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IMPLEMENTATION OF ON-RAMP TRAFFIC CONTROL ON THE BLACK CANYON FREEWAY

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16. ABSTRACT

This research implemented the ramp management strategy (RMS) developed in a previous study, on the Black Canyon Freeway.

The software system developed by Safe-Trans was modified to include the RMS algorithm for controlling the entry of ramp vehicles according to speed-volume-occupancy relationships on the freeway. Decisions on metering rates were made at each ramp location on a minute-by-minute basis and may depend on the volume, percentage occupancy and average speed on the outside freeway lane.

Limited field tests were conducted to verify the capabilities of the system. This report contains the details on the RMS, Nova III computer system, ramp controllers and program listings.

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CHAPTER 1

OBJECTIVES OF PROPOSED RESEARCH

As a part of the research project "Design of On-Ramp Traffic Control on the Black Canyon Freeway," Arizona State University developed a new algorithm for controlling the entry of ramp vehicles according to speed-volume-occupancy relationships on the freeway as well as providing for a ramp closure in the event of a non-recurring incident [1].

Decisions on metering rates are made at each ramp location on a minute-by-minute basis and they depend on the volume, percentage occupancy, and average speed on the outside freeway lane.

The effects of the ramp metering strategy were not measured directly in this project. In the absence of direct information on the effect of different metering rates on freeway volume, an on-site test of the strategy and final adjustment of criteria for satisfactory freeway operation needs to be made.

Objectives

The objective of this research work is to implement this management strategy for controlling on-ramp traffic volumes which would minimize the chances of exceeding critical freeway lane volumes and the resulting congestion and stoppage of the freeway. Specifically, this research focuses on accomplishing the following:

1. Implementing the flow diagram for ramp management strategy (RMS) on the NOVA III system.
2. Modifying the existing software developed by Safe-Trans [2] so that appropriate information can be sent from the NOVA to the ramp controllers and back.

3. The programming style of the RMS includes external control of:
    a. The upper and lower speeds and percentage of freeway occupancy
    b. The length of time in minutes for volume-occupancy-speed values to remain in the monitor range before ramp closure.
    c. The values of percentage occupancy which define the boundaries for metering rates.
    d. The metering rates for fixed upper and lower values of percentage occupancy.
    e. The minimum one-minute value of outside freeway lane volume for metering to begin.
    f. The maximum one-minute value of outside freeway lane volume which, if exceeded, causes ramp closure.
    g. The minimum one-minute value of outside freeway lane speed below which a ramp is closed.
    h. The maximum one-minute value of outside freeway lane percentage occupancy which, if exceeded, causes ramp closure.

Background and Significance of Work

Stoppage of morning traffic flow on the southbound lanes of the Black Canyon Freeway is a frequent occurrence during the months of heaviest traffic flow. Such stoppages may be caused by an isolated incident involving a single vehicle. Or, they may be caused by traffic volumes which approach or exceed the carrying capacity of the freeway.

When freeway volumes approach capacity, any number of events may cause slowing or stoppage of traffic. Lane changes in the vicinity of the interchanges, slowing to avoid exiting or entering vehicles, and differing performance characteristics of both drivers and vehicles, all contribute to freeway congestion. This can lead to a significant reduction in average

freeway speed and may, in turn, cause traffic flow to 'grind to a halt' for periods ranging from seconds to several minutes and may occur repeatedly until the excess volume is finally dissipated and flow returns to normal.

Satisfactory speed-volume relationships can be maintained on the freeway if entering ramp volumes are controlled at each interchange to prevent freeway lane volumes from exceeding a critical level beyond which congestion and stoppage are likely to occur. The volume of ramp traffic entering the freeway can be controlled by metering the rate at which ramp vehicles are allowed to enter the freeway.

The California Department of Transportation conducted a study on freeway incident detection. While the California study reported the results of tests on many algorithms for incident detection it did not provide a strategy for controlling traffic volumes until traffic flow could be restored to normal. The management strategy for controlling on-ramp traffic volumes that would minimize the chances of exceeding critical freeway lane volumes and the resulting congestion and stoppage of traffic was carried out by Professor Blackburn [1]. The objective of the proposed study was to implement this strategy.

This report is divided into six chapters and an appendix. The original software developed by Safe-Trans is discussed first. The details on hardware and software are presented briefly. Next, the ramp management strategy (RMS) is discussed with a view towards the modified software. Changes to the existing software are presented in detail. The operating procedures follow next. The step-by-step procedure from booting the computer system to configuring the RMS is presented. The emphasis is on easy user-system interface and all new software is designed to be user-oriented. Finally, details on the system testing are presented. The report

concludes with a discussion on the impact on freeway traffic due to ramp metering and possible system enhancements.

CHAPTER 2

OVERVIEW OF ORIGINAL SOFTWARE

The original software developed by Safe-Trans Corporation was designed to provide information on traffic flow on the Black Canyon Freeway. A Data General Nova III minicomputer, connected to controllers and loop detectors via telephone (communication) lines, gathered information at fixed intervals (usually 5 mins) from the 19 ramps. The information on speed, volume and occupancy can be printed in a tabular form or displayed graphically on a Tektronix graphics terminal.

A historical database is continually updated and stored by the system with information for the preceding 31 days residing on the computer disk for easy preview. In addition, the system also provides a mechanism to either read or write data on the ramp controllers. Such data include the cycle lengths for red and green signals, the detector volume counts, start time and end time for metering operation. If and when a detector fails, the detector code and time of failure are recorded in a detector status database.

In this chapter, the overview of the original software is presented. First, the database files are explained in terms of their format and functions. These files are used by one or more modules for data processing. Second, the main modules themselves are explained. These modules continually run in a predefined sequence gathering information from the ramps and communicating with the ramps and peripheral devices when required to do so by utility programs. Some of the utility programs are explained next. They display data or communicate with the ramp controllers. Finally, the capabilities of the NOVA III computer are discussed. The text editor is explained in detail since some system parameter changes or the development

or modifications of modules require the usage of the editor. The procedural steps for the creation of FORTRAN files, their compilation, linking (or loading) and execution are also explained.

2.1 Database Files

The current software for the ramp metering computer system abstracts information from five important database files for processing information essential to the ramp management strategy for decision making. The files are named as below:

1. DATABASS - Database file for southbound ramps
2. DATABASN - Database file for northbound ramps
3. ISFILES - Internal storage file for southbound ramp
4. ISFILEN - Internal storage file for northbound ramp
5. HISn - History storage file (n: 0 to 31)

DATABASS and DATABASN are created by the user and provided to the system, whereas the other database files, namely ISFILES, ISFILEN and HISMK are opened and updated by the software at a pre-fixed time and in a designated format. A description of each database file is given below.

DATABASS & DATABASN

These two files are used by the Main Line Status Report (MLSR) program to plot volume, occupancy, and speed information as an analog bar chart on a Tektronix graphic terminal. The database file for north and southbound ramps depict a similar format. The general format of this database file is as follows:

```
NUMI  D1   CT   RS   MF  IBAUD
INN1 NL1  SC1  IN1
INN2 NL2  SC2  IN2
 -    -    -    -
 -    -    -    -
INNn NLn  SCn  INn
```

The above abbreviations may be expanded as:

NUMI = Number of ramps in the database file for which the report is to be prepared by MLSR.

D1 = Average vehicle length in feet

CT = Occupancy clock frequency in Hertz (cycles/sec)

MF = Constant for converting speed units from miles/hr to kilometers/hr.

IBAUD = Transmission rate to graphic terminal in characters/sec (i.e., Baud rate divided by 10)

INNn = n^{th} ramp name

NLn = Number of lanes in the n^{th} ramp

SCn = Normal signal cycle length in seconds for the n^{th} ramp

INn = Ramp number of the n^{th} ramp

ISFILES & ISFILEN

These two files are created by the Interval Storage Maker (ISMK) program every interval time specified when booting the system ("INTERVAL IN MINUTES = ? (1-180)"). Database files are named as IST files during the first interval time, after which new IST files are opened and the previous IST files are renamed ISFILES and ISFILEN. On the completion of the second interval time, again new IST files are opened and the previous IST files are

renamed ISFILES and ISFILEN. ISFILES and ISFILEN which were present previously are renamed ISFILES1 and ISFILES2.

The general format of ISFILE is as shown in Fig. 2.1.

The abbreviations shown in Fig. 2.1 are listed below:

First Line

IMO = Month of the year

IDY = Day of the month

IYR = Year — In which the file

IM = Hour of the day — was created

IMN = Minute of hour

ISEC = Second of the minute

IMI = Used as a test bit

IDI = Ramp number for which data is filed

Second Line

IF1 & IF2 = volume parameters collected by two frontage detectors

IR = volume parameter collected by the ramp detector

IC2 & IC1 = volume parameters collected by the two check-in detectors

IQ = volume parameter collected by the queue detector.

IS(I+2),
IS(I+1),
IS(I) = volume parameters collected by the three secondary detectors

IP(I+3),
IP(I+2),
IP(I+1),
IP(I) = volume parameters collected by the four primary detectors

Third Line

IOF2,
IOF1 = occupancy parameters collected by the two frontage detectors

IMO	IDY	IYR	IM	IMN	ISEC	ISI	IMI	IDI					
IF2	IF1	IR	IC2	IC1	IQ	IS(I+2)	IS(I+1)	IS(I)	IP(I+3)	IP(I+2)	IP(I+1)	IP(J)	
IOF2	IOF1	IOR	IOC2	IOC1	IOQ	ISP(I+2)	ISP(I+1)	ISP(I)	IOP(I+3)	IOP(I+2)	IOP(I+1)	IOP(I)	IPCTV

Fig. 2.1 General format of file ISFILE

IOR = occupancy parameter collected by the ramp detector

IOC2,
IOC1 = occupancy parameters collected by the two check-in detectors

IOQ = occupancy parameter collected by the queue detector

ISP(I+2),
ISP(I+1),
ISP(I) = occupancy parameters collected by the three secondary detectors

IOP(I+3),
IOP(I+2),
IOP(I+1),
IOP(I) = occupancy parameters collected by the four primary detectors

IPCTV = percentage violation recorded at that particular ramp

HISn

This database file is created by History Maker (HISMK) program for the use of Traffic Data Summary Report (TDSR) program. HISMK stores data in the HSMKn database file once each history interval time specified when booting the system ("HISTORICAL TIME IN MINUTES = ?(5-180)"). The alphabet 'n' used in the above database file represents the day of the month, taking values from 0 to 31.

Initially when HISMK creates this file, it stores data every history time in HSMKØ, for a period of 24 hours. After 24 hours, HISMK creates a new HISØ and starts storing data, while previous HISØ is renamed as HIS1. At the end of the second day, HISØ is renamed as HIS1 and HIS1 is renamed as HIS2 and so on until n is equal to 31.

The general format of HISn in database file is shown below:

First Line

1) Hour of the day

2) Minute of the hour of opening the file

3) Second of the minute

4) Last history time in minutes

5) Flag for metering or nonmetering

1 --> metering

0 --> nonmetering

6) Ramp number for which the data is filed

Second Line

1) First frontage detector volume parameter stored in history buffer

2) Second frontage detector volume parameter stored in history buffer

3) Ramp detector volume parameter stored in history buffer

4) First check-in detector volume parameter stored in history buffer

5) Second check-in detector volume parameter stored in history buffer

6) Queue detector volume parameter stored in history buffer

7) First secondary detector volume parameter stored in history buffer

8) Second secondary detector volume parameter stored in history buffer

9) Third secondary detector volume parameter stored in history buffer

10) First primary detector volume parameter stored in history buffer

11) Second primary detector volume parameter stored in history buffer

12) Third primary detector volume parameter stored in history buffer

13) Fourth primary detector volume parameter stored in history buffer

Third Line

The third line is exactly similar to the second line, except that instead of volume parameters, occupancy parameters are stored for the respective detectors in the history buffer.

2.2 Description of Main Modules

1. RMPT

Ramp Communication initializer

This program is used to get the initial data from operator. It will ask five questions when the system just booted up. They are listed below.

1. "DAY OF THE WEEK IS ? (0-6 SUNDAY-SATURDAY)"
2. "INTERVAL IN MINUTES=? (1-180)"
3. "FIRST INTERVAL IN MINUTES=? (1-180)"
4. "HISTORICAL TIME IN MINUTES=? (5-180)"
5. "FIRST HISTORICAL TIME IN MINUTES=? (1-4320)"

The answer for the second question is used to determine the interval time of collecting data from the ramp controller and hence the interval data must be compatible with the ramp controller, i.e., the data in address FEF4 of ramp controller must have the same value as the answer times 60. Normally this is set to 5 minutes for nonmetering mode and to 1 minute for metering mode of operation.

Historical time is used for the interval time of historical file to be stored. Normally this is set to 15 minutes.

The first historical time should be set to the value. Initially the database files are read and data initialized. RMPT then will chain to COMMT when the minute changes. In Fortran V, it is represented by the statement "CALL FCHAN("COMMT.SV")." Before chaining to COMMT, common data is saved by SCOMW, SDATW, PASCW routines.

2. COMMT

Communication Handler

This is a communication generating program. It sets up messages for the various ramps, and reports communication failures to ERRORSTOR.

In the beginning, SCOMR and PASCR are called to pass the values of the common block. Subroutine PRNT is called to check if the background program is asking for printing or graphing or ramp communication. If a print request exists then the background's request is executed by PRNT subroutine. For the next 20 cycles, COMMT checks the status flag to see if communication data is to be sent to any of the ramps. If message is needed for one particular ramp, then the message is formatted by subroutine RMT. SXMIT is the next subroutine to be called to perform two tasks. One is to receive the collected data from the detectors in order to calculate the volume, occupancy and velocity, the other is to send the message to the ramp controller to read or write data. Within the loops, COMMT keeps checking to see if time has changed. If it has, then COMMT chains to DATAP. Before chaining, SCOMW and PASCW are called again to save the common data into files.

Routines Ramp Response is used to pack up the collected data into IDAT in order to be used in DATAP, and Comm Error is used to store communication errors, if any.

3. DATAP

Data Processor

This program generates IST files which will be renamed to the ISFILEN/S the next time DATAP is executed. ISFILEN/S are used in the MLSR program for calculating volume, occupancy and velocity. DATAP also creates HSMK , which will be appended to HIS^0 for every historical interval. The HIS^0 file will be renamed to HIS^1 when the data is changed and the HISTORY program is chained. ERSTOR is called in this program to write the error message to the SYSLOG.

The first 60 statements write messages to the SYSLOG. The next DO loop update the data buffer and reset the flag for the next cycle. ISMK subroutine is for creating IST file, DATAP calls it twice to get the northbound and southbound, respectively. HISMK subroutine is for creating HSMK , which will append to HIS . CLKUP reads backup clock and compares it with system clock. If system clock is behind it is set equal to the backup. If system is ahead the date is advanced one day and the clock is then set equal to the backup. Finally, DATAP checks to see if the date has changed. If it is has then DATAP chains to HISTORY; else it chains to COMMT.

4. HISTORY

History Handler

This program basically does two tasks:

1. It moves and renames history files at midnight, and
2. It sets up clock synchronize messages to ramp controllers

PASCR, SCOMR and SDATR are called in the beginning to pass the common data, then HISTORY renames the 30 files to advance every data file by one day. The ramp clocks are then synchronized with the computer clock. Finally, HISTORY chains back to COMMT again.

The whole kernel for Ramp Control System is shown in Fig. 2.1.

2.3 Utility Programs

1. MLSR

MainLine Status Report

This program performs the tasks of graphing volume, occupancy and speed information in "near-to-real" time. Six files are used in this program:

1. DATABASN and DATABASS contain the information about average vehicle length, frequency of the occupancy clock (refer to description of the database file on page 6).

2. ISFILES, ISFILEN, ISFILES1 and ISFILEN1 contain information for the last sampling and the next to last sampling interval for northbound and southbound ramps.

MLSR reads the data from the above files and takes the average volume and occupancy from all lanes and converts it to vehicles per hour and percentage occupancy. Velocity is calculated from volume and occupancy. SPLR is a temporary buffer to contain the output from either graphics or file. The rest of the program deals with graphic functions and sets interground flag to queue ouput to the foreground. Note that MLSR calculates and draws the chart of volume, occupancy and

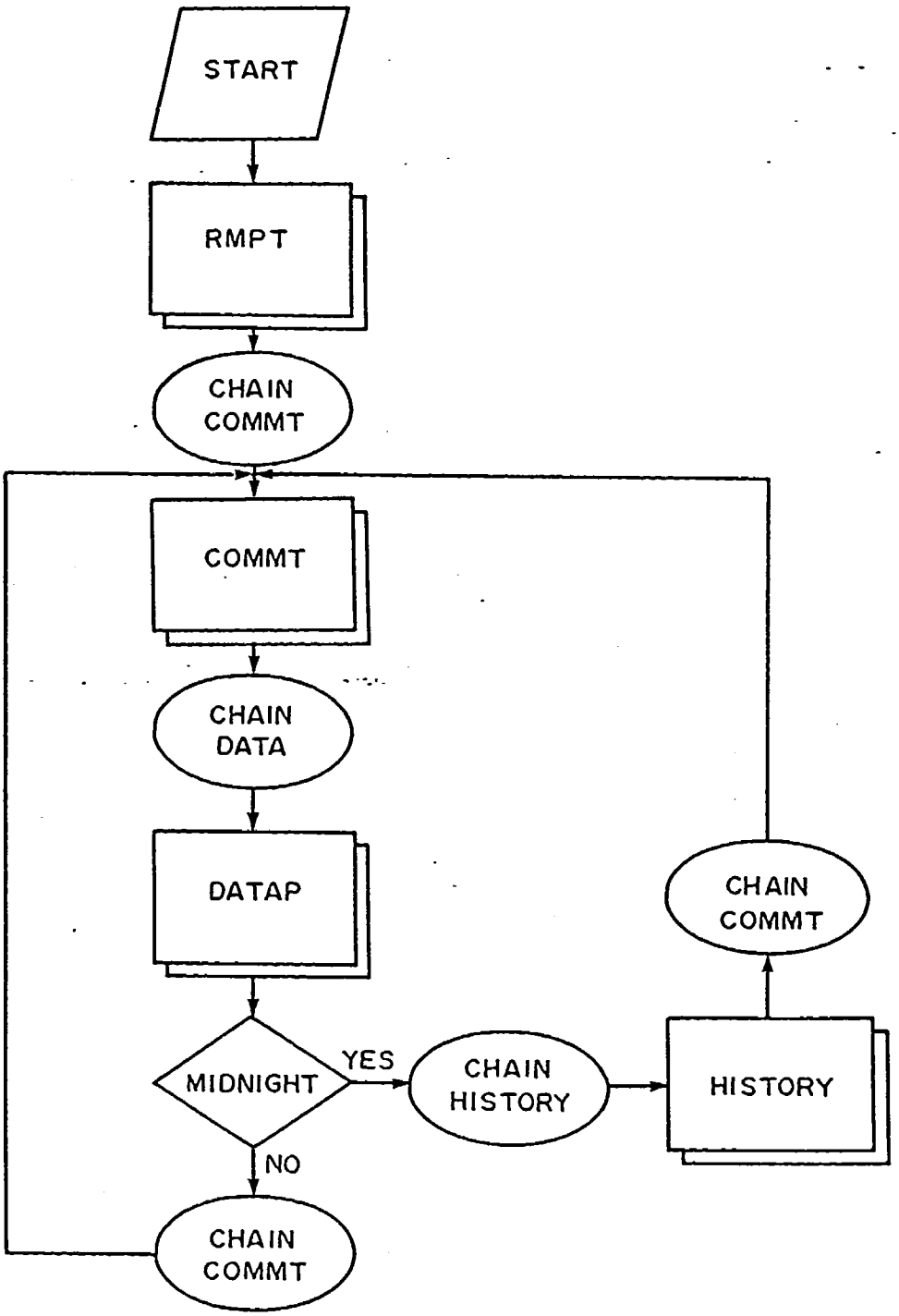


Fig. 2.2 Flow Diagram of Ramp Controller System

velocity according to the data of files ISFILES/N which are created by the foreground program DATAP.

2. RAMPTALK

Ramp Controller Communicator

This background program can read or write to ramp controllers. It runs in the background with RMPT, COMMT and DATAP running in the foreground. RAMPTALK packs the information into a file called "RDATA", then sets the interground flag to inform the foreground. The foreground program then opens the file to read those data into common block IRDATA. COMMT then uses SXMIT to send or receive the information to or from the ramp controller.

The operator is required to answer some questions in order to communicate with the controllers. The four answers needed are:

1. IRF (flag): if read then IRF=1, if write then IRF=2.
2. IRI (ramp number): 1010-1018, 1020-1029.
3. IRA (address): FE00-FEFF
4. IRD (data): refer to the controller instructions.

If the IRI is specified to be 1255, it means that the message is to be sent to all the ramp controllers.

3. RMPSR

Ramp Status Report

This program produces reports on either the CRT or the printer. These reports use information collected for the last interval and are contained in files ISFILEN and ISFILES. It prints out south- or northbound ramp status information and

occupancy information for the ramp and detector. The message which comes back from the detector will be -1 if the detector received no information. So, to decide if communication line is on, the program just checks to see if all the detectors send back -1 data.

2.4 Capabilities of NOVA III

NOVA III minicomputer used as the central processor in the ramp metering, is a 16 bit minicomputer. The total primary memory capacity of the NOVA III minicomputer is 128K words. The system further provides 10 megabytes of secondary memory on two disks, one fixed and another a removeable disk cartridge. Either of the two disks can store a maximum of 5 megabytes of information.

The real time disk operating system (RDOS) used by the NOVA III system provides the capability to program interactively. The RDOS also governs the allocation of cpu time to its two users, namely Foreground and Background. The ratio of the percentage of cpu allocation, to Foreground and Background is called the Foreground-Background ratio. This ratio may be changed, if the need arises. At present the RDOS allocates more cpu time to the Foreground, as various calculations and interaction between the communication routines and the system is achieved by this user. Other functions of the RDOS include disk stored data and program files manipulation.

In the present ramp metering system, the Safetran software is implemented by using a Datageneral CRT terminal as the background terminal and a Datageneral Dasher printer is used as the Foreground terminal.

Compiling a FORTRAN 5 Program Under RDOS

Each program must be compiled separately by issuing the following command:

```
FORTRAN  filename
```

This command produces a relocatable binary file named filename.RB, with no listing and sends error messages to the console, if any.

The general form of the FORTRAN5 command line is:

```
FORTRAN  [global switch] inputfilename  filename [local switch] . . .
```

Some useful switches, both global and local have been listed below with their function.

Global switches

/B	Produce a brief listing. This includes the input source program, the list of all sub programs called the cross-reference, and the error list (but not the generated code).
/C	Check the syntax of the source program. If a listing file is specified, the source program and error list are sent to it. The error list is also sent to the error file, if one exists.
/D	Debug. It allows the error trace back routine to output line number.
/L	Produce a listing. If a listing file is explicitly specified using the local /L switch, the global /L switch has no effect. Global /L produces a listing filename, input filename.LS.
/N	Do not produce an object file.

Local switches

/B	Direct the relocatable binary output to the file named. No listing is received of the generated code when this switch is used.
/E	Direct any error messages to the file named.

/L Direct the listing to the specified file. The listing contains the input source program, a storage map, a list of all subprograms called, a listing of the generated code, a cross reference and a list of errors.

Loading FORTRAN5 Programs

After all programs necessary for a particular task have been compiled, and ascertained they are in the same directory, they can be loaded using the following command.

RLDR filename1, filename2, . . . @ FLIB @

In general, a program is loaded in the following sequence:

1) Main FORTRAN5 program

2) User subroutines

Subroutines must be entered in the order in which they are called from the beginning of the main program.

3) Support libraries

In this case we use only @FLIB@

The load command RLDR loads the main program and other routines and creates a save file, namely, main program.SV. If a program or a subroutine which is being loaded is not in the current directory, or is not compiled, an error message will be reported by the system.

Executing a Program

A program may be executed after it has been properly compiled and loaded by the system. This can be done by simply typing the filename and pressing the carriage return key. For example:

MAIN PROGRAM

Text Editor

The ability to key a program successfully into a computer or to make suitable correction in a pre-existing program is achieved by gaining dexterity over the text editor. The text editor commands can be explained broadly in two parts, namely: 1. To create a new file or open a pre-existing file for editing, and 2. Line editing of files. The present system uses NSPEED text editor for editing files.

1. Creating a new file

A new file can be opened by typing the following command and pressing carriage return.

```
NSPEED filename
```

where "filename" is the name of the file to be opened. The system responds to this command by typing out the message

```
CREATING NEW FILE
!
```

The prompt symbol in the NSPEED mode is an exclamation mark, '!'.

Opening a pre-existing file

If a file already existing in the current directory is to be edited, the same command as above may be used. The system then responds to this command by opening the file named by "filename", and prompts.

Note: After a new file is created or an old file is opened using the above command, the system, before prompting, outputs the following line.

```
WARNING: EXPANDED ERROR TEXT NOT AVAILABLE
```

This may be disregarded as inconsequential, as all text editing commands in this manual lie within the four walls of the warning.

2. Line editing commands

Before the line editing commands are introduced it would be beneficial to understand the editing cursor, termed in this manual as the character pointer (CP).

The character pointer is an editing cursor, which may be viewed as a '^' on the console. Character pointer is always positioned between two characters, and never at a character. When a text is to be modified, the CP must be positioned exactly before the beginning of that particular line or word or character. For example,

a) An insert command to insert letter 'T' when the CP is as shown below

S(^)OP

will insert 'T' as

STOP

b) A search command for letter A when CP is in the beginning of the word

(^) DATA

will place the CP before

D(^)ATA

If again a search command is executed for letter A, the cp is placed in front of the second A in the word DATA.

DAT(^)A

So it must be remembered that any change is effective to only those strings or characters which follow the cp, and not those which precede it in a file.

For example, when cp is as shown below

SO(^)TOP

a change command intentional of removing the extra 'O' from the word STOP will lead to the removal of the letter 'O', following the cp, thus resulting in SOTP.

Escape character

The escape character serves two important functions.

1. A single ESCape, which is viewed on the screen as $, is used to separate a single editing command or a command string from the next command character. For example,

J $ T $ . . .

Editing commands

Escape character used as command separator

2. Two consecutive ESCapes, which is viewed on the screen as $$, is used as a carriage return in the NSPEED editing mode. It must be remembered that in the editing mode, the conventional carriage return is never used to execute the command. For example,

2L $ 10T $$

Editing commands

NSPEED carriage return

Command separator

Hence the double ESCape tells NSPEED to execute the command string. The ESCape character is keyed by pressing the ESC key on the keyboard.

Erasing characters while typing

The DEL key is used to erase any incorrect character detected while typing. Each time this key is pressed, NSPEED deletes the last character entered and echoes that character on the terminal. For example

```
! SUBROTINE ENIT UTINE

      1     2     3
```

Three steps may be understood as follows:

1. An error is detected after the word 'SUBROUTINE' is typed.
2. DEL key is pressed four times, which echoes the characters erased.
3. The correct string is entered.

If the DEL key is pressed more than the number of characters in a line, it echoes all the characters and gives a new prompt. For example,

```
! END DNE
!
```

Command structure

The general format of NSPEED command is as below:

[num-arg]...COMMAND[string arg]...$$

where:

num-arg is a decimal number

COMMAND is any NSPEED command

string-arg is a string of ASCII characters

Character pointer commands

The character pointer (CP) commands are necessary to move the editing cursor to that part of the program where correction is necessary. Using this command the CP can be moved forward or backward, by characters or by lines. The CP commands can be documented as follows.

COMMAND	DESCRIPTION
J	Move the CP to the beginning of the buffer's first line.
nJ {n is a numeric value}	Move the CP to the beginning of line n in the current buffer. n is always relative to line 1, the first line of current buffer.
nL	Move the CP n lines forward relative to its present position.
-nL	Move the CP n lines backward relative to its present position
L	Move the CP to the beginning of the current line
nM	Move the CP n characters to the right, relative to the current position.
-nM	Move the CP n characters to the left, relative to the current position.

Insert command I

Insert command is used to insert text in a newly opened file or to insert strings in a pre-existing file.

1. Newly opened file

After the prompt appears, an 'I' is typed and the desired text is keyed into the computer. For example,

```
! IFORTRAN.....
        ____________
        ____________ $$
!
```

2. Pre-existing file

In a pre-existing file an insert command is usually used to insert text between two lines. This can be done by first moving the cp to the end of the line preceding the new line to be added. After this step, an I is typed and RETURN carriage return pressed. The desired text may be now entered. This can be shown by an example as below.

STEP 1:	FORTRAN SUBROUTINE (^) CALL LINK	A line is to be inserted between them
STEP 2:	II	I and carriage return
STEP 3:	INIT = EXEC $$	Text is entered
STEP 4:	FORTRAN SUBROUTINE INIT = EXEC CALL LINK	RESULT

Points to remember

1. Any number of lines may be inserted by typing the line and pressing RETURN key when desired.
2. When a FORTRAN code is to be inserted, it is important to realize that the FORTRAN commands start from the seventh column on the screen.

Therefore when an insert I is typed for the first line, the FORTRAN command must start from the eighth column, as I occupies the first column. For example,

```
   123456789.....
I  I100   FORTRAN                  First line
   23     DO10I=                   second line
```

If confusion arises while counting the columns for entering the FORTRAN command in the first line, then sufficient space may be given and command started from the 9th or 10th column (or onwards), as FORTRAN accepts command starting from any column after the seventh column.

Search command S:

The search command searches for a particular string and places the CP after that string, if it is found. If more than one string of the same type exist, then it stops after the first string which follows the current position of the CP. Strings which precede the current position of the CP cannot be detected and will result in an error. It would be advisable to jump the CP to the beginning of the text before issuing a search command, if the approximate location of the string is not known. For example,

```
                        J $ S T A B L E $$
CP Jump                      string                    NSPEED
 command                                                carriage
                                                         return
                           Search
                           command
                  command
                  separator
```

If a string is not found, the terminal displays the error message

ERROR: UNSUCCESSFUL SEARCH

The general format of search command is

Sxtring$

Type-out command T

The function of the T command is to type out the current line of text, along with the symbol (^) which includes the current cp position. The T commands may be documented as below.

COMMAND	DESCRIPTION
T	Type out the current line where cp resides with (^)
nT where n is numeric	Type out n lines following the current position of cp
-nT	Type out n lines preceding the current position of cp.
#T	Type out the entire text in the buffer.

It must be remembered that the T command does not change the position of the cp.

Change command C

The C command is a combination search and modify command. General format of this command is

C Stringl $ String2 $

change command — command separator

string to be changed — new string

The change command searches the stringl from the current position of the cp and replaces when the string is found by string2. It must be

remembered that it will replace the very first string it finds, if there is more than one string of the same type. Therefore it is imperative to position the cp suitably before issuing the change command. An example of change command can be seen below.

```
I J $ FORTAN $ FORTRAN $ T $$
```

NSpeed positions the cp at the beginning of the buffer, then searches for FORTAN. NSpeed finds the string, inserts FORTRAN in its place, and types out the edited line.

Kill command K

Kill command is used to kill one or more lines following the current position of cp. The general format of the command is as shown below.

```
                n K $
number of                    command
 lines                        separator

      kill
     command
```

How to save a text after editing

If a file is to be saved after inserting text then Home command may be used. The general format of this command is:

```
I UEH $$
R
```

This command saves the content of the buffer and exits from NSPEED at the end of an editing session, and returns to the CLI. If any files are open they are closed before returning to the CLI. If files were opened and no correction made, then it would suffice if the following command is issued.

```
! H $$
R
```

The R is RDOS CLI prompt. Once it appears, any CLI command can be issued.

CHAPTER 3

RAMP MANAGEMENT STRATEGY

The overall intent of the Ramp Management Strategy (RMS) is to achieve a smooth flow of traffic on the mainline freeway and ease the merging of traffic entering the freeway via the ramp, with the mainline traffic. The status of the traffic at any ramp is monitored by loop detectors placed at several locations on the freeway and the ramp. The ramp controller obtains the information from the loop detectors and stores the data. Upon request from the computer, it sends this information back for data processing.

In this chapter the locations of the detectors and controller are shown. The description of the controller follows next. The addresses and functions are explained via the Ramp Metering Timing Card. Using the information obtained from the controller, the formulae for the calculation of volume, occupancy and speed are outlined. Finally, the actual RMS and its simplified version are discussed.

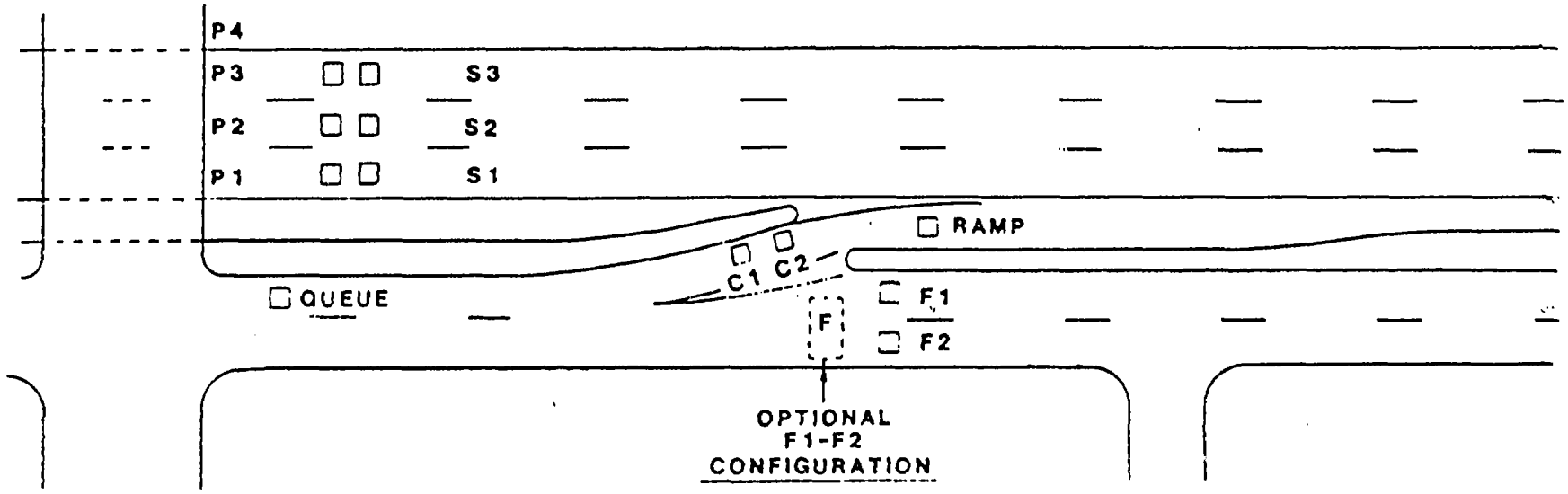
3.1 Positioning of Controllers and Detectors

The typical detector locations and identification labels are shown in Fig. 3.1.

The 13 mainline detectors are used to accumulate volumes and occupancies for each lane. In addition to volumes and occupancies, the detectors on the ramp provide the capability to accumulate data on the number of violations.

3.2 Description of Controller

In order to interface effectively with the ramp controller it is imperative to understand the functions it provides and the steps required to manipulate the variables which govern this function.



Detector Placement

Fig. 3.1 Detector Placement

The heart of the CR 1610 is a 16 bit microprocessor that performs the logical and timing functions of the controller. The parameters of the functions provided are stored in appropriate memory locations which can be accessed and manipulated. Functions necessary for the ramp management strategy and their respective addresses are described below.

When the toggle switch used in the front panel of the controller is turned on to DISPLAY & DET FAIL, it causes the seven segment LED to display the current value in memory selected by the CYCLE and INTERVAL thumbwheel switches. The details are shown in Fig. 3.2.

Figure 3.2 shows that the value at the memory location, cycle 6-Interval 2 is 0700. Each thumbwheel has 16 demarcations from 0 to 15, and hence providing for a total 16 x 16 addressable memory locations. All the values in the memory can be referenced at one time by tabulating them in a table, called Ramp Metering Timing Card, as shown in Table 3.1.

The general format of an address in this table is

FE CYCLE, INTERVAL

In the above example the address value in the hexadecimal system is FE62 (Fig. 3.2).

Important addresses

FE00 --> FIRST YELLOW is used when the controller is starting to meter. It can be set to zero and the CR1610 will ignore this parameter. Range: 0 to 799.9 entered in tenth of seconds.

FE02 --> TIME OUT is the time the metering sign remains ON after the last red indication.
Range: 0 to 799.9 entered in tenth of seconds.

FE03 --> LEAD IN is the time the metering sign is ON prior to displaying first yellow
Range: 0 to 799.9 entered in tenth of seconds.

FE30 --> This is the total cycle time for a RED-GREEN cycle. It is used in conjunction with FE32 which provides the GREEN time in a

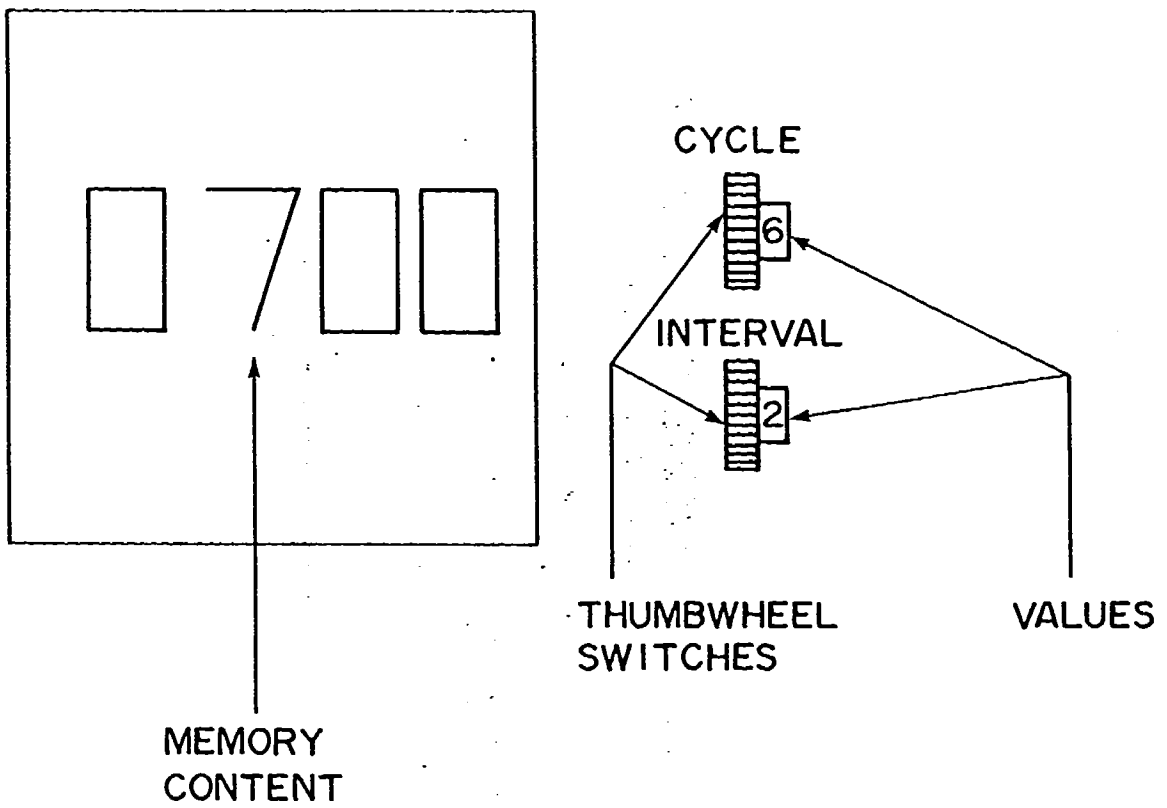


Fig. 3.2 Schematic diagram of ramp controller

Table 3.1 RAMP METERING TIMING CARD

LOCATION _____ FE - CYCLE, INT DIRECTION _____
ID NO _____ RAMP # _____

		CYCLE										10	11	12	13	14	15
INTERVAL		0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0		FE00			FE30												FEF0
1																	FEF1
2		FE02			FE32												FEF2
3		FE03															
4																	FEF4
5																	
6																	
7																	
8																	
9										FE89							
10	A									FE8A							
11	B									FE8B							
12	C																
13	D																
14	E																
15	F	SEC	MIN	HR	WKDY 0-6												
		FE0F	FE1F	FE2F	FE3F												

0 = SUNDAY

cycle. Therefore a value of 0050 in FE 30 and a value of 0020 in FE32 will result in 3 seconds RED and 2 seconds GREEN.
Range: 0 to 240.0 in tenths of seconds

FE32 --> FIXED GREEN is the number of seconds of green.
Range: 0 to 240.0 in tenths of seconds

FEF0 --> ID number of the ramp controller at that location.
Range: 0 to 254 entered in whole numbers only.

FEF1 --> WATCHDOG ON TIME is the maximum length of time a detector can remain ON before the watchdog reports that detector as failed.
Range: 0 to 7999 entered in seconds.

FEF2 --> WATCHDOG OFF TIME is the maximum length of time a detector can remain OFF before the watchdog reports that detector as failed.
Range: 0 to 7999 entered in seconds.

FEF4 --> LONG COUNT TIME determines how long the controller will count volumes, violations, occupancy etc. prior to storing them in memory and starting a new count.
Range: 0 to 7999 entered in seconds.

FE89,
FE8A,
FE8B --> These three addresses are used in conjunction and they may be explained as follows.

FE89: The first digit determines the operating pattern:

0	ignore the time clock
1-6	run cycle chosen
7	nonmetering operation
8	operate traffic responsive
9	ignore the detector watchdog timer

The second digit is always entered as zero. The last two digits select the days of the week the pattern is to operate.

00 --> off

01 --> Sunday

02 --> Monday

03 --> Tuesday

04 --> Wednesday

05 --> Thursday

06 --> Friday

07 --> Saturday

08 --> Monday through Friday

09 --> Saturday and Saturday

10 --> Tuesday through Thursday

11 --> Monday through Friday

12 --> Sunday through Saturday.

FE8A: START TIME is a four-digit number representing the time the pattern is to start operating with hours in the first two digits and minutes in the last two digits. Only whole numbers can be entered for minutes.

FE8B: END TIME is a four digit number representing the time the pattern is to stop operating. First two digits are again for hours and the last two digits are for minutes.

FE0F,
FE1F,
FE2F,
FE3F, --> They are respectively the second, minute, hour and weekday (0-6 --> Sunday - Saturday) of the clock used by the ramp controller.

How to Erase and Load Values (Manual Operation)

In order to erase a value in a particular address, the toggle switch is first set to DISPLAY & DETAIL which displays the memory value at the address shown by the thumbwheel switches, i.e., FE Cycle, Interval. If the address is not the one which is desired, it is set using thumbwheel switches. After

the correct address has been set, the E erase key is pressed which erases the value and enters 0000 in that address. Now to load the desired value, the numerical values on the keyboard are used.

It must be remembered that all values entered must be four digits. For example,

240 is entered as 0240

7 is entered as 0007

After the values are loaded, the L load key is pressed firmly. When this is done, care must be taken to see if the LED blinks momentarily, if not it implies that the new values are not loaded. Therefore the load key must be pressed repeatedly until the LED blinks.

Points to remember

1) After erasing a value, if no new value is loaded, then the old values are retained.
2) If 0000 are to be entered as a new value, then it is not sufficient if the old values are erased. The load key must be pressed so that 0000 displayed by the LED after erasing, are loaded.

Calculation of volume, occupancy and speed

The formula used in the software is shown below, with an explanation of each variable.

Volume calculation

$$VOL(K) = \frac{(SA + PA)}{(E+D)/ISI} * 3600$$

where

VOL = Is the acronym for volume

K = Index of an array which stores calculated volume for all freeway lanes in DATABASS or DATABASN.

SA = Is the total of volume parameters collected by the controller from all or any of the three working secondary detectors.

PA = Is the total of volume parameters collected by the controller from all or any of the four working primary detectors.

E = number of working secondary detectors

D = number of working primary detectors

ISI = Time in sec, for which the data was collected. Also known as the interval time or LONG COUNT TIME.

OCCUPANCY CALCULATION

$$OC = \frac{OPA + OSA}{D+E}$$

where

OSA = Is the total of occupancy parameters collected by the controller from all or any of the three working secondary detectors

OC = occupancy for a particular freeway lane
OPA = Is the total of occupancy parameters collected by the controller from all or any of the four working primary detectors

D = Number of working primary detectors

E = Number of working secondary detectors

Calculation of percent occupancy

$$OCC(K) = \frac{OC}{AMX} * 100$$

where

OCC = Is the acronym for percent occupancy

K = Index of an array which stores calculated percent occupancy for all freeway lanes in DATABASS or DATABASN.

OC = Occupancy for that particular freeway lane
AMX = CT * ISI

where

CT = Occupancy clock frequency in Hertz

ISI = Interval time or LONG COUNT TIME, for which data was collected, in seconds.

Speed calculation

$$V(K) = \frac{DT}{TV} * \frac{3600}{5280} * MF$$

V = Abbreviation for speed

K = Index of an array which stores calculated speed for all freeway lanes in DATABASS or DATABASN.

DT = [D1 + RS]

where

D1 = Average vehicle length in feet

RS = Range of detectors in feet

$$TV = \left[\frac{OC}{VI}\right]/_{CT}$$

where

OC = occupancy for that particular freeway lane

$V1 = \frac{[SA + PA]}{[E + D]}$ variables are the same as explained in volume calculation

CT = occupancy clock frequency in hertz.

3.3 The Ramp Management Strategy (Original)

The decision making process of the Ramp Metering Strategy is shown in Fig. 3.3, Ramp Metering Strategy Flow Diagram, which uses volume, occupancy and speed as parameters.

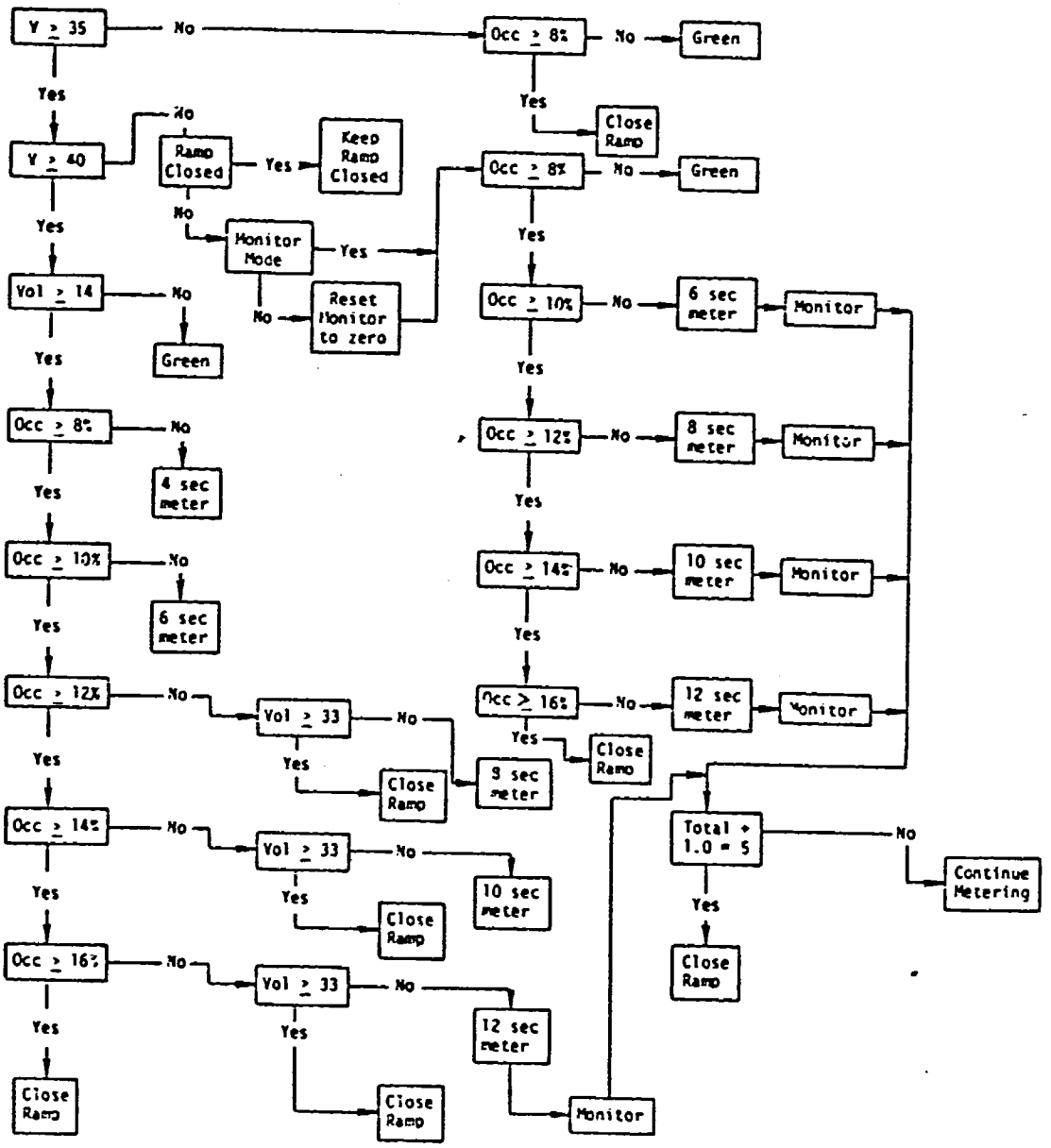


Fig. 3.3 Ramp Metering Strategy Flow Diagram

What is meant by metering

In the ramp management strategy the RED-GREEN cycle used to control traffic is called metering operation. For example, 4sec metering implies 4 seconds RED signal and 2 seconds GREEN signal, and 10 sec metering implies 10 seconds RED signal and 2 seconds GREEN signal. GREEN time is always fixed to 2 seconds in a RED-GREEN cycle. In the revised RMS n sec metering implies n-1 sec RED and 1 sec GREEN.

Address and data to achieve metering

The two most important addresses to achieve the desired RED-GREEN cycle is FE30 and FE32, as previously explained. FE30 is the address for the total cycle parameter and is the RED-GREEN cycle time. FE32 is the address for the GREEN time in the RED-GREEN cycle. Listed below are certain values of RED-GREEN cycle used in the Ramp Management Strategy (original).

SIGNAL	FE30	FE32
Green Signal	0240	0240
Meter 4 secs	0060	0020
Meter 6 secs	0080	0020
Meter 8 secs	0100	0020
Meter 10 secs	0120	0020
Meter 12 secs	0140	0020
Close ramp (red signal)	0240	0000

CHAPTER 4

MODIFIED SOFTWARE

The original Safe-Trans software is not designed for real-time control of the ramp entrances. In order to implement the RMS, the software was modified. In this chapter, the modifications are listed. The new common blocks that store the data and status information are explained. Then the changes made to the main modules - RMPT, COMMT and DATAP, are discussed in detail. Finally, modifications to other routines that figure in other programs, and development of new routines, are discussed briefly. The listing of the complete system is given in the Appendix.

4.1 Common Blocks

```
COMMON/ASU/ISKIP(2)

COMMON/SMTRC/MDATA(2,10,2,4),IACTR(2,10),IFLAG(2,10,),NFLAG
COMMON/LIEN/MTB(2,10,2,7)
```

Description:

ISKIP(1) - The time period for which decision-making won't be implemented by the program when the system is booted up. The unit is second. This prevents spurious data from affecting the RMS. Default value is 600 seconds.

ISKIP(2) - The time period which synchronizes with interval in minutes. The unit is second.

MDATA(2,10,2,4) - The first two digits are used to specify the ramp (southbound from (1,1) to (1,9) northbound from (2,1) to (2,10)).

The third digit indicates message 1 or message 2. (For every RMS strategy, we need to send two messages to each ramp controller.)

The fourth digit is used as follows:

If the digit is:

1 - done flag, telling COMMT if data needs to be sent (1 means completed formating, ready to be sent; 0 is no communication).

2 - in combination with the third digit: (1,2) for monitor count use (ref. RMETR), (2,2) for close ramp flag, i.e., if it is 1, ramp is closed, otherwise it isn't.

3 - the address of the message.

4 - the data of the message.

IACTR(2,10) - Flag used to indicate if we need to apply the RMS to the specified ramp controller.

IFLAG(2,10) - Contains the last RMS's decision. The purpose of remembering the last RMS's decision is to speed up all the program's functions. If the current decision is the same as the last decision then COMMT will not send message to the ramp controller.

The value in each block represents a different decision:

1 - GREEN

2 - RED

3 - 6 SEC METER

NFLAG - Indicates whether RMS is in operation or whether the computer system is in data collection mode only.

MTB(2,10,2,7) - Similar to ITB(2,10,10), used for containing the formatted message for TXMIT to send.

4.2 Modifications to Different Modules

RMPT

Modifications include the following:

1. Addition of the new common blocks to the program.
2. Ask information from operator to get the ramp status values.

   IACTR(2,10) - active flag for the ramp controllers.

   If value is 1, then COMMT will send the data to the ramp controller.

   If value is 0, then COMMT will not send the data to the ramp controller.
3. Print out information for validation of input data.

COMMT

Modifications include the following:

1. Before calling PRNT routine, three do loops are added to send the messages out to every ramp controller. It calls MRMT to format the messages and TXMIT to transmit the message to the controller.
2. New Common Block /ASU/, /SMTRC/ and /LIEN/ are attached.
3. New block MTB(2,10,2,7) is used only in the COMMT routine. It is used to contain the format message for transmission.

DATAP

Modifications include the following:

1. Addition of statements to skip control RMS for the first ten minutes.
2. ISMK routine is called to calculate the volume, occupancy and velocity.
3. New Common Block /ASU/, /SMTRC/ and /LIEN/ are attached.

HISTORY

Modification only includes addition of the new Common Block before DIMENSION statement.

ISMK

ISMK is modified to produce the volume, occupancy and velocity. The reason to do so in this routine is all the collected data will be cleared after the IST file is created. The RMS uses the volume, occupancy and velocity for decision making in RMETR routine. IDD data block contains all the collected data we need to calculate the volume, occupancy and speed. Volume is the maximum number between P(1) and S(1). Occupancy is the maximum number between OP(1) and OS(1). Velocity is calculated from volume and occupancy.

PASCR

It is used to pass the values in the Common block from one program to the other. Before chaining from one program to the other, e.g. form COMMT to DATAP or from DATAP to HISTORY, one external file is used to save the values. The file is "PASC". PASCR routine is used to read all the values back to Common block, so it is called every time a program begins execution.

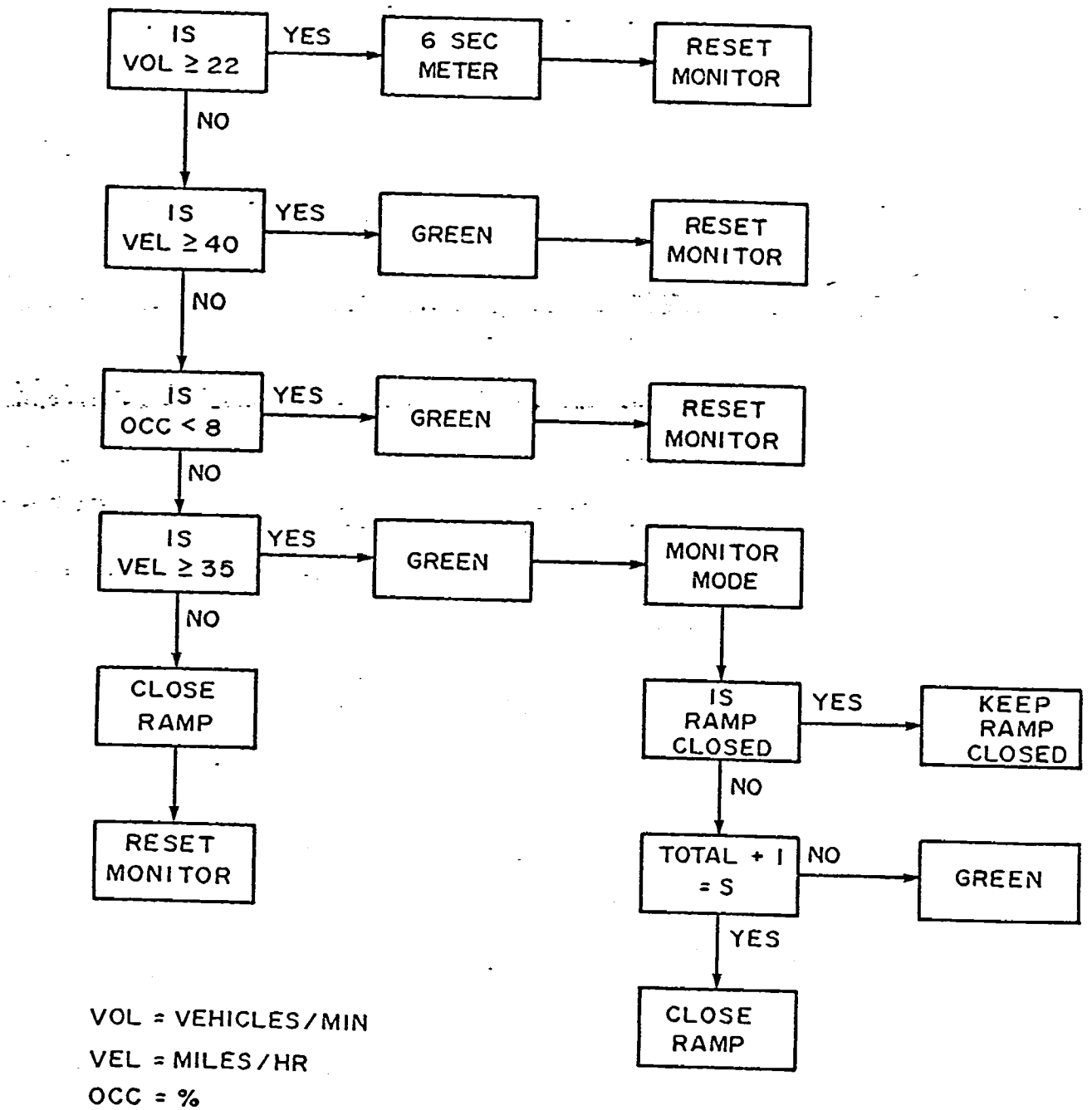


Fig. 4.1 Revised Ramp Management Strategy

PASCW

Similar to PASCR. It writes the common block data to the PASC file.

4.3 New Routines

MRMT

This new routine is used to format the message similar to RMT routine except that it uses fixed IC value (i.e., 16, for write only).

TXMIT

This new routine is used to send the message out without waiting for the response from the ramp controller. It is actually part of SXMIT routine without the receive part. The Common Block used for this routine is MTB(2,10,2,7).

RMETR

RMETR is a revised version of the original RMS developed for this project. RMETR starts metering only if the number of vehicles per hour exceeds 1200 in the outer lane. At any time, depending upon the traffic conditions, the decisions which can be made by this revised strategy are as shown below.

1) Rest on green.
2) Meter at 6 sec
   5 sec red
   1 sec green
3) Rest on green and monitor.
4) Close ramp.

The traffic conditions at which these decisions are made can be easily understood by the flow diagram (Fig. 4.1) provided for

this revised strategy. In order to invoke this subroutine the parameter passed by the calling program are:

1) vol - volume
2) occ - occupancy
3) v - velocity
4) I - direction, i.e. northbound or southbound
   I = 1 southbound
   I = 2 northbound
5) J - ramp number
   J may assume values from 1 to 10.

To understand the coding for the flow diagram the variable names used in it are explained.

MDATA(i,j,k,l) This is an array with maximum subscript values MDATA (2,10,2,4) where
i = direction (northbound or southbound)
j = ramp number
k,l = for a detailed explanation refer to Chapter 4

IACTR(i,j) This is an array with maximum subscript values IACTR(2,10) where
i = direction (northbound or southbound)
j = ramp number

Each location in this array may store a value of either 0 or 1, respectively, indicating whether ramp management strategy is to be implemented on that ramp or not.

IFLAG(i,j) This is an array with maximum subscript values IFLAG(2,10) where

i = direction (northbound or southbound)

j = ramp number

Each location in this array may store for a particular ramp a value of either

1 for green signal

2 for close ramp

3 for 6 sec meter

Each decision time, this variable is checked for a ramp to see if the current decision is the same as the previous decision. It if is the same, then the current decision is not sent to that ramp in order to save time.

The original RMS details are omitted here since it was never used in the field tests.

CHAPTER 5

OPERATING PROCEDURES

The step-by-step procedure for operating the RMS system is discussed in the first part of this chapter. The user-system interaction is shown with appropriate user responses. The system flexibility can be seen in the following sections. The modified RAMPTALK program can be used to change most of the parameters that affect the RMS. Finally, the location of all pieces of software are given if changes to the system need to be made at a later date.

5.1 Booting System

1. Make sure you are in the DPOF:RP directory.

   Type in "DIR DPOF:RP" to get into RP directory.

2. Type in "@up@" and CR.

3. Go over to foreground terminal, the printer, and answer the following questions:

   Day of the week? (0-6 Sunday - Saturday) _____

   Interval in minutes = ? (1-180) answer _____

   First interval in minutes = ? (5-180) answer __1__

   Historical time in minutes = ? (5-180) answer __15__

   First historical time in minutes = ? (1-4320) answer # minutes to next quarter-hour.

   What ramp will be implemented?

   ALL (1)? NONE (2)? SPECIFIED (3)? answer _____

   if the answer is 3, it will keep asking

   START (1)? MORE (2)? END (3)? answer __1__

   What ramp number? answer (1010-1029)

START (1)? MORE (2)? END (3)? answer _____

.
.
.

START (1)? MORE (2)? END (3)? answer __3__

4. After system is booted up, it will point out the information concerning the first skip interval and skip interval, and the status of the ramp controllers.

5. Wait for 1 minute, then go over to background terminal (console) type in "RAMPTALK" <CR>.

   console: "WHAT RAMP NUMBER?"

   answer: 1255

   console: "ALL"

   "CORRECT RAMP? (YES,NO)"

   answer: YES

   console: "READ, WRITE, START AGAIN, END? (R,W,S,E)"

   answer: W

   console: "ADDRESS?"

   answer: FEF4

   console: "DATA?"

   answer: answer should be compatible with the answer for "Interval in minutes = ?" (Step 3).

   e.g., if answer for "Interval in minutes" is 5, then answer should be 5*60 = 0300.

   if answer for "Interval in minutes" is 2, then answer should be 2*60 = 0120.

   wait for few minutes,

   console: "WRITE ALL COMPLETE"

console: "READ, WRITE, START AGAIN, END? (R,W,S,E)"

answer: E

This completes the booting procedure.

5.2 System Changes and Enhancements

Most of the changes have been discussed in this chapter and the preceding chapters. Here the focus is on the new version of RAMPTALK which when used in conjunction with the rest of the system, can give the user control over all the parameters that influence the RMS.

5.3 Directories and Files

All the modified files are in the DPOF:ASU directory and named as follows:

MRMPT - Modified RMPT

MCOMMT - Modified COMMT

MDATAP - Modified DATAP

MHISTORY - Modified HISTORY

LISMK - Modified ISMK

MPASCR - Modified PASCR

MPASCW - Modified PASCW

All the new routines are all in the DPOF:ASU directory:

MRMT, TXMIT, RMETR.

There are also back up disks containing all the modified and new files.

CHAPTER 6

CONCLUDING REMARKS

The current research completes the second phase of the research that began in 1980 with a fixed-time ramp metering system. The original software has been expanded to incorporate strategies, on a real-time basis, to maintain satisfactory flow rates and speed on the freeway. In this chapter, the impact of the ramp management strategy on the freeway traffic is discussed. The discussions are based on the tests carried out by the researchers and ADOT personnel. The report concludes with some thoughts on future enhancements that would make the system more effective.

6.1 Impact on Freeway Traffic

The preliminary tests indicate that ramp metering strategies can be implemented successfully under certain conditions. During peak hour traffic, under test conditions, the system was able to successfully detect the correct volume, occupancy and speed, and implement the strategies in the RMS. In addition to the entry of ramp vehicles according to the speed-volume-occupancy relationships on the freeway, the RMS also provides for ramp closure in the event of a non-recurring incident.

Test 1 (Date: 10/3/85)

This test was carried out on the southbound ramps during morning peak hour traffic. The test began at 7:15 am and continued until 7:45 am at the Glendale and Bethany Home ramps. The revised version of the RMS was used. When the traffic volume reached 1200 vph, the system went into the 6 sec metering mode. This was verified by a manual count of the vehicles on the outer freeway lane. The system did not rest on red as the traffic volume did not exceed 2200 vph and the speed did not fall below 35 mph. However,

since the system was working at 2 min interval (the RMS updated the decisions based on 2 min data), it was felt that the system did not respond adequately to quickly changing conditions on the freeway. These changes were to be incorporated for the next test of the system.

Test 2 (Date: 10/11/85)

This test was carried out during the evening peak hour traffic (3:45 pm to 4:30 pm). The decision-making time was reduced from 2 minutes to 1 minute. As in the previous test, the system went into the 6 sec metering mode when the outer lane volume exceeded 1200 vph. For most of the time, the signal did rest on green at the Bethany Home ramp. At the Glendale ramp the signal finally rested on red. This was caused by an incident on the freeway. A stalled vehicle on the shoulder followed by a Highway Patrol car, slowed the traffic in the outer lane below 35 mph. The signal was made to rest on red for about 10 minutes until the speed and the volume started increasing again.

More tests are planned for the future.

6.2 Future Enhancements

The tests were carried out on a limited number of ramps. Present experience indicates that it takes about 20 seconds to complete one communication sequence with a ramp. Hence a one minute turnaround with the 19 ramps on the system is impossible. The enormous amount of time that is currently consumed is due to several factors listed below.

(a) The Data General Nova III is an old computer system. The CPU can be easily outperformed even by today's small microcomputers. Since a large number of input/output operations are involved, a considerable amount of time is taken up by the disk operations on obsolete disk

hardware. It is suggested that the computer system be upgraded for faster throughput.

(b) The original software is written in Fortran V. It is not very efficient and is poorly documented. Furthermore, the modularity is forced by hardware limitations. It is suggested that the language be changed to either FORTRAN 77 or C or a combination of both (where such code mixing is allowed).

(c) The communication linkup between the main computer and the ramp controllers plays one of the most important roles. At present, the speed (1200 baud) and the reliability (telephone line set-up) are both inadequate. It is suggested that a more reliable and faster system be installed.

(d) The ramp controller is inflexible in its operation. It cannot be made to rest on red or green in the telemetry mode. Also, apart from the initial boot up, the signal cannot be changed from green to yellow to red, so as to warn the motorist of the changing status. A more versatile controller is required to implement complex ramp metering strategies.

In conclusion, the second phase of the ramp traffic control on the Black Canyon Freeway indicates that an effective system can be installed and made operational with the existing technology.

REFERENCES

[1] J.B. Blackburn, W.E. Lewis, G.T. Mackulak and R.H. Rucker, "Design of On-Ramp Traffic Control on the Black Canyon Freeway," Final Report, Project No. 190, Arizona Department of Transportation, 198 .

[2] A. Greist and J. Goosman, Ramp Central Software Manual Arizona, Safetran Traffic Systems, Colorado Springs, CO, May 1980.

PROGRAM LISTINGS

The following pages contain the listing of the FORTRAN V programs used on the Data General NOVA III system. Only the routines that were modified to implement the RMS strategy are shown.

```
                REPORT PREPARED ON    9 28 1985
C ***********************************************************
C **                          RMPT                           **
C **        PRIMARY PROGRAM FOR RAMP CONTROL AND DATA        **
C **        GATHERING.                                       **
C ***********************************************************
      COMMON IDAT(2,10,33),KT(3),IRF(2),IRDATA(4),ITB(2,10,10),
     +  IFAIL(2,10),IDD(2,10,31,3),INT(5),ICF,IPF,IBUF(2,66)
      COMMON/ASU/ ISKIP(2)
      COMMON/SMTRC/ MDATA(2,10,2,4),IACTR(2,10),IFLAG(2,10),NFLAG
      DIMENSION CMSG(4)
      DOUBLE PRECISION CMSG
1005      ACCEPT " DAY OF THE WEEK IS ? (0-6  SUNDAY-SATURDAY)  ",INT(5)
      IF(INT(5).GT.6)GOTO 1005                ;WAIT TIL WEEKDAY IS DEFINED
      IF(INT(5).LT.0)GOTO 1005
1006      ACCEPT " INTERVAL IN MINUTES=? (1-180)     ",IN
      IF(IN.LE.0)GOTO 1006
      IF(IN.GT.180)GOTO 1006
      INT(2)=IN*60                                        ;SET INTERVAL
1016      ACCEPT " FIRST INTERVAL IN MINUTES=? (1-180)     ",IN
      IF(IN.LE.0)GOTO 1016
      IF(IN.GT.180)GOTO 1016
      INT(1)=IN*60                                      ;SET FIRST INTERVAL
      ISKIP(1)=660
      ISKIP(2)=INT(2)
1007      ACCEPT " HISTORICAL TIME IN MINUTES=? (5-180)    ",IN
      IF(IN.LE.4)GOTO 1007
      IF(IN.GT.180)GOTO 1007
      INT(4)=IN*60                                        ;SET HISTORY
1017      ACCEPT " FIRST HISTORICAL TIME IN MINUTES=? (1-4320)    ",IN
      IF(IN.LE.0)GOTO 1017
      IF(IN.GT.4320)GOTO 1017
      INT(3)=IN*60                                    ;SET FIRST HISTORY
      WRITE(10,29)
 29   FORMAT(' WHAT RAMP WILL BE IMPLEMENTED ?')
1019  WRITE(10,30)
 30   FORMAT(" ALL(1)? NONE(2)? SPECIFIED(3)?   ",Z)
      READ (11,21)IDX
 31   FORMAT(I1)
      IF(IDX.EQ.1) GOTO 1020
      IF(IDX.EQ.2) GOTO 1023
      IF(IDX.EQ.3) GOTO 1021
      GO TO 1019
1020  DO 299 I=1,2
      DO 299 J=1,10
 299  IACTR(I,J) = 1
      GO TO 1099
1023  NFLAG = 1
      GO TO 1099
1021  WRITE(10,32)
 32   FORMAT(" START(1)? MORE(2)? END(3)?   ",Z)
      READ(11,31)JDX
      IF(JDX.EQ.1) GOTO 1025
      IF(JDX.EQ.2) GOTO 1025
      IF(JDX.EQ.3) GOTO 1099
1025  WRITE(10,437)
 437  FORMAT(" WHAT RAMP NUMBER ?  ",Z)
      READ(11,34) NUM
 34   FORMAT(I4)
      I1 = NUM - 1000
      IF(I1.LT.10) GOTO 1025
      IF(I1.GT.29) GOTO 1025
      I = I1/10
```

```
        J = I1-I*10+1
        IACTR(I,J) = 1
        GO TO 1021
1099    WRITE(10,399)ISKIP(1),ISKIP(2)
399      FORMAT(1X,"  FIRST SKIP INTERVAL :",I5/
     &   1X," SECOND SKIP INTERVAL :",I5)
        DO 99 I=1,2
       WRITE(10,401)(IACTR(I,J),J=1,10)
401     FORMAT(1X," STATUS OF RAMPS : "/(10I2))
 99     CONTINUE
        CALL TIME(KT,IER)
        CALL SCOMW                                          ;SAVE COMM
        CALL SDATW                                          ;SAVE DATA
        IC1=0
        IC2=0
        CALL ERWRT(IC1,IC2)
1010        ITOLD=KT(2)                                     ;SAVE OLD MIN
        CALL WAIT(2,2,IER)
        CALL TIME(KT,IER)
        IF(ITOLD.EQ.KT(2))GOTO 1010                         ;WAIT FOR CHANGE
        CMSG(1)=3100607
        CMSG(2)="          "
        CMSG(3)="          "
        CMSG(4)=0
        CALL ERSTOR(CMSG)
        CALL PASCW                                          ;SAVE COMMON
        CALL FCHAN("COMMT.SV")                                  ;GOTO COMMUNICATIONS
        STOP
        STOP
        END
        BLOCK DATA
        COMMON IDAT(2,10,33),KT(3),IRF(2),IRDATA(4),ITB(2,10,10),
     +  IFAIL(2,10),IDD(2,10,31,3),INT(5)
        COMMON/ASU/ ISKIP(2)
       COMMON/SMTRC/ MDATA(2,10,2,4),IACTR(2,10),IFAIL(2,10),NFLAG
        DATA IDAT/660*1/KT/3*0/IRF/0,0/IRDATA/4*0/ITB/200*0/
        DATA IFAIL/20*0/IDD/1860*1/INT/60,60,600,600,10/
        DATA ISKIP/600,60/
       DATA MDATA/201*0/
        END
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C                                                                       PAGE 3-1-4
C ***************************************************************
C **                        COMM                                    **
C **                  COMMUNICATIONS HANDLER                          **
C ***************************************************************
        COMMON IDAT(2,10,33),KT(3),IRF(2),IRDATA(4),ITB(2,10,10),
     +  IFAIL(2,10),IDD(2,10,31,3),INT(5),ICFLG,IPRNTF,IBUF(2,66)
        COMMON/ASU/ ISKIP(2)
       COMMON/SMTRC/ MDATA(2,10,2,4),IACTR(2,10),IFLAG(2,10),NFLAG
        COMMON/LIEN/MTB(2,10,2,7)
        DIMENSION CMSG(4),LTIME(3)
        DOUBLE PRECISION CMSG
        CALL SCOMR        |                                 ;RESTORE COMMON
        CALL PASCR        |                                 ;READ COMMON
        IDAT(1,10,32)=0   |                                      ;NO DATA FOR SITE 1019
        CALL CINIT                                          ;INITIALIZE COMM
C ***************************************************************
C **        FORMAT MESSAGES                                        **
C ***************************************************************
        IF(NFLAG.EQ.1) GOTO 10
        DO 5010 M=1,2
        DO 5010 J=1,10
        DO 5010 K=1,2
        IF(MDATA(1,J,K,1).EQ.0)GOTO 601
        I1=-1
```

```
      IXB1=13
      CALL MRMT(1,J,K)
      GO TO 750
 601  I1=0
      IXB1=0
 750  IF(MDATA(2,J,K,1).EQ.0)GOTO 801
      I2=-1
      IXB2=13
      CALL MRMT(2,J,K)
      GO TO 950
 801  I2=0
      IXB2=0
      IF((I1.NE.-1).AND.(I2.NE.-1))GOTO 5010
 950  CALL TXMIT(I1,I2,J,K,IXB1,IXB2,IER1,IER2)
      MDATA(1,J,K,1)=0
      MDATA(2,J,K,1)=0
      IF(IER1.EQ.1034) MDATA(1,J,K,1)=1
      IF(IER2.EQ.1034) MDATA(2,J,K,1)=1
5010  CONTINUE
10      CALL PRNT                              ;OUTPUT FROM BACKGROUND
      DO 1001 J=1,10                             ;DO 10 DROPS
       DO 3020 I=1,2                             ;DO BOTH LINES
      IF(IDAT(I,J,32).NE.0)GOTO 2020             ;NEED DATA?
      IF(IRDATA(1).LE.0)GOTO 3021               ;NO,RAMPTALK?
      IF(IRF(I).EQ.1)GOTO 3021                ;YES,THIS LINE DONE?
      IF(IRDATA(2).EQ.1255)GOTO 3000             ;NO,ALL DROPS?
      J1=IRDATA(2)-1000
      IF(J1/10.NE.I)GOTO 2900                     ;THIS LINE?
      J1=J1-J1/10*10                             ;YES,DROP #
      IF(J1.NE.J-1)GOTO 3021                     ;THIS DROP?
      IRF(I)=(J)*10                             ;YES
      GOTO 3010
2900      IRF(I)=1                              ;NOT THIS LINE, SET DONE FLA(
      GOTO 3020
3000      IF(IRF(I).EQ.0) IRF(I)=5
      IRDATA(1)=2
3010      CALL RMT(I,J)
3020      CONTINUE
      GOTO 24
3021      ITB(I,J,8)=0                              ;NO MESSAGE REQUIRED
      ITB(I,J,9)=0                             ;CLEAR ALL
      ITB(I,J,10)=0                             ;FLAGS
      GOTO 3020
2020      IF(ITB(I,J,10).EQ.-1)GOTO 3020              ;MESSAGE ALREADY SET UP
      I1=(10*I+J-1)                            ;ID#
      ITB(I,J,1)=I1*256+5                     ;ADDRESS&BYTES
      ICM=128                                    ;COMMAND
      ICSM=I1+5+ICM                             ;CHECK SUM
      ICSMM=(ICSM/256)*256
      ICSML=ICSM-ICSMM

C                                                          PAGE 3-1-5
      CALL BYTP(ITB(I,J,2),ICM,ICSML)            ;PACK FOR ITB(2)
      ITB(I,J,3)=ICSMM
      ITB(I,J,8)=66                             ;66 BYTES RESPONSE
      ITB(I,J,9)=5                             ;5 BYTES XMIT
      ITB(I,J,10)=-1                            ;MESSAGE READY FLAG
      GOTO 3020
C ***************************************************
C **       TRANSMIT & RECEIVE                      **
C ***************************************************
24      I1=ITB(1,J,10)                                    3
      I2=ITB(2,J,10)
      IF((I1.NE.-1).AND.(I2.NE.-1))GOTO 1000      ;NOT REQUIRED THESE DROPS
701       IXB1=ITB(1,J,9)                            ;# OF XMIT BYTES
      IRB1=ITB(1,J,8)                             ;# OF RECEIVE BYTES
```

```
        IXB2=ITB(2,J,9)
        IRB2=ITB(2,J,8)
        CALL SXMIT(I1,I2,J,IXB1,IXB2,IRB1,IRB2,IERR1,IERR2)
500       ITB(1,J,10)=1
        ITB(2,J,10)=1
        IF(IRB1.EQ.0) ITB(1,J,10)=0
        IF(IRB2.EQ.0) ITB(2,J,10)=0
        IF(IERR1.NE.1) ITB(1,J,10)=-3
        IF(IERR2.NE.1) ITB(2,J,10)=-3
        IF(IERR1.EQ.1040) ITB(1,J,10)=-2
        IF(IERR2.EQ.1040) ITB(2,J,10)=-2
        DO 2010 I=1,2
        IF(ITB(I,J,10).GT.0) GOTO 100
        IF(ITB(I,J,10).LT.0) GOTO 200
        IF(IRDATA(1).LE.0) GOTO 2010
        IF(IRDATA(2).NE.1255) GOTO 2010
        IRF(I)=IRF(I)-1
        IF(IRF(I).LE.1) IRF(I)=1
2010        CONTINUE
1000         ITOLD=KT(2)                                ;SAVE OLD MINIUTE
        CALL TIME(KT,IER)
        IF(ITOLD.EQ.KT(2)) GO TO 1002
1112        CALL SCOMM
        CALL PASCW
        CALL FCHAN("DATAP.SV")
1002        IF(IRDATA(1).LE.0)GOTO 1001                ;NEED RAMPTALK?
        IF((IRF(1).NE.1).OR.(IRF(2).NE.1)) GOTO 1001
1003        IRDATA(1)=0
1004        IRF(1)=0                                   ;YES, RESET LINE 1 FLAG
        IRF(2)=0                                   ;RESET LINE 2 FLAG
        CALL FOPEN(0,"RDATA")                          ;OPEN RAMPTALK FILE
        WRITE BINARY(0)IRDATA                          ;PASS RAMPTALK DATA
        CALL FCLOSE(0)
        IFLG=0
        CALL WRCMM(IFLG,0,1,IER)                   ;TELL RAMPTALK WE ARE DONE
1001        CONTINUE
        CALL WAIT(500,1,IER)                           ;DELAY FOR BACKGROUND
        GOTO 10
C ***************************************************
C **        RAMP RESPONSE                           **
C ***************************************************
3001        CALL BYTP(IRDATA(4),IBUF(I,6),IBUF(I,5))
        GOTO 1003
C

C                                                                  PAGE 3-1-7
C-------- TEST FOR CHECKSUM & MODEL #, THEN PROCESS
C
100         ICSM=0
        DO 210 L=1,64
210         ICSM=ICSM+IBUF(I,L)
        IF(IRF(I)/10.EQ.J) GOTO 3001
        IF(ICSM.NE.(IBUF(I,65)+IBUF(I,66)*256)) GOTO 200
        IF(IBUF(I,2).NE.162) GOTO 200
        IF(IFAIL(I,J).LT.90) GOTO 2056
        CMSG(1)=3120011                                ;YES, REPORT RESTORED
        CMSG(2)="      "
        CMSG(3)="      "
        CMSG(4)=(10*I+J-1+1000)
        CALL ERSTOR(CMSG)
2056        IFAIL(I,J)=0
        CALL BYTP(IDAT(I,J,1),IBUF(I,4),IBUF(I,3))         ;PACK FOR DATA
        DO 2070 L=56,6,-4
        CALL BYTP(IDAT(I,J,30-(L/2)),IBUF(I,L-2),IBUF(I,L-3))
2070        CALL BYTP(IDAT(I,J,31-(L/2)),IBUF(I,L),IBUF(I,L-1))
        DO 2075 L=58,64,2
```

```
2075          CALL BYTP(IDAT(I,J,(L-1)/2),IBUF(I,L),IBUF(I,L-1))
              IDAT(I,J,33)=0                                    ;SET GOOD COMM FLAG
              ITB(I,J,10)=0                                     ;RESET STATUS
              IDAT(I,J,32)=0                                    ;RESET DATA REQUEST
              GOTO 2010
C *************************************************
C **          COMM ERROR                                       **
C *************************************************
290           IF(IRF(I)/10.EQ.J)GOTO 2100
              ITB(I,J,10)=0
              IF(IFAIL(I,J).GT.89)GOTO 2092                     ;ERSTOR ALREADY
              IFAIL(I,J)=IFAIL(I,J)+1
              IF(IFAIL(I,J).NE.90)GOTO 2091
              CMSG(1)=3120003
              CMSG(2)="          "
              CMSG(3)="          "
              CMSG(4)=(10*I+J-1+1000)
              CALL ERSTOR(CMSG)
2091          IDAT(I,J,32)=1                                    ;TRY COMM AGAIN
              GOTO 2010
2100          IRDATA(1)=ITB(I,J,10)+1
              GOTO 1004
2092          IDAT(I,J,32)=0                                    ;FAILED TRY NEXT MINUT
              WRITE(10,999)
999           FORMAT("<BEL>",Z)                                 ;RING BELL FOR COMM FAIL
              GOTO 2010
              END
                    REPORT PREPARED ON     9 28 1985
C *************************************************************************
C **                          MRMT                                        **
C **          FORMS TRANSMIT MESSAGE                                        **
C *************************************************************************
              SUBROUTINE MRMT(I,J,K)
              COMMON/SMTRC/ MDATA(2,10,2,4),IACTR(2,10)
              COMMON/LIEN/MTB(2,10,2,7)
              ID=10*I+J-1                                       ID =
              IB=13                                               NUMBER OF BYTES
              LA=MDATA(I,J,K,3)                                     ADDRESS
              CALL BYTS(LA,MA)
              LD=MDATA(I,J,K,4)                                   DATA
              CALL BYTS(LD,MD)
              LAN=255-LA                                        COMPLIMENTS
              MAN=255-MA
              LDN=255-LD
              MDN=255-MD
              IC=16
10            CALL BYTP(MTB(I,J,K,1),ID,IB)                       ID,IB,IC
              MTB(I,J,K,2)=IC*256+LA
              CALL BYTP(MTB(I,J,K,3),MA,LD)
              CALL BYTP(MTB(I,J,K,4),MD,LAN)
              CALL BYTP(MTB(I,J,K,5),MAN,LDN)
              ICS=ID+IB+IC+1020                                 ;CHECK SUM
              MCS=ICS/256*256
              CALL BYTP(MTB(I,J,K,6),MDN,ICS-MCS)
              MTB(I,J,K,7)=MCS
              RETURN
              END
                    REPORT PREPARED ON     9 28 1985
C;////////////////////////////////////////////////////////////////////////
C;////////////////////////////////////////////////////////////////////////
C;//          3          3
C;//                              TRANSMIT                              /
C;//                              ROUTINE                                 /
C;//
C;//
C;////////////////////////////////////////////////////////////////////////
```

```
      SUBROUTINE TXMIT(I1,I2,J,K,IXB1,IXB2,IER1,IER2)
      COMMON/SMTRC/ MDATA(2,10,2,4),IACTR(2,10)
      COMMON/LIEN/MTB(2,10,2,7)
      DIMENSION L1B(15),L2B(15)
      ITCNT1=30 ----------------;CHAR TIMER LINE 1
      ITCNT2=30                ; "    "     "   2
      IER1=1
      IER2=1
      II1=I1
      II2=I2
      TAG=0
      IA=1
      IB=1
      L1=1
      L2=1
      IXBT1=IXB1
      IXBT2=IXB2
      CALL CINIT
C-  SET UP L1B & L2B
1      L1B(IA+1)=MTB(1,J,K,IB)
      CALL BYTS(L1B(IA+1),L1B(IA))
      L2B(IA+1)=MTB(2,J,K,IB)
      CALL BYTS(L2B(IA+1),L2B(IA))
      IA=IA+2
      IB=IB+1
      IF(IB.LT.8) GO TO 1
      IA=1
      IB=1
      IT1=L1B(1)
      IT2=L2B(1)
C-  READ STATUS WORD FROM 1600CH
7      CALL INSTAT(ICSTAT)
      IF(IXB1.EQ.IXBT1) GOTO 4                ;BR IF PREVIOUS BYTE NOT SENT
C-  LOAD NEXT BYTE LINE 1
      L1=L1+1
      IXBT1=IXB1
      IT1=L1B(L1)
4      IF(IXB2.EQ.IXBT2) GOTO 6                ;BR IF PREVIOUS BYTE NOT SENT
C-  LOAD NEXT BYTE LINE 2
      L2=L2+1
      IXBT2=IXB2
      IT2=L2B(L2)
C-  TRANSMITT LINES 1&2
6      IF(II1.NE.-1) GO TO 3                   ;NO DATA LINE 1
      TAG=TAG+1
      IF(ITEST(ICSTAT,3).NE.0) GOTO 61        ;BR IF READY TO XMIT
      ITCNT1=ITCNT1-1                          ;DEC TIME OUT
      GO TO 3
61       CALL OUTOTS(IT1,4)                   ;FIRST LINE
      IXB1=IXB1-1                             ;DEC BYTE CNTR
      ITCNT1=70                               ;RESET TIME OUT
3      IF(II2.NE.-1) GO TO 5                   ;NO DATA LINE 2
      IF(ITEST(ICSTAT,5).NE.0)GOTO 31          ;BR IF READY TO XMIT
      ITCNT2=ITCNT2-1                          ;DEC TIME OUT
      GO TO 5
31       CALL OUTOTS(IT2,16)                  ;XMIT SECOND LINE
      IXB2=IXB2-1                             ;DEC BYTE COUNTER
      ITCNT2=70                               ;RESET TIME OUT
5      IF((IXB1.LE.0).OR.(ITCNT1.LE.0)) II1=0   ;LINE 1 FINISHED
      IF((IXB2.LE.0).OR.(ITCNT2.LE.0)) II2=0   ;LINE 2 FINISHED
      IF(ITCNT1.EQ.0) IER1=1034               ;TIME OUT CODE
      IF(ITCNT2.EQ.0) IER2=1034
      IF((II1.EQ.0).AND.(II2.EQ.0)) GOTO 900
      GO TO 7
900      CALL WAIT(250,1,IER)                 ;WAIT FOR MODEM
```

```
      RETURN
      END
                REPORT PREPARED ON    9 28 1985
C ***************************************************************
C **                          DATAP                              **
C **                    DATA PROCESSOR                           **
C **          CONVERTS DATA FROM RAMPS INTO VOLUMES AND          **
C **          OCCUPANCIES.  BUILDS ISFILES.  BUILDS HIS0         **
C **          FILE.  CALLS HISTORY AND SYNC.                     **
C ***************************************************************
      COMMON IDAT(2,10,33),KT(3),IRF(2),IRDATA(4),ITB(2,10,10),
     +  IFAIL(2,10),IDD(2,10,31,3),INT(5)
      COMMON/ASU/ ISKIP(2)
       COMMON/SMTRC/ MDATA(2,10,2,4),IACTR(2,10),IFLAG(2,10),NFLAG
      DOUBLE PRECISION CMSG
      DIMENSION ITIME(3),JTIME(3),KTT(5),KD(3),CMSG(4),CM(13)
      CM(1)="P1"
      CM(2)="P2"
      CM(3)="P3"
      CM(4)="P4"
      CM(5)="S1"
      CM(6)="S2"
      CM(7)="S3"
      CM(8)=" Q"
      CM(9)="C1"
      CM(10)="C2"
      CM(11)=" R"
      CM(12)="F1"
      CM(13)="F2"
      CALL PASCR
      CALL SDATR
      CALL ERREC(ILCNT1,ILCNT2)
      IFCNT2=0
      IFCNT1=0
      DO 1 J=1,10
      IFCNT1=IDAT(1,J,33)+IFCNT1
      IFCNT2=IDAT(2,J,33)+IFCNT2
1       CONTINUE
      IF(IFCNT1.LT.5) GO TO 2
      ILCNT1=ILCNT1+1                    ;LINE  TIMER
      GOTO 3
2       IF(ILCNT1.GE.4) GOTO 15
      ILCNT1=0
3       IF(IFCNT2.LT.5) GO TO 5
      ILCNT2=ILCNT2+1
      GOTO 4
5       IF(ILCNT2.GE.4) GOTO 11
      ILCNT2=0
4       IF(ILCNT1.EQ.4) GOTO 6
 9       IF(ILCNT2.EQ.4) GOTO 7
      GOTO 9
6       CMSG(1)=3061203
      CMSG(2)="LINE #  "
      CMSG(3)="ONE"
      CMSG(4)=0
      CALL ERSTOR(CMSG)
      GOTO 8
7       CMSG(1)=3061203
      CMSG(2)="LINE #  "
      CMSG(3)="TWO"
      CMSG(4)=0
      CALL ERSTOR(CMSG)
      GOTO 9
15       CMSG(1)=3061211
      CMSG(2)="LINE #  "
      CMSG(3)="ONE"
```

```
15      CMSG(1)=3061211
        CMSG(2)="LINE #  "
        CMSG(3)="ONE"
        CMSG(4)=0
        CALL ERSTOR(CMSG)
        ILCNT1=0
        GOTO 3
11        CMSG(1)=3061211
        CMSG(2)="LINE #  "
        CMSG(3)="TWO"
        CMSG(4)=0
        CALL ERSTOR(CMSG)
        ILCNT2=0
        GOTO 4
9       CONTINUE
        DO 100 I=1,2
        DO 99 J=1,10
        IF(IDAT(I,J,33).NE.0)GOTO 96                ;NO COMM THIS TIME
        IDD(I,J,29,3)=0                               ;FLAG FOR ISMK
        IDAT(I,J,33)=1                               ;RESET COMM FLAG
        DO 90 K=2,26,+2                               ;EACH DETECTOR
        CALL BCDB(IDAT(I,J,K))                       ;CONVERT BCD TO BINARY
        IVOL=IDAT(I,J,K)-IDD(I,J,K,2)                ;DELTA VOL
        IF(IVOL.LT.0)IVOL=IVOL+10000                 ;CORRECT OVERFLOW
        IDD(I,J,K,3)=IDD(I,J,K,3)+IVOL                ;UPDATES INTERVAL BUFFER
        IDD(I,J,K,1)=IDD(I,J,K,1)+IVOL                ;UPDATES HISTORY BUFFER
        IDD(I,J,K,2)=IDAT(I,J,K)                    ;FOR NEXT TIME
        IOO=IDD(I,J,K+1,2)                            ;OLD OCC
        ION=IDAT(I,J,K+1)                            ;NEW OCC
        IF((IOO.GT.0).AND.(ION.LT.0))GOTO 80          ;OVERFLOW HAPPENED
        IOCC=ION-IOO                                  ;DELTA OCC
        IF(IOCC.LT.0)IOCC=0
89        IDD(I,J,K+1,3)=IDD(I,J,K+1,3)+IOCC          ;UPDATES INTERVAL BUFFER
        IDD(I,J,K+1,1)=IDD(I,J,K+1,1)+IOCC           ;UPDATES HISTORY BUFFER
        IDD(I,J,K+1,2)=IDAT(I,J,K+1)                  ;FOR NEXT TIME
90        CONTINUE
        IF(IDD(I,J,29,3).EQ.0)GOTO 96                 ;FIRST TIME THIS DROP?
        IDD(I,J,29,3)=0                               ;YES, RESET FLAG
        DO 95 K=2,27                                 ;ZERO INTERVAL AND HISTORY
        IDD(I,J,K,3)=0
95        IDD(I,J,K,1)=0
        IDD(I,J,29,2)=0                                ;CLEAR DETECTOR ERRORS
96        IDAT(I,J,32)=1                               ;REQUEST NEW DATA
98        IF(IDAT(I,J,29)-IDD(I,J,29,2)) 300,99,300
300         IDEO=IDD(I,J,29,2)          ;OLD DETECTOR ERRORS
        IDEN=IDAT(I,J,29)          ;NEW ERRORS
        ID=.NOT.(IDEO.AND.IDEN)
        IDER=(IDEO.AND.ID)
        IDEF=(IDEN.AND.ID)          ;FAILED DET
        MSK=1
        DO 310 K=1,13
        IF((IDER.AND.MSK).NE.0) GOTO 320          ;RESTORED
        IF((IDEF.AND.MSK).NE.0) GOTO 330 ,        ;JUST FAILED
310       MSK=MSK*2                                 ;SHIFT TO LEFT
        GO TO 350
320       CMSG(1)=3000111                                ;DET RESTORED
        GOTO 340
330       CMSG(1)=3000103                                ;DET FAILEXD
340       CMSG(3)=CM(K)                               ;GET DET NAME
        CMSG(2)="        "
        CMSG(4)=10*I+J-1+1000                         ;RAMP NO.
3       CALL ERSTOR(CMSG)                        3        ;SET ERROR
        GOTO 310
350       IDD(I,J,29,2)=IDEN                          ;SET NEW ERRORS
99      CONTINUE
100       CONTINUE
```

```
100         CONTINUE
102         CALL TIME(KT,IER)
            ISKIP(1)=ISKIP(1)-60
            INT(1)=INT(1)-60                          ;INTERVAL TIMER
            IF(INT(1).GT.0)GOTO 150                     ;INTERVAL DONE?
            INT(1)=INT(2)                              ;YES, RESET TIMER
            IDD(1,1,1,3)=INT(1)
            CALL DATE(KD,IER)
200            CALL WAIT(10,1,IER)
            CALL OPEN(1,"DATBASM",1,IER)
            IF(IER.NE.1)GOTO 200
205            CALL ISMK
105            CALL WAIT(10,1,IER)
            CALL DFILW("ISFILEM1",IER)                 ;DELETE OLD
            IF(IER.EQ.51)GOTO 105
119            CALL WAIT(10,1,IERR)
220            CALL RENAME("ISFILEM","ISFILEM1",IER)       ;CURRENT FILE =LAST
            IF(IER.EQ.51) GOTO 119
225            CALL RENAME("IST","ISFILEM",IER)        ;NEW CURRENT FILE
230            CALL WAIT(10,1,IER)
            CALL OPEN(1,"DATBASS",1,IER)
            IF(IER.NE.1)GOTO 230
235            CALL ISMK
            IF(ISKIP(1).GT.0)GOTO 110
            ISKIP(1)=ISKIP(2)
110            CALL WAIT(10,1,IER)
            CALL DFILW("ISFILES1",IER)
            IF(IER.EQ.51)GOTO 110
149            CALL WAIT(10,1,IERR)
            CALL RENAME("ISFILES","ISFILES1",IER)
            IF(IER.EQ.51) GO TO 149
255            CALL RENAME("IST","ISFILES",IER)
150            INT(3)=INT(3)-60
            IF(INT(3).GT.0)GOTO 10                    ;HISTORY TIMER
            INT(3)=INT(4)                               ;HISTORY DONE?
            CALL HISMK                                 ;YES, RESET TIMER
            OPEN 1,"HSMK0"
171             CALL APPEND(2,"HIS0",0,IER)
            IF(IER.NE.1) CALL WAIT(10,1,IERA)
            IF(IER.NE.1) GO TO 171
170            READ BINARY(1,END=160)I
            WRITE BINARY(2)I
            GOTO 170
160            CLOSE 2
            CLOSE 1
            CALL DFILW("HSMK0",IER)
C ***************************************************
C **                    CLKUP                      **
C **    READS BACKUP CLOCK AND COMPARES WITH SYSTEM **
C **    CLOCK.  IF SYSTEM CLOCK IS BEHIND IT IS SET **
C **    EQUAL TO THE BACKUP.  IF SYSTEM IS AHEAD THE**
C **    DATE IS ADVANCED ONE DAY AND THE CLOCK IS THEN**
C **    SET EQUAL TO THE BACKUP.                    **
C ***************************************************
10          CALL RCLK(IHOUR,IMINSEC)                 ;READ THE BACKUP CLOCK
            CALL WAIT(10,1,IERR)                       ;WAIT 10 MSEC
            CALL RCLK(ITIME(1),ITIME(3))               ;READ THE CLK AGAIN
            IF (IMINSEC.NE.ITIME(3))GOTO 10               ;STILL THE SAME?
            IF(IHOUR.NE.ITIME(1))GOTO 10
            CALL BYTS(ITIME(3),ITIME(2))               ;SEPARATE MIN/SEC
            CALL BYTS(ITIME(1),IDUM)                  ;SEPARATE HOUR
            CALL BCDB(ITIME(3))                        ;CONVERT BCD SEC TO BINARY
            CALL BCDB(ITIME(2))                        ;CONVERT BCD MIN TO BINARY
            CALL BCDB(ITIME(1))                        ;CONVERT BCD HOUR TO BINARY
            CALL TIME(JTIME,IER)                       ;GET CURRENT SYSTEM TIME
            IF(JTIME(3).LT.10)GOTO 155                ;TOO CLOSE TO MINUTE CHANGE
```

```
      CALL TIME(JTIME,IER)                                  ;GET CURRENT SYSTEM TIME
      IF(JTIME(3).LT.10)GOTO 155                            ;TOO CLOSE TO MINUTE CHANGE
      IF(JTIME(3).GT.50)GOTO 155                            ;  "    "    "    "      "
      IF(JTIME(1).GT.ITIME(1))GOTO 2040                     ;SYSTEM HOURS>BACKUP HOURS
      IF(JTIME(1).NE.ITIME(1))GOTO 2000                     ;SYSTEM HOURS NE BACKUP HOURS
      IF(JTIME(2).NE.ITIME(2))GOTO 2000                     ;SYSTEM MIN NE BACKUP MIN
      IF(ITIME(3)-JTIME(3).GT.2)GOTO 2000                     ;SYSTEM SEC NE BACKUP SEC
      GOTO 1002
2000      CMSG(1)=3100403
      CMSG(2)="         "
      CMSG(3)="         "
      CMSG(4)="         "
      CALL ERSTOR(CMSG)
2011      CALL RCLK(IHOUR,IMINSEC)                          ;READ THE BACKUP CLOCK
      CALL WAIT(10,1,IERR)                                  ;WAIT 10 MSEC
      CALL RCLK(ITIME(1),ITIME(3))                          ;READ THE CLK AGAIN
      IF (IMINSEC.NE.ITIME(3))GOTO 2011                   ;STILL THE SAME?
      IF(IHOUR.NE.ITIME(1))GOTO 2011                        ;YES
      CALL BYTS(ITIME(3),ITIME(2))                          ;SEPARATE MIN/SEC
      CALL BYTS(ITIME(1),IDUM)                            ;SEPARATE HOUR
      CALL BCDB(ITIME(3))                                   ;CONVERT BCD SEC TO BINAR
      CALL BCDB(ITIME(2))                                   ;CONVERT BCD MIN TO BINARY
      CALL BCDB(ITIME(1))                                   ;CONVERT BCD HOUR TO BINARY
      CALL STIME(ITIME,IER)
      KT(1)=ITIME(1)
      KT(2)=ITIME(2)
      KT(3)=ITIME(3)
      CMSG(1)=3100411
      CALL ERSTOR(CMSG)
2097      CALL WAIT(1,1,IER)
      CALL OPEN(5,"#TT01",1,IER)
      IF(IER.NE.1)GOTO 2097
      WRITE(5,2100)
      WRITE(5,2101)
      WRITE(5,2102)ITIME(1),ITIME(2),ITIME(3),KD(1),KD(2),KD(3)
      CLOSE 5
2100      FORMAT(1X,"POWER FAIL HAS OCCURED")
2101      FORMAT(1X,"SYSTEM TIME IS")
2102      FORMAT(1X,I2,":",I2,":",I2,4X,I2,"/",I2,"/",I4)
      GOTO 1001
2040      ITIME(1)=23
      ITIME(2)=59
      ITIME(3)=59
1002      CALL STIME(ITIME,IER)                                 ;SET TIME=23 59 59
      KT(1)=ITIME(1)
      KT(2)=ITIME(2)
      KT(3)=ITIME(3)
C ***************************************************************
C **              HISTORY                                        **
C **      UPDATES HISTORY FILES WHENEVER THE CURRENT               **
C **      DATE IS NEWER THAN THE DATE OF HIS0                       **
C **      FILE.  HIS31 IS DELETED AND A NEW HIS0                     **
C **      CREATED.                                                  **
C ***************************************************************
155       CALL DATE(KD,IER)
      OPEN 0,"HIS0"
      READ (0,END=71)IMON,IDAY,IYR
      CLOSE 0
      IF(KD(3)-IYR)1001,65,120
65      IF(KD(1)-IMON)1001,75,120
75      IF(KD(2)-IDAY)1001,1001,120
120       CALL FASCW                                          ;DAY HAS CHANGED
      CALL SDATM                                            ;CALL HISTORY
      CALL FCHAN("HISTORY.SV")
71      WRITE(0)KD(1),KD(2),KD(3)
      CLOSE 0
```

```
      CALL SDATW                                        ;CALL HISTORY
      CALL FCHAN("HISTORY.SV")
71      WRITE(0)KD(1),KD(2),KD(3)
      CLOSE 0
1001      CALL PASCW
      CALL SDATW
      CALL ERWRT(ILCNT1,ILCNT2)
      CALL FCHAN("COMMT.SV")
80      IOCC=(32767-100)+(32767+ION)+2
      GOTO 89
      END                    REPORT PREPARED ON    9 28 1985
      SUBROUTINE RMETR(VOL,OCC,V,I,J)
     COMMON/SMTRC/MDATA(2,10,2,4),IACTR(2,10),IFLAG(2,10)
      WRITE(10,666)IACTR(I,J)
666   FORMAT(4X,I2,2)
     IF((I.EQ.1).AND.(J.EQ.9)) GO TO 1000
     IF(VOL.NE.0.0) GO TO 1000
     MDATA(I,J,1,1) = 0
     MDATA(I,J,2,1) = 0
     WRITE(10,2345)
2345  FORMAT(' NO COMMUN.')
     GO TO 777
1000  MDATA(I,J,1,1) = 1
      MDATA(I,J,2,1) = 1
      IF(IACTR(I,J).EQ.0) GO TO 702
      MDATA(I,J,1,3) = -464
      MDATA(I,J,2,3) = -462
      GO TO 703
702   MDATA(I,J,1,3) = -349
      MDATA(I,J,2,3)=-333
703   VOL = VOL/54.6
      IF(VOL.LT.22.0)GOTO 19
      WRITE(10,6)
 6    FORMAT(' 6SEC METER')
      IF(IFLAG(I,J).EQ.3) GOTO 888
      IFLAG(I,J)=3
      MDATA(I,J,1,4) = 96
      MDATA(I,J,2,4) = 72
      MDATA(I,J,1,2) = 0
      MDATA(I,J,2,2) = 0
      GO TO 777
 19   IF (V.LT.40.0) GOTO 21
25    WRITE(10,3)
3     FORMAT(' GREEN')
      IF(IFLAG(I,J).EQ.1) GOTO 888
      IFLAG(I,J)=1
      MDATA(I,J,1,4) = 0
      MDATA(I,J,2,4) = 576
      MDATA(I,J,1,2) = 0
      MDATA(I,J,2,2) = 0
      GO TO 777
 21   IF(OCC.GT.8.0) GOTO 37
      GO TO 25
 37   IF(V.GT.35.0) GOTO 51
15    MDATA(I,J,2,2) = 1
      WRITE(10,4)
4     FORMAT(' CLOSE RAMP')
      IF(IFLAG(I,J).EQ.2) GOTO 888
      IFLAG(I,J)=2
      MDATA(I,J,1,4) = 288
      MDATA(I,J,2,4) = 0
      MDATA(I,J,1,2) = 0
      GO TO 777
51    ICLOSE = MDATA(I,J,2,2)
      IF(ICLOSE.EQ.1) GO TO 15
      MDATA(I,J,1,2) = MDATA(I,J,1,2) + 1
```

```
      IF(ICLOSE.EQ.1) GO TO 15
      MDATA(I,J,1,2) = MDATA(I,J,1,2) + 1
      ICOUNT = MDATA(I,J,1,2)
      IF(ICOUNT.GE.5) GO TO 15
      GO TO 25
888   MDATA(I,J,1,1)=0
      MDATA(I,J,2,1)=0
777   RETURN
       EN                    REPORT PREPARED ON    9 28 1985
C ***************************************************
C **                        HISTORY                    **
C **        ONCE EACH DAY THE HISTORY FILES ARE        **
C **        MOVED AND THE CLOCK SYNC CALLED            **
C ***************************************************
      COMMON IDAT(2,10,33),KT(3),IRF(2),IRDATA(4),ITB(2,10,10),
     +  IFAIL(2,10),IDD(2,10,31,3),INT(5)
      COMMON/ASU/ ISKIP(2)
      COMMON/SNTRC/ MDATA(2,10,2,4),IACTR(2,10),IFLAG(2,10),NFLAG
      DIMENSION KD(3),ICLKDTA(11)
      CALL PASCR
      CALL SCOMR
      CALL SDATR
      CALL DATE(KD,IER)
      CALL DIR("ARIZ",IER)
      IF(IER.EQ.1)GOTO 10
      WRITE(10,11)
11      FORMAT(" CAN NOT FIND DP0:ARIZ.  MADE HIS1 IN  RP.")
10      CALL DFILW("HIS31",IER)
      CALL RENAME("HIS30","HIS31",IER)
      CALL RENAME("HIS29","HIS30",IER)
      CALL RENAME("HIS28","HIS29",IER)
      CALL RENAME("HIS27","HIS28",IER)
      CALL RENAME("HIS26","HIS27",IER)
      CALL RENAME("HIS25","HIS26",IER)
      CALL RENAME("HIS24","HIS25",IER)
      CALL RENAME("HIS23","HIS24",IER)
      CALL RENAME("HIS22","HIS23",IER)
      CALL RENAME("HIS21","HIS22",IER)
      CALL RENAME("HIS20","HIS21",IER)
      CALL RENAME("HIS19","HIS20",IER)
      CALL RENAME("HIS18","HIS19",IER)
      CALL RENAME("HIS17","HIS18",IER)
      CALL RENAME("HIS16","HIS17",IER)
      CALL RENAME("HIS15","HIS16",IER)
      CALL RENAME("HIS14","HIS15",IER)
      CALL RENAME("HIS13","HIS14",IER)
      CALL RENAME("HIS12","HIS13",IER)
      CALL RENAME("HIS11","HIS12",IER)
      CALL RENAME("HIS10","HIS11",IER)
      CALL RENAME("HIS9","HIS10",IER)
      CALL RENAME("HIS8","HIS9",IER)
      CALL RENAME("HIS7","HIS8",IER)
      CALL RENAME("HIS6","HIS7",IER)
      CALL RENAME("HIS5","HIS6",IER)
      CALL RENAME("HIS4","HIS5",IER)
      CALL RENAME("HIS3","HIS4",IER)
      CALL RENAME("HIS2","HIS3",IER)
      CALL RENAME("HIS1","HIS2",IER)
      OPEN 0,"HIS1"
      OPEN 1,"RP:HIS0"
60      READ BINARY(1,END=70)I
      WRITE BINARY(0)I
      GOTO 60
70      CLOSE 0
      CLOSE 1
      CALL DIR("DP0",IER)
```

```
      CLOSE 1
      CALL DIR("RP",IER)
      CALL DFILW("HIS0",IER)
      OPEN 0,"HIS0"
      WRITE(0)KD(1),KD(2),KD(3)
      CLOSE 0
C ***************************************************************
C **                                                           **
C **       ONCE EACH DAY AFTER HISTORY IS UPDATED,             **
C **       SECONDS,MINUTES,HOURS,DAYS AND LONG                 **
C **       COUNTER ARE SYNCRONIZED AT ALL CONTROLLERS.         **
C ***************************************************************
      INT(5)=INT(5)+1                          ;UPDATE WEEK DAY
      IF(INT(5).GT.6)INT(5)=0
      CALL TIME(KT,IER)
      ICLKDTA(2)=-497
      CALL BBCD(KT(3))
      ICLKDTA(3)=KT(3)+14                      ;SECONDS
      ICLKDTA(4)=-76
      ICLKDTA(5)=0                             ;LONG COUNT
      ICLKDTA(6)=-481
      CALL BBCD(KT(2))
      ICLKDTA(7)=KT(2)                         ;MINUTES
      ICLKDTA(8)=-465
      CALL BBCD(KT(1))
      ICLKDTA(9)=KT(1)                         ;HOURS
      ICLKDTA(10)=-449
      ICLKDTA(11)=INT(5)                       ;DAYS
C ***************************************************************
C **                        CKSYNC                             **
C **       SETS UP FIVE CLOCK SYNC MESSAGES ONE AT A TIME      **
C **       ON EACH COMM LINE                                   **
C ***************************************************************
      ICNT=0
      IC=1
      IM=5
      DO 21 I=1,2                              ;DO BOTH LINES
30      DO 22 J1=IC,IM
      ITB(I,J1,1)=-243                         ;ID& BYTES, 255 & 13
      ICMD=4096                                ;COMMAND
      LA=ICLKDTA(12-2*(6-J1))                  ;ADDRESS
      CALL BYTS(LA,MA)
      ITB(I,J1,2)=ICMD+LA
      LD=ICLKDTA(13-2*(6-J1))                  ;DATA
      CALL BYTS(LD,MD)
      CALL BYTP(ITB(I,J1,3),MA,LD)
      LAN=255-LA                               ;COMPLIMENT LSBYTE ADDRESS
      CALL BYTP(ITB(I,J1,4),MD,LAN)
      LDN=255-LD
      MAN=255-MA
      CALL BYTP(ITB(I,J1,5),MAN,LDN)
      MDN=255-MD
      CALL BYTP(ITB(I,J1,6),MDN,24)
      ITB(I,J1,8)=0                            ;NO RESPONSE REQUIRED
      ITB(I,J1,9)=13                           ;13 BYTES
      ITB(I,J1,7)=1280                         ;MSBYTE CHECK SUM
      ITB(I,J1,10)=-1                          ;MESSAGE READY FLAG
22      CONTINUE
      ICNT=ICNT+1
      IF(ICNT.GE.2) GOTO 31
      IC=6
      IM=10
      GO TO 30
31        ICNT=0
      IC=1
```

```
      IMC=1
      IM=5
21    CONTINUE
      CALL PASCW
      CALL SCOMW
      CALL SOATW
      CALL FCHAN("COMMT.SV")
      END
                REPORT PREPARED ON     9 28 1985
C ***************************************************************
C **                          PASCR                              **
C ***************************************************************
      SUBROUTINE PASCR
      COMMON IDAT(2,10,33),KT(3),IRF(2),IRDATA(4),ITB(2,10,10),
     +  IFAIL(2,10),IDD(2,10,31,3),INT(5)
      COMMON/ASU/ ISKIP(2)
      COMMON/SMTRC/ MDATA(2,10,2,4),IACTR(2,10),IFLAG(2,10),NFLAG
      OPEN 0,"PASC",LEN=1326,ATT="C"                    ;COMMON FILE
10      READ BINARY(0)(IDAT(I),I=1,663)
      READ BINARY(0)(ISKIP(I),I=1,2)
      READ BINARY(0)(MDATA(I),I=1,201)
      CLOSE 0
      RETURN
      END
                REPORT PREPARED ON     9 28 1985
C ***************************************************************
C **                          PASCW                              **
C ***************************************************************
      SUBROUTINE PASCW
      COMMON IDAT(2,10,33),KT(3),IRF(2),IRDATA(4),ITB(2,10,10),
     +  IFAIL(2,10),IDD(2,10,31,3),INT(5)
      COMMON/ASU/ ISKIP(2)
      COMMON/SMTRC/ MDATA(2,10,2,4),IACTR(2,10),IFLAG(2,10),NFLAG
      OPEN 0,"PASC",LEN=1326,ATT="C"                    ;COMMON FILE
      WRITE BINARY(0)(IDAT(I),I=1,663)
      WRITE BINARY(0)(ISKIP(I),I=1,2)
       WRITE BINARY(0)(MDATA(I),I=1,201)
      CLOSE 0
      RETURN
      END
       REPORT PREPARED ON     9 28 1985
      SUBROUTINE ISMK
      COMMON IDAT(2,10,33),KT(3),IRF(2),IRDATA(4),ITB(2,10,10),
     +  IFAIL(2,10),IDD(2,10,31,3),INT(5)
      COMMON/ASU/ ISKIP(2)
      COMMON/SMTRC/ MDATA(2,10,2,4),IACTR(2,10),IFLAG(2,10),NFLAG
     DIMENSION ITIM(3),IDATE(3),IDP(4),ISP(3),IP(4),IS(3),KD(3)
C
      CALL DATE(KD,IER)
      READ FREE(1)INUM
 1    FORMAT(I6)
      OPEN 2, "IST"
      N=1
      DO 201 M=1,INUM
      READ(1,7)J1,J2,J3,J4
 7    FORMAT(S8,2I4,I7)
      J3=J4-1000
      I=J3/10
      J=J3-10*I+1
      J2=ITEST(IDAT(I,J,31),3)
      WRITE(2)KD(1),KD(2),KD(3),KT(1),KT(2),KT(3),IDD(1,1,1,3),J2,J4
      K=IDAT(I,J,29)
      DO 200 L=1,13
      IF(IDD(I,J,28,3).NE.0) GOTO 205
       L1=ITEST(K,13-L)
```

```
      IF(IDD(I,J,28,3).NE.0) GOTO 205
      L1=ITEST(K,13-L)
      IF(L1.EQ.0) GOTO 200
205   IDD(I,J,2*L,3)=-1
      IDD(I,J,2*L+1,3)=-1
200    CONTINUE
      IDD(I,J,28,3)=1
      DO 210 M1=2,26,+2
210   WRITE(2)IDD(I,J,M1,3)
      DO 220 M1=3,27,+2
220   WRITE(2) IDD(I,J,M1,3)
      CALL BCDB(IDAT(I,J,28))
      WRITE(2) IDAT(I,J,28)
      IF(ISKIP(1).GT.0) GOTO 1000
      IF(NFLAG.EQ.1) GOTO 1000
     IF(N.NE.1) GOTO 50
      WRITE(10,6)
      WRITE(10,8)
    6  FORMAT(' RAMP',6X,'DATE',8X,'TIME',6X,
     &   'VOL',4X,'OCC   SPEED',2X,'STATUS  RMS')
    8  FORMAT('  NO',29X,'VPH',4X,'(%)',4X,'MPH')
50     CALL DATE(IDATE,IER)
      ITIM(1)=KT(1)
      ITIM(2)=KT(2)
      ITIM(3)=KT(3)
      ISI=IDD(1,1,1,3)
      IP(1)=IDD(I,J,26,3)
      IS(1)=IDD(I,J,18,3)
      IOP(1)=IDD(I,J,27,3)
      ISP(1)=IDD(I,J,19,3)
      PA=IP(1)
      SA=IS(1)
      V1=AMAX1(PA,SA,0.0)
      IF(V1.EQ.0.0) GOTO 113
      VOL=(V1/ISI)*3600*0.91
     GO TO 115
  113 VOL=0.
  115  OPA=IOP(1)
      OSA=ISP(1)
      OC=AMAX1(OPA,OSA,0.0)
      IF(OC.EQ.0.0) GOTO 119
     GO TO 121
  119 OC=0.
  121 AMX=30.*ISI
      OCC=(OC/AMX)*100
      IF(V1.EQ.0.0) V=0.
      IF(V1.EQ.0.0) GO TO 99
      TV=(OC/V1)/30.
      DT=22.
      V=(DT/TV)*(3600./5280.)
  100 CONTINUE
99     WRITE(10,2) J4,IDATE,ITIM,VOL,OCC,V
    2  FORMAT(I5,2I4,I5,I5,2I3,F8.0,F7.0,F7.0,2)
      CALL RMETR(VOL,OCC,V,I,J)
      IF(N.NE.INUM) GOTO 1000
      WRITE(10,4)
    4  FORMAT(5X,' ')
1000   DO 202 L=2,27
  202  IDD(I,J,L,3)=0
      N=N+1
  201  CONTINUE
      IDD(1,1,1,3)=INT(1)
      CLOSE 2
      CLOSE 1
      RETURN
```

```
201   CONTINUE
      IDD(1,1,1,3)=INT(1)
      CLOSE 2
      CLOSE 1
      RETURN
      END
```