A COMPUTER SYSTEM FOR PIPING BILLS OF MATERIAL

Feasibility Study On
The Design Of A Computer System
For Piping Layout Bills Of Material

By

SATISH AJMANI

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AUTHOR: SATISH AJMANI,B.E. (B.I.T.S., India)

SUPERVISOR: Professor W.R. Newcombe

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SCOPE AND CONTENTS: This thesis describes the approach to, and the outcome of, a feasibility study on designing a user-oriented computer system for piping bills of material. The system is treated as an integral part of a "total system" for piping layout contracts.

The designed system is described in detail. The dissertation is such that the text is

understandable to the user.

Software developed for the system is completely documented in the form of source listings and generalized flow charts. Explanations on how to use the system and sample inputs are included. Recommendations are made for the proposed estimation system and for the integrated total system.

T A B L E O F C O N T E N T S

	Descriptive Note	ii
	Table of Contents	iv
	List of Illustrations	vi
	List of Tables	vii
	Acknowledgements	viii
	Abstract	1
1.	Introduction	3
2.	Literature Survey	4a
3.	System Analysis	5
4.	System Synthesis	12
5.	System Details	33
6.	Conclusions	36
7.	Recommendations	37
Appendix A		38
	Discussion of the data-base management system used for creating the master files.	
Appendix B-1		42
	System Input Sheet; description and use.	
Appendix B-2		61
	Details of the programme "DDSP".	
Appendix B-3		66
	Flow Chart of the programme "DDSP".	

Appendix C-1 69

Specification Input Sheet; description and use.

Appendix C-2 76

Details of the programme "SDSP"

Appendix C-3 83

Flow Chart of the programme "SDSP"

Appendix D-1 87

Details of the programme "BOMP"

Appendix D-2 99

Flow Chart of the programme "BOMP"

Appendix E 112

Economic Evaluation.

Bibliography 116

L I S T O F I L L U S T R A T I O N S

FIGURE	TITLE	PAGE
1.	Outline of the total system	6
2.	Typical bill of material	17
3.	Organization of design specifications	25
4.	Organization of drawing data	28
5.	System run chart	30
6.	Positive Isometric Directions	52
7.	Record Layout of the file PDDF	63
8.	Record Layout of the file SDFL	77
9.	Bill of Material control sheet	89

L I S T O F T A B L E S

TABLE NO.	TITLE	PAGE
1.	System Input Sheet	22
2.	Specification Input Sheet	23
3.	List of Coded Fittings	56
4.	Cost estimate of a bill of material for an isometric drawing	115

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ABSTRACT

A computer system has been designed to produce piping layout bills of material.

Information from two major sources is required for the Bills of Material and the associated Isometric Drawing System. These two sources are the design specifications and design drawings. Design specification data is written and maintained, on a mass-storage device, as a master file. System input sheets are used to introduce the design drawing data to the Isometric System which in turn stores such information on a mass-storage device as a data file.

The main computer programme of the Bills of Material System performs the following functions:

(1) Retrieves the relevant data from the system input storage, based on the type of bill of material required.

(2) Accumulates like items based on line service and on line size.

(3) Matches and retrieves relevant specifications from storage.

(4) Writes the bill of material.

Bills of material of four types are possible in the designed system. These are: by bulk, by area (and

sub-area), by line number, and by isometric drawing number.

The bill of material may be printed on pre-printed forms. The flexibility of output and arrangement of data on a bill of material is a design characteristic of this system.

Information flow charts and logic flow charts of the software developed for the system are included.

Complete documentation for the computer programmes developed, is submitted along with this thesis, as a "Detail Documentation Package".

1. INTRODUCTION

Typical contract procedures followed by the construction industry dictate that the tendering documents to prospective contractors contain preliminary design drawings and design specifications.

In a computerized estimation system design-data taken from the tendering documents would be used as input. Labour cost and material cost data may be stored on random access devices for retrieval by execution of the main computer programme of the system which will be designed to compute a cost estimate and a preliminary material usage list.

The contractor can now submit a relatively realistic bid and, if awarded the contract, can reduce delays caused by long delivery times by ordering the bulk of the material based on the preliminary material usage list.

Isometric piping drawings are required for the fabrication of pipe spools. These drawings also facilitate field assembly, and experience has shown the contractor that it pays to produce these drawings, although a lot of drafting time and cost is involved. For each isometric drawing a compatible bill of material is required to enable material to be requistioned by the fabrication shop

and by the field. Bills of material based on material usage by specification or layout sub-divisions are required by the contractor for material control, scheduling, purchasing, estimating and other activities necessary for the completion of the contract.

Information required by the computerized Isometric Drawing System and by the Bill of Material System, comes from design specifications and design orthographic drawings.

The Isometric Drawing System has been investigated and designed by Mr. R.E. Pauls at McMaster University. This system produces isometric drawings on a digital incremental plotter in conjunction with the IBM-7040 digital computer. Software for the EAI-1500 plotter has been developed. The system and the software has been documented as a thesis at McMaster University. (1)

The primary purpose of this project was to conduct a feasibility study on the design of the aforementioned Bills of Material System and to combine it with the existing Isometric Drawing System. In order to achieve this objective - also taking into consideration that an Estimation System may be incorporated at a later date - it was clear that a "total systems" approach had to be taken.

2. LITERATURE SURVEY

To determine the "state of the art" in automated pipework systems, an extensive survey of existing publications was carried out. An initial survey was conducted prior to embarking on the thesis project, in 1968-1969. A follow-up search was undertaken in 1973-1974, after the computerized piping system presented in this dissertation had been designed.

In both instances, the majority of the relevant publications found, were generalized summaries of the procedures employed by a particular organization in production management and material control. These publications simply stated, without much detail, that computer systems were being used for such diverse tasks as material and cost estimation, material procurement and control, pipe-line design and drawings, etc. Typical of such publications are references (5), (6), and (7).

In, "A Production Control System Based on the Bill-of-material Processor", J. BYRD and N. SIEMENS, (8), describe the application of the "bill of material processor" to production planning and control. The "bill of material processor" appears to be a commercially available software package which defines methods of organizing, maintaining and retrieving bills of materials in a variety of output formats. A comprehensive discussion of "BOMP - the bill of material processor" can also be found in "BOMP Integrates Your Information Retrieval", by J.M. BLAIR, (9).

Aside from the generalized papers discussed above, two publications of particular interest and relevance to the

thesis topic were found. Each publication contains an informative overview of a computer system for piping layout contracts.

In "An Integrated System for Pipework Estimating, Detailing and Control", Messers P.T. DANIEL AND M. HALL, (10), describe the computer system used by Imperial Chemical Industries Limited, England, to automate the transfer of information and documentation in the following pipework fields - estimating, ordering, detailing, fabrication, erection, costing and control. Their computer system, called ISOPEDAC, is capable of dealing with one or more projects, and within each project, a range of pipeline specifications can be handled. Details of the computer sub-systems for each of the aforementioned pipework fields are presented in the paper. Included are samples of the various input forms, and of the isometric drawings, fabrication/erection schedules, bills of cost, parts lists and material forecasts the system is capable of producing. The computer system appears to be very complex, particularly the input forms. The drawing data take-off input sheet, for instance, requires the learning of a new take-off "computer" language for its use. It is interesting to note that the isometric drawings are not the primary guidelines in the fabrication and erection of pipelines. The fabrication and erection schedules, which are "merely a written description of the isometric drawings", are used for this purpose. The main theme of the ICI computer system seems to be costing, for which the

numerous schedules of rates submitted by fabrication and erection contractors can be stored in the computer system. These are, at a latter stage, used to produce the bills of cost. The authors of the paper claim that the ISOPEDAC computer system resulted in a saving of 66 percent in drawing office time and a 40 percent saving in cost, on the first full project the system was used for.

The publication titled, "Piping Isometric Drawings via Computer/Plotter", by J.R. AICHER, (11), describes the computer system used by the Sun Oil Company of Philadelphia, to produce isometric drawings and bills of material for piping configurations. Although the computer system is capable of producing requisitions, purchase orders, cost estimates and inventory control information, these aspects of the system are not discussed in the paper. In sharp contrast to the computer system described in reference (10), the design philosophy for the Sun Oil Company computer system seems to have been one of simplicity and, from an users viewpoint, to keep the system as similar as possible to a former manual used by the company. This is evident from the fact the computerized system allows the draftsman to fill out drawing data take-off sheets using terms with which he is familiar. A computer programme, called "EDITOR", is then used to edit the drawing data for completeness and accuracy. The same programme is used to reformat the drawing data into a form suitable to the operation of the rest

of the computer system. Another significant feature of this system is that of a single input sheet initiating the computer process. It should be noted that the Sun Oil Company computer system is capable of producing bills of material in one category only; those which accompany an isometric drawing.

In concluding, it must be said that few computer systems of this nature exist, or at least, have been made public. Secondly, in the design of a computer system of any kind, it is desirable to examine the environment around which the system is to operate, rather than to examine existing computer systems.

3. SYSTEM ANALYSIS

The outcome of the longest phase of this system design project is summarized under the following headings. The activities leading thereto, (a period of fact finding and analysis) cannot be documented in the sense required by this dissertation. However, this first phase was devoted to the analysis of an existing information system and to the task of defining the new systems objectives, requirements and boundaries.

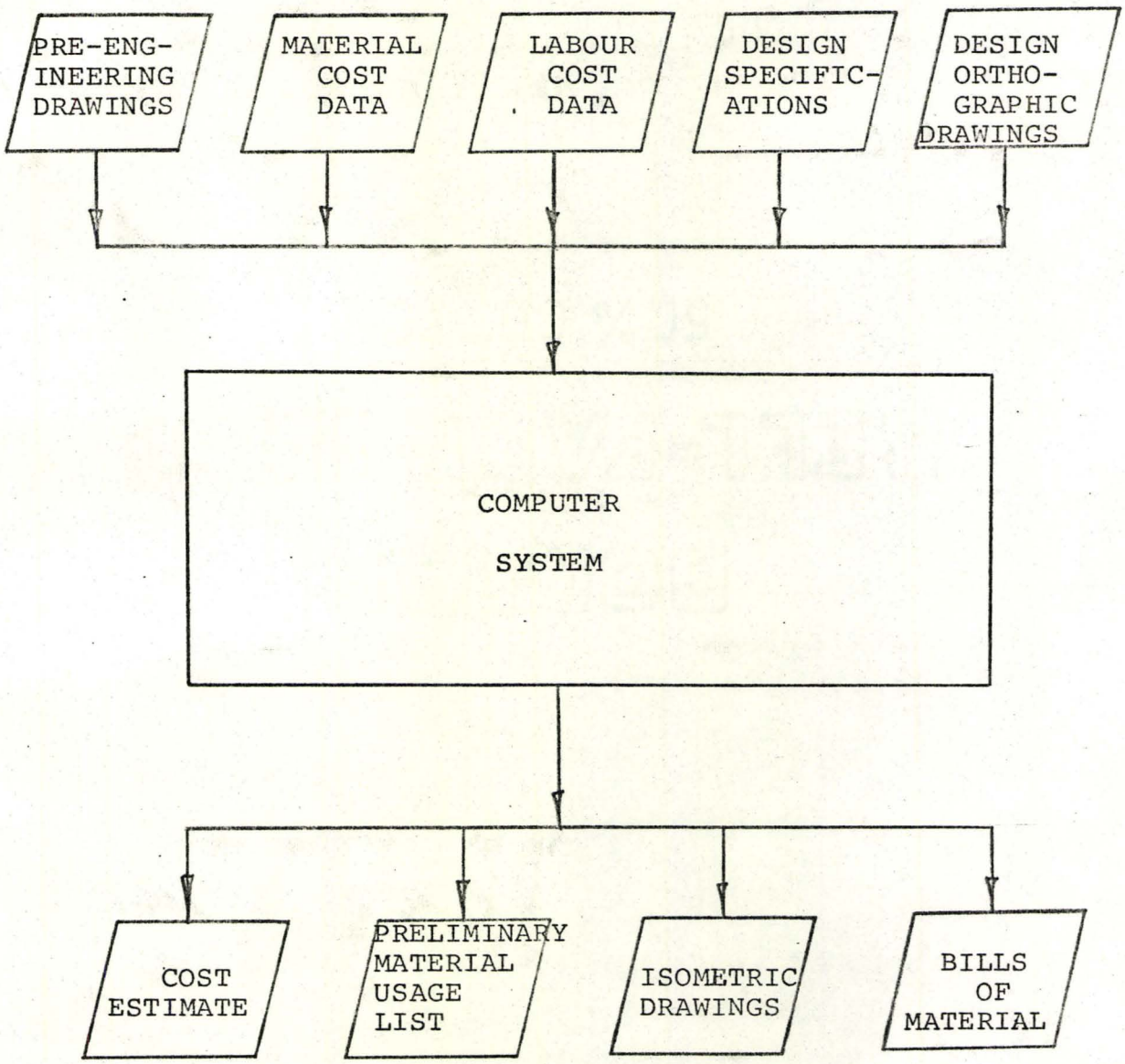
3.1 THE 'TOTAL' SYSTEM

A diagramatic outline of the "total system" under consideration is shown in Figure 1. It depicts the input information available and the desired output. The purpose of this project was to design and organize the format of the desired output information and to develop the interlaying stages of the system, those between the raw input available and the finalized output.

No distinct division can be made between the systems possible within the total system shown. For the ease of writing, however, the total system shall be treated with the assumption that it contains three separable systems. These are:

(1) The Estimation System,

(2) The Isometric Drawing System,



OUTLINE OF THE TOTAL SYSTEM

FIGURE 1

(3) The Bills of Material System.

3.2 ESTIMATION SYSTEM, RECOMMENDATIONS FOR THE

The input to this proposed system would consist of data taken off the pre-engineering drawings on what is commonly called a "take-off" sheet. This information would be key-punched, verified and then introduced into the computer as a punched-card data file. Supporting input information, in the form of labour cost data, material cost data, and design specifications, may be stored on random access equipment, to be put on-line when an estimation run has to be made. A storage sub-system will have to be developed for the material cost and labour cost data. It would be necessary to build into the storage sub-system an update run, designed to introduce an escalation clause to modify labour cost and material cost data at pre-determined time intervals or as desired. It may be pointed out that only an estimate of material and labour costs is required. Hence a procedure, capable of taking into account (a) discernible, and seasonal fluctuations in the cost of material: (b) any discounts available on large orders of material and (c) changes in labour cost, would be adequate. The decision criteria for such a procedure would have to be based upon statistics available on past changes in material cost, in labour cost, in seasonal fluxations in material

prices, in quantity discount available, etc.

A sub-system has been developed to write the design specifications as a master file on disk. The basic functions of accumulating like items, retrieving and matching specifications, are necessary requirements for producing the preliminary material usage list. As is evident the cost estimates will have to be based on the preliminary material usage list. Hence, the software developed for the Bill of Material System could be modified to suit the Estimation System.

Pre-printed forms could be used for printing the cost estimate and the material usage list.

3.3 ISOMETRIC DRAWING SYSTEM

From the orthographic design drawings, pertinent data concerning the line for the required isometric drawing, is taken down on a "System Input Sheet". Some of the chief arguments deal with pipe line length; line size or diameter; the axis in which it lies; the type(s) of fitting(s) incorporated; and its position on the line, etc. This data is key-punched and verified to form the input to the Isometric Drawing Computer System as a punched-card data file. This computer system is divided into three phases. The first phase produces (as punched-card output) coordinates of the computed three-dimensional configuration of the pipe line. These punched cards, along with control cards, are used as input to the second phase which rotates

the three-dimensional pipe line into the isometric configuration, computes two-dimensional instructions for the plotter and then writes them on magnetic tape. In the third phase of the system, the coded instructions on the magnetic tape drive an "off-line" digital incremental plotter to produce the required isometric drawing.

For each isometric drawing an input sheet is required. If the proper control cards are used more than one isometric drawing may be produced in one run of each phase.

3.4 BILLS OF MATERIAL SYSTEM, PRELIMINARY CONCEPT OF THE

Orthographic design drawings and design specifications are the two sources of data for the Bill of Material System.

Following the total systems concept, material usage data is taken from the orthographic design drawings on the system input sheet used in the Isometric Drawing System. Each system input sheet only contains data relevant to one isometric drawing. If a bill of material is required in any other form than that which is compatible with a particular isometric drawing, data from all system input sheets has to be stored on disk as a master file. Design specifications are stored as a master file on disk.

Clearly such files are relevant to one particular job only. The material usage data file will have to be completely rewritten for each new job. It is conceivable that pipe lines subject to the same service conditions may

have the same specifications. In practice however, this is seldom true. Thus the design specification data file will also have to be rewritten or revised to some extent. Rewriting a file only involves, preparation of the card file and a computer run of the respective storage programmes to be mentioned subsequently. It may be noted, however, that the files have been designed to permit the storage of data for more than one job on the same physical file.

Software has been developed to perform the function of writing the design specifications and the drawing data master files. In addition the programme "Configuration Generator" (1) has been modified to incorporate software to perform the function of writing the drawing data as a disk file for storage.

To complete the computer system, software has been developed to perform the following broad functions:

(1) Retrieve the relevant data from the material usage data file, based upon the type of bill of material required.

(2) Accumulate like items and pipe lengths according to size and service code.

(3) Retrieve the relevant specification from storage.

(4) Edit the retrieved specification and print out the bill of material according to the desired format.

The different types of bills of material that may be required have been determined and provided for in the software. Output formats and bill of material organization have been designed. A design feature of this system is the complete flexibility of the output.

4. SYSTEM SYNTHESIS

4.1 ISOMETRIC DRAWING SYSTEM

Details of this system are available in reference (1), which describes and gives a source listing of the software developed.

To accomodate the incorporation of the Bills of Material System, programme modifications were made on the source programme "Configuration Generater" (1). Included in the "Detail Documentation Package" with this thesis is a listing of the revised programme.

A new plotting programme (software for phase two of the Isometric Drawing System) was written for the Benson-Lenhner digital incremental plotter in conjunction with the IBM-7040 digital computer. Unfortunately the author was unable to completely test this programme due to changes in the hardware facilities at McMaster University. A list of this programme (called DRAFT2) is also included in the "Detail Documentation Package" with this thesis.

4.2 BILL OF MATERIAL SYSTEM

The design aspects of this system are discussed under the headings which follow.

4.2.1 OUTPUT CONSIDERATIONS

In general, large piping systems are organized into designated areas and sub-areas. Piping within the layout is

designated by a code name based on the service conditions. Ordinarily, one code designated pipe line may extend into more than one area and any one area may contain more than one code designated pipe line. It thus became apparent that a prospective user of this system would desire bills of material in the four categories described later.

Piping design drawings, bills of materials produced within existing conventional systems and design specifications provided by industry were studied and discussed. The feasible categories within which bills of material may be required were subsequently determined. A general format for a bill of material and the organization of data on it also evolved from the above activities.

4.2.1.1 BILL OF MATERIAL CATEGORIES

The word "items", as used in the following text, defines the type, size and quantity of piping, fittings, valves and special field requirements. (flow-meters, control-valves, pumps, etc.)

Using the system described herein, bills of material can be obtained in the following categories:

(1) BULK

A "bulk" bill of material contains a list of items which constitute the entire layout. The basic identification is by Job Number.

Such a bill of material could be put to the uses below. However, it is not limited to these uses alone.

(a) Estimating a similar job

(b) Purchasing by bulk to take advantage of quantity discounts

(c) Cost control

(d) Material control.

(2) AREA

A listing of items falling in any one area or sub-area forms a bill of material in this category. It is identified by the Job Number: by the area number; and, if applicable, by the sub-area number. A list of the line numbers of the piping or part(s) thereof constituting that area can be obtained if so desired.

A bill of material in this category may be used for:

(a) Resource allocation

(b) Material control

(c) Purchasing schedule

(d) Estimating.

(3) LINE

A bill of material in this category contains a listing of items constituting any one line designated by a line number. A line identified by a unique line number may contain "spools" of more than one size and hence, "fittings, valves etc." of more than one size, and specification.

Such a bill of material is to be identified, primarily, by the line number and by the Job Number.

Identification by area(s) is optional.

A "line" bill of material may be used for:

(1) Planning and scheduling

(2) Field Requisition

(3) Resource allocation.

The above uses are particularly relevant to a work programme where piping is installed by line numbers as a basis.

(4) ISOMETRIC

A listing of items consistent with a particular isometric drawing is contained in a bill of material in this category.

Basic identification is by the Isometric Drawing Number with which the bill of material is associated. If desired, the area number and the various line numbers can be listed. Identification by Job Number is mandatory.

This bill of material may be called the "basic" bill of material produced by this system. It will be used primarily for material requisition by the fabrication shop and by the field. It will be accompanied by the isometric drawing to which it refers.

4.2.1.2 BILL OF MATERIAL ORGANIZATION

The basic data required on any bill of material

produced by this system is:

(a) Piping - the length of pipes segregated by the size and service code (listed on the bill of material) and the associated description of the material specifications, the mechanical standards applicable and the type of joint. Remarks, such as the one shown in Figure 2, "Typical Bill of Material", may be included.

(b) Fittings - (not including those to be installed in the field) the unit quantity, the size and the service code, followed by the specification, mechanical standards and any remarks necessary.

(c) Valves - the unit quantity, the size and code. Accompanying data would be the function of the valves, the manufacture data and the description.

(d) Fittings - (those to be installed in the field) same as in (b).

Figure 2 shows the physical division which has been made between the placing of the field and fabrication requirements on a bill of material associated with an isometric drawing. This was done to facilitate usage for (1) material control, (2) shop fabrication and (3) field assembly. The advantages of such a design are evident. All bills of material produced in conjunction with isometric drawings will have this division incorporated automatically. If such a division is desired in any other category of bill of

BILL OF MATERIAL PAGE OF

JØBNØ:	AREA NØ:	INITIATED BY:
LINENØ:	ISØMETRIC DRAWING NØ:	DATE:

FABRICATION REQUIREMENT

QTY	SIZE	ITEM	MATERIAL SPECIFICATIØN	CLASS	JOINT	REMARKS
120	3.00	PIPE	ASTM A-167 TYPE 304L	MECH M1001-105	BUTT WELD	3" T.A.
4	3.00	ELBOW	ASTM A-167 TYPE 304L			
1	3.00	V0035 FLANGE		TUFLINE 067	150 LBS; TYPE 316	

QTY	SIZE	ITEM	TYPE	FUNCTIØN	NAME / MANUFACTURE	NØ	DESCRIPTIØN	REMARKS

FIELD REQUIREMENT

NAME OF THE CØNTRACTING FIRM				
	REVISIØN NØ.	APPROVAL	BY	DATE

FIGURE 2 TYPICAL BILL OF MATERIAL

material the user will have to specify a control variable accordingly.

General arrangement of data in a bill of material is as shown in Figure 2. However the output and its arrangement is very flexible and can be easily manipulated. Ease of reading and understanding is the design criterion for the chosen format. The data contained in the top two lines identifies the bill of material . That data which is not applicable, as determined by the category within which the bill of material falls, will be omitted. Pre-printed output forms for the line printer may be used in practice.

4.2.2 INPUT CONSIDERATIONS

In the design of a user oriented computer system, the systems designer must formulate the simplest possible input that will be efficient, practical, and attractive from the user's standpoint. The input must also establish the desired and useful output. The system should also be efficient in the use of computer time, but it is important to note that contrary to the views of computer specialists this has not been given top priority for this project.

Based upon the need to establish compatibility between the existing Isometric Drawing System and the Bill of Material System it was found desirable to accept, as a part of the new input, the input designed for the first system.

This meant a deviation from the system design concepts outlined above, because some parts of the input data for the Isometric Drawing System were found to be irrelevant as far as the requirements of the Bills of Material System were concerned. Moreover, it was found that the input for the Isometric Drawing System did not completely satisfy the input requirements of the Bill of Material System. However, acceptance of the pre-designed input was necessary in order to have a user oriented system.

The input requirements of the Bills of Material System can be classified into

(a) Design drawing data

(b) Design specification data.

4.2.2.1 DESIGN DRAWING DATA INPUT

The concept of the "system input sheet" as a means of transforming information from design orthographic drawings into a form suitable for this computer system has been introduced previously. Also discussed were reasons for storing each system input sheet on random access equipment for subsequent retrieval and processing. A programme has been developed to store the system input sheets on a disk file. Appendix B-(2) contains the details of this programme.

The storage function has also been incorporated in the "Configuration Generator Programme" of the Isometric

Drawing System. This means that at the time of an isometric drawing run, one of the requirements of the Bill of Material System will be met. This design characteristic eliminates duplication of data, simplifies the system and reduces computer time by reducing the number of runs.

The input sheet designed and used for the Isometric Drawing System is shown in Table 2, of reference (1).

On reviewing this input sheet it was found that only a few of the input variables were required for the Bills of Material System. These were NN, FEET, AINCH, ANUM and DENOM for the case where NN was equal to 1 which gives us the value for the length of pipe incorporated. A part of the information required about fittings and valves was satisfied by the variable NN where it took on the values 3, 4, 5, or 7. (See reference (1) for details.) The other variables and their assigned values were found to be superfluous.

Thus the only requirement of the Bill of Material System completely met by the "original" input sheet is for the pipe lengths and the coded fittings: flanged globe valves; reducers; flanges and unflanged globe valves. For the desired Bill of Material System to exist and function, identification data, pipe sizes and service codes, and data for numerous other fittings is required. Hence some additions were made to the original input sheet and it was

called the "system input sheet". Retrieval, by the "main functional programme" of the system, from storage is selective and is based on the Job Number, the Area Number, the Sub-Area Number, and Isometric Drawing Number and Line Number for each logical record. Table 1 shows the system input sheet. Appendix B-(1) gives (1) a list and description of the new variables introduced on the system input sheet; (2) a list of coded fittings; (3) the card file organization and (4) details about the use of the system input sheet.

4.2.2.2 DESIGN SPECIFICATION DATA INPUT

Part (b) of the system input requirements consists of a list of design specifications for the various service coded pipes, fittings and valves for the entire contract.

A utility programme has been developed to write the master file containing the design specifications. The specification for each item identified by a service code and line size is contained as one logical record. The service code, the item type and line size are the key variable for subsequent retrieval.

The "Specification Input Sheet" developed to contain the design specifications and the control variables for the storage utility programme is shown in Table 2.

Appendix C - (1) contains a description of the variables, details of the card-file organization and instructions for the use of the specification input sheet.

SYSTEM INPUT SHEET	JOB NO:	DATE:	PAGE OF
	RUN NO:	COMPILED BY:	K.P. BY:
	RUN DATE:		

I-D CARD

VARIABLE NAME	NN	JØBNØ	LAREA	LSUB	ISØNØ	FIELD REQUIREMENT			RUN DATE		
						NDAY	MNTH	NYEAR	DAY	MONTH	YEAR
FORMAT	I5	A6	A4	A4	A6	I2	I2	I4	I2	A4	I2
K.P. COLUMN	1 5	6 11	12 15	16 19	20 25	26 27	28 29	30 33	34 35	36 39	40 41
	999										

DATA CARDS

VARIABLE NAME	NN	KVAL	I	ASIGN	FEET	AINCH	ANUM	DENØM	J	SIG	DØT	DIST	MTRI	NVNØS	NS-PEEL	NFLD	LSIZE	LSPEC	LNØ	IF-SIG
FORMAT	I5	I5	I1	F3.0	F5.0	F5.0	F5.0	F5.0	I1	F3.0	F3.0	F5.0	I1	A5	A3	A6	F6.2	A6	A4	A1
K.P. COLUMN	1 5	6 10	11	12 14	15 19	20 24	25 29	30 34	35	36 38	39 41	42 46	47	48 52	53 55	56 61	62 67	68 73	74 77	78

TABLE 1

SPECIFICATIØN INPUT SHEET	JOB NO:	DATE:	PAGE OF
	RUN NO:	COMPILED BY:	K.P. BY:
	RUN DATE:		

I-D CARD

VARIABLE NAME	CC	JØBNØ	DAY	MONTH	YEAR
FORMAT	I1	A6	I2	A4	I2
K.P. COLUMN	1	2 7	8 9	10 13	14 15
	1				

DATA CARDS 1 and 2

		CARD 1				CARD 2			
VARIABLE NAME	CC	LSPEC	LTYPE	LSIZE	MATERIAL SPECIFICATIØN	CC	CLASS SPECIFICATIØN	JØINT TYPE	REMARKS
FORMAT	I1	A6	A6	A6	10A5	I1	7A5	2A6	A6
K.P. COLUMN	1	2 7	8 13	14 19	20 69	1	2 36	37 48	49 56
	2					3			

DATA CARDS 3 and 4

		CARD 1				CARD 2					
VARIABLE NAME	CC	LSPEC	LTYPE	LSIZE	DESCRIPTIØN ØF ITEM	CC	TYPE	FUNC.	MANUF. NAME	MANUF. NØ.	REMARKS
FORMAT	I1	A6	A6	A6	11A5	I1	2A5	A5	3A5	A6	A6
K.P. COLUMN	1	2 7	8 13	14 19	20	1	2 11	12 16	17 31	32 37	38 43
	4					5					

TABLE 2

4.2.3. MASTER FILE(S) CREATION

From the outset, it became apparent that the system to be designed would require direct access equipment and software for its proper functioning.

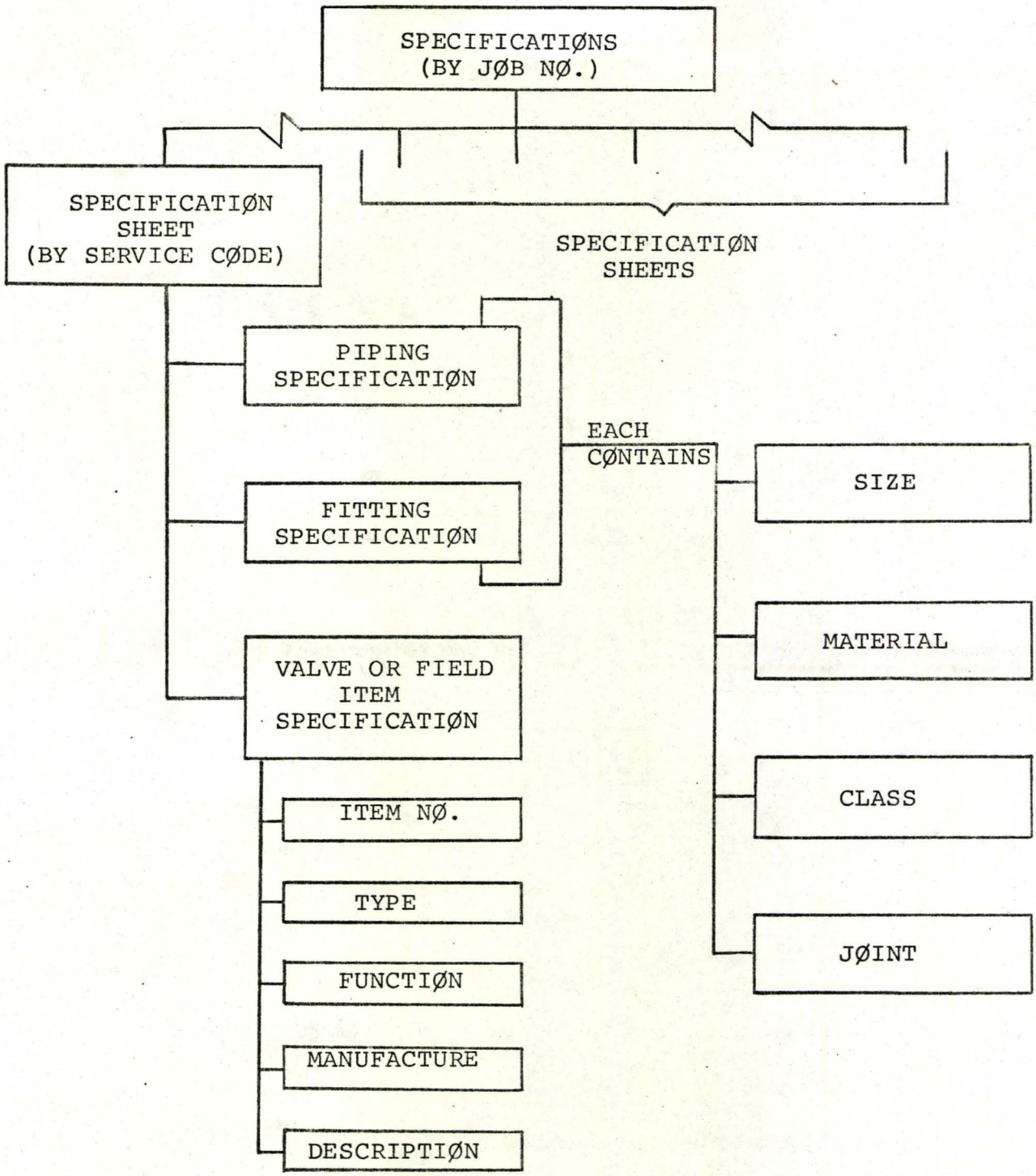
One of the functions to be performed by the software for the Bill of Material System is to retrieve relevant specification from storage for each item to appear on the bill of material. The obvious organization of the specifications for storage is by the designated service code. Sequential or tape processing would require a tremendous amount of computer time since a lot of searching would be involved. Initially however, a complete tape storage design was evolved. The reason for this was that at the time no random access facility was available on the IBM-7040.

A discussion of the file management system used for the creation of the master files and for retrieval appears in Appendix A.

4.2.3.1 SPECIFICATIONS STORAGE

The intricate organization of the design specifications for a piping layout job is pictorally depicted in Figure 3.

As shown, the specification list for the job is divided into a number of "specification sheets" based upon the designated service code. Each specification sheet lists the specifications for all items of different



ORGANIZATION OF DESIGN SPECIFICATIONS

FIGURE 3

sizes.

For retrieval, the key (identifying) variables in procedural order are:

(1) The service code

(2) The item type

(3) The size.

Each specification along with its key fields, is stored as one logical record. Such a design makes the identification for retrieval purposes relatively simple.

As examples, key fields would be:

(1) SC 3.0UP 1 - where SC is the service code, 1 is the designation for piping and 3.0UP signifies sizes of three inches.

(2) SC 2.5 UP NSPEEL or NFLD - where, with respect to (1), the only change is the designation NSPEEL or NFLD, which is the code for the fitting involved. See Table 3, Appendix B-(1).

(3) SC V136 - SC is the service code as in (1) and (2) and V136 is the valve number for the valve involved.

Once the specification has been identified by means of the key fields, the entire logical record will be transfered from storage to memory. This function becomes the responsibility of the main functional programme of the Bills of Material System.

4.2.3.2 DESIGN DRAWING DATA STORAGE

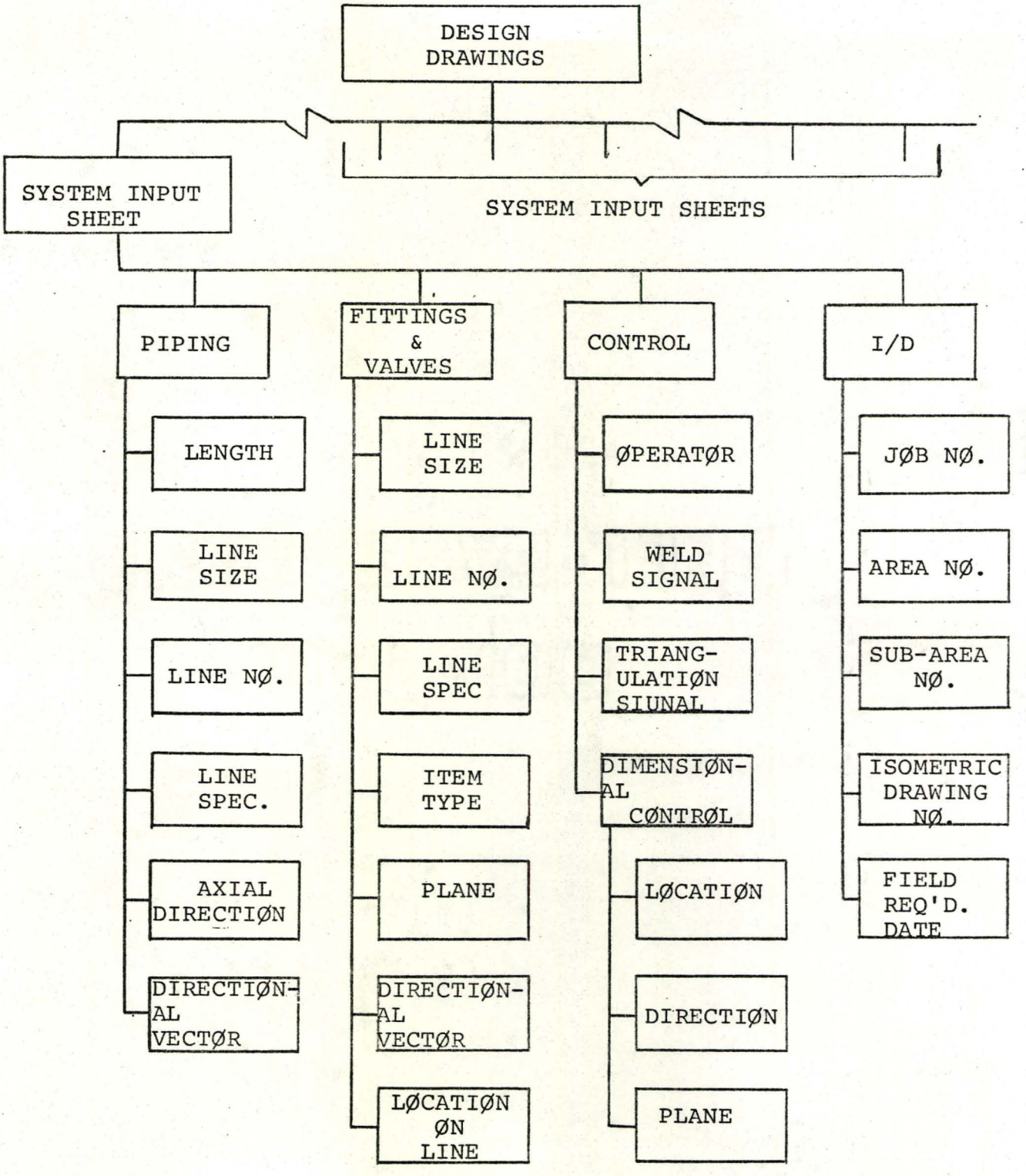
A second master file is comprised of the data contained on the system input sheets.

The useful data from the design drawings is organized as shown in Figure 4.

Each system input sheet is associated with an isometric drawing produced by the Isometric Drawing system, which usually contains part(s) of a line or lines. All sheets are identified as shown in Figure 4 under the heading I/D. Each entry on the sheet also contains a line number. This is based on the organization of the piping layout.

Having established the type of bill of material required, the various stored input system sheets which are relevant have to be identified and retrieved. For instance, if a bill of material is to be compiled for a specific area then all stored system input sheets bearing this area number are required for further processing. This is achieved by storing each entry on the input sheet as a logical record containing the I/D data and line number as keys.

Part of the processing in the storage programme involves searching the first field of each logical record (entry) to determine what it can yield. For instance, if NN is 1, we can obtain the length of piping used from this logical record and hence it must be stored. Logical records



ORGANIZATION OF DESIGN DRAWING DATA

FIGURE 4

which are immaterial to the Bills of Material System are not stored.

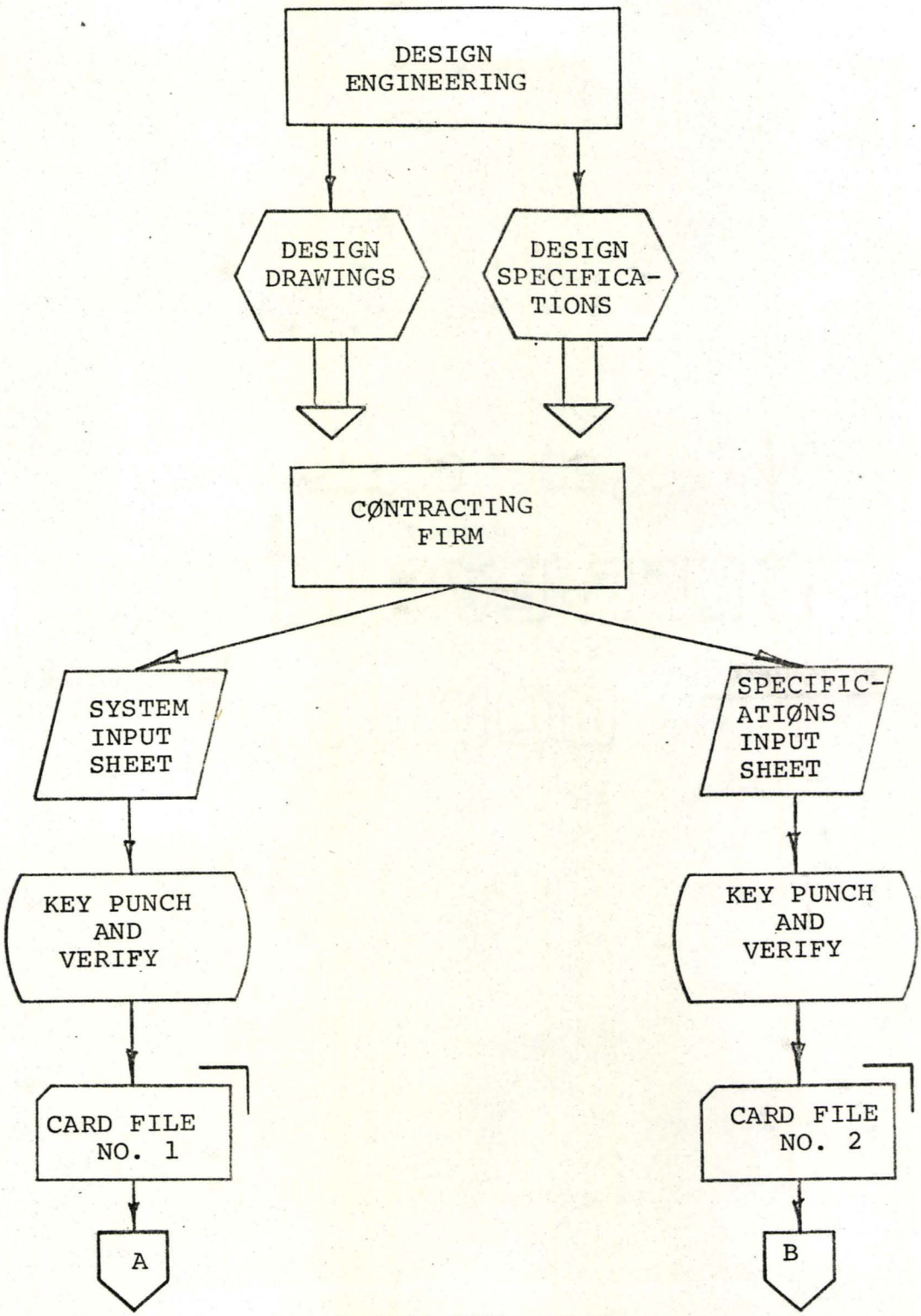
4.2.4 SYSTEM FLOW CHART

A major step in the synthesis of a new system is the derivation of an overall logical block diagram representing the steps for going from input to output. Attempts at this diagram begin almost with the initial analysis since it represents one mode of collecting and co-relating information. When the block diagram is finished it represents a logical description of the application.

The system flow chart for the Bills of Material and for the Isometric Drawing System is shown in Figure 5. It illustrates the flow of information and the computer runs involved in processing it. The Estimation System is omitted from the flow chart since it is only a proposed system to date.

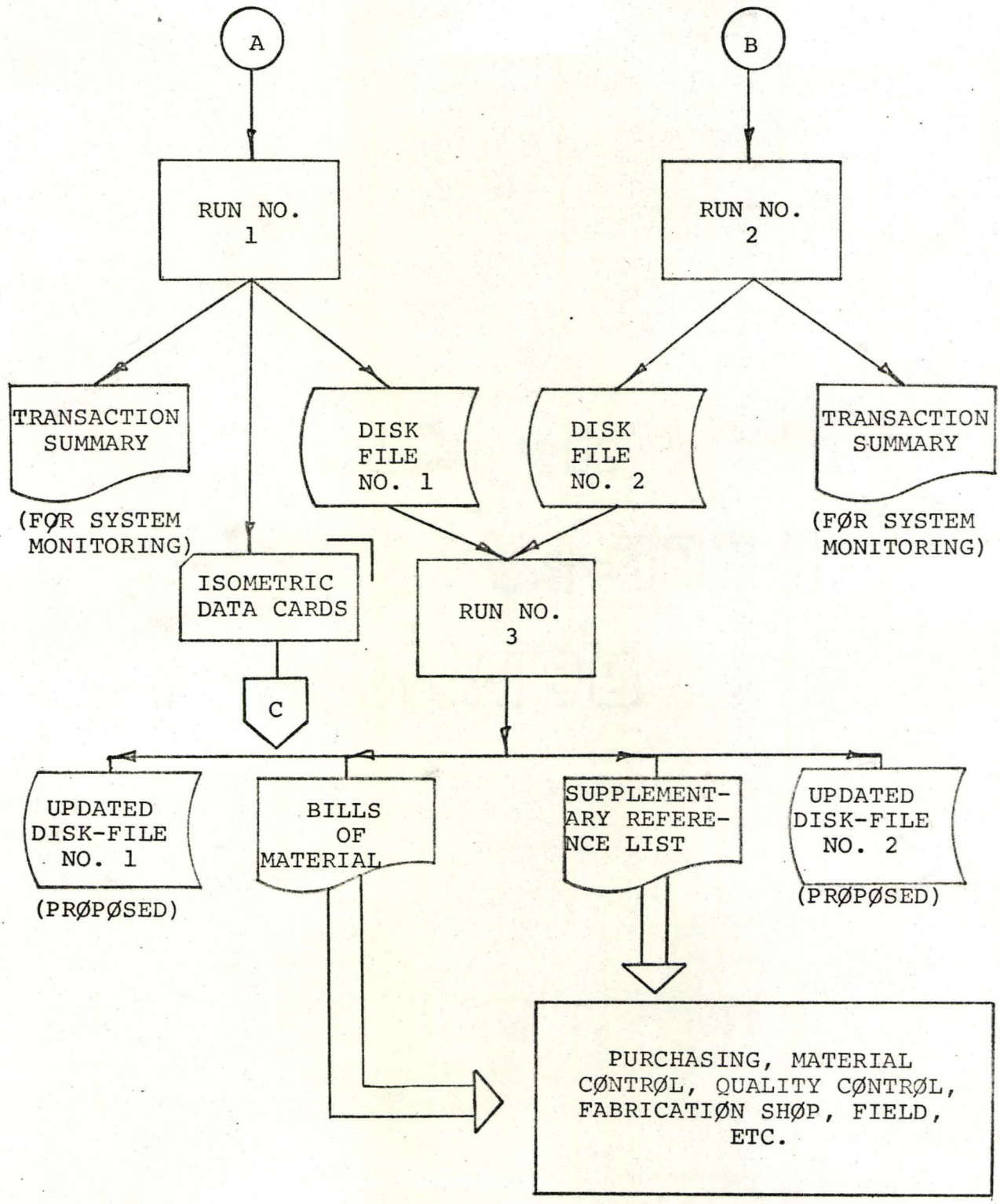
The updating function as shown in Run 3 is meant to incorporate changes in the Master Files after creation. This does not include rewriting the Master Files for a new contract. The updating function as described above is, however, beyond the scope of this project but can easily be incorporated at a later date.

The flow chart is self explanatory.



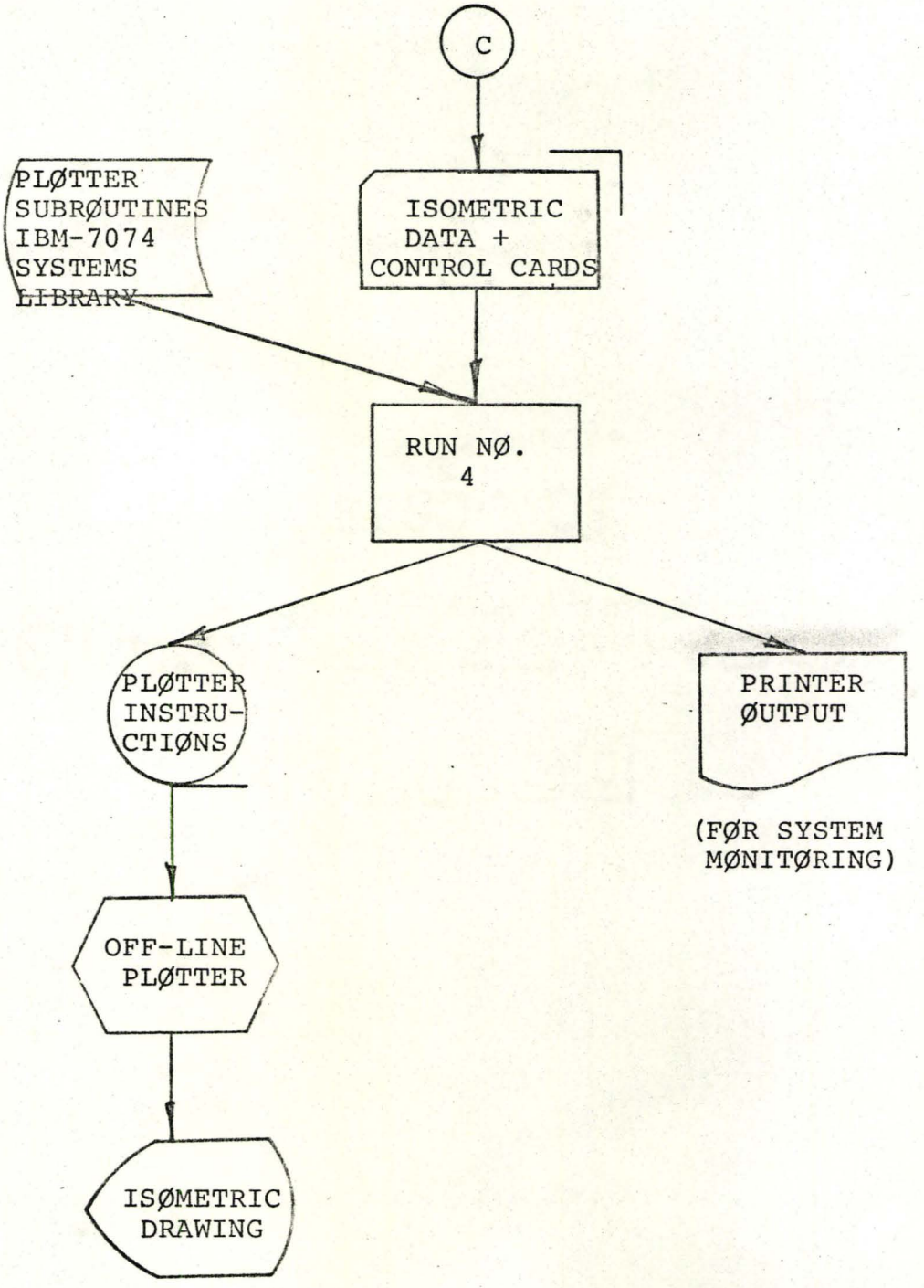
SYSTEM FLOW CHART

FIGURE 5



SYSTEM FLOW CHART

FIGURE 5 (CONT.)



SYSTEM FLOW CHART

FIGURE 5 (CONT.)

5. SYSTEM DETAILS

Beyond the synthesis stage, the narrower technical functions of programming begin. With a rough conception of the way in which the available memory will be used, a detailed flow chart was developed. The flow charts show the logical instructions required to describe the runs involved. With the flow chart in hand, one can proceed to develop precise sequence of instructions in a source language suitable for the particular application.

The source languages used here are, FORTRAN-IV for the 7040 FORTRAN-IV Compiler, (2); COBOL for the UNIVAC-1108.

Details of this system are described according to its run structure. Referring to Figure 5, the runs shown therein are:

RUN 1:

Run 1 performs two functions;

(a) Compiles the three dimensional configuration of the piping layout. Output is in the form of a punched-card data file.

(b) Stores the data useful to the Bill of Material System on a disk file. A list of "transactions" (records handled) is printed.

Both functions are shown as the responsibility of the source programme "CONSTO". CONSTO consists of the "Configuration Generator Programme" (1), revised to accommodate the logic for the storage function. However, a separate storage programme, "DDSP" has been written. Appendix B gives the details of the storage programme. A source listing of the programme "CONSTO" appears in the "Detail Documentation Package".

RUN 2:

Run 2 contains the source programme "SDSP" which performs the functions of storing the design specifications for the job on disk. Printed output lists the "transaction" summary.

Appendix C gives the details of Run 2.

RUN 3:

Run 3 performs the function of producing the required bills of material. The source programme name is "BOMP". The update functions shown as part of Run 3 in Figure 5 is beyond the scope of this project and hence, has not been programmed.

Appendix D gives the details of Run 3.

RUN 4:

Run 4 is comprised of the source programme "DRAFT 2" and/or "DRAFT". Both programmes perform the function of compiling plotter instructions to drive-off-line digital plotters.

Software used for "DRAFT 2" is from the IBM-7040

library. It compiles instructions for the Benson-Lehner digital plotter. The programme "DRAFT" compiles instructions for the EAI-1500 plotter.

Details of "DRAFT" appear in Reference (1).

A source listing of the programme "DRAFT 2" is included in the "Detail Documentation Package".

6. CONCLUSIONS

This feasibility study has achieved the objective of showing that bills of material can be economically produced by a computerized system. As a natural result of the study, a working computer system has been designed, programmed and tested. This system can be easily adapted, with few changes, to an installation where a COBOL compiler and a data-base management system is available. Considering the economic attractiveness and versatility of the system and the high cost of trained personnel, (required for a manual system), this system can be recommended to any piping layout contractor.

7. RECOMMENDATIONS

Although, the bill of material system presented here is complete in itself, the following may be recommended as further enhancements.

(a) The use of preprinted forms for the bills of material will add to the attractiveness of the system. This will only require changes to the print routines of the programme "BOMP".

(b) An update feature should be built into the two storage programmers "DDSP" and "SDSP". This will allow the user to easily correct any erroneous data on the two master files. A simple update feature is already present in the two programmes, but is not versatile enough for a large piping layout project. The feasibility of combining the two storage programmes into one may also be investigated.

To complete the "total" system the recommendations made for an estimation system (section 3.2) may be acted upon.

APPENDIX A

DISCUSSION OF THE FILE MANAGEMENT SYSTEM USED FOR CREATING THE MASTER FILES

The file management system used for creating the two data-base storage files, is called IMS-8. It operates under control of the EXEC-8 operating system on the UNIVAC-1108. The data-base is defined as a group of mass-storage files. The data-base is organized in an Index Sequential manner. Each data-base file is composed of one or more logical records, which are located by the use of a search key which is an integral part of the record. The search key may be divided into a maximum of five separate keys. A search key must uniquely define a record; duplicate records (records with the same keys) are not possible on the same data-base file. The data-base collating sequence is accending.

A user program accesses the data-base by using specific acquisition functions through a COBOL (or FORTRAN) interface. The COBOL verb ENTER is used to call the subroutine to perform the acquisition of a record. Associated with the ENTER verb is a calling sequence where the following information has to be supplied:

(1) The File-Name where the desired record is located

(2) The Search-Key(s) of the desired record

(3) The Function to be performed on the specified record

(4) The Buffer area, in the user programme, associated with the record.

The coding for the acquisition functions, as it appears in an user programme, is:

```
ENTER LEVELO-FMS-8 SUBRØUTINE REFERENCING
                FUNCTION
                FILE NAME
                BUFFER NAME
                SEARCH KEY(S).
```

A status code, as to the success of a requested function, is returned by the IMS-8 processor in the first word of the user programme's common-storage section. Prior to accessing a data-base file it has to be initialized. A standard system subroutine (USERPROCED SECTION) is used in the procedure division of the user programme to initialize the data-base files required. The COBOL verb INCLUDE, is used to copy the initialization procedure into the COBOL programme. This would appear in the user programme as;

```
INCLUDE USERPRØCED SECTIØN.
```

The acquisition functions used in the bill of material system are described below. As used below, NOT-FOUND is a condition word (level 88) in the first word of the user programme's common-storage section.

(1) INSERT function

This function is used to insert a record which does

not already exist on the file. If a record, with the search keys specified, already exists, a NOT-FOUND status is returned.

(2) MODIFY function

This function is used to modify a record existing on file. The modify function, actually, enters the record into the file by overlaying the existing record. If no record can be found with the specified search keys, a NOT-FOUND status is returned.

(3) INQUIRE function

The inquire function retrieves the specified record and brings it into the user's buffer. The search keys must be supplied for this function. If the record does not exist on the file, a NOT-FOUND status is returned.

(4) CHAIN-KEYn

This function retrieves the next sequential record, from the specified file, with a search key greater than the one supplied. However, a portion of the supplied search key must be equal to the corresponding portion of retrieved record's search key, otherwise a NOT-FOUND status is returned. The part of the key that must be equal is defined by the value of 'n'. This number indicates how many of the specified search keys are to be used for the equal comparison. This function, there-

fore, provides the facility to successively retrieve a logical group of records and have a NOT-FOUND status returned at the end of that group.

APPENDIX B-1

SYSTEM INPUT SHEET; DESCRIPTION and USE

The system input sheet (Table 1) is used to enter drawing data into the system. The data is used for the production of isometric drawings by the programme "CONSTO". The data is also stored on a data base file to be used by the bill-of-material system. The storage function is performed by the programme "CONSTO" or a special storage programme called "DDSP". The system input sheet provides room for control information such as job number, run number, run date etc. This control information is not used by any programme in this system, and is for documentation purposes only.

The system input sheet has been so designed that once it has been filled, it can be key punched onto computer cards without any further transcribing. The format and key punch columns for each field are included on the sheet. This design minimizes errors in transcribing.

Each system input sheet consists of one I-D CARD followed by multiple DATA CARDS.

I-D CARD

One I-D CARD per system input sheet is required. The variables on this card are:

NN - This is control variable which must have the value '999', left justified in the five position field. This value designates the card as an I-D CARD.

JOBNO - is a six position alphanumeric field. Blanks and special characters are permissable as part of the field. The job number for a particular job should be input in this field. It must be the same as used on the specification input sheets (see Appendix C-1).

LAREA - is a four position alphanumeric field. It is to be used to input the area number to which this system input sheet pertains. Blanks and special characters are permissable as part of the field.

LSUB - is a four position alphanumeric field to be used to input the sub-area number to which this system input sheet pertains. Blanks and special characters are permissable as part of the field.

ISONO - is a six position field to be used to input the isometric drawing number to which this system input sheet pertains. Blanks and special characters are permissable as part of the field.

FIELD REQUIREMENT -

This field contains 3 sub-fields. In the present system this field is NOT USED. However, it may be used to input a date by which the material must be available in the field. This would then

appear on the bill of material.

RUN DATE

- This field contains 3 sub-fields. The field is used to input the run date which is to appear on the transaction summary produced by the programme "DDSP".

The sub-fields are.

DAY - is a two position numeric field to be used to input the date. Its value must be in the range '01' and '31' inclusive.

MONTH - is a four position alphabetic field to be used to input the month. Any alphabetic abbreviation of the month is permissable.

YEAR - is a two position numeric field to be used to input the year.

DATA CARDS

Each DATA CARD consists of the following variables:

NN - is a five position numeric field. It is a control variable and must be present. The numeric data input must be right justified. The valid values of NN and their meanings are as detailed below:

NN = 1:

(a) For the bill of material system this signifies that the information contained on the card is for piping. The variables FEET, AINCH, ANUM, DENOM, LSIZE, LSPEC, LNO and IFSIG are of

significance to the bill of material system when NN = 1 and must be completed according to the instructions given herein.

(b) For the isometric drawing system, the variable 'NN' taking on the value 1 specifies the generation of a main line. This line length will be generated at the end of the previous line or at the end of the line specified by KVAL. The dimension lines and dimensioning information related to this line will also be generated if called for by the variable SIG.

NN = 2:

(a) For the bill of material system when NN = 2, the data on the card is of no significance. The programme "DDSP" will ignore a card with NN = 2.

(b) For the isometric drawing system, when NN = 2, instructions will be generated to write

C ELEV FEET' AINCH-ANUM/DENOM

where the values for FEET, AINCH-ANUM and DENOM are read in according to the input sheet. This information will be written immediately above the line specified by KVAL, in the direction and plane specified by 'I' and 'J', respectively. The length in feet from the

beginning of the line to the start of the written material is specified by DIST.

NN = 3:

(a) For the bill of material system this signifies that the information contained on the card is for a flanged globe value. The variables LSIZE, LSPEC, LNO and IFSIG are of significance and must be completed according to the instructions given herein.

(b) For the isometric drawing system when NN = 3, instructions will be generated to insert the symbol for a flanged globe valve in the line specified by KVAL. The symbol will appear in the direction and plane specified by 'I' and 'J'. The symbol will be inserted the length given by DIST from the beginning of the line and this length will be dimensioned, if called for by the variable SIG.

NN = 4:

(a) For the bill of material system this signifies that the information contained on the card is for a reducer. The variables LSIZE, LSPEC, LNO and IFSIG are of significance and must be completed according to the instructions given herein.

(b) For the isometric drawing system when NN = 4, instructions will be generated to insert the symbol for a reducer in the line specified by KVAL. The positive direction of the reducer is defined as the large diameter occurring first, in the direction in which the line is drawn. The reducer may be drawn in the negative direction by making KVAL the negative value of the line number. The other variables have the meaning as defined previously.

NN = 5:

(a) For the bill of material system, when NN = 5 it signifies that the information contained on the card is for a flange. The variables NSIZE, NSPEC, LNO and IFSIG are of significance and must be completed according to the instructions given herein.

(b) For the isometric drawing system, a flange will be drawn at the end of the line specified by KVAL.

NN = 6:

(a) For the bill of material system when NN = 6, the data on the card is of no significance. The programme "DDSP" will ignore a card with NN = 6.

(b) For the isometric drawing system, when NN = 6 an arrow showing direction of flow will be generated at the centre of the line specified by KVAL. 'I' and 'J' indicate the direction of the line and the plane of the arrow, as before. ASIGN does not refer to 'I' in this case but specifies the direction of the arrow and must have a value of +1. or -1.

NN = 7:

(a) For the bill of material system, NN = 7 signifies that the information contained on the card is for an unflanged globe value. The variables LSIZE, NSPEC, LNO and IFSIG must be completed according to the instructions given herein.

(b) For the isometric drawing system, when NN = 7, the symbol for an unflanged globe valve will be generated in the line called for by the variable KVAL. The instructions for the other variables are as given before.

NN = 8:

NN = 99999:

(a) For the bill of material system cards containing NN = 8 or NN = 99999 are of no significance and are ignored by the programme "DDSP". In

addition any data cards between a card with NN = 8 and a card with NN = 99999 are also ignored. (See (b) below.)

(b) For the isometric drawing system, the variable 'NN' taking on the value '8' indicates that the next series of cards will contain lines of alphanumeric information to be printed by the printer head. The variables which have to be defined for each line of alphanumeric information are: KVAL, I, ASIGN, DISTI, J, SIG, DISTJ, ORIENT, V, W, X, Y, and Z. These variables are read in by FORMAT (2I5, 2F5.0, I5, 3F5.0, 5A6). KVAL indicates the line at whose end the offset is measured from. The offset is the distance DISTI in the ASIGN direction of 'I', and the distance DISTJ in the SIG direction of 'J'. ORIENT signals whether the printer is to print in the horizontal or vertical orientation by the values 'O' and 'l', respectively. The last five variables contain alphanumeric data, up to thirty characters in length which will be printed exactly as they appear. To signal the end of information to be printed, the variable KVAL takes on a value of 99999 (which is in effect NN).

NN = 9

(a) For the bill of material system a card with NN = 9 is of no significance and will be ignored by the programme "DDSP".

(b) For the isometric drawing system and the programme "CONSTO"; after all the lines and symbols desired have been called, the variable 'NN' must take on the value of 9. This will initiate the output process. All the stored information will be punched out, along with appropriate control cards to instruct the programme DRAFT (or DRAFT 2).

NN = 0

(a) For the bill of material system, NN = 0 signifies that the information contained on the card is for a valve, a field item or a coded fitting. One of the variables NVNOS, NSPEEL or NFLD must be present. The variables NSIZE, NSPEC, LNO and IFSIG must also be completed according to the instructions given herein.

(b) A card with NN = 0 is of no significance to the isometric drawing system and is ignored.

KVAL - is a five position numeric field which has no significance for the bill of material system and is ignored by the programme "DDSP".

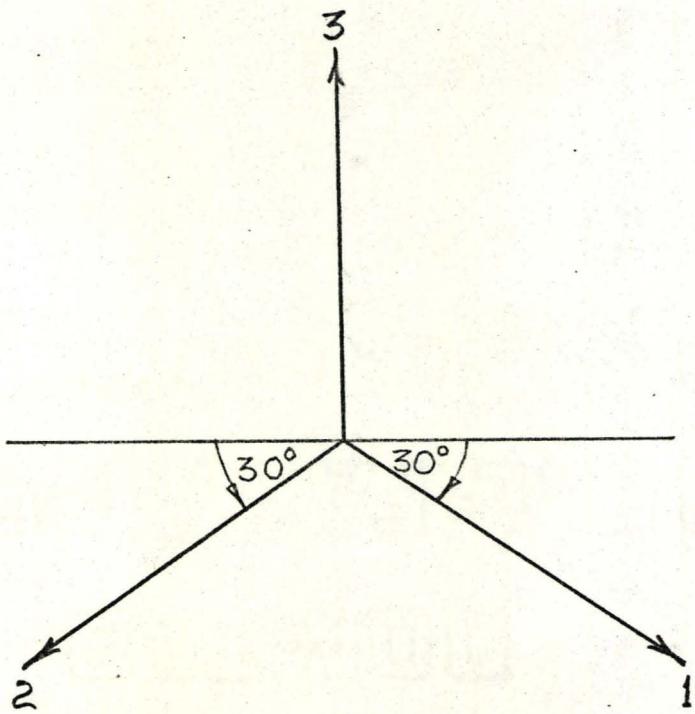
For the isometric drawing system KVAL is a coding number associated with each line or symbol for identification purposes. All lines and symbols are numbered sequentially in the order in which they are generated.

I - is a one position numeric field which has no significance for the bill of material system and is ignored by the programme "DDSP". For the isometric drawing system, I must have an integer value of 1, 2, or 3 which specifies the axial direction of the line or symbol with directions as shown in Figure 6.

ASIGN - is a three position (F3.0) field which has no significance for the bill of material system and is ignored by the programme "DDSP". For the isometric drawing system, ASIGN is a variable referring to 'I'. It may have a value of +1. or -1. which yields the positive and negative directions, respectively, as defined in Figure 6.

FEET, AINCH, ANUM and DENOM

- are five position (F5.0) fields each. These variables specify the length of piping in feet, inches, and fractions of an inch respectively. These variables are stored on the drawing data file by the programme "DDSP" when NN = 1. For



POSITIVE ISOMETRIC DIRECTIONS

FIGURE 6

the isometric drawing system, these values also appear as dimensions on the isometric drawing.

J - The variable J is a one position numeric field which is of no significance to the bill of material system and is ignored by the programme "DDSP". For the isometric drawing system J is similar to 'I', except that 'J' refers to the plane of the symbol and dimensioning (see Figure 6).

SIG - is a three position (F3.0) field which is of no significance to the bill of material system and is ignored by the programme "DDSP". For the isometric drawing system the variable SIG has the same function and meaning as ASIGN except that it refers to 'J', the plane of the symbol and dimensioning.

DOT - is a three position (F3.0) field which is of no significance to the bill of material system and is ignored by the programme "DDSP". For the isometric drawing system, DOT is a control variable to instruct the computer to generate instructions for drawing welding dot symbols. In the case of main lines, the welding dot will appear 0.4 feet from the end or ends of

the line governed by the following values for DOT:

Blank - no welding dot will appear

2. - welding dots placed near both ends of the line

+1. - welding dot will be placed near last end of line

-1. - welding dot will be placed near beginning of line

For the case of the symbol, welding dots will appear at both ends of a symbol if DOT = 2.; no welding dots will appear if DOT is blank.

DIST - is a five position (F5.0) field which is of no significance to the bill of material system and is ignored by the programme "DDSP". For the isometric drawing system; if the line is desired to be scaled, DIST is left blank; otherwise the line will be drawn the length in feet specified in DIST. For the case of symbols, they will be inserted the length specified in DIST from the beginning of the line.

MTRI - is a one position numeric field which is of no significance to the bill of material system and is ignored by the programme "DDSP". For the isometric drawing system; if a main line

occurs in a direction other than a coordinate direction, MTRI is given a value of 1. This suppresses storage of the previous end point and combines it with the present line. Triangulation and dimensioning of the triangulation lines is possible.

NVNOS - is a five position alphanumeric field which must contain the valve number when the card is being used for specifing a valve to the bill of material system, (NN =0). LSIZE and LSPEC are not used when NVNOS is present. Blanks and special characters are permissable as part of the field. This variable must be left completely blank when the card does not define a valve. This variable has no significance for the isometric drawing system.

NSPEEL- is a three position alphanumeric field which must contain the code for a coded-fitting (Table 3) when the card is being used for specifing a coded-fitting to the bill of material system, (NN = 0 and NVNOS = blanks). Blanks and special characters are permissible as part of the field. This variable must be left completely blank if the card does not define a coded-fitting. This variable has

L I S T O F C O D E D F I T T I N G S

VALUE OF 'NSPEEL'	ABBREVIATION PRINTED	CODED FITTING
11	BOLTNG	Bolting
12	CAP	Cap
13	RCPLNG	Coupling Right Hand
14	RLCPLN	Coupling Right & Left
15	CRØSS	Cross
16	EL90	Elbow, 90°
17	EL45	Elbow, 45°
18	EL22.5	Elbow, 22½°
19	EL1125	Elbow, 11¼°
20	ELDROP	Elbow, Drop
21	ELHEEL	Elbow, Heel Outlet
22	ELSIDE	Elbow, Side Outlet
23	EL90ST	Elbow, 90° Street
24	EL45ST	Elbow, 45° Street
25	ELTWAY	Elbow, Three-way
26	EXTNSN	Extention Piece
27	BUFLNG	Flange, Back-up
28	BLFLNG	Flange, Blind
29	GASKTS	Gaskets

TABLE 3

VALUE OF 'NSPEEL'	ABBREVIATION PRINTED	CODED FITTING
30	NIPPLE	Nipples
31	LCKNUT	Nut, Lock
32	WSTNUT	Nut, Waste
33	RTRBND	Return Bend
34	ROFCON	Roof Connection
35	TEE	Tee
36	DROPTE	Tee, Drop
37	FRWYTE	Tee, Four-way
38	SERVTE	Tee, Service
39	YBND45	Y-Bend, 45^{o}
40	EXTRA	Not Used

TABLE 3 (Continued)

no significance for the isometric drawing system.

NFLD - is a six position alphanumeric field which must contain the code for a field item when the card is being used for specifying a field item to the bill of material system (NN = 0; NVNOS and NSPEEL both blank). Blanks and special characters are permissible as part of the field. LSIZE and LSPEC are not used when this field is present. If this field is left blank when it should be present, the card will be rejected by the programme "DDSP". This variable is of no significance to the isometric drawing system.

LSIZE - is a six position (F6.2) numeric field which must contain the size in inches (diameter) of the piping, fitting or coded-fitting being specified to the bill of material system. The field must be completed right justified and must contain a decimal point (.). Only leading blanks are permissable. The field must be present when NN = 1, 3, 4, 5, 7 or 0. This field is of no significance to the isometric drawing system.

LSPEC - is a six position alphanumeric field which must contain the line service code for the pipe line being defined to the bill of material system. Blanks and special characters are permissible as part of the field; however, the field must not be left completely blank when NN has a value of 1, 3, 4, 5, 7 or 0. This variable is of no significance to the isometric drawing system.

LNO - is a four position alphanumeric field which must contain the line number of the pipe line being defined to the bill of material system. Blanks and special characters are permissible; however, the field must not be left completely blank when NN has a value of 1, 3, 4, 5, 7 or 0. This variable is of no significance to the isometric drawing system.

IFSIG - is a one position alphanumeric field which is significant to the bill of material system when NN = 1, 3, 4, 5, 7 or when NN = 0 and NSPEEL is not blank. Under these circumstances the item being defined on the card is treated as a fabrication requirement if the variable IFSIG is left blank. If IFSIG is not blank (it may contain any

alphanumeric character) the item is designated as a field requirement.

OTHER CONSIDERATIONS

As mentioned, one system input sheet, (describing an isometric drawing), must contain one I-D CARD followed by a number of DATA CARDS. Each system input sheet must contain a unique combination of JOBNO, LAREA, LSUB and ISONO on the I-D CARD. However, if it becomes impossible to completely describe an isometric drawing on one system input sheet and it becomes necessary to use multiple sheets, then the I-D CARD(S) must be excluded from the subsequent sheets until the isometric drawing number changes.

APPENDIX B-2

DETAILS OF THE PROGRAMME "DDSP"

The purpose of this programme is to create a data-base master file to contain the drawing data relevant to the bill of material system. The input consists of a punched card file containing the drawing data taken from system input sheets. A summary of input transactions (cards) processed by the programme is printed. The programme has been written in COBOL for the UNIVAC-1108. It uses a data base management system called IMS-8. The operating system under which this programme is designed to execute is called EXEC-8. It requires 15.4 K (six character) words of memory, a card-reader, a line-printer, and a disk file for its execution.

INPUT

The input consists of a punched card file. The format of the file and keying instructions have been described in detail in Appendix B-1.

OUTPUT

The output from the programme consists of

(1) the drawing data master file (called PDDF) on disk

and

(2) a transaction summary on the line-printer.

Figure 7 shows the record layout of the PDDF data-base file. The "Detail Documentation Package" contains a report layout of the transaction summary and a COBOL description of the data-base file PDDF.

PROCEDURE

After the data-base file PDDF has been initiated and the input card file and the output print file has been opened, the first card is read. The programme examines the card to ensure that it is an I-D CARD (see Appendix B-1). If this is not the case, an appropriate message is displayed and the run is terminated. Each data card is now read and examined to see what it can yield. If it is of no significance to the bill of material system it is ignored and the next data card is read. If the data card is significant and valid, the necessary information is moved to the data-base file buffer and the IMS-8 processor is called to INSERT the record on the file. If the INSERT is not successful, (indicating that a record with these keys already exists on the file), then the IMS-8 processor is called to MODIFY the record on file. The data card along with the action taken (INSERT, MODIFY or REJECT) is moved to the print file buffer and written. When an end-of-file is encountered on the input card file, a message indicating the end of run is displayed, all files are closed and the run is terminated.

A COBOL source listing of the programme appears in

FIELD	JOBNO	AREANO	SUB-AREA NO	ISONO	LINENO		NN	NSPEEL	NVNOS	NFLD	LSIZE	LSPEC	IFSIG
					LNO	LNSQ							
FORMAT	X(6)	X(4)	X(4)	X(6)	X(4)	X(3)	9(5)	XXX	X(5)	X(6)	9(3)V99	X(6)	9

PIPE LENGTH			
FEET	AINCH	ANUM	DENOM
9(4)	99	9(4)	9(4)

RECORD LAYOUT OF FILE PDDF

FIGURE 7

the "Detail Documentation Package". A flow chart for the programme appears in Appendix B-3.

LIST OF MESSAGES

The following messages may be displayed by the programme:

(1) 'NO INPUT RUN TERMINATED'

This message will be displayed only if an end-of-file is encountered on the first read. It indicates that there was no input to the run.

(2) 'NO I-D CARD RUN TERMINATED'

This message will appear if the first card read by the programme is not an I-D CARD (NN not equal to 999). Subsequent occurances of an I-D CARD are not checked for, but are correctly processed by the programme.

(3) 'END OF RUN DDSP'

This message is displayed to indicate the normal termination of the run.

TEST RESULTS

Included in the "Detail Documentation Package" are:

(1) A list of the input card file used for the test.

(2) A character, by character dump of the data base file created. The dump programme used, assumes a 100 character record. However, the valid character length for the PDDF file is 72 character. The rest of the record (containing the character '@') should be ignored.

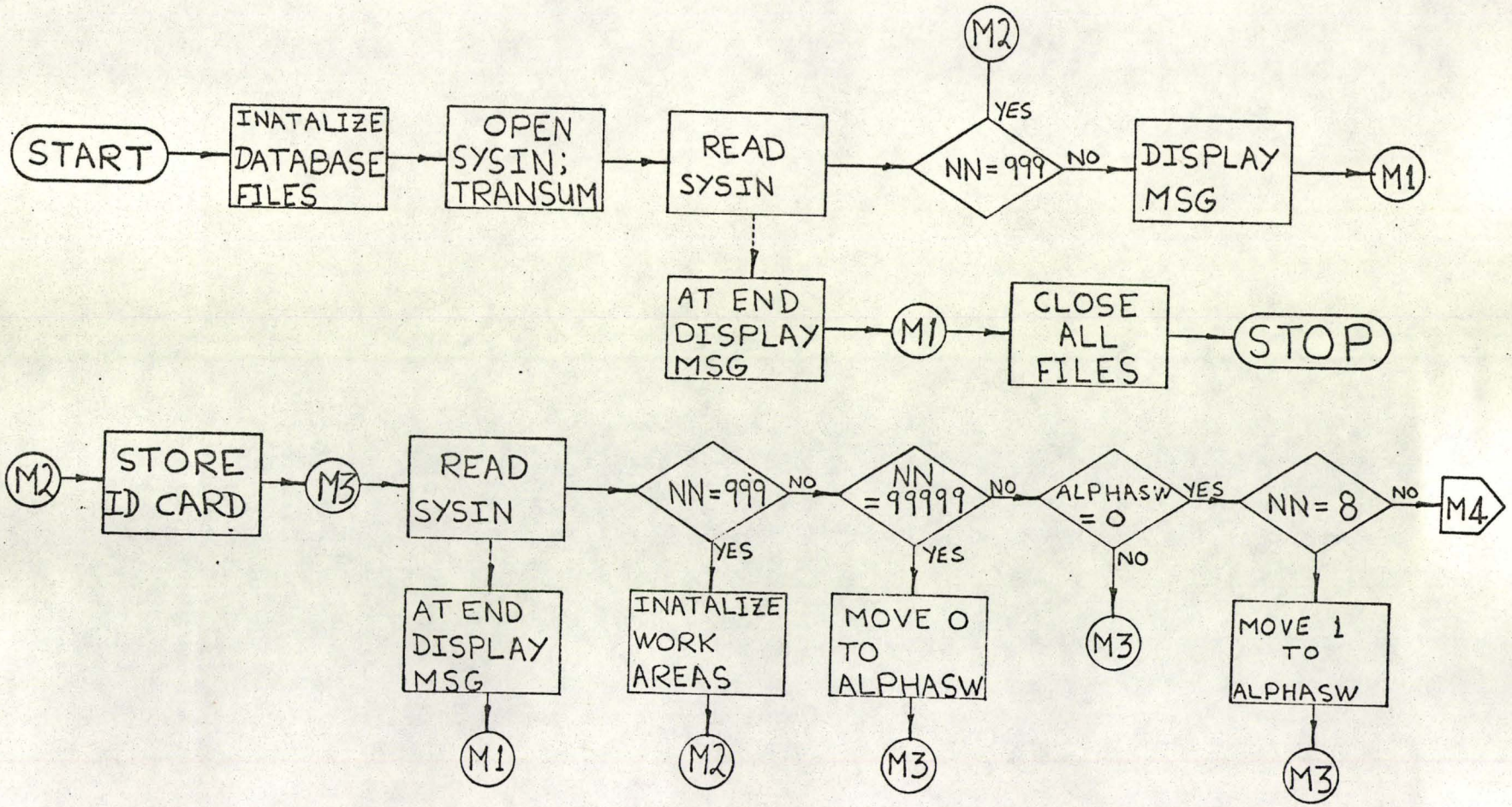
(3) The transaction summary produced by the programme

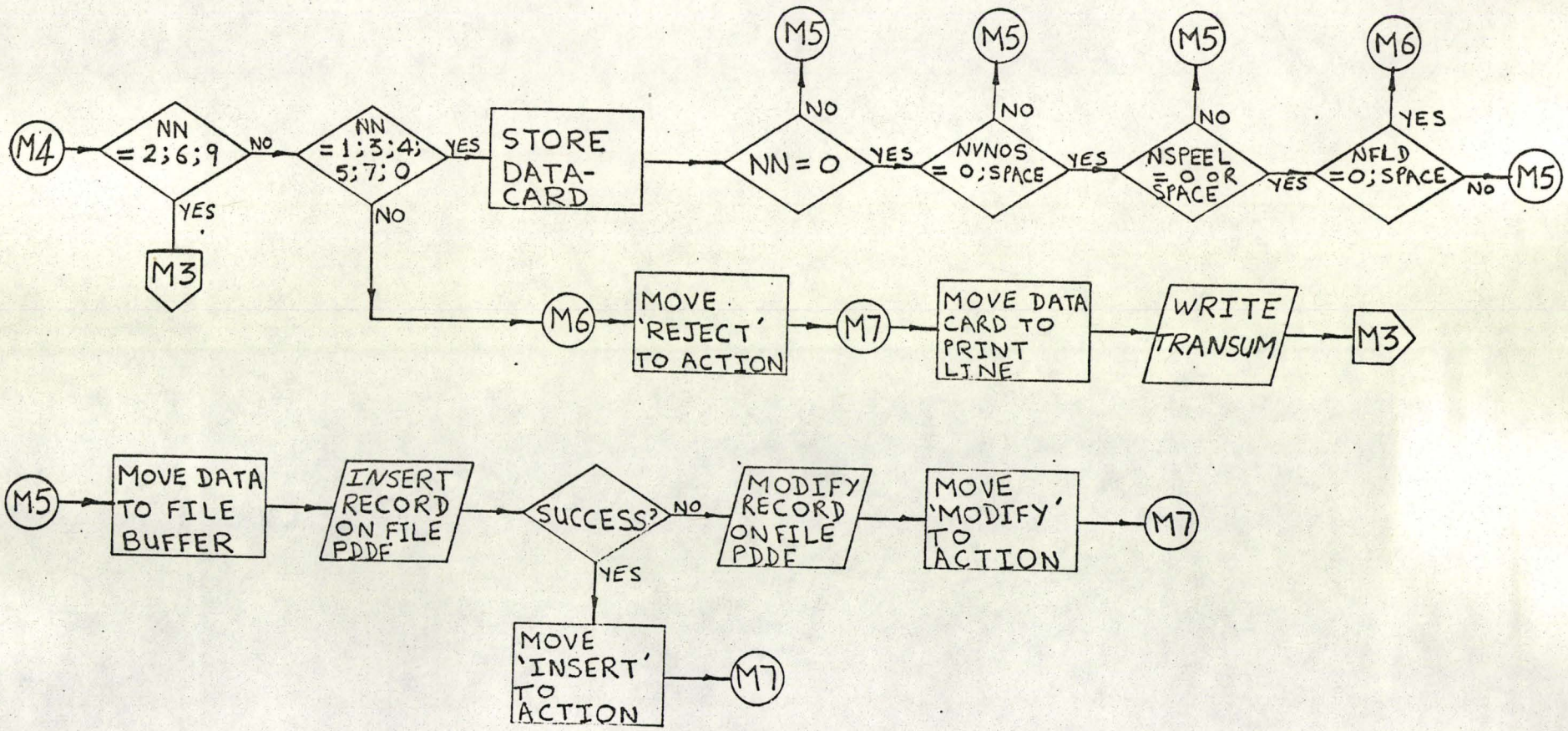
for this test.

(4) The control stream required to execute the test.

APPENDIX B-3

Flow Chart of the programme "DDSP".


START
INATALIZE DATABASE FILES
OPEN SYSIN; TRANSUM
READ SYSIN
M2
YES
NN=999
NO
DISPLAY MSG
M1
AT END DISPLAY MSG
M1
CLOSE ALL FILES
STOP
M2
STORE ID CARD
M3
READ SYSIN
NN=999
NO
YES
NN =99999
NO
YES
ALPHASW =0
YES
NO
NN=8
NO
M4
AT END DISPLAY MSG
M1
INATALIZE WORK AREAS
M2
MOVE 0 TO ALPHASW
M3
M3
MOVE 1 TO ALPHASW
M3


M4
NN = 2;6;9
NO
YES
M3
NN = 1;3;4; 5;7;0
YES
NO
STORE DATA-CARD
M5
NO
NN = 0
YES
M5
NO
NVNOS = 0;SPACE
YES
M5
NO
NSPEEL = 0 OR SPACE
YES
M6
YES
NFLD = 0;SPACE
No
M5
M6
MOVE 'REJECT' TO ACTION
M7
MOVE DATA CARD TO PRINT LINE
WRITE TRANSUM
M3
M5
MOVE DATA TO FILE BUFFER
INSERT RECORD ON FILE PDDF
SUCCESS?
NO
YES
MODIFY RECORD ON FILE PDDF
MOVE 'MODIFY' TO ACTION
M7
MOVE 'INSERT' TO ACTION
M7

APPENDIX C-1

SPECIFICATION INPUT SHEET; DESCRIPTION and USE

The specification input sheet (Table 2) is used to enter specification data into the bill of material system. The data is stored on a data-base file by the programme "SDSP". The specification data file thus created will be used in the production of the bills of material.

The specification input sheet provides room for control information such as job number, run number, run date, etc. This control information is not used by any programme in the system, and is for documentation purposes only.

The specification input sheet has been so designed that once it has been completed, it can be key-punched on to computer cards without any further transcribing. The format and the key-punch columns for each field are shown on the sheet. This design minimizes errors in transcribing.

Each specification input sheet consists of one I-D CARD followed by DATA CARDS. DATA CARDS 1 AND 2 completely define a specification of piping or fittings. DATA CARDS 3 AND 4 completely define a specification of a valve or special field item. The specification input sheet has been designed to simplify the task of transcribing as well as en-

suring that the various types of DATA CARDS are keypunched in a particular order. DATA CARDS 2 and 3 are provided on the same line on the sheet. Similarly, DATA CARDS 4 and 5 are on the same line. The card code is pre-printed on the sheet. The programme "SDSP" ensures that a DATA CARD 3 follows a DATA CARD 2 and a DATA CARD 5 follows a DATA CARD 4.

Unless otherwise specified, blanks and special characters are permissable in the fields discussed herewith. Invalid input will be rejected by the programme.

I-D CARD

One I-D CARD per specification input sheet is required. The variables on this card are:

CC - is a one position control variable which must have the value '1'. This signifies to the programme "SDSP", that this is an I-D CARD.

JOBNO - is a six position alphanumeric field which must contain the job number for the project these specifications are for. The job number must be the same as used on the system input sheets (see Appendix B-1).

RUN DATE

- This field contains 3 subfields. The field is used to input the run date which is to appear on the transaction summary produced by the programme "SDSP". The subfields are:

DAY - is a two position numeric field to be used to input the date. Its value must be in the range '01' and '31' inclusive.

MONTH - is a four position alphabetic field to be used to input the month. Any alphabetic abbreviation of the calander month is permissable.

YEAR - is a two position numeric field to be used to input the year.

DATA CARDS 2 AND 3

These cards are to be used to input specifications for piping or fittings. If a card 2 is present, then a card 3 must be present even if there is no inforamtion to input. It may be left blank except for the card code (variable CC). In addition, a card 3 cannot be present without a card 2.

DATA CARD 2

The variables on this card are:

CC - is a one position control variable which must have the value '2'. This signifies to the programme "SDSP", that this is a DATA CARD 2.

LSPEC - is a six position alphanumeric field which must contain the line service code for the specification being defined. Blanks and special characters are permissable; however, the field must not be left completely blank.

LTYPE - is a six position alphanumeric field which must contain a code, (signifying the type of item the specification is for), a valve number or a field item number. If the specification being input is not for a valve or a field item, the codes to be used are:

'000001' - for piping

'000003' - for a flanged globe valve

'000004' - for a reducer

'000005' - for a flange

'000007' - for an unflanged globe valve

For all other coded-fittings the value of the code (from table 3) must be entered in this field, right justified, (with leading blanks).

LSIZE - is a six position alphanumeric field which must contain the size of the item being specified. The size (diameter) of the item is input in inches in the first four positions of the field with a two position assumed decimal point. The last two positions of the field are either left blank or contain the literal 'UP' to signify that this specification applies to all items of this size (in inches) and greater. As an example, if we wish to enter a size of three and one half inches and over, we would input

'0350UP' in this field. The field cannot be left blank; however, leading blanks are permissable.

MATERIAL SPECIFICATION

- is a 50 position alphanumeric field where the material specification of the item being desired may be input.

DATA CARD 3

The variables on this card are:

CC - is a one position control variable and must contain the value '3'. This signifies to the programme "SDSP" that this is a DATA CARD 3.

CLASS SPECIFICATION

- is a 35 position alphanumeric field where the class specification information may be entered. Blanks and special characters are permissable. The field may be left completely blank.

JOINT TYPE

- is a 12 position alphanumeric field where the joint information for the item being described may be input.

REMARKS

- is a 6 position alphanumeric field where any remarks to be printed on the bill of material may be entered. These may consist of specifying the amount of trim allowance, as an example.

DATA CARDS 4 AND 5

These cards are to be used to input specifications for valves or field items, like flow meters, etc. If a card 4 is present then a card 5 must must be present even if there is no information to be input. It may be left blank except for the card code (variable CC). In addition, a card 5 cannot be present without a card 4.

DATA CARD 4

CC - is a one position control variable which must contain the literal '4'. This signifies to the programme "SDSP" that this is a DATA CARD 4.

LSPEC - same as in DATA CARD 2.

LTYPE - same as in DATA CARD 2.

LSIZE - same as in DATA CARD 2.

DESCRIPTION OF ITEM

- is a 55 position alphanumeric field where the description of the item being specified may be entered.

DATA CARD 5

CC - is a control variable which must have the value '5' on input. This signifies to the programme "SDSP" that this is a DATA CARD 5.

TYPE - is a 10 position alphanumeric field where the type of the item being specified may be entered.

FUNC - is a five position alphanumeric field which may be used to specify the function of the item being

described.

MANUF. NAME

- is a 15 position alphanumeric field which may be used to input the name of the manufacturer of the item.

MANUF. NO.

- is a six position alphanumeric field which may be used to input the manufacturer's number of the item being described.

REMARKS

- same as DATA CARD 3.

OTHER CONSIDERATIONS

If the facility to signify that a specification is to be used for sizes greater than or equal to the LSIZE value, is used then this specification must be the last one within the same LSPEC and LTYPE. For example, if a record where LSIZE = '0350UP' exists on the specification data file, then a record with LSIZE = '0400bb' or LSIZE = '0400UP' is invalid and will never be retrieved by the bill of material programme "BOMP". However, records with LSIZE = '0100bb', etc. are valid, and will be searched for, if required, by the programme "BOMP".

APPENDIX C-2

DETAILS OF THE PROGRAMME "SDSP"

The purpose of this programme is to create a data-base master file to contain specification data relevant to the bill of material system. The input consists of a punched card file containing the specification input sheets. A summary of the transactions processed by the programme is printed. The programme has been written in COBOL for the UNIVAC-1108, operating under EXEC-8. It uses a data-base management system called IMS-8. The programme requires 15.4 K (6 character) words of memory, a card-reader, a line-printer and a disk file for its execution.

INPUT

The input consists of a punched card file. The format of the file and the keying instructions have been described in detail in Appendix C-1.

OUTPUT

The output from the programme consists of:

(1) the specification data master file (called SDFL) on disk.

(2) a transaction summary on the line-printer.

Figure 8 shows the record layout of the SDFL data-base file. Included in the "Detail Documentation

TYPE 1

FIELD	JOBNO	LSPEC	LTYPE	LSIZE		MATSPEC
				SIZE	LMT	
FORMAT	X(6)	X(6)	X(6)	99V99	XX	X(50)

CLASSPEC	JOINT	RMRKS
X(35)	X(12)	X(6)

TYPE 2

FIELD	JOBNO	LSPEC	LTYPE	LSIZE		DSCRPT
FORMAT	X(6)	X(6)	X(6)	99V99	XX	X(55)

TYPE	FUNC	MANUF	MANUNO	RMRKS
X(10)	X(5)	X(15)	X(6)	X(6)

RECORD LAYOUT OF FILE SDFL

FIGURE 8

Package" are a report layout of the transaction summary and a COBOL listing of the database file SDFL.

PROCEDURE

After the data-base file SDFL has been initialized and the input and output files have been opened, the first card is read. The programme then examines the CARD-CODE to ensure that the card is an I-D CARD (card-code = 1). If this is not the case then a message is displayed and the run is terminated. A further edit takes place on the JOBNO field. If this field is blank, a message is displayed and the run is terminated. If the I-D CARD read is valid, the information is stored. The programme will then read two cards and build in a work area, a "complete" transaction consisting of either, card types 2 and 3 or card types 4 and 5. If the cards read are not in the proper sequence or a card is missing, (for example, if a card type 3 does not follow a card type 2) then the cards read will appear on the transaction summary with appropriate reject codes, (defined later). If the programme is successful in building a "complete" transaction, it proceeds to validate the information contained herein. The validation follows the criteria defined while describing the specification input sheet in Appendix C-1. If the validization is unsuccessful then the "complete" transaction is moved to the transaction summary and is printed

along with an appropriate reject code. Information from a valid "complete" transaction is moved to the data-base file buffer and the IMS-8 processor is called to INSERT the record on the file. If the insert is not successful, (indicating that record with these keys exists on file), then the IMS-8 processor is called to MODIFY the record on file. The "complete" transaction along with the action taken is then printed on the transaction summary. The programme then continues reading the cards on input until an end-of-file is encountered. At this point a message is displayed and the run is terminated.

A COBOL source listing of the programme appears in the "Detail Documentation Package". A flow chart of the programme appears in Appendix C-3.

LIST OF MESSAGES

The following messages may be displayed by the programme:

(1) 'NO INPUT RUN TERMINATED'

This message will be displayed only if an end-of-file is encountered on the first read. This indicates that the run was initiated without any input.

(2) 'NO I-D CARD RUN TERMINATED'

This message will appear if the card-code on the first card read is not equal to 1. Subsequent occurances of an I-D CARD are not checked for, but are correctly processed by the programme.

(3) 'INVALID JOBNO ON I-D CARD'

'RUN TERMINATED'

These messages are displayed by the programme if the JOBNO field on an I-D CARD is blank.

(4) 'NO CARDS FOLLOWING NEW ID CARD'

'RUN TERMINATED'

These messages appear if an end-of-file is encountered on the first read following the read of an I-D CARD.

(5) 'NO DATA CARD 3 FOR FOLLOWING DATA CARD 2'

'END OF INPUT RUN TERMINATED'

'IMAGE OF DATA CARD 2'

These messages and an image of the data card, type 2, last read will appear if an end-of-file is encountered on the next read.

(6) 'NO DATA CARD 5 FOR FOLLOWING DATA CARD 4'

'END OF INPUT RUN TERMINATED'

'IMAGE OF DATA CARD 4'

These messages and an image of the data card type 4 last read will appear if an end-of-file is encountered on the next read.

(7) 'END OF RUN SDSP'

This message is displayed to indicate the normal termination of the run.

LIST OF REJECT CODES

(1) R-001

When this reject code appears in the ACTION field on the transaction summary, it means that a data card type 3 did not follow the data card type 2 shown. No processing is done on the data card type 2 which has been rejected.

(2) R-002

When this reject code appears in the ACTION field on the transaction summary, it means that a data card type 5 did not follow the data card type 4 shown. No processing is done on the rejected data card type 4.

(3) R-003

When this reject code appears in the ACTION field on the transaction summary, it indicates that the card shown has an invalid card code. No processing is done on the rejected card.

(4) R-004

When this reject code appears on the transaction summary along with an image of the "complete" transaction, it indicates that a field is invalid. No processing takes place on the rejected "complete" transaction.

TEST RESULTS

Included in the "Detail Documentation Package are:

(1) A list of the input card file used for the test.

(2) A character by character dump of the data-base file created. The dump programme assumes a 100 character record.

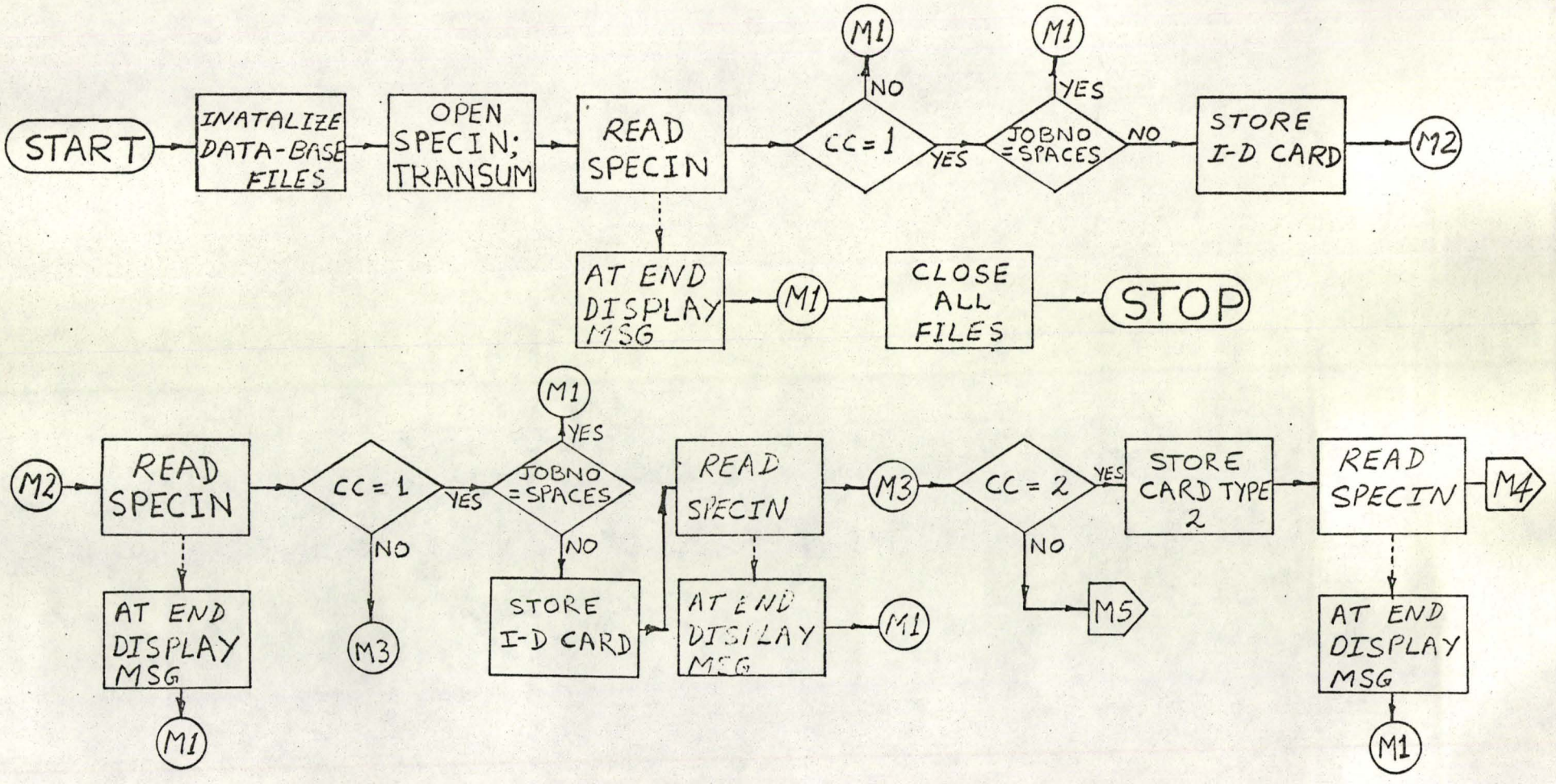
However, the size of the SDFL record is 172 characters. This means that 2 records on the dump constitute one record on the file. The rest of the second record (containing the character '@') should be ignored.

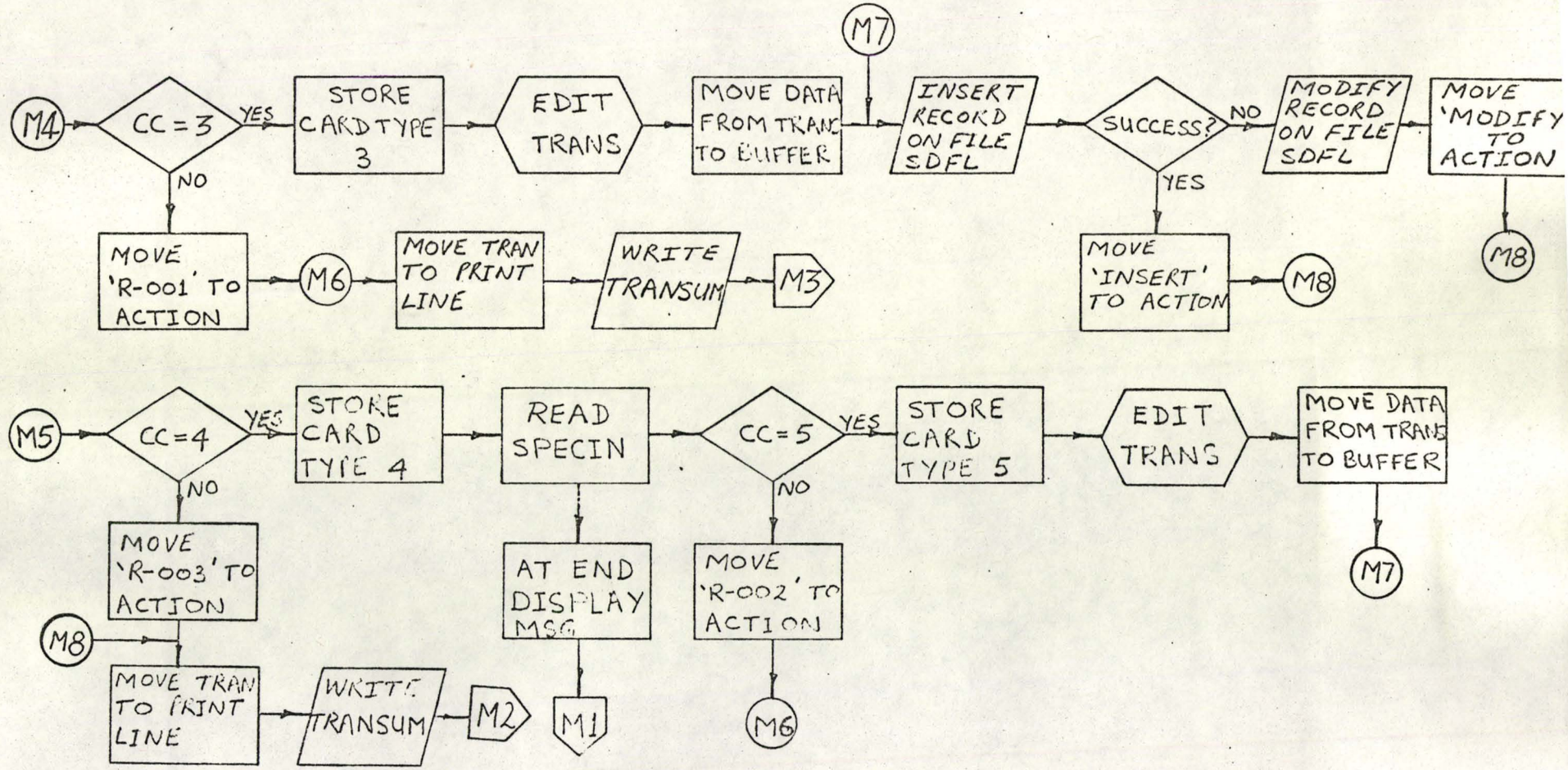
(3) The transaction summary produced by the programme for this test.

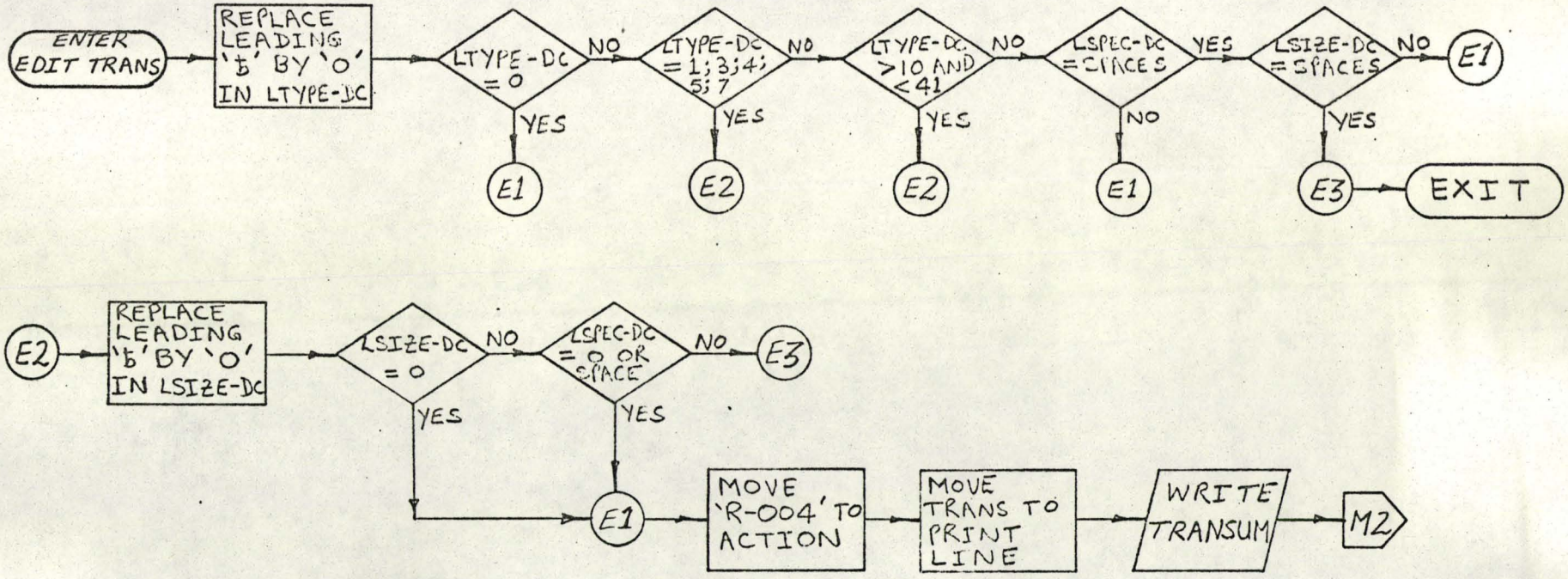
(4) The control stream required to execute the test.

APPENDIX C-3

Flow Chart of the programme "SDSP".


START
INATALIZE DATA-BASE FILES
OPEN SPECIN; TRANSUM
READ SPECIN
M1
NO
CC = 1
YES
M1
YES
JOBNO = SPACES
NO
STORE I-D CARD
M2
AT END DISPLAY MSG
M1
CLOSE ALL FILES
STOP
M2
READ SPECIN
CC = 1
YES
NO
M1
YES
JOBNO = SPACES
NO
M3
STORE I-D CARD
READ SPECIN
M3
CC = 2
YES
NO
M5
STORE CARD TYPE 2
READ SPECIN
M4
AT END DISPLAY MSG
M1
AT END DISPLAY MSG
M1
AT END DISPLAY MSG
M1


M4
CC = 3
YES
NO
STORE CARD TYPE 3
EDIT TRANS
MOVE DATA FROM TRANS TO BUFFER
M7
INSERT RECORD ON FILE SDFL
SUCCESS?
NO
YES
MODIFY RECORD ON FILE SDFL
MOVE 'MODIFY' TO ACTION
M8
MOVE 'R-001' TO ACTION
M6
MOVE TRAN TO PRINT LINE
WRITE TRANSUM
M3
MOVE 'INSERT' TO ACTION
M8
M5
CC=4
YES
NO
STORE CARD TYPE 4
READ SPECIN
CC=5
YES
NO
STORE CARD TYPE 5
EDIT TRANS
MOVE DATA FROM TRANS TO BUFFER
M7
MOVE 'R-003' TO ACTION
M8
AT END DISPLAY MSG
MOVE 'R-002' TO ACTION
MOVE TRAN TO PRINT LINE
WRITE TRANSUM
M2
M1
M6


ENTER EDIT TRANS
REPLACE LEADING 'b' BY '0' IN LTYPE-DC
LTYPE-DC = 0
NO
YES
E1
LTYPE-DC = 1; 3; 4; 5; 7
NO
YES
E2
LTYPE-DC > 10 AND < 41
NO
YES
E2
LSPEC-DC = SPACES
YES
NO
E1
LSIZE-DC = SPACES
NO
YES
E1
E3
EXIT
E2
REPLACE LEADING 'b' BY '0' IN LSIZE-DC
LSIZE-DC = 0
NO
YES
LSPEC-DC = 0 OR SPACE
NO
YES
E3
E1
MOVE 'R-004' TO ACTION
MOVE TRANS TO PRINT LINE
WRITE TRANSUM
M2

APPENDIX D-1

DETAILS OF THE PROGRAMME "BOMP"

The purpose of the programme is to produce a bill of material based on the arguments present on a control card read by the programme. The input consists of two database files, one containing the utilization data (drawing data) and the other containing specification data. The output consists of the bill of material and a supplementary reference list which is produced on the line-printer. The programme has been written in COBOL for the UNIVAC-1108 operating under EXEC-8. It uses a database management system called IMS-8. The programme requires 33.4K (six character) words of memory, a card-reader, a line-printer and two disk files for its execution.

INPUT

The input to the programme consists of:

(1) The database file PDDF containing the drawing data. The file is created by the programme "DDSP". Details appear in Appendix B-2.

(2) The database file SDFL containing the specification data. The file is created by the programme "SDSP". Details appear in Appendix C-2.

(3) A card file consisting of one I-D CARD followed by BILL OF MATERIAL DATA CARDS, one for each type of bill of

material desired. The bill of material control sheet from which this card file is created is shown in Figure 9. The sheet is discussed in detail later in this appendix.

OUTPUT

The output from the programme consists of:

(1) The Bill(s) of Material requested.

(2) The supplementary reference list which consists of the line numbers, area numbers and sub-area numbers encountered, if applicable. This list is produced only on request.

The "Detail Documentation Package" includes Report layouts for the bill of material and the supplementary reference list.

PROCEDURE

The procedures required for the production of a bill of material are too involved to describe herein. They can be best presented by a flow chart as shown in Appendix D-2. However, the basic functions performed by the programme are as below:

(1) Edits are performed on the control cards.

(2) Based on the type of bill of material requested, retrieve the relevant utilization data from the file PDDF.

(3) Accumulate the quantities of like items.

(4) Retrieve the relevant specification data from the file SDFL.

(5) Create the printed output for the bill of material and the supplementary reference list (if requested).

FIGURE 9

BILL OF MATERIAL CONTROL SHEET	JOB NO:	DATE:	PAGE OF
	RUN NO:	COMPILED BY:	K.P. BY:
	RUN DATE:		

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

CONTROL CARD

RUN DATE			NAME OF INITIATOR	NAME OF FIRM	ID
DD	MMMM	YY			
					**

BILL OF MATERIAL DATA CARDS

MBILL	JOBNO	AREA NO.	SUB-AREA NO.	ISONO	LNO	FLD-SIG	LINE-SIG	AREA-SIG

In addition the programme performs certain validity checks on the contents of the PDDF and SDFL files. Invalid data is displayed along with an appropriate message. If an item is encountered for which specifications do not exist on the SDFL file an appropriate message is displayed along with the details of the item. Invalid bill of material data cards are rejected by the programme and a message to that effect is also displayed.

BILL OF MATERIAL CONTROL SHEET

The bill of material control sheet (Figure 11) is used to enter bill of material request information into the programme "BOMP". The sheet provides room for control information, such as run number, name of initiator, etc. This control information is not used by the programme "BOMP" and is for documentation purposes only. Each bill of material control sheet consists of one CONTROL CARD followed by BILL OF MATERIAL DATA CARDS, one for each type of bill of material requested.

CONTROL CARD

Only one control card per execution of the programme "BOMP" is permissable. The information on the card is printed on all the bills of material requested by the bill of material data cards which follow the control card. The arguments on the control card are:

RUN DATE

- This is the date which will be printed on each bill

of material requested. It consists of three subfields:

DD - is a two position field used to enter the numeric date (day). Its value must be within the range '01' and '31' inclusive.

MMMM - is a four position alphabetic field used to enter the month. Any alphabetic abbreviation of the month is permissable.

YY - is a two position numeric field used to enter the year of the date.

NAME OF INITIATOR

This a 20 position alphanumeric field used to enter the name of the initiator to be printed on the bills of material requested.

NAME OF FIRM

- is a 50 position alphanumeric field used to enter the name of the firm to be printed on the bills of material requested.

ID - is a two position field which must contain the literal '**'. This indicates to the bill of material programme "BOMP", that this is a control card. It may be noted that if the first card read by the programme "BOMP" is not a control card, the run will terminate.

BILL OF MATERIAL DATA CARDS

One bill of material data card per type of bill of material desired is required. The arguments on this card are:

MBILL - is a one position numeric field used to designate the type of bill of material being requested. This argument may have the values listed below.

(a) MBILL = 1: When MBILL = 1, a bill of material by BULK is produced. The JOBNO field must be completed as detailed later. The arguments AREANO, SUB-AREA-NO, ISONO and LNO must be left blank. The use of the argument FLD-SIG is optional. The arguments LINE-SIG and AREA-SIG are not used in this case.

(b) MBILL = 2: When MBILL = 2, a bill of material for a specified AREA NUMBER (within a JOB NUMBER) is produced. The JOBNO and AREANO fields must be completed. The arguments SUB-AREA-NO, ISONO and LNO must be left blank. Use of the arguments FLD-SIG and LINE-SIG is optional. The argument AREA-SIG is not used.

(c) MBILL = 3: When MBILL = 3, a bill of material for a specified SUB-AREA NUMBER (within an AREA and JOB NUMBER) is produced. The JOBNO, AREANO and SUB-AREA-NO must be completed. The ISONO and LNO fields must be left blank. Use of the arguments FLD-SIG and LINE-SIG is optional. The argument AREA-SIG is not used.

(d) MBILL = 4: When MBILL = 4, a bill of material by ISOMETRIC DRAWING NUMBER (within a JOB NUMBER) is produced. The JOBNO and ISONO field must be completed.

The AREANO, SUB-AREA-NO and LNO field must be left blank. Use of the arguments LINE-SIG and AREA-SIG is optional. The argument FLD-SIG is not used in this case.

(e) MBILL = 5: When MBILL = 5, a bill of material by LINE NUMBER (within a JOB NUMBER) is produced. The JOBNO and LNO fields must be completed. The AREANO, SUB-AREA-NO and ISONO field must be left blank. The use of the argument FLD-SIG is optional. The arguments LINE-SIG and AREA-SIG are not used in this case.

JOBNO - is a six position alphanumeric field used to enter the job number for the bill of material required. This field must be completed in all cases. Blanks and special characters are permissable as part of the field.

AREANO

- is a four position alphanumeric field used to enter the area number of the bill of material required. This field is mandatory when a bill of material by area (MBILL =2) or a bill of material by sub-area (MBILL = 3) is requested. Blanks and special characters are permissable as part of the field.

SUB-AREA-NO

- is a four position alphanumeric field used to enter the sub-area number of the bill of material required. This field is mandatory when requesting a bill of material

for a particular sub-area number (MBILL = 3). Blanks and special characters are permissable as part of the field.

ISONO - is a six position alphanumeric field used to enter the isometric drawing number of the bill of material required. The field must be completed only when MBILL = 4. Blanks and special characters are permissable as part of the field.

LNO - is a four position alphanumeric field used to enter the line number of the bill of material required. The field is mandatory only when MBILL = 5. Blanks and special characters are permissable as part of the field.

FLD-SIG

- is a one position alphanumeric field and is used to signify the segregation of fabrication and field requirements on the bill of material requested. If the field is left blank no segregation takes place. The use of any alphanumeric character in the field will cause the segregation of fabrication and field requirements. If segregation is not requested, but items designated for the field are encountered while producing the bill of material, an '*' will appear (following the quantity) on the bill of material. Since segregation of fabrication and field requirements on a bill of material by isometric drawing number (MBILL = 4) is automatic, this field is not used.

LINE-SIG

- is a one position alphanumeric field used to signify to the bill of material programme, that a list of line numbers encountered, while producing the requested bill of material, is to be printed on the supplementary reference list. The use of this field is relevant only when requesting a bill of material by area, sub-area or isometric drawing number; (MBILL = 2, 3, 4 respectively). If the field is left blank no list is produced. Any alpha-numeric character may be used to initiated a supplementary reference list of line numbers encountered.

AREA-SIG

- is a one position alphanumeric field used to signify to the bill of material programme, that a list of area numbers encountered, while producing the requested bill of material, is to be printed on the supplementary reference list. The use of this field is relevant only when request-ing a bill of material by isometric drawing number (MBILL = 4). If the field is left blank no list is produced. Any alphanumeric character may be used to initiate the pro-duction of a list of area numbers encountered.

LIST OF MESSAGES

(1) 'NO ID CARD RUN TERMINATED'

This message will appear if an end of file is encountered on the first read of the input card file.

This indicates that the "BOMP" programme was initiated without any input.

(2) 'INVALID CARD-ID RUN TERMINATED'

This message appears if the first card read by the programme is not a control card (columns 79-80 equal to '**'). It would indicate that the control card was missing.

(3) An image of each bill of material data card read by the programme is displayed along with the message

'IMAGE OF INPUT CONTROL CARD'.

(4) 'INVALID JOBNO'

This message will be displayed if the JOBNO on the bill of material control card read is blank or equal to zero.

(5) 'INVALID AREA NUMBER'

This message will be displayed if a bill of material is requested by area number (MBILL = 2), or by sub-area number (MBILL = 3) and the AREANO field on the bill of material control card is blank or equal to zero.

(6) 'INVALID SUB-AREA NUMBER'

This message will be displayed if a bill of material by sub-area number (MBILL = 3) and the SUB-AREA-NO field on the bill of material control card is blank or equal to zero.

(7) 'INVALID ISOMETRIC DRAWING NUMBER'

This message will be displayed if a bill of material by isometric drawing number (MBILL = 4) is requested and the

ISONO field on the bill of material control card is blank or equal to zero.

(8) 'INVALID LINE NUMBER'

This message will be displayed if a bill of material by line number (MBILL = 5) is requested and the LNO field on the bill of material control card is blank or equal to zero.

(9) 'INVALID VALUE OF ARGUMENT MBILL'

This message will appear if the value of MBILL on the bill of material control card is not equal to 1, 2, 3, 4 or 5.

In addition to the above, appropriate messages and information is displayed when the following occur:

1. A table overflow occurs on any one of the tables used for accumulating the quantities of like items.
2. An item is encountered on the PDDF database file (utilization data) for which there is no specification on the SDFL file (specification data).
3. An invalid item is encountered on the PDDF file.

TEST RESULTS

Included in the "Detail Documentation Package are:

(1) A list of the input control cards used for the test,

(2) The bills of material produced,

(3) The supplementary reference lists produced,

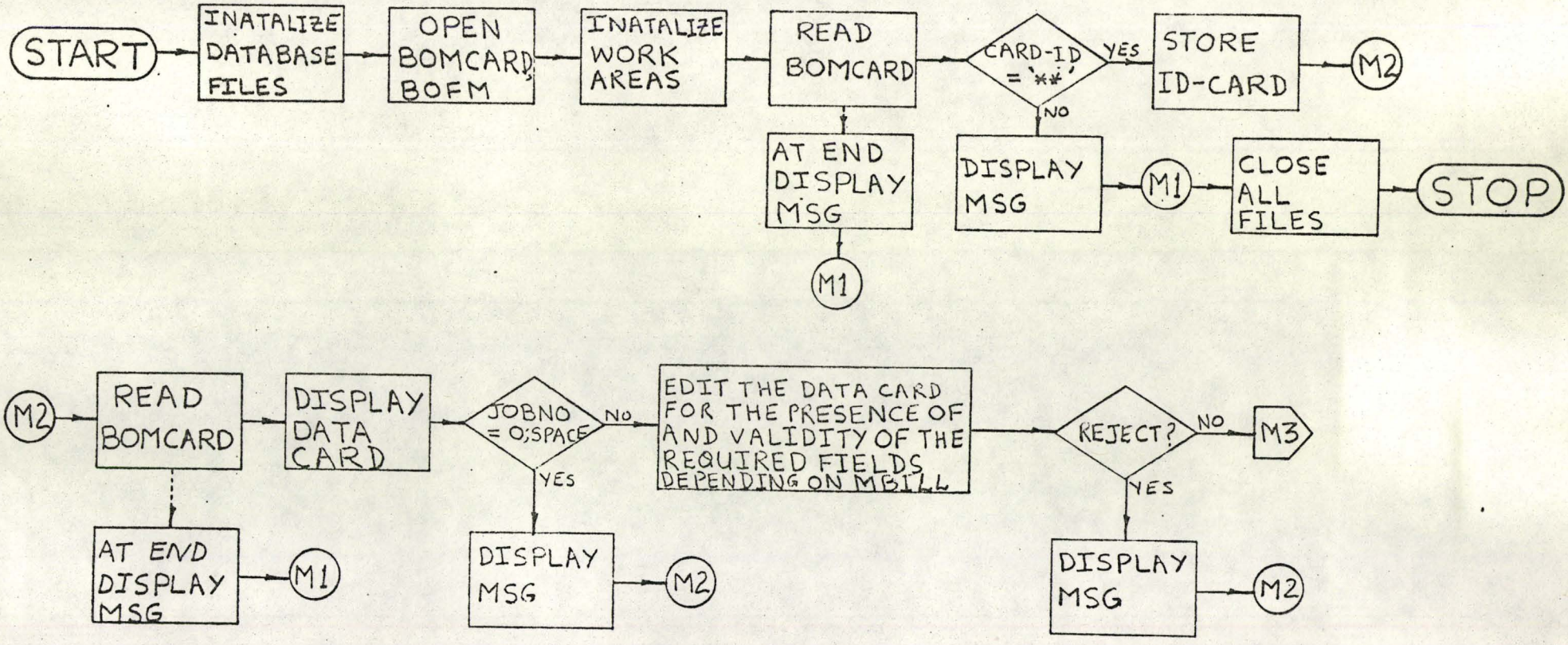
(4) The messages displayed by the programme,

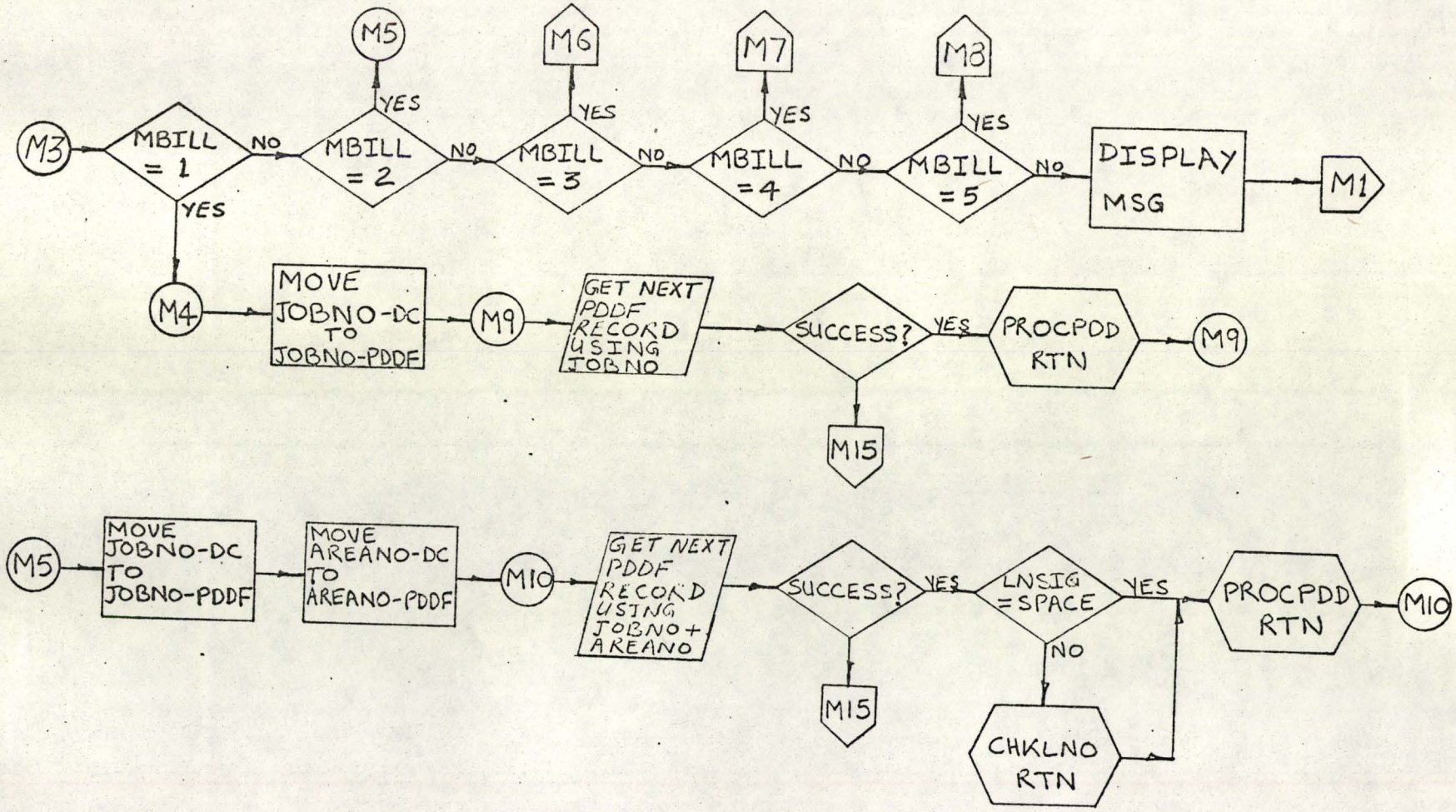
(5) The control stream required to execute the test.

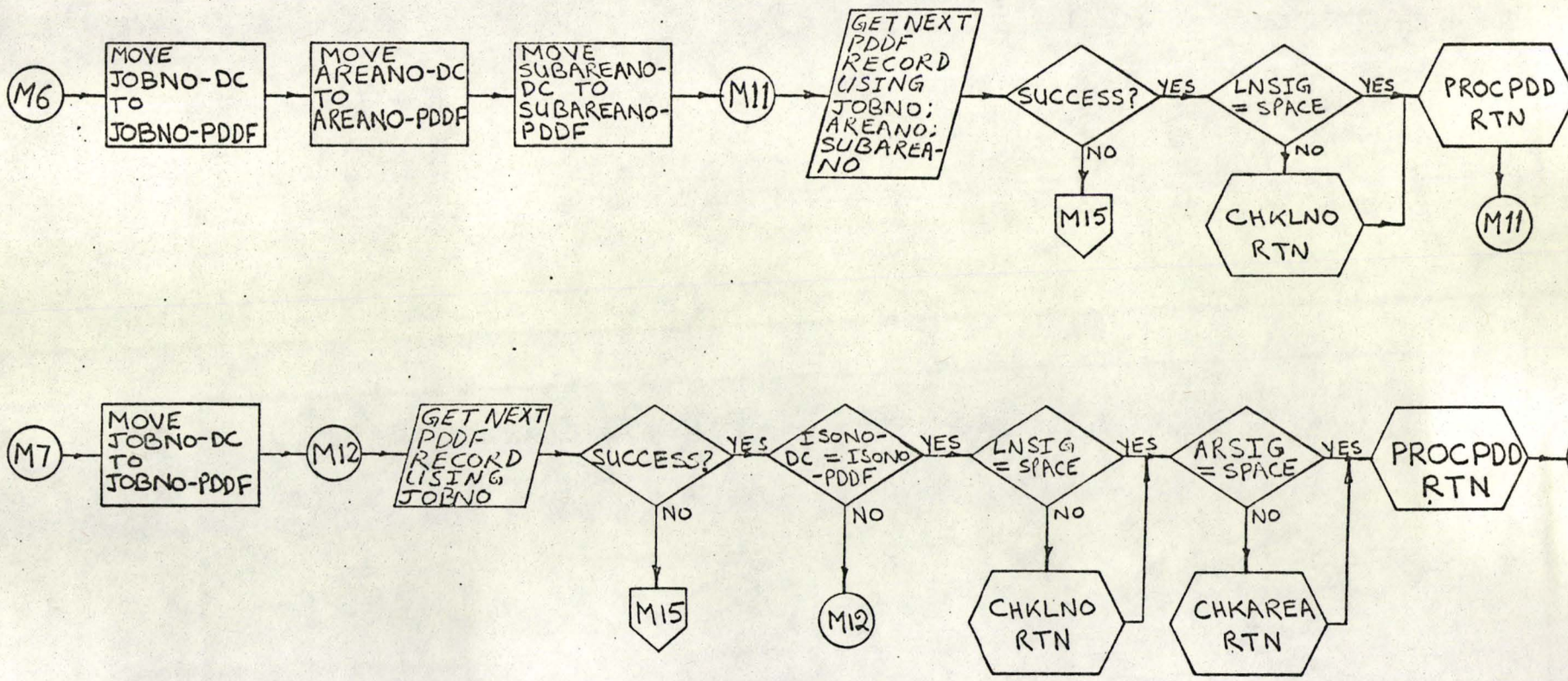
(6) A character by character dump of the files (PDDF and SDFL) used for this test.

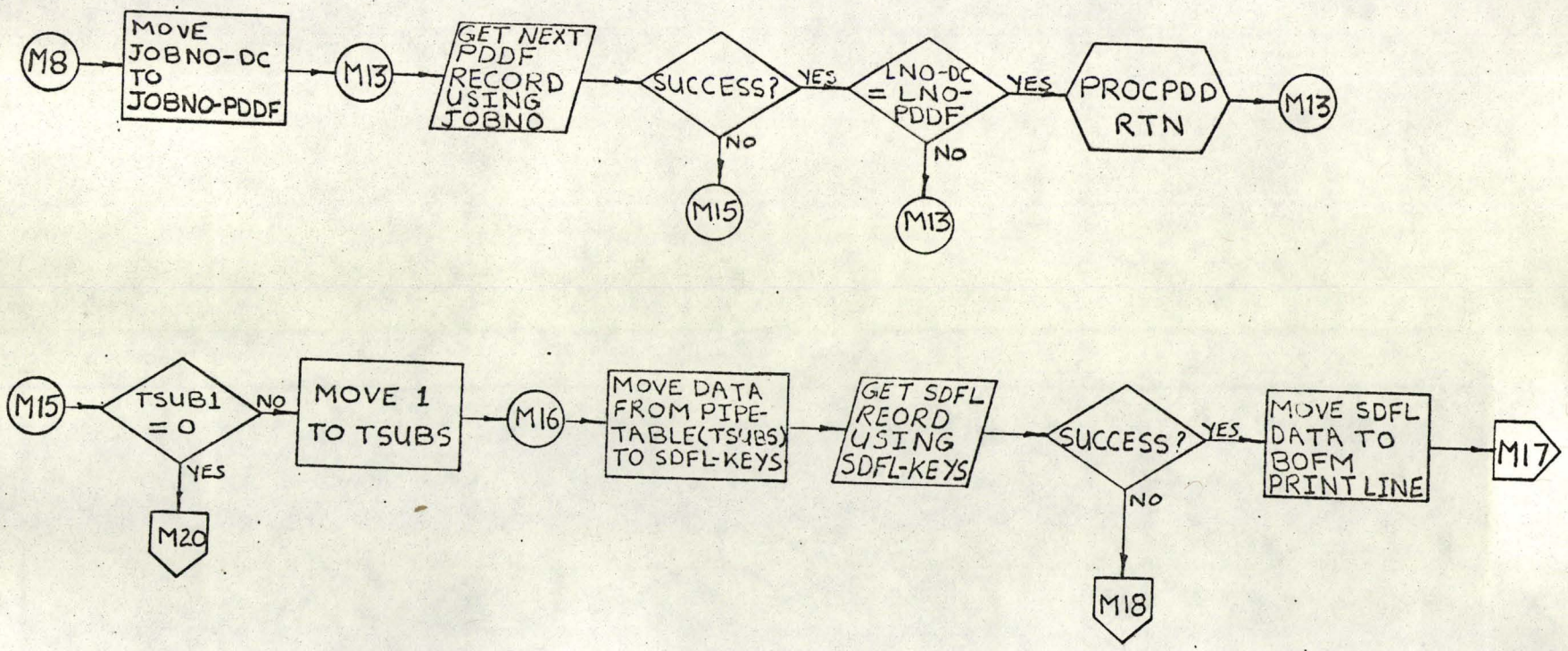
APPENDIX D-2

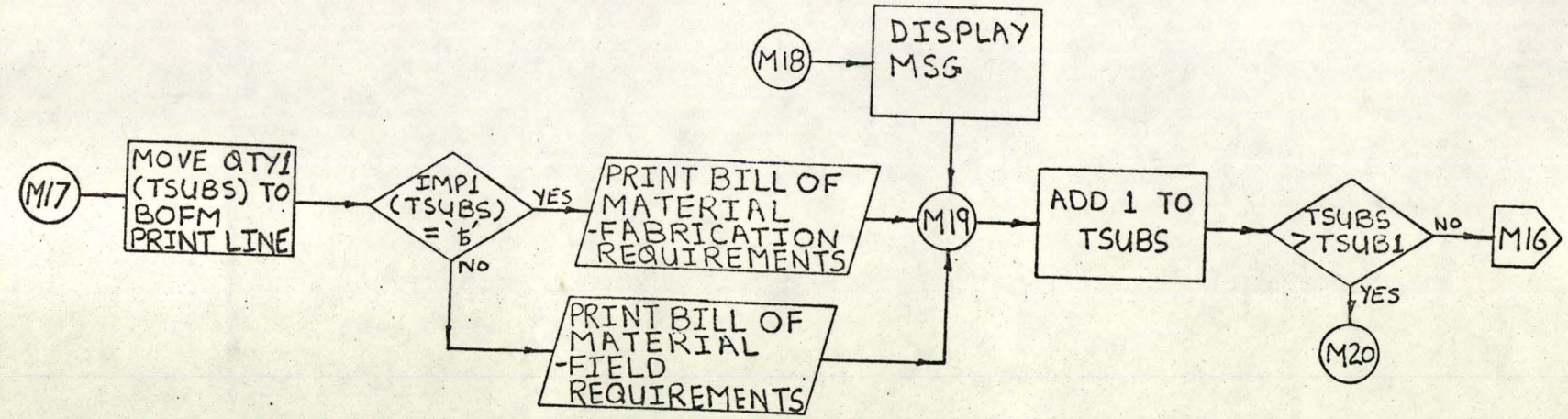
Flow Chart of the programme "BOMP".

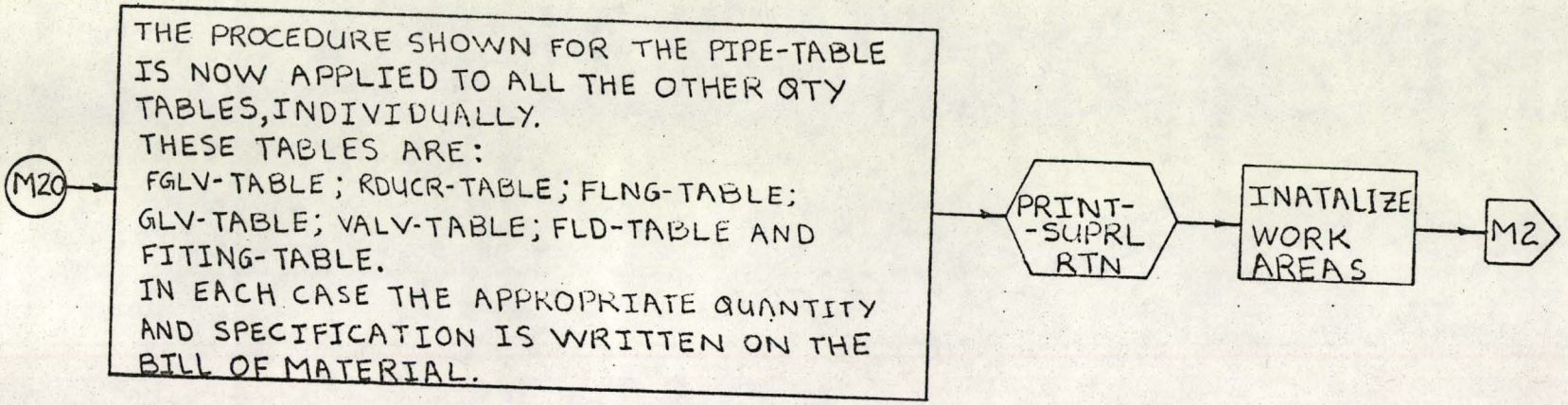

START
INATALIZE DATABASE FILES
OPEN BOMCARD, BOFM
INATALIZE WORK AREAS
READ BOMCARD
CARD-ID = '**'
YES
STORE ID-CARD
M2
NO
AT END DISPLAY MSG
M1
DISPLAY MSG
M1
CLOSE ALL FILES
STOP
M2
READ BOMCARD
DISPLAY DATA CARD
JOBNO = 0;SPACE
NO
EDIT THE DATA CARD FOR THE PRESENCE OF AND VALIDITY OF THE REQUIRED FIELDS DEPENDING ON MBILL
REJECT?
NO
M3
YES
AT END DISPLAY MSG
M1
YES
DISPLAY MSG
M2
DISPLAY MSG
M2

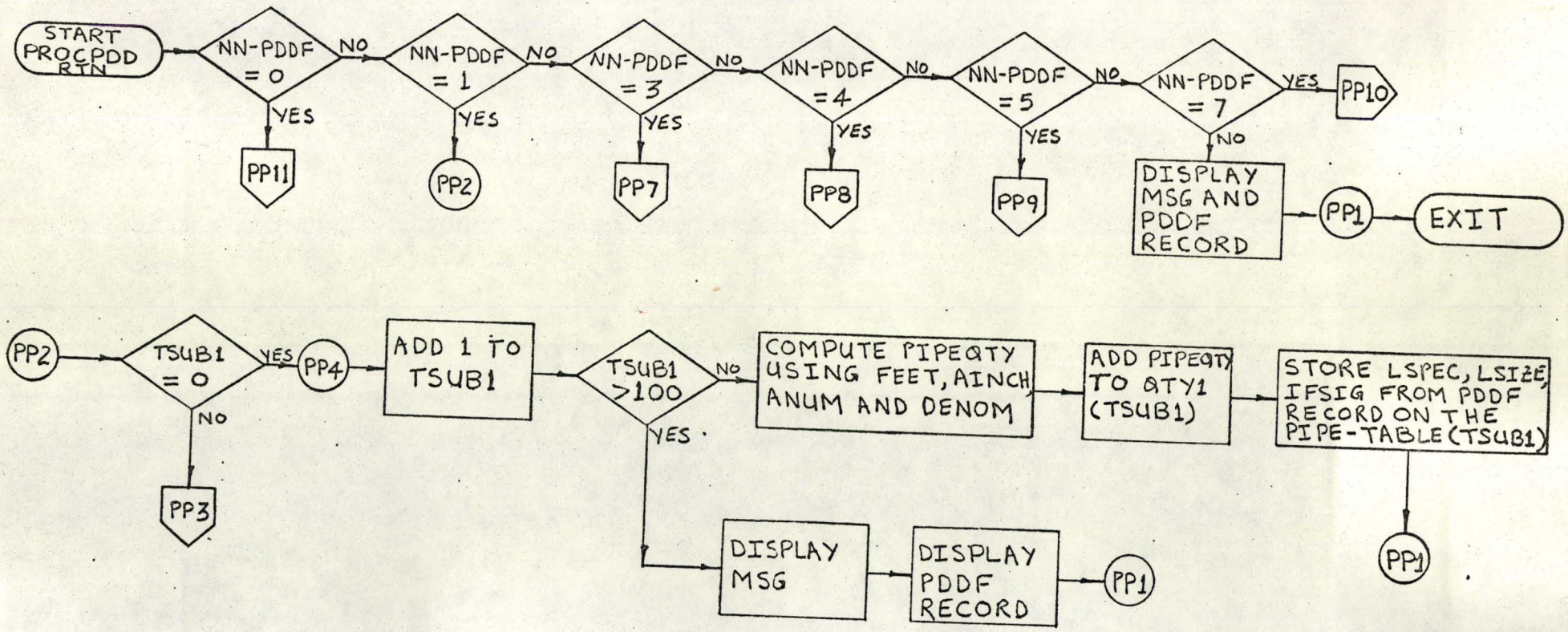

M3
MBILL = 1
NO
YES
M5
MBILL = 2
NO
YES
M6
MBILL = 3
NO
YES
M7
MBILL = 4
NO
YES
M8
MBILL = 5
NO
YES
DISPLAY MSG
M1
M4
MOVE JOBNO-DC TO JOBNO-PDDF
M9
GET NEXT PDDF RECORD USING JOBNO
SUCCESS?
YES
PROCPDD RTN
M9
M15
M5
MOVE JOBNO-DC TO JOBNO-PDDF
MOVE AREANO-DC TO AREANO-PDDF
M10
GET NEXT PDDF RECORD USING JOBNO + AREANO
SUCCESS?
YES
LNSIG = SPACE
YES
NO
PROCPDD RTN
M10
M15
CHKLNO RTN

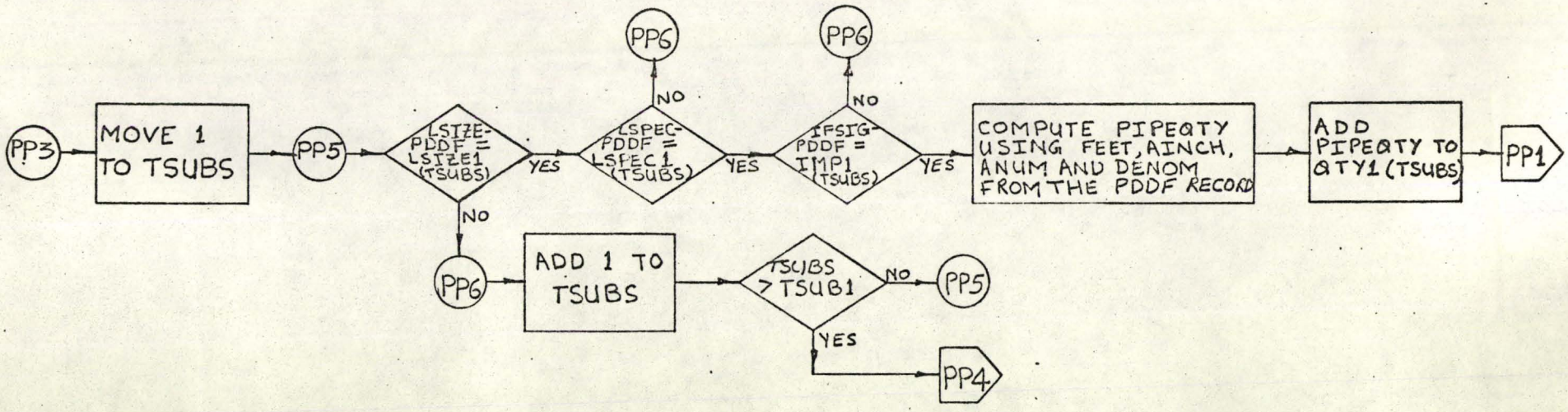

M6
MOVE JOBNO-DC TO JOBNO-PDDF
MOVE AREANO-DC TO AREANO-PDDF
MOVE SUBAREANO-DC TO SUBAREANO-PDDF
M11
GET NEXT PDDF RECORD USING JOBNO; AREANO; SUBAREA-NO
SUCCESS?
YES
NO
M15
LNSIG = SPACE
YES
NO
CHKLNO RTN
PROC PDD RTN
M11
M7
MOVE JOBNO-DC TO JOBNO-PDDF
M12
GET NEXT PDDF RECORD USING JOBNO
SUCCESS?
YES
NO
M15
ISONO-DC = ISONO -PDDF
YES
NO
M12
LNSIG = SPACE
YES
NO
CHKLNO RTN
ARSIG = SPACE
YES
NO
CHKAREA RTN
PROC PDD RTN
M12


M8
MOVE JOBNO-DC TO JOBNO-PDDF
M13
GET NEXT PDDF RECORD USING JOBNO
SUCCESS?
YES
NO
M15
LNO-DC = LNO-PDDF
YES
NO
M13
PROCPDD RTN
M13
M15
TSUB1 = 0
NO
YES
M20
MOVE 1 TO TSUBS
M16
MOVE DATA FROM PIPE-TABLE(TSUBS) TO SDFL-KEYS
GET SDFL REORD USING SDFL-KEYS
SUCCESS?
YES
NO
M18
MOVE SDFL DATA TO BOFM PRINT LINE
M17


M18
DISPLAY MSG
M17
MOVE QTY1 (TSUBS) TO BOFM PRINT LINE
IMPI (TSUBS) = 'b'
YES
NO
PRINT BILL OF MATERIAL -FABRICATION REQUIREMENTS
PRINT BILL OF MATERIAL -FIELD REQUIREMENTS
M19
ADD 1 TO TSUBS
TSUBS > TSUB1
NO
YES
M16
M20


M20
THE PROCEDURE SHOWN FOR THE PIPE-TABLE IS NOW APPLIED TO ALL THE OTHER QTY TABLES, INDIVIDUALLY.
THESE TABLES ARE:
FGLV-TABLE; RDUCR-TABLE; FLNG-TABLE; GLV-TABLE; VALV-TABLE; FLD-TABLE AND FITING-TABLE.
IN EACH CASE THE APPROPRIATE QUANTITY AND SPECIFICATION IS WRITTEN ON THE BILL OF MATERIAL.
PRINT--SUPRL RTN
INATALIZE WORK AREAS
M2


START PROCPDD RTN
NN-PDDF = 0
YES
PP11
NO
NN-PDDF = 1
YES
PP2
NO
NN-PDDF = 3
YES
PP7
NO
NN-PDDF = 4
YES
PP8
NO
NN-PDDF = 5
YES
PP9
NO
NN-PDDF = 7
YES
PP10
NO
DISPLAY MSG AND PDDF RECORD
PP1
EXIT
PP2
TSUB1 = 0
YES
PP4
NO
PP3
ADD 1 TO TSUB1
TSUB1 >100
NO
YES
COMPUTE PIPEQTY USING FEET, AINCH ANUM AND DENOM
ADD PIPEQTY TO QTY1 (TSUB1)
STORE LSPEC, LSIZE, IFSIG FROM PDDF RECORD ON THE PIPE-TABLE (TSUB1)
PP1
DISPLAY MSG
DISPLAY PDDF RECORD
PP1

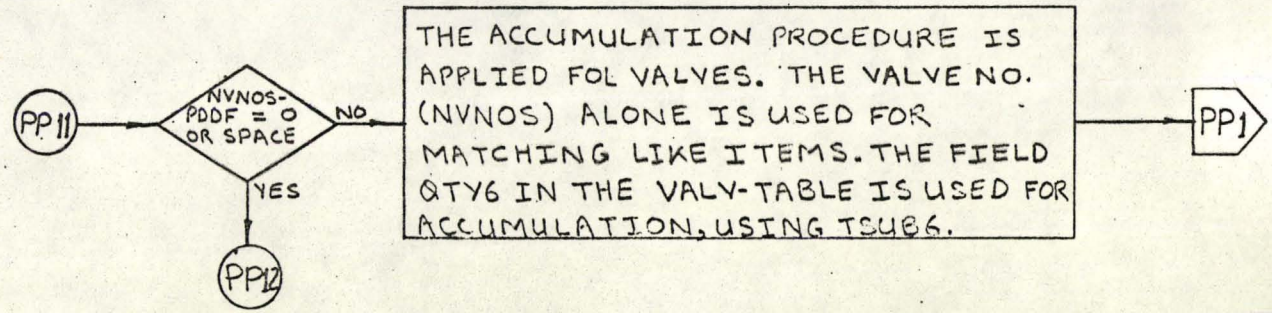


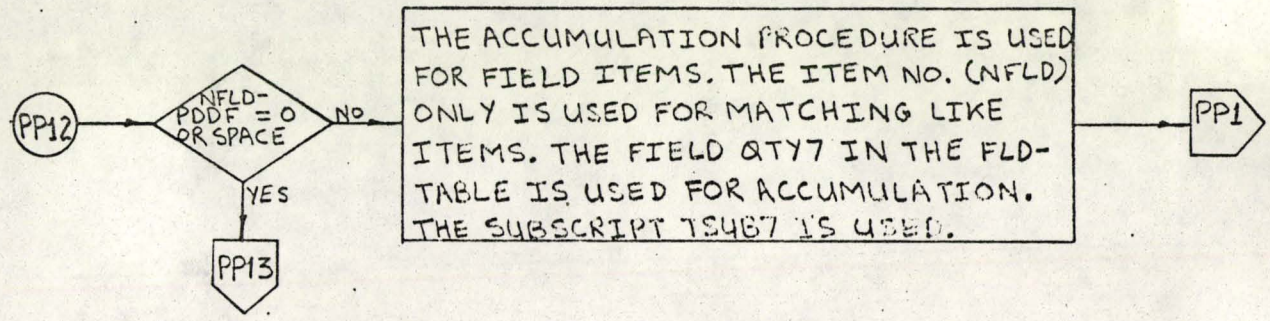
PP7 → THE PROCEDURE SHOWN FOR ACCUMULATING PIPING QUANTITIES IS APPLIED FOR FLANGED GLOBE VALVES. QTY2 IN THE FGLV-TABLE AND TSUB2 ARE USED. → PP1

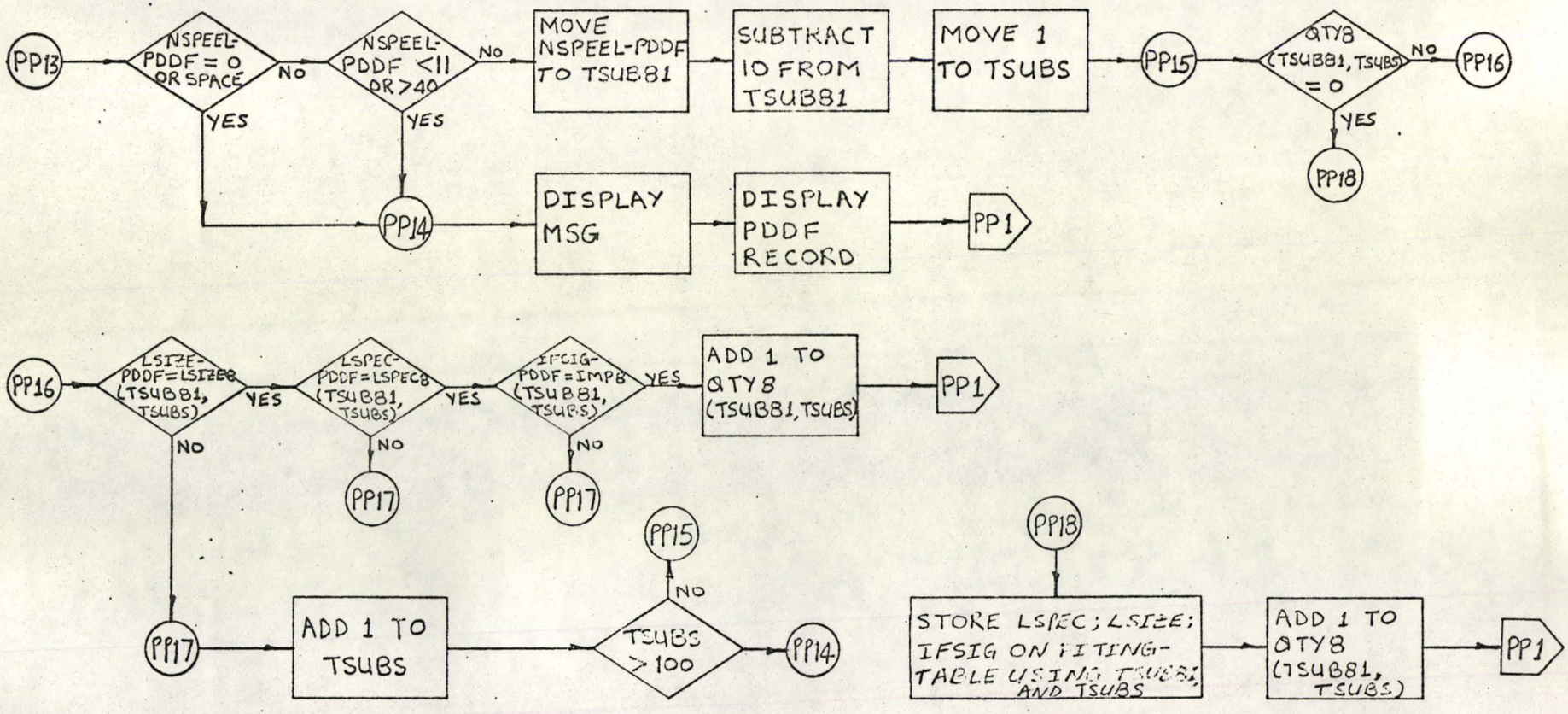
PP8 → A SIMILAR PROCEDURE IS APPLIED FOR REDUCERS. THE FIELD QTY3 IN THE RDUCR-TABLE IS USED FOR ACCUMULATION. THE SUBSCRIPT TSUB3 IS USED. → PP1

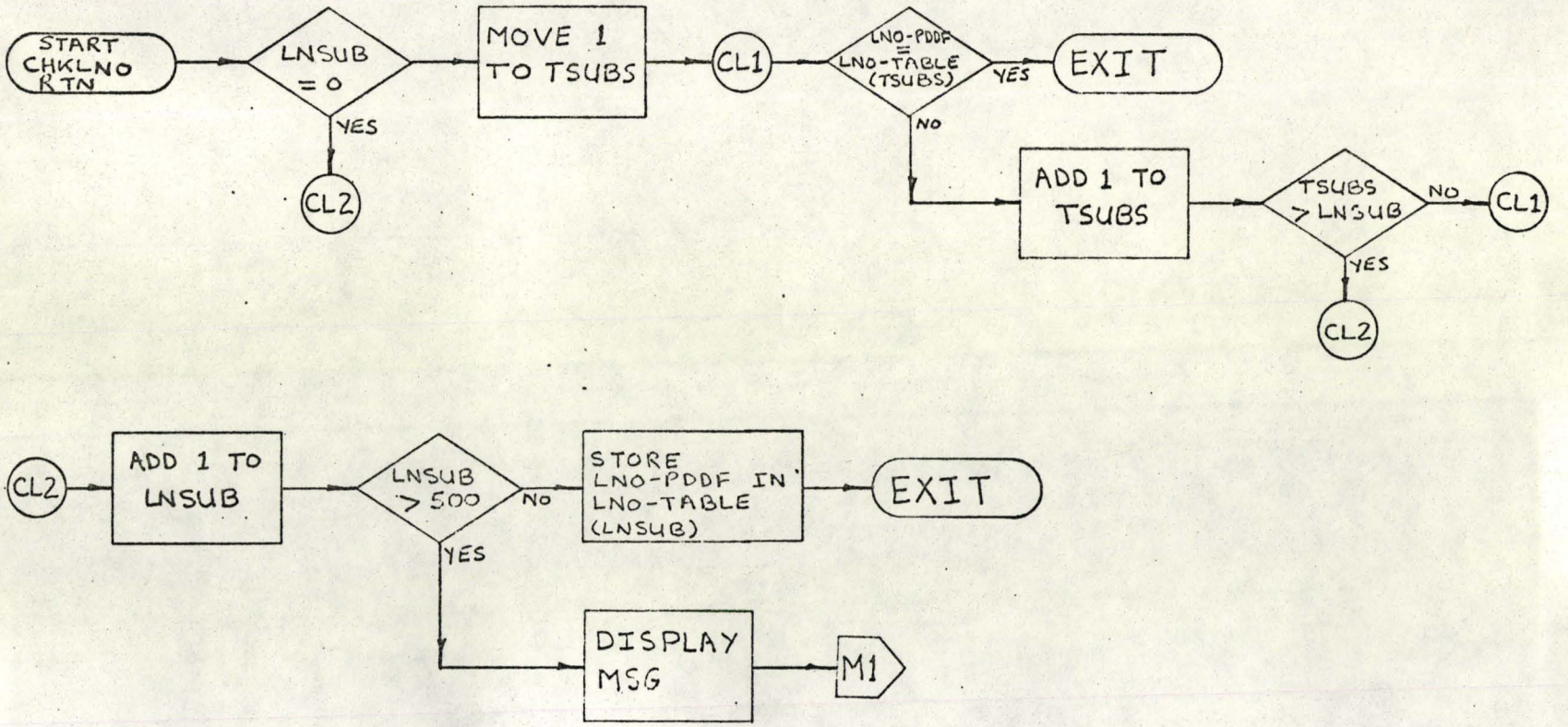
PP9 → A SIMILAR PROCEDURE IS APPLIED FOR FLANGES. THE FIELD QTY4 IN THE FLNG-TABLE IS USED FOR ACCUMULATION. THE SUBSCRIPT ISUB4 IS USED. → PP1

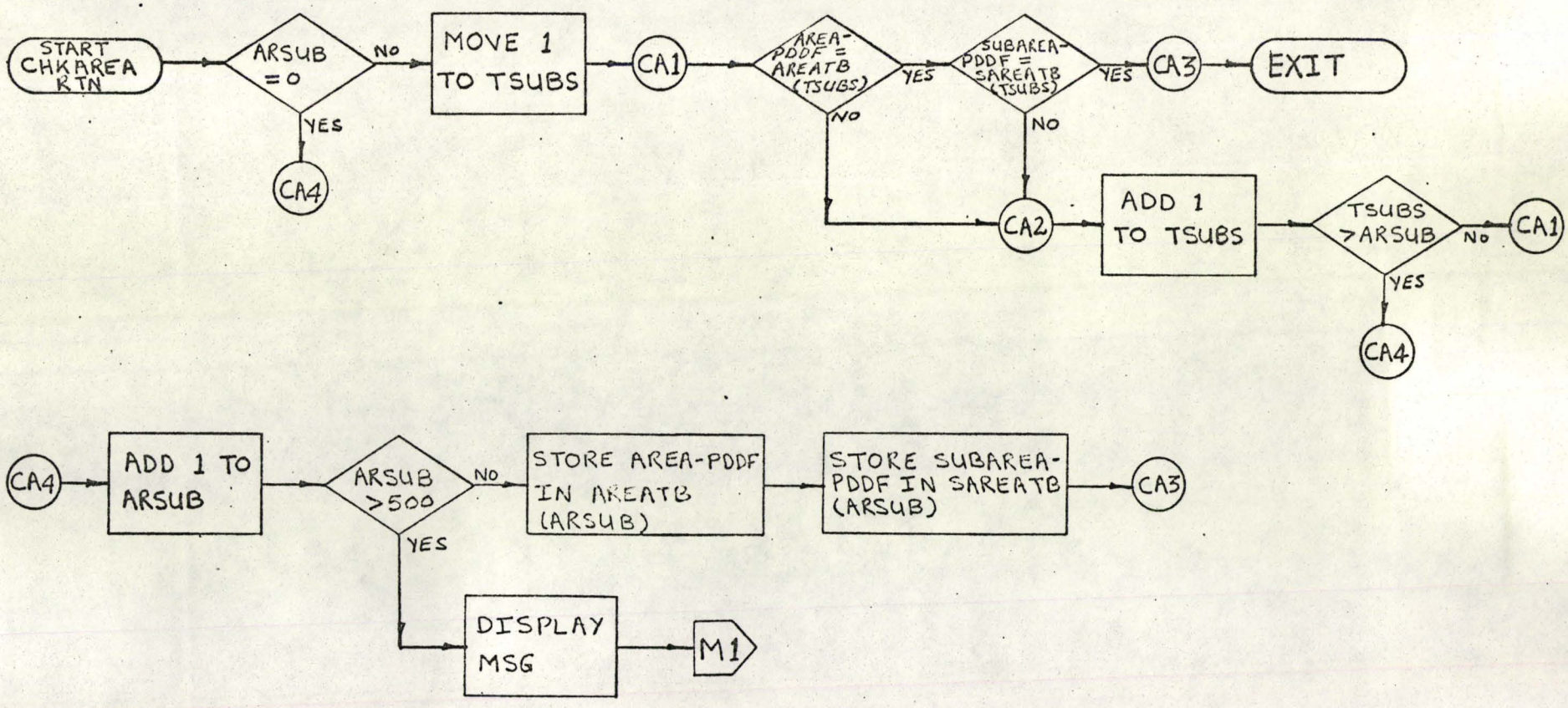
PP10 → A SIMILAR PROCEDURE IS USED FOR GLOBE VALVES. THE FIELD QTY5 IN THE GLV-TABLE IS USED FOR ACCUMULATION. THE SUBSCRIPT TSUB5 IS USED. → PP1

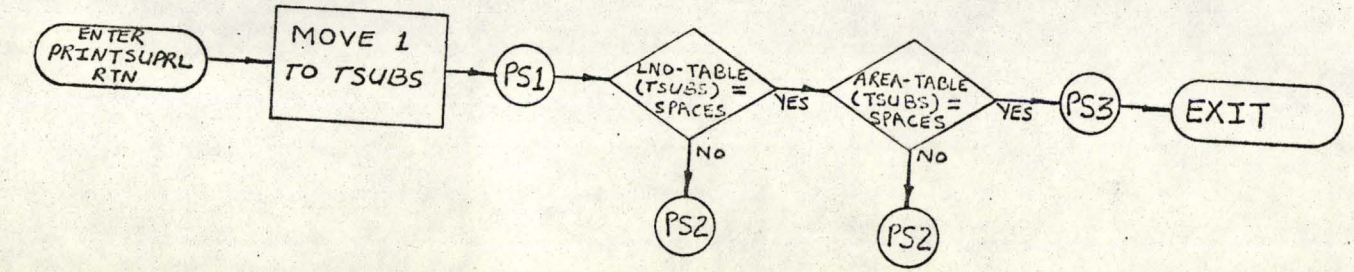

PP11
NVNOS-PDDF = 0 OR SPACE
NO
YES
PP12
THE ACCUMULATION PROCEDURE IS APPLIED FOL VALVES. THE VALVE NO. (NVNOS) ALONE IS USED FOR MATCHING LIKE ITEMS. THE FIELD QTY6 IN THE VALV-TABLE IS USED FOR ACCUMULATION, USING TSUB6.
PP1

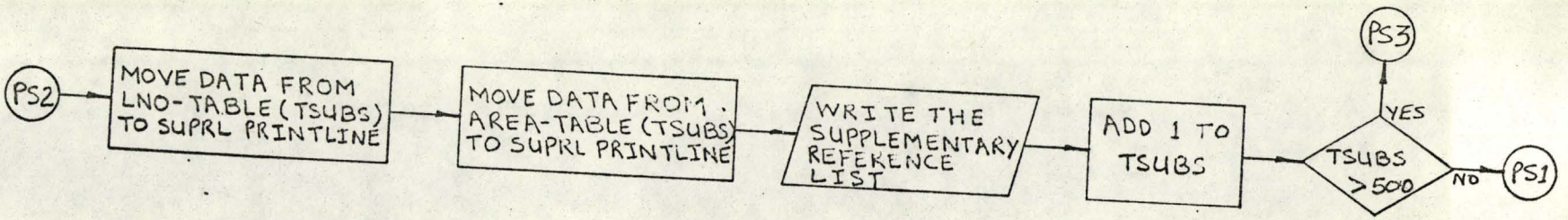

PP12
NFLD-PDDF = 0 OR SPACE
No
YES
PP13
THE ACCUMULATION PROCEDURE IS USED FOR FIELD ITEMS. THE ITEM NO. (NFLD) ONLY IS USED FOR MATCHING LIKE ITEMS. THE FIELD QTY7 IN THE FLD-TABLE IS USED FOR ACCUMULATION. THE SUBSCRIPT TSUB7 IS USED.
PP1


PP13
NSPEEL-PDDF = 0 OR SPACE
No
YES
NSPEEL-PDDF <11 OR >40
No
YES
MOVE NSPEEL-PDDF TO TSUB81
SUBTRACT 10 FROM TSUB81
MOVE 1 TO TSUBS
PP15
QTY8 (TSUB81, TSUBS) = 0
NO
YES
PP16
PP18
PP14
DISPLAY MSG
DISPLAY PDDF RECORD
PP1
PP16
LSIZE-PDDF=LSIZE8 (TSUB81, TSUBS)
YES
LSPEC-PDDF=LSPEC8 (TSUB81, TSUBS)
YES
IFSIG-PDDF=IMP8 (TSUB81, TSUBS)
YES
ADD 1 TO QTY8 (TSUB81, TSUBS)
PP1
NO
NO
NO
PP17
PP17
PP15
NO
PP17
ADD 1 TO TSUBS
TSUBS >100
PP14
PP18
STORE LSPEC; LSIZE; IFSIG ON HITING-TABLE USING TSUB81 AND TSUBS
ADD 1 TO QTY8 (TSUB81, TSUBS)
PP1


START CHKLNO RTN
LNSUB = 0
YES
CL2
MOVE 1 TO TSUBS
CL1
LNO-PDDF = LNO-TABLE (TSUBS)
YES
EXIT
NO
ADD 1 TO TSUBS
TSUBS > LNSUB
NO
CL1
YES
CL2
CL2
ADD 1 TO LNSUB
LNSUB > 500
NO
STORE LNO-PDDF IN LNO-TABLE (LNSUB)
EXIT
YES
DISPLAY MSG
M1


START CHKAREA RTN
ARSUB =0
NO
YES
CA4
MOVE 1 TO TSUBS
CA1
AREA-PDDF = AREATB (TSUBS)
YES
NO
SUBAREA-PDDF = SAREATB (TSUBS)
YES
NO
CA3
EXIT
CA2
ADD 1 TO TSUBS
TSUBS >ARSUB
NO
YES
CA1
CA4
CA4
ADD 1 TO ARSUB
ARSUB >500
NO
YES
STORE AREA-PDDF IN AREATB (ARSUB)
STORE SUBAREA-PDDF IN SAREATB (ARSUB)
CA3
DISPLAY MSG
M1


ENTER PRINTSUPRL RTN
MOVE 1 TO TSUBS
PS1
LNO-TABLE (TSUBS) = SPACES
YES
NO
AREA-TABLE (TSUBS) = SPACES
YES
NO
PS3
EXIT
PS2
PS2


PS2
MOVE DATA FROM LNO-TABLE (TSUBS) TO SUPRL PRINTLINE
MOVE DATA FROM AREA-TABLE (TSUBS) TO SUPRL PRINTLINE
WRITE THE SUPPLEMENTARY REFERENCE LIST
ADD 1 TO TSUBS
PS3
YES
TSUBS > 500
NO
PS1

APPENDIX E

ECONOMIC EVALUATION

In projecting the estimated cost of producing a bill of material by the use of the system described in this thesis, the following basic assumptions have been made.

(1) Trained personnel, familiar with the system input sheet, the specification input sheet and the bill-of-material control sheet are available. It is assumed that they have been given a training programme and have been using the system for a fair period of time; thus, the incidence of errors is minimal.

(2) It is assumed that computer time required for the execution of the three programmes in the system, is directly proportional to the amount of data being processed. The computer time required to test the three programmes will be used as a basis for projecting the computer time required for a "live" run.

For the production of a bill of material using the system described, the following tasks have been identified as necessary:

(a) Transcribing information from orthographic design drawings to system input sheet.

(b) Transcribing information from design specifications and piping standards to specification input sheets.

(c) Key-punching and verification of the system and specification input sheets.

(d) Running the programme "SDSP" to store the specification data.

(e) Running the programme "DDSP" to store the utilization (drawing) data.

(f) Compiling the bill of material control sheet.

(g) Key-punching and verification of the bill of material control sheet

(h) Running the programme "BOMP" to produce the bill of material.

Table 4 shows the cost estimate for producing a bill of material for one isometric drawing. It is assumed that only two specification input sheets are necessary to describe the specifications necessary for this bill of material. Of course, only one system input sheet is required.

An isometric drawing bill of material was chosen for the cost estimate because it is the "basic" bill of material. It is expected that this type of bill of material will be most frequently produced by the system described in this thesis. As can be seen from Table 4, the production of bills of materials by the use of this system is an economically attractive proposition. In the author's estimate manual production of a bill of material (for an isometric drawing) would cost more. It is estimated

that it would take 3 hours for an experienced person to compile the bill of material considered here. At approximately $5.00 per hour, this cost alone would be $15.00.

COST ESTIMATE OF A BILL OF MATERIAL FOR AN ISOMETRIC DRAWING

TASK	ESTIMATED TIME	APPROXIMATE RATE	ESTIMATED COST
Completing system input sheet	0.50 HRS	$5.00/HR	$ 2.50
Completing two specification input sheets	0.50 HRS	$3.00/HR	$ 1.50
Keypunching and verification of input sheets	0.25 HRS	$3.00/HR	$ 0.75
Computer time for programme "SDSP"	1 SEC	$120/MIN	$ 2.00
Computer time for programme "DDSP"	0.5 SEC	$120/MIN	$ 1.00
Compiling the bill of material control sheet	0.10 HRS	$5.00/HR	$ 0.50
Keypunching and verification of control sheet	0.10 HRS	$3.00/HR	$ 0.30
Computer time for programme "BOMP"	2 SEC	$120/MIN	$ 4.00
TOTAL COST			$12.55

TABLE 4

B I B L I O G R A P H Y

(1) Pauls, R.E., "Feasibility Study on Computerizing the drawing of Isometric Piping Drawings", M. Engg. Thesis, McMaster University, 1968.

(2) Univac Publication, "Preliminary Design Specifications for IMS-8.

(3) Univac Publication, "Fundamentals of Cobol".

(4) ANS-STD. 2-1967, "A Code of Good Practicies for the Documentation of Digital Computer Programmes".

(5) Taggart, G.P., "Future Chemical Plant Design and Construction", Chemical Age (London), Vol. 95, No. 2446, May 28, 1966.

(6) ----------., "Materials Management Starts at Drawing Board", Material Handling Engineering, Vol. 21, No. 10, October 1966.

(7) Bollwark, J.J., "How Esso Cuts Costs of Piping", Oil and Gas Journal, Vol. 66, No. 22, May 1968.

(8) Byrd, J., and Siemens, N., "Production Control System Based on Bill of Material Processor", Industrial Engineering, Vol. 3, No. 7, July 1971.

(9) Blair, J.M., "BOMP Integrates Your Information Retrieval", Factory and Plant, Vol. 56, N.8, August 1968.

(10) Daniel, P.T., and Hall, M., "Integrated System for Pipework Estimating, Detailing and Control", Chemical Engineering (London), No. 228, May 1969.

(11) Aicher, J.R., "Piping Isometric Drawings via Computer/Plotter", Presented at the British Computer Society meeting, Darlington, England, October 20, 1966.