1964

A systems analysis and design for the digital representation of circuit information

Robert Jay Edelman
Lehigh University

ABSTRACT

DIRECTION

A SYSTEMS ANALYSIS AND DESIGN

FOR THE DIGITAL REPRESENTATION

OF CIRCUIT INFORMATION

Many companies in the electrical equipment industry continue to prepare circuit schematic drawings in a conventional pictorial format for many and varied reasons. Valid as these reasons might be, the advantages of converting the circuit information to a digital representation are quite substantial.

From an engineering viewpoint, there are advantages to be gained in the ease of retrieval when information is stored in a machine processable form. The circuit information can be presented to the engineer in a variety of formats, each one suitable for a particular engineering function. Along with proper presentation of output, a number of routine design checks can be performed by the computer in a more efficient manner than a human. This ease of verification allows substantially more checking than would be possible with manual methods.

From a manufacturing viewpoint, the format of a pictorial circuit schematic is not suitable. Wire color, gauge and method, order of multing, which involves specifying the specific order in which electrically common points are connected together, and detailed wire run information are not indicated. It is a normal engineering function to prepare this manufacturing information. This thesis proposes that

maintenance of circuit information in a digital format would allow preparation of manufacturing information using automatic data processing equipment.

In order to realize the advantages both to engineering and manufacturing, that are indicated above, the author of this thesis has proposed a systems design which will allow conversion of both existing and new pictorial circuit schematics to a digital representation. These schematics could then be maintained on magnetic tape or in random access computer memory. Incorporated into this system are schemes for highly flexible additions, modifications and deletions of the master files and preparation of informative reports on a selective basis.

Implementation of this proposed system has been accomplished using a COBOL (Common Business Oriented Language) type processor on a General Electric Company, GE 225, computer. The system of programs required utilized approximately 45,000 words of storage and included over 3400 source statements.

Use of the system titled DIRECTION, for Digital Representation of Circuit Information, would in the author's opinion, result in considerable savings in time and manpower in implementation of new circuit designs and incorporation of changes to existing ones. Additional advantages would be gained by better verification of design accuracy and by lower design cost. The latter stems from the ability of the system to assist the designer in maintaining higher performance, thereby eliminating the need for accuracy verification at each stage of the design activity. One of the greatest advantages would come from the ability of the manufacturing organization to operate under shortened schedules.

The thesis concludes with an assessment of the additional work which must be accomplished before a completely integrated system can be developed which will take design information as input and produce an output consisting of complete manufacturing information for wiring, assembly and testing of electromechanical and electronic equipment. Included in this output would be a media for controlling automatic wiring and testing machines.

DIRECTION

A SYSTEMS ANALYSIS AND DESIGN FOR THE DIGITAL REPRESENTATION OF CIRCUIT INFORMATION

by

Robert Jay Edelman

A THESIS
Presented to the Graduate Faculty
Of Lehigh University
In Candidacy for the Degree of
Master of Science

Lehigh University

1964

This thesis is accepted and approved in partial fulfillment of the requirement for the degree of Master of Science.

23 March 1964 — William A. Smith Jr.

(Date)

William A. Smith, Jr.
Professor in Charge

Arthur F. Gould

Arthur F. Gould
Head of the Department

ACKNOWLEDGEMENTS

I should like to express my appreciation to all those people who contributed their time and effort toward the successful completion of this study. In particular, I would like to thank:

Prof. William A. Smith, Jr., who provided assistance and guidance.

The Western Electric Company and in particular Mr. E. J. Tanana of the Engineering Research Center, for endorsement of the study.

Mr. Gordon Whitney of the Western Electric Company and his group engaged in Computer Programming Studies, for assistance in a great many peripheral tasks.

Many others including Mr. L. J. Trimnell and Mr. G. T. Hornung of Bell Telephone Laboratories, and Mr. E. W. Aeschlimann of the Western Electric Company, for help in formulating many of the early ideas.

TABLE OF CONTENTS

		PAGE
	List of Figures	vi
	Abstract	1
1.	Introduction	4
2.	History of the Application of Machine Aided Methods in the Preparation of Wiring and Testing Information	8
3.	Objectives	17
4.	DIRECTION	
	4.1 Introduction	22
	4.11 Choice of Sample Circuits	24
	4.12 Computer Restrictions	25
	4.2 APPARATUS MASTER FILE	28
	4.21 APMSTRIN	32
	4.22 APMSTROUT	33
	4.3 UNIT FILE	33
	4.31 UNITMSTR	38
	4.32 UNITRPT	40
	4.4 WIRE FILE	41
	4.41 WIREMSTR	47
	4.42 WIRERPTS - APPLIST	48
	4.5 DESIGN VERIFICATION	53
	4.51 DUPLICATEFD	57
5.	Conclusion	58
6.	Future Considerations	64

TABLE OF CONTENTS (Cont'd.)

PAGE

Bibliography 191

Vita 194

LIST OF FIGURES

FIGURE		PAGE
1	Explosion of Man Hours	65
2	Explosion of Information	66
3	Creativity Profile	67
4	Pictorial Circuit Schematic Drawing	68
5	Framework Similar to Trunk Switch Frame	70
6	Flow Chart - APMSTRIN	72
7	Flow Chart - APMSTROUT	75
8	Flow Chart - UNITMSTR	79
9	Flow Chart - UNITRPT	87
10	Flow Chart - WIREMSTR	90
11	Flow Chart - WIRERPTS	100
12	Flow Chart - APPLIST	107
13	Flow Chart - DUPLICATEFD	113
14	Output - MASTER APPARATUS LIST	116
15	Output - UNIT LIST	123
16	Output - APP LIST	130
17	Output - ALL LIST	138
18	Output - NOTE LIST	152
19	Output - APP FIG LIST	155
20	Output - PAGE LIST	160
21	Output - NODE LIST	165
22	Output - FS LIST	168
23	Output - DUPLICATE FD	174

LIST OF FIGURES (Cont'd.)

FIGURE		PAGE
24	Structure of APPARATUS MASTER FILE	177
25	Sample Input Data for APPARATUS MASTER FILE	180
26	Use of Control-keys in APPARATUS MASTER FILE	181
27	Structure of UNIT FILE	182
28	Sample Input Data for UNIT FILE	185
29	Structure of WIRE FILE	186
30	Sample Input Data for WIRE FILE	190

ABSTRACT

DIRECTION

A SYSTEMS ANALYSIS AND DESIGN

FOR THE DIGITAL REPRESENTATION

OF CIRCUIT INFORMATION

Many companies in the electrical equipment industry continue to prepare circuit schematic drawings in a conventional pictorial format for many and varied reasons. Valid as these reasons might be, the advantages of converting the circuit information to a digital representation are quite substantial.

From an engineering viewpoint, there are advantages to be gained in the ease of retrieval when information is stored in a machine processable form. The circuit information can be presented to the engineer in a variety of formats, each one suitable for a particular engineering function. Along with proper presentation of output, a number of routine design checks can be performed by the computer in a more efficient manner than a human. This ease of verification allows substantially more checking than would be possible with manual methods.

From a manufacturing viewpoint, the format of a pictorial circuit schematic is not suitable. Wire color, gauge and method, order of multing, which involves specifying the specific order in which electrically common points are connected together, and detailed wire run information are not indicated. It is a normal engineering function to prepare this manufacturing information. This thesis proposes that

maintenance of circuit information in a digital format would allow preparation of manufacturing information using automatic data processing equipment.

In order to realize the advantages both to engineering and manufacturing, that are indicated above, the author of this thesis has proposed a systems design which will allow conversion of both existing and new pictorial circuit schematics to a digital representation. These schematics could then be maintained on magnetic tape or in random access computer memory. Incorporated into this system are schemes for highly flexible additions, modifications and deletions of the master files and preparation of informative reports on a selective basis.

Implementation of this proposed system has been accomplished using a COBOL (Common Business Oriented Language) type processor on a General Electric Company, GE 225, computer. The system of programs required utilized approximately 45,000 words of storage and included over 3400 source statements.

Use of the system titled DIRECTION, for Digital Representation of Circuit Information, would in the author's opinion, result in considerable savings in time and manpower in implementation of new circuit designs and incorporation of changes to existing ones. Additional advantages would be gained by better verification of design accuracy and by lower design cost. The latter stems from the ability of the system to assist the designer in maintaining higher performance, thereby eliminating the need for accuracy verification at each stage of the design activity. One of the greatest advantages would come from the ability of the manufacturing organization to operate under shortened schedules.

The thesis concludes with an assessment of the additional work which must be accomplished before a completely integrated system can be developed which will take design information as input and produce an output consisting of complete manufacturing information for wiring, assembly and testing of electromechanical and electronic equipment. Included in this output would be a media for controlling automatic wiring and testing machines.

1. Introduction

The engineering activities that precede the introduction of every new product can be broken into a number of steps: Research and Design, Development, and Preparation for Manufacturing. In actual practice these steps are not discrete but tend to diffuse into each other. A later period during which actual manufacturing takes place will be omitted from this discussion for the present time.

Research and Design, the first stage in the development of a new product, in comparison to the later stages, requires the least expenditure of man hours of effort.[1] It is during this period that ideas are formalized and goals are delineated. Preliminary circuits are designed and in most all cases, models are constructed to test the feasibility of the prospective system.

If a critical evaluation of the results of the research and design activity is favorable, effort on the project proceeds into the development stage. By no means does research and design activity cease at this point. Circuit improvements and the incorporation of additional features continue at an ever increasing pace. What has actually happened is that the project has grown to the point that practical implementation is receiving its share of the total effort.

The second stage, development activity, concerns itself with the design of circuit elements, equipment layouts and most

1. See Figure 1.

important, the application of sound engineering principles to the more theoretical results of the research. It is particularly important to note that the manpower requirements of the project have grown to meet the increasing scope of the activity at hand.

Before the development activity on a new product is concluded, work begins on the third stage, implementation for manufacturing. This area encompasses the preparation of manufacturing layouts, preparation of wiring and testing information and of course acquisition of tools and facilities for the actual manufacturing operation.

As a result of increased competition and shorter schedules there is invariably considerable overlapping of all of the above functions. The significant point to recognize is that any project that has as its ultimate goal the manufacture of a new product, starts with a relatively small expenditure of man hours of effort during the research stage, but with each successive step on the road to actual manufacturing, requires the expenditure of a larger amount of effort. In a similar manner the volume of data that is generated increases progressively with advancement from research, to development, to manufacturing planning.[2] The output of the research group may be a relatively small number of sheets containing the basic circuit design and a description of its operation. The development engineers will increase this volume several times with the inclusion of apparatus information and specifications. The

2. Hoberecht, V. L. "Design Information Systems" Unpublished Paper, IBM Corporation, 1962.

manufacturing engineers, finally, will create a veritable flood of information on wiring, tooling, testing, etc.[3] Corresponding to this increase in man hours expended and volume of information produced, there is a decline in the creativity level of the activity on the project.[4,5] The very nature of much of the work in planning for manufacturing is routine. Preparation of wiring and testing information, in particular, is essentially a restatement of information shown in a different form on the original circuit design.

It has been estimated that the expenditures for fundamental and applied research and development from all sources in the United States for 1961-1962 was approximately 14.7 billion dollars.[6] If the relationships between research and development and preparation for manufacturing that have been presented are true, then the total annual expenditures for the latter must be staggering. The combination of the large expenditure in man hours, increase in volume of information, and decline in creativity required for the preparation of manufacturing information, coupled with the very detailed nature of manufacturing information, makes this area very attractive for the application of machine aided methods.

One particular area of manufacturing information, more than any other, is especially susceptible to these automatic techniques.

3. See Figure 2.
4. Hoberecht. op. cit.
5. See Figure 3.
6. Statistical Abstract of the United States, U. S. Dept. of Commerce, 1963, P. 543.

This is the area of wiring and testing information. The circuitry for any electronic or electro-mechanical system is first produced by the research and development organizations. This information can generally take one of two broad forms. If the development of the logic for the circuit has been done by computer aided methods, then it is likely that the completed circuit design, or as it is commonly titled, circuit schematic, is in a format which reflects the methods used in its preparation namely, tabular format. Since a computer has been used in the development of this electrical circuit, preparation of wiring and continuity testing information may very possibly be merely an extension of the technique used in developing the logic of the circuit.

The second form of circuit information, namely the conventional pictorial schematic drawing, arises as a result of strictly manual design techniques or because the needs of the business require a pictorial type representation of the circuit.[7] This thesis will be concerned with this second form of schematic drawing and the resultant methods which can be used to translate pictorial information into a digital form so that the many advantages of machine processing can come into play.

7. See Figure 4.

2. <u>History of the Application of Machine Aided Methods in the Preparation of Wiring and Testing Information</u>

It might be useful in a study of applying machine methods to the representation of circuit information and the preparation of manufacturing information to review some of the techniques and methods that have already been developed.

The first real theoretical breakthrough in the processing of information came from the work of Weiner and Shannon during the Second World War and documented by them in 1948[8] and 1949[9] respectively. It is as a result of this work that a really scientific approach to the problem of information and information transmission is possible. According to Shannon, "The fundamental problem of communication is that of reproducing at one point exactly or approximately a message selected at another point." Shannon stated, the semantic aspects of the communication problem are irrelevant, and accordingly he concerned himself with the technical aspects only. However, Weaver[10] in a generalization of Shannon's work, restates the communication problem in three levels:

1. How accurately can the symbols be transmitted (the technical problem).

2. How precisely is the meaning conveyed (the semantic problem).

3. How effectively does the received meaning affect conduct (the effectiveness problem).

8. Weiner, N. Cybernetics. New York: The Technology Press & John Wiley and Sons, 1948.
9. Shannon, C. E. and Weaver, W. The Mathematical Theory of Communications. Champaign, Illinois: University of Illinois Press, 1949. P. 3.
10. ibid., P. 96.

It is this generalization, in particular the latter two levels, that is especially related to the problem of circuit and manufacturing information. Information Theory postulates the idea that any part of the communication that is predicatable is redundant. As a result it has been estimated that as much as 99% of the information in a TV picture is unnecessary.[11] It seems that Shannon and Wiener have discredited the old adage that a picture is worth a thousand words.

These particular ideas are germaine to the problem of preparation of wiring and testing information from pictorial schematics in that they show the considerable advantage that is to be gained in utilizing machine methods. Pictorial schematics and their resultant pictorial wiring diagrams do not offer the best method of solving the communication problem in the levels of semantics and effectiveness, and as a result of redundancy, do not convey as much information as may appear. These schematics, being designed and drawn by humans, are not especially adaptable to modern methods of data processing and information retrieval.[12] They are bulky and difficult to change. A method must be developed to adapt this technique of presenting schematic information to the more modern methods of processing information.

11. Editors of Fortune. The Mighty Force of Research. New York: McGraw-Hill, 1956. P. 285.
12. Martin, R. B. "Wiring Run Lists: Preparation By Electronic Accounting Machine Methods." Unpublished Paper, Bell Telephone Laboratories Memorandum, [redacted], 1961.

Utilizing the theoretical knowledge gained from Shannon and Wiener, methods for thinking through and recording the logic of complex information systems have been developed. One of particular note is TABSOL.[13] Developed by the General Electric Company, TABSOL has as its essential element, Decision Structure Tables. Similar to the truth tables utilized in Boolean Algebra, Decision Structure Tables provide a standard method of describing complex, multi-variate, multi-result decision systems. The table consists of rectangular arrays of blocks, the left side containing the decision logic, the right side the results or functions. By making the appropriate logical decisions, the table will provide a path to the correct result or function. TABSOL makes it possible to state complex information systems in a logical nature that allows selection of the proper path through the system to a logical solution. The TABSOL method of decision making is easily implemented on computing machines. Considerable work has been done along this line with very effective results.[14,15]

Techniques have been developed which were specifically designed as an application of automatic data processing methods to the manufacturing information problem. Among these are "Design Mechanization"

13. Kavanagh, T. F. "TABSOL - The Language of Decision Making," Computers and Automation, Vol. 10, No. 9 (Sept. 1961), PP. 15-22.
14. Evans, O. Y. "Decision Tables." Unpublished Paper, IBM Corporation, 1961.
15. The General Electric Company has developed a compiler titled GECOM which allows source programming in TABSOL with direct translation into machine language instructions. This technique was used in implementing part of DIRECTION.

programs developed by IBM Corporation[16] which produce back panel wiring lists and other related information in accordance with certain design requirements including least total wire length and isolation of wire runs from each other to minimize electrical interference. The input to this system of programs is a digital description of the electrically common points in the regular matrix of terminals on the back panel. A modification of the procedure developed by Loberman and Weinberger[17] for connecting terminals with a minimum quantity of wire is used in this system.

Minneapolis-Honeywell Regulator Company has also been active in this area with a system of computer programs called GDWRAP.[18] The IBM and M-H systems are very similar, both reaching the ultimate in automation in that the programs, in addition to preparing information on wiring, also provide punched card input to Gardner-Denver Automatic Wiring Machines.

The Gardner-Denver wire wrapping machine is a numerically controlled machine that, upon receiving instructions from a punched card, proceeds to wire wrap one end of a continuous strand of

16. Altman, G. W., Decampo, L. A. and Warburton, C. R. "Automation of Computer Panel Wiring," AIEE Communications and Electronics, No. 48 (May, 1960), PP. 118-125.
17. Loberman, H. and Weinberger, A. "Formal Procedures of Connecting Terminals With A Minimum Total Wire Length," Journal of the Association for Computing Machinery, Vol. 4, No. 4, (Oct. 1957), PP. 428-437.
18. Brown, R. R. and Putnam, G. R. "The Automation of Topological Layout," AIEE Communications and Electronics, No. 60 (May 1962), PP. 136-139.

insulated wire on one terminal in an array of terminals, run the wire over a predetermined path under control of information on the punched card, to another terminal where the wire is cut and the loose end wrapped on the terminal. This machine runs one wire for each card in the input deck.[19,20] Use of this technique reduces errors and results in a time saving factor over manual methods of approximately 36:1.[21]

Another group active in this area has been the Aerospace Division of Martin Marietta Corporation.[22] Martin's approach has been principally to produce "drawings" in a tabular format on 8½ x 11 inch sheets for test stand cabling on the Titan Project.

Some of the most significant work that has been done in the area of utilization of computer methods in schematic representation and preparation of manufacturing information has been at the Bell Telephone Laboratories. Systems for not only preparing manufacturing information but also tabular format schematic circuit drawings have been developed. Some of these are BLADES (Bell

19. Grimm, R. J. and Brouwer, D. P. "Wiring Terminal Panels by Machine", Control Engineering, Vol. 8 No. 8 (Aug. 1961) PP. 77-81.
20. "Automatic Computer Directed Wiring Machines for Making Computers," Computers and Automation, Vol. 10 No. 9 (Sept. 1961), P. 12B.
21. Brown and Putnam. op. cit.
22. Lanford, C. D. "Lineless Drawings Aid Titan Work", Missiles and Rockets, Vol. 11, No. 11 (Sept. 10, 1962), PP. 30,35,40.

Laboratories Automatic Design System),[23,24,25] MAPID (Machine Aides in the Preparation of Instruction Data),[26,27] UNICOM (Universal Integrated Communications Equipment),[29,30,31] and other systems without specific names including one that produces wiring

23. Morzenti, O. J. "Implications of Machine Aids To Design," AIEE Paper, No. 61-104.
24. Herbst, R. T., Leagus, D. G. and Sellers, G. A. "Machine Processing of Manufacturing Information For Digital Systems." Unpublished Paper, Bell Telephone Laboratories Memorandum, [redacted], 1962.
25. Winans, R. C. "The Use of The BLADES Automatic Design System Computer Program for the Mechanical Design and Preparation of Manufacturing Drawings for Nike-Zeus "C" Planes." Unpublished Paper, Bell Telephone Laboratories Memorandum, [redacted], 1960.
26. Kalish, H. M. "The Automatic Print Out of a Sample Functional Schematic for MAPID." Un-Published Paper, Bell Telephone Laboratories Memorandum, [redacted], 1961.
27. Kalish, H. M. "A Study of the Feasibility of Using Machine Aids in the Preparation of Instruction Data." Unpublished Paper, Bell Telephone Laboratories Memorandum, [redacted], 1961.
28. Switak, F. E. "Unicom Computer Aided Wiring Program." Unpublished Paper, Bell Telephone Laboratories, 1962.
29. Rosenthal, C. W. "Computing Machine Aids to a Development Project," IRE Transactions on Electronic Computers, Vol. EC-10, No. 3 (Sept. 1961), PP. 400-406.
30. Kirby, D. B. and Rosenthal, C. W. "Computer Program for Preparing Wiring Diagrams," AIEE Paper, No. 60-1007.
31. Kirby, D. B. and Rosenthal, C. W. "A Computer Program for Preparing Wiring Diagrams." Unpublished Paper, Bell Telephone Laboratories Memorandum, [redacted], 1960.

information for conventional telephone circuits using machine aided methods.[32] A brief description of these systems might be useful at this point.

The DIPS programs provide the user with a vocabulary of two dozen words which enable him to verify design data, locate electronic logic packages, route interconnecting wires and prepare documents to support the above. Input to this system is a running list or interconnection list that is prepared from the logic diagram by the design engineer.

MAPID is a system which proposes to produce instruction data automatically. Included in this classification are pictorial functional schematics, functional theory, turn on/shut off procedures, check and adjustment procedures and maintenance procedures. The preparation of pictorial functional schematics using MAPID is particularly interesting in that it is proposed that this is accomplished utilizing an IBM 7090 Computer and a Stromberg Carlson 4020 Printer. The S-C 4020 is a CRT/microfilm-printer which, when directed by a program prepared on the IBM 7090, photographically produces high quality pictorial schematics.

The BLADES System is the most advanced development of all those produced by Bell Telephone Laboratories. BLADES starts with a

32. Hornung, G. T. and Weber, L. J. P., Jr., "A Method of Producing Wiring Information for Conventional Type Telephone Circuits Using Machine Aided Methods." Unpublished Paper Bell Telephone Laboratories Memorandum, [redacted], 1960.

logic diagram of the circuit to be represented which is then translated into a set of TOPO-LOGIC equations. The term TOPO-LOGIC is used, because in addition to the logic of the circuit, the equation also includes topographical information such as terminal numbers, etc. The BLADES system is a large group of IBM 704 programs which, utilizing the TOPO-LOGIC equations, assigns logic functions to specific printed wiring board packages, places these packages to satisfy wire-run restrictions, generates the necessary wire runs, selects certain component values, and assigns power supplies. The total system of programs utilizes approximately 37,000 instructions for the IBM 704. At the conclusion of the wire placement, most of the required manufacturing information is present but not in proper form. Output routines present an electrical parts list, assembly information, and wiring information in an acceptable format. All information is stored on magnetic tape so that the full power of electronic data processing can be brought to bear on the information maintenance problem. The magnetic tape becomes the official record. The BLADES program also provides input to a Gardner-Denver automatic wire wrapping machine.

The UNICOM System is really only an application of a small part of BLADES, namely that part which produces the wire running information. The particular advantages gained in using UNICOM were in a reduction in the number of errors made in the preparation of the wire running lists.

BLADES, MAPID, UNICOM and DIPS have several very important things in common. They are all based on working from logic diagrams that were formulated particularly for the processing system involved. In most cases, this involved skipping entirely the development of a conventional pictorial schematic drawing. In addition, the layout of the apparatus involved was very regular. This means that the terminals to which the wiring was connected were arranged in a completely symetrical matrix.

One processing system, however, has been developed to operate on apparatus which has its terminals arranged in an irregular manner.[33] This is the system previously mentioned that has been developed by the Bell Telephone Laboratories in their Columbus, Ohio Laboratories. The original system utilized IBM Unit Record equipment to produce wiring information for changes that were to be made on existing crossbar type telephone equipment. Later plans include the use of an IBM 1401 with large random access storage to replace the Unit Record equipment. This system has attempted to solve the many problems that arise when the apparatus is not regular in arrangement. Since the principal purpose of this system is to provide information for wiring changes on laboratory apparatus, it does not satisfy all of the necessary requirements that would be present in a regular manufacturing situation. The necessity of keeping permanent records that are easily updated to reflect the latest changes, while at the same time keeping a record

33. Hornung & Weber. op. cit.

of the old wiring, is one of the requirements of a regular manufacturing situation.

3. Objectives

The objectives of this study are to evaluate the feasibility of designing a computer oriented system for quantifying pictorial type schematic drawings so that they can be represented in a digital manner suitable for storage on magnetic media. The system must have the capability of easy updating and rapid information retrieval with selective production of informative engineering reports, and also should have the capacity to conduct routine design verification procedures. Design verification, in this application, should consist of automatically checking the accuracy of a number of the more routine design functions, for example, the assignment of apparatus identification codes to circuit elements. Preparation of detailed manufacturing information is not an objective of this study, it is, instead, a logical extension of this system.

In order to justify these objectives it might be worthwhile to summarize the previous historical discussion.

It has been shown that the greatest engineering effort, from a man-hour consideration, is centered in the area of preparation of manufacturing information and that certain parts of this information, by its very nature, is especially adaptable to machine aided methods. This fact is especially pointed out by the significant amount of effort that has been expended by industrial organizations in the direction of automating the preparation of wiring information. Interestingly enough though, almost all of this effort has been accomplished as a part of an overall development program to utilize input information restricted to a format particularly suited to the later stages of processing and to equipment design that is easily adapted to this type of processing. In these cases the layout of apparatus has been completely regular and even within a particular type of apparatus, the terminals have been arranged on a symetrical matrix. In addition, the effort has been in the direction of military type equipment that does not require extensive historical record keeping procedures. These records are necessary in the telephone industry for example because of the necessity of making all vintages of equipment compatible within one large system.

The intention, therefore, is to direct attention to the large segment of industry that finds itself unable to utilize the very considerable gains that have already been made in applying machine aids to the preparation of highly structured manufacturing information. Many research organizations are organized in such a way that the result of their activities is a pictorial type schematic circuit drawing.[34] While it is immediately recognized that this procedure may not be the most efficient from the view of later processing of information or even from the aspects of design activity itself, the needs of the business or of the ultimate

34. See Figure 4.

customer seemingly may require this procedure. The apparatus involved, while including circuit packs or printed wiring boards as they are more commonly known, which have terminals arranged in a symetrical matrix, also includes wire spring relays and other types of conventional electro-mechanical devices which are very irregular in layout.

The situation, therefore, is one in which the input to the processing system is a pictorial schematic drawing that has been developed by mostly manual methods and utilizes apparatus which is partially regular and partially irregular in arrangement.

What is needed is a method of keeping a master record of the circuit schematic and equipment arrangement in digital language that is easily updated or corrected and that also lends itself to further data processing methods for the production of manufacturing information. The vehicle that will best accomplish this objective is either:

1. A random access memory device such as IBM's RAMAC or NCR's CRAM (Card Random Access Memory) or,

2. Magnetic tape.

The appropriate vehicle for containing the master record of the circuit schematic must be coupled with a method of easily updating this record. The input information normally does not arrive in a complete package. More likely, as a result of short schedules and last minute design changes, the schematic is produced in a piecemeal fashion. The processing procedure must be capable of merging additional information with that already available and to allow insertions, deletions, and modifications. The ideal situation of course is to have all data inserted at the beginning and then to allow the computer to run free of human interference to the very end of the process.[35] The approach taken to this problem of flexibility is similar to that used in DIPS in that a vocabulary of order words[36] will call on a library of subroutines that will enable an un-experienced person to utilize the computer to manipulate the information which is contained in the master record. Using this procedure, circuit options which are required by price changes or circuit improvements, for ease of manufacturing or, simply, for record keeping purposes can be handled.

Once the information on the circuit schematic is translated into a digital language that is easily updated, problems of information retrieval must be solved. The information in the circuit schematic must be presented to the engineer in a logical manner for his corrections and modifications. It may be desirable to do this in several different formats: for example, a format that shows the electrically functional relationships or one that is arranged to conform to the physical relationship of the apparatus involved. Of course, the computer will be used to make extensive checks on the accuracy of the design data. Such things as multiple use of relay contacts, stray leads that are never terminated, interconnection

35. Weiner, op. cit. P. 139.
36. Rosenthal, op. cit.

with other circuits and physical interference between apparatus can be easily identified. The problem becomes, largely, one of file organization.

The total problem of converting conventional pictorial circuit schematic information into a digital form and producing manufacturing information from that media, is a very large one. Previous activities in this area have been accompanied by an expenditure measured in terms of tens of man-years of effort. Accordingly, this thesis shall be concerned only with the first part of the problem: representing circuit schematic information in a digital format.

During the systems design consideration will be given to the following stage, preparation of manufacturing information. Hopefully, sufficient flexibility will be built into the first phase so as to make implementation of the second as easy as possible.

4. DIRECTION

4.1 Introduction

DIRECTION is an acronym for DIgital REpresentation of Circuit InformaTION. It consists of a number of computer programs designed to accomplish the objectives listed in the previous section, principally the representation of pictorial circuit schematics in a digital format. Any system of this sort can be divided into two major categories: coding methods for quantifying the pictorial input information and information retrieval methods for the production of informative, useful output reports. Efficient organization of the required files is the single most important requirement common to both of these categories. The file organization must be so structured as to allow a meaningful conversion of the input pictorial information; it must have sufficient flexibility to allow the inclusion of certain classes of exception items; it must include provisions for the extension of the system design to future requirements; it must be organized in a manner best suited to easy updating; and finally it should be sequenced in a manner that will allow the production of reports of the highest entropy coincident with their intended use. At the start of a system design such as this one, these ideas are relatively meaningless platitudes. As work progresses, the real importance of file organization takes on its true significance in that the peak effort required in this design is reached not at the middle or end of the design but rather near the beginning when the basic groundwork is laid. In fact, some of the seemingly more difficult aspects of the objectives, namely the design verification, proved to be relatively easy as a result of the file organization which was in existence at the time this phase of the system design was under active development.

DIRECTION itself consists of three types of basic files. The first, called the APPARATUS MASTER FILE contains information for the many items of standard apparatus or building blocks that can be combined within a circuit to construct a useful functional piece of equipment. Included in this category are relays, transistors, keys, lamps, capacitors, etc. This file is not in any way oriented toward the particular circuit that is being processed by the system but is simply a dictionary containing a vocabulary of all the available standard components which might be used in that circuit.

The remaining two types of files differ from the first in that they are unique to the particular circuit being considered. The first of these is the UNIT FILE. This file, utilizes standard apparatus in the APPARATUS MASTER FILE and any necessary special items such as brackets or other special hardware to create a stocklist for the circuit involved and information to show the physical arrangement of the apparatus according to some coordinate system.

The third type of file, also unique to a particular circuit and most important of the system, is the WIRE FILE. It is here that information concerning the wiring of the circuit is contained in a carefully stratified organization oriented toward later processing requirements. In the discussion to follow the organization of each of these files will be covered in more detail including a description of the implementation of the system in terms of specific computer programs and a specific circuit vehicle. Perhaps at this time it might be worth while to include an introduction to both the circuit schematic and the computer used.

4.11 Choice of Sample Circuit

In selecting a pictorial circuit schematic to serve as the vehicle for the first implementation of DIRECTION it was desired to utilize apparatus of many types. Electronic as well as electromechanical apparatus are common in the electrical equipment industry and any system which could process circuits containing only one of these types would be severely limited in applicability. Accordingly the circuit selected is the Trunk Switching Circuit, a component of the Electronic Telephone Switching System currently being introduced into the telephone network of the Bell Telephone System. The design of this circuit is new. It contains however, along with the latest electronic devices, many electromechanical components such as wire spring relays which have been in common use for a number of years.

The second requirement of the circuit selected is that it be of the proper size. The Trunk Switch Frame, one of a number of different apparatus configurations used in an Electronic Telephone Central Office is composed almost entirely of the Trunk Switching Circuit. This complex of equipment is mounted on a framework four feet wide and nine feet high.[37] It contains over 10,000 terminals and includes a variety of different wiring methods. The size of this frame was considered optimal for a first implementation in that it was not so large as to obscure the objectives in its implementation (the largest circuit contains over 90,000 terminals) nor was it so small as to be considered a trivial application (the smaller units are of the order of ten inches by ten inches and contain about a hundred terminals).

4.12 Computer Restrictions

From the relative size of the circuits involved it is apparent that in order to process this volume of information a computer of the upper medium or large class is required. Such a computer, as will be shown later, must have high speed input-output devices and a relatively large core capacity. The computing facilities available for this study did not, in general, meet these qualifications. The Computing Laboratory at Lehigh University included an LGP 30 computer, a small machine, and a General Electric Company GE 225, a medium sized machine. The GE 225 at Lehigh University included a 900 line per minute printer, a 400 card per minute reader, a card punch, four 15K tape units and 8K positions of magnetic core storage. While the GE 225 is basically of the proper size, the

37. Figure 5 shows a framework similar to the Trunk Switch Frame.

particular configuration at Lehigh University was severely limited in the number and speed of the tape units and in the available core storage. As a result of these hardware constraints certain limitations were necessary in the system design. These limitations are not fundamental and where a compromise has been made an indication of the improved design is included.

Available for use on the GE 225 is a general purpose compiler titled GECOM. GECOM is essentially COBOL, the common business oriented language. Included however, are certain elements of ALGOL, an algebraic language and TABSOL, a tabular solution language. This compiler, while more rigid in form then COBOL-61, fulfills the requirement for a more or less universally interchangeable language. The first hardware limitation comes into play with the use of GECOM. In order to compile a GECOM program and assign the object program to magnetic tape, a minimum of five tape units are required. Since only four were available, object programs were placed on punched cards. While most programs were written so as to require the use of a call or parameter word to start processing, the usefulness of this procedure was severely limited by the assignment of object programs to punched cards. A better design would be to have all programs in a single magnetic tape library. An executive routine utilizing the call-words could call up the required program at each stage of the processing. This change in operating procedure does not reflect any fundamental system variation.

In this discussion mention is made of the GECOM programs that have been written to implement this system. The detailed coding for these programs is contained in a separate appendix to this thesis.

4.2 APPARATUS MASTER FILE

The APPARATUS MASTER FILE is a magnetic tape file containing information concerning the various items of standard apparatus that can be utilized in an electrical circuit. Included in this category are relays, electron tubes, capacitors, transistors, tube sockets, resistors, circuit packs, etc. Since producing the circuit design is not one of the objectives of DIRECTION, apparatus design parameters need not be included within this file. Information is necessary that will be useful to uniquely identify the particular piece of apparatus involved and to identify each terminating point for a wire on that apparatus. Hopefully, this information should be contained in a reasonable sized record. The file organization of the APPARATUS MASTER FILE was designed with these objectives in mind.

In establishing the organization of this file, every piece of apparatus containing more than one terminal must have a unique system of terminal identification if the function of the terminals, in terms of the apparatus, is different. In order to clarify this statement, consider the following examples:

1. Relay - every terminal on a relay has a unique function in terms of the relay contacts. Each terminal must be identified. Any identification scheme used is satisfactory provided it is used consistently in all files in the system.

2. Resistor - most pigtail resistors do not require differentiation between terminals in terms of the resistance itself. Normally, a resistor cannot be connected backwards in the circuit. The pigtail leads need not, therefore, be uniquely identified and they can simply both be labeled PT. At first examination it seemed necessary that each of these terminals be uniquely identified. Later developments indicated that the two PT leads of a resistor will appear to be uniquely identified in the wiring information with each terminal in the proper wire run.

3. Terminal Strip - each terminal in a terminal strip is electrically separate from every other. A unique identification scheme must be consistently used so as to avoid any confusion in identification.

Having established a method of uniquely or non-uniquely identifying apparatus terminals, it immediately becomes obvious that there is a wide variance in the possible number of terminals on an apparatus unit. The pigtail resistor for example has only two leads which are both normally called PT. A large terminal strip on the other hand may have hundreds of terminals each uniquely identified. The problem that must be addressed is the selection of a fixed or variable record length. With a fixed length record system, each record must be equal in size to that for the apparatus with the most terminals. Most of the apparatus included in the file have less than 36 terminals while a very few may have as many as 300 terminals. Fixed length records would, therefore, be a great waste of the medium used to store this type of information. Variable length records on the other hand, while tailor-made to each piece of apparatus, would be sufficiently random in size so as to prevent the blocking of records. With an expected large sized APPARATUS MASTER FILE, the apparatus file utilized by the Bell Telephone System alone contains in excess of 30,000 items, and the use of this file in DIRECTION being somewhat limited, it was decided to utilize variable length records with a control-key to identify the record length.

Control-keys are a feature common to the entire DIRECTION system. They are used to indicate the type and size of the input record being processed. Two alphabetic characters which occupy the first two positions within the record comprise the control-keys in DIRECTION. Using alphabetics allows the largest number of control-keys in the smallest number of character positions. In the APPARATUS MASTER FILE control-keys are used as follows:

CONTROL-KEY	NO. OF TERMINALS
JA	16
JB	42
JD	68
JF	94
JH	120

The remaining item of information which must be included in this file concerns the unique identification of the apparatus itself. Various coding schemes consisting of letters and numbers, with sophisticated check bit systems, have previously been developed. Each of these methods, while minimizing the number of digits used, require the translation of the code to a meaningful English identification before the information can be used by humans. This type of translation was avoided in every stage of DIRECTION. Instead, information was stored in a useful English language format. Each item of apparatus is therefore identified by its generic name or type, and the code number within that type. For example, a 481 Relay is a REL 481. A 185C Network is a NET 185C. Ten alphabetic digits are sufficient to identify the type while twenty alphanumerics comprise the code number.

The APPARATUS MASTER FILE, therefore, contains variable length records on magnetic tape, one for each piece of standard apparatus available. An individual record consists of, in addition to the control-key which indicates the length and type of the record, information about the apparatus type, code number within the type and an identification for each terminal.[38] For the particular application of DIRECTION included in this study a master file of only that apparatus required for the Trunk Switching Circuit was

38. For the detailed structure of the APPARATUS MASTER FILE and examples of input records see Figures 24 and 25 respectively.

created. This file consists of sixty-eight records of various lengths.

In order to create this file and produce a printed report containing information on the file contents, two programs have been written. They are respectively APMSTRIN[39] and APMSTROUT.[40]

4.21 APMSTRIN

APMSTRIN is a program which provides for the creation of a magnetic tape file from a punched card input. In order to provide for a variable length input record which involves a variable number of punched cards, control-keys are used. The control-key, occupying the first two columns of each punched card being used as input, not only indicates the contents of the remainder of that card but also identifies the number of additional cards which together contain all the information about a single item of apparatus. Use of control-keys in this instance becomes a very useful but complicated procedure.[41] During processing, the program detects the improper use of control-keys, printing a suitable message on the high speed printer which will enable identification of the incorrect record. Completion of processing is also indicated on the printer.

39. See FIGURE 6.
40. See FIGURE 7.
41. Figure 26, in TABSOL format shows the use of control-keys in APMSTRIN.

4.22 APMSTROUT

APMSTROUT produces a printed report titled MASTER APPARATUS LIST which contains the information in the APPARATUS MASTER FILE.[42] A single parameter card is required which is identified by a control-key and contains the current date. The report utilizes this date on its cover sheet. Additional pages of the report include information on every record in the file. The apparatus type, code and identification for each terminal is shown. When all information in the file has been printed, the end of file is indicated. The pages of the report are numbered, continuations are shown and in general every effort is made to produce a meaningful, easily read and understood document. For the Trunk Switching Circuit the MASTER APPARATUS LIST contained nineteen pages of computer output.

No provision has been made for updating the APPARATUS MASTER FILE. The feasibility of the system design did not hinge on this flexibility and the application involved did not require it. Accordingly, any file updating requires the creation of an entirely new file. It is expected that an extension of the present design would include provision for updating this file in a manner similar to that included in another part of the system.

4.3 UNIT FILE

The UNIT FILE is a magnetic tape file which contains information concerning the physical arrangement of a particular

42. FIGURE 14 contains a sample MASTER APPARATUS LIST report.

equipment unit. It is different in concept from the APPARATUS MASTER FILE in that while the APPARATUS MASTER FILE is a file of apparatus useful in many circuits, the UNIT FILE, being applicable to a particular physical arrangement, applies only to the circuits for that arrangement. This file includes a variety of information including a stocklist, functional designations of apparatus, quantities and physical location.

The file is organized around the identifying code for a unit or frame of equipment. This frame or major assembly usually will consist of a number of subassemblies each with their own code identification which, in some way, is related to the code for the entire assembly. The subassemblies in turn can be broken into individual items of apparatus, piece parts, hardware, etc. The Trunk Switch Frame is stratified in exactly this manner, the entire frame being identified as J1A030A-1. This major assembly consists of subassemblies coded J1A030AX-Y and EDZZZZZ-YY, where the Z represents an alphanumeric character, the X an alphabetic and the Y a numeric digit. The ED classification generally represents an unwired hardware subassembly while the J indicates a wired one. Each of the J and ED subassemblies are in turn composed of other J or ED subassemblies of piece parts, of apparatus items or of hardware. In order to make this coding system more general, the J and ED units are further broken into lists or groups. Each list or group symbolizes a particular application or function of the assembly and may be selected for inclusion if desired in a particular unit being manufactured. Generally, the first list or group is always required with additional ones providing optional extra features.

Up to this point, the description of the UNIT FILE has consisted of that information which would normally be considered as a stock list. The UNIT FILE contains much more than this. Individual pieces of apparatus are assigned functional designations within the circuit to indicate their function. For example, a 34A Transistor (designated as TRSTR 34A in the APPARATUS MASTER FILE and the UNIT FILE)might also be known as the SCR.O Transistor in the circuit. The functional designation, SCR.O, indicating that this transistor is in the zero circuit and has a screening function. These functional designations are included in the UNIT FILE for each piece of apparatus.

Some place within DIRECTION, information should be provided concerning the physical relationship of each piece of apparatus with each other piece. This information is included in the UNIT FILE. A system of coordinates must be established for each physical complex of apparatus. It is not within the scope of this study to consider all the ramifications of the establishment of such a coordinate system. Let it suffice to say that this phase of the system organization is one of the most important with implications reaching into the earliest stages of the circuit design. It is not at all difficult to design a circuit, in particular the equipment arrangement, that makes impossible the assignment of any reasonable, workable, coordinate system. The key is consistency. When the equipment layout is first undertaken certain rules must be established and consistently followed. For the Trunk Switch Frame a vertical coordinate system of two inch inrements and a horizontal one of one-eighth or one-tenth inch increments, depending on the type of apparatus involved, was established. If automatic machine wiring is contemplated, an accurate system must be used. For this frame, due to the lack of consistency in terminal configuration, such a wiring method is unfeasible and the coordinate scheme used, while inexact, is sufficient.

The UNIT FILE in order to contain the various items of information discussed above for the various assemblies, subassemblies, piece parts, apparatus, hardware and purchased materials, consists of three types of records each identified by its own unique two digit control-key. The order of records in the file is significant in that it indicates the hierachy of assemblies, subassemblies, etc. within the file.

The first type of record is used to provide information about apparatus items which are contained in the APPARATUS MASTER FILE. The usual information consisting of apparatus type, code and functional designation along with the physical location and quantity required are included in this record. The second type, for subassemblies of the J and ED classification includes information to identify the required sub-unit, its lists or groups (up to ten per sub-unit) and the necessary quantity of each. The third record type was created to provide for all the other items of hardware which might be included in the UNIT FILE. Part numbers, descriptions and quantities make up the various items in this record type. In addition to the contents indicated above, all of the record types contain information which allows them to be related to the main unit code and sub unit code of which they are a part.[43]

In order to create the UNIT FILE and produce a report of its contents two programs UNITMSTR[44] and UNITRPT[45] have been written. Input to these programs is a deck of punched cards with a magnetic tape file and a printed report respectively as the outputs. Extensive provision for easy updating of this file is provided due to the anticipated information changes concerning the physical arrangement of the unit during all phases of development. Shortened schedules and design reappraisals will make this necessary. The UNIT FILE is capable of fast, simple reaction to these changes. The following description of UNITMSTR will indicate how this updating is accomplished.

43. FIGURES 27 and 28 contain information which shows the detailed structure of the three record types and some input examples.
44. See Figure 8 for a flow chart of UNITMSTR.
45. Figure 9 consists of a flow chart of UNITRPT.

4.31 <u>UNITMSTR</u>

UNITMSTR converts an input deck of punched cards into an output file on magnetic tape. In accomplishing this objective, extensive error detection routines are included to detect improper use of control-keys and call-cards. Illogical situations in file updating, mainly end of file signals, are detected and printouts of error messages on the high speed printer are used to inform the operator of these situations. As much as possible, processing is designed to continue without operator intervention. A vocabulary of four words is used to control the operation of the program. These words are:

START

MODIFY

DELETE

ADDITION

In creating a new file, a single card with a control-key indicating that it contains one of the four vocabulary words, and the word START will signal the start of a new file. The following cards in the input deck will then be transcribed to a newly created magnetic tape file.

If updating of an already created file is required, the call words MODIFY, DELETE and ADDITION, are used. A call card consisting of the word ADDITION signals that an addition is to be made to an already existing file. Since it is necessary that the addition be made in exactly the proper place in the existing file, a method must be provided to search that file in a sequential manner. This is accomplished by using so called qualifier input cards. The qualifier is identified by the use of an appropriate control-key. The function of the qualifier is to provide a means of searching the UNIT FILE. The search is successful when a match is made between the UNIT FILE and the qualifier. Any number of qualifiers may be used, the sequential search being concluded when the UNIT FILE is positioned so that its last read record matches the last qualifier. The next input card, not being a qualifier, is inserted into the UNIT FILE as the next record. If no qualifiers are present in the input data, the input records are added to the UNIT FILE as the first ones in that file. Examination of the program flow charts will show exactly how this operation is performed. The call words MODIFY and DELETE operate in a similar manner except that the qualifiers are used for a first level search with the first following card used for a second level search. In the DELETE operation, when the second level search is concluded, the record in the output file which matches the next input record is deleted. In the MODIFICATION operation, conclusion of the second level search causes the computer to insert the next input card in place of the second level matching record. Any number of qualifiers can be used, any number of additions, modifications or deletions can be made in one run and in fact the three types of operations can be mixed provided the input data is in the same sequence as the UNIT FILE. This system allows extensive updating in one easy run. If the input deck should be incorrectly structured, error messages on the printer will provide information for correcting the error.

4.32 UNITRPT

The UNIT FILE has been created and kept up to date using the program UNITMSTR outlined in the previous section. In order to have a record of the contents of that file, which among other reasons is necessary for updating, the program UNITRPT has been written. UNITRPT requires as input the UNIT FILE created on tape as a result of UNITMSTR and a single parameter card containing the control-key PA and the current date. The program then produces a report titled UNIT LIST.[46] The cover sheet of this report in addition to the title and date includes the main unit code, in the case of the Trunk Switch Frame, J1A030. The body of the report is presented not in the information sequence used in the UNIT FILE, but reorganized to convey the greatest amount of useful information to the persons desiring the report. For the Trunk Switching Frame the UNIT FILE consisted of 609 records and the UNIT LIST contained 34 pages of computer output. Examination of this report will show that it contains a complete picture of the equipment stratification including quantities, physical arrangement and functional designations for the Trunk Switch Frame. Blank fields are present because at the time of implementation complete information was not available for this frame.

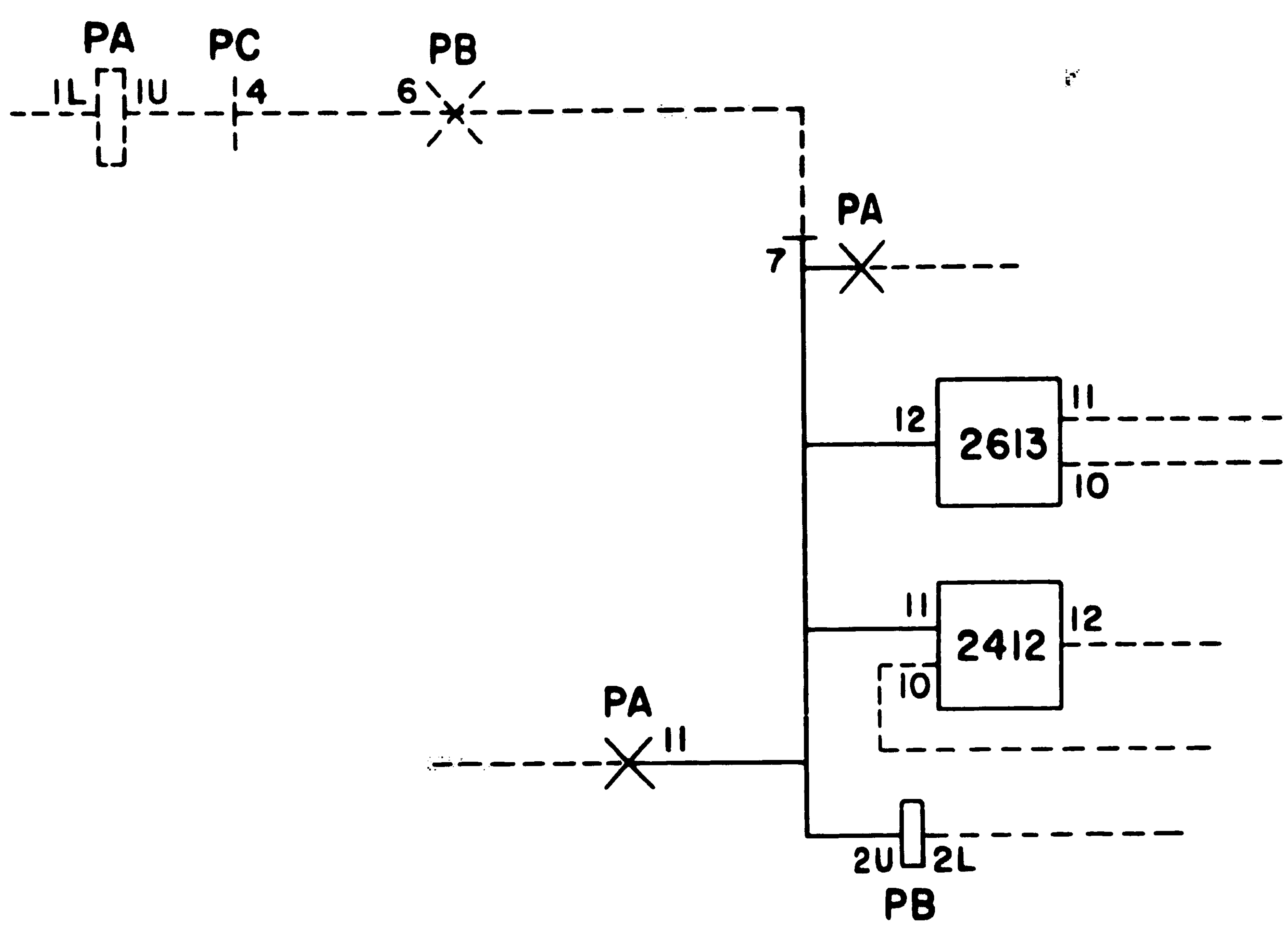
46. FIGURE 15 contains a sample UNIT LIST report.

4.4 WIRE FILE

The WIRE FILE is the most important single file in DIRECTION. Its purpose is to systematically provide a structured system of recording the information necessary to define the point to point wire runs in a particular circuit schematic. Since this is also one of the primary objectives of DIRECTION, the two previously described files, APPARATUS MASTER FILE and UNIT FILE, are in a large sense supporting information for the WIRE FILE. In addition to wire run information the WIRE FILE also contains provisions for later additions of information pertaining to the preparation of manufacturing data necessary for the wiring operation. Since the detailed wiring runs shown on the circuit schematic are subject to a great probability of change, the WIRE FILE must be resilient enough to respond to these changes in a simple manner. Another characteristic of the wiring information is the great variety of special situations that are included. The file organization must be flexible enough to allow the inclusion of information for most all of these special situations.

The basic coding system used in the organization of the WIRE FILE is that known as the nodal or equipotential system. In this method, which has been used in a number of other systems, all those wire terminations, or terminals, which are electrically common are assigned a single unique coded identification number. This identification is never repeated for another group of electrically common terminals within an entire circuit. There may be any quantity of wire ends or terminals within any single node, however, no wire run can originate in one node and terminate in another. The node system does not indicate in what order terminals are to be connected together, merely that they are electrically common.

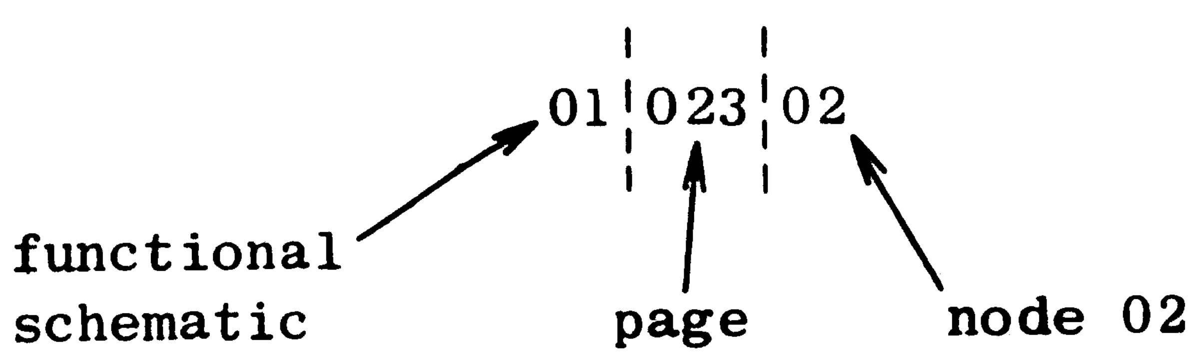
The following example may help clarify the use of the nodal identification system. That part of the circuit drawn with solid lines comprises a single node. The terminals in that single node are listed.



Terminal	Functional Designation	Apparatus Type
7F	PA	RELAY
12	2613	CIRCUIT PACK
11	2412	CIRCUIT PACK
2U	PB	RELAY
11F	PA	RELAY

The most important contribution of this system is that it allows the reduction of a single, large, complicated circuit into a large number of small, simple circuits. Each of these small circuits or nodes can be studied individually. This system is well suited to computer technology which provides for extremely high speed solution of a large number of individually simple problems.

In DIRECTION, the coding system used to identify each node has a meaning in terms of the pictorial schematic drawing for the circuit. In order to provide some useful subdivision of the wiring information contained in the circuit schematic, the design engineer usually breaks the circuit into a number of modules each of which perform a different function. The quantity of these subdivisions may vary from one to a hundred and usually a one or two digit number is sufficient to identify these functional subdivisions or functional schematics. This functional schematic number is used as the first two digits of the seven digit node identification numbering system used in DIRECTION. The next three digits of the node number is the number of the circuit schematic page on which either all or part of the node appears. The last two digits are merely an arbitrarily assigned number starting from 01 for a particular page of the circuit schematic. A typical node identification number might be:



The WIRE FILE consists of a large quantity of records, sequenced on node numbers. Each record represents information for a single terminal or connection to an external circuit. Since a node has been defined to include all wire terminations or terminals that are electrically connected together; within apparatus a path is not considered to be continuous; it is possible and in fact necessary that a node number be common to more than one record in the file. While the node numbers are in themselves unique, they are not unique between records. With records sequenced on node numbers, one record for each terminal or external circuit connection, the final organization of the file places information concerning all terminals or external connections in a single node contiguous within the file.

In addition to records containing information on wire terminations and external connections other record types are necessary for the inclusion of the circuit title, issue, circuit notes and a cross reference of apparatus functional designations and type and code numbers. This latter category, apparatus information, is a duplication of some of the information contained in the UNIT FILE but because of the order in which the circuit is designed and the timing of the availability of documents it must be included in the WIRE FILE. When the circuit is being designed the primary consideration is to connect circuit elements, relays transistors, etc., together in a manner that will accomplish the desired objective. The circuit elements are identified by a functional designation which indicates the use of the apparatus and does not provide a clue to its specific physical identification. Knowing the purpose of each circuit element and the necessary design parameters, an apparatus specialist can, at a later time, select the specific codes to be used from a master file. The fragmentation of design effort results in wiring information containing only functional designations for apparatus and a separate cross reference of functional designation and type and code number. The circuit schematic that is finally issued by the design group consists of several sections including all of this information.

The various record types that make up the WIRE FILE are identified by the use of control-keys. The record containing the circuit number, issue and title is always the first type in the file. It serves as a file label. The next record type contains circuit notes and is sequenced on the note number. The third type of record found in the file provides the cross reference between the apparatus functional designation and the apparatus type. This information is grouped in Apparatus Figures which define, to some degree, the functional unit subdivisions of the equipment configuration (J Units). Some apparatus items have dual functional designations hence, the field for upper half functional designation. Sequencing of this record type is by Apparatus Figure number. The remainder of the WIRE FILE consists of apparatus terminal information and information concerning connections to external circuits. These two types of records, about 90% of the total, are intermingled and sequenced on the node identification. An explanation of the purpose of some of the fields might be useful.[47] The field titled option is used to designate wiring which has been included in the circuit to provide optional features or to reflect changes mostly caused by improvements in the circuit. Methods of historical record keeping are predicated on this type of designation. Wire gauge, type and color information is usually not available on the circuit schematic although it is sometimes provided in circuit notes. The main purpose of including these fields at the present time is to provide flexibility for the extension of DIRECTION to the preparation of manufacturing information. It is expected that information for these fields will be provided automatically by another system. The Wiring Method, Strap and Loop fields are also provided for future flexibility. The field titled Pair-Triple-Quad is required to indicate the pairing, tripling and quading of wires in the circuit. This information is included, by the designer, in the circuit schematic. A P, T or Q is inserted for each end of the runs if any of the three conditions exist. The field titled Miscellaneous is used to interrelate the necessary nodes involved in the pairing, tripling or quading. In addition to this use for the Miscellaneous field, it serves as a catch-all for many other types of information. For example, a lead to an external circuit will frequently have a functional name assigned to it. This

47. FIGURES 29 and 30 contain detailed information on the structure of the WIRE FILE and present some examples of the input data.

information could be indicated under Miscellaneous.

4.41 WIREMSTR

Creation and maintenance of the WIRE FILE requires the use of the program titled WIREMSTR.[48] This program is similar to UNITMSTR in that it utilizes the four call words

START

MODIFY

DELETE

ADDITION

to create and update the file. The updating process in both UNITMSTR and WIREMSTR causes the creation of a new master file from the old one with incorporation of the necessary changes. Qualifiers are used in updating WIREMSTR just as in UNITMSTR with suitable control-keys identifying the qualifying records. It is possible that the fields containing miscellaneous and note information might not be sufficiently large to contain all the necessary information. The program allows the use of input cards in addition to the first which contain only a continuation of the miscellaneous or note information along with the node identification if applicable. This extra material is stored as a separate record immediately after its related one in the output WIRE FILE. Extensive error detection routines are included in this program as well as in all others in DIRECTION.

48. A flow chart of WIREMSTR is shown in FIGURE 10.

4.42 WIRERPTS - APPLIST

Once the magnetic tape file, WIRE FILE, has been created by the use of WIREMSTR, retrieval of information is accomplished by the programs titled WIRERPTS[49] and APPLIST.[50] Two programs are required for this purpose only because of the physical limitations of the computer configuration involved. A single program required approximately 10,000 core positions, more than was available. The WIRE FILE created for the Trunk Switching Circuit consists of 9,971 records. This is considered an average size file for this type of circuitry. With such a large number of records, it is important that a great deal of care be exercised in producing reports that will be useful. A complete listing of all the information in this particular WIRE FILE is a large cumbersome document. It is so large that its only usefulness might be for possible documentation purposes. The principal objective of WIRERPTS and APPLIST is, therefore, to provide reports of such flexibility that they can be almost tailor made to their intended use. This flexibility of output is attained by the extensive use of call-cards. The engineer, or any other user, has been provided with a vocabulary which enables him to command the computer to produce any one of several documents from the WIRE FILE. The vocabulary consists of

49. See FIGURE 11 for the WIRERPTS flow chart.
50. FIGURE 12 contains a flow chart of APPLIST.

the following seven words:

1. ALL LIST
2. NOTE LIST
3. FS LIST
4. PAGE LIST
5. NODE LIST
6. APP FIG LIST
7. APP LIST

The use of each of these call-words results in the production of a different type of report. The first card in the input deck to either program, provided only once per run, is a card containing the current date. The date is used on the cover sheet of each report as a chronological index. The following paragraphs contain detailed information on each of the reports which can be produced.

The first report to be considered is titled ALL LIST.[51] This report, which has been previously alluded to, is a complete listing of the contents of the WIRE FILE, presented in a suitable format consistent with the size of the file. Wiring information in this report is sequenced in node identification numbers and includes circuit notes and apparatus cross references. Production of this report is accomplished by use of a single call-card, in addition to the date card, containing the appropriate control-key followed by the words ALL LIST. For the Trunk Switching Circuit, this report

51. Some sample pages from an ALL LIST report are shown in FIGURE 17.

consisted of 376 pages. An engineer could hardly be expected to assimilate this volume of information, hence its use, as indicated, is primarily for documentation.

A report titled NOTE LIST[52] is also available. Again, just a single call-card is required containing the words NOTE LIST. The ease in controlling DIRECTION should be apparent. NOTE LIST is merely a listing of the circuit notes contained in the WIRE FILE, presented in a meaningful format with suitable page and section headings.

FS LIST[53] is a report containing information on from one to ten functional schematic subdivisions of the circuit schematic. Two call-cards must be utilized. The first contains FS LIST, the second has provision for from one to ten functional schematic identification numbers. Each of these numbers is represented by a two digit numeric field. The desired FS numbers must be listed in the order they appear in the WIRE FILE. The report generated by this routine will include all the wiring information for the functional schematics listed on the call-card.

PAGE LIST[54] is a listing of wiring information contained on a single page of the pictorial circuit schematic from which the WIRE FILE was created. Two call-cards, the first with the words PAGE LIST and the second with from one to ten page numbers, in the order

52. See FIGURE 18 for an example of a NOTE LIST.
53. See FIGURE 22 for an example of an FS LIST.
54. See FIGURE 20 for an example of a PAGE LIST.

listed in the wire file, each expressed in three numeric digits, are required for this routine. The report printed on the high speed printer contains wiring information for the desired pages of the pictorial circuit schematic.

NODE LIST[55] is a report which contains information concerning certain specified wiring nodes in the WIRE FILE. As many as ten individual nodes may be included in this report but all the nodes must be from one page of the pictorial circuit schematic and must be listed in ascending order. Two call-cards are required for this segment of WIRERPTS. The first, as usual, contains the call words NODE LIST. The second, in three numeric digits, contains a pictorial circuit schematic page number followed by as many as ten arbitrary node numbers, each represented by two numeric digits. These two items, page number and node number, along with the functional schematic number, make up the complete node identification. This output report presents, to the user, wiring information for a carefully defined area of the source document. The area covered, being so defined, presents a large amount of information in a very simple, short report.

APP FIG LIST[56] the last type of report produced by WIRERPTS contains information for as many as ten apparatus figures. As previously defined, an apparatus figure represents the apparatus which comprises a physical unit. The information contained in this

55. See FIGURE 21 for a sample NODE LIST.
56. FIGURE 19 contains a sample APP FIG LIST.

classification is a cross reference between apparatus codes and functional designations. The usual two card calling format is used. The first contains the words APP FIG LIST, the second card providing from one to ten apparatus figure numbers each in four alphanumeric digits. The output report is a simple printed cross reference table of the desired apparatus figures.

The program titled APPLIST produces a single report called APP LIST.[57] A two card control format is used including the title of the report and up to four repeats of apparatus functional designations and generic names such as P38 REL. The output report, using this input information, produces, from the WIRE FILE, the associated apparatus codes and apparatus figure numbers. In addition, a complete list of all information concerning the wiring of each of these pieces of apparatus is included. This report in one operation produces complete information about any piece of apparatus in the circuit with knowledge only of its functional designation and generic name. By relating information from various parts of the file together and then presenting that material in a logical structure APP LIST may well be the most useful report of all those generated by both WIRERPTS and APPLIST.

The WIRE FILE part of DIRECTION, containing both input routines to create a tape file and output procedures for the production of a variety of useful reports from that file, has been designed to be flexible enough to provide a base for the extension of

57. See FIGURE 16 for sample of APP LIST.

DIRECTION to the area of preparation of manufacturing information. In addition, by the use of a calling vocabulary, the selective production of reports covering almost every possible format, is possible. These reports can be generated on the basis of one report per program run or, by stacking the input call cards, an unlimited number can be printed in a single pass. From a design or engineering viewpoint, this flexibility of file establishment and information retrieval is very useful. The ease of retrieval is particularly dependent on the file organization that has been established.

4.5 DESIGN VERIFICATION

One of the principal objectives of DIRECTION is to provide a simple automatic method of conducting certain checks on the accuracy of the design information contained in the pictorial circuit schematic. These checks might range from the simplest test for duplication to the most elaborate analysis of the circuit logic. In order to reduce the complexity of such a procedure to that which could reasonably be considered at this time, it was decided to eliminate checks on circuit logic from the system. Instead, an area of design verification that would be most useful and at the same time lend itself to concentrated study was selected. DESIGN VERIFICATION, therefore, was defined to consist of five parts:

1. Multiple use of terminals.
2. Duplication of functional designations.

3. Presence of a functional designation in an apparatus figure but not in a functional schematic and vice versa.

4. Use of illegal terminals.

5. List of used and unused terminals.

It was expected that the DESIGN VERIFICATION portion of DIRECTION would be the most difficult to accomplish. At this point, the true value of efficient file organization was made evident. As a result of the structuring of the three files, the accomplishment of this portion of DIRECTION proved to be mostly a matter of re-sorting the files in a different manner so as to allow a comparison of various records.

Frequently, in a large circuit, terminals on a particular piece of apparatus are inadvertently used more than once. This type of an error is difficult to locate until the item is actually wired. That late in the procedure, the detection of the error creates a great deal of difficulty. What is desired is a method for checking every wire termination in the WIRE FILE against every other termination to see if there exists a terminal duplication. The solution is simple. The magnetic tape WIRE FILE is resorted on three keys. The high order key is terminal number, the middle order is the functional designation of the apparatus on which the terminal appears, and the low order key is apparatus type. This resorting program can be a standard sort-merge routine produced by a sort generator. The resultant reordered file will contain all of the, say terminal number eights, together. Furthermore, the secondary keys of functional designation and apparatus type will cause the multiple use of a particular terminal to appear in adjacent records. A procedure for comparing adjacent records with a branch-on-equal to a print routine would conclude the check.

The determination of the duplicate use of functional designations is equally simple. If the portion of the WIRE FILE containing the apparatus type and functional designation cross reference was to be resorted on a primary key of functional designation and a secondary key of apparatus type, any multiple use of functional designations would appear in adjacent records. A comparison like that indicated above would produce a list of the duplications.

In order to determine the presence of a functional designation in an apparatus figure which is not used any place in the functional schematics, several sorting procedures must be used. The cross reference tables in the WIRE FILE must be resorted on a primary key of functional designation and a secondary key of apparatus type. This order is exactly that used in the check for duplicate functional designations. In addition, a sort must be conducted on the wiring type records in the WIRE FILE. These records, containing information on wire terminations on apparatus terminals, are sequenced in exactly the same manner as the apparatus cross reference type records with the additional requirement that there be no duplicate records. Once these two new files have been properly established, a record comparison will reveal whether a functional designation shown in an apparatus figure is present in a functional schematic or vice versa.

A check for the use of non-existent or illegal terminals is most important. The variety of terminal configurations on different types of apparatus makes this test necessary. Three sorting procedures, a merge and a comparison, are necessary to accomplish this objective. First the wiring type records in the WIRE FILE are sorted on three keys. The primary one is functional designation, the secondary is apparatus type and the low order key is terminal. The apparatus cross reference type records in the WIRE FILE must also be sorted on three keys. The keys are, in order, functional designation, apparatus type and apparatus code. These two files are then merged to produce a new file containing four fields; functional designation, apparatus type, apparatus code and terminal. The merged file is sorted again, this time on apparatus type, apparatus code, terminal and functional designation. This file is now exactly in sequence with the APPARATUS MASTER FILE which contains information on the terminal configuration of all apparatus. A comparison of the two files will produce a list of illegal or non-existent terminals which are indicated as used in the WIRE FILE.

Once the procedures for determination of the use of illegal terminals has been completed, the same two files, one the merged and resorted WIRE FILE, the other the APPARATUS MASTER FILE, can be used to determine used and unused terminals. Each record in the new modified WIRE FILE represents a used terminal. A comparison of these records with the APPARATUS MASTER FILE will indicate legal but unused terminals. This type of information is of value to the designer trying to make additions to the circuit and faced with the problem of locating vacant terminals.

4.51 DUPLICATEFD

Determination of duplicate use of functional designations is the one portion of DESIGN VERIFICATION which has been implemented. Due to the size of the appropriate portion of the WIRE FILE for the Trunk Switching Circuit, sorting was accomplished within core instead of on tape. The program developed for this check is titled DUPLICATEFD.[58] The output is a list containing only the duplicated functional designations.[59] Since the core sort used in DUPLICATEFD is limited to seven hundred functional designations, extensions to DIRECTION should include a conversion of this program to a tape oriented sort.

58. See FIGURE 13 for the flow chart of DUPLICATEFD.
59. FIGURE 23 contains sample output of DUPLICATEFD.

5. Conclusion

The objective of this study was to design and evaluate a system to represent electrical circuit schematic information in a manner suitable for storage on a magnetic media with:

1. Provision for easy updating.
2. The capacity to rapidly produce selective engineering reports.
3. The ability to conduct routine design checks.

Each part of this objective has been accomplished.

Conversion of a pictorial circuit schematic drawing to a digital format was accomplished by the use of the nodal or equipotential method of reducing a large complex circuit into a number of simple circuits each with a unique seven digit identification number. A magnetic tape file has been designed, called the WIRE FILE, which contains information about each of these small circuits or nodes. Other information such as circuit notes and apparatus cross reference tables are also included in the WIRE FILE. With the WIRE FILE containing mostly wiring or electrical information, another file titled UNIT FILE has been designed to include information about the physical components which comprise a unit of electrical equipment. Part numbers, quantities, descriptions and stock list information was included in the records of this file. A third file was necessary to provide information about the many standard items of apparatus which may be used in the design of a circuit. This file has been titled AP MSTR FILE. Within these three files:

1. WIRE FILE

2. UNIT FILE

3. AP MSTR FILE

can be contained all of the information necessary to completely describe an electrical circuit.

The next objective was to provide a means for the rapid updating of the three files. This was made necessary by the transitory condition of the design information. Shortened schedules require the release of design information before it is either complete or thoroughly tested. As a result it can be expected that many changes will be required right up to the time for manufacturing to start. This updating problem has been solved by the use of a vocabulary of four call-words:

1. START

2. ADDITION

3. MODIFY

4. DELETE

A person, not highly trained in computer technology, through the use of these four call-words and the associated computer programs which have been prepared, can easily maintain the magnetic tape files for any circuit.

The ability to rapidly produce selective engineering reports was a key one in this system design. Using the present method of representing the circuit information in a pictorial format the user is presented with a number of large documents from which he must cull the information he desires to use. This technique violates the most elementary principles of information presentation.[60] If the value of a report is to be measured by its usefulness to the user, some technique should be used to present only the information which the user desires. DIRECTION does this by providing him with a vocabulary of seven words with which he can direct the computer to produce the report he desires. These words are:

1. ALL LIST
2. NOTE LIST
3. FS LIST
4. PAGE LIST
5. NODE LIST
6. APP FIG LIST
7. APP LIST

The resulting seven types of output are each designed to provide a different type of information, each in a different form.

The ability of the system to conduct certain routine design checks was a key objective. Consider the design problem. In order to do what is considered a good job there should be few errors in the circuit drawing. Errors in this document can originate either with the designer or with the draftsman. In order to eliminate the errors an elaborate system of manually checking the circuit at each stage in its preparation is presently followed. Use of DIRECTION

60. Gregory, R. H. and Van Horn, R. L. Automatic Data Processing Systems: Principles and Procedures. Belmont, California: Wadsworth, 1963, P. 3.

makes possible the elimination of some of this tedious non-productive effort. While checking for errors in logic is not included, the detection of other types of errors is so simple and rapid that finding them by any other method is without merit. In the implementation of DIRECTION used in this study, keypunched data was machine verified. Further consideration in this area indicates that even this effort might not be necessary. The system itself should and can be used to check its own input. The few errors it detects can then be corrected manually.

Some of the savings which are made possible by the use of DIRECTION are worthy of consideration. Some of these savings might result from:

1. Reduction in required manpower.

2. Improvement in communication.

The press of competition and expanding technology has resulted in an ever increasing, more rapid, flow of manufacturing information from designer to factory. It has been estimated that 40% to 80% of this information concerns itself with wiring.[61] In addition to the great increase in volume of wiring information and the press toward a shorter engineering interval, an even greater problem in available engineering manpower is looming over the horizon. Estimates have been made that by the mid 1970's it will be

61. Bedell, E. H., "New Techniques in Preparation and Use of Manufacturing Information". Speech given before Bell System Executives, Cherry Hill, New Jersey, June 20, 1963.

impossible to recruit sufficient engineering talent to process design information into manufacturing information by manual methods.[62] A parallel is drawn that if the automatic dial telephone system had not been perfected, approximately one fourth of the total female working population would presently be required as telephone operators.[63] The use of DIRECTION will help to solve this problem by allowing the computer to accomplish much of the work presently being done by engineers and draftsman. For example, in translating the Trunk Switching Circuit onto punched cards approximately four man weeks were required for both analysis and keypunching effort. With the exception of manual intervention in special situations, this represents the total manual effort required on this circuit. All additional processing, including all of the drafting effort, toward the production of manufacturing information will be done by the computer. Using more conventional techniques the engineering and drafting effort on a medium sized circuit might amount to as much as one and a half man years. The indicated saving in man effort, therefore, is of the order of 20 to 1.

The communications problem that exists in transmitting circuit and wiring information between manufacturing or engineering locations is another area of savings. Elaborate data transmission systems

62. "Regional Computer Utilization: Costs and Savings". Unpublished Paper, Western Electric Company - Systems Equipment Engineering, 1963.
63. ibid.

which are capable of high speeds are in existence. They depend, however, on a magnetic input media. DIRECTION allows the utilization of this transmission network while more conventional methods of circuit representation are dependent on slower communication media.

6. Future Considerations

DIRECTION must be considered as merely the first step in the process of completely automatic preparation of manufacturing information. The area in which the expenditure of additional effort will result in the greatest gain will therefore be in the extension of DIRECTION to the actual preparation of local cable design, surface wiring lists and other detailed wiring information. Techniques exist, as outlined in Section 3. of this thesis, which should make possible the accomplishment of these goals. Before this ominously large undertaking is started, a number of limitations which have been included in DIRECTION should be removed. These limitations, including the absence of an overall executive routine to interconnect each of the eight programs comprising DIRECTION and the incomplete detailed programming of the design verification phase, are largely caused by the shortcomings of the computer hardware configuration used. A larger machine must be utilized. With the present programming in COBOL, conversion to almost any other machine should be easily facilitated.

EXPLOSION OF MAN HOURS[64]

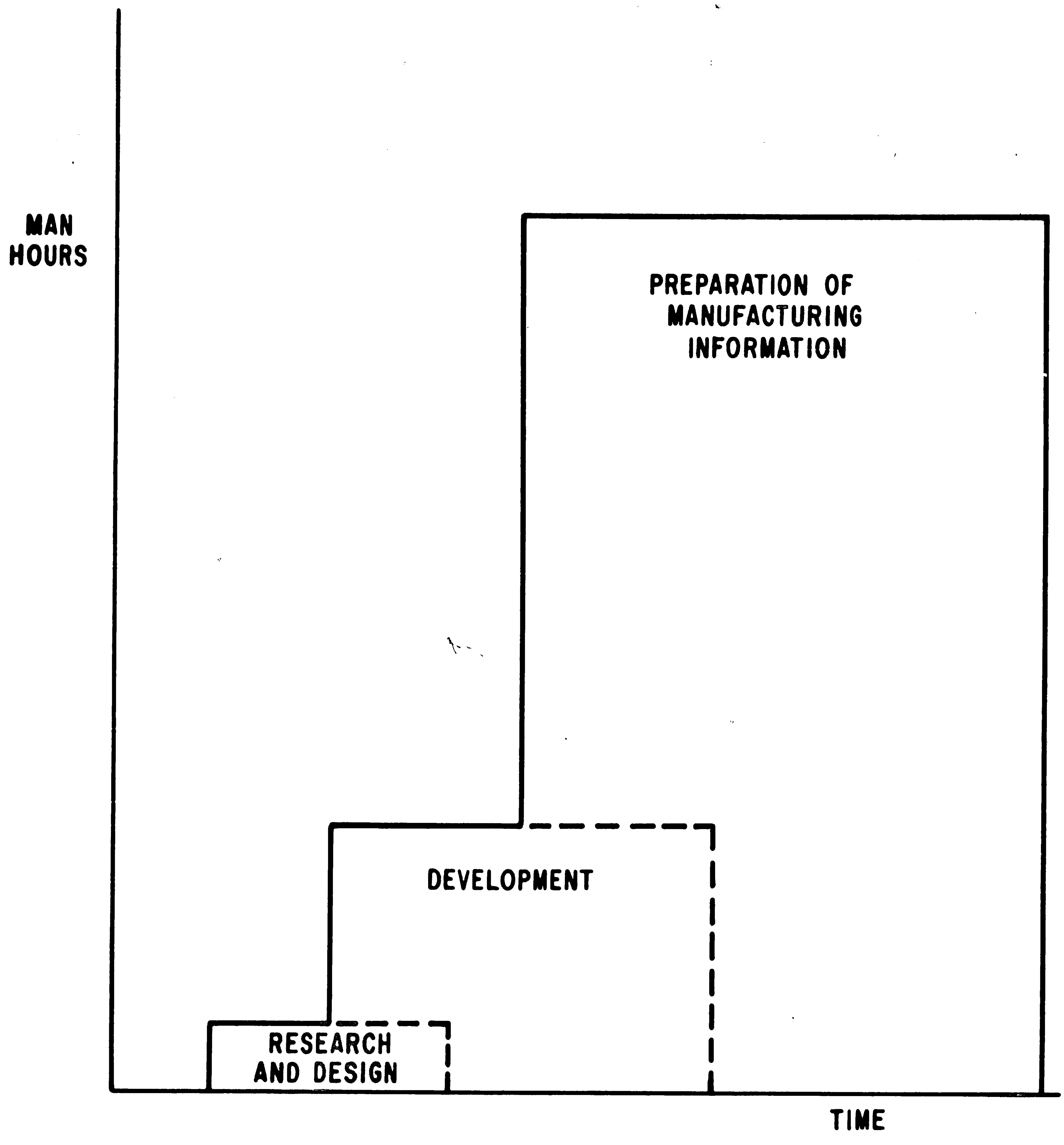


FIGURE I.

64. SELLERS, G. A. JR. PERSONAL INTERVIEW, BELL TELEPHONE LABORATORIES, APRIL 1963.

EXPLOSION OF INFORMATION [65]

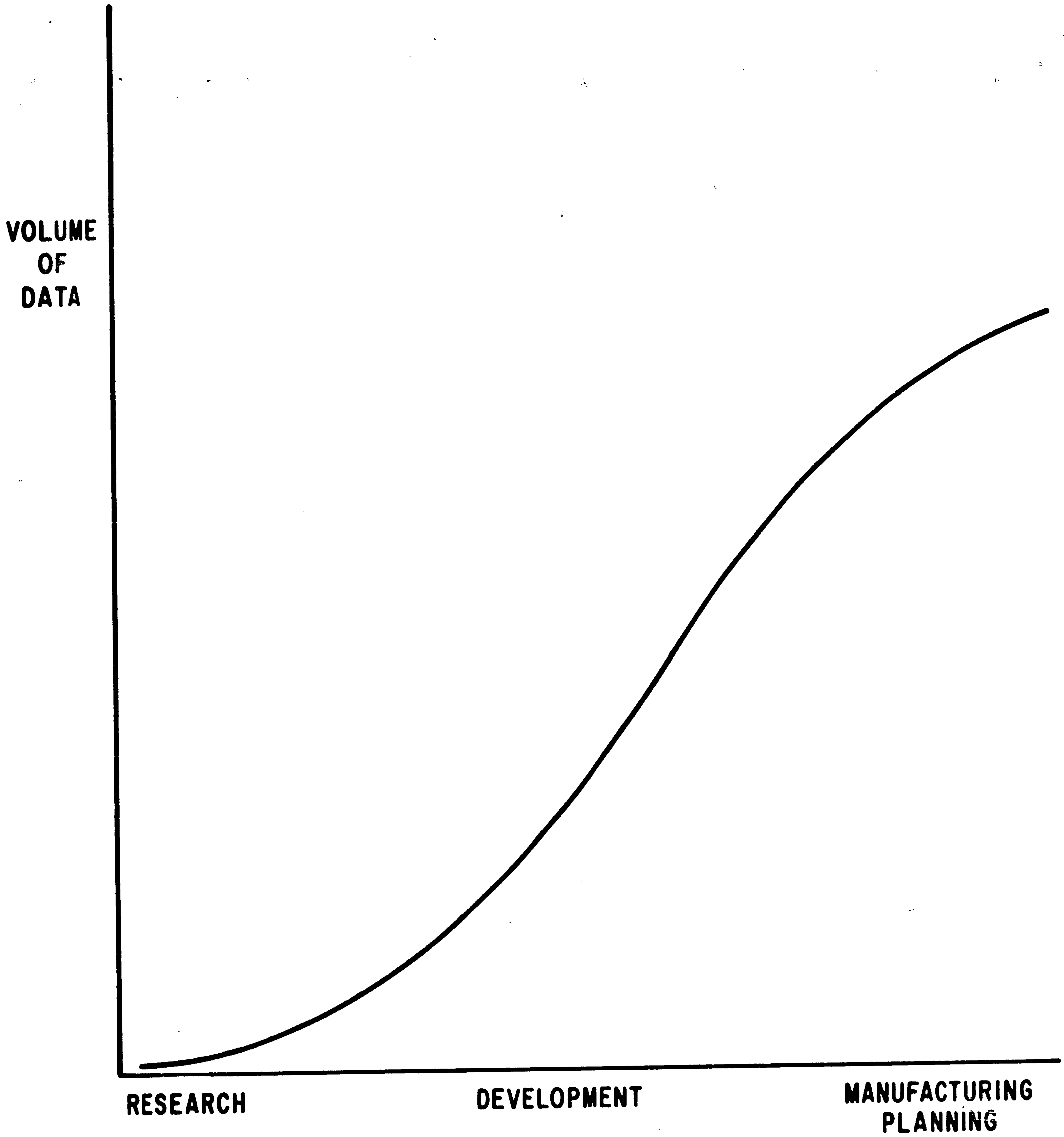


FIGURE 2.

65. HOBERECHT, V. L. op. cit.

CREATIVITY PROFILE [66]

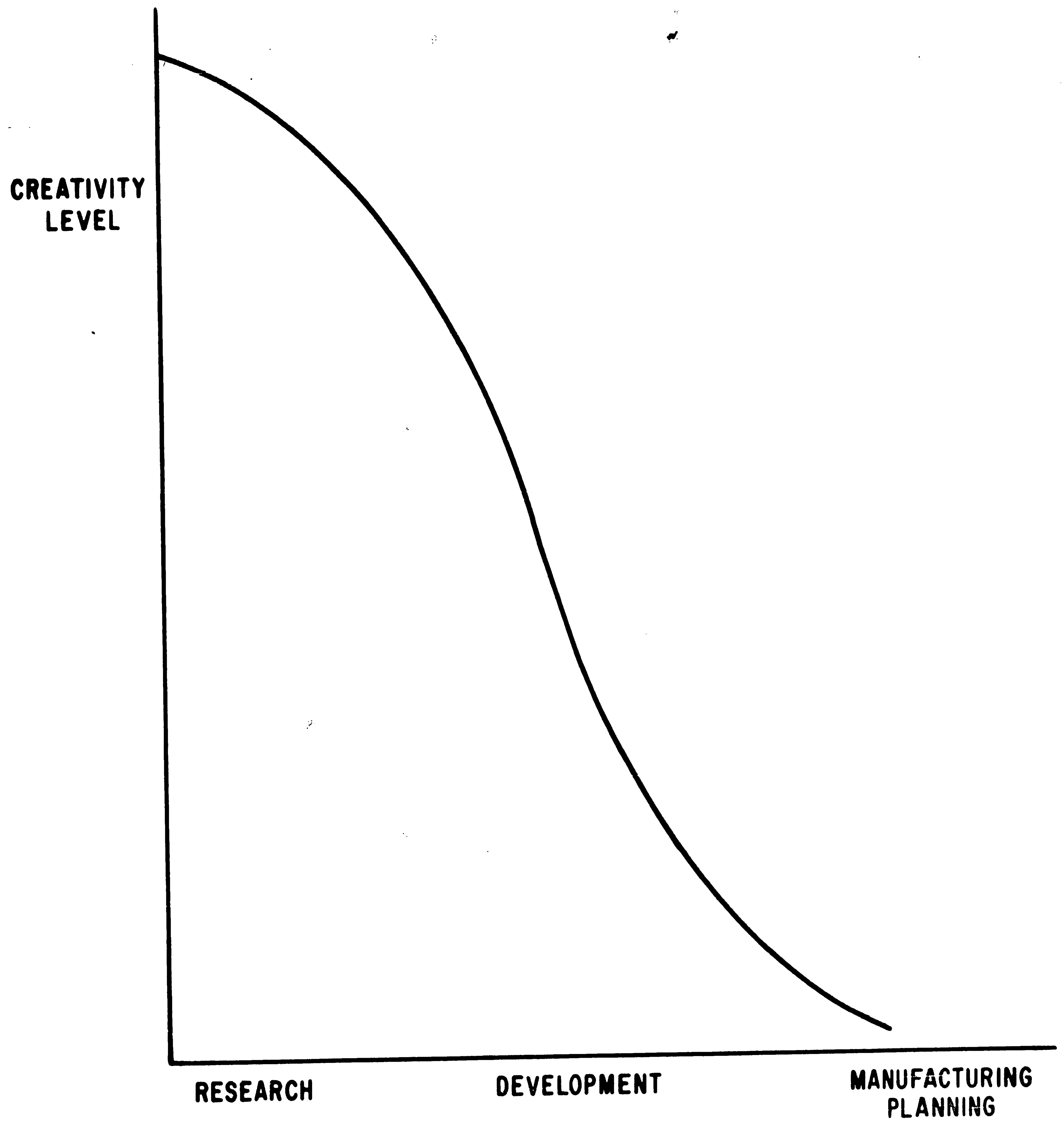


FIGURE 3.

66. HOBERECHT, V. L. op. cit.

FIGURE 4

Pictorial Circuit Schematic Drawing

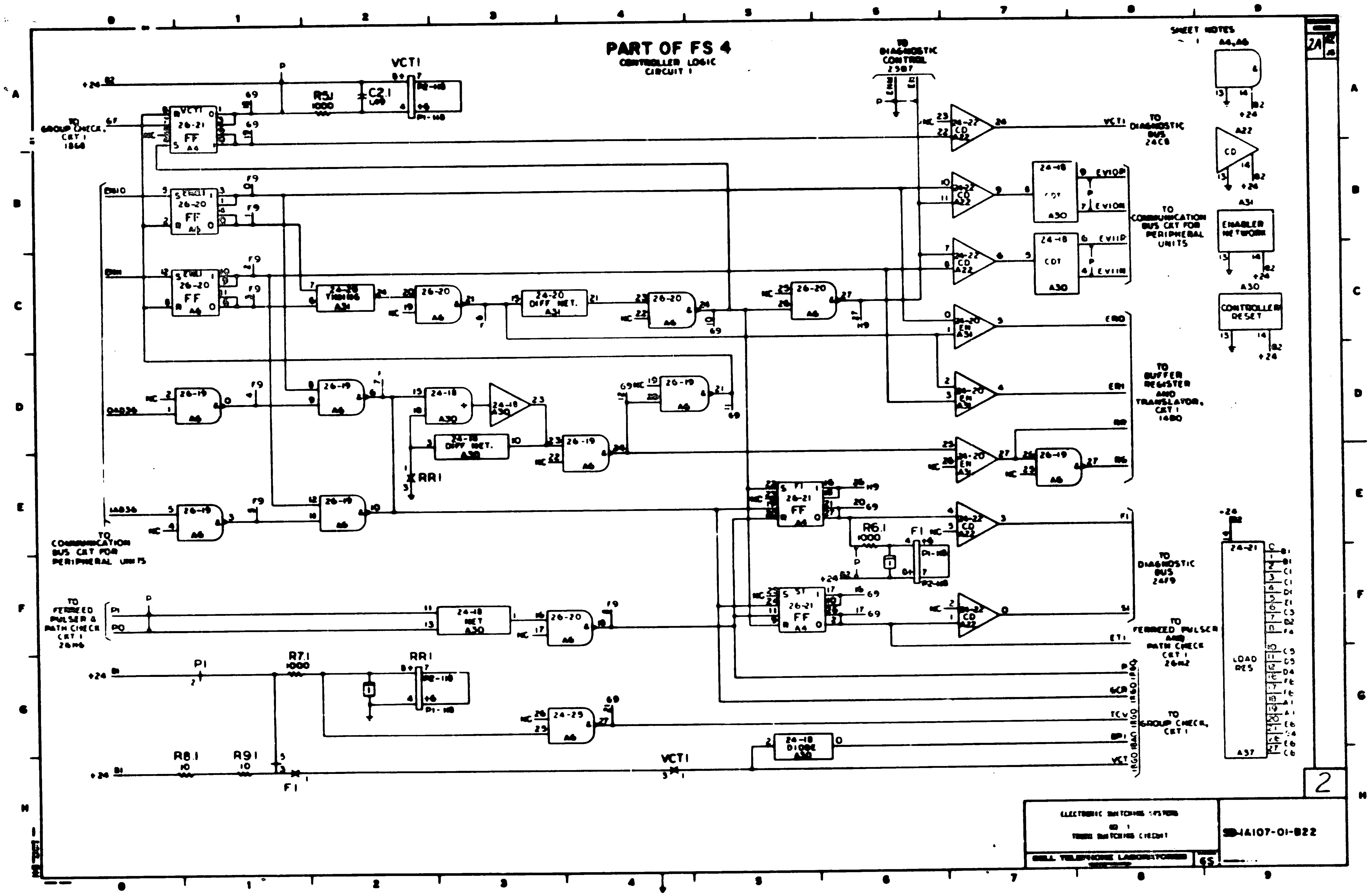

PART OF FS 4
CONTROLLER LOGIC
CIRCUIT 1
SHEET NOTES
TO DIAGNOSTIC CONTROL
TO GROUP CHECK, CKT 1
TO DIAGNOSTIC BUS
TO COMMUNICATION BUS CKT FOR PERIPHERAL UNITS
TO BUFFER REGISTER AND TRANSLATOR, CKT 1
TO DIAGNOSTIC BUS
TO FERREED PULSER & PATH CHECK CKT 1
TO GROUP CHECK, CKT 1
ENABLER NETWORK
CONTROLLER RESET
LOAD RES
VCT1
RR1
R5.1
R6.1
R7.1
R8.1
R9.1
C2.1
P1
F1
FF
TIMING
DIFF NET.
DIODE
2
BELL TELEPHONE LABORATORIES
SD-1A107-01-B22

FIGURE 5

Framework Similar to

Trunk Switch Frame

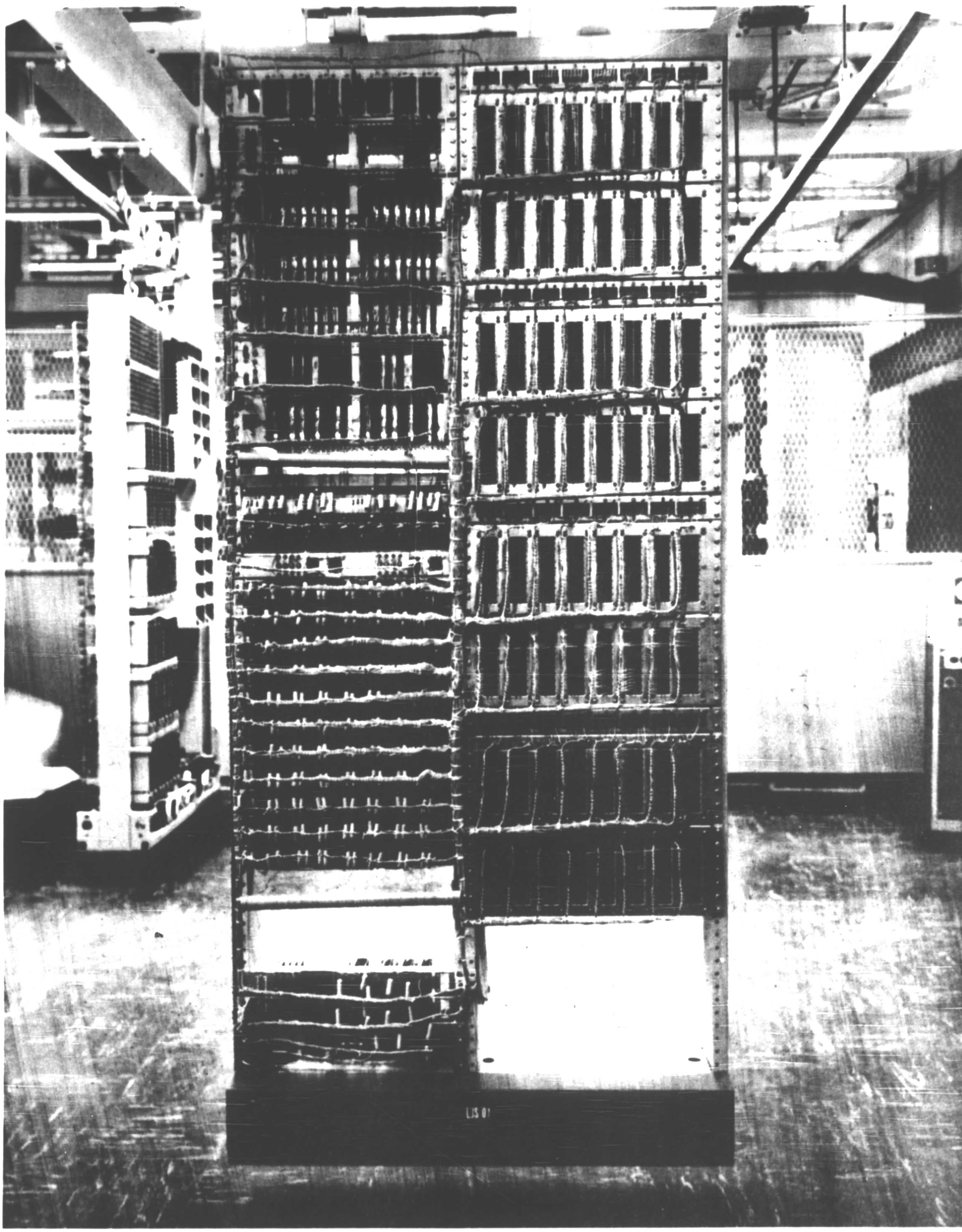
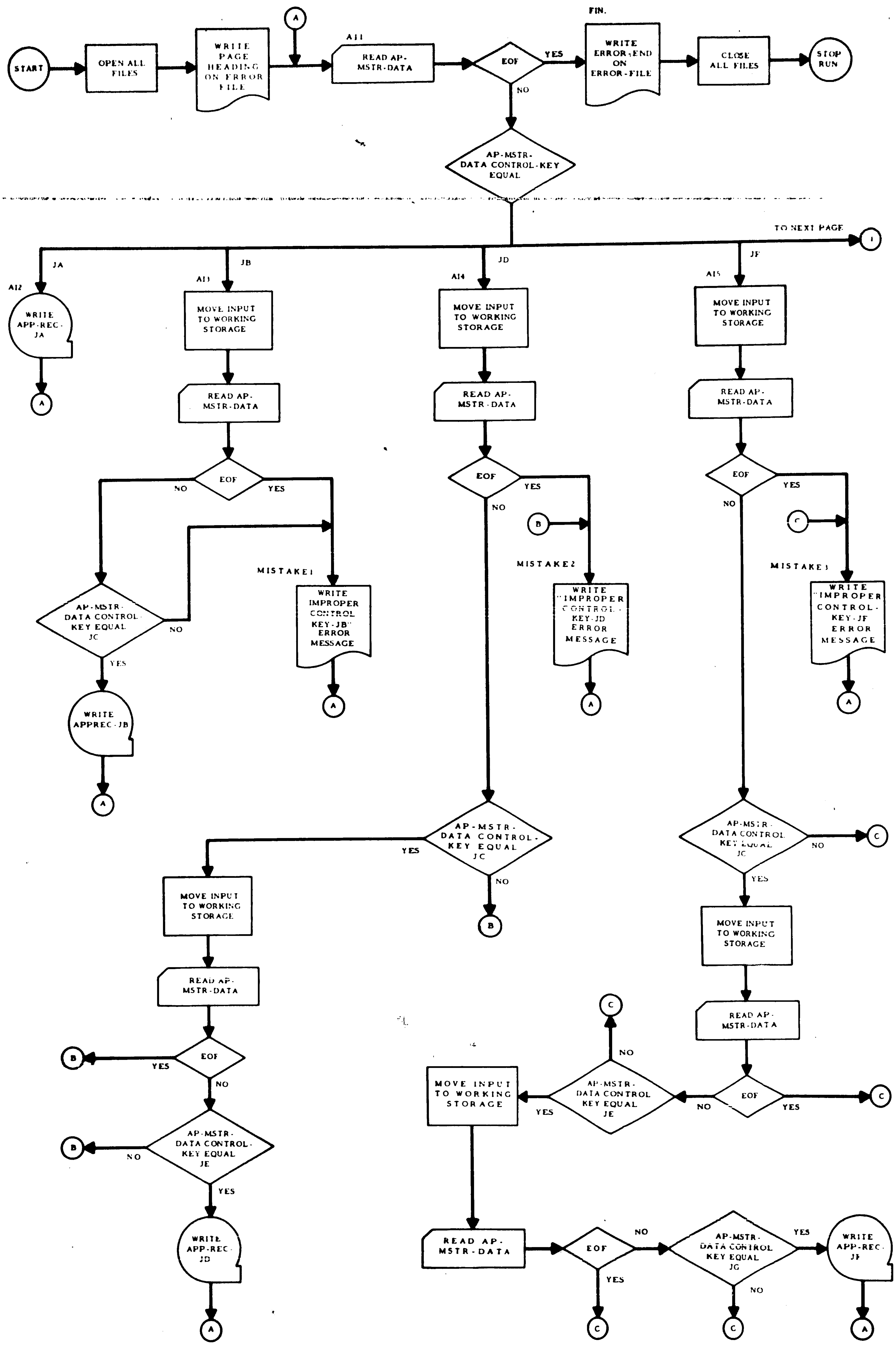
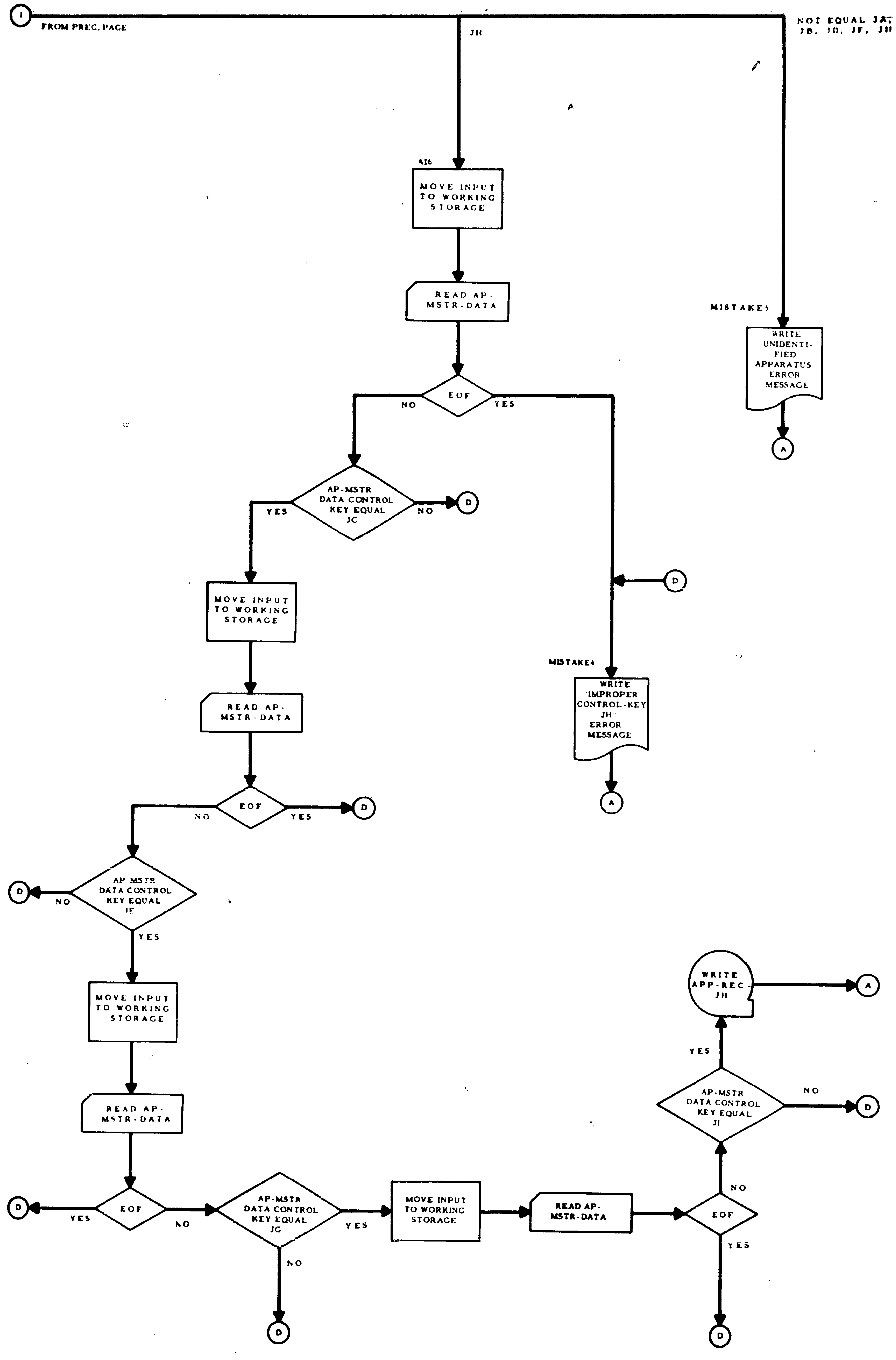


FIGURE 6

Flow Chart - APMSTRIN

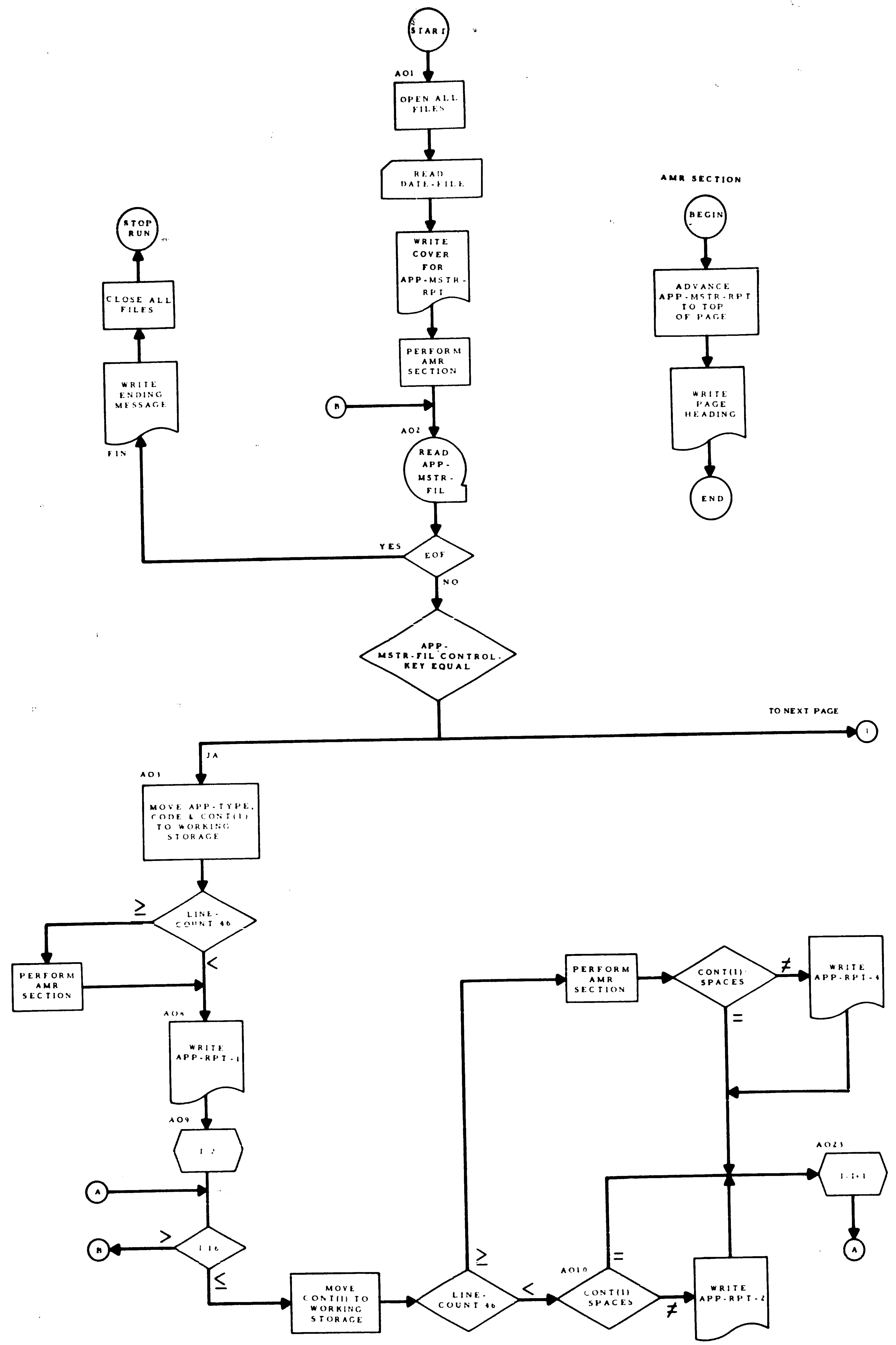

START
OPEN ALL FILES
WRITE PAGE HEADING ON ERROR FILE
A11
READ AP-MSTR-DATA
EOF
YES
NO
FIN.
WRITE ERROR-END ON ERROR-FILE
CLOSE ALL FILES
STOP RUN
AP-MSTR-DATA CONTROL-KEY EQUAL
TO NEXT PAGE
JA
JB
JD
JF
A12
WRITE APP-REC-JA
A13
MOVE INPUT TO WORKING STORAGE
A14
A15
READ AP-MSTR-DATA
MISTAKE1
WRITE IMPROPER CONTROL KEY-JB" ERROR MESSAGE
MISTAKE2
WRITE "IMPROPER CONTROL-KEY-JD ERROR MESSAGE
MISTAKE3
WRITE "IMPROPER CONTROL-KEY-JF ERROR MESSAGE
AP-MSTR-DATA CONTROL KEY EQUAL JC
WRITE APPREC-JB
AP-MSTR-DATA CONTROL-KEY EQUAL JC
AP-MSTR-DATA CONTROL KEY EQUAL JE
WRITE APP-REC-JD
AP-MSTR-DATA CONTROL KEY EQUAL JG
WRITE APP-REC-JF

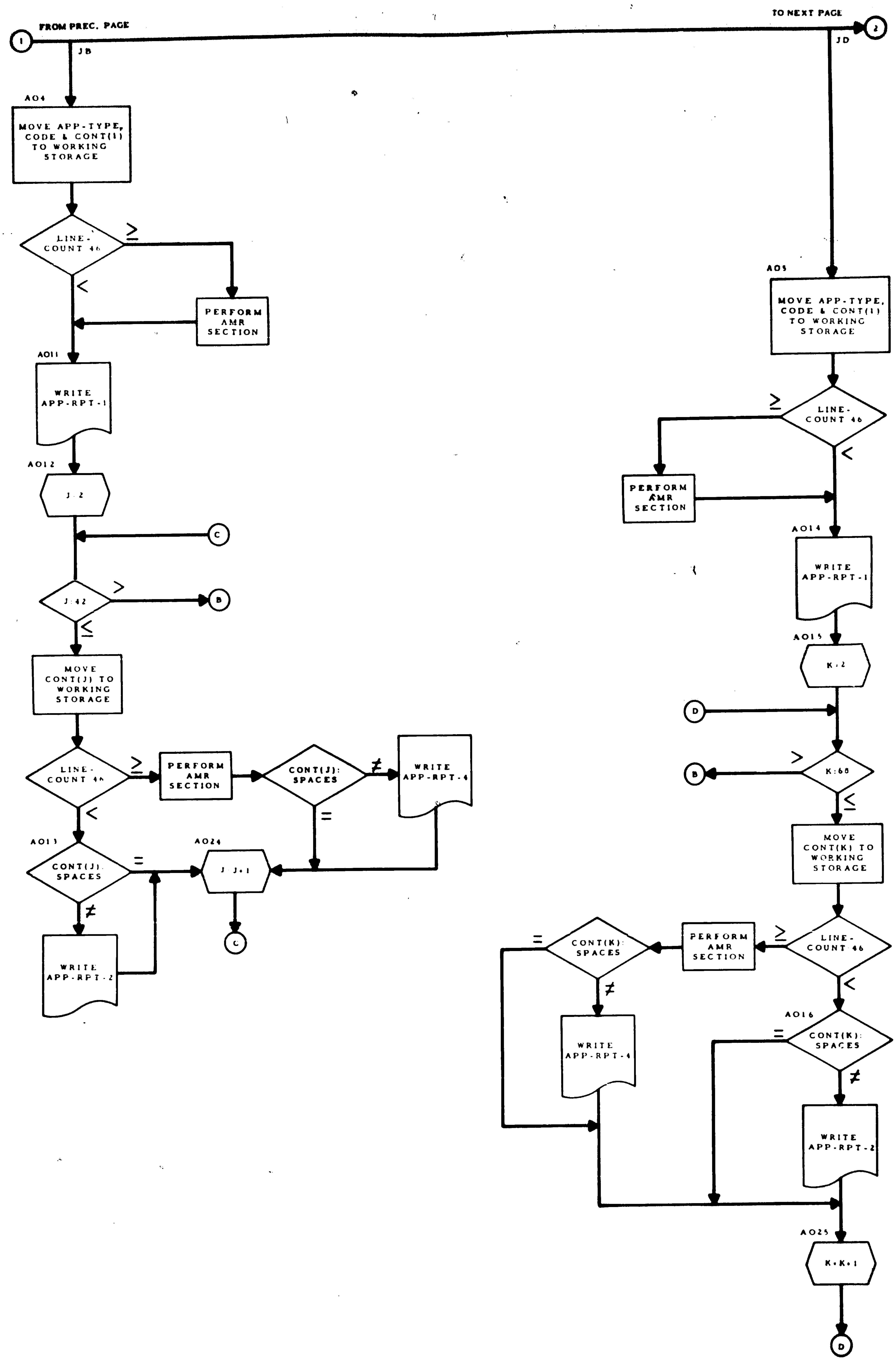


1
FROM PREC. PAGE
JH
NOT EQUAL JA, JB, JD, JF, JH
416
MOVE INPUT TO WORKING STORAGE
READ AP-MSTR-DATA
EOF
NO
YES
MISTAKES
WRITE UNIDENTIFIED APPARATUS ERROR MESSAGE
A
AP-MSTR DATA CONTROL KEY EQUAL JC
YES
NO
D
MOVE INPUT TO WORKING STORAGE
READ AP-MSTR-DATA
EOF
NO
YES
D
MISTAKE4
WRITE 'IMPROPER CONTROL-KEY JH' ERROR MESSAGE
A
AP-MSTR DATA CONTROL KEY EQUAL JF
NO
YES
D
MOVE INPUT TO WORKING STORAGE
READ AP-MSTR-DATA
EOF
YES
NO
D
AP-MSTR DATA CONTROL KEY EQUAL JG
YES
NO
D
MOVE INPUT TO WORKING STORAGE
READ AP-MSTR-DATA
EOF
NO
YES
D
AP-MSTR DATA CONTROL KEY EQUAL JI
YES
NO
D
WRITE APP-REC-JH
A

FIGURE 7

Flow Chart - APMSTROUT


START
A01
OPEN ALL FILES
READ DATE-FILE
WRITE COVER FOR APP-MSTR-RPT
PERFORM AMR SECTION
B
A02
READ APP-MSTR-FIL
EOF
YES
NO
FIN
WRITE ENDING MESSAGE
CLOSE ALL FILES
STOP RUN
AMR SECTION
BEGIN
ADVANCE APP-MSTR-RPT TO TOP OF PAGE
WRITE PAGE HEADING
END
APP-MSTR-FIL CONTROL-KEY EQUAL
TO NEXT PAGE
1
JA
A03
MOVE APP-TYPE, CODE & CONT(1) TO WORKING STORAGE
LINE-COUNT 46
≥
<
PERFORM AMR SECTION
WRITE APP-RPT-1
A09
A
B
>
≤
MOVE CONT(I) TO WORKING STORAGE
LINE-COUNT 46
≥
<
PERFORM AMR SECTION
CONT(I) SPACES
≠
=
WRITE APP-RPT-4
A010
CONT(I) SPACES
=
≠
WRITE APP-RPT-2
A023
I:I+1
A


FROM PREC. PAGE
TO NEXT PAGE
JB
JD
AO4
MOVE APP-TYPE, CODE & CONT(1) TO WORKING STORAGE
LINE-COUNT 46
PERFORM AMR SECTION
AO11
WRITE APP-RPT-1
AO12
J:2
J:42
MOVE CONT(J) TO WORKING STORAGE
CONT(J): SPACES
WRITE APP-RPT-4
AO13
AO24
J:J+1
WRITE APP-RPT-2
AO5
AO14
AO15
K:2
K:68
MOVE CONT(K) TO WORKING STORAGE
CONT(K): SPACES
AO16
AO25
K:K+1

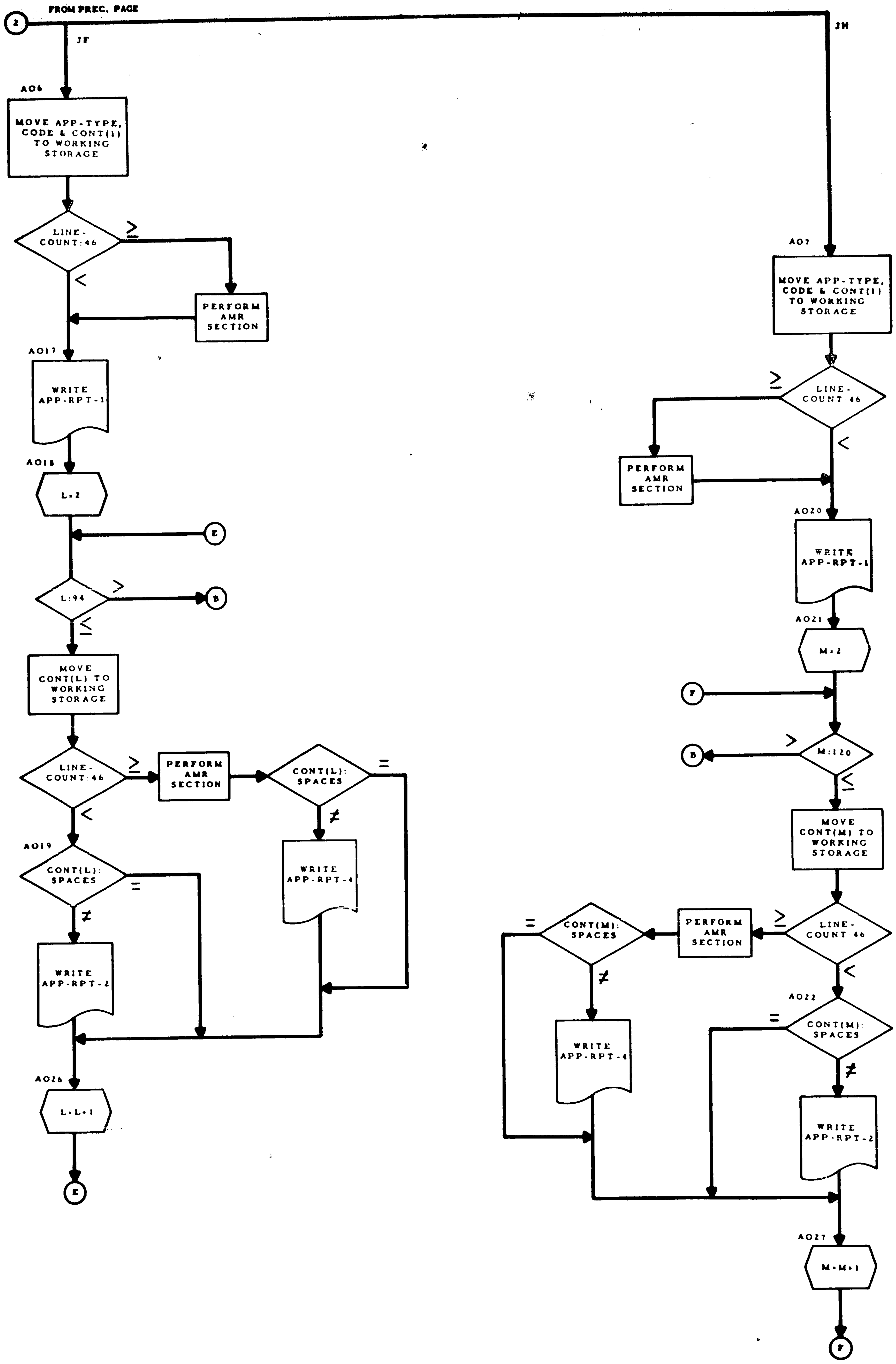
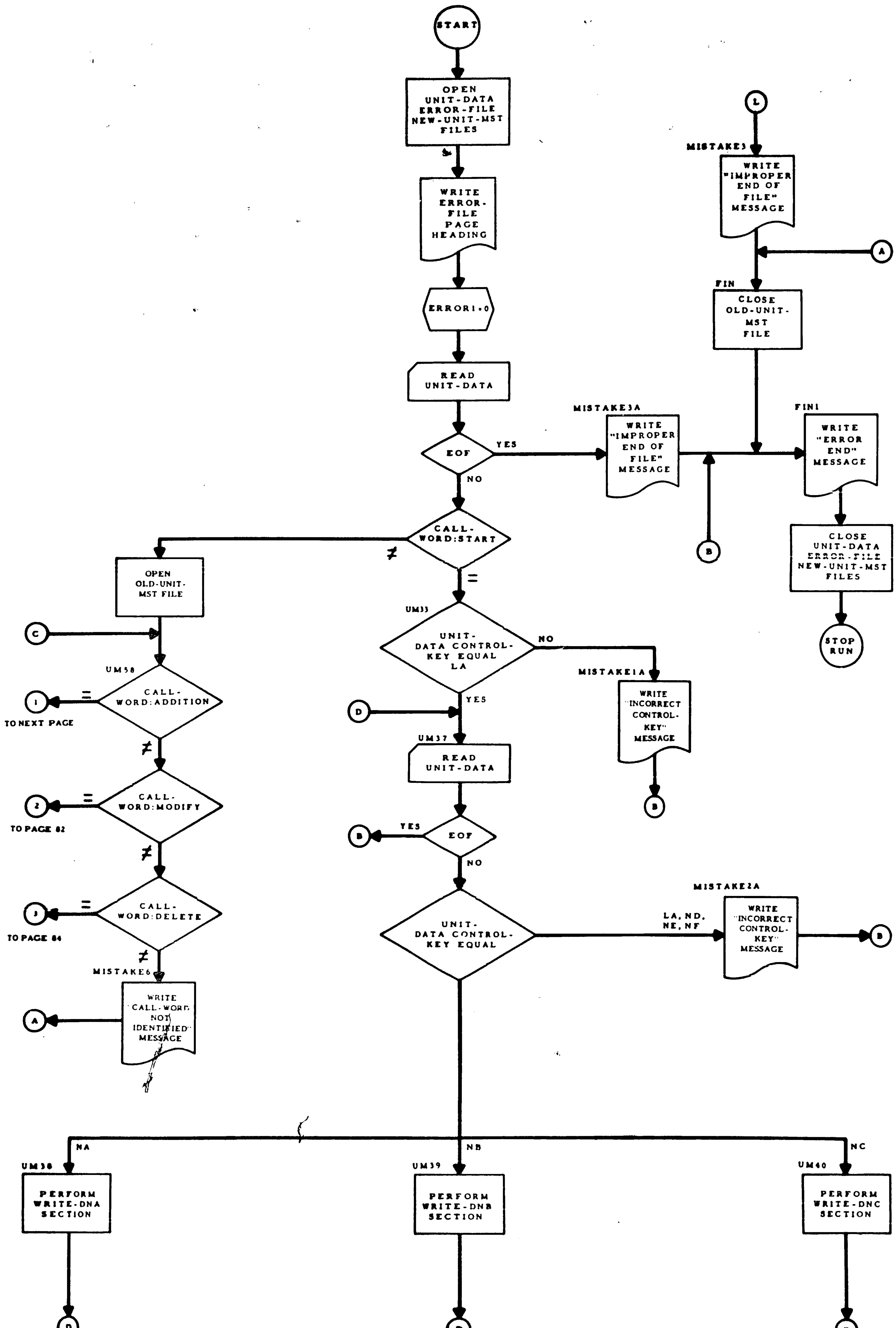
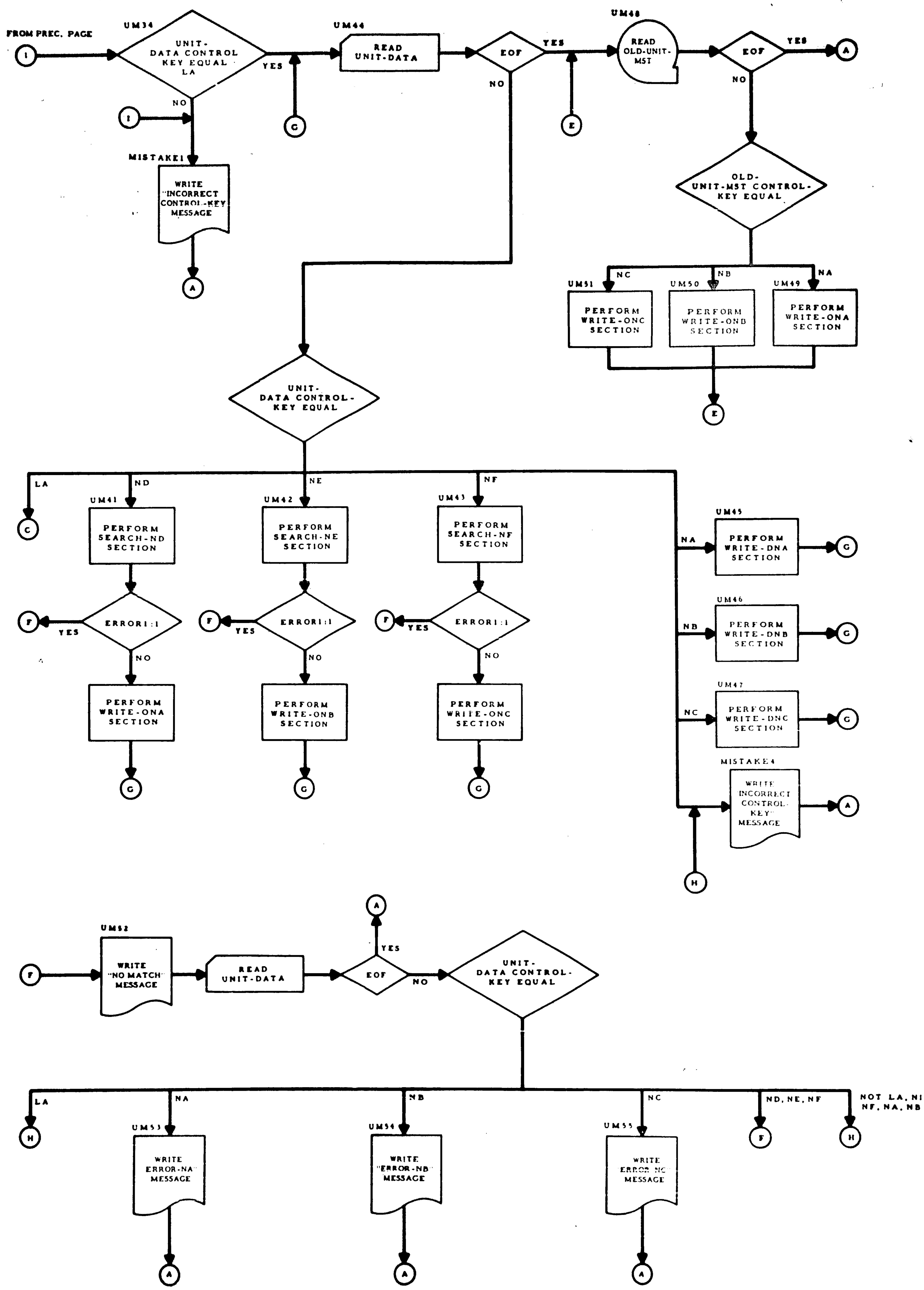

FROM PREC. PAGE
A06
MOVE APP-TYPE, CODE & CONT(1) TO WORKING STORAGE
LINE-COUNT:46
PERFORM AMR SECTION
A017
WRITE APP-RPT-1
A018
L=2
L:94
MOVE CONT(L) TO WORKING STORAGE
LINE-COUNT:46
PERFORM AMR SECTION
CONT(L): SPACES
WRITE APP-RPT-4
A019
CONT(L): SPACES
WRITE APP-RPT-2
A026
L=L+1
A07
MOVE APP-TYPE, CODE & CONT(1) TO WORKING STORAGE
LINE-COUNT 46
PERFORM AMR SECTION
A020
WRITE APP-RPT-1
A021
M=2
M:120
MOVE CONT(M) TO WORKING STORAGE
LINE-COUNT 46
PERFORM AMR SECTION
CONT(M): SPACES
WRITE APP-RPT-4
A022
CONT(M): SPACES
WRITE APP-RPT-2
A027
M=M+1

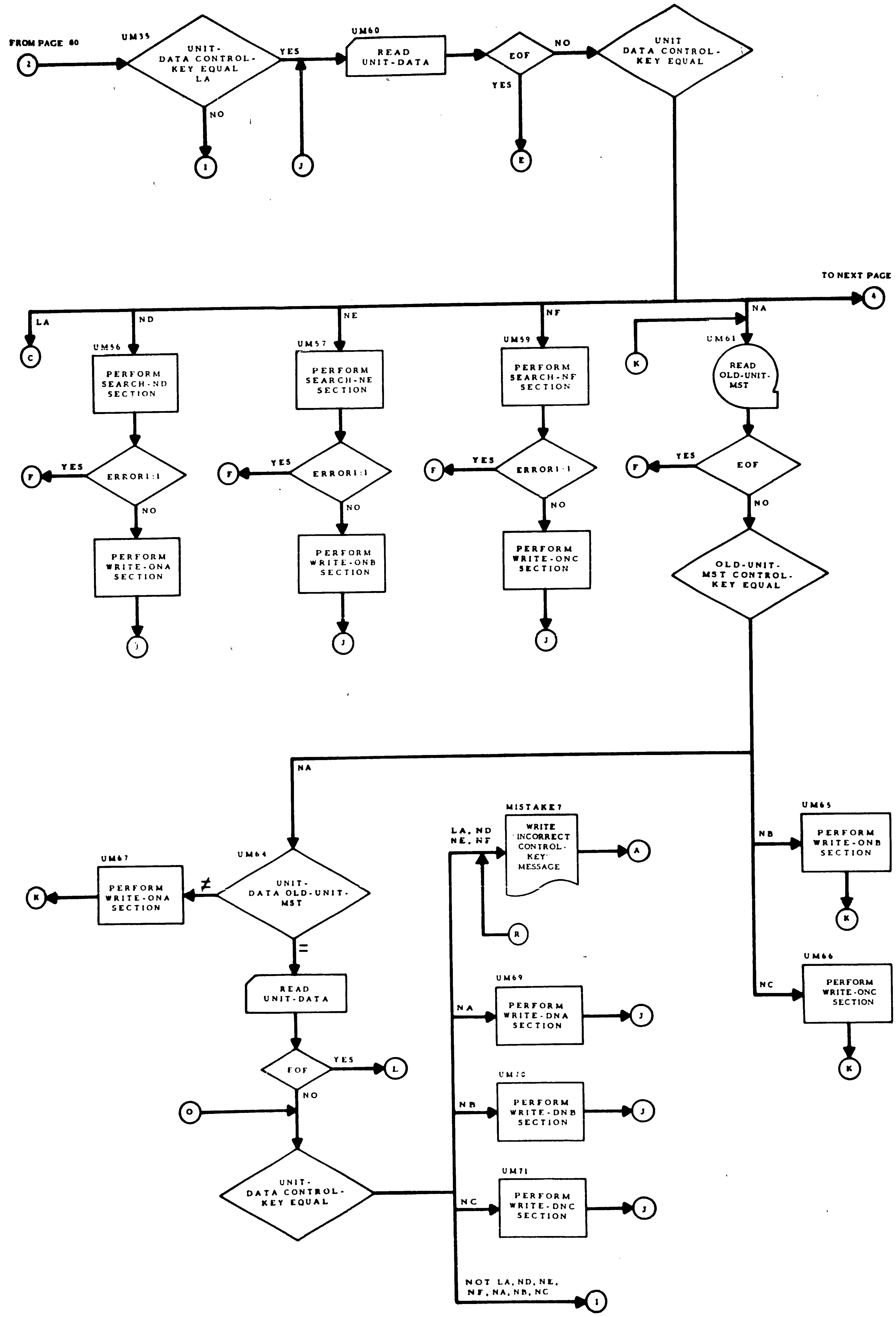
FIGURE 8

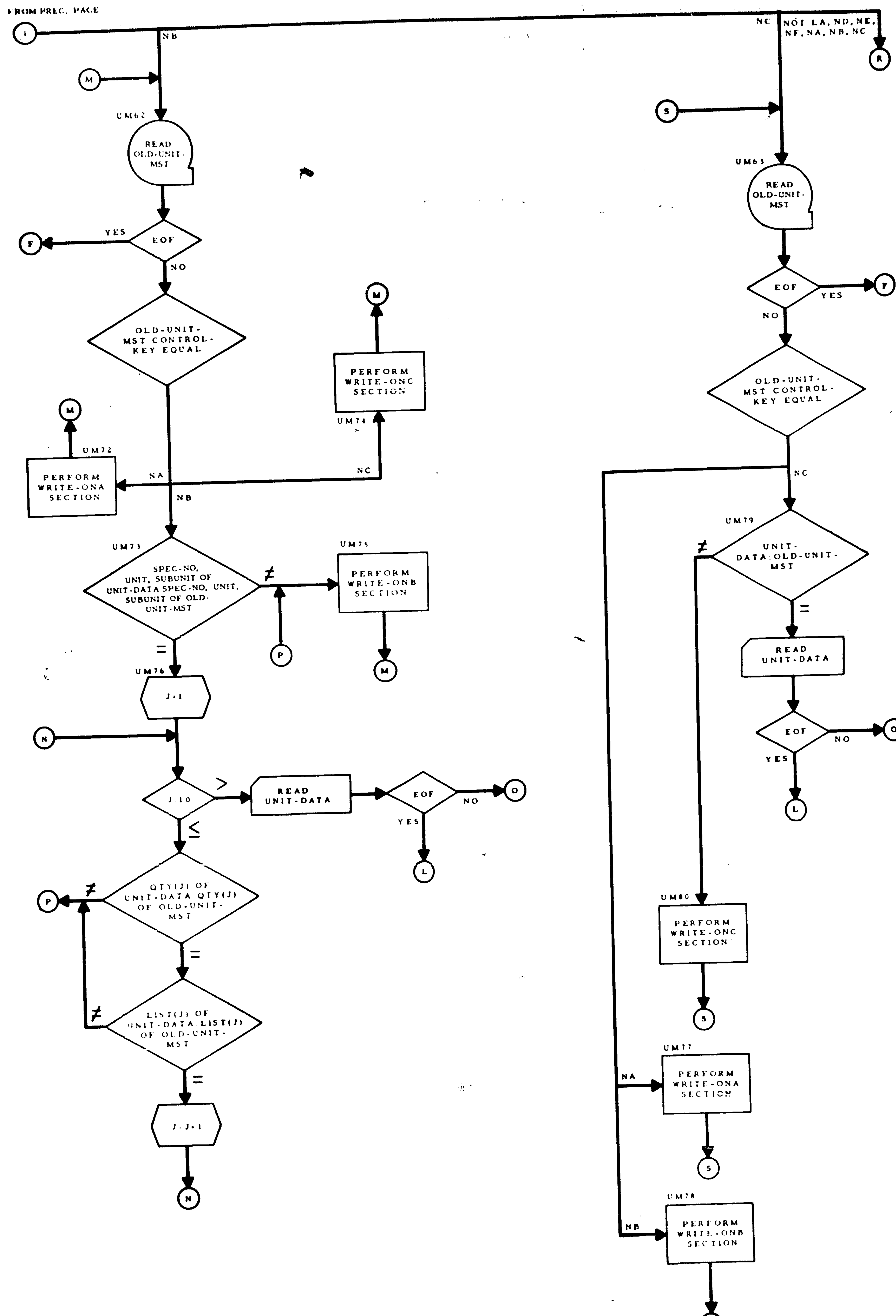
Flow Chart - UNITMSTR

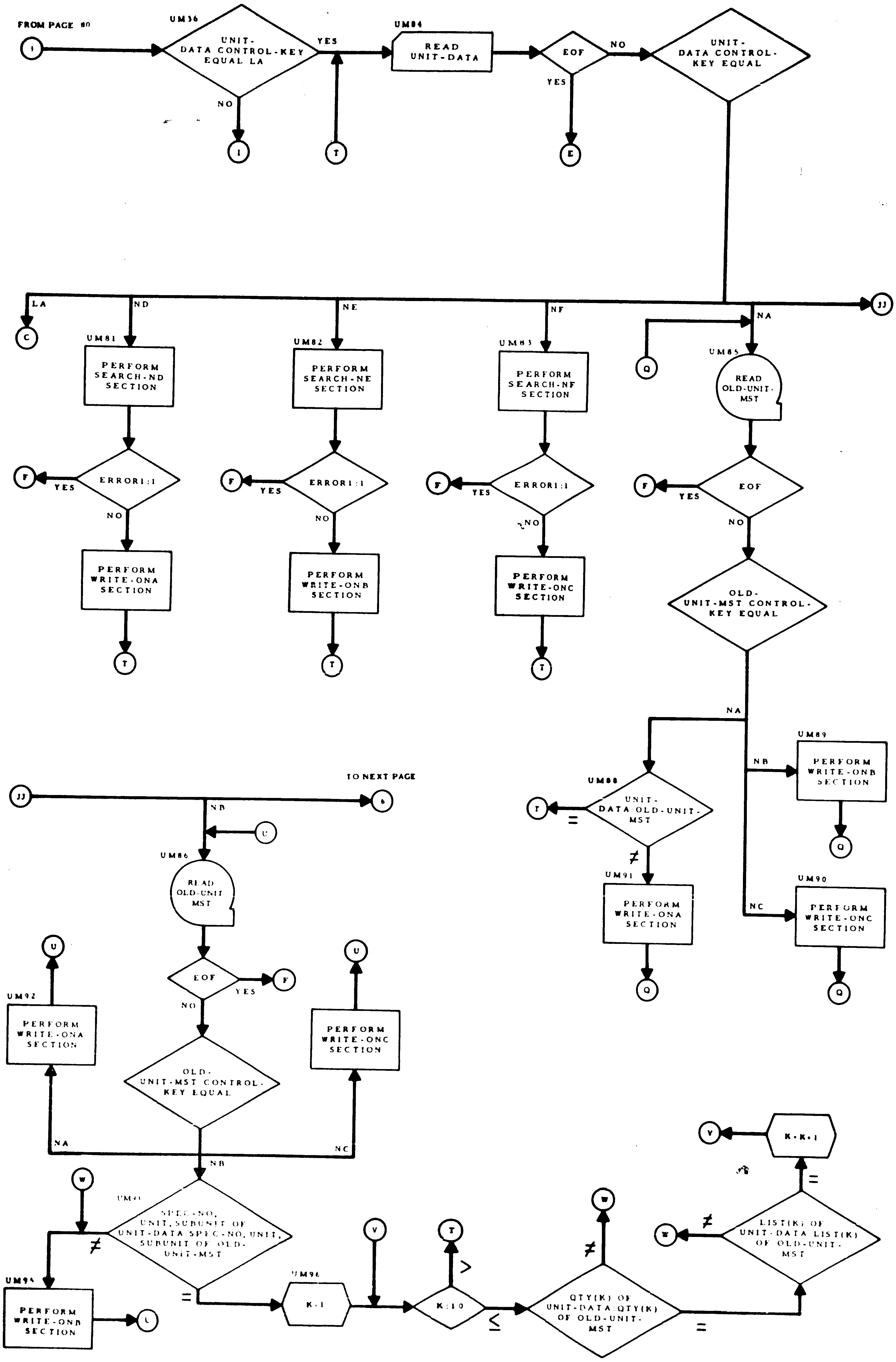

START
OPEN UNIT-DATA ERROR-FILE NEW-UNIT-MST FILES
WRITE ERROR-FILE PAGE HEADING
ERROR1=0
READ UNIT-DATA
EOF
YES
NO
MISTAKE3A
WRITE "IMPROPER END OF FILE" MESSAGE
MISTAKE3
WRITE "IMPROPER END OF FILE" MESSAGE
FIN
CLOSE OLD-UNIT-MST FILE
FIN1
WRITE "ERROR END" MESSAGE
CLOSE UNIT-DATA ERROR-FILE NEW-UNIT-MST FILES
STOP RUN
CALL-WORD:START
OPEN OLD-UNIT-MST FILE
UM58
CALL-WORD:ADDITION
TO NEXT PAGE
CALL-WORD:MODIFY
TO PAGE 82
CALL-WORD:DELETE
TO PAGE 84
MISTAKE6
WRITE "CALL-WORD NOT IDENTIFIED" MESSAGE
UM33
UNIT-DATA CONTROL-KEY EQUAL LA
MISTAKE1A
WRITE "INCORRECT CONTROL-KEY" MESSAGE
UM37
READ UNIT-DATA
EOF
MISTAKE2A
UNIT-DATA CONTROL-KEY EQUAL
LA, ND, NE, NF
WRITE "INCORRECT CONTROL-KEY" MESSAGE
NA
NB
NC
UM38
PERFORM WRITE-DNA SECTION
UM39
PERFORM WRITE-DNB SECTION
UM40
PERFORM WRITE-DNC SECTION

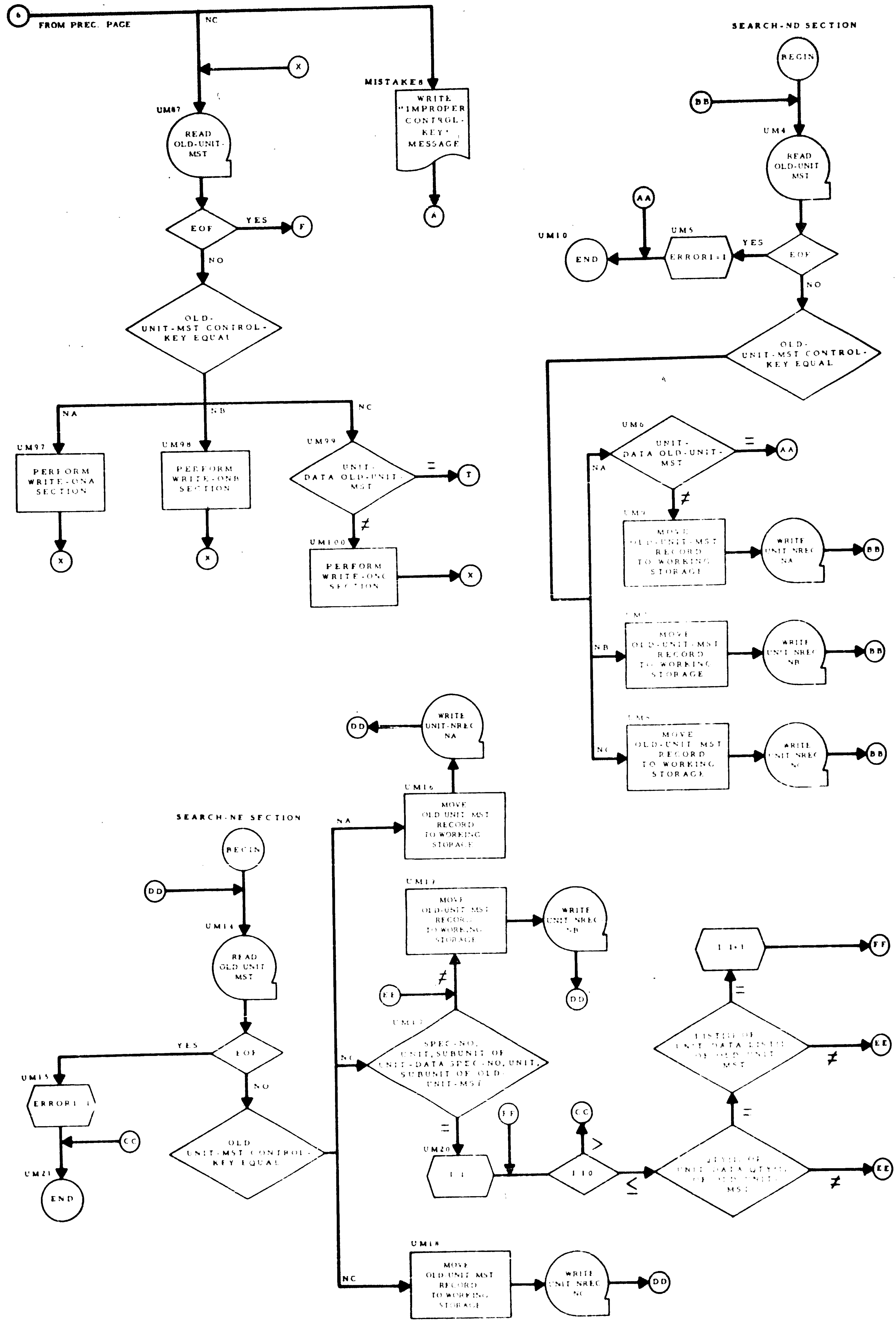


FROM PREC. PAGE
UM34
UNIT-DATA CONTROL KEY EQUAL LA
YES
NO
MISTAKE1
WRITE "INCORRECT CONTROL-KEY" MESSAGE
UM44
READ UNIT-DATA
EOF
YES
NO
UM48
READ OLD-UNIT-MST
EOF
YES
NO
OLD-UNIT-MST CONTROL-KEY EQUAL
NC
NB
NA
UM51
PERFORM WRITE-ONC SECTION
UM50
PERFORM WRITE-OND SECTION
UM49
PERFORM WRITE-ONA SECTION
UNIT-DATA CONTROL-KEY EQUAL
LA
ND
NE
NF
UM41
PERFORM SEARCH-ND SECTION
UM42
PERFORM SEARCH-NE SECTION
UM43
PERFORM SEARCH-NF SECTION
ERROR1:1
YES
NO
PERFORM WRITE-ONA SECTION
PERFORM WRITE-ONB SECTION
PERFORM WRITE-ONC SECTION
UM45
NA
PERFORM WRITE-DNA SECTION
UM46
NB
PERFORM WRITE-DNB SECTION
UM47
NC
PERFORM WRITE-DNC SECTION
MISTAKE4
WRITE INCORRECT CONTROL-KEY MESSAGE
UM52
WRITE "NO MATCH" MESSAGE
READ UNIT-DATA
EOF
YES
NO
UNIT-DATA CONTROL-KEY EQUAL
LA
NA
NB
NC
ND, NE, NF
NOT LA, ND, NF, NA, NB
UM53
WRITE ERROR-NA MESSAGE
UM54
WRITE "ERROR-NB" MESSAGE
UM55
WRITE ERROR-NC MESSAGE

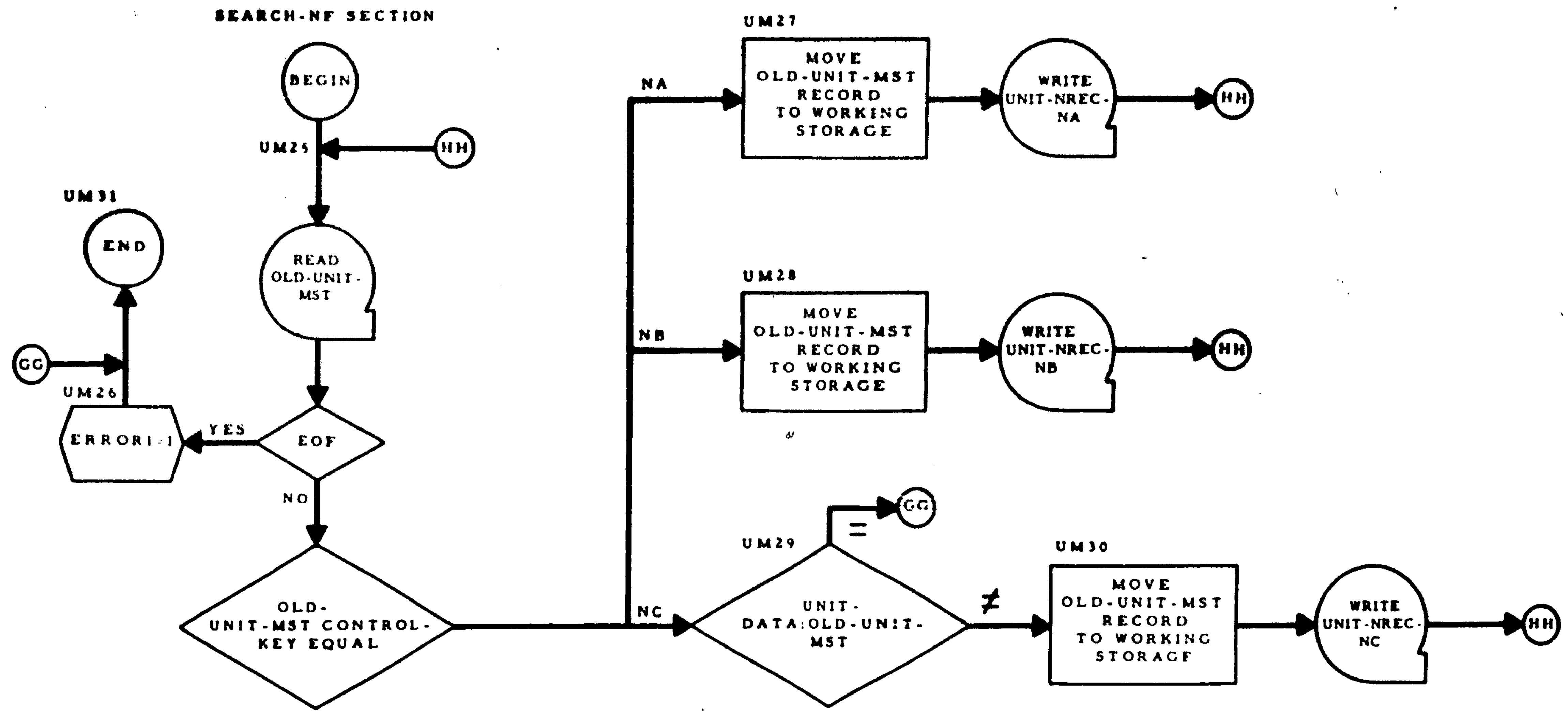

FROM PAGE 80
UM35
UNIT-DATA CONTROL-KEY EQUAL LA
YES
NO
UM60
READ UNIT-DATA
EOF
NO
YES
UNIT DATA CONTROL-KEY EQUAL
TO NEXT PAGE
LA
ND
NE
NF
NA
UM56
PERFORM SEARCH-ND SECTION
UM57
PERFORM SEARCH-NE SECTION
UM59
PERFORM SEARCH-NF SECTION
UM61
READ OLD-UNIT-MST
ERROR1:1
YES
NO
EOF
PERFORM WRITE-ONA SECTION
PERFORM WRITE-ONB SECTION
PERFORM WRITE-ONC SECTION
OLD-UNIT-MST CONTROL-KEY EQUAL
NA
NB
NC
MISTAKE7
WRITE INCORRECT CONTROL-KEY MESSAGE
LA, ND NE, NF
UM65
PERFORM WRITE-ONB SECTION
UM66
PERFORM WRITE-ONC SECTION
UM67
PERFORM WRITE-ONA SECTION
UM64
UNIT-DATA OLD-UNIT-MST
≠
=
READ UNIT-DATA
EOF
UM69
PERFORM WRITE-DNA SECTION
UM70
PERFORM WRITE-DNB SECTION
UM71
PERFORM WRITE-DNC SECTION
UNIT-DATA CONTROL-KEY EQUAL
NOT LA, ND, NE, NF, NA, NB, NC


FROM PREC. PAGE
NB
NC
NOT LA, ND, NE, NF, NA, NB, NC
UM62
READ OLD-UNIT-MST
EOF
YES
NO
OLD-UNIT-MST CONTROL-KEY EQUAL
PERFORM WRITE-ONC SECTION
UM74
UM72
PERFORM WRITE-ONA SECTION
NA
NC
NB
UM73
SPEC-NO, UNIT, SUBUNIT OF UNIT-DATA SPEC-NO, UNIT, SUBUNIT OF OLD-UNIT-MST
UM75
PERFORM WRITE-ONB SECTION
UM76
READ UNIT-DATA
EOF
NO
YES
QTY(J) OF UNIT-DATA QTY(J) OF OLD-UNIT-MST
LIST(J) OF UNIT-DATA LIST(J) OF OLD-UNIT-MST
UM63
READ OLD-UNIT-MST
EOF
YES
NO
OLD-UNIT-MST CONTROL-KEY EQUAL
NC
UM79
UNIT-DATA:OLD-UNIT-MST
READ UNIT-DATA
EOF
NO
YES
UM80
PERFORM WRITE-ONC SECTION
UM77
NA
PERFORM WRITE-ONA SECTION
UM78
NB
PERFORM WRITE-ONB SECTION

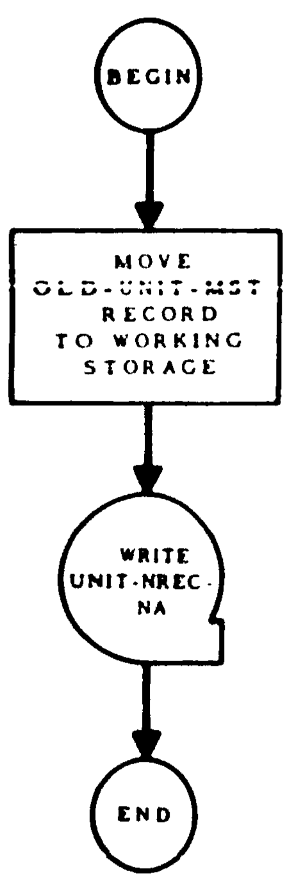

FROM PAGE 80
UM36
UNIT-DATA CONTROL-KEY EQUAL LA
YES
NO
UM84
READ UNIT-DATA
EOF
NO
YES
UNIT-DATA CONTROL-KEY EQUAL
LA
ND
NE
NF
NA
UM81
PERFORM SEARCH-ND SECTION
UM82
PERFORM SEARCH-NE SECTION
UM83
PERFORM SEARCH-NF SECTION
UM85
READ OLD-UNIT-MST
ERROR1:1
PERFORM WRITE-ONA SECTION
PERFORM WRITE-ONB SECTION
PERFORM WRITE-ONC SECTION
OLD-UNIT-MST CONTROL-KEY EQUAL
NB
NC
UM88
UNIT-DATA OLD-UNIT-MST
UM89
UM90
UM91
TO NEXT PAGE
UM86
READ OLD-UNIT MST
UM92
UM95
UM96
K:1
K:10
SPEC-NO, UNIT, SUBUNIT OF UNIT-DATA SPEC-NO, UNIT, SUBUNIT OF OLD-UNIT-MST
QTY(K) OF UNIT-DATA QTY(K) OF OLD-UNIT-MST
LIST(K) OF UNIT-DATA LIST(K) OF OLD-UNIT-MST
K=K+1


FROM PREC. PAGE
MISTAKE8
WRITE "IMPROPER CONTROL-KEY" MESSAGE
UM87
READ OLD-UNIT-MST
EOF
YES
NO
OLD-UNIT-MST CONTROL-KEY EQUAL
NA
NB
NC
UM97
PERFORM WRITE-ONA SECTION
UM98
PERFORM WRITE-ONB SECTION
UM99
UNIT-DATA OLD-UNIT-MST
UM100
PERFORM WRITE-ONC SECTION
SEARCH-ND SECTION
BEGIN
UM4
READ OLD-UNIT MST
UM5
ERROR1+1
UM10
END
UM6
UNIT-DATA OLD-UNIT-MST
MOVE OLD-UNIT-MST RECORD TO WORKING STORAGE
WRITE UNIT-NREC NA
WRITE UNIT-NREC NB
WRITE UNIT-NREC NC
SEARCH-NE SECTION
UM14
READ OLD UNIT MST
UM15
ERROR1+1
UM21
END
UM16
UM17
UM18
UM20
SPEC-NO, UNIT, SUBUNIT OF UNIT-DATA SPEC-NO, UNIT, SUBUNIT OF OLD-UNIT-MST
I 10
I I+1

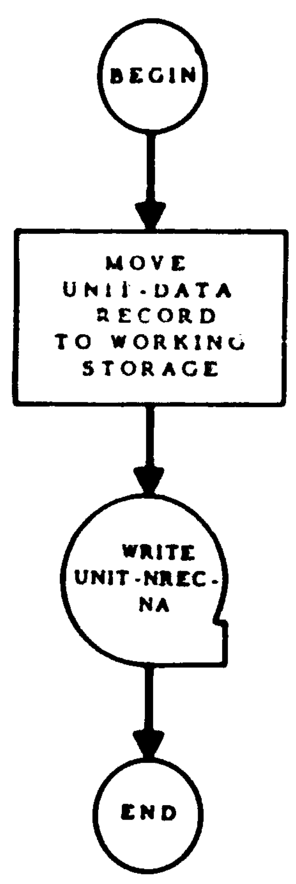
SEARCH-NF SECTION



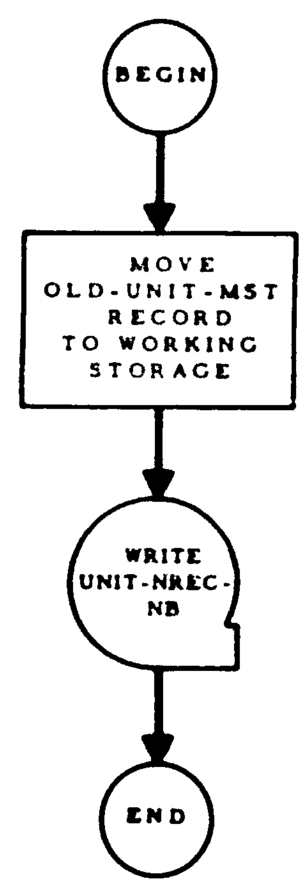
WRITE-ONA SECTION



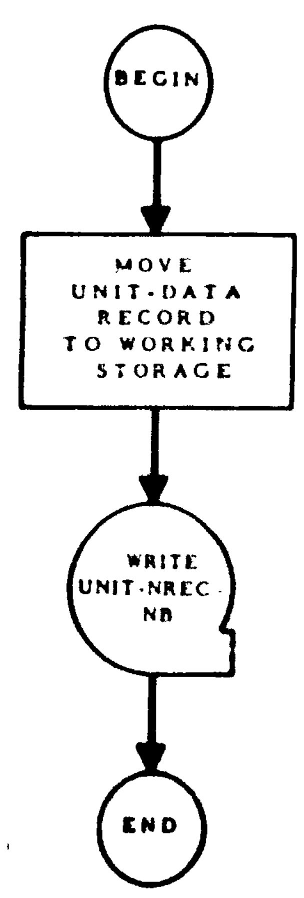
WRITE-DNA SECTION



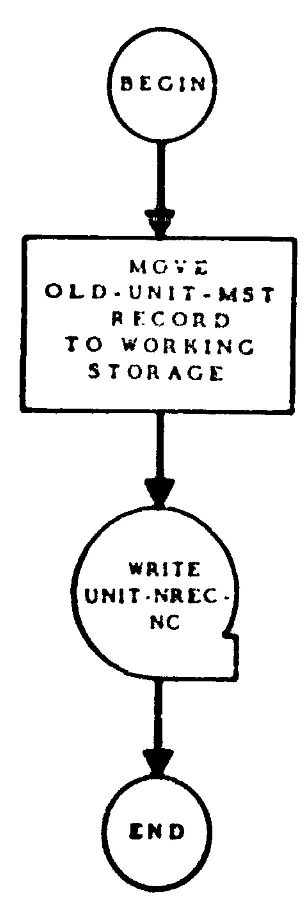
WRITE-ONB SECTION



WRITE-DNB SECTION



WRITE-ONC SECTION



WRITE-DNC SECTION

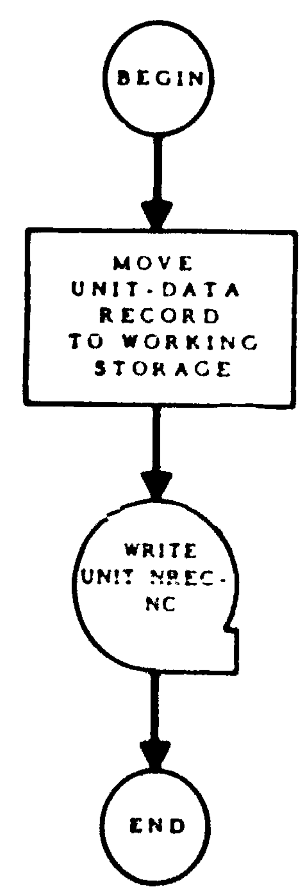
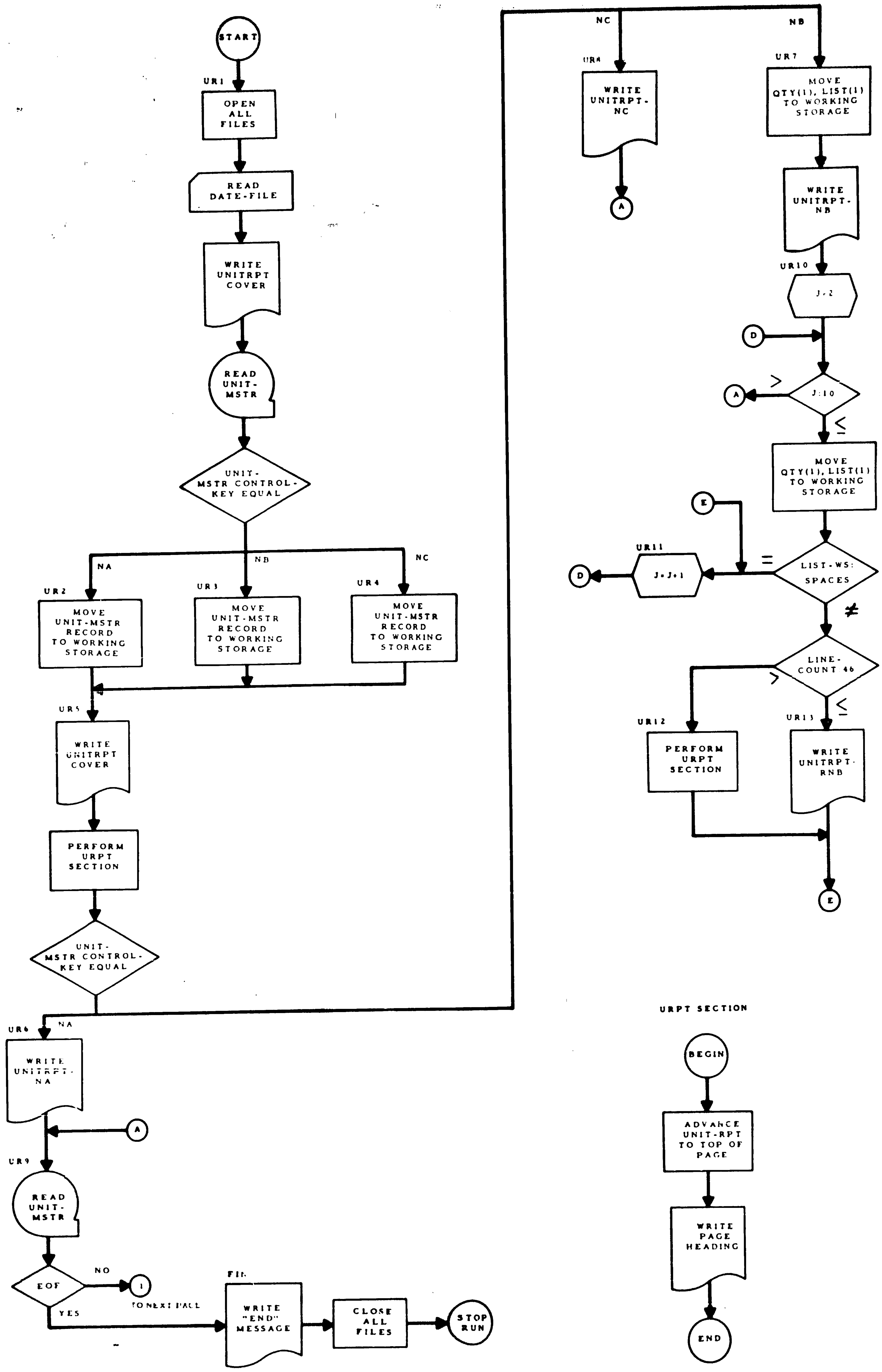
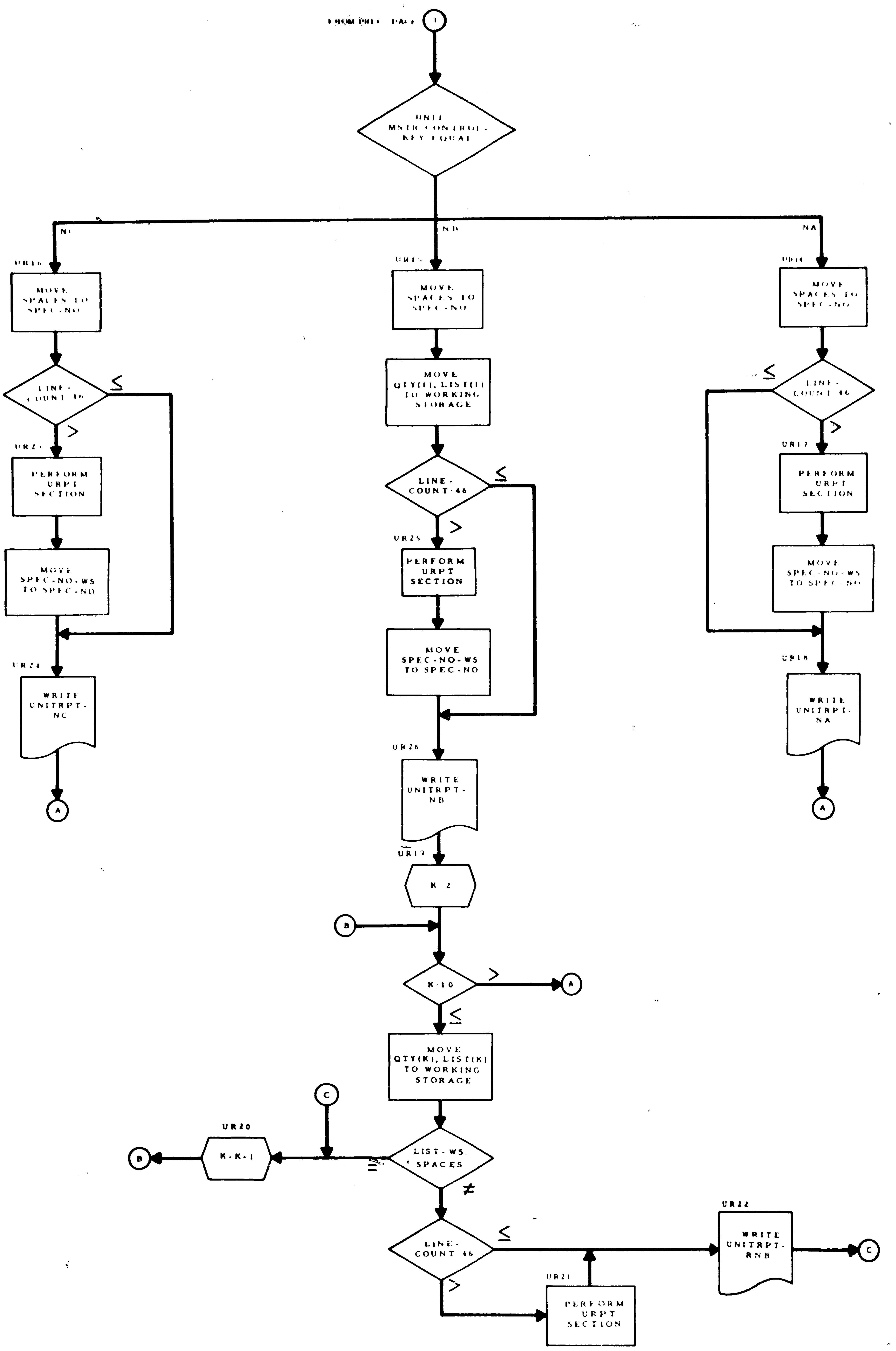


FIGURE 9

Flow Chart - UNITRPT



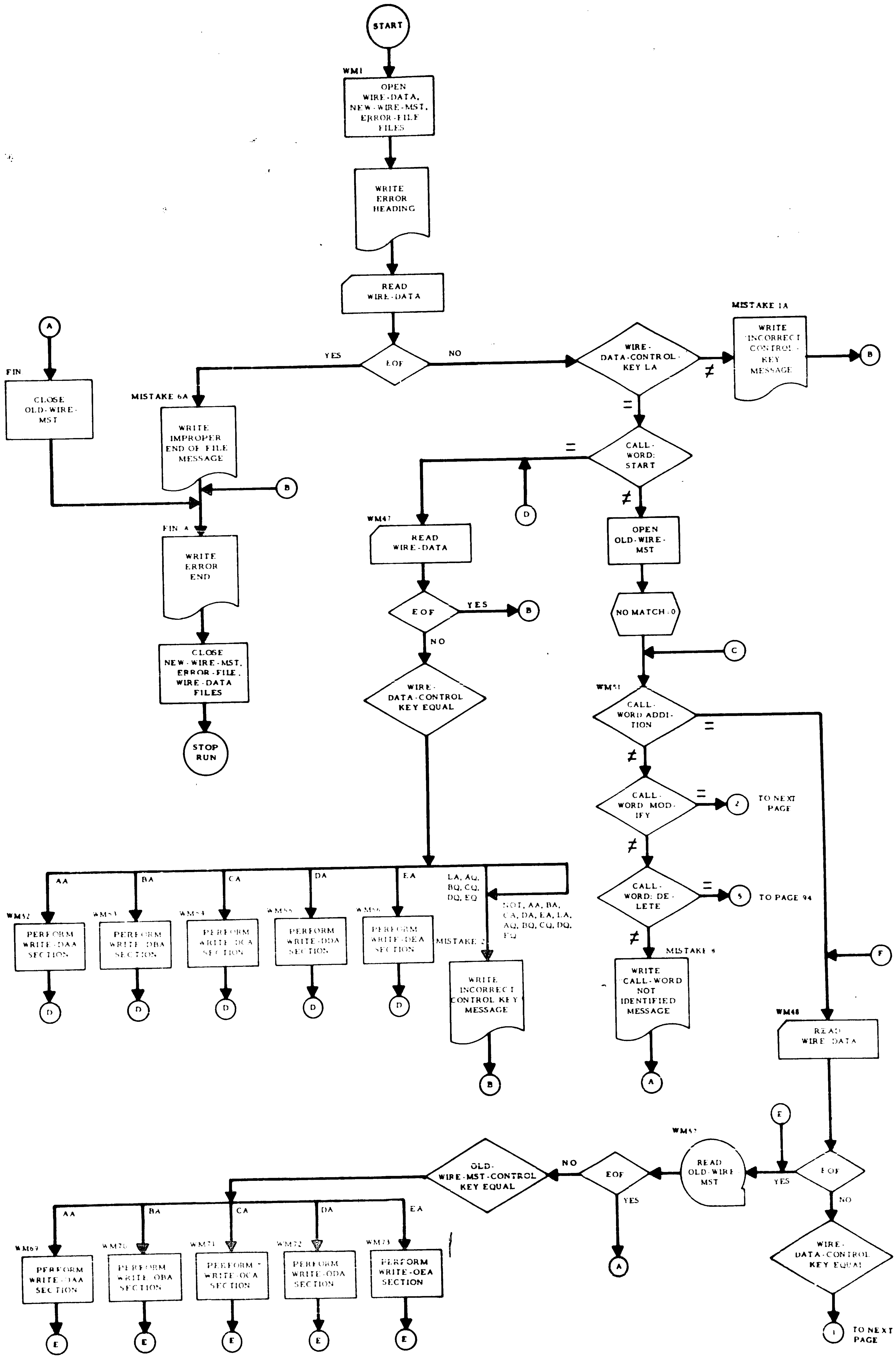
START
UR1
OPEN ALL FILES
READ DATE-FILE
WRITE UNITRPT COVER
READ UNIT-MSTR
UNIT-MSTR CONTROL-KEY EQUAL
NA
NB
NC
UR2
MOVE UNIT-MSTR RECORD TO WORKING STORAGE
UR3
MOVE UNIT-MSTR RECORD TO WORKING STORAGE
UR4
MOVE UNIT-MSTR RECORD TO WORKING STORAGE
UR5
WRITE UNITRPT COVER
PERFORM URPT SECTION
UNIT-MSTR CONTROL-KEY EQUAL
UR6
NA
WRITE UNITRPT-NA
A
UR9
READ UNIT-MSTR
EOF
NO
1
TO NEXT PAGE
YES
FIN
WRITE "END" MESSAGE
CLOSE ALL FILES
STOP RUN
NC
NB
UR8
WRITE UNITRPT-NC
A
UR7
MOVE QTY(1), LIST(1) TO WORKING STORAGE
WRITE UNITRPT-NB
UR10
J=2
D
A
>
J:10
≤
MOVE QTY(1), LIST(1) TO WORKING STORAGE
E
UR11
J=J+1
D
=
LIST-WS: SPACES
≠
LINE-COUNT 46
>
≤
UR12
PERFORM URPT SECTION
UR13
WRITE UNITRPT-RNB
E
URPT SECTION
BEGIN
ADVANCE UNIT-RPT TO TOP OF PAGE
WRITE PAGE HEADING
END

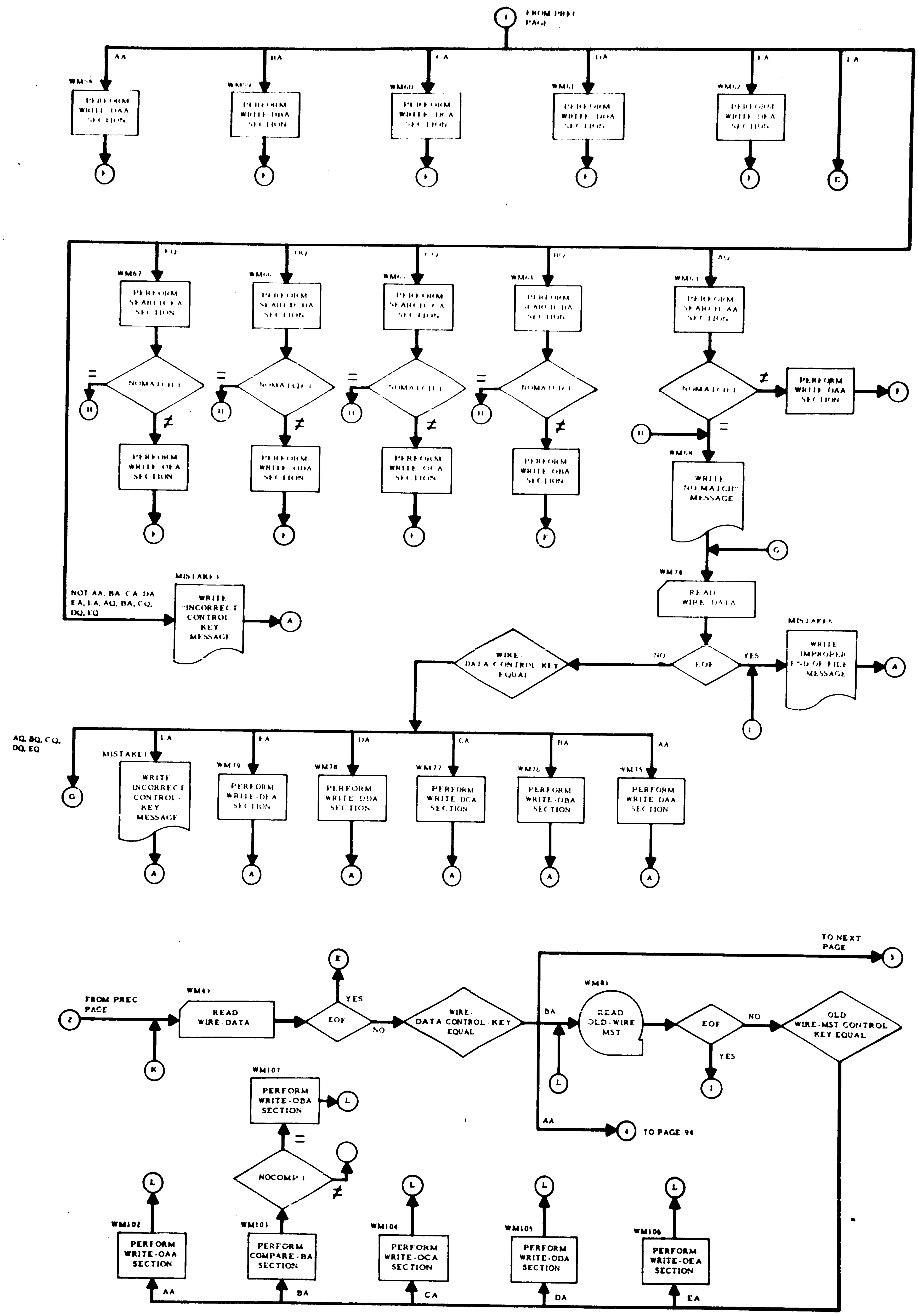


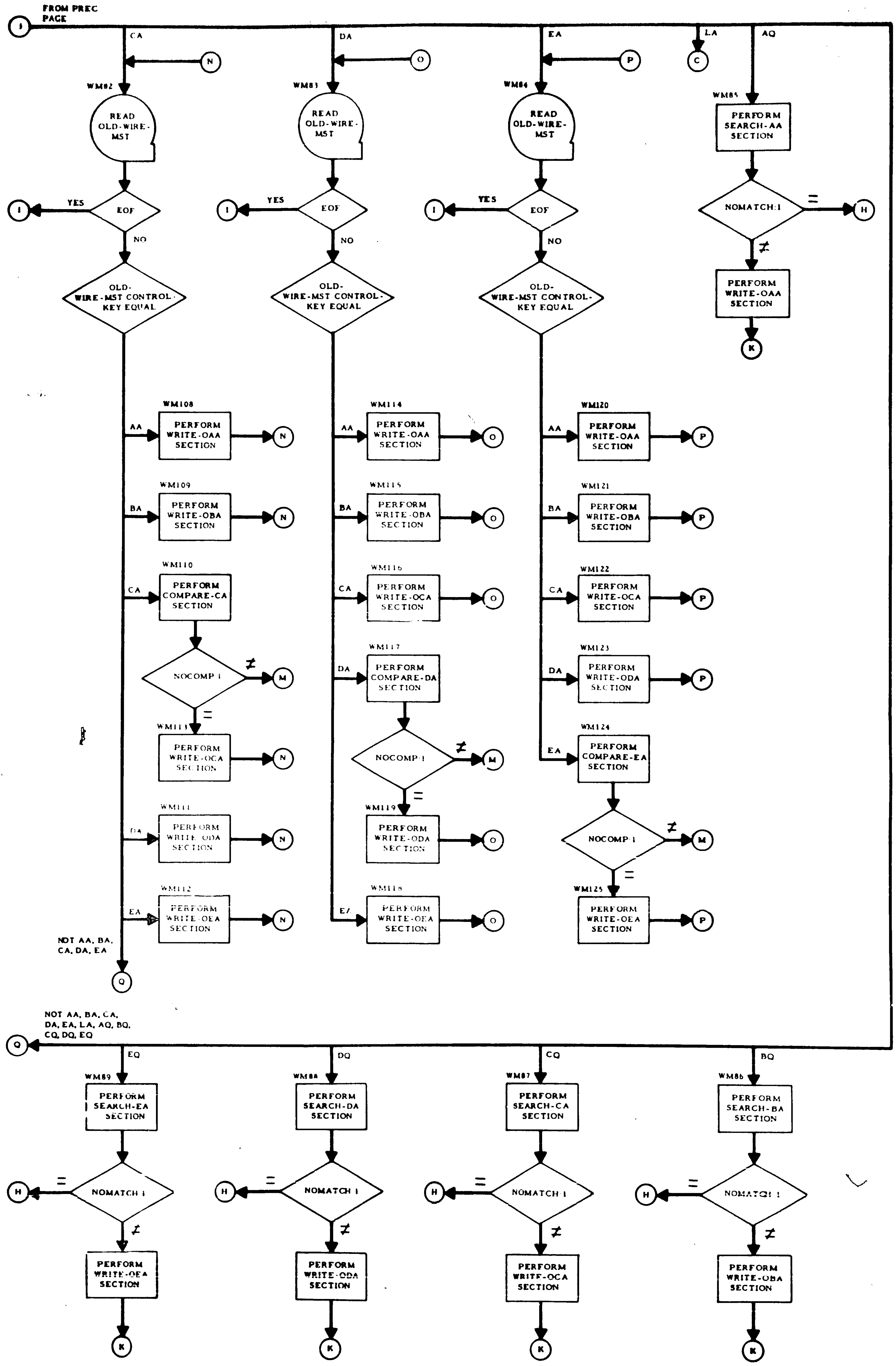
FROM PREC PAGE
UNTIL MSTR-CONTROL-KEY EQUAL
NC
NB
NA
MOVE SPACES TO SPEC-NO
LINE-COUNT 46
PERFORM URPT SECTION
MOVE SPEC-NO-WS TO SPEC-NO
WRITE UNITRPT-NC
MOVE QTY(I), LIST(I) TO WORKING STORAGE
UR25
WRITE UNITRPT-NB
UR26
UR19
K 2
K 10
WRITE UNITRPT-NA
MOVE QTY(K), LIST(K) TO WORKING STORAGE
UR20
K K+1
LIST-WS SPACES
UR22
WRITE UNITRPT-RNB
UR21
PERFORM URPT SECTION

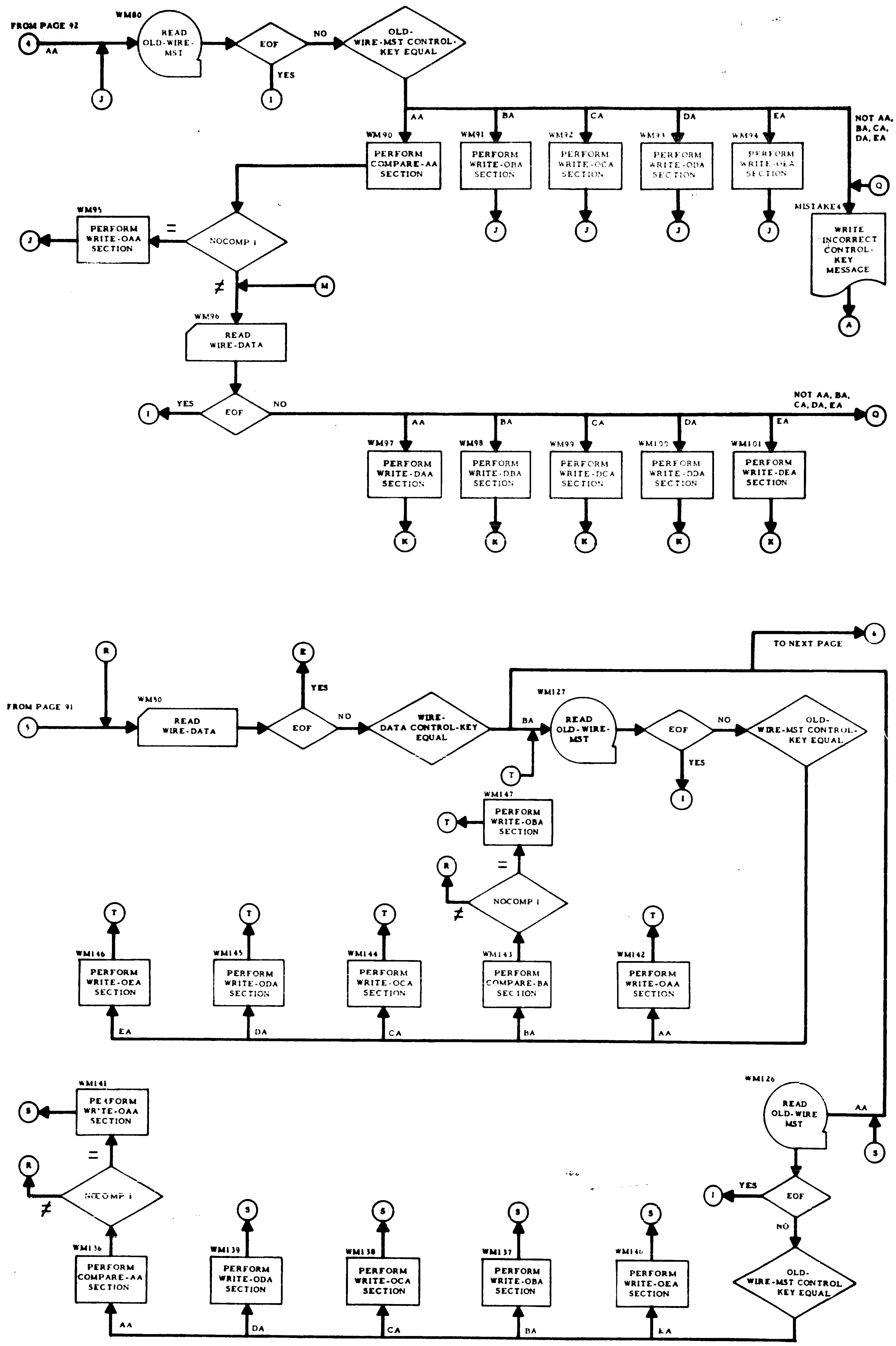
FIGURE 10

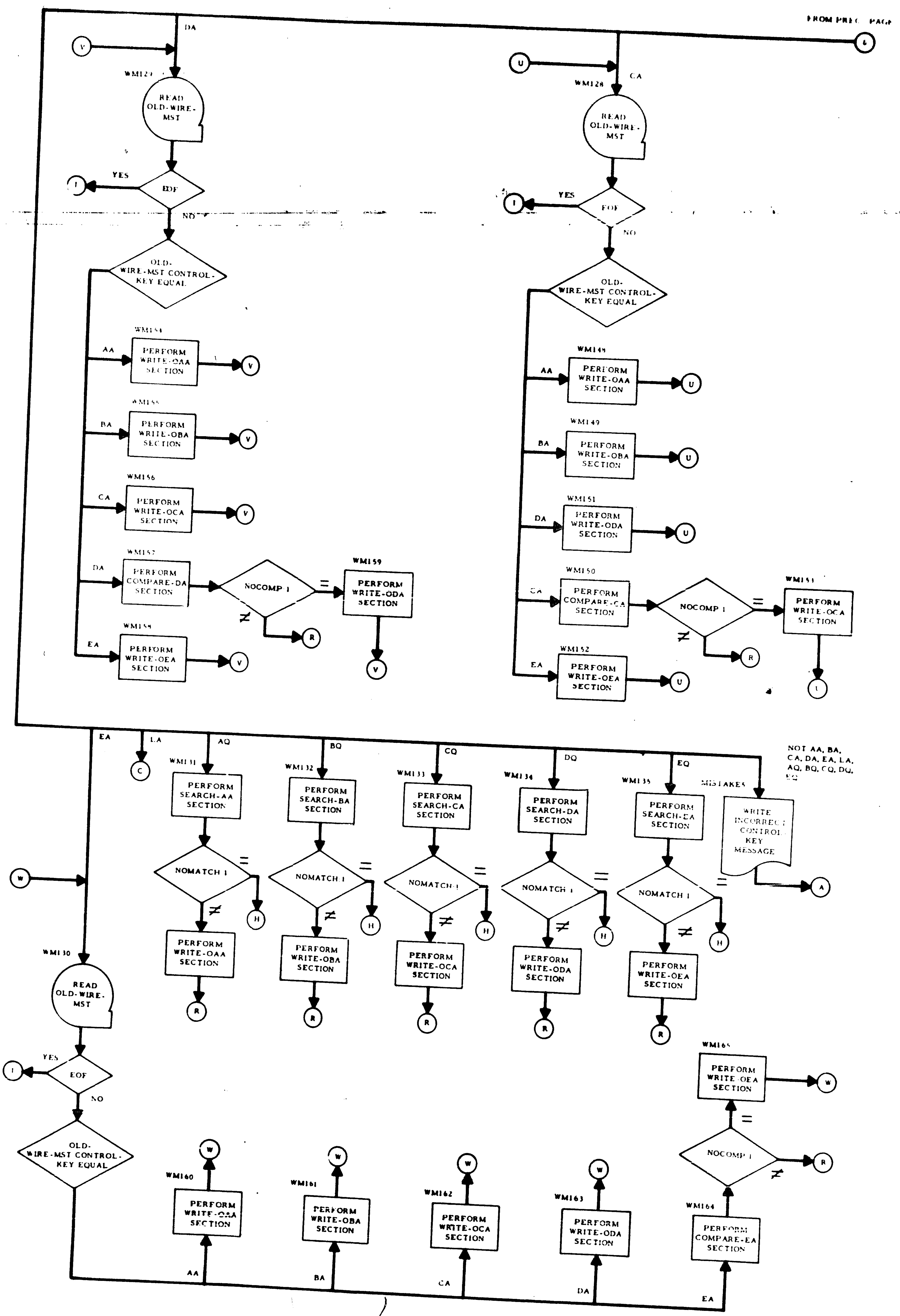
Flow Chart - WIREMSTR


START
WM1
OPEN WIRE-DATA, NEW-WIRE-MST, ERROR-FILE FILES
WRITE ERROR HEADING
READ WIRE-DATA
EOF
YES
NO
WIRE-DATA-CONTROL-KEY LA
MISTAKE 1A
WRITE INCORRECT CONTROL-KEY MESSAGE
FIN
CLOSE OLD-WIRE-MST
MISTAKE 6A
WRITE IMPROPER END OF FILE MESSAGE
CALL-WORD: START
OPEN OLD-WIRE-MST
WM47
READ WIRE-DATA
WRITE ERROR END
CLOSE NEW-WIRE-MST, ERROR-FILE, WIRE-DATA FILES
STOP RUN
NO MATCH-0
WIRE-DATA-CONTROL KEY EQUAL
CALL-WORD ADDITION
CALL-WORD MODIFY
TO NEXT PAGE
CALL-WORD: DELETE
TO PAGE 94
MISTAKE 4
WRITE CALL-WORD NOT IDENTIFIED MESSAGE
AA
BA
CA
DA
EA
LA, AQ, BQ, CQ, DQ, EQ
NOT, AA, BA, CA, DA, EA, LA, AQ, BQ, CQ, DQ, EQ
WM52
PERFORM WRITE-DAA SECTION
PERFORM WRITE-DBA SECTION
PERFORM WRITE-DCA SECTION
PERFORM WRITE-DDA SECTION
PERFORM WRITE-DEA SECTION
MISTAKE 2
WRITE INCORRECT CONTROL KEY MESSAGE
WM48
READ WIRE-DATA
WM57
READ OLD-WIRE MST
OLD-WIRE-MST-CONTROL KEY EQUAL
WM69
PERFORM WRITE-OAA SECTION
PERFORM WRITE-OBA SECTION
PERFORM WRITE-OCA SECTION
PERFORM WRITE-ODA SECTION
PERFORM WRITE-OEA SECTION
TO NEXT PAGE


NOT AA, BA, CA, DA
EA, EA, AQ, BA, CQ,
DQ, EQ
WRITE
INCORRECT
CONTROL
KEY
MESSAGE
NO
YES
AQ, BQ, CQ,
DQ, EQ
WRITE
INCORRECT
CONTROL
KEY
MESSAGE
PERFORM
WRITE-OEA
SECTION
PERFORM
WRITE-ODA
SECTION
PERFORM
WRITE-OCA
SECTION
PERFORM
WRITE-OBA
SECTION
PERFORM
WRITE-OAA
SECTION
TO NEXT
PAGE
FROM PREC
PAGE
WM45
READ
WIRE-DATA
EOF
YES
NO
WIRE-
DATA CONTROL-KEY
EQUAL
BA
WM81
READ
OLD-WIRE
MST
EOF
NO
YES
OLD
WIRE-MST CONTROL
KEY EQUAL
AA
TO PAGE 94
WM107
PERFORM
WRITE-OBA
SECTION
=
NOCOMP 1
≠
WM102
PERFORM
WRITE-OAA
SECTION
WM103
PERFORM
COMPARE-BA
SECTION
WM104
PERFORM
WRITE-OCA
SECTION
WM105
PERFORM
WRITE-ODA
SECTION
WM106
PERFORM
WRITE-OEA
SECTION
AA
BA
CA
DA
EA

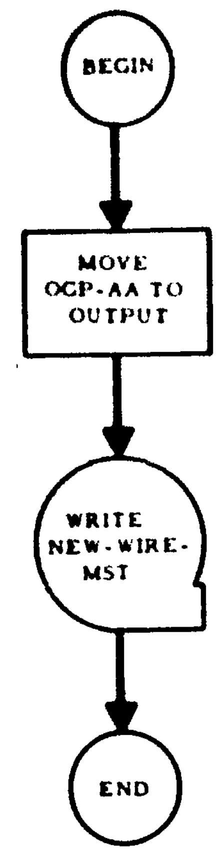

FROM PREC PAGE
CA
DA
EA
LA
AQ
WM82
READ OLD-WIRE-MST
WM83
READ OLD-WIRE-MST
WM84
READ OLD-WIRE-MST
WM85
PERFORM SEARCH-AA SECTION
EOF
YES
NO
NOMATCH-1
PERFORM WRITE-OAA SECTION
OLD-WIRE-MST CONTROL-KEY EQUAL
WM108
PERFORM WRITE-OAA SECTION
WM109
PERFORM WRITE-OBA SECTION
WM110
PERFORM COMPARE-CA SECTION
NOCOMP-1
WM113
PERFORM WRITE-OCA SECTION
WM111
PERFORM WRITE-ODA SECTION
WM112
PERFORM WRITE-OEA SECTION
NOT AA, BA, CA, DA, EA
WM114
PERFORM WRITE-OAA SECTION
WM115
PERFORM WRITE-OBA SECTION
WM116
PERFORM WRITE-OCA SECTION
WM117
PERFORM COMPARE-DA SECTION
WM119
PERFORM WRITE-ODA SECTION
WM118
PERFORM WRITE-OEA SECTION
WM120
PERFORM WRITE-OAA SECTION
WM121
PERFORM WRITE-OBA SECTION
WM122
PERFORM WRITE-OCA SECTION
WM123
PERFORM WRITE-ODA SECTION
WM124
PERFORM COMPARE-EA SECTION
WM125
PERFORM WRITE-OEA SECTION
NOT AA, BA, CA, DA, EA, LA, AQ, BQ, CQ, DQ, EQ
EQ
DQ
CQ
BQ
WM89
PERFORM SEARCH-EA SECTION
WM88
PERFORM SEARCH-DA SECTION
WM87
PERFORM SEARCH-CA SECTION
WM86
PERFORM SEARCH-BA SECTION
PERFORM WRITE-OEA SECTION
PERFORM WRITE-ODA SECTION
PERFORM WRITE-OCA SECTION
PERFORM WRITE-OBA SECTION


FROM PAGE 92
WM80
READ OLD-WIRE-MST
EOF
NO
YES
OLD-WIRE-MST CONTROL-KEY EQUAL
AA
BA
CA
DA
EA
NOT AA, BA, CA, DA, EA
WM90
PERFORM COMPARE-AA SECTION
WM91
PERFORM WRITE-OBA SECTION
PERFORM WRITE-OCA SECTION
PERFORM WRITE-ODA SECTION
WM94
PERFORM WRITE-OEA SECTION
MISTAKE4
WRITE INCORRECT CONTROL-KEY MESSAGE
WM95
PERFORM WRITE-OAA SECTION
NOCOMP 1
WM96
READ WIRE-DATA
EOF
NOT AA, BA, CA, DA, EA
WM97
PERFORM WRITE-DAA SECTION
WM98
PERFORM WRITE-DBA SECTION
PERFORM WRITE-DCA SECTION
PERFORM WRITE-DDA SECTION
WM101
PERFORM WRITE-DEA SECTION
TO NEXT PAGE
FROM PAGE 91
WM50
READ WIRE-DATA
EOF
WIRE-DATA CONTROL-KEY EQUAL
WM127
READ OLD-WIRE-MST
EOF
OLD-WIRE-MST CONTROL-KEY EQUAL
WM147
PERFORM WRITE-OBA SECTION
NOCOMP 1
WM146
PERFORM WRITE-OEA SECTION
WM145
PERFORM WRITE-ODA SECTION
WM144
PERFORM WRITE-OCA SECTION
WM143
PERFORM COMPARE-BA SECTION
WM142
PERFORM WRITE-OAA SECTION
WM141
PERFORM WRITE-OAA SECTION
WM126
READ OLD-WIRE MST
WM136
PERFORM COMPARE-AA SECTION
WM139
PERFORM WRITE-ODA SECTION
WM138
PERFORM WRITE-OCA SECTION
WM137
PERFORM WRITE-OBA SECTION
PERFORM WRITE-OEA SECTION

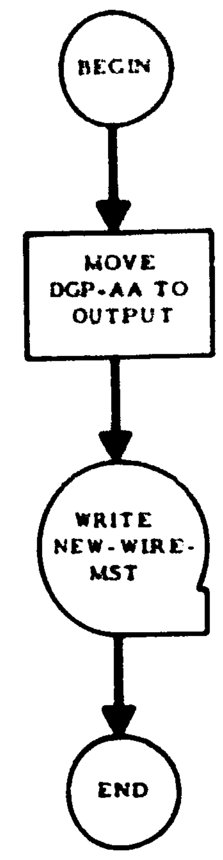


FROM PREC PAGE
DA
CA
WM127
READ OLD-WIRE-MST
EOF
YES
NO
OLD-WIRE-MST CONTROL-KEY EQUAL
WM154
AA
PERFORM WRITE-OAA SECTION
WM155
BA
PERFORM WRITE-OBA SECTION
WM156
CA
PERFORM WRITE-OCA SECTION
WM157
DA
PERFORM COMPARE-DA SECTION
NOCOMP 1
WM159
PERFORM WRITE-ODA SECTION
WM158
EA
PERFORM WRITE-OEA SECTION
WM128
WM145
PERFORM WRITE-OAA SECTION
WM149
PERFORM WRITE-OBA SECTION
WM151
PERFORM WRITE-ODA SECTION
WM150
PERFORM COMPARE-CA SECTION
PERFORM WRITE-OCA SECTION
WM152
PERFORM WRITE-OEA SECTION
LA
AQ
BQ
CQ
DQ
EQ
WM131
PERFORM SEARCH-AA SECTION
WM132
PERFORM SEARCH-BA SECTION
WM133
PERFORM SEARCH-CA SECTION
WM134
PERFORM SEARCH-DA SECTION
WM135
PERFORM SEARCH-EA SECTION
MISTAKES
NOT AA, BA, CA, DA, EA, LA, AQ, BQ, CQ, DQ, EQ
WRITE INCORRECT CONTROL KEY MESSAGE
NOMATCH 1
PERFORM WRITE-OAA SECTION
PERFORM WRITE-OBA SECTION
PERFORM WRITE-OCA SECTION
PERFORM WRITE-ODA SECTION
PERFORM WRITE-OEA SECTION
WM130
READ OLD-WIRE-MST
EOF
OLD-WIRE-MST CONTROL-KEY EQUAL
WM165
PERFORM WRITE-OEA SECTION
NOCOMP 1
WM160
PERFORM WRITE-OAA SECTION
WM161
PERFORM WRITE-OBA SECTION
WM162
PERFORM WRITE-OCA SECTION
WM163
PERFORM WRITE-ODA SECTION
WM164
PERFORM COMPARE-EA SECTION

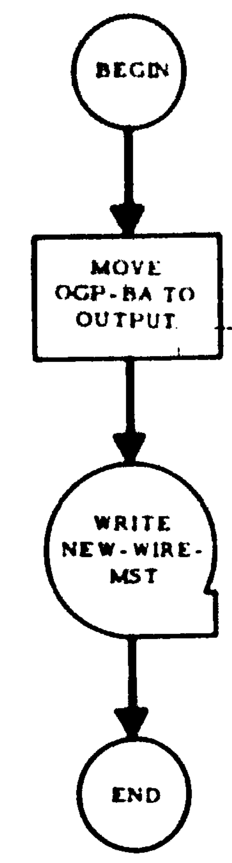
WRITE-OAA SECTION



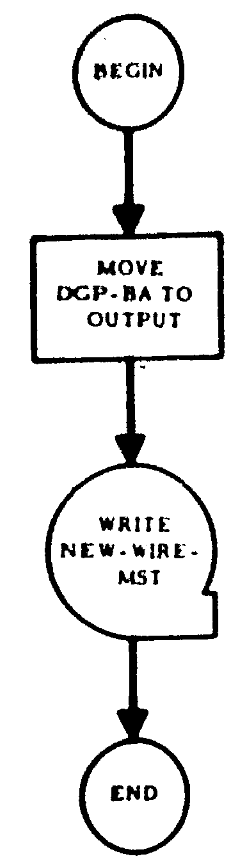
WRITE-DAA SECTION



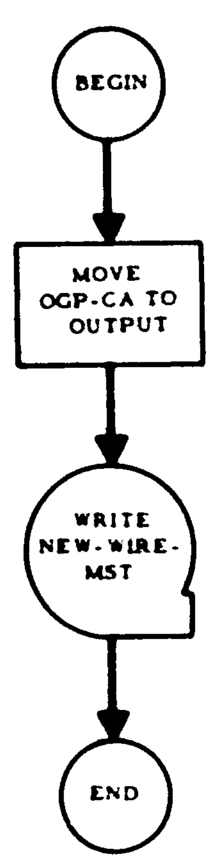
WRITE-OBA SECTION



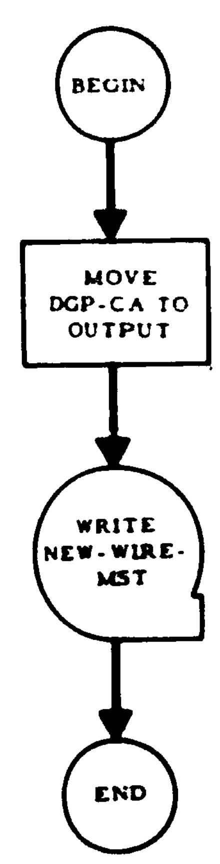
WRITE-DBA SECTION



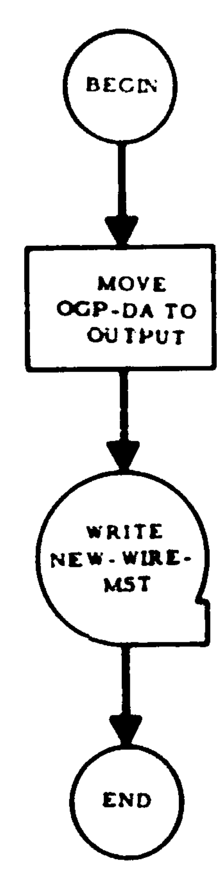
WRITE-OCA SECTION



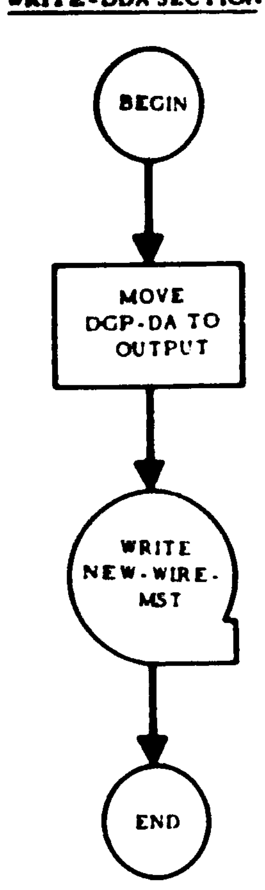
WRITE-DCA SECTION



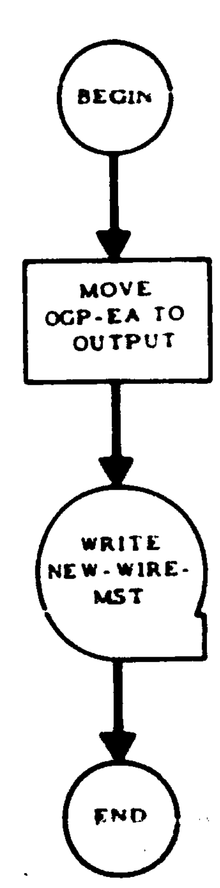
WRITE-ODA SECTION



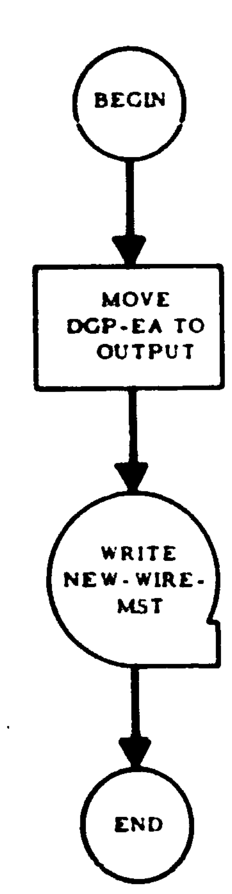
WRITE-DDA SECTION



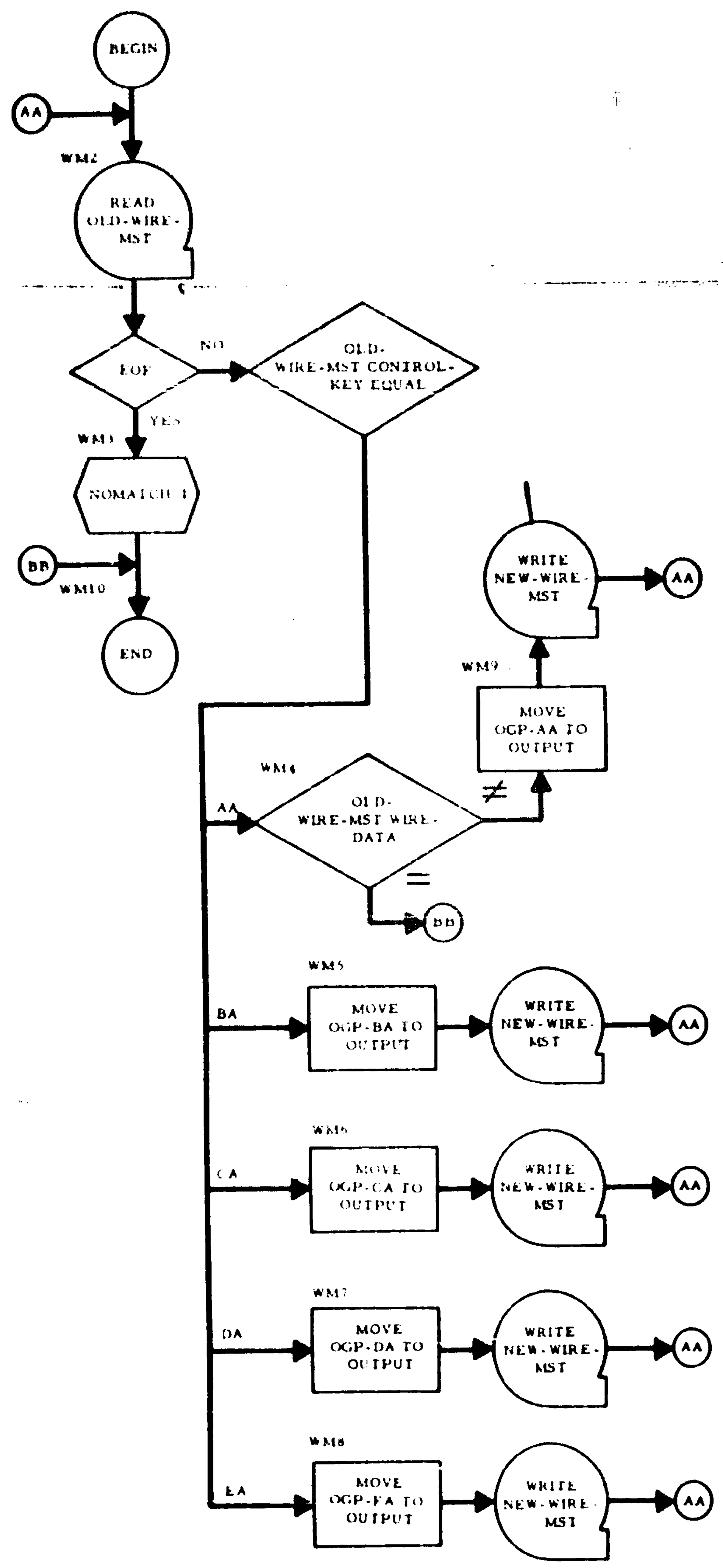
WRITE-OEA SECTION



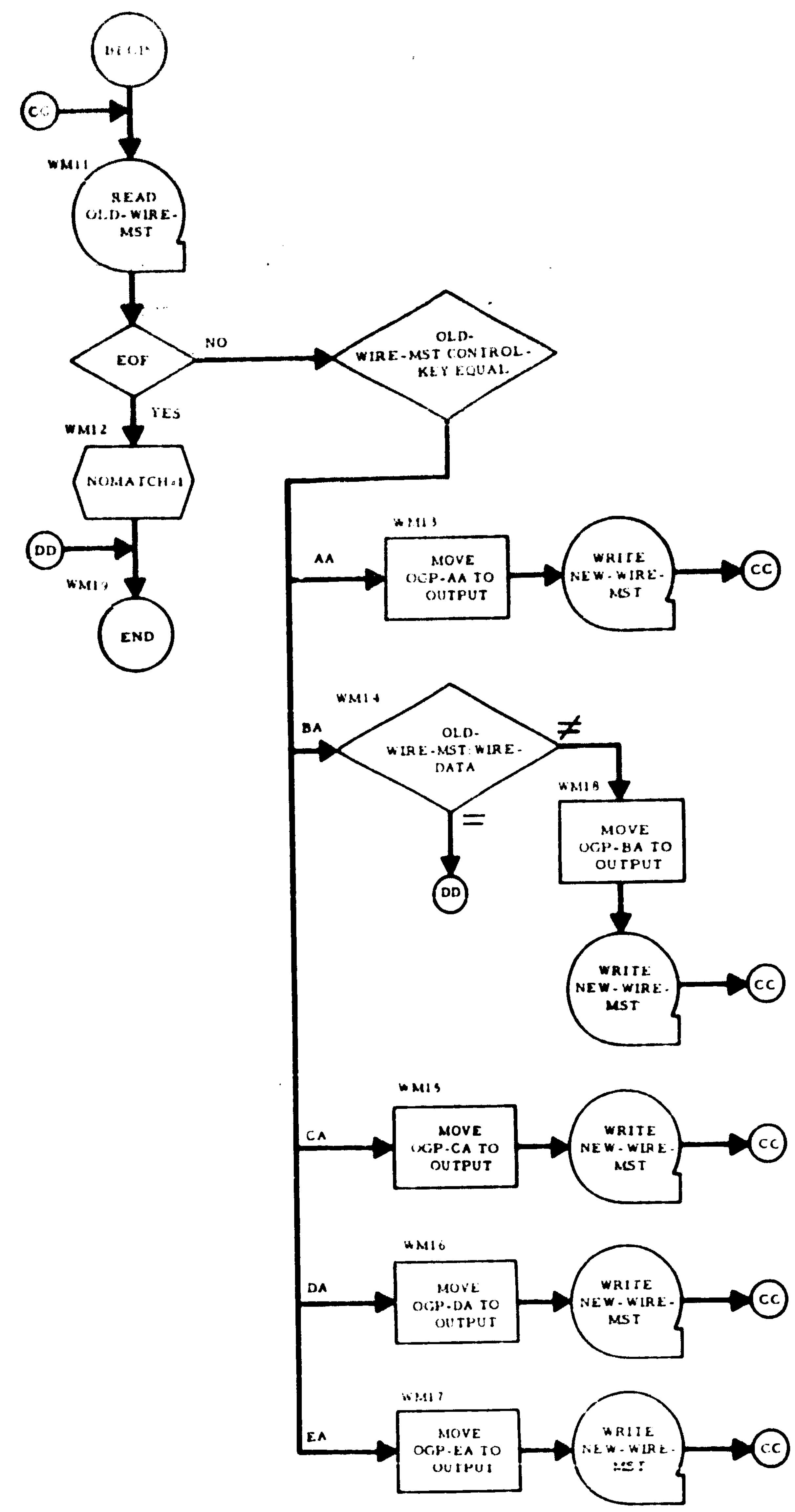
WRITE-DEA SECTION



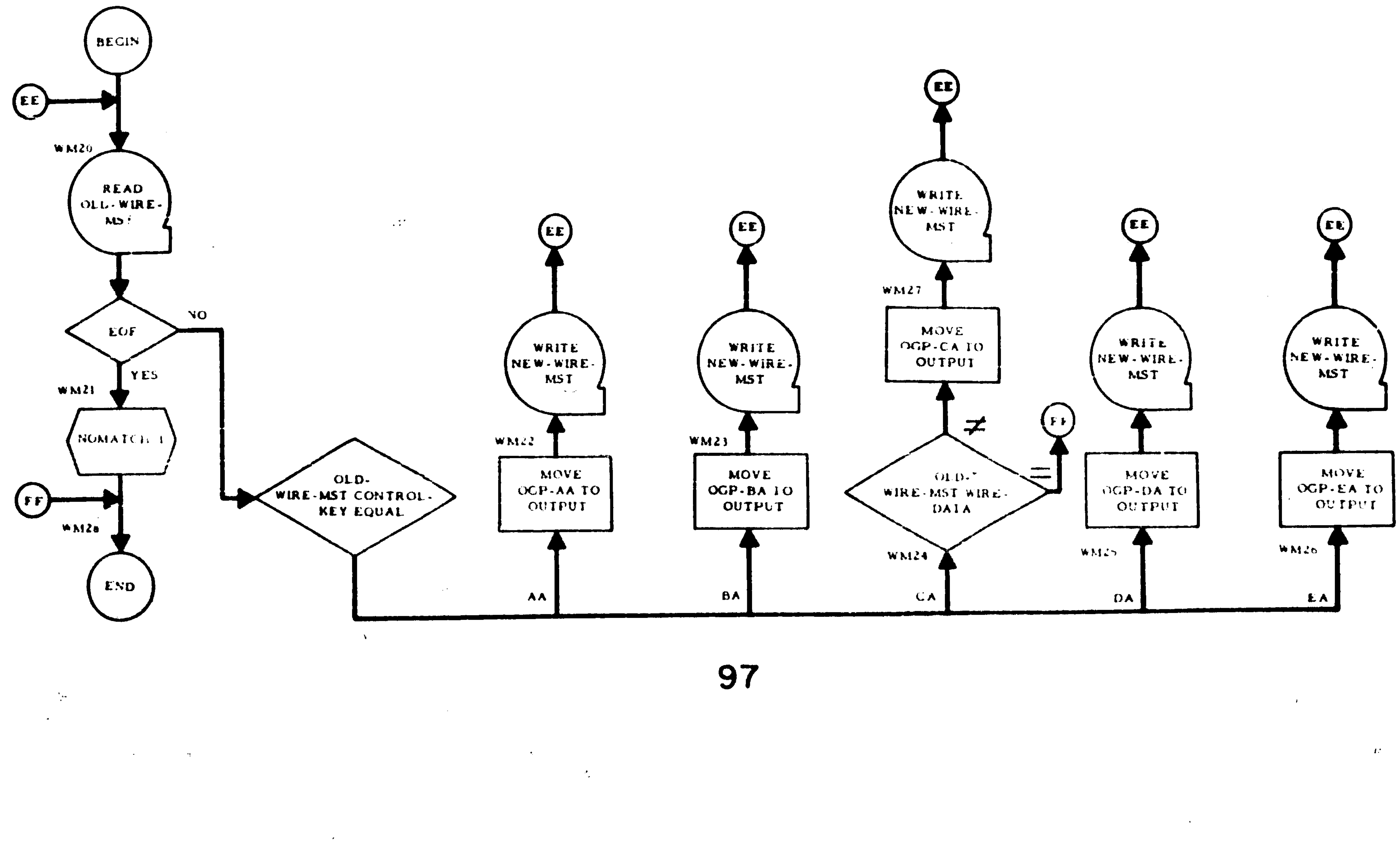
SEARCH-AA SECTION



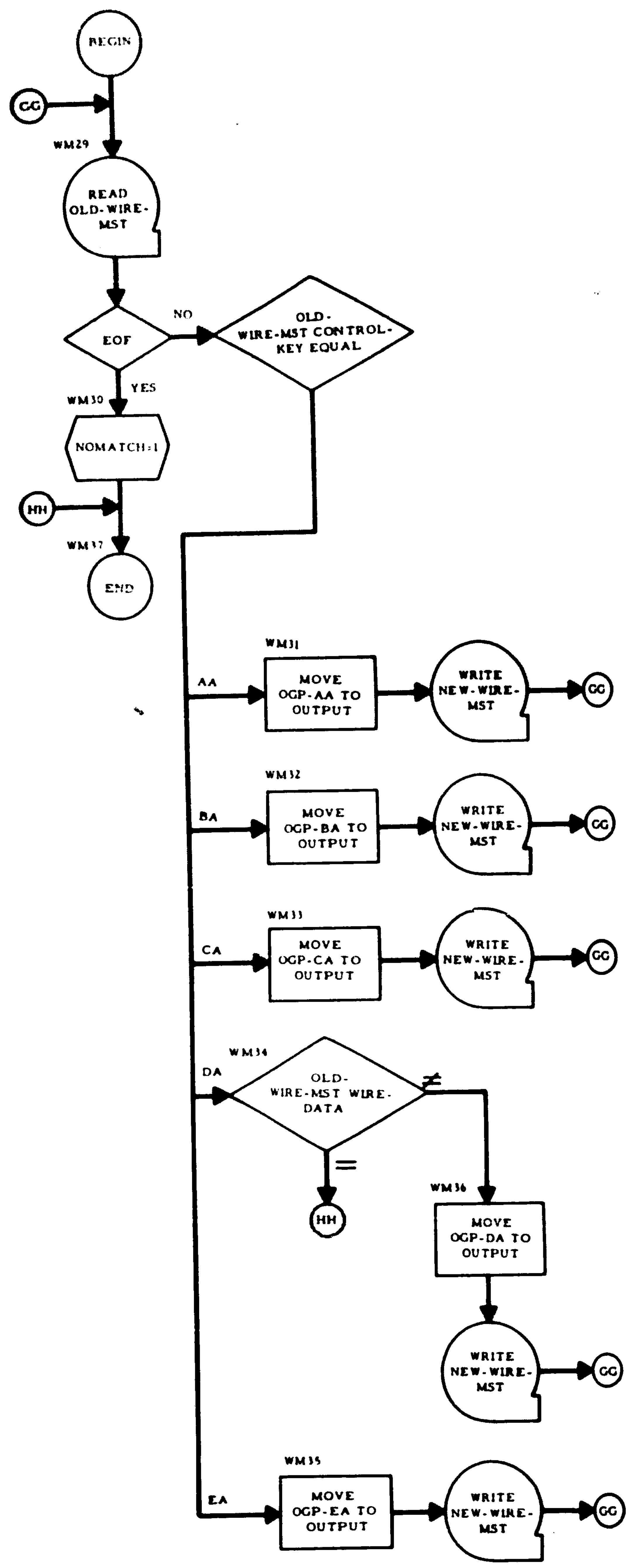
SEARCH-BA SECTION



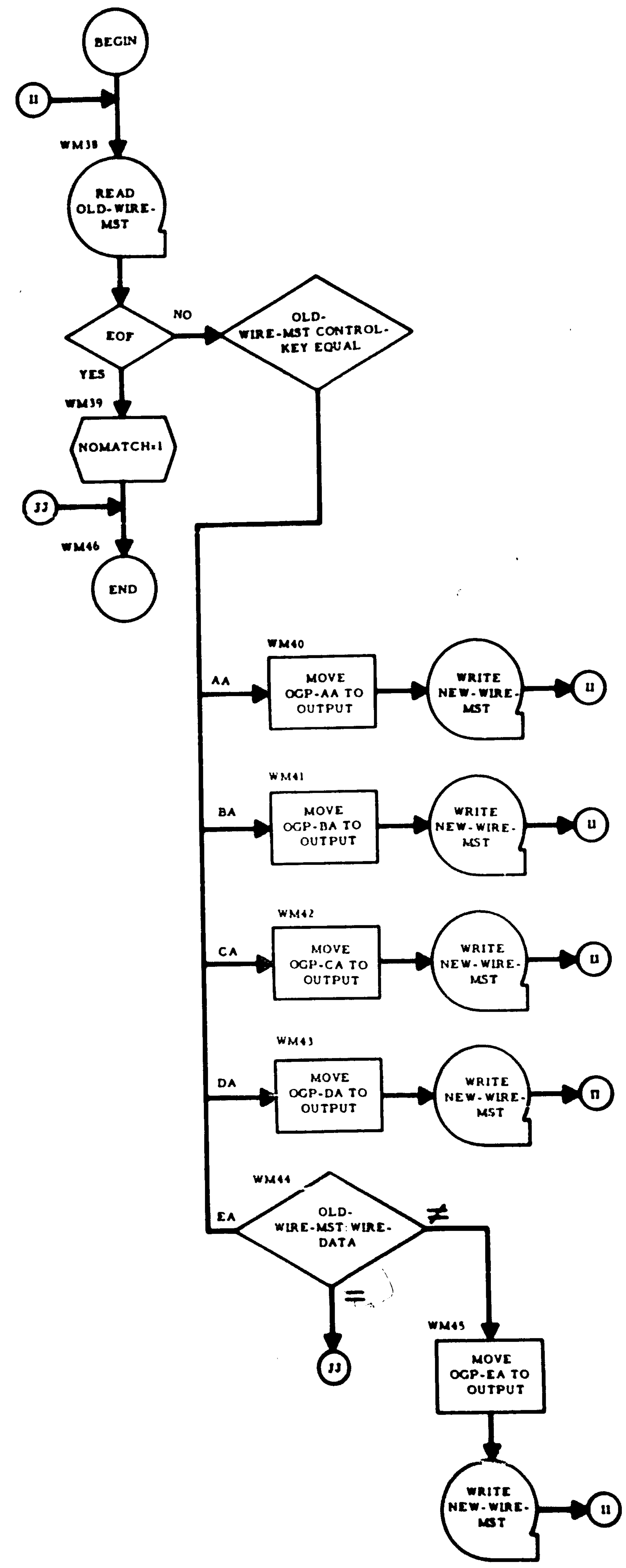
SEARCH-CA SECTION



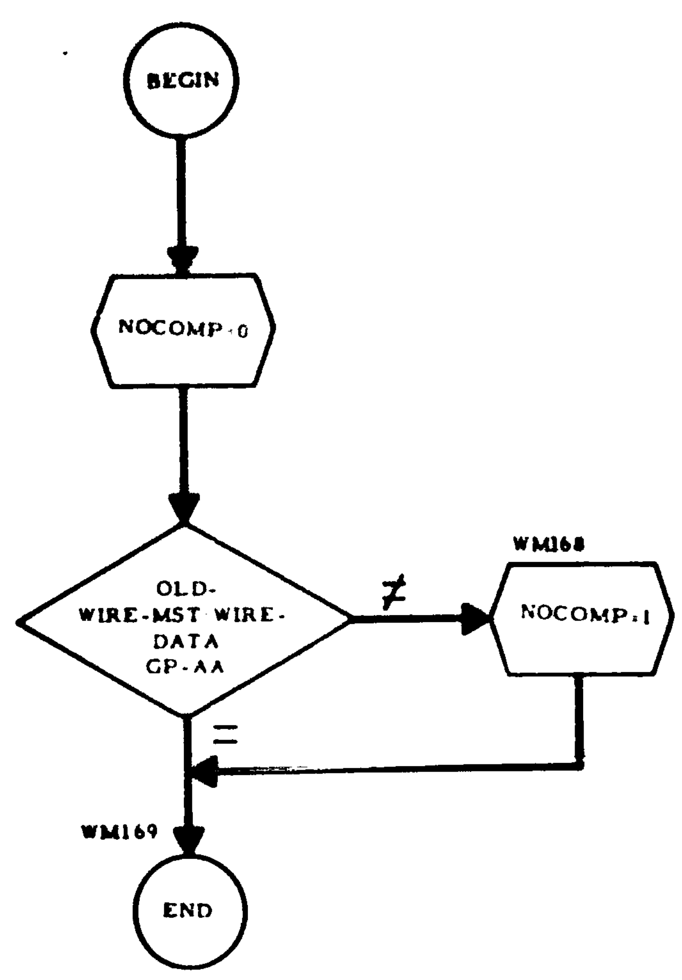
SEARCH-DA SECTION



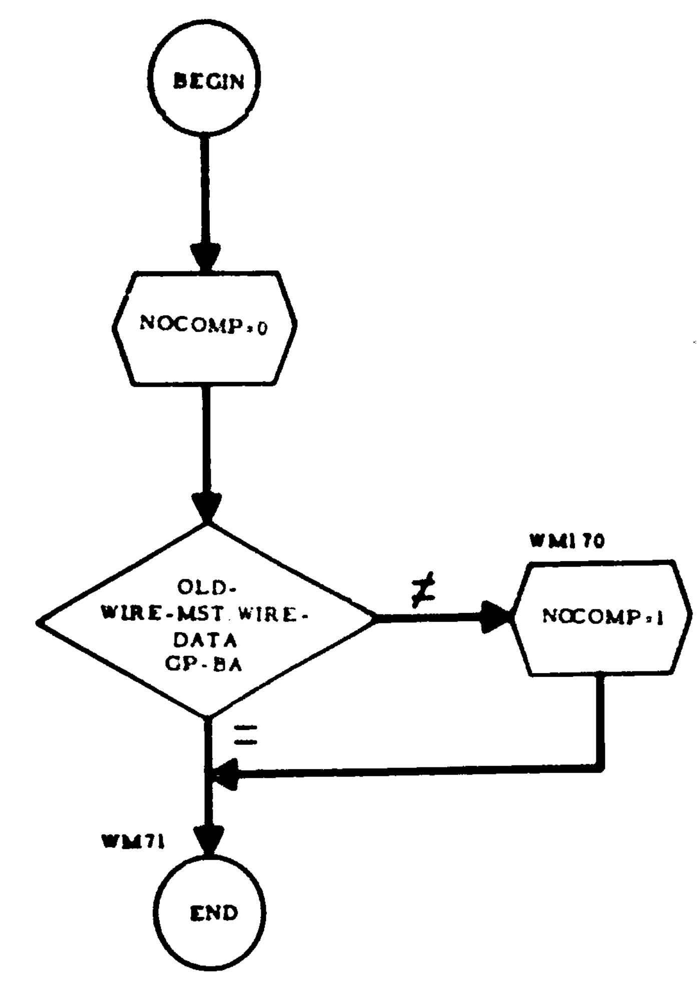
SEARCH-EA SECTION



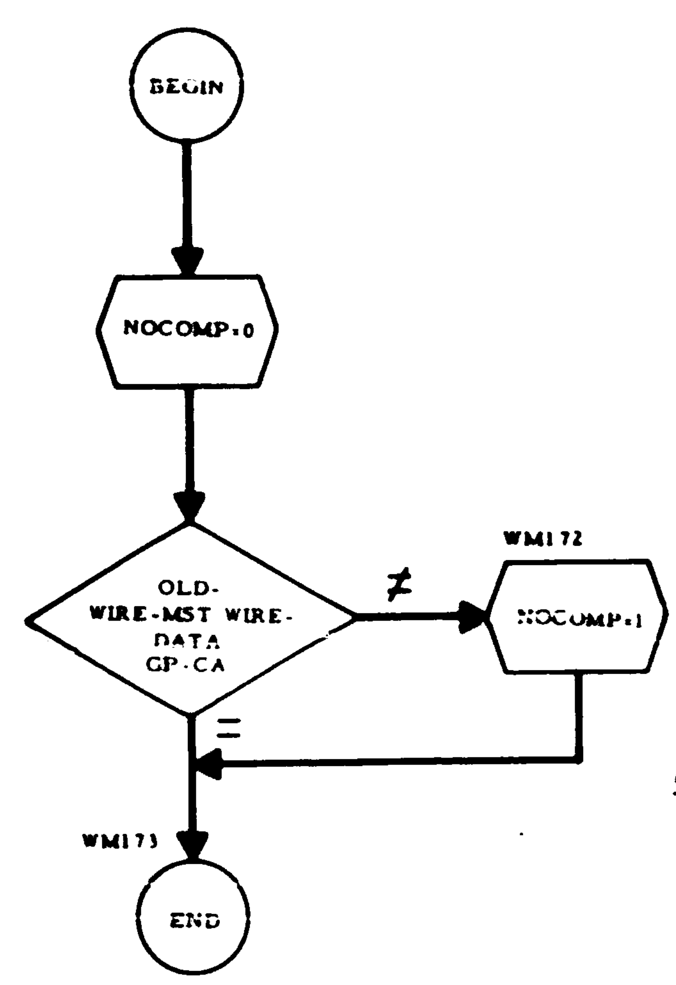
COMPARE-AA SECTION



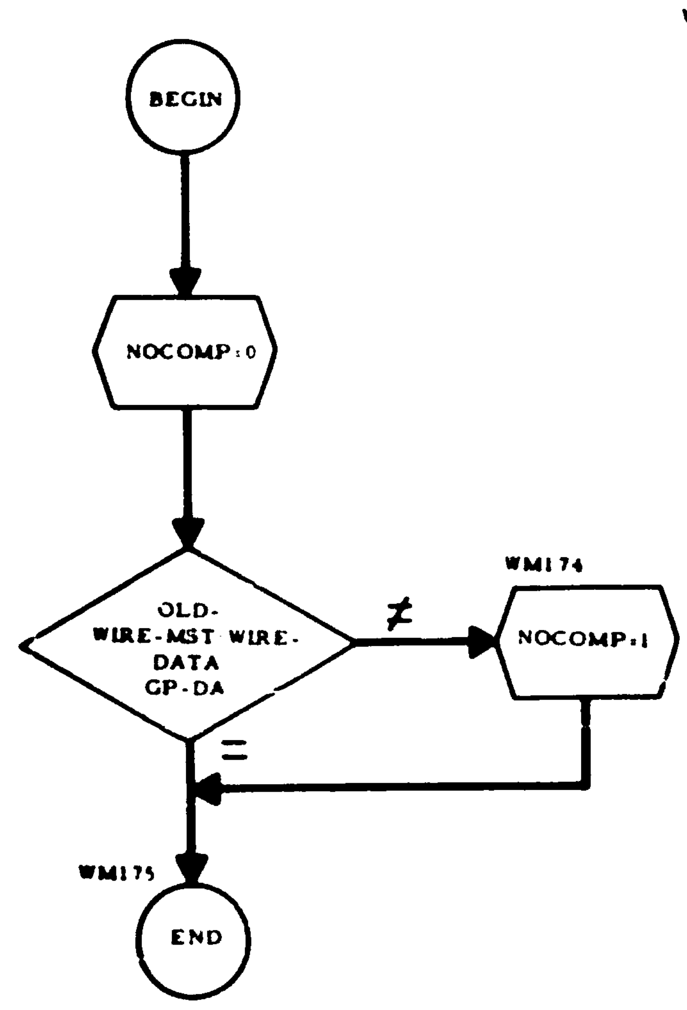
COMPARE-BA SECTION



COMPARE-CA SECTION



COMPARE-DA SECTION



COMPARE-EA SECTION

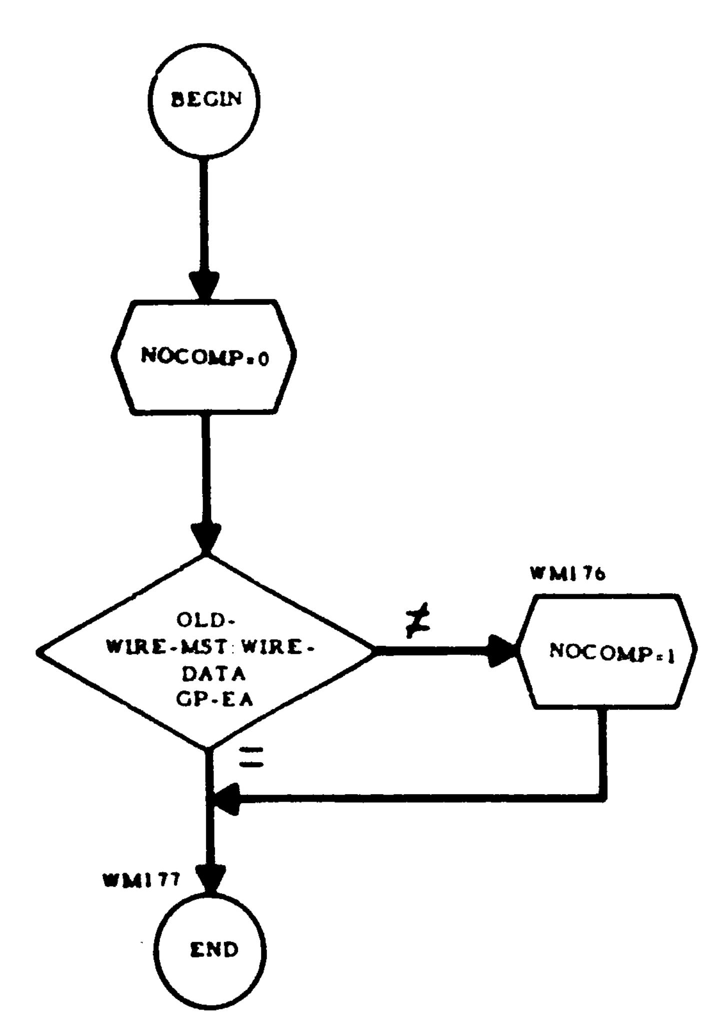
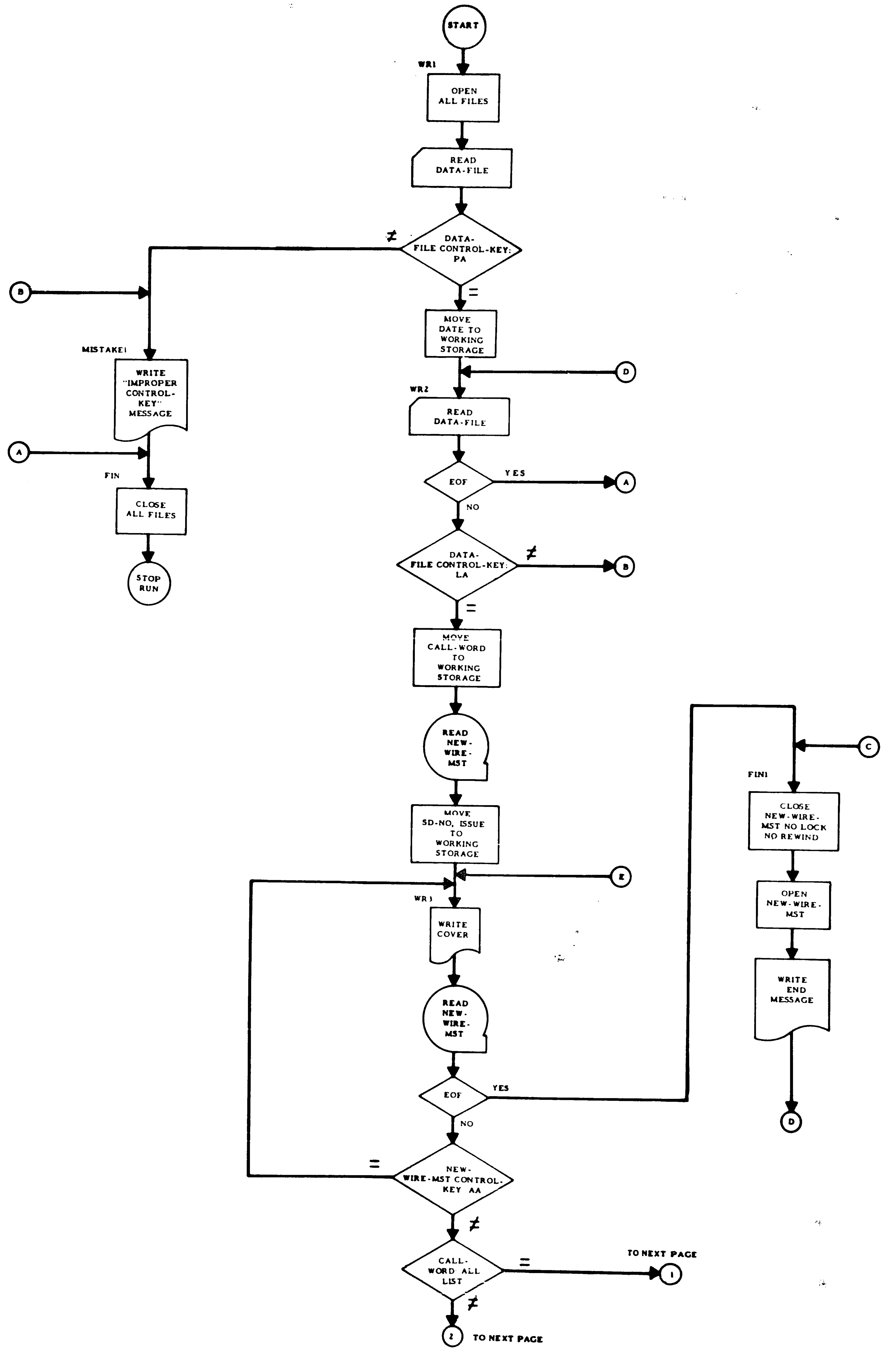


FIGURE 11

Flow Chart - WIRERPTS


START
WR1
OPEN ALL FILES
READ DATA-FILE
DATA-FILE CONTROL-KEY: PA
≠
=
MOVE DATE TO WORKING STORAGE
MISTAKE1
WRITE "IMPROPER CONTROL-KEY" MESSAGE
FIN
CLOSE ALL FILES
STOP RUN
WR2
READ DATA-FILE
EOF
YES
NO
DATA-FILE CONTROL-KEY: LA
MOVE CALL-WORD TO WORKING STORAGE
READ NEW-WIRE-MST
MOVE SD-NO, ISSUE TO WORKING STORAGE
WR3
WRITE COVER
READ NEW-WIRE-MST
EOF
YES
NO
NEW-WIRE-MST CONTROL-KEY AA
CALL-WORD ALL LIST
TO NEXT PAGE
TO NEXT PAGE
FIN1
CLOSE NEW-WIRE-MST NO LOCK NO REWIND
OPEN NEW-WIRE-MST
WRITE END MESSAGE

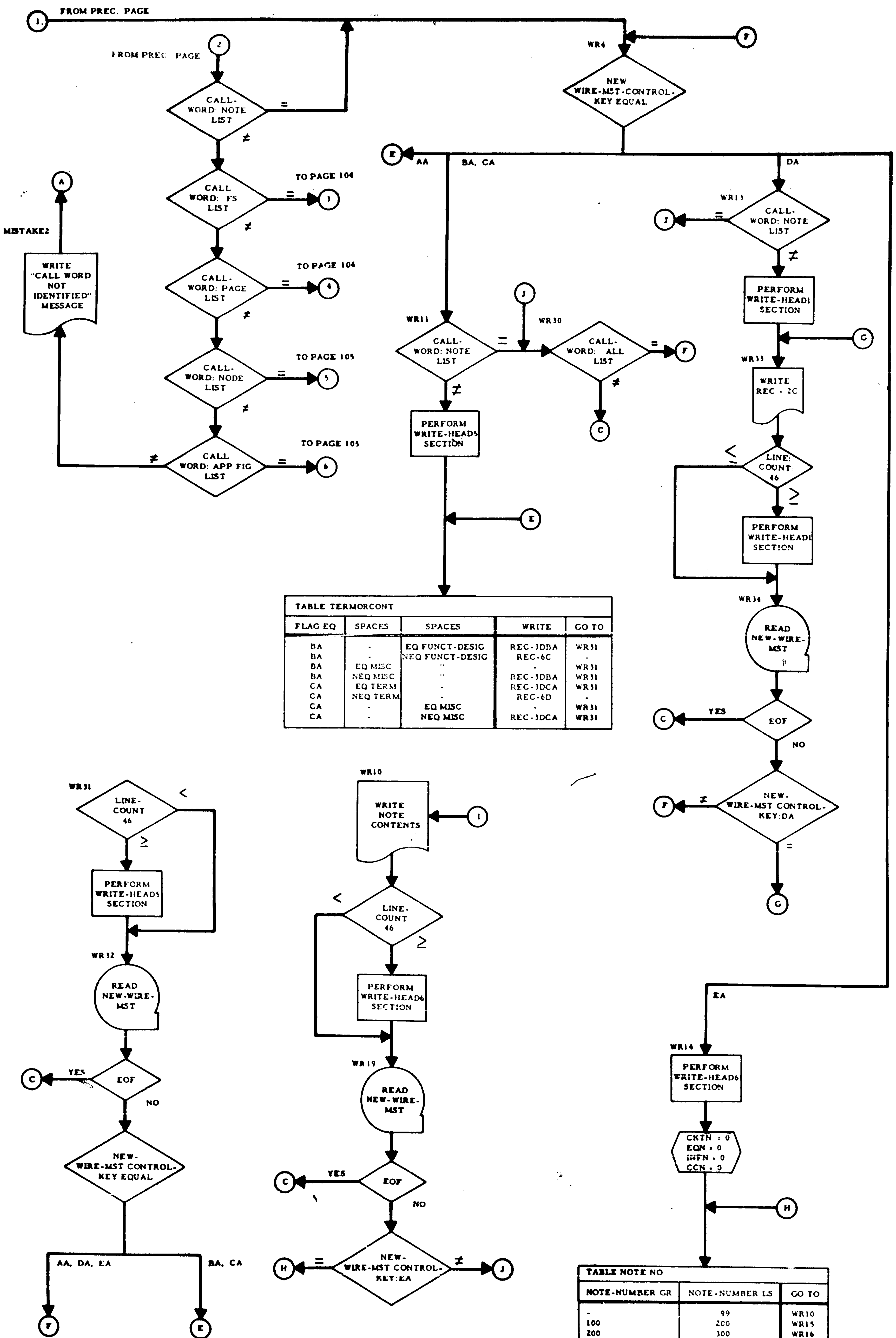
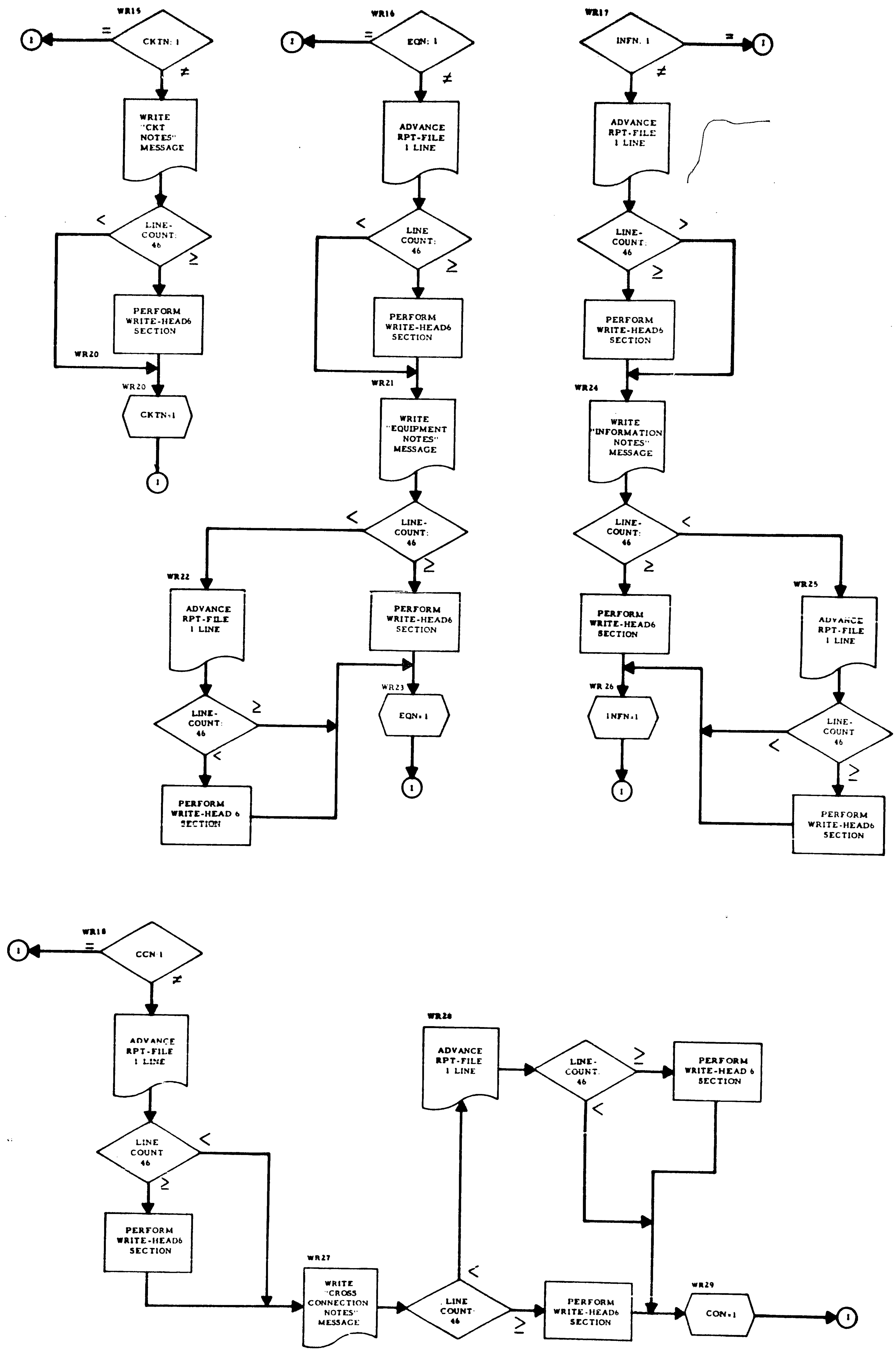


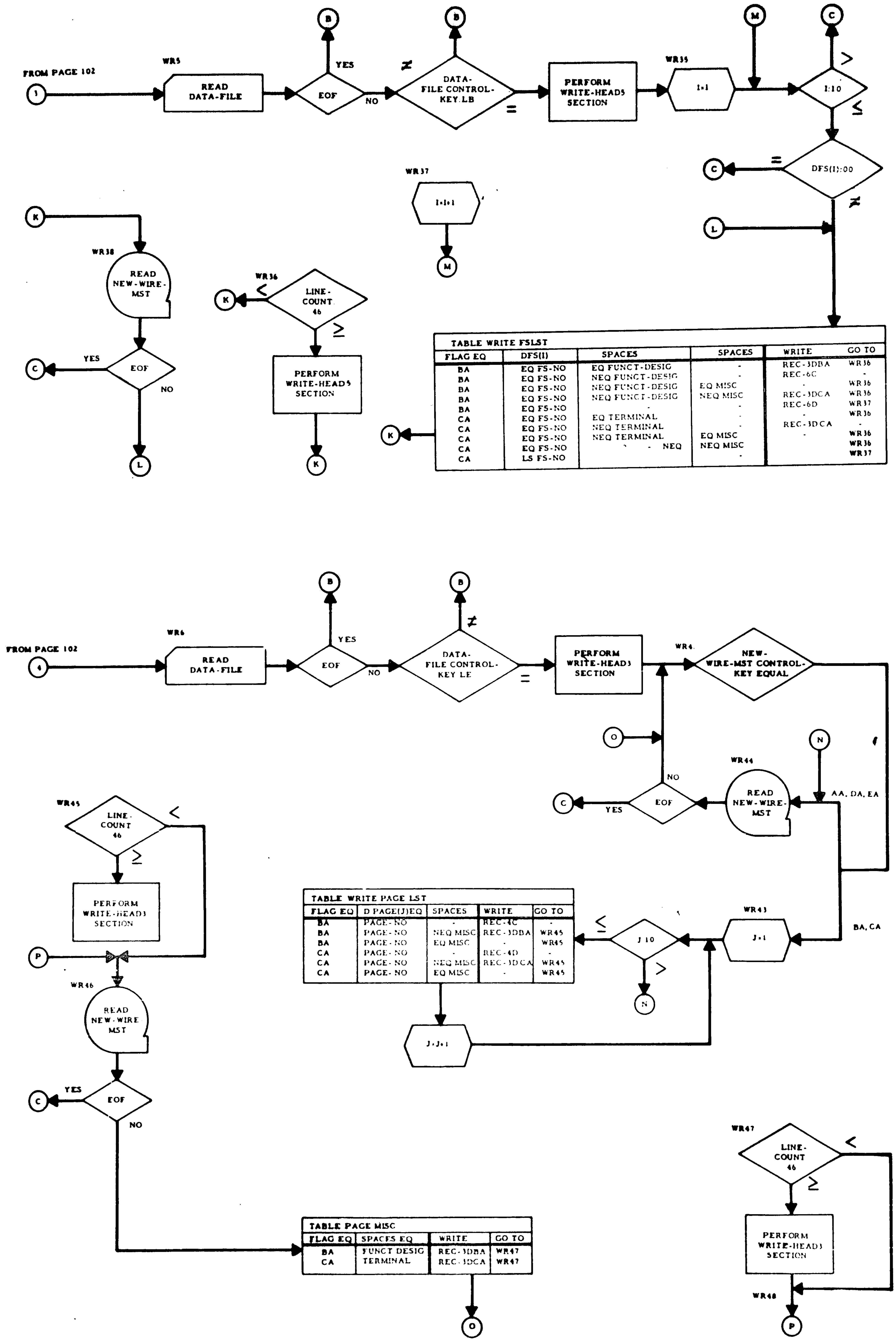
TABLE TERMORCONT

FLAG EQ	SPACES	SPACES	WRITE	GO TO
BA	-	EQ FUNCT-DESIG	REC-3DBA	WR31
BA	-	NEQ FUNCT-DESIG	REC-6C	-
BA	EQ MISC	"	-	WR31
BA	NEQ MISC	"	REC-3DBA	WR31
CA	EQ TERM	-	REC-3DCA	WR31
CA	NEQ TERM	-	REC-6D	-
CA	-	EQ MISC	-	WR31
CA	-	NEQ MISC	REC-3DCA	WR31

TABLE NOTE NO

NOTE-NUMBER GR	NOTE-NUMBER LS	GO TO
-	99	WR10
100	200	WR15
200	300	WR16
300	400	WR17
400	500	WR18


WR15
CKTN: 1
WRITE "CKT NOTES" MESSAGE
LINE-COUNT: 46
PERFORM WRITE-HEAD6 SECTION
WR20
CKTN+1
WR16
EQN: 1
ADVANCE RPT-FILE 1 LINE
LINE-COUNT: 46
PERFORM WRITE-HEAD6 SECTION
WR21
WRITE "EQUIPMENT NOTES" MESSAGE
LINE-COUNT: 46
WR22
ADVANCE RPT-FILE 1 LINE
LINE-COUNT: 46
PERFORM WRITE-HEAD 6 SECTION
PERFORM WRITE-HEAD6 SECTION
WR23
EQN+1
WR17
INFN: 1
ADVANCE RPT-FILE 1 LINE
LINE-COUNT: 46
PERFORM WRITE-HEAD6 SECTION
WR24
WRITE "INFORMATION NOTES" MESSAGE
LINE-COUNT: 46
PERFORM WRITE-HEAD6 SECTION
WR25
ADVANCE RPT-FILE 1 LINE
LINE-COUNT 46
PERFORM WRITE-HEAD6 SECTION
WR26
INFN+1
WR18
CCN: 1
ADVANCE RPT-FILE 1 LINE
LINE COUNT 46
PERFORM WRITE-HEAD6 SECTION
WR27
WRITE "CROSS CONNECTION NOTES" MESSAGE
LINE COUNT 46
WR28
ADVANCE RPT-FILE 1 LINE
LINE-COUNT: 46
PERFORM WRITE-HEAD 6 SECTION
PERFORM WRITE-HEAD6 SECTION
WR29
CON+1


FROM PAGE 102
WR5
READ DATA-FILE
EOF
YES
NO
DATA-FILE CONTROL-KEY LB
PERFORM WRITE-HEADS SECTION
WR35
I=1
I:10
DFS(I):00
WR37
I=I+1
WR38
READ NEW-WIRE-MST
EOF
YES
NO
WR36
LINE-COUNT 46
PERFORM WRITE-HEADS SECTION
TABLE WRITE FSLST
FLAG EQ | DFS(I) | SPACES | SPACES | WRITE | GO TO
BA | EQ FS-NO | EQ FUNCT-DESIG | - | REC-3DBA | WR36
BA | EQ FS-NO | NEQ FUNCT-DESIG | - | REC-6C | -
BA | EQ FS-NO | NEQ FUNCT-DESIG | EQ MISC | - | WR36
BA | EQ FS-NO | NEQ FUNCT-DESIG | NEQ MISC | REC-3DCA | WR36
BA | EQ FS-NO | - | - | REC-6D | WR37
CA | EQ FS-NO | EQ TERMINAL | - | - | WR36
CA | EQ FS-NO | NEQ TERMINAL | - | REC-3DCA | -
CA | EQ FS-NO | NEQ TERMINAL | EQ MISC | - | WR36
CA | EQ FS-NO | - NEQ | NEQ MISC | | WR36
CA | LS FS-NO | | - | | WR37
FROM PAGE 102
WR6
READ DATA-FILE
EOF
YES
NO
DATA-FILE CONTROL-KEY LE
PERFORM WRITE-HEADS SECTION
WR4
NEW-WIRE-MST CONTROL-KEY EQUAL
WR44
READ NEW-WIRE-MST
EOF
YES
NO
AA, DA, EA
BA, CA
WR43
J=1
J 10
J=J+1
TABLE WRITE PAGE LST
FLAG EQ | D PAGE(J)EQ | SPACES | WRITE | GO TO
BA | PAGE-NO | - | REC-4C | -
BA | PAGE-NO | NEQ MISC | REC-3DBA | WR45
BA | PAGE-NO | EQ MISC | - | WR45
CA | PAGE-NO | - | REC-4D | -
CA | PAGE-NO | NEQ MISC | REC-3DCA | WR45
CA | PAGE-NO | EQ MISC | - | WR45
WR45
LINE-COUNT 46
PERFORM WRITE-HEADS SECTION
WR46
READ NEW-WIRE MST
EOF
YES
NO
TABLE PAGE MISC
FLAG EQ | SPACES EQ | WRITE | GO TO
BA | FUNCT DESIG | REC-3DBA | WR47
CA | TERMINAL | REC-3DCA | WR47
WR47
LINE-COUNT 46
PERFORM WRITE-HEADS SECTION
WR48

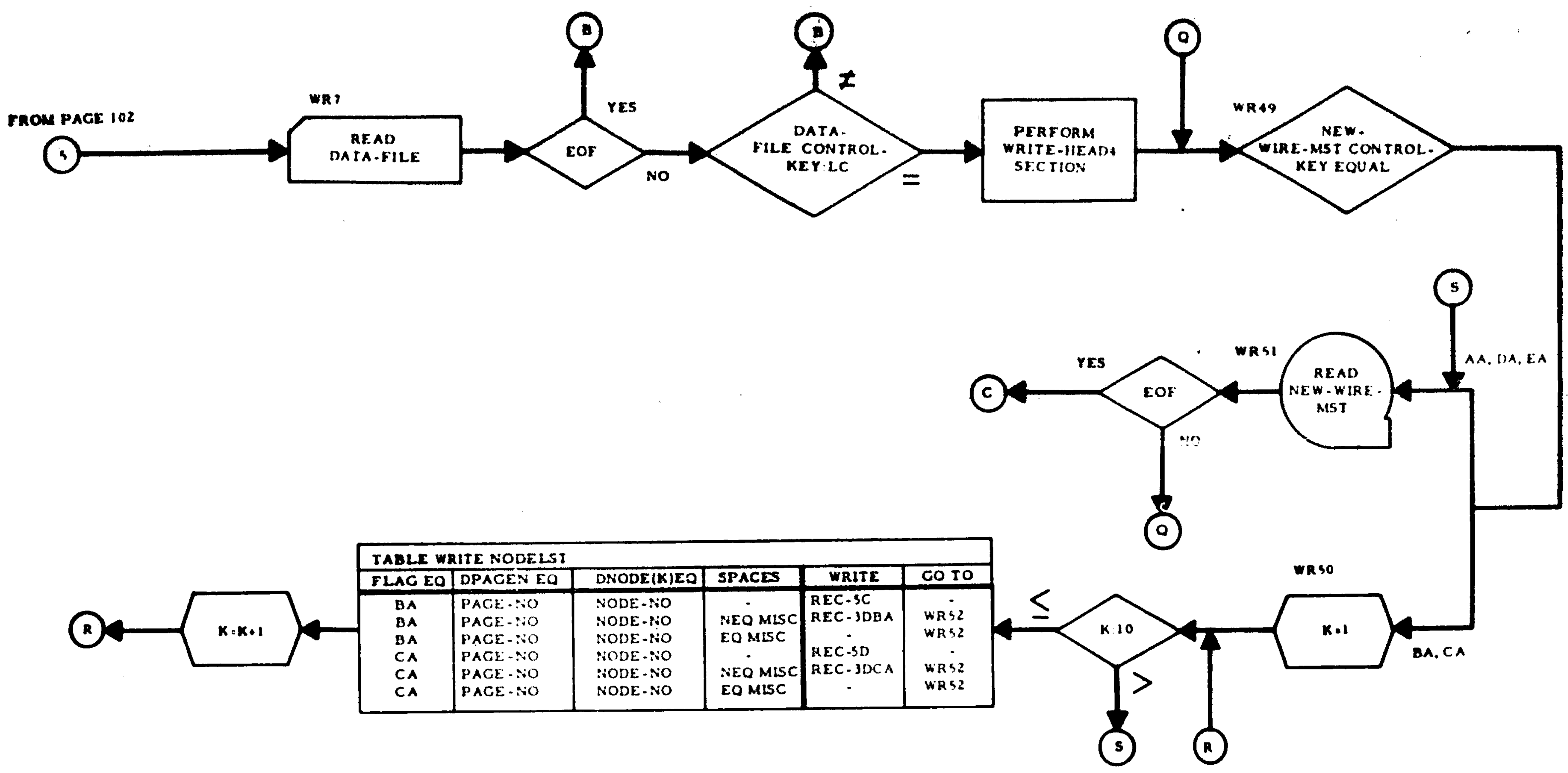


TABLE WRITE NODELST					
FLAG EQ	DPAGEN EQ	DNODE(K)EQ	SPACES	WRITE	GO TO
BA	PAGE-NO	NODE-NO	-	REC-5C	-
BA	PAGE-NO	NODE-NO	NEQ MISC	REC-3DBA	WR52
BA	PAGE-NO	NODE-NO	EQ MISC	-	WR52
CA	PAGE-NO	NODE-NO	-	REC-5D	-
CA	PAGE-NO	NODE-NO	NEQ MISC	REC-3DCA	WR52
CA	PAGE-NO	NODE-NO	EQ MISC	-	WR52

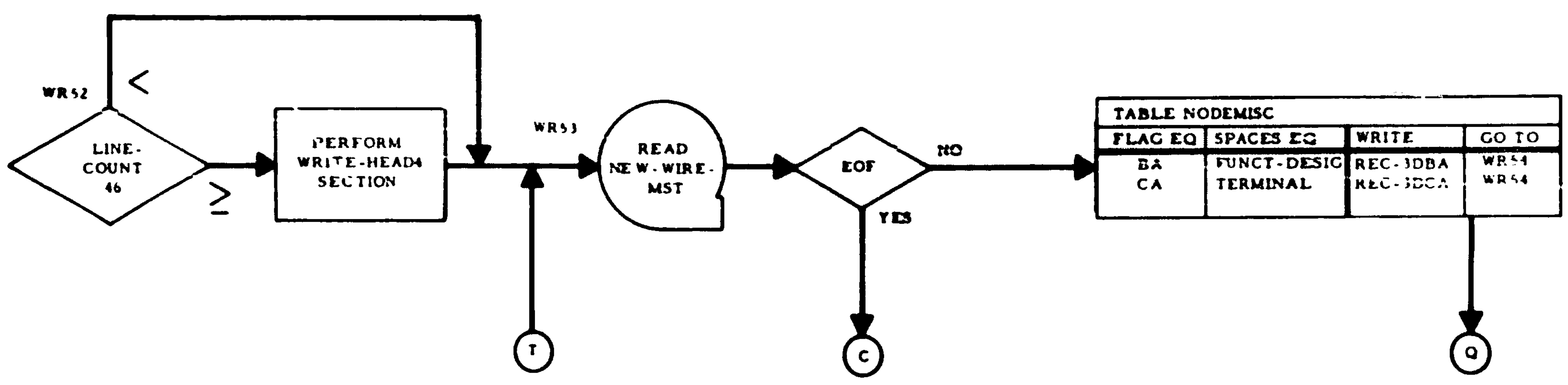


TABLE NODEMISC			
FLAG EQ	SPACES EQ	WRITE	GO TO
BA	FUNCT-DESIG	REC-3DBA	WR54
CA	TERMINAL	REC-3DCA	WR54

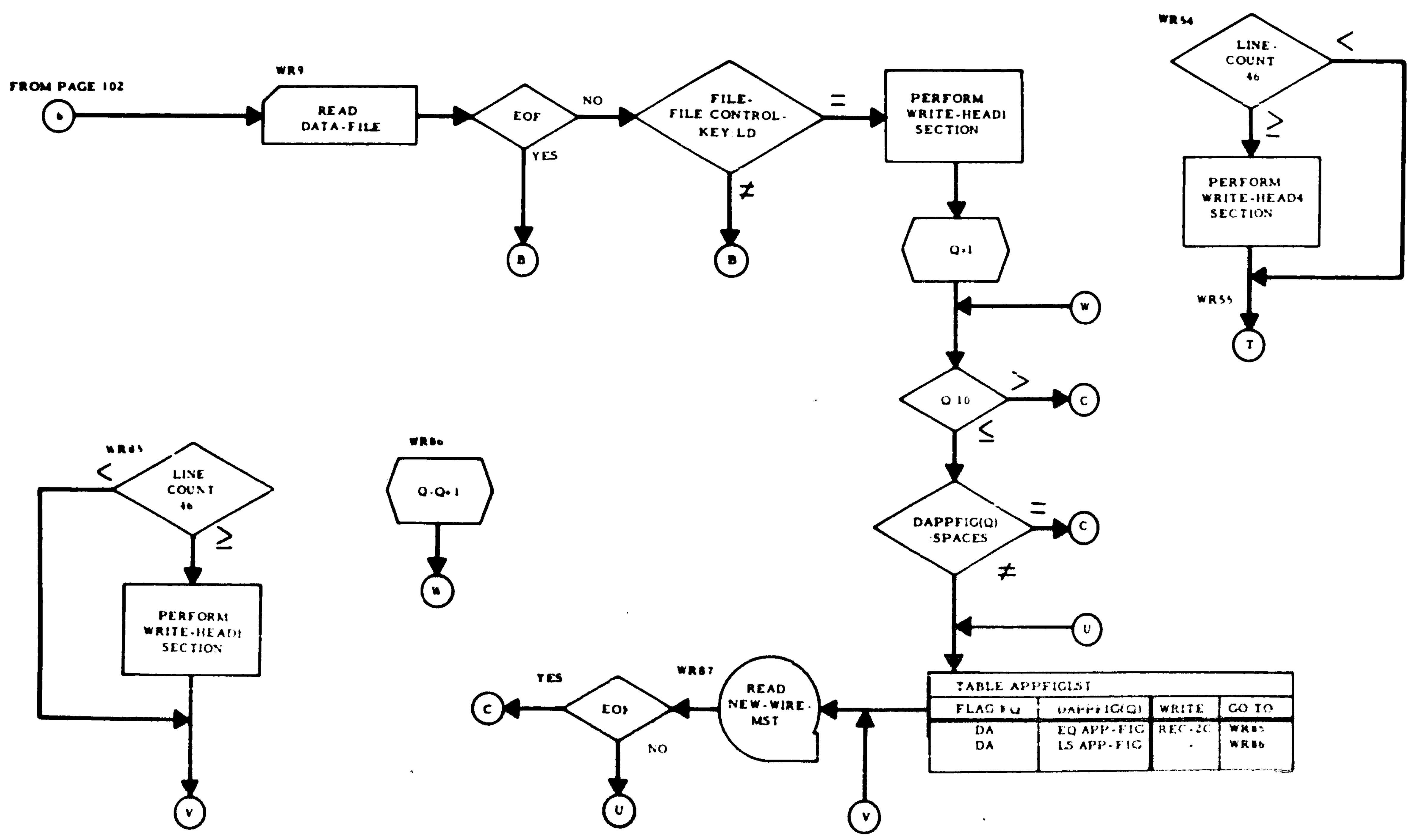
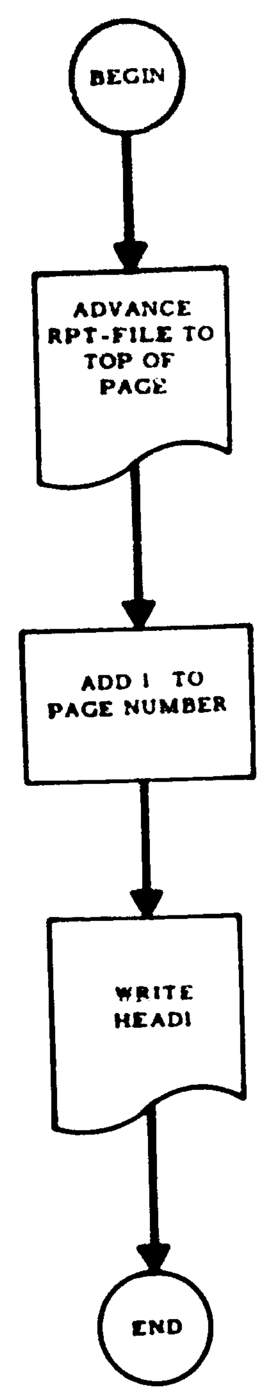
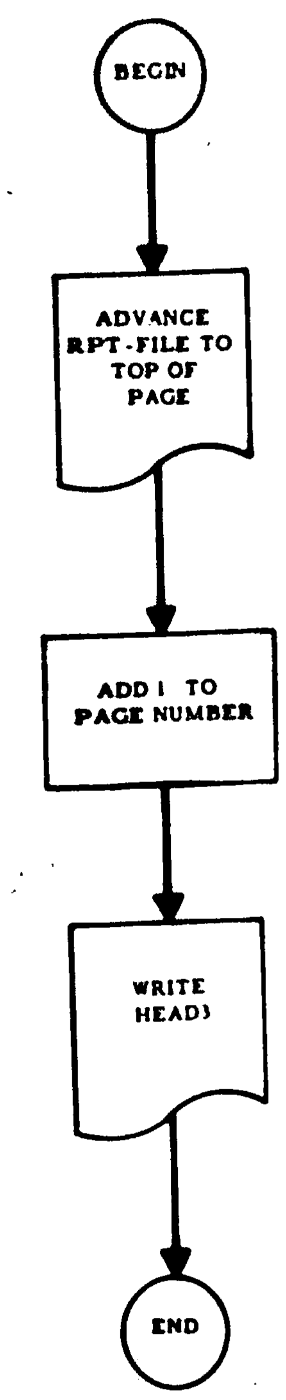


TABLE APPFIGLST			
FLAG EQ	DAPPFIG(Q)	WRITE	GO TO
DA	EQ APP-FIG	REC-2C	WR85
DA	LS APP-FIG	-	WR86

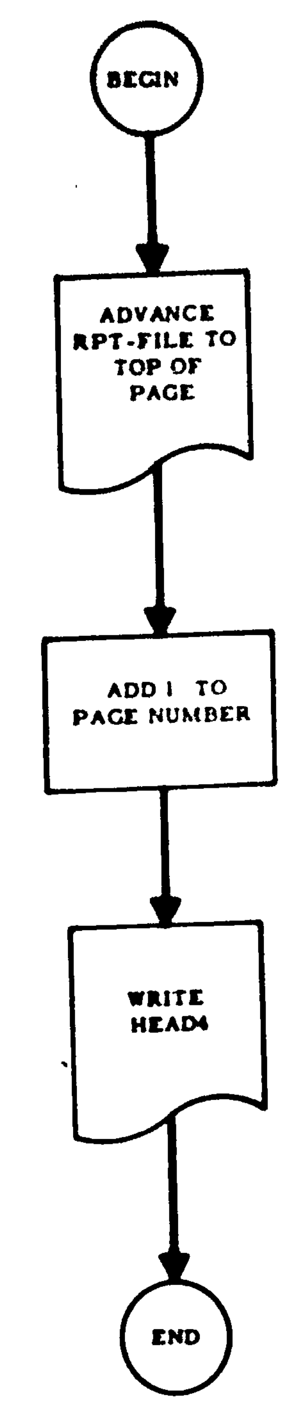
WRITE-HEAD1 SECTION



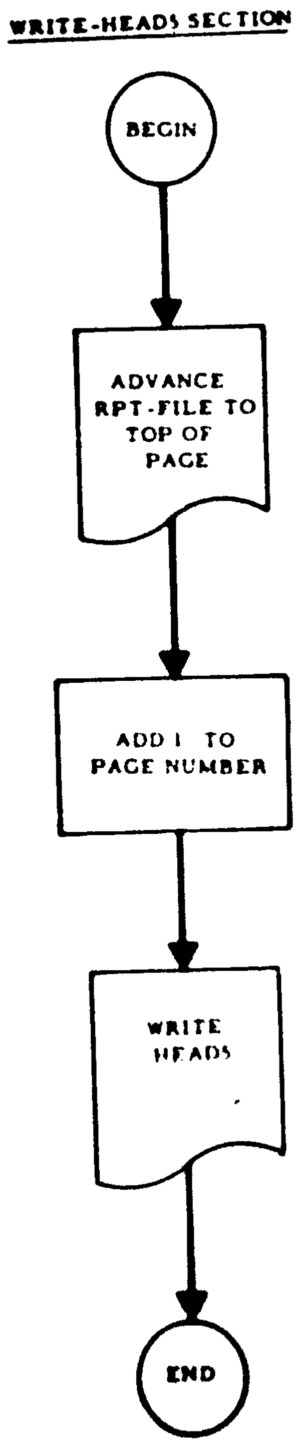
WRITE-HEAD3 SECTION



WRITE-HEAD4 SECTION



WRITE-HEAD5 SECTION



WRITE-HEAD6 SECTION

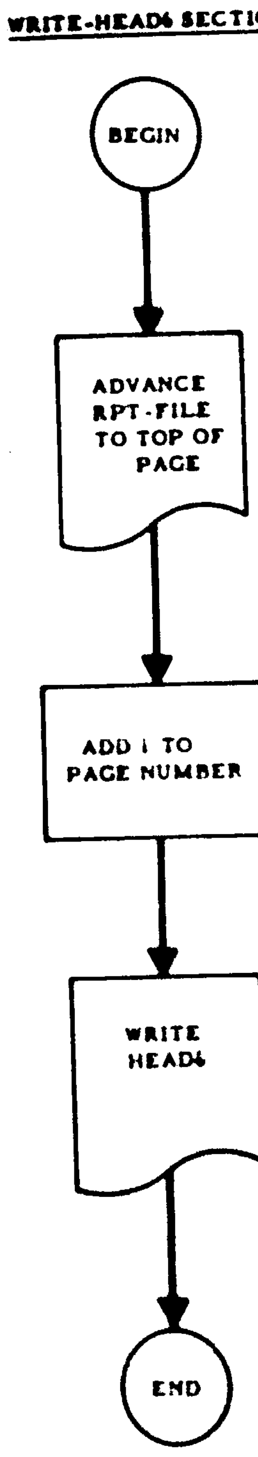
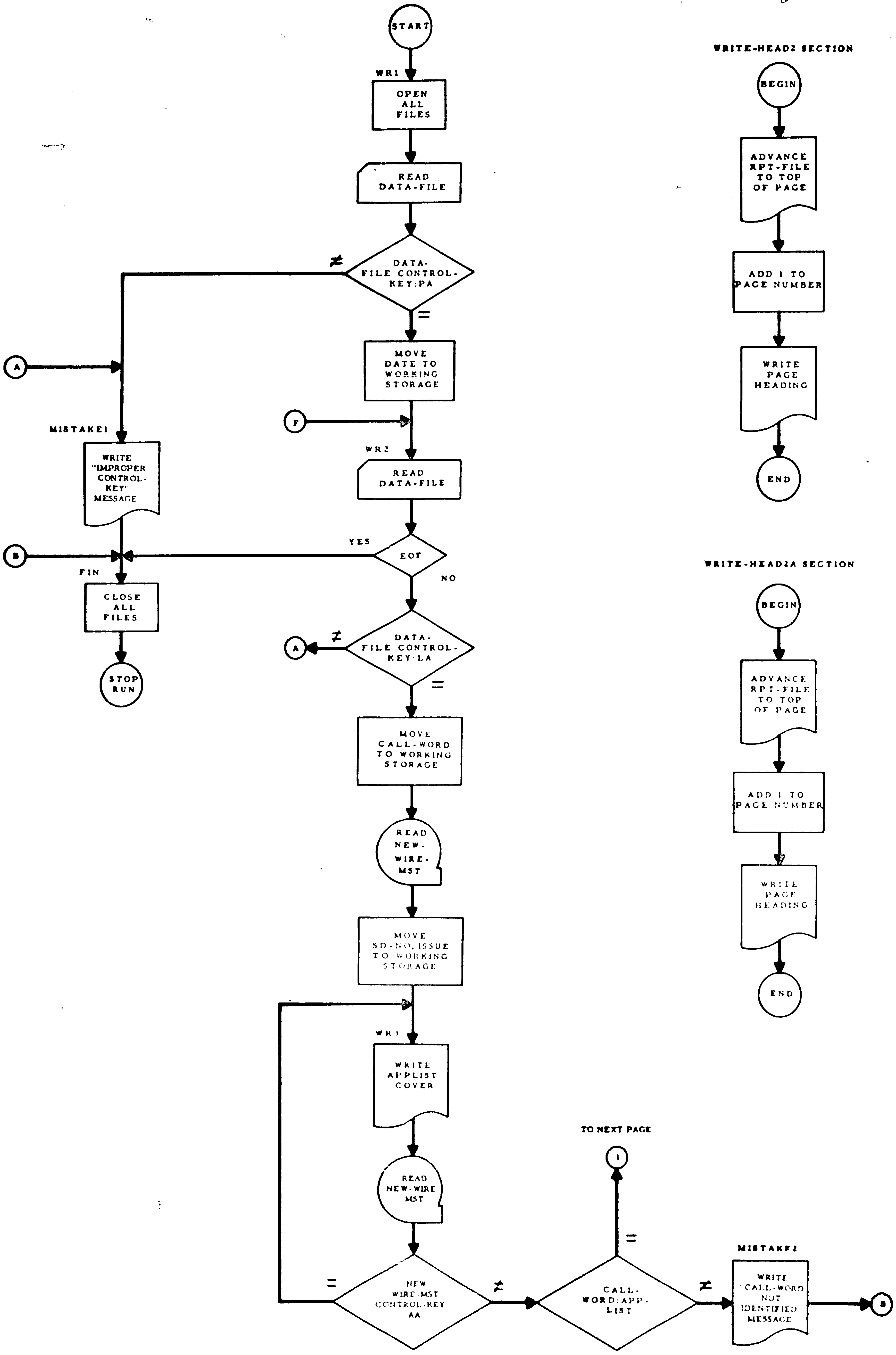


FIGURE 12

Flow Chart - APPLIST


START
WR1
OPEN ALL FILES
READ DATA-FILE
DATA-FILE CONTROL-KEY:PA
≠
=
MOVE DATE TO WORKING STORAGE
A
MISTAKE1
WRITE "IMPROPER CONTROL-KEY" MESSAGE
F
WR2
READ DATA-FILE
YES
EOF
NO
B
FIN
CLOSE ALL FILES
STOP RUN
DATA-FILE CONTROL-KEY:LA
A
MOVE CALL-WORD TO WORKING STORAGE
READ NEW-WIRE-MST
MOVE SD-NO, ISSUE TO WORKING STORAGE
WR3
WRITE APPLIST COVER
READ NEW-WIRE MST
NEW WIRE-MST CONTROL-KEY AA
CALL-WORD:APP-LIST
TO NEXT PAGE
1
MISTAKE2
WRITE "CALL-WORD NOT IDENTIFIED MESSAGE
B
WRITE-HEAD2 SECTION
BEGIN
ADVANCE RPT-FILE TO TOP OF PAGE
ADD 1 TO PAGE NUMBER
WRITE PAGE HEADING
END
WRITE-HEAD2A SECTION
BEGIN
ADVANCE RPT-FILE TO TOP OF PAGE
ADD 1 TO PAGE NUMBER
WRITE PAGE HEADING
END

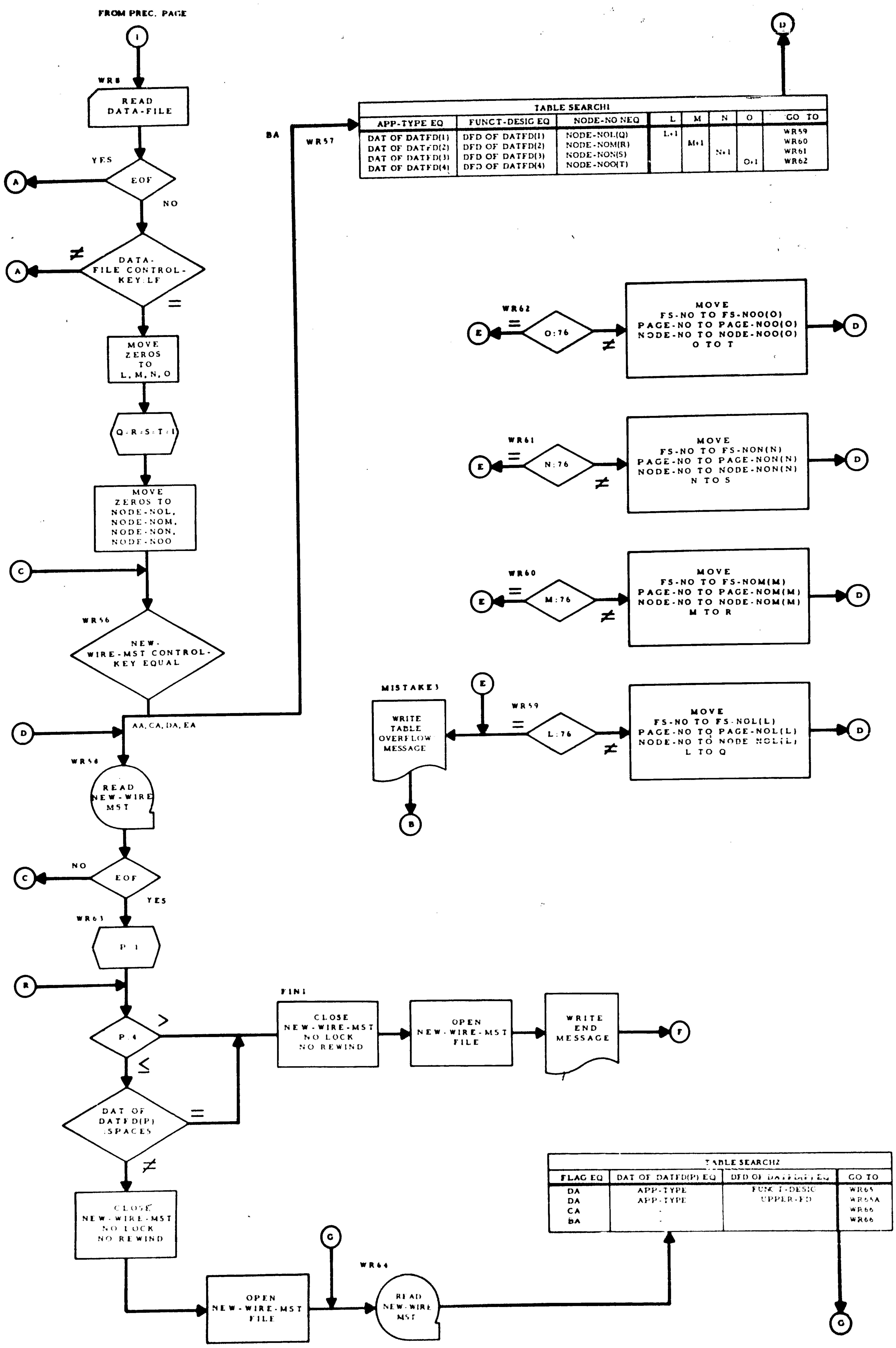


TABLE SEARCH1

APP-TYPE EQ	FUNCT-DESIG EQ	NODE-NO NEQ	L	M	N	O	GO TO
DAT OF DATFD(1)	DFD OF DATFD(1)	NODE-NOL(Q)	L+1				WR59
DAT OF DATFD(2)	DFD OF DATFD(2)	NODE-NOM(R)		M+1			WR60
DAT OF DATFD(3)	DFD OF DATFD(3)	NODE-NON(S)			N+1		WR61
DAT OF DATFD(4)	DFD OF DATFD(4)	NODE-NOO(T)				O+1	WR62

TABLE SEARCH2

FLAG EQ	DAT OF DATFD(P) EQ	DFD OF DATFD(P) EQ	GO TO
DA	APP-TYPE	FUNCT-DESIG	WR65
DA	APP-TYPE	UPPER-FD	WR65A
CA	-		WR66
BA	-		WR66

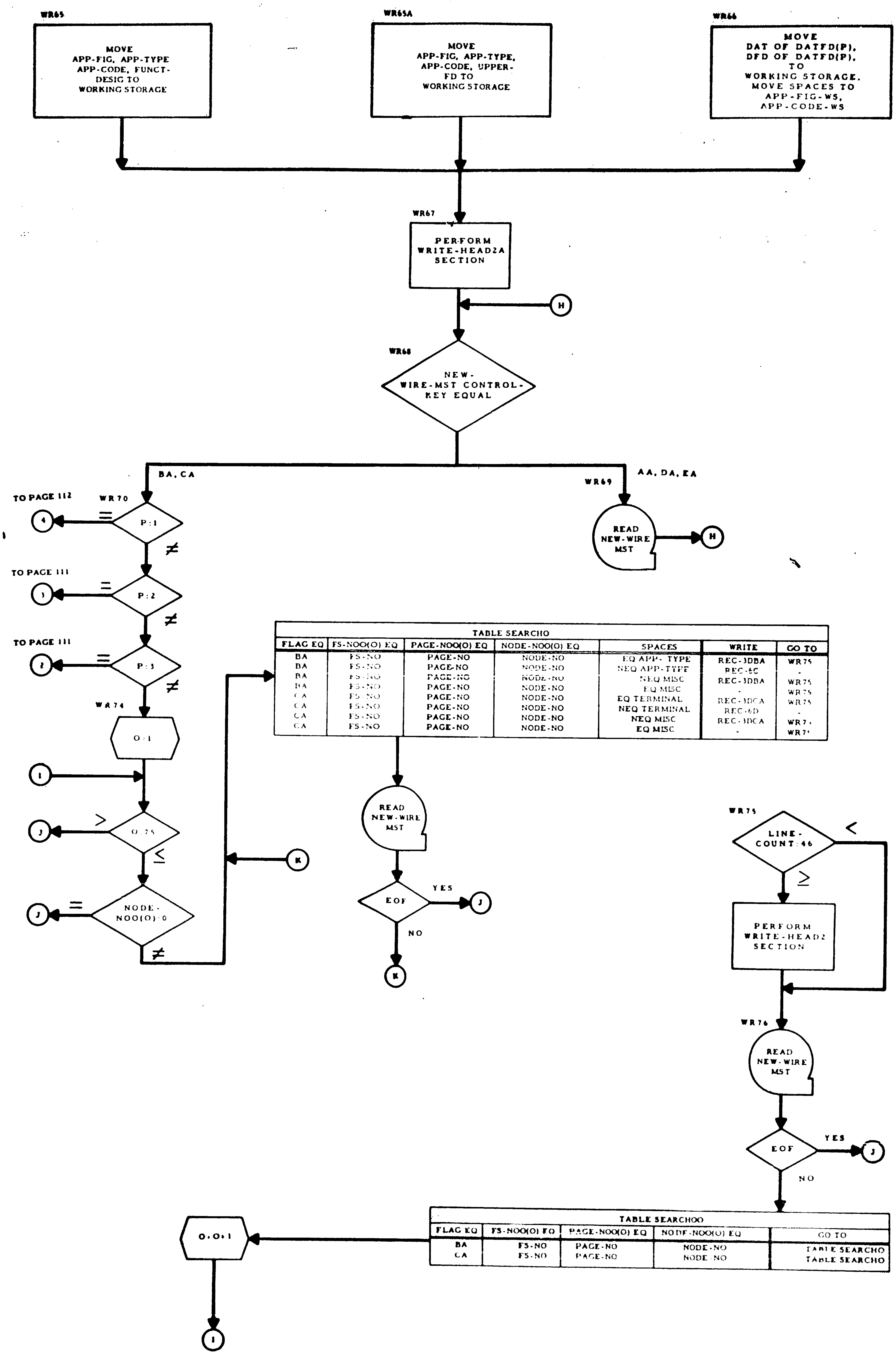


TABLE SEARCHO

FLAG EQ	FS-NOO(O) EQ	PAGE-NOO(O) EQ	NODE-NOO(O) EQ	SPACES	WRITE	GO TO
BA	FS-NO	PAGE-NO	NODE-NO	EQ APP-TYPE	REC-3DBA	WR75
BA	FS-NO	PAGE-NO	NODE-NO	NEQ APP-TYPE	REC-6C	-
BA	FS-NO	PAGE-NO	NODE-NO	NEQ MISC	REC-3DBA	WR75
BA	FS-NO	PAGE-NO	NODE-NO	EQ MISC	-	WR75
CA	FS-NO	PAGE-NO	NODE-NO	EQ TERMINAL	REC-3DCA	WR75
CA	FS-NO	PAGE-NO	NODE-NO	NEQ TERMINAL	REC-6D	-
CA	FS-NO	PAGE-NO	NODE-NO	NEQ MISC	REC-3DCA	WR7[illegible]
CA	FS-NO	PAGE-NO	NODE-NO	EQ MISC	-	WR7[illegible]

TABLE SEARCHOO

FLAG EQ	FS-NOO(O) EQ	PAGE-NOO(O) EQ	NODE-NOO(O) EQ	GO TO
BA	FS-NO	PAGE-NO	NODE-NO	TABLE SEARCHO
CA	FS-NO	PAGE-NO	NODE-NO	TABLE SEARCHO

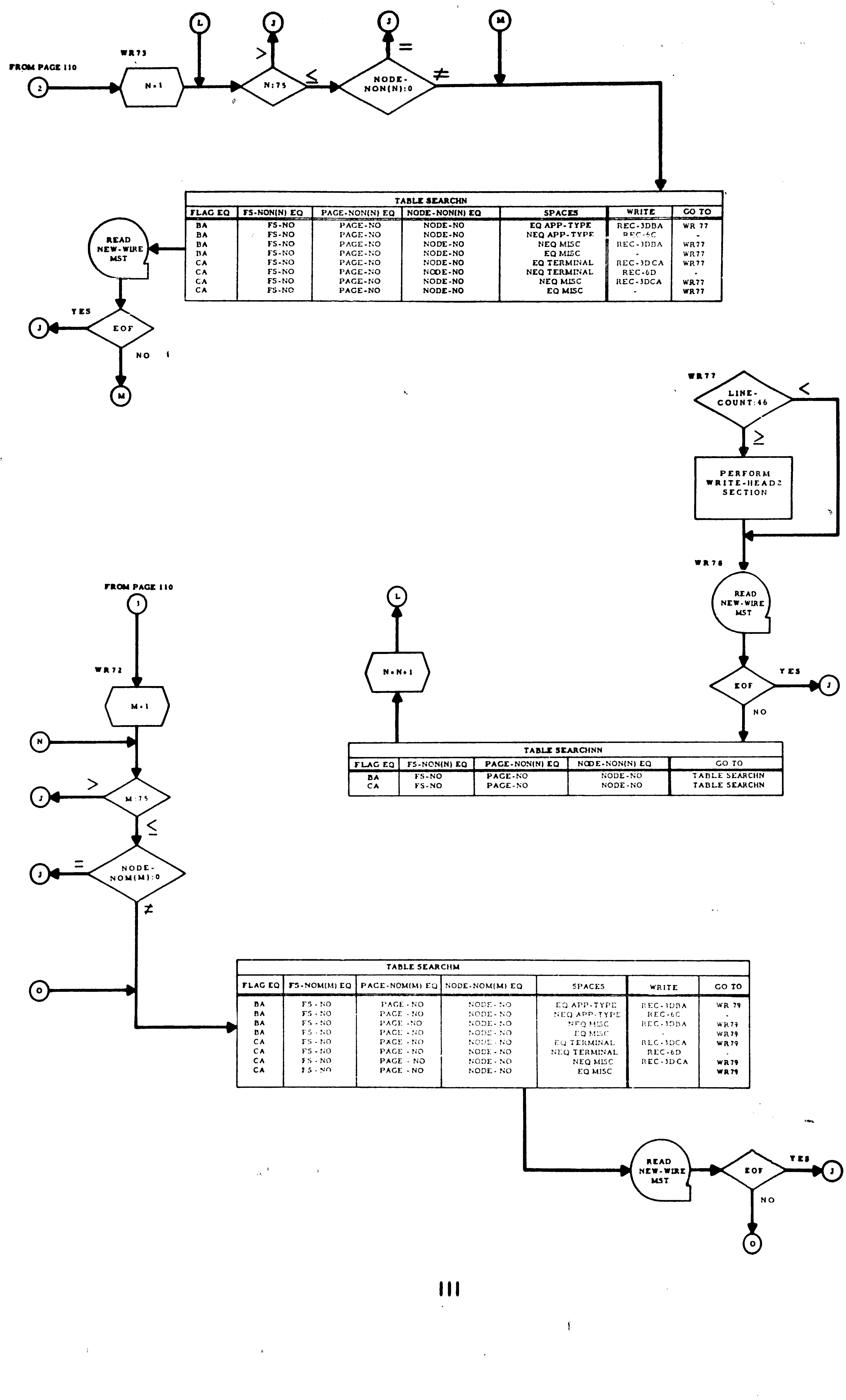


TABLE SEARCHN						
FLAG EQ	FS-NON(N) EQ	PAGE-NON(N) EQ	NODE-NON(N) EQ	SPACES	WRITE	GO TO
BA	FS-NO	PAGE-NO	NODE-NO	EQ APP-TYPE	REC-3DBA	WR 77
BA	FS-NO	PAGE-NO	NODE-NO	NEQ APP-TYPE	REC-6C	-
BA	FS-NO	PAGE-NO	NODE-NO	NEQ MISC	REC-3DBA	WR77
BA	FS-NO	PAGE-NO	NODE-NO	EQ MISC	-	WR77
CA	FS-NO	PAGE-NO	NODE-NO	EQ TERMINAL	REC-3DCA	WR77
CA	FS-NO	PAGE-NO	NODE-NO	NEQ TERMINAL	REC-6D	-
CA	FS-NO	PAGE-NO	NODE-NO	NEQ MISC	REC-3DCA	WR77
CA	FS-NO	PAGE-NO	NODE-NO	EQ MISC	-	WR77

TABLE SEARCHNN				
FLAG EQ	FS-NON(N) EQ	PAGE-NON(N) EQ	NODE-NON(N) EQ	GO TO
BA	FS-NO	PAGE-NO	NODE-NO	TABLE SEARCHN
CA	FS-NO	PAGE-NO	NODE-NO	TABLE SEARCHN

TABLE SEARCHM						
FLAG EQ	FS-NOM(M) EQ	PAGE-NOM(M) EQ	NODE-NOM(M) EQ	SPACES	WRITE	GO TO
BA	FS-NO	PAGE-NO	NODE-NO	EQ APP-TYPE	REC-3DBA	WR 79
BA	FS-NO	PAGE-NO	NODE-NO	NEQ APP-TYPE	REC-6C	-
BA	FS-NO	PAGE-NO	NODE-NO	NEQ MISC	REC-3DBA	WR79
BA	FS-NO	PAGE-NO	NODE-NO	EQ MISC	-	WR79
CA	FS-NO	PAGE-NO	NODE-NO	EQ TERMINAL	REC-3DCA	WR79
CA	FS-NO	PAGE-NO	NODE-NO	NEQ TERMINAL	REC-6D	-
CA	FS-NO	PAGE-NO	NODE-NO	NEQ MISC	REC-3DCA	WR79
CA	FS-NO	PAGE-NO	NODE-NO	EQ MISC		WR79

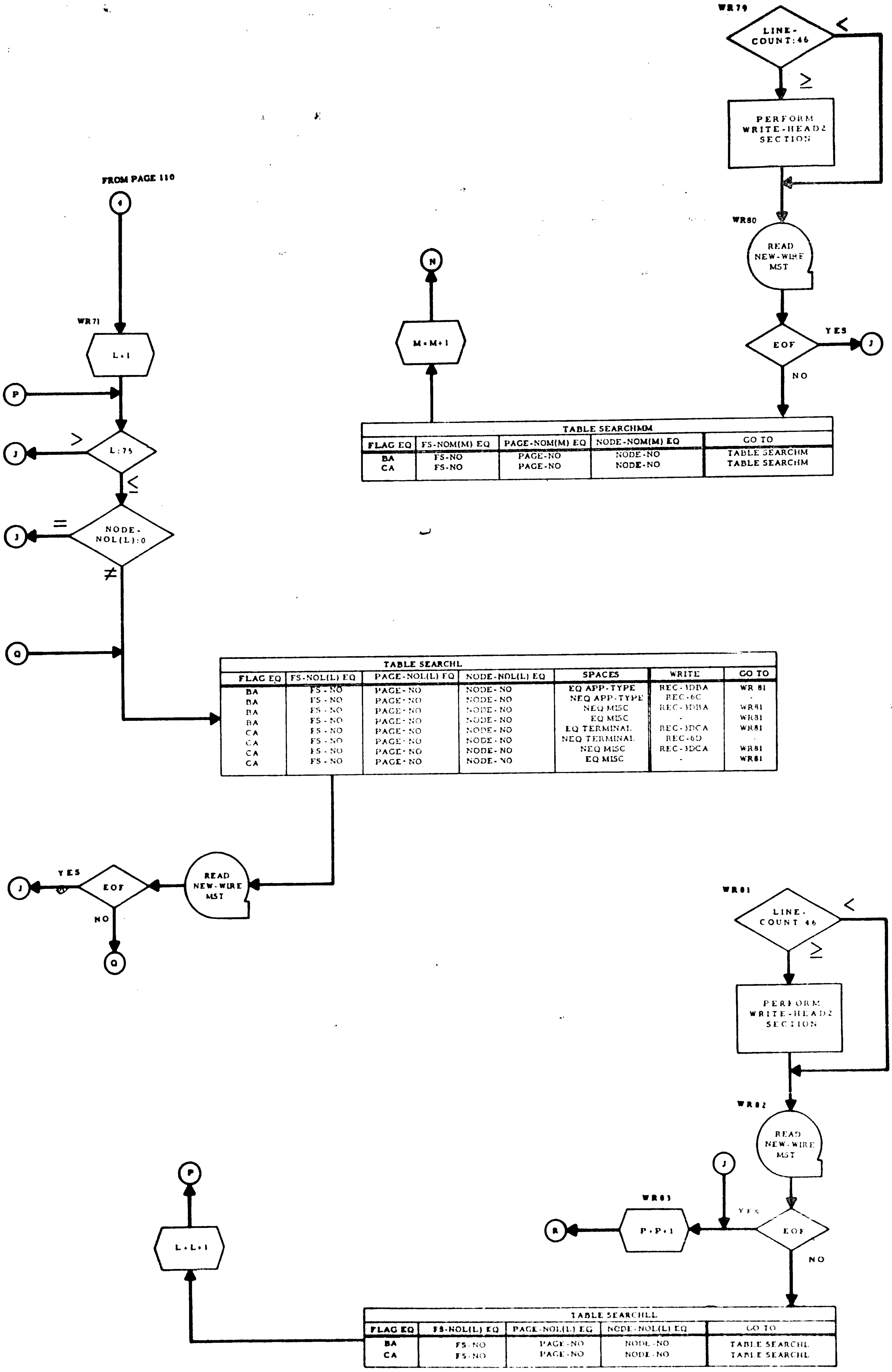


TABLE SEARCHMM

FLAG EQ	FS-NOM(M) EQ	PAGE-NOM(M) EQ	NODE-NOM(M) EQ	GO TO
BA	FS-NO	PAGE-NO	NODE-NO	TABLE SEARCHM
CA	FS-NO	PAGE-NO	NODE-NO	TABLE SEARCHM

TABLE SEARCHL

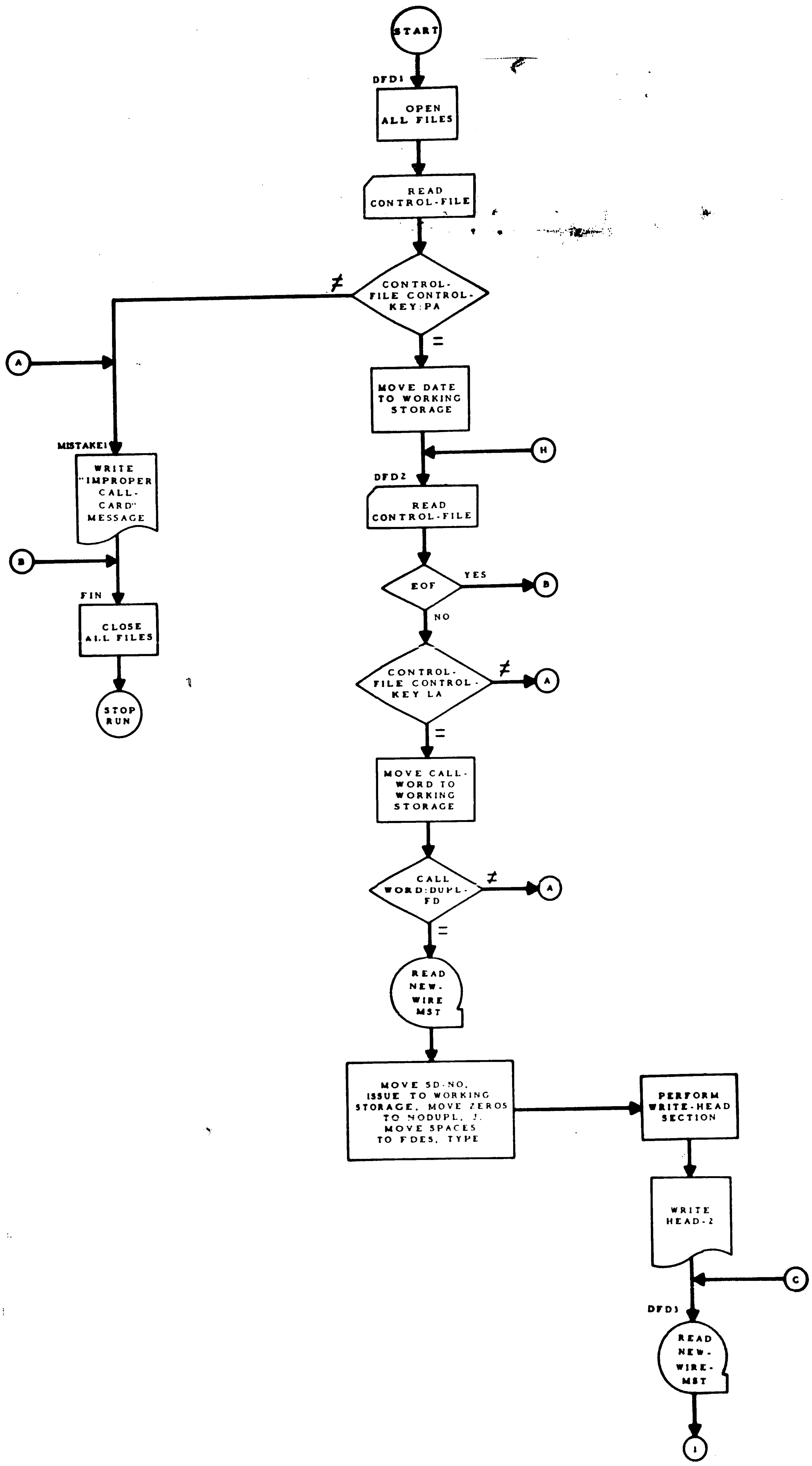
FLAG EQ	FS-NOL(L) EQ	PAGE-NOL(L) EQ	NODE-NOL(L) EQ	SPACES	WRITE	GO TO
BA	FS-NO	PAGE-NO	NODE-NO	EQ APP-TYPE	REC-3DBA	WR 81
BA	FS-NO	PAGE-NO	NODE-NO	NEQ APP-TYPE	REC-6C	-
BA	FS-NO	PAGE-NO	NODE-NO	NEQ MISC	REC-3DBA	WR81
BA	FS-NO	PAGE-NO	NODE-NO	EQ MISC	-	WR81
CA	FS-NO	PAGE-NO	NODE-NO	EQ TERMINAL	REC-3DCA	WR81
CA	FS-NO	PAGE-NO	NODE-NO	NEQ TERMINAL	REC-6D	-
CA	FS-NO	PAGE-NO	NODE-NO	NEQ MISC	REC-3DCA	WR81
CA	FS-NO	PAGE-NO	NODE-NO	EQ MISC	-	WR81

TABLE SEARCHLL

FLAG EQ	FS-NOL(L) EQ	PAGE-NOL(L) EQ	NODE-NOL(L) EQ	GO TO
BA	FS-NO	PAGE-NO	NODE-NO	TABLE SEARCHL
CA	FS-NO	PAGE-NO	NODE-NO	TABLE SEARCHL

FIGURE 13

Flow Chart - DUPLICATEFD


START
DFD1
OPEN ALL FILES
READ CONTROL-FILE
CONTROL-FILE CONTROL-KEY:PA
≠
=
A
MOVE DATE TO WORKING STORAGE
H
MISTAKE1
WRITE "IMPROPER CALL-CARD" MESSAGE
B
FIN
CLOSE ALL FILES
STOP RUN
DFD2
READ CONTROL-FILE
EOF
YES
NO
CONTROL-FILE CONTROL-KEY LA
MOVE CALL-WORD TO WORKING STORAGE
CALL WORD:DUPL-FD
READ NEW-WIRE MST
MOVE SD-NO, ISSUE TO WORKING STORAGE, MOVE ZEROS TO NODUPL, J. MOVE SPACES TO FDES, TYPE
PERFORM WRITE-HEAD SECTION
WRITE HEAD-2
C
DFD3
READ NEW-WIRE-MST
I
TO NEXT PAGE

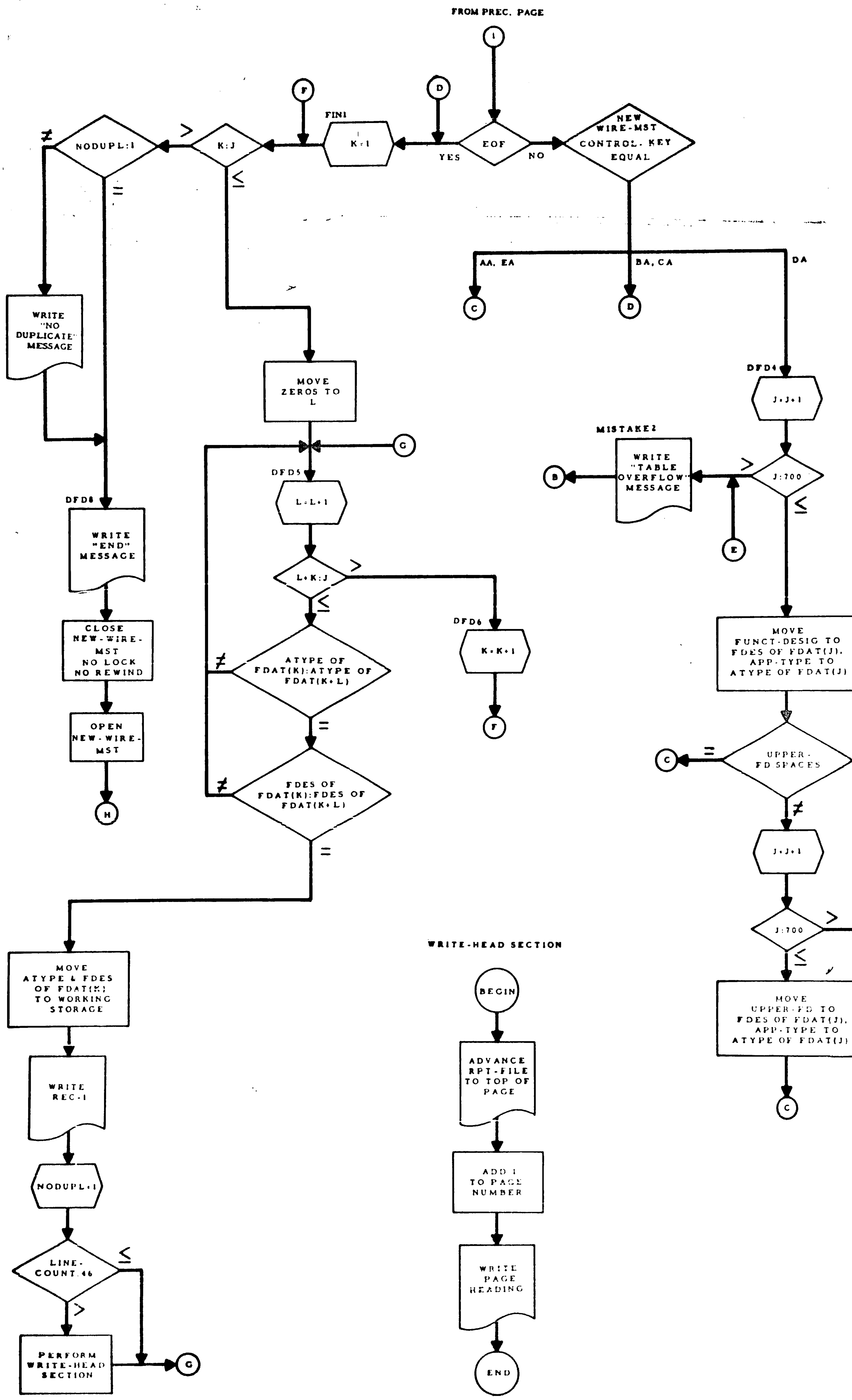

FROM PREC. PAGE
NEW WIRE-MST CONTROL-KEY EQUAL
EOF
YES
NO
FIN1
K+1
K:J
NODUPL:1
AA, EA
BA, CA
DA
WRITE "NO DUPLICATE" MESSAGE
MOVE ZEROS TO L
DFD5
L+L+1
L+K:J
DFD6
K+K+1
ATYPE OF FDAT(K):ATYPE OF FDAT(K+L)
FDES OF FDAT(K):FDES OF FDAT(K+L)
DFD8
WRITE "END" MESSAGE
CLOSE NEW-WIRE-MST NO LOCK NO REWIND
OPEN NEW-WIRE-MST
DFD4
J+J+1
MISTAKE2
WRITE "TABLE OVERFLOW" MESSAGE
J:700
MOVE FUNCT-DESIG TO FDES OF FDAT(J), APP-TYPE TO ATYPE OF FDAT(J)
UPPER-FD SPACES
J+J+1
J:700
MOVE UPPER-FD TO FDES OF FDAT(J), APP-TYPE TO ATYPE OF FDAT(J)
MOVE ATYPE & FDES OF FDAT(K) TO WORKING STORAGE
WRITE REC-1
NODUPL+1
LINE-COUNT:46
PERFORM WRITE-HEAD SECTION
WRITE-HEAD SECTION
BEGIN
ADVANCE RPT-FILE TO TOP OF PAGE
ADD 1 TO PAGE NUMBER
WRITE PAGE HEADING
END

FIGURE 14

Output - MASTER APPARATUS LIST

117

MASTER APPARATUS LIST

DEC 6, 1963

APPARATUS TYPE	APPARATUS CODE	CONTACTS OR TERMINALS
BIAS CORE	2604B	1
		2
		3
		4
		5
		6
		7
		8
CAP	437A	A
		B
CAP	513C	1
		2
CAP	535EA	PT
CAP	535GA	PT
CAP	601A	PT
CAP	601E	PT
CAP	KS14056,L6-220	PT
CAP	KS19066,L1-.0056	PT
CP	A4	0
		1
		2
		3
		4
		5
		6
		7
		8
		9

118

APPARATUS TYPE	APPARATUS CODE	CONTACTS OR TERMINALS
CP	A35	17 (CONT)
		18
		19
		20
		21
		22
		23
		24
		25
		26
		27
DIO	426AC	1
		2
INDR	1037A	1
		2
KEY	KS19223,L2	1B
		2B
		3B
		4B
		1T
		2T
		3T
		4T
		5T
LP	A3	1
		2
NET	185A	PT
NET	185C	PT

APPARATUS TYPE	APPARATUS CODE	CONTACTS OR TERMINALS
NET	186D	PT
REL	303A	1
		3
		5
		6
		8
REL	303G	1
		3
		4
		5
		6
		7
		8
REL	AJ5	1B
		2B
		3B
		4B
		5B
		6B
		7B
		8B
		9B
		10B
		11B
		12B
		1F
		2F
		3F

APPARATUS TYPE	APPARATUS CODE	CONTACTS OR TERMINALS
REL	AK6	10M (CONT)
		11M
		12M
		1U
		2U
		1L
		2L
RES	18R	1
		2
RES	18CJ	1
		2
RES	18FC	1
		2
RES	19EY	1
		2
		3
RES	KS8512,L11-10	PT
RES	KS13492,L2-2200	PT
RES	KS14603,L1A-316	PT
RES	KS14603,L1A-619	PT
RES	KS14603,L1D-562	PT
RES	KS14603,L3B-301	PT
RES	KS19150,L2-1000	PT
RES	KS19150,L2-1800	PT
RES	KS19150,L2-8200	PT
RES	KS19150,L2-27000	PT
RES	KS19150,L2-0.1MEG	PT
RES	KS19151,L2-680	PT

APPARATUS TYPE	APPARATUS CODE	CONTACTS OR TERMINALS
SW	242A	38R (CONT)
		39R
TRNSF	2074A	1
		2
		3
		4
		5
		6
TRSTR	34A	B
		C
		E

122

END MASTER APPARATUS LIST

FIGURE 15

Output - UNIT LIST

124

UNIT LIST

DEC 6, 1963

J1A030

UNIT	QTY	APPARATUS CODE, GROUP OR LIST, OR PART NO.	APPARATUS TYPE, SUB UNIT OR DESC.	FUNCT DESIG	POSITION
J1A030A-1	1	1	J1A030AA-1		
A-1	1	1	J1A030AB-1		
A-1	1	1	J1A030AD-1		
A-1	1	1	J1A030AF-1		
A-1	1	1	J1A030AR-1		
A-1	1	1	J1A030AG-1		
A-1	1	1	J1A030AH-1		
	1	SA			
A-1	1	1	J1A030AH-1		
	1	SB			
A-1	1	1	J1A030AH-1		
	1	SC			
A-1	1	1	J1A030AH-1		
	1	SD			
A-1	1	1	J1A030AM-1		
A-1	1	1	J1A030AN-1		
A-1	1	1	J1A053A-1		
A-1	1	1	J1A053B-1		
A-1	1	2	ED1A151-70		
	1	C			
A-1	2	4	ED1A157-70		
A-1	1	P-45G418	VERT GRD BUS		
A-1	6	P-45G785	GROMMET		
A-1	3	P-45G781	CAPS		
A-1	6	P-45G032	CABLE ASSY		
A-1	2	P-45G032	STA-KON TERMS T-B CAT NO C126		
A-1	7	P-45G414	CABLE RING		
A-1	2	P-45G415	CABLE BKT		

UNIT	QTY	APPARATUS CODE, GROUP OR LIST, OR PART NO.	APPARATUS TYPE, SUB UNIT OR DESC.	FUNCT DESIG	POSITION
J1A030A-1	2	P-45G416	CABLE BKT		
A-1	4	P-45G439	CABLE SUPPORT		
A-1	5	P-423662	CLIP		
A-1	2		SNAP BUSHING HEYMAN MFG CO KENILWORTH NJ CAT NO SB100-12		
A-1	3	P-43A298	RHST SCR .164-32 X 11/16		
A-1	18	P-41C930	PHST SCR .138-32 X 1/2		
A-1	2	P-353449	RHM SCR .216-24 X 3/4		
A-1	11	P-174399	PHST SCR .216-24 X 1		
AA-1	2	P-45G804	MTG BAR		
AA-1	1	286A	MTG PLATE		
AA-1	1	2598M	TRNSF	0AD	8B
AA-1	1	2598M	TRNSF	1AD	72B
AA-1	1	2598R	TRNSF	0AD	24B
AA-1	1	2598R	TRNSF	1AD	88B
AA-1	1	288M	TS	0C	40B
AA-1	1	288M	TS	MISC	56B
AA-1	1	288M	TS	1C	104B
AA-1	1	KS16645,L2-100	RES	TR40.0	24R
AA-1	1	KS16645,L2-100	RES	TR41.0	24R
AA-1	1	KS16645,L2-100	RES	TR40.1	88R
AA-1	1	KS16645,L2-100	RES	TR41.1	88R
AA-1	1	286B	MTG PLATE		
AA-1	1	36A	APP MTG		1
AA-1	1	36A	APP MTG		2
AA-1	1	905A	CONN		3
AA-1	1	905A	CONN		4
AA-1	1	905A	CONN		5
AA-1	1	905A	CONN		6

UNIT	QTY	APPARATUS CODE, GROUP OR LIST, OR PART NO.	APPARATUS TYPE, SUB UNIT OR DESC.	FUNCT DESIG	POSITION
J1A030AM-1	8	72A	FUSE DUMMY		
AM-1	13	KS14174,L1	DESIG PIN		
AM-1	2	KS14174,L2	DESIG PIN	SWA1	
AM-1	2	KS14174,L2	DESIG PIN	SWB1	
AM-1	1	KS8512,L4A-178	RES		36R
AM-1	1	KS8512,L4A-178	RES		42R
AM-1	1	KS8512,L4A-178	RES		62R
AM-1	1	KS8512,L4A-178	RES		68R
AM-1	1	KS8512,L4A-825	RES		10R
AM-1	1	KS8512,L4A-825	RES		16R
AM-1	12	P-374596	WASHER,CUP SPRING		
AM-1	12	P-95836	WASHER,MICA		
AM-1	2	P-338014	ALARM TERM BUS BAR		
AM-1	6	KS15977,L13	CONN		
AM-1	12	P-181358	BHM SCR .138-32 X 3/8		
AM-1	12	P-183146	LOCK WASHER .022-.320		
AM-1	24	P-386216	HEX NUT .138-32		
AM-1	6		TERMINAL STA-KON T-B CAT NO C126U		
AM-1	6		HEAT SHRINKABLE INS. T-B CAT NO N375-2		
AM-1	6	P-181470	RHM SCR .164-32 X 1 1/4		
AM-1	4	P-182142	BHM SCR .216-24 X 1/4		
AM-1	1	P-174399	PHST SCR .216-24 X 1		
AM-1	2	P-148634	RHM SCR .216-24 X 1/4		
AM-1	1	P-388493	PHST SCR .216-24 X 5/8		
AN-1	2	P-45G801	MTG BAR		
AN-1	1	285A(1H21)	MTG PLATE		
AN-1	1	AK6	REL		7
AN-1	1	19EY	RES		16

UNIT	QTY	APPARATUS CODE, GROUP OR LIST, OR PART NO.	APPARATUS TYPE, SUB UNIT OR DESC.	FUNCT DESIG	POSITION
J1A030AN-1	1	19EY	RES		20
AN-1	1	AJ5	REL		29
AN-1	1	AJ5	REL		41
AN-1	1	AF11	REL		79
AN-1	2	185C	NET		7R
AN-1	1	185C	NET		29R
AN-1	1	185C	NET		41R
AN-1	1	185A	NET	N	79R
AN-1	1	186A	NET	P	79R
AN-1	1	KS19150,L2-560	RES	SS00	79R
AN-1	1	KS19150,L2-3900	RES	SC00	79R
AN-1	1	210A	TERM		88R
AN-1	1	P-174399	PHST SCR .216-24 X 1		
AN-1	2	P-148634	RHM SCR .216-24 X 1/4		
AN-1	1	P-388493	PHST SCR .216-24 X 5/8		
AP-1	1	P-45G534	MTG PANEL		
AP-1	1	P-45G789	BKT		
AP-1	1	P-45G500	HOUSING ASSY		
AP-1	4	KS14523,L1	CONN		
AP-1	1	KS19150,L2-12000	RES	HRG	
AP-1	1	122A	DES STRIP		
AP-1	3	306A	TS		
AP-1	1	P-45G526	PANEL ASSY		
AP-1	1	P-45G505	JK MTG		
AP-1	2	223A	JK	TEL	
AP-1	1	238A	JK	SP	
AP-1	4	KS14523,L1	CONN		
AP-1	4	P-45G539	MTG BKT		

UNIT	QTY	APPARATUS CODE, GROUP OR LIST, OR PART NO.	APPARATUS TYPE, SUB UNIT OR DESC.	FUNCT DESIG	POSITION
J1A030AR-1	1	KS14056,L6-220	CAP	C116.0	
AR-1	1	KS14056,L6-220	CAP	C116.1	
AR-1	1	535GA	CAP	C117.0	
AR-1	1	535GA	CAP	C117.1	
AR-1	2		LUG ZIERICK MFG CO NEW ROCHELLE,NY. CAT NO 7		
AR-1	4	P-388493	PHST SCR .216-24 X 5/8		
AR-1	8	P-353501	RHM SCR .216-24 X 5/16		
AR-1	4	P-180781	RHM SCR .099-48 X 5/16		
AR-1	4	P-384948	HEX NUT .099-48		
AR-1	24	P-210800	RHM SCR .112-40 X 1/4		
AR-1	24	P-210828	HEX NUT .112-40		
AR-1	4	P-205654	FHM SCR .164-32 X 3/8		
AR-1	4	P-206519	RHM SCR .164-32 X 3/8		
AR-1	4	P-125949	RHM SCR .138-32 X 1/2		
AR-1	4	P-125952	HEX NUT .138-32		
AR-1	8	P-206518	HEX NUT .164-32		

END UNIT REPORT

FIGURE 16

Output - APP LIST

SD-1A107-01

ISSUE 1

APP LIST

DEC 6, 1963

ELECTRONIC SWITCHING SYSTEMS
NO 1
TRUNK SWITCHING CIRCUIT

131

APPARATUS TYPE	FUNCT DESIG	APP FIG	APP CODE
REL	P13	0003	AJ703

FS	PAGE	NODE	CONTACT	FUNCT DESIG	APPARATUS TYPE	OPT	GA	TYPE	COLOR	WIRING METHOD
1	11	76	25	3204	CP					
1	11	76	1U	P13	REL					
1	11	76	PT	P13A	NET					
1	14	58	25	3220	CP					
1	14	58	2U	P13	REL					
1	14	58	PT	P13B	NET					
2	17	10	8	2611	CP					
2	17	10	1L	P10	REL					
2	17	10	PT	P10A	NET					
2	17	10	1L	P11	REL					
2	17	10	PT	P11A	NET					
2	17	10	1L	P12	REL					
2	17	10	PT	P12A	NET					
2	17	10	1L	P13	REL					
2	17	10	PT	P13A	NET					
2	17	10	1L	P14	REL					
2	17	10	PT	P14A	NET					
2	17	10	1L	P15	REL					
2	17	10	PT	P15A	NET					
2	17	10	1L	P16	REL					
2	17	10	PT	P16A	NET					
2	17	10	1L	P17	REL					
2	17	10	PT	P17A	NET					
2	18	16	8	2427	CP					

FS	PAGE	NODE	CONTACT	FUNCT DESIG	APPARATUS TYPE	OPT	GA	TYPE	COLOR	WIRING METHOD
2	18	16	2L	P10	REL					
2	18	16	PT	P10B	NET					
2	18	16	2L	P11	REL					
2	18	16	PT	P11B	NET					
2	18	16	2L	P12	REL					
2	18	16	PT	P12B	NET					
2	18	16	2L	P13	REL					
2	18	16	PT	P13B	NET					
2	18	16	2L	P14	REL					
2	18	16	PT	P14B	NET					
2	18	16	2L	P15	REL					
2	18	16	PT	P15B	NET					
2	18	16	2L	P16	REL					
2	18	16	PT	P16B	NET					
2	18	16	2L	P17	REL					
2	18	16	PT	P17B	NET					
6	24	06	PT	R7	RES					
6	24	06	24F	P10	REL					
6	24	06	24F	P11	REL					
6	24	06	24F	P12	REL					
6	24	06	24F	P13	REL					
6	24	06	24F	P14	REL					
6	24	06	24F	P15	REL					
6	24	06	24F	P16	REL					
6	24	06	24F	P17	REL					
6	24	12	9F	T0	REL					
6	24	12	24M	P10	REL					
6	24	12	24M	P11	REL					
6	24	12	24M	P12	REL					
6	24	12	24M	P13	REL					

APPARATUS TYPE	FUNCT DESIG	APP FIG	APP CODE
SW	003	0006	242A

FS	PAGE	NODE	CONTACT	FUNCT DESIG	APPARATUS TYPE	OPT	GA	TYPE	COLOR	WIRING METHOD
9	28	01	09R	003	SW					
9	28	01	10R	003	SW					
9	28	06	4F	P10	REL		24	BU		
9	28	06	00R	003	SW		24	BU		
9	28	07	4F	P11	REL		24	BU		
9	28	07	01R	003	SW		24	BU		
9	28	08	4F	P12	REL		24	BU		
9	28	08	02R	003	SW		24	BU		
9	28	09	4F	P13	REL		24	BU		
9	28	09	03R	003	SW		24	BU		
9	28	10	4F	P14	REL		24	BU		
9	28	10	04R	003	SW		24	BU		
9	28	11	4F	P15	REL		24	BU		
9	28	11	05R	003	SW		24	BU		
9	28	12	4F	P16	REL		24	BU		
9	28	12	06R	003	SW		24	BU		
9	28	13	4F	P17	REL		24	BU		
9	28	13	07R	003	SW		24	BU		
9	28	14	19R	003	SW		24	BU		
9	28	14	8F	P33	REL		24	BU		
9	28	15	18R	003	SW		24	BU		
9	28	15	7M	P33	REL		24	BU		
9	28	16	17R	003	SW		24	BU		
9	28	16	6F	P33	REL		24	BU		

FS	PAGE	NODE	CONTACT	FUNCT DESIG	APPARATUS TYPE	OPT	GA	TYPE	COLOR	WIRING METHOD
9	28	17	16R	003	SW		24	BU		
9	28	17	5M	P33	REL		24	BU		
9	28	18	15R	003	SW		24	BU		
9	28	18	4F	P33	REL		24	BU		
9	28	19	14R	003	SW		24	BU		
9	28	19	3M	P33	REL		24	BU		
9	28	20	13R	003	SW		24	BU		
9	28	20	2F	P33	REL		24	BU		
9	28	21	12R	003	SW		24	BU		
9	28	21	1M	P33	REL		24	BU		
11	44	01	00F	003	SW					
11	44	01	TO TRK DIST CKT LEAD T30							
11	44	02	01F	003	SW					
11	44	02	TO TRK DIST CKT LEAD R30							
11	44	03	02F	003	SW					
11	44	03	TO TRK DIST CKT LEAD T31							
11	44	04	03F	003	SW					
11	44	04	TO TRK DIST CKT LEAD R31							
11	44	05	04F	003	SW					
11	44	05	TO TRK DIST CKT LEAD T32							
11	44	06	05F	003	SW					
11	44	06	TO TRK DIST CKT LEAD R32							
11	44	07	06F	003	SW					
11	44	07	TO TRK DIST CKT LEAD T33							

APPARATUS TYPE	FUNCT DESIG	APP FIG	APP CODE
CP	2603	0002	A6

FS	PAGE	NODE	CONTACT	FUNCT DESIG	APPARATUS TYPE	OPT	GA	TYPE	COLOR	WIRING METHOD
2	17	21	15	2402	CP					
2	17	21	24	2605	CP					
2	17	21	19	2605	CP					
2	17	21	10	2603	CP					
2	17	21	6	2603	CP					
2	17	21	7	2405	CP					
2	17	21	9	2609	CP					
2	17	21	20	2609	CP					
2	17	21	8	2609	CP					
4	21	07	8	2605	CP					
4	21	07	2	2604	CP					
4	21	07	8	2604	CP					
4	21	07	21	2603	CP					
4	21	07	11	2405	CP					
4	21	11	1	2603	CP					
4	21	11	COMM BUS CKT LEAD 0AD36							
4	21	12	5	2603	CP					
4	21	12	COMM BUS CKT LEAD 1AD36							
4	21	16	3	2604	CP					
4	21	16	1	2604	CP					
4	21	16	0	2405	CP					
4	21	16	10	2406	CP					

FS	PAGE	NODE	CONTACT	FUNCT DESIG	APPARATUS TYPE	OPT	GA	TYPE	COLOR	WIRING METHOD
4	21	16	0	2404	CP					
4	21	16	8	2603	CP					
4	21	18	10	2604	CP					
4	21	18	9	2604	CP					
4	21	18	2	2405	CP					
4	21	18	12	2603	CP					
4	21	18	8	2406	CP					
4	21	18	3	2404	CP					
4	21	20	0	2603	CP					
4	21	20	4	2405	CP					
4	21	20	9	2603	CP					
4	21	21	3	2603	CP					
4	21	21	5	2405	CP					
4	21	21	11	2603	CP					
4	21	26	20	2603	CP					
4	21	26	25	2404	CP					
4	21	26	12	2405	CP					
4	21	26	24	2603	CP					
4	21	30	23	2402	CP					
4	21	30	10	2402	CP					
4	21	30	23	2603	CP					
4	21	55	13	2603	CP				BK	
4	21	55	GRD						BK	
4	21	58	14	2603	CP				RED	
4	21	58	+24 A2 BATT						RED	

END LIST

FIGURE 17

Output - ALL LIST

SD-1A107-01

ISSUE 1

ALL LIST

DEC 6, 1963

ELECTRONIC SWITCHING SYSTEMS
NO 1
TRUNK SWITCHING CIRCUIT

139

NOTES

CIRCUIT NOTES.

103 NETWORK NO 1 CODE 185C 560 OHMS 0.25MF
NETWORK NO 2 CODE 186D 270 OHMS 0.5MF

EQUIPMENT NOTES.

201 ALL (GR),(PS), AND (P) RELAYS SHALL BE MOUNTED WITH LP19A890 FLEXIBLE MOUNT AND THIS MOUNTING SHALL BE ADJUSTED AS FOLLOWS TIGHTEN MOUNTING SCREWS TIGHT AGAINST PLATE AND BACK OFF FOUR #CLICKS#.

202 UNLESS OTHERWISE SPECIFIED ALL LEADS ARE IN #OPEN TROUGH#.

INFORMATION NOTES.

301 UNLESS OTHERWISE SPECIFIED
RESISTANCE VALUES ARE IN OHMS.
CAPACITANCE VALUES ARE IN MICROFARADS.

302 THE CIRCUIT DESIGN INFORMATION AVAILABLE FOR ISSUE 1 DOES NOT INCLUDE THE CIRCUIT DESCRIPTION(CD),EQUIPMENT MANUFACTURING TESTING REQUIREMENTS(X-SPECIFICATION),SEQUENCE CHARTS AND CIRCUIT REQUIREMENTS TABLE (CRT).

CROSS CONNECTING INFORMATION AND NOTES.

402 THE INTERCONNECTING INFORMATION TO THE JUNCTOR SWITCHING CIRCUIT (B-LINK WIRING) IS NOT AVAILABLE FOR ISSUE 1. THIS INFORMATION WILL BE AVAILABLE AS A J-SPECIFICATION.

APP FIG	APPARATUS TYPE	APPARATUS CODE	FUNCT DESIG	UPPER HALF FUNCT DESIG
0001	CP	A32	2810	
0001	CP	A32	2812	
0001	CP	A32	2814	
0001	CP	A32	2826	
0001	CP	A32	2828	
0001	CP	A32	2830	
0001	CP	A32	3010	
0001	CP	A32	3012	
0001	CP	A32	3014	
0001	CP	A32	3026	
0001	CP	A32	3028	
0001	CP	A32	3030	
0001	CP	A32	3210	
0001	CP	A32	3212	
0001	CP	A32	3214	
0001	CP	A32	3226	
0001	CP	A32	3228	
0001	CP	A32	3230	
0001	CP	A29	2802	
0001	CP	A29	2804	
0001	CP	A29	2806	
0001	CP	A29	2808	
0001	CP	A29	2818	
0001	CP	A29	2820	
0001	CP	A29	2822	
0001	CP	A29	2824	
0001	CP	A29	3002	
0001	CP	A29	3004	
0001	CP	A29	3006	
0001	CP	A29	3008	

APP FIG	APPARATUS TYPE	APPARATUS CODE	FUNCT DESIG	UPPER HALF FUNCT DESIG
0007	RES	KS19150,L1-1000	R65	
0007	RES	KS19150,L1-1000	R66	
0007	RES	KS19150,L2-1800	R67	
0007	RES	KS19150,L2-1800	R68	
0007	RES	KS19150,L2-1800	R69	
0007	RES	KS19150,L2-1800	R70	
0007	RES	18R	R83	
0007	RES	18R	R84	
0007	RES	18R	R85	
0007	RES	18R	R86	
0007	RES	18R	R87	
0007	RES	18R	R88	
0007	RES	18R	R89	
0007	RES	18R	R90	
0008	REL	AK6	P1	P0
0008	REL	AJ5	PW0	
0008	REL	AJ5	PW1	
0008	NET	185C	P0	
0008	NET	185C	P1	
0008	NET	185C	PW0	
0008	NET	185C	PW1	
0008	RES	19EY	R81	
0008	RES	19EY	R82	
0008	KEY	KS19223,L2	NOR	
0008	KEY	KS19223,L2	OFF-0	
0008	KEY	KS19223,L2	OFF-1	
0008	LP	A3	OFFNOR	
0008	LP	A3	OS-0	
0008	LP	A3	OS-1	

FS	PAGE	NODE	CONTACT	FUNCT DESIG	APPARATUS TYPE	OPT	GA	TYPE	COLOR	WIRING METHOD
1	11	01	12	3012	CP					
1	11	01	27	2404	CP					
1	11	01	12	3014	CP					
1	11	01	12	3010	CP					
1	11	01	12	3214	CP					
1	11	01	12	3212	CP					
1	11	01	12	3210	CP					
1	11	01	12	2814	CP					
1	11	01	12	2812	CP					
1	11	01	12	2810	CP					
1	11	02	4	2404	CP					
1	11	02	5	3214	CP					
1	11	02	5	3212	CP					
1	11	02	5	3210	CP					
1	11	02	5	3014	CP					
1	11	02	5	3012	CP					
1	11	02	5	3010	CP					
1	11	02	5	2814	CP					
1	11	02	5	2812	CP					
1	11	02	5	2810	CP					
1	11	03	5	2404	CP					
1	11	03	8	3214	CP					
1	11	03	8	3212	CP					
1	11	03	8	3210	CP					
1	11	03	8	3014	CP					
1	11	03	8	3012	CP					
1	11	03	8	3010	CP					
1	11	03	8	2814	CP					
1	11	03	8	2812	CP					
1	11	03	8	2810	CP					

FS	PAGE	NODE	CONTACT	FUNCT DESIG	APPARATUS TYPE	OPT	GA	TYPE	COLOR	WIRING METHOD
1	12	77	1U	P41	REL					
1	12	77	PT	P41A	NET					
1	12	78	23	3002	CP					
1	12	78	1U	P42	REL					
1	12	78	PT	P42A	NET					
1	12	79	25	3002	CP					
1	12	79	1U	P43	REL					
1	12	79	PT	P43A	NET					
1	12	80	20	3002	CP					
1	12	80	1U	P44	REL					
1	12	80	PT	P44A	NET					
1	12	81	22	3002	CP					
1	12	81	1U	P45	REL					
1	12	81	PT	P45A	NET					
1	12	82	24	3002	CP					
1	12	82	1U	P46	REL					
1	12	82	PT	P46A	NET					
1	12	83	26	3002	CP					
1	12	83	1U	P47	REL					
1	12	83	PT	P47A	NET					
1	12	84	13	3014	CP				BK	
1	12	84	GRD						BK	
1	12	85	13	3012	CP				BK	
1	12	85	GRD						BK	
1	12	86	13	3010	CP				BK	
1	12	86	GRD						BK	
1	12	87	14	3014	CP				RED	
1	12	87	+24 AO BATT						RED	
1	12	88	14	3012	CP				RED	
1	12	88	+24 AO BATT						RED	

FS	PAGE	NODE	CONTACT	FUNCT DESIG	APPARATUS TYPE	OPT	GA	TYPE	COLOR	WIRING METHOD
2	17	34	5M	CP0	REL					
2	17	34	A	C1.0	CAP					
2	17	35	B	C1.0	CAP				BK	
2	17	35	GRD						BK	
2	17	36	19	2613						
2	17	36	19	2611						
2	17	36	19	2413						
2	17	36	19	2411						
2	17	36	5	2409						
2	17	36	12	2408						
2	17	37	22	2613						
2	17	37	22	2611						
2	17	37	22	2413						
2	17	37	22	2411						
2	17	37	2	2409						
2	17	37	11	2408						
2	17	38	10	2413	CP				RED	
2	17	38	10	2411	CP				RED	
2	17	38	-48 A0 BATT						RED	
2	17	39	0	2409	CP					
2	17	39	4	2408	CP					
2	17	39	8	2409	CP					
2	17	40	6	2409	CP					
2	17	40	6	2408	CP					
2	17	40	23	2609	CP					
2	17	41	16	2609	CP					
2	17	41	18	2609	CP					
2	17	41	1	2408	CP					
2	17	41	20	2409	CP					
2	17	41	PT	R1	RES					

FS	PAGE	NODE	CONTACT	FUNCT DESIG	APPARATUS TYPE	OPT	GA	TYPE	COLOR	WIRING METHOD
2	18	55	+24 B2 BATT						RED	
2	18	56	14	2427	CP				RED	
2	18	56	+24 B2 BATT						RED	
2	18	57	13	2625	CP				BK	
2	18	57	GRD						BK	
2	18	58	14	2625	CP				RED	
2	18	58	+24 B2 BATT						RED	
2	18	59	13	2425	CP				BK	
2	18	59	GRD						BK	
2	18	60	14	2425	CP				RED	
2	18	60	+24 B2 BATT						RED	
3	20	01	1L	PS00	REL				RED	
3	20	01	PT	PS00A	NET					
3	20	01	1L	PS01	REL				RED	
3	20	01	PT	PS01A	NET					
3	20	01	-48 A0 BATT						RED	
3	20	02	1L	PS10	REL				RED	
3	20	02	PT	PS10A	NET					
3	20	02	1L	PS11	REL				RED	
3	20	02	PT	PS11A	NET					
3	20	02	-48 B0 BATT						RED	
4	21	01	1M	CP0	REL					P
			PR WITH 0402102							
4	21	01	11	2406	CP					P
4	21	01	7	2406	CP					
4	21	01	27	2405	CP					
4	21	01	27	2604	CP					
4	21	02	1F	CP0	REL					P
			PR WITH 0402101							
4	21	02	GRD							P

FS	PAGE	NODE	CONTACT	FUNCT DESIG	APPARATUS TYPE	OPT	GA	TYPE	COLOR	WIRING METHOD
4	21	38	4	2406	CP					
4	21	38	PT	R6.0	RES					P
			PR WITH 0402139							P
4	21	39	+24 A2 BATT							
			PR WITH 0402138							P
4	21	39	PT	F0	NET					
4	21	39	8	F0	REL					
4	21	40	6	F0	REL					P
4	21	40	7	F0	REL					
4	21	41	PT	F0	NET					
4	21	41	PT	R6.0	RES					
4	21	41	4	F0	REL					
4	21	42	17	2605	CP					
4	21	42	10	2605	CP					
4	21	42	16	2405	CP					
4	21	43	2	2605	CP					
4	21	43	26	2605	CP					
4	21	43	17	2405	CP					
4	21	43	1	2406	CP					
4	21	43	PT	R109.0	RES					
			V1A J0 AND P0 T3							
4	21	44	0	2406	CP					
4	21	44	PT	R11	RES					
4	21	45	3	2406	CP					
4	21	45	PT	R10	RES					
4	21	46	6	2406	CP					
4	21	46	5	2402	CP					
4	21	47	9	2406	CP					
4	21	47	8	2402	CP					
4	21	48	24	2406	CP					

FS	PAGE	NODE	CONTACT	FUNCT DESIG	APPARATUS TYPE	OPT	GA	TYPE	COLOR	WIRING METHOD
6	24	13	8F	TP0	REL					
6	24	13	24M	P50	REL					
6	24	13	24M	P51	REL					
6	24	14	PT	R9	RES					
6	24	14	6F	TP0	REL					
6	24	15	PT	R1	RES					
6	24	15	3F	TP0	REL					
6	24	16	PT	R2	RES					
6	24	16	1F	TP0	REL					
6	24	17	1M	T0	REL					
6	24	17	1M	T1	REL					P
			PR WITH 0602426							
6	24	17	TO PREC OR SUCC FR OR MS LEAD 0G							P
6	24	18	3M	T0	REL					
6	24	18	3M	T1	REL					P
			PR WITH 0602427							
6	24	18	TO PREC OR SUCC FR OR MS LEAD G4							P
6	24	19	5M	T0	REL					
6	24	19	5M	T1	REL					P
			PR WITH 0602428							
6	24	19	TO PREC OR SUCC FR OR MS LEAD G3							P
6	24	20	7M	T0	REL					
6	24	20	7M	T1	REL					P
			PR WITH 0602429							
6	24	20	TO PREC OR SUCC FR OR MS LEAD G2							P
6	24	21	9M	T0	REL					

FS	PAGE	NODE	CONTACT	FUNCT DESIG	APPARATUS TYPE	OPT	GA	TYPE	COLOR	WIRING METHOD
10	36	32	3F	P22	REL		24	BU		
10	36	32	02R	012	SW		24	BU		
10	36	33	3F	P23	REL		24	BU		
10	36	33	03R	012	SW		24	BU		
10	36	34	3F	P24	REL		24	BU		
10	36	34	04R	012	SW		24	BU		
10	36	35	3F	P25	REL		24	BU		
10	36	35	05R	012	SW		24	BU		
10	36	36	3F	P26	REL		24	BU		
10	36	36	06R	012	SW		24	BU		
10	36	37	3F	P27	REL		24	BU		
10	36	37	07R	012	SW		24	BU		
10	36	38	3M	P20	REL					
10	36	38	3M	P21	REL					
10	36	38	3M	P22	REL					
10	36	38	3M	P23	REL					
10	36	38	3M	P24	REL					
10	36	38	3M	P25	REL					
10	36	38	3M	P26	REL					
10	36	38	3M	P27	REL					
10	36	38	17M	P42	REL					
10	36	39	2M	P37	REL		24	BU		
10	36	39	19R	011	SW		24	BU		
10	36	40	2M	P36	REL		24	BU		
10	36	40	18R	011	SW		24	BU		
10	36	41	2M	P35	REL		24	BU		
10	36	41	17R	011	SW		24	BU		
10	36	42	2M	P34	REL		24	BU		
10	36	42	16R	011	SW		24	BU		
10	36	43	2M	P33	REL		24	BU		

149

FS	PAGE	NODE	CONTACT	FUNCT DESIG	APPARATUS TYPE	OPT	GA	TYPE	COLOR	WIRING METHOD
11	60	14	TO TRK DIST CKT LEAD R16							
11	60	15	14F	201	SW					
11	60	15	TO TRK DIST CKT LEAD T17							
11	60	16	15F	201	SW					
11	60	16	TO TRK DIST CKT LEAD R17							
11	60	17	34R	201	SW					
11	60	17	22R	217	SW					
11	60	18	35R	201	SW					
11	60	18	23R	217	SW					
11	60	19	32R	201	SW					
11	60	19	22R	216	SW					
11	60	20	33R	201	SW					
11	60	20	23R	216	SW					
11	60	21	30R	201	SW					
11	60	21	22R	215	SW					
11	60	22	31R	201	SW					
11	60	22	23R	215	SW					
11	60	23	28R	201	SW					
11	60	23	22R	214	SW					
11	60	24	29R	201	SW					
11	60	24	23R	214	SW					
11	60	25	26R	201	SW					
11	60	25	22R	213	SW					
11	60	26	27R	201	SW					
11	60	26	23R	213	SW					
11	60	27	24R	201	SW					
11	60	27	22R	212	SW					

FS	PAGE	NODE	CONTACT	FUNCT DESIG	APPARATUS TYPE	OPT	GA	TYPE	COLOR	WIRING METHOD
20	3	33	3F	PW1	REL					
20	3	34	2M	PW1	REL					
20	3	34	3M	PW1	REL					
20	3	34	-48 B1 BATT							
20	3	35	TO MISC CKT							
20	3	35	-48 B2 BATT							
20	3	36	TO MISC CKT							
20	3	36	12F	PW1	REL					
20	3	37	12M	PW1	REL					
20	3	37	+24 B0 BATT							
20	3	38	TO MISC CKT							
20	3	38	10F	PW1	REL					
20	3	38	11F	PW1	REL					
20	3	39	+24 B1 BATT							
20	3	39	10M	PW1	REL					
20	3	39	11M	PW1	REL					
20	3	40	TO MISC CKT							
20	3	40	9F	PW1	REL					
20	3	41	9M	PW1	REL					
20	3	41	+24 B2 BATT							

END LIST

FIGURE 18

Output - NOTE LIST

SD-1A107-01

ISSUE 1

NOTE LIST

DEC 6, 1963

ELECTRONIC SWITCHING SYSTEMS
NO 1
TRUNK SWITCHING CIRCUIT

NOTES

CIRCUIT NOTES.

103 NETWORK NO 1 CODE 185C 560 OHMS 0.25MF
NETWORK NO 2 CODE 186D 270 OHMS 0.5MF

EQUIPMENT NOTES.

201 ALL (GR),(PS), AND (P) RELAYS SHALL BE MOUNTED WITH LP19A890 FLEXIBLE MOUNT AND THIS MOUNTING SHALL BE ADJUSTED AS FOLLOWS TIGHTEN MOUNTING SCREWS TIGHT AGAINST PLATE AND BACK OFF FOUR #CLICKS#.

202 UNLESS OTHERWISE SPECIFIED ALL LEADS ARE IN #OPEN TROUGH#.

INFORMATION NOTES.

301 UNLESS OTHERWISE SPECIFIED
RESISTANCE VALUES ARE IN OHMS.
CAPACITANCE VALUES ARE IN MICROFARADS.

302 THE CIRCUIT DESIGN INFORMATION AVAILABLE FOR ISSUE 1 DOES NOT INCLUDE THE CIRCUIT DESCRIPTION(CD),EQUIPMENT MANUFACTURING TESTING REQUIREMENTS(X-SPECIFICATION),SEQUENCE CHARTS AND CIRCUIT REQUIREMENTS TABLE (CRT).

CROSS CONNECTING INFORMATION AND NOTES.

402 THE INTERCONNECTING INFORMATION TO THE JUNCTOR SWITCHING CIRCUIT (B-LINK WIRING) IS NOT AVAILABLE FOR ISSUE 1. THIS INFORMATION WILL BE AVAILABLE AS A J-SPECIFICATION.

END LIST

FIGURE 19

Output - APP FIG LIST

SD-1A107-01

ISSUE 1

APP FIG LIST

DEC 6, 1963

ELECTRONIC SWITCHING SYSTEMS
NO 1
TRUNK SWITCHING CIRCUIT

156

APP FIG	APPARATUS TYPE	APPARATUS CODE	FUNCT DESIG	UPPER HALF FUNCT DESIG
0001	CP	A32	2810	
0001	CP	A32	2812	
0001	CP	A32	2814	
0001	CP	A32	2826	
0001	CP	A32	2828	
0001	CP	A32	2830	
0001	CP	A32	3010	
0001	CP	A32	3012	
0001	CP	A32	3014	
0001	CP	A32	3026	
0001	CP	A32	3028	
0001	CP	A32	3030	
0001	CP	A32	3210	
0001	CP	A32	3212	
0001	CP	A32	3214	
0001	CP	A32	3226	
0001	CP	A32	3228	
0001	CP	A32	3230	
0001	CP	A29	2802	
0001	CP	A29	2804	
0001	CP	A29	2806	
0001	CP	A29	2808	
0001	CP	A29	2818	
0001	CP	A29	2820	
0001	CP	A29	2822	
0001	CP	A29	2824	
0001	CP	A29	3002	
0001	CP	A29	3004	
0001	CP	A29	3006	
0001	CP	A29	3008	

APP FIG	APPARATUS TYPE	APPARATUS CODE	FUNCT DESIG	UPPER HALF FUNCT DESIG
0001	NET	186D	Z16.1	
0001	NET	186D	Z17.1	
0001	NET	186D	Z18.1	
0001	NET	186D	Z19.1	
0001	NET	186D	Z20.1	
0001	NET	186D	Z21.1	
0001	NET	186D	Z22.1	
0001	NET	186D	Z23.1	
0001	NET	186D	Z24.1	
0001	NET	186D	Z25.1	
0001	NET	186D	Z26.1	
0001	NET	186D	Z27.1	
0001	NET	186D	Z28.1	
0001	NET	186D	Z29.1	
0001	NET	186D	Z30.1	
0001	NET	186D	Z31.1	
0005	REL	303A	PC1.0	
0005	REL	303A	PC1.1	
0005	REL	303G	ET0.0	
0005	REL	303G	ET0.1	
0005	REL	303G	PC2.0	
0005	REL	303G	PC2.1	
0005	REL	303G	SC.0	
0005	REL	303G	SC.1	
0005	BIAS CORE	2604B	Z103.0	
0005	BIAS CORE	2604B	Z103.1	
0005	CAP	513C	C100.0	
0005	CAP	513C	C100.1	
0005	CAP	513C	C101.0	
0005	CAP	513C	C101.1	

APP FIG	APPARATUS TYPE	APPARATUS CODE	FUNCT DESIG	UPPER HALF FUNCT DESIG
0005	RES	KS14603,L1A-316	R105.0	
0005	RES	KS14603,L1A-316	R105.1	
0005	RES	KS19152,L2-470	R106.0	
0005	RES	KS19152,L2-470	R106.1	
0005	RES	KS14603,L1D-562	R107.0	
0005	RES	KS14603,L1D-562	R107.1	
0005	RES	KS14603,L3B-301	R108.0	
0005	RES	KS14603,L3B-301	R108.1	
0005	RES	KS19150,L2-1000	R109.0	
0005	RES	KS19150,L2-1000	R109.1	
0005	TRSTR	34A	SCR.0	
0005	TRSTR	34A	SCR.1	
0005	TRNSF	2074A	T100.0	
0005	TRNSF	2074A	T100.1	

END LIST

FIGURE 20

Output - PAGE LIST

SD-1A107-01

ISSUE 1

PAGE LIST

DEC 6, 1963

ELECTRONIC SWITCHING SYSTEMS
NO 1
TRUNK SWITCHING CIRCUIT

161

PAGE	FS	NODE	CONTACT	FUNCT DESIG	APPARATUS TYPE	OPT	GA	TYPE	COLOR	WIRING METHOD
28	9	01	09R	003	SW					
28	9	01	10R	003	SW					
28	9	02	09R	002	SW					
28	9	02	10R	002	SW					
28	9	03	09R	001	SW					
28	9	03	10R	001	SW					
28	9	04	09R	000	SW					
28	9	04	10R	000	SW					
28	9	05	4M	P50	REL					
28	9	05	4M	P10	REL					
28	9	05	4M	P11	REL					
28	9	05	4M	P12	REL					
28	9	05	4M	P13	REL					
28	9	05	4M	P14	REL					
28	9	05	4M	P15	REL					
28	9	05	4M	P16	REL					
28	9	05	4M	P17	REL					
28	9	06	4F	P10	REL		24	BU		
28	9	06	00R	003	SW		24	BU		
28	9	07	4F	P11	REL		24	BU		
28	9	07	01R	003	SW		24	BU		
28	9	08	4F	P12	REL		24	BU		
28	9	08	02R	003	SW		24	BU		
28	9	09	4F	P13	REL		24	BU		
28	9	09	03R	003	SW		24	BU		
28	9	10	4F	P14	REL		24	BU		
28	9	10	04R	003	SW		24	BU		
28	9	11	4F	P15	REL		24	BU		
28	9	11	05R	003	SW		24	BU		
28	9	12	4F	P16	REL		24	BU		

PAGE	FS	NODE	CONTACT	FUNCT DESIG	APPARATUS TYPE	OPT	GA	TYPE	COLOR	WIRING METHOD
28	9	62	1M	P15	REL		24	BU		
28	9	62	05R	000	SW		24	BU		
28	9	63	1M	P16	REL		24	BU		
28	9	63	06R	000	SW		24	BU		
28	9	64	1M	P17	REL		24	BU		
28	9	64	07R	000	SW		24	BU		
28	9	65	8F	P30	REL		24	BU		
28	9	65	19R	000	SW		24	BU		
28	9	66	7M	P30	REL		24	BU		
28	9	66	18R	000	SW		24	BU		
28	9	67	6F	P30	REL		24	BU		
28	9	67	17R	000	SW		24	BU		
28	9	68	5M	P30	REL		24	BU		
28	9	68	16R	000	SW		24	BU		
28	9	69	4F	P30	REL		24	BU		
28	9	69	15R	000	SW		24	BU		
28	9	70	3M	P30	REL		24	BU		
28	9	70	14R	000	SW		24	BU		
28	9	71	2F	P30	REL		24	BU		
28	9	71	13R	000	SW		24	BU		
28	9	72	1M	P30	REL		24	BU		
28	9	72	12R	000	SW		24	BU		
37	10	01	09R	117	SW					
37	10	01	10R	117	SW					
37	10	02	09R	116	SW					
37	10	02	10R	116	SW					
37	10	03	09R	115	SW					
37	10	03	10R	115	SW					
37	10	04	09R	114	SW					
37	10	04	10R	114	SW					

PAGE	FS	NODE	CONTACT	FUNCT DESIG	APPARATUS TYPE	OPT	GA	TYPE	COLOR	WIRING METHOD
37	10	69	5F	P45	REL		24	BU		
37	10	69	05R	114	SW		24	BU		
37	10	70	5F	P46	REL		24	BU		
37	10	70	06R	114	SW		24	BU		
37	10	71	5F	P47	REL		24	BU		
37	10	71	07R	114	SW		24	BU		
37	10	72	5M	P40	REL					
37	10	72	5M	P41	REL					
37	10	72	5M	P42	REL					
37	10	72	5M	P43	REL					
37	10	72	5M	P44	REL					
37	10	72	5M	P45	REL					
37	10	72	5M	P46	REL					
37	10	72	5M	P47	REL					
37	10	72	17M	P24	REL					

END LIST

FIGURE 21

Output - NODE LIST

SD-1A107-01

ISSUE 1

NODE LIST

DEC 6, 1963

ELECTRONIC SWITCHING SYSTEMS
NO 1
TRUNK SWITCHING CIRCUIT

166

PAGE	NODE	FS	CONTACT	FUNCT DESIG	APPARATUS TYPE	OPT	GA	TYPE	COLOR	WIRING METHOD
18	41	2	16	2625	CP					
18	41	2	18	2625	CP					
18	41	2	0	2424	CP					
18	41	2	20	2425	CP					
18	41	2	PT	R41	RES					
18	42	2	21	2625	CP					
18	42	2	27	2625	CP					
18	42	2	1	2424	CP					
18	47	2	17	2625	CP					
18	47	2	10	2625	CP					
18	47	2	2	2424	CP					
18	47	2	17	2425	CP					
18	47	2	PT	R42	RES					
18	48	2	26	2625	CP					
18	48	2	2	2625	CP					
18	48	2	3	2424	CP					

END LIST

FIGURE 22

Output - FS LIST

SD-1A107-01

ISSUE 1

FS LIST

DEC 6, 1963

ELECTRONIC SWITCHING SYSTEMS
NO 1
TRUNK SWITCHING CIRCUIT

169

FS	PAGE	NODE	CONTACT	FUNCT DESIG	APPARATUS TYPE	OPT	GA	TYPE	COLOR	WIRING METHOD
4	21	01	1M	CP0	REL					P
			PR WITH 0402102							
4	21	01	11	2406	CP					P
4	21	01	7	2406	CP					
4	21	01	27	2405	CP					
4	21	01	27	2604	CP					
4	21	02	1F	CP0	REL					P
			PR WITH 0402101							
4	21	02	GRD							P
4	21	03	+24 A2 BATT							P
			PR WITH 0402104							
4	21	03	8	VCT0	REL					P
4	21	03	PT	C2.0	CAP					
4	21	04	1	2605	CP					
4	21	04	3	2605	CP					
4	21	04	18	2405	CP					P
			PR WITH 0402103							
4	21	04	PT	R5.0	RES					P
4	21	05	PT	R5.0	RES					
4	21	05	PT	C2.0	CAP					
4	21	05	4	VCT0	REL					
4	21	06	6	VCT0	REL					
4	21	06	7	VCT0	REL					
4	21	07	8	2605	CP					
4	21	07	2	2604	CP					
4	21	07	8	2604	CP					
4	21	07	21	2603	CP					
4	21	07	11	2405	CP					
4	21	08	4	2605	CP					
4	21	08	24	2604	CP					

170

FS	PAGE	NODE	CONTACT	FUNCT DESIG	APPARATUS TYPE	OPT	GA	TYPE	COLOR	WIRING METHOD	
4	21	34	1	F0	REL						
4	21	35	3	F0	REL						
4	21	35	2	R9.0	RES						
4	21	36	2	R8.0	RES						
4	21	36	1	R9.0	RES						
4	21	37	1	R8.0	RES				RED		
4	21	37	+24 A1 BATT						RED		
4	21	38	21	2605	CP						
4	21	38	27	2605	CP						
4	21	38	20	2405	CP						
4	21	38	4	2406	CP						P
4	21	38	PT	R6.0	RES						P
			PR WITH 0402139								
4	21	39	+24 A2 BATT								P
			PR WITH 0402138								
4	21	39	PT	F0	NET						
4	21	39	8	F0	REL						P
4	21	40	6	F0	REL						
4	21	40	7	F0	REL						
4	21	41	PT	F0	NET						
4	21	41	PT	R6.0	RES						
4	21	41	4	F0	REL						
4	21	42	17	2605	CP						
4	21	42	10	2605	CP						
4	21	42	16	2405	CP						
4	21	43	2	2605	CP						
4	21	43	26	2605	CP						
4	21	43	17	2405	CP						
4	21	43	1	2406	CP						
4	21	43	PT	R109.0	RES						
			V1A J0 AND P0 T3								

FS	PAGE	NODE	CONTACT	FUNCT DESIG	APPARATUS TYPE	OPT	GA	TYPE	COLOR	WIRING METHOD
4	22	58	+24 B2 BATT						RED	
4	22	59	14	2425	CP				RED	
4	22	59	+24 B2 BATT						RED	
4	22	60	13	2422	CP				BK	
4	22	60	GRD						BK	
4	22	61	14	2422	CP				RED	
4	22	61	+24 B2 BATT						RED	
4	22	62	13	2420	CP				BK	
4	22	62	GRD						BK	
4	22	63	14	2420	CP				RED	
4	22	63	+24 B2 BATT						RED	
4	22	64	13	2418	CP				BK	
4	22	64	GRD						BK	
4	22	65	14	2418	CP				RED	
4	22	65	+24 B2 BATT						RED	
4	22	66	1	2418	CP					
4	22	66	16	2620	CP					
4	22	67	14	2421	CP				RED	
4	22	67	+24 B2 BATT						RED	
20	3	01	GRD						BK	
20	3	01	6F	PW0	REL				BK	
20	3	02	6M	PW0	REL					
20	3	02	1U	P0	REL					
20	3	02	PT	P0	NET					
20	3	03	2U	P0	REL					
20	3	03	PT	P0	NET					
20	3	03	1	R81	REL					
20	3	04	2	R81	REL				RED	
20	3	04	-48 A2 BATT						RED	
20	3	05	GRD						BK	

FS	PAGE	NODE	CONTACT	FUNCT DESIG	APPARATUS TYPE	OPT	GA	TYPE	COLOR	WIRING METHOD
20	3	39	+24 B1 BATT							
20	3	39	10M	PW1	REL					
20	3	39	11M	PW1	REL					
20	3	40	TO MISC CKT							
20	3	40	9F	PW1	REL					
20	3	41	9M	PW1	REL					
20	3	41	+24 B2 BATT							

END LIST

FIGURE 23

Output - DUPLICATE FD

THE FOLLOWING FUNCTIONAL DESIGNATIONS ARE DUPLICATED

3212	CP
Z01.0	NET
CT0.1	REL
R1.1	RES
P32	REL
C104.1	CAP
017	SW

END LIST

THE FOLLOWING FUNCTIONAL DESIGNATIONS ARE DUPLICATED

NO DUPLICATES
END LIST

FIGURE 24

Structure of APPARATUS MASTER FILE

In indicating the structure of a file it is necessary to define a hierarchy of information. This can be done as follows:

1. File - A major body of related data.
2. Record - Subdivision of file; contains data common to a subject or key.
3. Group - Subdivision of record.
4. Field - Specific items of data within a group of records.

The file is the highest level of information. In showing the structure of the file, the levels of information within the file will be shown by using a system of indentation; the first indentation indicating the record level, the second the group level, etc.

In addition to indicating the hierarchy of information, it is important to show the form that the input data is to assume. For this reason, the data image for each field is also shown. The symbol x is used to indicate an alphanumeric field, A and 9 represent alphabetic and numeric fields respectively. The quantity of characters in the field is shown either by repeating the symbol or by suffixing it with the quantity in parenthesis. For example, xxx is equivalent to x(3) which is a representation of a three digit alphanumeric field.

The structure of the APP MSTR FILE follows:

Name	Data Image
APP MSTR FILE	
Record 1	
Control-Key	A(2)
Apparatus Type	A(10)
Apparatus Code Number	X(20)
Terminal (Repeated 16 times)	X(3)
Record 2	
Control-Key	A(2)
Terminal (Repeated 26 times)	X(3)

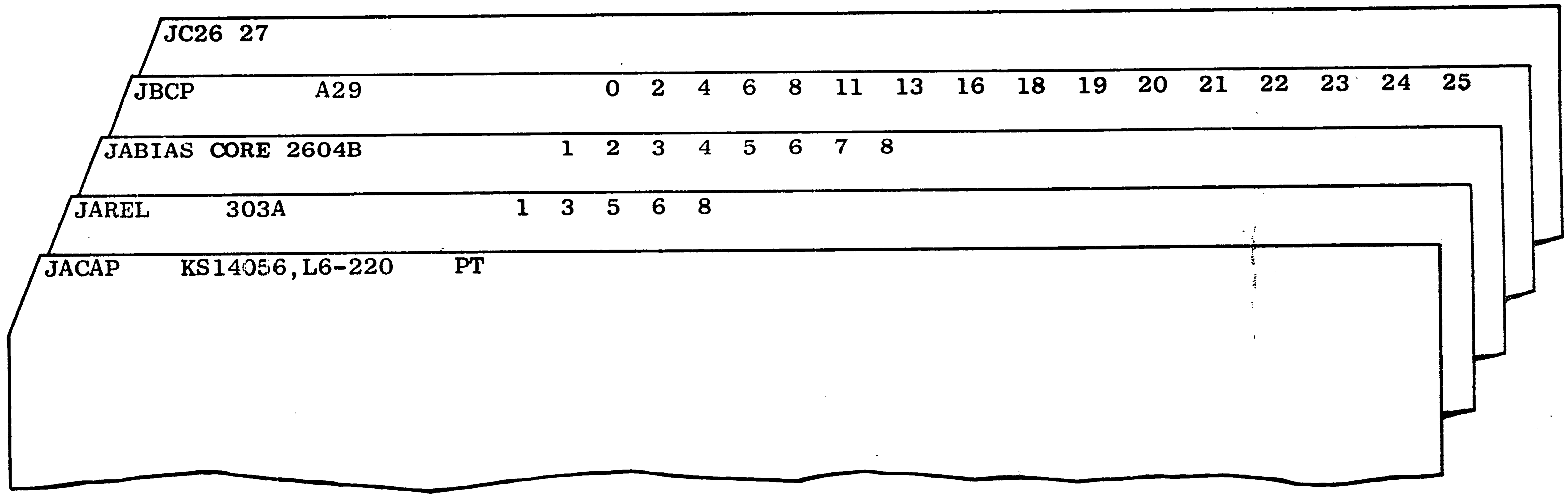


FIGURE 25

Sample Input - APPARATUS MASTER FILE

Number of Terminals On Apparatus ≤	Number of Input Data Cards EQ	Control-Key On First Card EQ	Control-Key On Second Card EQ	Control-Key On Third Card EQ	Control-Key On Fourth Card EQ	Control-Key On Fifth Card EQ	Control-Key On Output Record EQ
16	1	JA	-	-	-	-	JA
42	2	JB	JC	-	-	-	JB
68	3	JD	JC	JE	-	-	JD
94	4	JF	JC	JE	JG	-	JE
120	5	JH	JC	JE	JG	JI	JH

FIGURE 26

Use of Control-keys in APPARATUS MASTER FILE

FIGURE 27

Structure of UNIT FILE

Name[67]	Data Image
UNIT FILE	
Record NA	
Control-Key	"NA"[68]
Specification Number	X(6)
Unit Number	X(4)
Apparatus Type	A(10)
Apparatus Code	X(20)
Functional Designation	X(9)
Position	X(5)
Quantity	99
Record NB	
Control-Key	"NB"[68]
Specification Number	X(6)
Unit Number	X(4)
Sub Unit	X(10)
List OR Group (Repeated 10 Times)	
Quantity	99
List OR Group	X(3)

67. FIGURE 24 contains information concerning the indentation system and the data image symbols used.
68. When used as qualifiers Control-keys NA, NB and NC become ND, NE and NF respectively.

Name[67] (Cont'd.)	Data Image
Record NC	
Control-Key	"NC"[68]
Specification Number	X(6)
Unit Number	X(4)
Part Number	X(10)
Quantity	99
Description	X(56)

67. FIGURE 24 contains information concerning the indentation system and the data image symbols used.
68. When used as qualifiers Control-keys NA, NB and NC become ND, NE and NF respectively.

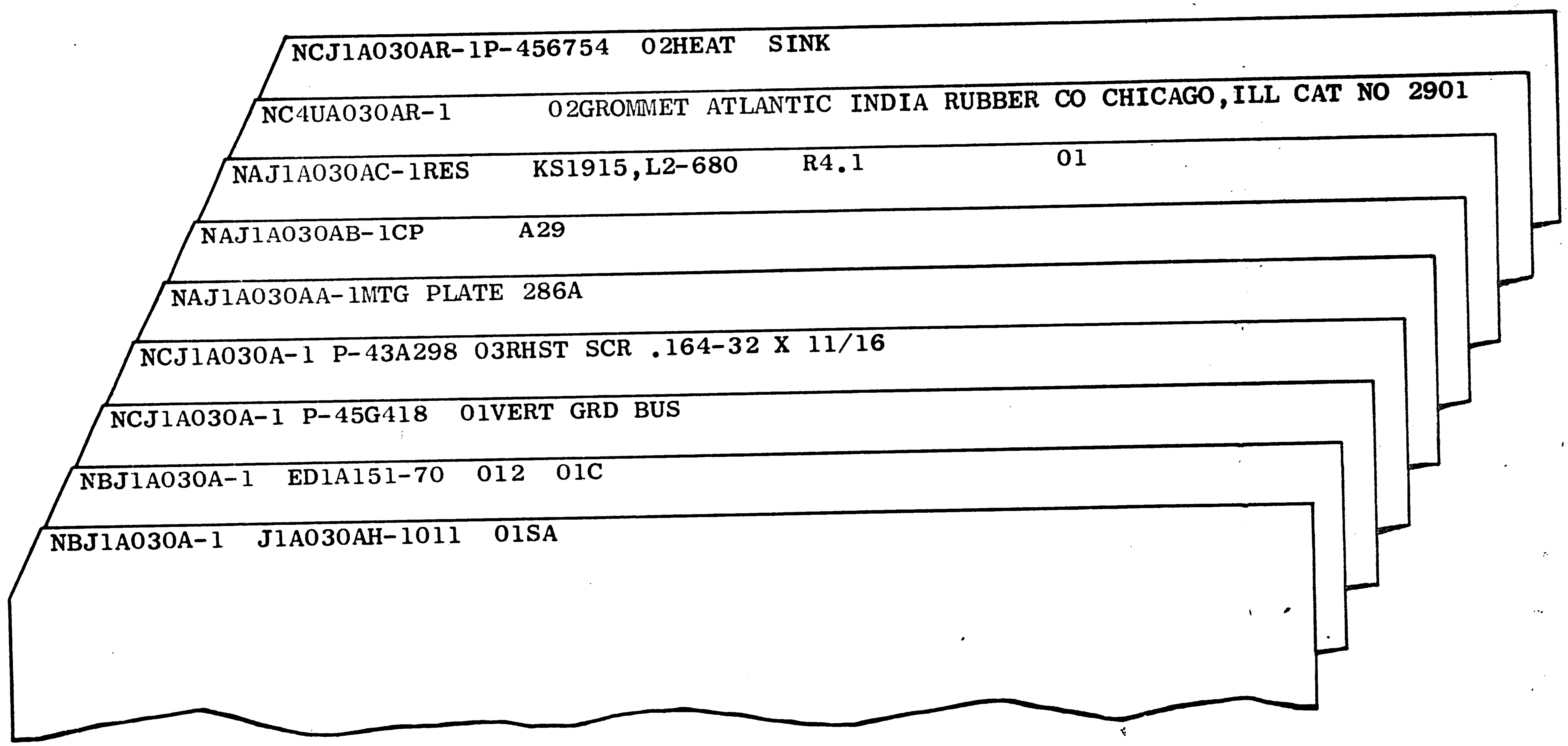


FIGURE 28

Sample Input - UNIT FILE

FIGURE 29

Structure of WIRE FILE

Name[69]	Data Image
WIRE FILE	
Record AA	
Control-Key	"AA"[70]
SD Number	X(9)
Issue	X(4)
Title	X(32)
Record EA	
Control-Key	"EA"[70]
Note Number	9(3)
Note	X(75)
Record DA	
Control-Key	"DA"[70]
Apparatus Figure	X(4)
Apparatus Type	A(10)
Apparatus Code Number	X(20)
Functional Designation	X(9)
Upper Half Functional Designation	X(9)
Record BA	
Control-Key	"BA"[70]

69. FIGURE 24 contains information concerning the indentation system and the data image symbols used.
70. When used as qualifiers control-keys AA, BA, DA and EA become AQ, BQ, DQ and EQ respectively.

Name	Data Image
Node Identification	
Functional Schematic Number	9(2)
Page Number	9(3)
Node Number	9(2)
Terminal	
Number	X(6)
Functional Designation	X(9)
Apparatus Type	A(10)
Wiring	
Option	X(4)
Gauge	9(2)
Type	X(3)
Color	X(12)
Wiring Condition	
Method	X(4)
Strap	X
Loop	X
Pair-Triple-Quad	X
Miscellaneous	
Miscellaneous	X(18)

Name (Cont'd.	Data Image
Record CA	
Control-Key	"CA"[71]
Node Identification	
Functional Schematic Number	9(2)
Page Number	9(3)
Node Number	9(2)
External Circuit	
Ckt. Name	X(25)
Wiring	
Option	X(4)
Gauge	9(2)
Type	X(3)
Color	X(12)
Wiring Condition	
Method	X(4)
Strap	X
Loop	X
Pair-Triple-Quad	X
Miscellaneous	
Miscellaneous	X(18)

71. When used as a qualifier control-key CA becomes CQ.

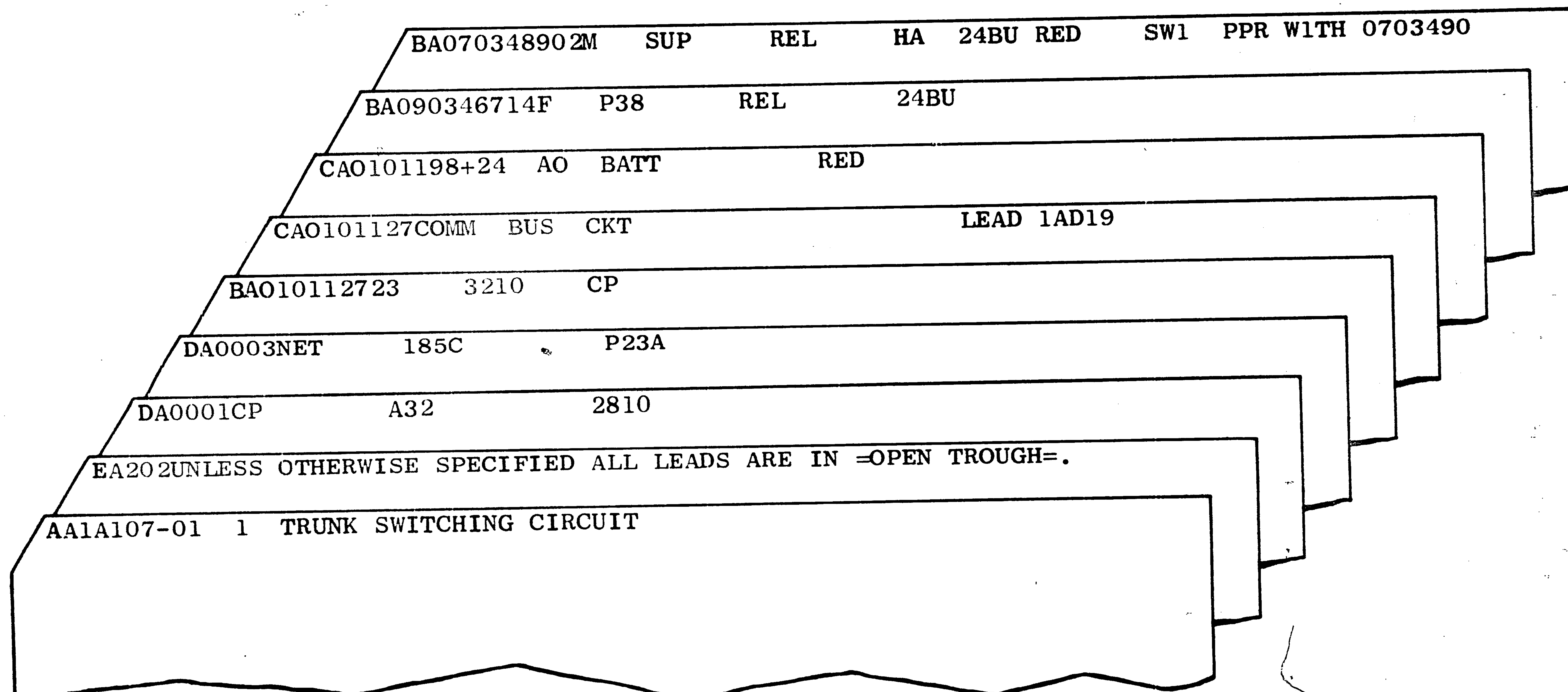


FIGURE 30

Sample Input - WIRE FILE

BIBLIOGRAPHY

Public Documents

U. S. Dept. of Commerce. Statistical Abstract of The United States: 1963.

Books

Editors of Fortune. The Mighty Force of Research. New York: McGraw-Hill, 1956.

Gregory, R. H. and Van Horn, R. L. Automatic Data Processing Systems: Principles and Procedures. Belmont, California: Wadsworth, 1963.

Shannon, C. E. and Weaver, W. The Mathematical Theory of Communication. Champaign, Illinois: University of Illinois Press, 1949.

Weiner, N. Cybernetics. New York: The Technology Press & John Wiley & Sons, 1948.

Articles

Altman, G. W., Decampo, L. A. and Warburton, C. R. "Automation of Computer Panel Wiring", AIEE Communications and Electronics, No. 48 (May 1960), PP. 118-125.

"Automatic Computer Directed Wiring Machines for Making Computers", Computers and Automation, Vol. 10 No. 9 (Sept. 1961), P. 12B.

Brown, R. R. and Putnam, G. R. "The Automation of Topological Layout", AIEE Communications and Electronics, No. 60 (May 1962), PP. 136-139.

Grimm, R. K. and Brouwer, D. P. "Wiring Terminal Panels by Machine", Control Engineering, Vol. 8 No. 8 (Aug. 1961), PP. 77-81.

Kavanagh, T. F. "TABSOL - The Language of Decision Making", Computers and Automation, Vol. 10 No. 9 (Sept. 1961), PP. 15-22.

Kirby, D. B. and Rosenthal, C. W. "Computer Program for Preparing Wiring Diagrams", AIEE Paper, No. 60-1007.

Lanford, C. D. "Lineless Drawings Aid Titan Work", Missiles and Rockets, Vol. 11 No. 11 (Sept. 10, 1962), PP. 30, 35, 40.

Loberman, H. and Weinberger, A. "Formal Procedures of Connecting Terminals With a Minimum Total Wire Length", Journal of the Association for Computing Machinery, Vol. 4 No. 4 (Oct. 1957), PP. 428-437.

Morzenti, O. J. "Implications of Machine Aids to Design", AIEE Paper, No. 61-104.

Rosenthal, C. W. "Computing Machine Aids to a Development Project", IRE Transactions on Electronic Computers, Vol. EC-10 No. 3 (Sept. 1961), PP. 400-406.

Unpublished Material

Bedell, E. H. "New Techniques in Preparation and Use of Manufacturing Information." Speech Given Before Bell System Executives, Cherry Hill, New Jersey, June 20, 1963.

Evans, O. Y. "Decisions Tables." Unpublished Paper, IBM Corporation, 1961.

Herbst, R. T., Leagus, D. G. and Sellers, G. A. "Machine Processing of Manufacturing Information For Digital Systems." Unpublished Paper, Bell Telephone Laboratories Memorandum, [redacted], 1962.

Hoberecht, V. L. "Design Information Systems." Unpublished Paper, IBM Corporation, 1962.

Hornung, G. T. and Weber, L. J. P., Jr. "A Method of Producing Wiring Information For Conventional Type Telephone Circuits Using Machine Aided Methods." Unpublished Paper, Bell Telephone Laboratories Memorandum, [redacted], 1960.

Kalish, H. M. "A Study of the Feasibility of Using Machine Aids in the Preparation of Instruction Data." Unpublished Paper, Bell Telephone Laboratories Memorandum, [redacted], 1961.

Kalish, H. M. "The Automatic Print Out of a Sample Functional Schematic For MAPID." Unpublished Paper, Bell Telephone Laboratories Memorandum, [redacted], 1961.

Kirby, D. B. and Rosenthal, C. W. "A Computer Program For Preparing Wiring Diagrams." Unpublished Paper, Bell Telephone Laboratories Memorandum, [redacted], 1960.

Martin, R. B. "Wiring Run Lists: Preparation By Electronic Accounting Machine Methods." Unpublished Paper, Bell Telephone Laboratories Memorandum, [redacted], 1961.

"Regional Computer Utilization: Costs and Savings." Unpublished Paper, Western Electric Company - Systems Equipment Engineering, 1963.

Switak, F. E. "Unicom Computer Aided Wiring Program." Unpublished Paper, Bell Telephone Laboratories, 1962.

Winans, R. C. "The Use of the BLADES Automatic Design System Computer Program for the Mechanical Design & Preparation of Manufacturing Drawings for Nike-Zeus "C" Planes." Unpublished Paper, Bell Telephone Laboratories Memorandum, [redacted], 1960.

Other Sources

Sellers, G. A. Jr. Personal Interview, Bell Telephone Laboratories, April 1963.

VITA

Personal History:

Name	Robert Jay Edelman
Birthplace	Chicago, Illinois
Birthdate	July 19, 1929
Parents	Abraham and Pearl Edelman
Wife	Fern L. Edelman
Children	Gail L. and Pamela A. Edelman

Institutions Attended:

Purdue University
West Lafayette, Indiana
Lehigh University
Bethlehem, Pennsylvania

Degrees Awarded:

Bachelor of Science, Electrical Engineering
Purdue University
June, 1951
Candidate for Master of Science, Industrial Engineering
Lehigh University
June, 1964

Honors Awarded:

Graduated with Distinction, Purdue University
Tau Beta Pi
Eta Kappa Nu

Professional Experience:

Sandia Corporation
Albuquerque, New Mexico
June, 1951 - June, 1952
U. S. Air Force
June, 1952 - Sept., 1953
Western Electric Co., Inc.
Feb., 1959

Professional Societies:

Member - Institute of Electrical and Electronics Engineers