON,H " PROGRAMMING-LANGUAGE-ORIENTED INSTRUCTION STREAMS " 196B                                         44
LINHARDT,R & MILLER,H " SYSTEM ARCHITECTURE FOR LARGE SCALE INTEGRATION " 1967                     BEELITZ,H; LEVY,S;        8
INSTRUCTION COMPUTER " 1966SPENCE,A " HAROWARE AND SOFTWARE INTERACTIONS; A MACHINE ORGANIZATION SOLUTION, THE VARIABLE      69
                                 WILKES,M " THE GROWTH OF INTEREST IN MICROPROGRAMMING " 196B                                82
                                 WILKES,M " THE GROWTH CF INTEREST IN MICROPROGRAMMING: A LITERATURE SURVEY " 1969           83
R " 1967                                           ROSE,G " INTERGRAPHIC,' A MICROPROGRAMMED GRAPHICAL-INTERFACE COMPUTE      63
                                  DECISION SYSTEMS,INC " INTERIM STATUS REPORT NO. 1 " 1968                                  24
   MEGGITT,J " A CHARACTOR COMPUTER FOR HIGH LEVEL LANGUAGE INTERPRETATION " 1964                                            53
TROL OF DIGITAL COMPUTING SYSTEMS " 195B       MORRISON,G " INVESTIGATION OF MICRO-PROGRAMMING AS A TECHNIQUE IN THE CON      57
                                                            IVERSON,K " A PROGRAMMING LANGUAGE " 1962                        41

OLLEO COMPUTER WITH ELEMENTARY STRUCTURE " 1960             KAMPE,T " THE OESIGN OF A GENERAL-PURPOSE MICROPROGRAM-CONTR      42
                                                   BECK,L & KEELER,F " THE C-B4DI DATA PROCESSOR " 1964                       7
                             BORSCHEV,V; VASILEVSKIY,P & KHOMYAKOV,M " A PROGRAMMING MICRO-LANGUAGE FOR URAL-4 " 1966        12
NTROL LOGIC " 196B                                          KLEIN,S & SCHWARTZ,S " MODEL 4200 - B2D0 READ-ONLY MEMORY CO      43
                                    BASHKOW,T; SASSON,A & KRONFELD,A " SYSTEM DESIGN OF A FORTRAN MACHINE " 1967              5
RANSISTOR FIXED MEMORY " 1962       MATSUSHITA,S ET AL " THE KT PILOT COMPUTER - A MICROPROGRAMMEO COMPUTER WITH A PHOTOT      33
RANSISTOR FIXEO MEMORY " 1962         YAMAUCHI,H ET AL " THE KT PILOT COMPUTER - A MICROPROGRAMMEO COMPUTER WITH A PHOTOT      33
RANSISTER FIXED MEMORY " 1962 HAGIWARA,H; AMO,K ET AL " THE KT PILOT COMPUTER - A MICROPROGRAMMEO COMPUTER WITH A PHOTOT      33

                              IVERSON,K " A PROGRAMMING LANGUAGE " 1962                                                      41
```

```
TEXT________________________________________________________ KEYWORD AND TEXT____________________________________________ INDEX___

                                      CHU,Y " A HIGHER-ORDER LANGUAGE FOR DESCRIBING MICROPROGRAMMED COMPUTERS " 1968       20
             MEGGITT,J " A CHARACTOR COMPUTER FOR HIGH LEVEL LANGUAGE INTERPRETATION " 1964                               53
       GREEN,J " MICROPROGRAMMING, EMULATORS AND PROGRAMMING LANGUAGES " 1966                                             31
 PYSZKIEWYCZ,I " MICROPROGRAMMED CONTROL IN PROBLEM-ORIENTED LANGUAGES " 1967                                         HAW  35
 ,H; LEVY,S; LINHARDT,R & MILLER,H " SYSTEM ARCHITECTURE FOR LARGE SCALE INTEGRATION " 1967                       BEELITZ   8
" 1968                                                       LAWSON,H " PROGRAMMING-LANGUAGE-ORIENTED INSTRUCTION STREAMS  44
             CALHOUN,R " DIAGNOSTICS AT THE MICROPROGRAMMING LEVEL " 1969                                                 18
                   MEGGITT,J " A CHARACTOR COMPUTER FOR HIGH LEVEL LANGUAGE INTERPRETATION " 1964                         53
                                                             LEVY,L " STATE OF THE ART OF MICROPROGRAMMING " 1965         45
E SCALE INTEGRATION " 1967                        BEELITZ,H; LEVY,S; LINHARDT,R & MILLER,H " SYSTEM ARCHITECTURE FOR LARG   8
INTEGRATION " 1967                        BEELITZ,H; LEVY,S; LINHARDT,R & MILLER,H " SYSTEM ARCHITECTURE FOR LARGE SCALE    8
    WILKES,M " THE GROWTH OF INTEREST IN MICROPROGRAMMING: A LITERATURE SURVEY " 1969                                     83
65                                                           LIVERANCE,H " A SYSTEM/360 PROFILE -- READ-ONLY STORAGE " 19  46
                      AMDAHL,L " MICROPROGRAMMING AND STORED LOGIC " 1964                                                  3
 S & SCHWARTZ,S " MODEL 4200 - 8200 READ-ONLY MEMORY CONTROL LOGIC " 1968                                          KLEIN,  43
                             SEMARNE,H & PORTER,R " A STORED LOGIC COMPUTER " 1961                                        67
                                SEMARNE,H & MCGEE,W " STORED LOGIC COMPUTING " 1961                                       66
 ALDECKER,D " THE MICROPROGRAM CONTROL TECHNIQUE FOR DIGITAL LOGIC DESIGN " 1969                           VANDLING,G & W  76
                                             HILL,R " STORED LOGIC PROGRAMMING AND APPLICATIONS " 1964                    38
 " 1966                                          INGALLS,R " LOGICAL DESIGN OF A MICROPROGRAMMED SPECIAL-PURPOSE COMPUTER  40
R " 1963                      BOUTWELL,E & HOSKINSON,E " THE LOGICAL ORGANIZATION OF THE PB 440 MICROPROGRAMMABLE COMPUTE  14
                                            BLANKENBAKER,J " LOGICALLY MICRO-PROGRAMMED COMPUTORS " 1960                  11

  WILKES,M " THE BEST WAY TO DESIGN AN AUTOMATIC CALCULATING MACHINE " 1951                                               80
 SHKOW,T; SASSON,A & KRUMFELD,A " SYSTEM DESIGN OF A FORTRAN MACHINE " 1967                                            BA   5
UTER " 1966SPENCE,A " HARDWARE AND SOFTWARE INTERACTIONS; A MACHINE ORGANIZATION SOLUTION, THE VARIABLE INSTRUCTION COMP  69
                                                   FLYNN,M & MACLAREN,M " MICROPROGRAMMING REVISITED " 1967                27
 THE TOSBAC DN-231 " 1968                                    MATSUSHITA,S " A MICROPROGRAMMED COMMUNICATION CONTROL UNIT,  47
ED COMPUTER WITH A PHOTOTRANSISTOR FIXED MEMORY " 1962       MATSUSHITA,S ET AL " THE KT PILOT COMPUTER - A MICROPROGRAMM  33
9                                                            MCCLURE,R & DAVIS,R " A SMALL MICROPROGRAMMED COMPUTER " 196  48
TURE ON THE IBM SYSTEM/360 MODEL 30 " 1965                   MCCORMACK,M; SCHANSMAN,T & WOMACK,K " 1401 COMPATIBILITY FEA  49
NTAL SCIENCES " 1965                                         MCGEE,W & PETERSON,H " MICROPROGRAM CONTROL FOR THE EXPERIME  51
 AND CONTROL " 1965                                          MCGEE,W & PETERSON,H " MICROPROGRAMMING FOR DATA ACQUISITION  52
                                                 SEMARNE,H & MCGEE,W " STORED LOGIC COMPUTING " 1961                      66
                                                             MCGEE,W " THE TRW-133 COMPUTER " 1964                        50
                                                  CONROY,E & MEADE,R " A MICROINSTRUCTION SYSTEM " 1961                   22
ERPRETATION " 1964                                           MEGGITT,J " A CHARACTOR COMPUTER FOR HIGH LEVEL LANGUAGE INT  53
OCESSING OF FORTRAN STATEMENTS " 1965                        MELBOURNE,A & PUGMIRE,J " A SMALL COMPUTER FOR THE DIRECT PR  54
 R - A MICROPROGRAMMED COMPUTER WITH A PHOTOTRANSISTOR FIXED MEMORY " 1962        YAMAUCHI,H ET AL " THE KT PILOT COMPUTE  33
 R - A MICROPROGRAMMED COMPUTER WITH A PHOTOTRANSISTOR FIXED MEMORY " 1962      MATSUSHITA,S ET AL " THE KT PILOT COMPUTE  33
 R - A MICROPROGRAMMED COMPUTER WITH A PHOTOTRANSISTOR FIXED MEMORY " 1962 HAGIWARA,H; AMU,K ET AL " THE KT PILOT COMPUTE  33
         BAILEY,S " FASTER COMPUTER CONTROL WITH A READ-ONLY MEMORY " 1967                                                 4
                        DREYER,L " PRINCIPLES OF A TWO-LEVEL MEMORY COMPUTER " 1968                                       25
          KLEIN,S & SCHWARTZ,S " MODEL 4200 - 8200 READ-ONLY MEMORY CONTROL LOGIC " 1968                                  43
                                                             MERCER,R " MICRO-PROGRAMMING " 1957                          55
                                          SLOBODYANYUK,T " A METHOD OF MINIMIZING MICROPROGRAMS " 1967                    68
     BORSCHEV,V; VASILEVSKIY,P & KHUMYAKOV,M " A PROGRAMMING MICRO-LANGUAGE FOR URAL-4 " 1966                             12
                                  BLANKENBAKER,J " LOGICALLY MICRO-PROGRAMMED COMPUTORS " 1960                            11
              GRASSELLI,A " THE DESIGN OF PROGRAM-MODIFIABLE MICRO-PROGRAMMED CONTROL UNITS " 1962                        30
                                                  MERCER,R " MICRO-PROGRAMMING " 1957                                     55
                                            VAN DER POEL,W " MICRO-PROGRAMMING AND TRICKOLOGY " 1962                      75
OMPUTING SYSTEMS " 1958        MORRISON,G " INVESTIGATION OF MICRO-PROGRAMMING AS A TECHNIQUE IN THE CONTROL OF DIGITAL C  57
                                      CONROY,E & MEADE,R " A MICROINSTRUCTION SYSTEM " 1961                               22
```

```
                                                      KWIC INDEX LISTING
                                                                                                           DATE       10/23/69
                                                                                                           TIME       01:42:03

TEXT_______________________________________________________ KEYWORD AND TEXT____________________________________________   INDEX____

 SIMULATION " 1968         BAZERQUE,G; FERRIE,J & HUGOT,P " MICROMACHINE UNIVERSAL STRUCTURE STUDY ORIENTED TO COMPUTERS      6
SON,J ET AL " CIRRUS, ECONOMICAL MULTIPROGRAM COMPUTER WITH MICROPROGRAM CONTROL " 1963                   ROSE,G; SANDER      2
NNY,J ET AL " CIRRUS, ECONOMICAL MULTIPROGRAM COMPUTER WITH MICROPROGRAM CONTROL " 1963           ALLEN,M; PEARCEY,T; PE      2
                     EMELYANOV-YAROSLAVSKY,L & TIMOFEEV,A " MICROPROGRAM CONTROL FOR DIGITAL COMPUTERS " 1962                26
                                                 TUCKER,S " MICROPROGRAM CONTROL FOR SYSTEM/360 " 1967                       73
                                     MCGEE,W & PETERSON,H " MICROPROGRAM CONTROL FOR THE EXPERIMENTAL SCIENCES " 1965        51
59                           VANDLING,G & WALDECKER,D " THE MICROPROGRAM CONTROL TECHNIQUE FOR DIGITAL LOGIC DESIGN " 19     76
 1960             KAMPE,T " THE DESIGN OF A GENERAL-PURPOSE MICROPROGRAM-CONTROLLED COMPUTER WITH ELEMENTARY STRUCTURE "     42
LL,E & HOSKINSON,E " THE LOGICAL ORGANIZATION OF THE PB 440 MICROPROGRAMMABLE COMPUTER " 1963                     BOUTWE     14
                                    REBOULOT,M " EXTRACTEUR MICROPROGRAMME D' INFORMATION RADAR " 1968                       62
1 " 1968                                   MATSUSHITA,S " A MICROPROGRAMMED COMMUNICATION CONTROL UNIT, THE TOSBAC ON-23     47
                               GREENBERG,M & WEGBREIT,E " A MICROPROGRAMMED COMPUTER " 1968                                  32
                              MCCLURE,R & DAVIS,R " A SMALL MICROPROGRAMMED COMPUTER " 1969                                  48
                                              SCHLAEPPI,H " MICROPROGRAMMED COMPUTER CONTROL " 1963                          65
 " 1962 HAGIWARA,H; AMO,K ET AL " THE KT PILOT COMPUTER - A MICROPROGRAMMED COMPUTER WITH A PHOTOTRANSISTER FIXED MEMORY     33
 " 1962      MATSUSHITA,S ET AL " THE KT PILOT COMPUTER - A MICROPROGRAMMED COMPUTER WITH A PHOTOTRANSISTOR FIXED MEMORY     33
 " 1962        YAMAUCHI,H ET AL " THE KT PILOT COMPUTER - A MICROPROGRAMMED COMPUTER WITH A PHOTOTRANSISTOR FIXED MEMORY     33
             CHU,Y " A HIGHER-ORDER LANGUAGE FOR DESCRIBING MICROPROGRAMMED COMPUTERS " 1968                                 20
                                                 GERACE,G " MICROPROGRAMMED CONTROL FOR COMPUTING SYSTEMS " 1963             28
                                         HAWRYSZKIEWYCZ,I " MICROPROGRAMMED CONTROL IN PROBLEM-ORIENTED LANGUAGES " 1967     35
                                  ROSE,G " INTERGRAPHIC,' A MICROPROGRAMMED GRAPHICAL-INTERFACE COMPUTER " 1967              63
OEL 30 " 1967                                   WEBER,H " A MICROPROGRAMMED IMPLEMENTATION OF EULER ON IBM SYSTEM/360 MO     78
                            INGALLS,R " LOGICAL DESIGN OF A MICROPROGRAMMED SPECIAL-PURPOSE COMPUTER " 1966                  40
                                             STRUGARU,C " A MICROPROGRAMMED UNIT FOR COMPUTER SYSTEMS " 1969                 72
                                       GLANTZ,H " A NOTE ON MICROPROGRAMMING " 1956                                          29
                                                 WILKES,M " MICROPROGRAMMING " 1959                                          81
                                                 CONROY,E " MICROPROGRAMMING " 1961                                          21
                               LEVY,L " STATE OF THE ART OF MICROPROGRAMMING " 1965                                          45
            PATZER,W & VANDLING,G " SYSTEMS IMPLICATIONS OF MICROPROGRAMMING " 1967                                          60
                       WILKES,M " THE GROWTH OF INTEREST IN MICROPROGRAMMING " 1968                                          82
                                                  WEBER,H " MICROPROGRAMMING " 1969                                          79
                                                 AMDAHL,L " MICROPROGRAMMING AND STORED LOGIC " 1964                          3
                                               STRINGER,J " MICROPROGRAMMING AND THE CHOICE OF ORDER CODE " 1953             71
N ELECTRONIC DIGITAL COMPUTER " 1953WILKES,M & STRINGER,J " MICROPROGRAMMING AND THE DESIGN OF THE CONTROL CIRCUITS IN A     84
                                   HARRAND,Y " EVOLUTION OF MICROPROGRAMMING CONCEPTS " 1963                                 34
968                                   VOLLBRECHT,J " MIDAS: MICROPROGRAMMING DESIGN AID SYSTEM FOR RCA SPECTRA 70/45 " I     77
                                     MCGEE,W & PETERSON,H " MICROPROGRAMMING FOR DATA ACQUISITION AND CONTROL " 1965         52
                             CALHOUN,R " DIAGNOSTICS AT THE MICROPROGRAMMING LEVEL " 1969                                    18
                                     IBM " DATA PROCESSING: MICROPROGRAMMING PI COURSE "                                     39
                                     FLYNN,M & MACLAREN,M " MICROPROGRAMMING REVISITED " 1967                                27
RUCTURE DIGITAL COMPUTER " 1962    CAMPBELL,C & NEILSON,D " MICROPROGRAMMING THE SPECTRA 70/35 " 1966    N A VARIABLE ST     19
                                                  GREEN,J " MICROPROGRAMMING, EMULATORS AND PROGRAMMING LANGUAGES " 1966     31
                       WILKES,M " THE GROWTH OF INTEREST IN MICROPROGRAMMING: A LITERATURE SURVEY " 1969                     83
                      HECKELMAN,F " SELF-CHECKING REDUNDANT MICROPROGRAMS " 1966                                             36
                    SLOBODYANYUK,T " A METHOD OF MINIMIZING MICROPROGRAMS " 1967                                             68
/45 " 1968                                   VOLLBRECHT,J " MIDAS: MICROPROGRAMMING DESIGN AID SYSTEM FOR RCA SPECTRA 70     77
                                    BILLING,H & HOPMANN,W " MIKROPROGRAMM-STEUERWERK " 1955                                  10
OMPUTER " 1967                                              MILLER,E " RELIABILITY ASPECTS OF THE VARIABLE INSTRUCTION C     56
 1967                       BEELITZ,H; LEVY,S; LINHARDT,R & MILLER,H " SYSTEM ARCHITECTURE FOR LARGE SCALE INTEGRATION "      8
                               SLOBODYANYUK,T " A METHOD OF MINIMIZING MICROPROGRAMS " 1967                                  68
WOMACK,K " 1401 COMPATIBILITY FEATURE ON THE IBM SYSTEM/360 MODEL 30 " 1965                   MCCORMACK,M; SCHANSMAN,T &     49
A MICROPROGRAMMED IMPLEMENTATION OF EULER ON IBM SYSTEM/360 MODEL 30 " 1967                                    WEBER,H "     78
                                     KLEIN,S & SCHWARTZ,S " MODEL 4200 - 8200 READ-ONLY MEMORY CONTROL LOGIC " 1968          43
```

```
TEXT________________________________________________ KEYWORD AND TEXT___________________________________________________ INDEX____

SON,D & PITKOWSKY,S " STRUCTURAL ASPECTS OF THE SYSTEM/360, MODEL 85 " 1968                                   CONTI,C; GIB      23
                                        VALASSIS,J " MODULAR COMPUTER DESIGN WITH PICOPROGRAMMED CONTROL " 1967              74
JE IN THE CONTROL OF DIGITAL COMPUTING SYSTEMS " 1958     MORRISON,G " INVESTIGATION OF MICRO-PROGRAMMING AS A TECHNIQ      57
     ALLEN,M; PEARCEY,T; PENNY,J ET AL " CIRRUS, ECONOMICAL MULTIPROGRAM COMPUTER WITH MICROPROGRAM CONTRUL " 1963         2
           ROSE,G; SANDERSON,J ET AL " CIRRUS, ECONOMICAL MULTIPROGRAM COMPUTER WITH MICROPROGRAM CONTROL " 1963         2

 & NEILSON,D " MICROPROGRAMMING THE SPECTRA 70/35 " 1966   N A VARIABLE STRUCTURE DIGITAL COMPUTER " 1962    CAMPBELL,C      19
 VARIABLE STRUCTURE DIGITAL COMPUTER " 1962    CAMPBELL,C & NEILSON,D " MICROPROGRAMMING THE SPECTRA 70/35 " 1966    N A      19
                                          OPLER,A " NEW UIRECTIONS IN SOFTWARE 196D-1966 " 1966                                59
                DECISIUN SYSTEMS,INC " INTERIM STATUS REPORT NO. I " 1968                                                     24
                                            GLANTZ,H " A NOTE ON MICROPROGRAMMING " 1956                                      29
                     BUCKINGHAM,B; CARTER,W; CRAWFORD,W & NOWELL,G " THE CONTROLS AUTOMATION SYSTEM " 1965                    17

            22 ENTRIES WERE SUPPRESSEU FOR KEYWORD -------> OF


             3 ENTRIES WERE SUPPRESSED FOR KEYWORD -------> ON


                                                            OPLER,A " FOURTH-GENERATION SOFTWARE: THE REALIGNMENT " 1967      58
                                                            OPLER,A " NEW DIRECTIONS IN SOFTWARE 1960-1966 " 1966             59
            STRINGER,J " MICROPROGRAMMING AND THE CHOICE OF ORDER CODE " 1953                                                 71
                     BOUTWELL,E & HOSKINSON,E " THE LOGICAL ORGANIZATION OF THE PB 440 MICROPROGRAMMABLE COMPUTER " 1963      14
966SPENCE,A " HARDWARE AND SOFTWARE INTERACTIONS; A MACHINE ORGANIZATION SOLUTION, THE VARIABLE INSTRUCTION COMPUTER " 1      69
FERRIE,J & HUGOT,P " MICROMACHINE UNIVERSAL STRUCTURE STUDY ORIENTED TO COMPUTERS SIMULATION " 1968         BAZERQUE,G;        6
                ALLEN-BABCOCK COMPUTING, INC " INFORMATION OUTLINE: REMOTE-ACCESS TIME-SHARING SYSTEM "                        1

                   STEVENS,W " THE STRUCTURE OF SYSTEM/360; PART II - SYSTEM IMPLEMENTATIONS " 1964                            70
MING " 1967                                                 PATZER,W & VANDLING,G " SYSTEMS IMPLICATIONS OF MICROPROGRAM      60
                                            BOUTWELL,E " THE PB 44D COMPUTER " 1964                                           13
 BOUTWELL,E & HOSKINSON,E " THE LOGICAL ORGANIZATION OF THE PB 44D MICROPROGRAMMABLE COMPUTER " 1963                          14
OMPUTER WITH MICROPROGRAM CONTROL " 1963            ALLEN,M; PEARCEY,T; PENNY,J ET AL " CIRRUS, ECONOMICAL MULTIPROGRAM C      2
H MICROPROGRAM CONTROL " 1963             ALLEN,M; PEARCEY,T; PENNY,J ET AL " CIRRUS, ECONOMICAL MULTIPROGRAM COMPUTER WIT      2
CES " 1965                                          MCGEE,W & PETERSON,H " MICROPROGRAM CONTROL FOR THE EXPERIMENTAL SCIEN      51
OL " 1965                                           MCGEE,W & PETERSON,H " MICROPROGRAMMING FOR DATA ACQUISITION AND CONTR      52
" THE KT PILOT COMPUTER - A MICROPROGRAMMED COMPUTER WITH A PHOTOTRANSISTER FIXED MEMORY " 1962 HAGIWARA,H; AMO,K ET AL      33
" THE KT PILOT COMPUTER - A MICROPROGRAMMED COMPUTER WITH A PHOTOTRANSISTOR FIXED MEMORY " 1962        YAMAUCHI,H ET AL      33
" THE KT PILOT COMPUTER - A MICROPROGRAMMED COMPUTER WITH A PHOTOTRANSISTOR FIXED MEMORY " 1962      MATSUSHITA,S ET AL      33
                 IBM " DATA PROCESSING: MICROPROGRAMMING PI COURSE "                                                          39
               VALASSIS,J " MODULAR COMPUTER DESIGN WITH PICOPROGRAMMED CONTROL " 1967                                        74
SISTOR FIXED MEMORY " 1962     MATSUSHITA,S ET AL " THE KT PILOT COMPUTER - A MICROPROGRAMMED COMPUTER WITH A PHOTOTRAN      33
SISTER FIXED MEMORY " 1962 HAGIWARA,H; AMO,K ET AL " THE KT PILOT COMPUTER - A MICROPROGRAMMED COMPUTER WITH A PHOTOTRAN      33
SISTOR FIXED MEMORY " 1962        YAMAUCHI,H ET AL " THE KT PILOT COMPUTER - A MICROPROGRAMMED COMPUTER WITH A PHOTOTRAN      33
 " 1968                             CONTI,C; GIBSON,D & PITKOWSKY,S " STRUCTURAL ASPECTS OF THE SYSTEM/36D, MODEL 85      23
                                                    VAN DER POEL,W " MICRO-PROGRAMMING AND TRICKOLOGY " 1962                  75
                                                 SEMARNE,H & PORTER,R " A STORED LOGIC COMPUTER " 1961                        67
                                                  DREYER,L " PRINCIPLES OF A TWO-LEVEL MEMORY COMPUTER " 1968                 25
                                                  BRILEY,B " PRIUPROGRAMMING " 1965                                           16
              HAWRYSZKIEWYCZ,I " MICROPROGRAMMED CONTROL IN PROBLEM-ORIENTED LANGUAGES " 1967                                 35
   MELBOURNE,A & PUGMIRE,J " A SMALL COMPUTER FOR THE DIRECT PROCESSING OF FORTRAN STATEMENTS " 1965                          54
                                                IBM " DATA PROCESSING: MICROPROGRAMMING PI COURSE "                           39
                       BECK,L & KEELER,F " THE C-8401 DATA PROCESSOR " 1964                                                    7
 IN IMPLEMENTING AN ASSOCIATIVE PROCESSOR FOR A TIME-SHARED PROCESSOR " 1968       HOERNES,G ET AL " CONTROL STORAGE USE      37
```

```
                                                            KWIC INDEX LISTING
                                                                                                                          DATE       10/23/69
                                                                                                                          TIME       01:42:03

TEXT_______________________________________________________ KEYWORD AND TEXT____________________________________________      INDEX____

 IN IMPLEMENTING AN ASSOCIATIVE PROCESSOR FOR A TIME-SHAKED PROCESSOR " 1968    HELLERMAN,L ET AL " CONTROL STORAGE USE      37
 ET AL " CONTRCL STORAGE USE IN IMPLEMENTING AN ASSOCIATIVE PROCESSOR FOR A TIME-SHARED PROCESSOR " 1968       HOERNES,G      37
 ET AL " CONTROL STORAGE USE IN IMPLEMENTING AN ASSOCIATIVE PROCESSOR FOR A TIME-SHARED PROCESSOR " 1968     HELLERMAN,L      37
                                 LIVERANCE,H " A SYSTEM/360 PROFILE -- READ-ONLY STORAGE " 1965                                46
                                GRASSELLI,A " THE DESIGN CF PRUGRAM-MODIFIABLE MICRO-PROGRAMMED CONTROL UNITS " 1962           30
                                      HILL,R " STOREU LOGIC PROGRAMMING AND APPLICATIONS " 1964                                38
                                              IVERSON,K " A PROGRAMMING LANGUAGE " 1962                                        41
                  GREEN,J " MICROPRUGRAMMING, EMULATORS AND PROGRAMMING LANGUAGES " 1966                                       31
                BORSCHEV,V; VASILEVSKIY,P & KHOMYAKOV,M " A PROGRAMMING MICRO-LANGUAGE FOR URAL-4 " 1966                       12
                                                 LAWSON,H " PROGRAMMING-LANGUAGE-ORIENTED INSTRUCTION STREAMS " 1968           44
RTRAN STATEMENTS " 1965                       MELBOURNE,A & PUGMIRE,J " A SMALL COMPUTER FOR THE DIRECT PROCESSING CF FO      54

      REBOULOT,M " EXTRACTEUR MICROPRUGRAMME D' INFORMATICN RADAR " 1968                                                       62
ION CONCEPT " 1969                                          RAKOCZI,L " THE COMPUTER-WITHIN-A-COMPUTER  A FOURTH GENERAT      61
OLLBRECHT,J " MIUAS: MICROPROGRAMMING DESIGN AID SYSTEM FCR RCA SPECTRA 70/45 " 1968                                   V      77
            BENJAMIN,R " THE SPECTRA 70/45 EMULATOR FOR THE RCA 301 " 1965                                                      9
                  BAILEY,S " FASTER COMPUTER CONTROL WITH A READ-ONLY MEMORY " 1967                                             4
                   KLEIN,S & SCHWARTZ,S " MODEL 4200 - 8200 READ-ONLY MEMORY CONTROL LOGIC " 1968                              43
                      LIVERANCE,H " A SYSTEM/360 PROFILE -- READ-ONLY STURAGE " 1965                                           46
                  UPLER,A " FOURTH-GENERATION SOFTWARE: THE REALIGNMENT " 1967                                                 58
" 1968                                                      REBOULOT,M " EXTRACTEUR MICROPROGRAMME D' INFORMATION RADAR       62
                                HECKELMAN,R " SELF-CHECKING REDUNDANT MICROPROGRAMS " 1966                                     36
                                  ROSEN,S " HARDWARE DESIGN REFLECTING SOFTWARE REQUIREMENTS " 1968                            64
967                                              MILLER,E " RELIABILITY ASPECTS OF THE VARIABLE INSTRUCTION COMPUTER " 1      56
        ALLEN-BABCOCK COMPUTING, INC " INFORMATION OUTLINE: REMOTE-ACCESS TIME-SHARING SYSTEM "                                 1
                      DECISION SYSTEMS,INC " INTERIM STATUS REPORT NO. 1 " 1968                                                24
              ROSEN,S " HARDWARE DESIGN REFLECTING SOFTWARE REQUIREMENTS " 1968                                                64
                    FLYNN,M & MACLAREN,M " MICROPROGRAMMING REVISITED " 1967                                                   27
E COMPUTER " 1967                                           ROSE,G " INTERGRAPHIC,' A MICROPROGRAMMED GRAPHICAL-INTERFAC      63
COMPUTER WITH MICROPROGRAM CONTROL " 1963                   ROSE,G; SANDERSON,J ET AL " CIRRUS, ECONOMICAL MULTIPROGRAM        2
 1968                                                       ROSEN,S " HARDWARE DESIGN REFLECTING SOFTWARE REQUIREMENTS "      64

 WITH MICROPROGRAM CONTROL " 1963                   RUSE,G; SANDERSON,J ET AL " CIRRUS, ECONOMICAL MULTIPROGRAM COMPUTER       2
 1967                                            BASHKOW,T; SASSON,A & KRONFELD,A " SYSTEM DESIGN OF A FORTRAN MACHINE "       5
VY,S; LINHARDT,R & MILLER,H " SYSTEM ARCHITECTURE FOR LARGE SCALE INTEGRATION " 1967                       BEELITZ,H; LE       8
3M SYSTEM/360 MODEL 30 " 1965                  MCCORMACK,M; SCHANSMAN,T & WOMACK,K " 1401 COMPATIBILITY FEATURE ON THE I      49
                                                            SCHLAEPPI,H " MICROPROGRAMMED COMPUTER CONTROL " 1963             65
C " 1968                                          KLEIN,S & SCHWARTZ,S " MODEL 4200 - 8200 READ-ONLY MEMORY CONTROL LOGI      43
,W & PETERSUN,H " MICROPROGRAM CONTROL FOR THE EXPERIMENTAL SCIENCES " 1965                                        MCGEE      51
                                              HECKELMAN,R " SELF-CHECKING REDUNDANT MICROPROGRAMS " 1966                      36
                                                            SEMARNE,H & MCGEE,W " STORED LOGIC COMPUTING " 1961               66
                                                            SEMARNE,H & PORTER,R " A STORED LOGIC COMPUTER " 1961             67
ICROMACHINE UNIVERSAL STRUCTURE STUDY ORIENTED TU COMPUTERS SIMULATION " 1968         BAZERQUE,G; FERRIE,J & HUGOT,P " M       6
                                                            SLOBODYANYUK,T " A METHOD OF MINIMIZING MICROPROGRAMS " 1967      68
TS " 1965                       MELBOURNE,A & PUGMIRE,J " A SMALL COMPUTER FOR THE DIRECT PROCESSING OF FORTRAN STATEMEN      54
                                    MCCLURE,R & DAVIS,R " A SMALL MICROPROGRAMMED COMPUTER " 1969                             48
VARIABLE INSTRUCTIUN COMPUTER " 1966SPENCE,A " HARDWARE AND SOFTWARE INTERACTIONS; A MACHINE ORGANIZATION SULUTION, THE       69
                       ROSEN,S " HARUWARE DESIGN REFLECTING SOFTWARE REQUIREMENTS " 1968                                      64
                                OPLER,A " NEW DIRECTIONS IN SOFTWARE 1960-1966 " 1966                                         59
                                OPLER,A " FOURTH-GENERATION SOFTWARE: THE REALIGNMENT " 1967                                  58
 HARDWARE AND SOFTWARE INTERACTIONS; A MACHINE ORGANIZATICN SOLUTION, THE VARIABLE INSTRUCTION COMPUTER " 1966SPENCE,A "      69
            INGALLS,R " LOGICAL DESIGN OF A MICRUPROGRAMMED SPECIAL-PURPOSE COMPUTER " 1966                                   40
TER " 1962    CAMPBELL,C & NEILSON,D " MICROPROGRAMMING THE SPECTRA 70/35 " 1966    N A VARIABLE STRUCTURE DIGITAL COMPU      19
```

```
                                                 KWIC INDEX LISTING
                                                                                                                   DATE      10/23/69
                                                                                                                   TIME      01:42:03

TEXT------------------------------------------------------ KEYWORD AND TEXT-------------------------------------------------  INDEX----

RECHT,J " MIDAS: MICROPROGRAMMING DESIGN AID SYSTEM FOR RCA SPECTRA 70/45 " 1968                                   VOLLB          77
                                           BENJAMIN,R " THE SPECTRA 70/45 EMULATOR FOR THE RCA 301 " 1965                         9
ANIZATION SOLUTION, THE VARIABLE INSTRUCTION COMPUTER " 1966SPENCE,A " HARDWARE AND SOFTWARE INTERACTIONS: A MACHINE ORG          69
                                                   LEVY,L " STATE OF THE ART OF MICROPROGRAMMING " 1965                          45
E,J " A SMALL COMPUTER FOR THE DIRECT PROCESSING OF FORTRAN STATEMENTS " 1965                       MELBOURNE,A & PUGMIR          54
                            DECISION SYSTEMS,INC " INTERIM STATUS REPORT NO. I " 1968                                            24
PLEMENTATIONS " 1964                                        STEVENS,W " THE STRUCTURE OF SYSTEM/360; PART II - SYSTEM IM          70
            LIVERANCE,H " A SYSTEM/360 PROFILE -- READ-ONLY STORAGE " 1965                                                       46
IME-SHARED PROCESSOR " 1968     HELLERMAN,L ET AL " CONTROL STORAGE USE IN IMPLEMENTING AN ASSOCIATIVE PROCESSOR FOR A T          37
IME-SHARED PROCESSOR " 1968       HOERNES,G ET AL " CONTROL STORAGE USE IN IMPLEMENTING AN ASSOCIATIVE PROCESSOR FOR A T          37
                            AMDAHL,L " MICROPROGRAMMING AND STORED LOGIC " 1964                                                   3
                                   SEMARNE,H & PORTER,R " A STORED LOGIC COMPUTER " 1961                                         67
                                      SEMARNE,H & MCGEE,W " STORED LOGIC COMPUTING " 1961                                        66
                                                   HILL,R " STORED LOGIC PROGRAMMING AND APPLICATIONS " 1964                     38
       LAWSON,H " PROGRAMMING-LANGUAGE-ORIENTED INSTRUCTION STREAMS " 1968                                                       44
 1953                                                       STRINGER,J " MICROPROGRAMMING AND THE CHOICE OF ORDER CODE "          71
CIRCUITS IN AN ELECTRONIC DIGITAL COMPUTER " 1953WILKES,M & STRINGER,J " MICROPROGRAMMING AND THE DESIGN OF THE CONTROL           84
                          CONTI,C; GIBSON,D & PITKOWSKY,S " STRUCTURAL ASPECTS OF THE SYSTEM/360, MODEL 85 " 1968                23
AL-PURPOSE MICROPROGRAM-CONTROLLED COMPUTER WITH ELEMENTARY STRUCTURE " 1960             KAMPE,T " THE DESIGN OF A GENER          42
" MICROPROGRAMMING THE SPECTRA 70/35 " 1966    N A VARIABLE STRUCTURE DIGITAL COMPUTER " 1962     CAMPBELL,C & NEILSON,D          19
1964                                        STEVENS,W " THE STRUCTURE OF SYSTEM/360; PART II - SYSTEM IMPLEMENTATIONS "           70
    BAZERQUE,G; FERRIE,J & HUGOT,P " MICROMACHINE UNIVERSAL STRUCTURE STUDY ORIENTED TO COMPUTERS SIMULATION " 1968                6
969                                                         STRUGARU,C " A MICROPROGRAMMED UNIT FOR COMPUTER SYSTEMS " 1          72
JE,G; FERRIE,J & HUGOT,P " MICROMACHINE UNIVERSAL STRUCTURE STUDY ORIENTED TO COMPUTERS SIMULATION " 1968         BAZERQ           6
 " THE GROWTH OF INTEREST IN MICROPROGRAMMING: A LITERATURE SURVEY " 1969                                       WILKES,M          83
TING, INC " INFORMATION OUTLINE: REMOTE-ACCESS TIME-SHARING SYSTEM "                                 ALLEN-BABCOCK COMPU           1
                    CONROY,E & MEADE,R " A MICROINSTRUCTION SYSTEM " 1961                                                        22
; CARTER,W; CRAWFORD,W & NOWELL,G " THE CONTROLS AUTOMATION SYSTEM " 1965                                   BUCKINGHAM,B          17
                 BEELITZ,H; LEVY,S; LINHARDT,R & MILLER,H " SYSTEM ARCHITECTURE FOR LARGE SCALE INTEGRATION " 1967                8
                         BASHKOW,T; SASSON,A & KRONFELD,A " SYSTEM DESIGN OF A FORTRAN MACHINE " 1967                             5
          VOLLBRECHT,J " MIDAS: MICROPROGRAMMING DESIGN AID SYSTEM FOR RCA SPECTRA 70/45 " 1968                                  77
         STEVENS,W " THE STRUCTURE OF SYSTEM/360; PART II - SYSTEM IMPLEMENTATIONS " 1964                                        70
                        TUCKER,S " MICROPROGRAM CONTROL FOR SYSTEM/360 " 1967                                                    73
ANSMAN,T & WOMACK,K " 1401 COMPATIBILITY FEATURE ON THE IBM SYSTEM/360 MODEL 30 " 1965                    MCCORMACK,M; SCH          49
 WEBER,H " A MICROPROGRAMMED IMPLEMENTATION OF EULER ON IBM SYSTEM/360 MODEL 30 " 1967                                           78
                                            LIVERANCE,H " A SYSTEM/360 PROFILE -- READ-ONLY STORAGE " 1965                       46
                               STEVENS,W " THE STRUCTURE OF SYSTEM/360; PART II - SYSTEM IMPLEMENTATIONS " 1964                  70
CONTI,C; GIBSON,D & PITKOWSKY,S " STRUCTURAL ASPECTS OF THE SYSTEM/360, MODEL 85 " 1968                                          23
GRAMMING AS A TECHNIQUE IN THE CONTROL OF DIGITAL COMPUTING SYSTEMS " 1958       MORRISON,G " INVESTIGATION OF MICRO-PRO          57
          GERACE,G " MICROPROGRAMMED CONTROL FOR COMPUTING SYSTEMS " 1963                                                        28
          STRUGARU,C " A MICROPROGRAMMED UNIT FOR COMPUTER SYSTEMS " 1969                                                        72
                                    PATZER,W & VANDLING,G " SYSTEMS IMPLICATIONS OF MICROPROGRAMMING " 1967                      60
                                                   DECISION SYSTEMS,INC " INTERIM STATUS REPORT NO. 1 " 1968                     24

        VANDLING,G & WALDECKER,D " THE MICROPROGRAM CONTROL TECHNIQUE FOR DIGITAL LOGIC DESIGN " 1969                            76
       MORRISON,G " INVESTIGATION OF MICRO-PROGRAMMING AS A TECHNIQUE IN THE CONTROL OF DIGITAL COMPUTING SYSTEMS " 1958          57

            34 ENTRIES WERE SUPPRESSED FOR KEYWORD -------> THE

 STORAGE USE IN IMPLEMENTING AN ASSOCIATIVE PROCESSOR FOR A TIME-SHARED PROCESSOR " 1968        HOERNES,G ET AL " CONTROL          37
 STORAGE USE IN IMPLEMENTING AN ASSOCIATIVE PROCESSOR FOR A TIME-SHARED PROCESSOR " 1968      HELLERMAN,L ET AL " CONTROL          37
BABCOCK COMPUTING, INC " INFORMATION OUTLINE: REMOTE-ACCESS TIME-SHARING SYSTEM "                                 ALLEN-           1
62                                EMELYANOV-YARUSLAVSKY,L & TIMOFEEV,A " MICROPROGRAM CONTROL FOR DIGITAL COMPUTERS " 19          26
```

```
                                            KWIC INDEX LISTING
                                                                                          DATE      10/23/69
                                                                                          TIME      01:42:03

TEXT_______________________________________________ KEYWORD AND TEXT____________________________________ INDEX____

            2 ENTRIES WERE SUPPRESSED FOR KEYWORD -------> TO

SHITA,S " A MICROPROGRAMMED COMMUNICATION CONTROL UNIT, THE TOSBAC ON-231 " 1968                        MATSU      47
                     VAN DER POEL,W " MICRO-PROGRAMMING AND TRICKOLOGY " 1962                                       75
                                              MCGEE,W " THE TRW-133 COMPUTER " 1964                                 50
                                                            TUCKER,S " MICROPROGRAM CONTROL FOR SYSTEM/360 " 1967   73
                              DREYER,L " PRINCIPLES OF A TWO-LEVEL MEMORY COMPUTER " 1968                           25

                                STRUGARU,C " A MICROPROGRAMMED UNIT FOR COMPUTER SYSTEMS " 1969                     72
     MATSUSHITA,S " A MICROPROGRAMMED COMMUNICATION CONTROL UNIT, THE TOSBAC ON-231 " 1968                          47
" THE DESIGN OF PROGRAM-MODIFIABLE MICRO-PROGRAMMED CONTROL UNITS " 1962                       GRASSELLI,A          30
 1968          BAZERQUE,G; FERRIE,J & HUGOT,P " MICROMACHINE UNIVERSAL STRUCTURE STUDY ORIENTED TO COMPUTERS SIMULATION "   6
ILEVSKIY,P & KHOMYAKOV,M " A PROGRAMMING MICRO-LANGUAGE FOR URAL-4 " 1966                     BORSCHEV,V; VAS    12
ED PROCESSOR " 1968        HOERNES,G ET AL " CONTROL STORAGE USE IN IMPLEMENTING AN ASSOCIATIVE PROCESSOR FOR A TIME-SHAR   37
ED PROCESSOR " 1968      HELLERMAN,L ET AL " CONTROL STORAGE USE IN IMPLEMENTING AN ASSOCIATIVE PROCESSOR FOR A TIME-SHAR   37

TROL " 1967                                                 VALASSIS,J " MODULAR COMPUTER DESIGN WITH PICOPROGRAMMED CON   74
                                                            VAN DER POEL,W " MICRO-PROGRAMMING AND TRICKOLOGY " 1962      75
E FOR DIGITAL LOGIC DESIGN " 1969                           VANDLING,G & WALDECKER,D " THE MICROPROGRAM CONTROL TECHNIQU   76
                                                 PATZER,W & VANDLING,G " SYSTEMS IMPLICATIONS OF MICROPROGRAMMING " 1967   60
SOFTWARE INTERACTIONS: A MACHINE ORGANIZATION SOLUTION, THE VARIABLE INSTRUCTION COMPUTER " 1966SPENCE,A " HARDWARE AND   69
                      MILLER,E " RELIABILITY ASPECTS OF THE VARIABLE INSTRUCTION COMPUTER " 1967                    56
EILSON,D " MICROPROGRAMMING THE SPECTRA 70/35 " 1966    N A VARIABLE STRUCTURE DIGITAL COMPUTER " 1962    CAMPBELL,C & N   19
OR URAL-4 " 1966                                BORSCHEV,V; VASILEVSKIY,P & KHOMYAKOV,M " A PROGRAMMING MICRO-LANGUAGE F   12
 RCA SPECTRA 70/45 " 1968                                   VOLLBRECHT,J " MIDAS: MICROPROGRAMMING DESIGN AID SYSTEM FOR   77

 LOGIC DESIGN " 1969                           VANDLING,G & WALDECKER,D " THE MICROPROGRAM CONTROL TECHNIQUE FOR DIGITAL   76
                                        WILKES,M " THE BEST WAY TO DESIGN AN AUTOMATIC CALCULATING MACHINE " 1951           80
YSTEM/360 MODEL 30 " 1967                                   WEBER,H " A MICROPROGRAMMED IMPLEMENTATION OF EULER ON IBM S   78
                                                            WEBER,H " MICROPROGRAMMING " 1969                              79
                                           GREENBERG,M & WEGBREIT,E " A MICROPROGRAMMED COMPUTER " 1968                     32
HE CONTROL CIRCUITS IN AN ELECTRONIC DIGITAL COMPUTER " 1953WILKES,M & STRINGER,J " MICROPROGRAMMING AND THE DESIGN OF T   84
                                                            WILKES,M " MICROPROGRAMMING " 1959                             81
ACHINE " 1951                                               WILKES,M " THE BEST WAY TO DESIGN AN AUTOMATIC CALCULATING M   80
                                                            WILKES,M " THE GROWTH OF INTEREST IN MICROPROGRAMMING " 1968   82
ERATURE SURVEY " 1969                                       WILKES,M " THE GROWTH OF INTEREST IN MICROPROGRAMMING: A LIT   83

            8 ENTRIES WERE SUPPRESSED FOR KEYWORD -------> WITH

MODEL 30 " 1965                 MCCORMACK,M; SCHANSMAN,T & WOMACK,K " 1401 COMPATIBILITY FEATURE ON THE IBM SYSTEM/360     49

 COMPUTER WITH A PHOTOTRANSISTOR FIXED MEMORY " 1962        YAMAUCHI,H ET AL " THE KT PILOT COMPUTER - A MICROPROGRAMMED   33

         DECISION SYSTEMS,INC " INTERIM STATUS REPORT NO. 1 " 1968                                                   24
1965              MCCORMACK,M; SCHANSMAN,T & WOMACK,K " 1401 COMPATIBILITY FEATURE ON THE IBM SYSTEM/360 MODEL 30 "   49
" THE BEST WAY TO DESIGN AN AUTOMATIC CALCULATING MACHINE " 1951                                          WILKES,M  80
TRINGER,J " MICROPROGRAMMING AND THE CHOICE OF ORDER CODE " 1953                                                 S  71
OF THE CONTROL CIRCUITS IN AN ELECTRONIC DIGITAL COMPUTER " 1953WILKES,M & STRINGER,J " MICROPROGRAMMING AND THE DESIGN   84
        BILLING,H & HOPMANN,W " MIKROPROGRAMM-STEUERWERK " 1955                                                      10
                      GLANTZ,H " A NOTE ON MICROPROGRAMMING " 1956                                                   29
                           MERCER,R " MICRO-PROGRAMMING " 1957                                                       55
S A TECHNIQUE IN THE CONTROL OF DIGITAL COMPUTING SYSTEMS " 1958      MORRISON,G " INVESTIGATION OF MICRO-PROGRAMMING A   57
                          WILKES,M " MICROPROGRAMMING " 1959                                                         81
```

```
                                                     KWIC INDEX LISTING
                                                                                                               DATE      10/23/69
                                                                                                               TIME      01:42:03

TEXT------------------------------------------------------- KEYWORD AND TEXT--------------------------------------------------------  INDEX----

    BLANKENBAKER,J " LOGICALLY MICRO-PROGRAMMED COMPUTORS " 1960                                                                11
ICROPROGRAM-CONTROLLED COMPUTER WITH ELEMENTARY STRUCTURE " 1960             KAMPE,T " THE DESIGN OF A GENERAL-PURPOSE M        42
                       OPLER,A " NEW DIRECTIONS IN SOFTWARE 1960-1966 " 1966                                                    59
                              CONROY,E " MICROPROGRAMMING " 1961                                                                21
           CONROY,E & MEADE,R " A MICROINSTRUCTION SYSTEM " 1961                                                                22
           SEMARNE,H & PORTER,R " A STORED LOGIC COMPUTER " 1961                                                                67
             SEMARNE,H & MCGEE,W " STORED LOGIC COMPUTING " 1961                                                                66
                       IVERSON,K " A PROGRAMMING LANGUAGE " 1962                                                                41
       VAN DER POEL,W " MICRO-PROGRAMMING AND TRICKOLOGY " 1962                                                                 75
SIGN OF PROGRAM-MODIFIABLE MICRO-PROGRAMMED CONTROL UNITS " 1962                                    GRASSELLI,A " THE DE        30
& TIMOFEEV,A " MICROPROGRAM CONTROL FOR DIGITAL COMPUTERS " 1962                                EMELYANOV-YAROSLAVSKY,L         26
ROPROGRAMMED COMPUTER WITH A PHOTOTRANSISTOR FIXED MEMORY " 1962        YAMAUCHI,H ET AL " THE KT PILOT COMPUTER - A MIC        33
ROPROGRAMMED COMPUTER WITH A PHOTOTRANSISTOR FIXED MEMORY " 1962      MATSUSHITA,S ET AL " THE KT PILOT COMPUTER - A MIC        33
A 70/35 " 1966    N A VARIABLE STRUCTURE DIGITAL COMPUTER " 1962    CAMPBELL,C & NEILSON,D " MICROPROGRAMMING THE SPECTR        19
ROPROGRAMMED COMPUTER WITH A PHOTOTRANSISTER FIXED MEMORY " 1962 HAGIWARA,H; AMO,K ET AL " THE KT PILOT COMPUTER - A MIC        33
 GERACE,G " MICROPROGRAMMED CONTROL FOR COMPUTING SYSTEMS " 1963                                                                28
           SCHLAEPPI,H " MICROPROGRAMMED COMPUTER CONTROL " 1963                                                                65
       HARRAND,Y " EVOLUTION OF MICROPROGRAMMING CONCEPTS " 1963                                                                34
CAL ORGANIZATION OF THE PB 440 MICROPROGRAMMABLE COMPUTER " 1963                     BOUTWELL,E & HOSKINSON,E " THE LOGI        14
CONOMICAL MULTIPROGRAM COMPUTER WITH MICROPROGRAM CONTROL " 1963                   ROSE,G; SANDERSON,J ET AL " CIRRUS, E         2
CONOMICAL MULTIPROGRAM COMPUTER WITH MICROPROGRAM CONTROL " 1963           ALLEN,M; PEARCEY,T; PENNY,J ET AL " CIRRUS, E         2
       HILL,R " STORED LOGIC PROGRAMMING AND APPLICATIONS " 1964                                                                38
                         BOUTWELL,E " THE PB 440 COMPUTER " 1964                                                                13
             BECK,L & KEELER,F " THE C-8401 DATA PROCESSOR " 1964                                                                7
                           MCGEE,W " THE TRW-133 COMPUTER " 1964                                                                50
             AMDAHL,L " MICROPROGRAMMING AND STORED LOGIC " 1964                                                                 3
CHARACTOR COMPUTER FOR HIGH LEVEL LANGUAGE INTERPRETATION " 1964                                         MEGGITT,J " A          53
STRUCTURE OF SYSTEM/360; PART II - SYSTEM IMPLEMENTATIONS " 1964                                       STEVENS,W " THE          70
                               BRILEY,B " PRIOPROGRAMMING " 1965                                                                16
  BENJAMIN,R " THE SPECTRA 70/45 EMULATOR FOR THE RCA 301 " 1965                                                                 9
  LIVERANCE,H " A SYSTEM/360 PROFILE -- READ-ONLY STORAGE " 1965                                                                46
            LEVY,L " STATE OF THE ART OF MICROPROGRAMMING " 1965                                                                45
SON,H " MICROPROGRAMMING FOR DATA ACQUISITION AND CONTROL " 1965                                         MCGEE,W & PETER        52
ON,H " MICROPROGRAM CONTROL FOR THE EXPERIMENTAL SCIENCES " 1965                                        MCGEE,W & PETERS        51
W; CRAWFORD,W & NOWELL,G " THE CONTROLS AUTOMATION SYSTEM " 1965                                   BUCKINGHAM,B; CARTER,        17
 COMPUTER FOR THE DIRECT PROCESSING OF FORTRAN STATEMENTS " 1965                       MELBOURNE,A & PUGMIRE,J " A SMALL        54
1401 COMPATIBILITY FEATURE ON THE IBM SYSTEM/360 MODEL 30 " 1965                  MCCORMACK,M; SCHANSMAN,T & WOMACK,K "         49
      HECKELMAN,R " SELF-CHECKING REDUNDANT MICROPROGRAMS " 1966                                                                36
           OPLER,A " NEW DIRECTIONS IN SOFTWARE 1960-1966 " 1966                                                                59
J " MICROPROGRAMMING, EMULATORS AND PROGRAMMING LANGUAGES " 1966                                                  GREEN,        31
ICAL DESIGN OF A MICROPROGRAMMED SPECIAL-PURPOSE COMPUTER " 1966                                         INGALLS,R " LOG        40
P & KHOMYAKOV,M " A PROGRAMMING MICRO-LANGUAGE FOR URAL-4 " 1966                                BORSCHEV,V; VASILEVSKIY,        12
MPBELL,C & NEILSON,D " MICROPROGRAMMING THE SPECTRA 70/35 " 1966    N A VARIABLE STRUCTURE DIGITAL COMPUTER " 1962    CA        19
 ORGANIZATION SOLUTION, THE VARIABLE INSTRUCTION COMPUTER " 1966SPENCE,A " HARDWARE AND SOFTWARE INTERACTIONS; A MACHINE        69
    OPLER,A " FOURTH-GENERATION SOFTWARE: THE REALIGNMENT " 1967                                                                58
                           BREUER,M  " ADAPTIVE COMPUTERS " 1967                                                                15
           TUCKER,S " MICROPROGRAM CONTROL FOR SYSTEM/360 " 1967                                                                73
    SLOBODYANYUK,T " A METHOD OF MINIMIZING MICROPROGRAMS " 1967                                                                68
        FLYNN,M & MACLAREN,M " MICROPROGRAMMING REVISITED " 1967                                                                27
AILEY,S " FASTER COMPUTER CONTROL WITH A READ-ONLY MEMORY " 1967                                                       B         4
W & VANDLING,G " SYSTEMS IMPLICATIONS OF MICROPROGRAMMING " 1967                                                 PATZER,        60
S,J " MODULAR COMPUTER DESIGN WITH PICOPROGRAMMED CONTROL " 1967                                                 VALASSI        74
 RELIABILITY ASPECTS OF THE VARIABLE INSTRUCTION COMPUTER " 1967                                             MILLER,E "         56
```

```
TEXT_______________________________________________________ KEYWORD_AND_TEXT____________________________________________________ INDEX____

ASSON,A & KRONFELD,A " SYSTEM DESIGN OF A FORTRAN MACHINE " 1967                                            BASHKOW,T; S           5
RGRAPHIC,' A MICROPROGRAMMED GRAPHICAL-INTERFACE COMPUTER " 1967                                           ROSE,G " INTE          63
I " MICROPROGRAMMED CONTROL IN PROBLEM-ORIENTED LANGUAGES " 1967                                         HAWRYSZKIEWYCZ,          35
RAMMED IMPLEMENTATION OF EULER ON IBM SYSTEM/360 MODEL 30 " 1967                                   WEBER,H " A MICROPROG          78
ILLER,H " SYSTEM ARCHITECTURE FOR LARGE SCALE INTEGRATION " 1967                       BEELITZ,H; LEVY,S; LINHARDT,R & M           8
       DECISION SYSTEMS,INC " INTERIM STATUS REPORT NO. 1 " 1968                                                                  24
     DREYER,L " PRINCIPLES OF A TWO-LEVEL MEMORY COMPUTER " 1968                                                                  25
    GREENBERG,M & WEGBREIT,E " A MICROPROGRAMMED COMPUTER " 1968                                                                  32
    WILKES,M " THE GROWTH OF INTEREST IN MICROPROGRAMMING " 1968                                                                  82
OSEN,S " HARDWARE DESIGN REFLECTING SOFTWARE REQUIREMENTS " 1968                                                       R          64
BOULOT,M " EXTRACTEUR MICROPROGRAMME D' INFORMATION RADAR " 1968                                                      RE          62
SON,H " PROGRAMMING-LANGUAGE-ORIENTED INSTRUCTION STREAMS " 1968                                                     LAW          44
ARTZ,S " MODEL 4200 - 8200 READ-ONLY MEMORY CONTROL LOGIC " 1968                                          KLEIN,S & SCHW          43
R-ORDER LANGUAGE FOR DESCRIBING MICROPROGRAMMED COMPUTERS " 1968                                         CHU,Y " A HIGHE          20
OPROGRAMMED COMMUNICATION CONTROL UNIT, THE TOSBAC DN-231 " 1968                                   MATSUSHITA,S " A MICR          47
 MICROPROGRAMMING DESIGN AID SYSTEM FOR RCA SPECTRA 70/45 " 1968                                   VOLLBRECHT,J " MIDAS:          77
KOWSKY,S " STRUCTURAL ASPECTS OF THE SYSTEM/360, MODEL 85 " 1968                                 CONTI,C; GIBSON,D & PIT          23
NIVERSAL STRUCTURE STUDY ORIENTED TO COMPUTERS SIMULATION " 1968         BAZERQUE,G; FERRIE,J & HUGOT,P " MICROMACHINE U           6
TING AN ASSOCIATIVE PROCESSOR FOR A TIME-SHARED PROCESSOR " 1968       HOERNES,G ET AL " CONTROL STORAGE USE IN IMPLEMEN          37
TING AN ASSOCIATIVE PROCESSOR FOR A TIME-SHARED PROCESSOR " 1968     HELLERMAN,L ET AL " CONTROL STORAGE USE IN IMPLEMEN          37
 STRUGARU,C " A MICROPROGRAMMED UNIT FOR COMPUTER SYSTEMS " 1969                                                                  72
   MCCLURE,R & DAVIS,R " A SMALL MICROPROGRAMMED COMPUTER " 1969                                                                  48
    CALHOUN,R " DIAGNOSTICS AT THE MICROPROGRAMMING LEVEL " 1969                                                                  18
                               WEBER,H " MICROPROGRAMMING " 1969                                                                  79
E COMPUTER-WITHIN-A-COMPUTER  A FOURTH GENERATION CONCEPT " 1969                                          RAKOCZI,L " TH          61
OWTH OF INTEREST IN MICROPROGRAMMING: A LITERATURE SURVEY " 1969                                       WILKES,M " THE GR          83
E MICROPROGRAM CONTROL TECHNIQUE FOR DIGITAL LOGIC DESIGN " 1969                           VANDLING,G & WALDECKER,D " TH          76

,K " 1401 COMPATIBILITY FEATURE ON THE IBM SYSTEM/360 MODEL 30 " 1965                  MCCORMACK,M; SCHANSMAN,T & WOMACK          49
OPROGRAMMED IMPLEMENTATION OF EULER ON IBM SYSTEM/360 MODEL 30 " 1967                                   WEBER,H " A MICR          78
        BENJAMIN,R " THE SPECTRA 70/45 EMULATOR FOR THE RCA 301 " 1965                                                             9

                               KLEIN,S & SCHWARTZ,S " MODEL 4200 - 8200 READ-ONLY MEMORY CONTROL LOGIC " 1968                      43
                                        BOUTWELL,E " THE PB 440 COMPUTER " 1964                                                   13
JTWELL,E & HOSKINSON,E " THE LOGICAL ORGANIZATION OF THE PB 440 MICROPROGRAMMABLE COMPUTER " 1963                     BO          14

62    CAMPBELL,C & NEILSON,D " MICROPROGRAMMING THE SPECTRA 70/35 " 1966    N A VARIABLE STRUCTURE DIGITAL COMPUTER " 19          19
" MIDAS: MICROPROGRAMMING DESIGN AID SYSTEM FOR RCA SPECTRA 70/45 " 1968                                    VOLLBRECHT,J          77
                                   BENJAMIN,R " THE SPECTRA 70/45 EMULATOR FOR THE RCA 301 " 1965                                  9

                        KLEIN,S & SCHWARTZ,S " MODEL 4200 -      8200 READ-ONLY MEMORY CONTROL LOGIC " 1968                        43
& PITKOWSKY,S " STRUCTURAL ASPECTS OF THE SYSTEM/360, MODEL 85 " 1968                                  CONTI,C; GIBSON,D          23
```

```
                          KWIC TEXT LISTING
                                                                                    DATE      10/23/69
                                                                                    TIME      01:42:03

INDEX_____  KEYWORD TEXT_______________________________________________________________________________

        1   ALLEN-BABCOCK COMPUTING, INC " INFORMATION OUTLINE: REMOTE-ACCESS TIME-SHARING SYSTEM "
        2   ROSE,G; SANOERSUN,J ET AL " CIRRUS, ECONOMICAL MULTIPROGRAM COMPUTER WITH MICROPROGRAM CONTROL " 1963
        2   ALLEN,M; PEARCEY,T; PENNY,J ET AL " CIRRUS, ECONOMICAL MULTIPROGRAM COMPUTER WITH MICROPROGRAM CONTROL " 1963
        3   AMOAHL,L " MICROPROGRAMMING ANO STORED LOGIC " 1964
        4   BAILEY,S " FASTER COMPUTER CONTROL WITH A READ-ONLY MEMORY " 1967
        5   BASHKOW,T; SASSON,A & KRONFELD,A " SYSTEM DESIGN OF A FORTRAN MACHINE " 1967
        6   BAZERQUE,G; FERRIE,J & HUGOT,P " MICROMACHINE UNIVERSAL STRUCTURE STUDY ORIENTEO TO COMPUTERS SIMULATION " 1968
        7   BECK,L & KEELER,F " THE C-8401 OATA PROCESSOR " 1964
        8   BEELITZ,H; LEVY,S; LINHAROT,R & MILLER,H " SYSTEM ARCHITECTURE FOR LARGE SCALE INTEGRATION " 1967
        9   BENJAMIN,R " THE SPECTRA 70/45 EMULATOR FOR THE RCA 301 " 1965
       10   BILLING,H & HOPMANN,W " MIKROPROGRAMM-STEUERWERK " 1955
       11   BLANKENBAKER,J " LOGICALLY MICRO-PROGRAMMED COMPUTORS " 196D
       12   BORSCHEV,V; VASILEVSKIY,P & KHOMYAKOV,M " A PROGRAMMING MICRO-LANGUAGE FOR URAL-4 " 1966
       13   BOUTWELL,E " THE PB 440 COMPUTER " 1964
       14   BOUTWELL,E & HOSKINSON,E " THE LOGICAL ORGANIZATION OF THE PB 44D MICROPROGRAMMABLE COMPUTER " 1963
       15   BREUER,M  " ADAPTIVE COMPUTERS " 1967
       16   BRILEY,B " PRIOPROGRAMMING " 1965
       17   BUCKINGHAM,B; CARTER,W; CRAWFORD,W & NOWELL,G " THE CONTROLS AUTOMATION SYSTEM " 1965
       18   CALHOUN,R " DIAGNOSTICS AT THE MICROPROGRAMMING LEVEL " 1969
       19   CAMPBELL,C & NEILSON,D " MICROPROGRAMMING THE SPECTRA 70/35 " 1966    N A VARIABLE STRUCTURE DIGITAL COMPUTER " 1962
       20   CHU,Y " A HIGHER-OROER LANGUAGE FOR OESCRIBING MICROPROGRAMMED COMPUTERS " 196B
       21   CONROY,E " MICROPROGRAMMING " 1961
       22   CONROY,E & MEAOE,R " A MICROINSTRUCTION SYSTEM " 1961
       23   CUNTI,C; GIBSON,O & PITKOWSKY,S " STRUCTURAL ASPECTS OF THE SYSTEM/36O, MODEL 85 " 1968
       24   OECISION SYSTEMS,INC " INTERIM STATUS REPORT NO. 1 " 196B
       25   DREYER,L " PRINCIPLES OF A TWO-LEVEL MEMORY COMPUTER " 196B
       26   EMELYANOV-YAROSLAVSKY,L & TIMOFEEV,A " MICROPROGRAM CONTROL FOR DIGITAL COMPUTERS " 1962
       27   FLYNN,M & MACLAREN,M " MICROPROGRAMMING REVISITED " 1967
       28   GERACE,G " MICROPROGRAMMED CONTROL FOR COMPUTING SYSTEMS " 1963
       29   GLANTZ,H " A NOTE ON MICROPROGRAMMING " 1956
       30   GRASSELLI,A " THE DESIGN OF PROGRAM-MODIFIABLE MICRO-PROGRAMMED CONTROL UNITS " 1962
       31   GREEN,J " MICROPROGRAMMING, EMULATORS AND PROGRAMMING LANGUAGES " 1966
       32   GREENBERG,M & WEGBREIT,E " A MICROPROGRAMMED COMPUTER " 1968
       33   MATSUSHITA,S ET AL " THE KT PILOT COMPUTER - A MICROPROGRAMMEO COMPUTER WITH A PHOTOTRANSISTOR FIXED MEMORY " 1962
       33   HAGIWARA,H; AMO,K ET AL " THE KT PILOT COMPUTER - A MICROPROGRAMMED COMPUTER WITH A PHOTOTRANSISTER FIXED MEMORY " 1962
       33   YAMAUCHI,H ET AL " THE KT PILOT COMPUTER - A MICROPROGRAMMEO COMPUTER WITH A PHOTOTRANSISTOR FIXED MEMORY " 1962
       34   HARRAND,Y " EVOLUTION OF MICROPROGRAMMING CONCEPTS " 1963
       35   HAWRYSZKIEWYCZ,I " MICROPROGRAMMEO CONTROL IN PROBLEM-ORIENTEO LANGUAGES " 1967
       36   HECKELMAN,R " SELF-CHECKING REDUNOANT MICROPROGRAMS " 1966
       37   HUERNES,G ET AL " CONTROL STORAGE USE IN IMPLEMENTING AN ASSOCIATIVE PROCESSOR FOR A TIME-SHAREO PROCESSOR " 1968
       37   HELLERMAN,L ET AL " CONTROL STORAGE USE IN IMPLEMENTING AN ASSOCIATIVE PROCESSOR FOR A TIME-SHARED PROCESSOR " 1968
       38   HILL,R " STORED LOGIC PROGRAMMING AND APPLICATIONS " 1964
       39   IBM " DATA PROCESSING: MICROPROGRAMMING PI CCURSE "
       40   INGALLS,R " LOGICAL OESIGN OF A MICROPROGRAMMED SPECIAL-PURPOSE COMPUTER " 1966
       41   IVERSON,K " A PROGRAMMING LANGUAGE " 1962
       42   KAMPE,T " THE OESIGN OF A GENERAL-PURPOSE MICROPROGRAM-CONTROLLEO COMPUTER WITH ELEMENTARY STRUCTURE " 1960
       43   KLEIN,S & SCHWARTZ,S " MODEL 42DD - B20D READ-ONLY MEMORY CONTROL LOGIC " 196B
       44   LAWSON,H " PROGRAMMING-LANGUAGE-ORIENTED INSTRUCTION STREAMS " 1968
       45   LEVY,L " STATE OF THE ART OF MICROPROGRAMMING " 1965
       46   LIVERANCE,H " A SYSTEM/36D PROFILE -- READ-ONLY STORAGE " 1965
       47   MATSUSHITA,S " A MICROPROGRAMMEO COMMUNICATION CUNTROL UNIT, THE TOSBAC DN-231 " 196B
       48   MCCLURE,R & DAVIS,R " A SMALL MICROPROGRAMMED COMPUTER " 1969
       49   MCCORMACK,M; SCHANSMAN,T & WOMACK,K " 1401 COMPATIBILITY FEATURE ON THE IBM SYSTEM/36D MODEL 3D " 1965
```

```
                                KWIC TEXT LISTING
                                                                                     DATE      10/23/69
                                                                                     TIME      01:42:03
INDEX____  KEYWORD TEXT_________________________________________________________________________________

      50  MCGEE,W " THE TRW-133 COMPUTER " 1964
      51  MCGEE,W & PETERSON,H " MICROPROGRAM CONTROL FOR THE EXPERIMENTAL SCIENCES " 1965
      52  MCGEE,W & PETERSON,H " MICROPROGRAMMING FOR DATA ACQUISITION AND CONTROL " 1965
      53  MEGGITT,J " A CHARACTOR COMPUTER FOR HIGH LEVEL LANGUAGE INTERPRETATION " 1964
      54  MELBOURNE,A & PUGMIRE,J " A SMALL COMPUTER FOR THE DIRECT PROCESSING OF FORTRAN STATEMENTS " 1965
      55  MERCER,R " MICRO-PROGRAMMING " 1957
      56  MILLER,E " RELIABILITY ASPECTS OF THE VARIABLE INSTRUCTION COMPUTER " 1967
      57  MORRISON,G " INVESTIGATION OF MICRO-PROGRAMMING AS A TECHNIQUE IN THE CONTROL OF DIGITAL COMPUTING SYSTEMS " 1958
      58  OPLER,A " FOURTH-GENERATION SOFTWARE: THE REALIGNMENT " 1967
      59  OPLER,A " NEW DIRECTIONS IN SOFTWARE 1960-1966 " 1966
      60  PATZER,W & VANDLING,G " SYSTEMS IMPLICATIONS OF MICROPROGRAMMING " 1967
      61  RAKOCZI,L " THE COMPUTER-WITHIN-A-COMPUTER  A FOURTH GENERATION CONCEPT " 1969
      62  REBOULOT,M " EXTRACTEUR MICROPROGRAMME D' INFORMATION RADAR " 1968
      63  ROSE,G " INTERGRAPHIC,' A MICROPROGRAMMED GRAPHICAL-INTERFACE COMPUTER " 1967
      64  ROSEN,S " HARDWARE DESIGN REFLECTING SOFTWARE REQUIREMENTS " 1968
      65  SCHLAEPPI,H " MICROPROGRAMMED COMPUTER CONTROL " 1963
      66  SEMARNE,H & MCGEE,W " STORED LOGIC COMPUTING " 1961
      67  SEMARNE,H & PORTER,R " A STORED LOGIC COMPUTER " 1961
      68  SLOBODYANYUK,T " A METHOD OF MINIMIZING MICROPROGRAMS " 1967
      69  SPENCE,A " HARDWARE AND SOFTWARE INTERACTIONS; A MACHINE ORGANIZATION SOLUTION, THE VARIABLE INSTRUCTION COMPUTER " 1966
      70  STEVENS,W " THE STRUCTURE OF SYSTEM/360; PART II - SYSTEM IMPLEMENTATIONS " 1964
      71  STRINGER,J " MICROPROGRAMMING AND THE CHOICE OF ORDER CODE " 1953
      72  STRUGARU,C " A MICROPROGRAMMED UNIT FOR COMPUTER SYSTEMS " 1969
      73  TUCKER,S " MICROPROGRAM CONTROL FOR SYSTEM/360 " 1967
      74  VALASSIS,J " MODULAR COMPUTER DESIGN WITH PICOPROGRAMMED CONTROL " 1967
      75  VAN DER POEL,W " MICRO-PROGRAMMING AND TRICKOLOGY " 1962
      76  VANDLING,G & WALDECKER,D " THE MICROPROGRAM CONTROL TECHNIQUE FOR DIGITAL LOGIC DESIGN " 1969
      77  VOLLBRECHT,J " MIDAS: MICROPROGRAMMING DESIGN AID SYSTEM FOR RCA SPECTRA 70/45 " 1968
      78  WEBER,H " A MICROPROGRAMMED IMPLEMENTATION OF EULER ON IBM SYSTEM/360 MODEL 30 " 1967
      79  WEBER,H " MICROPROGRAMMING " 1969
      80  WILKES,M " THE BEST WAY TO DESIGN AN AUTOMATIC CALCULATING MACHINE " 1951
      81  WILKES,M " MICROPROGRAMMING " 1959
      82  WILKES,M " THE GROWTH OF INTEREST IN MICROPROGRAMMING " 1968
      83  WILKES,M " THE GROWTH OF INTEREST IN MICROPROGRAMMING: A LITERATURE SURVEY " 1969
      84  WILKES,M & STRINGER,J " MICROPROGRAMMING AND THE DESIGN OF THE CONTROL CIRCUITS IN AN ELECTRONIC DIGITAL COMPUTER " 1953
```

```
                                   KWIC KEY WORD SUPPRESSION LISTING
                                                                                    DATE      10/23/69
                                                                                    TIME      01:42:03

KEY WORDS SELECTED FOR SUPPRESSION_______________________

&
-
--
*
A
AL
AN
AND
ET
FOR
IN
OF
ON
THE
TO
WITH
```

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)* The MITRE Corporation Bedford, Massachusetts	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE
ANNOTATED MICROPROGRAMMING BIBLIOGRAPHY

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*
N/A

5. AUTHOR(S) *(First name, middle initial, last name)*
Microprogramming Group (Thomas P. Berschback, coordinator)

6. REPORT DATE JULY 1970	7a. TOTAL NO. OF PAGES 70	7b. NO. OF REFS 0

8a. CONTRACT OR GRANT NO. F19(628)-68-C-0365	9a. ORIGINATOR'S REPORT NUMBER(S) ESD-TR-70-204
b. PROJECT NO. 700A	
c.	9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)* M69-65
d.	

10. DISTRIBUTION STATEMENT
This document has been approved for public release and sale; its distribution is unlimited.

11. SUPPLEMENTARY NOTES N/A	12. SPONSORING MILITARY ACTIVITY Directorate of Planning and Technology, Electronic Systems Division, AF Systems Command, L. G. Hanscom Field, Bedford, Massachusetts

13. ABSTRACT

This bibliography provides an indexed, annotated list of publications related to the field of microprogramming, from the introduction of the term in 1951 to the present time.

DD FORM 1 NOV 65 1473

Security Classification

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
MICROPROGRAMMING						
MICROPROGRAMMING BIBLIOGRAPHY						
ANNOTATED MICROPROGRAMMING BIBLIOGRAPHY						

Security Classification

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS ELECTRONIC SYSTEMS DIVISION (AFSC)
LAURENCE G. HANSCOM FIELD, BEDFORD, MASSACHUSETTS 01730

DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

REPLY TO ATTN OF: ~~ESAI~~ ESGEI/5322 16 June 1970

SUBJECT: Review of Technical Document

TO: ESTI

Identification: ESD-TR-70-204

ESAI has no objection to release of the above-cited document to the Clearinghouse for Scientific and Technical Information.

John T. O'Brien
JOHN T. O'BRIEN
Chief, Public Information Division
Information Office

1 Atch
n/c