

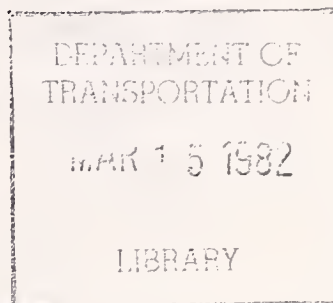
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# **A Computer Program (HEVSIM) for Heavy Duty Vehicle Fuel Economy and Performance Simulation**

## **Volume 2: Users' Manual**

**Richard E. Buck**



**Transportation Systems Center  
Cambridge MA 02142**

**September 1981  
Final Report**

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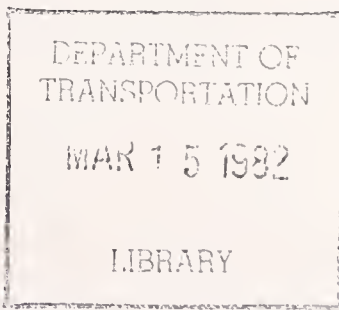
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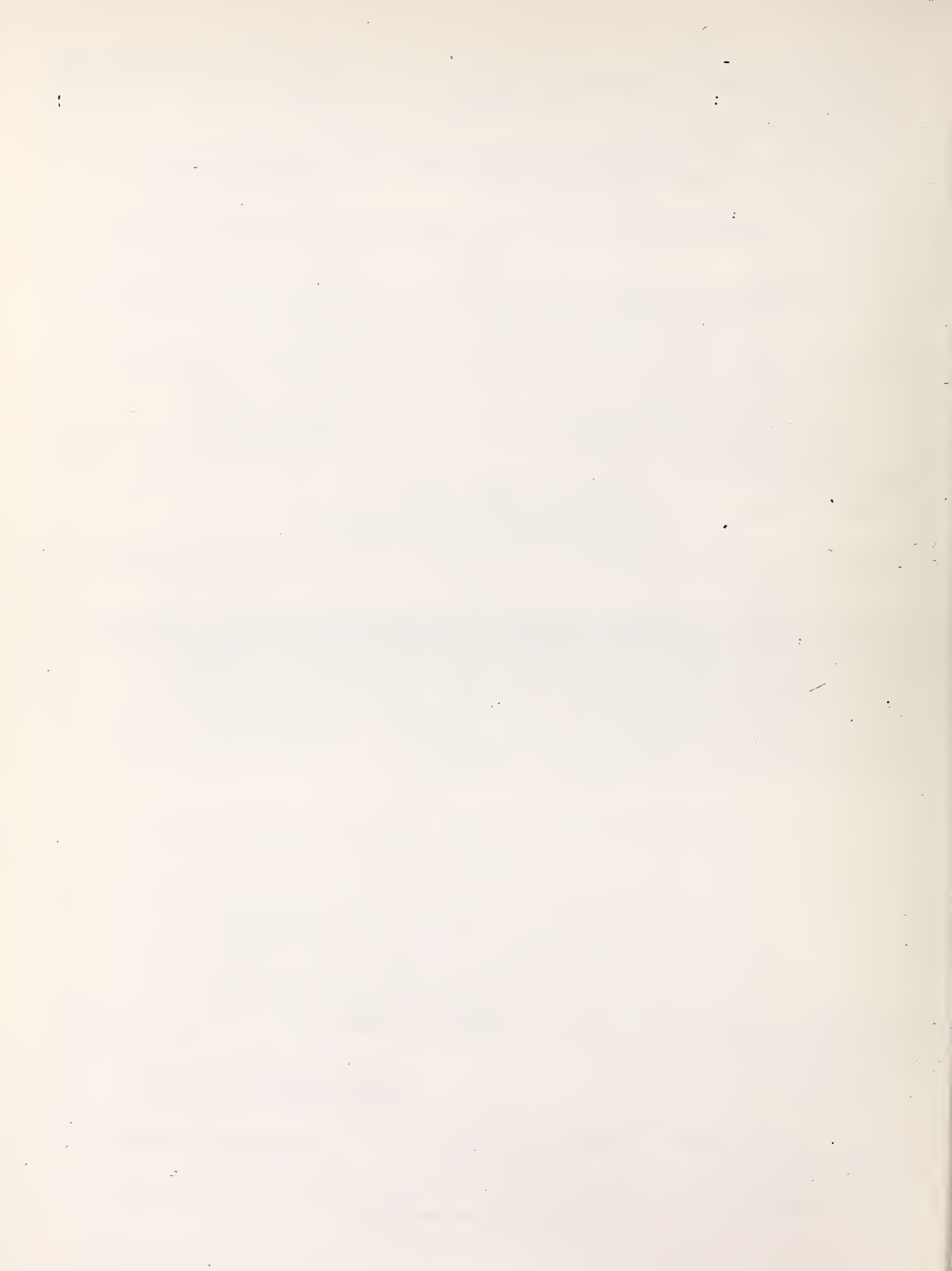
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| 16. Abstract<br><br>This report presents a description of a vehicle simulation program, HEVSIM, which can determine the fuel economy and performance of a specified motor vehicle over a defined route as it executes a given driving schedule. Vehicle input accommodated by HEVSIM includes accessories, engine, rear axle, converter, transmission, tires, aerodynamic drag coefficient, and shift logic. The report consists of three volumes. Volume I presents a description of the numerical approach and equations, Volume II is a user's manual, and Volume III contains the program listings. |  |                                                      |                                                                                                                                                       |                                                                                          |           |
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## PREFACE

Volume II is the second volume of a three volume document describing the computer program HEVSIM for use with automobiles and light trucks. This volume is a user's manual describing how to prepare data input and execute the program.

A strong effort has been made to prepare this manual from a user's viewpoint. Sample cases have been included to illustrate the various simulation methods available, and the most frequently used HEVSIM options.

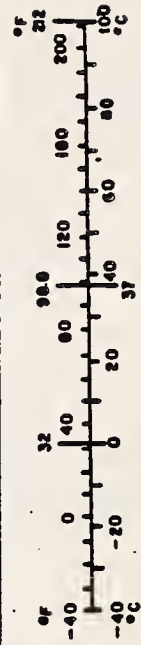
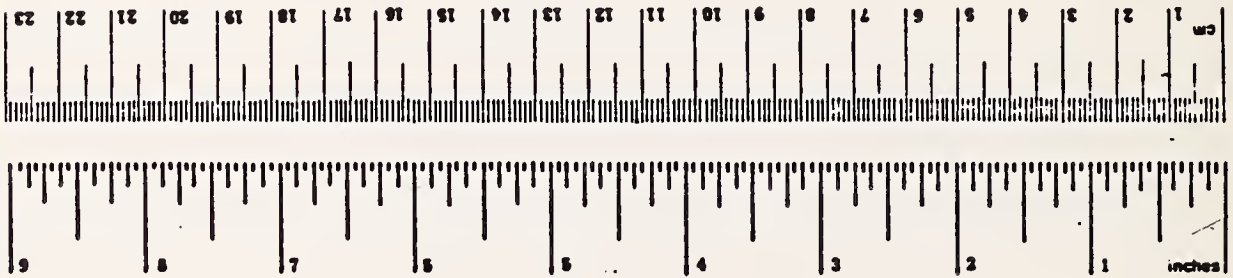
# METRIC CONVERSION FACTORS

## Approximate Conversions to Metric Measures

| Symbol                     | When You Know          | Multiply by                | To Find             | Symbol          |
|----------------------------|------------------------|----------------------------|---------------------|-----------------|
| <b>LENGTH</b>              |                        |                            |                     |                 |
| in                         | inches                 | 2.5                        | centimeters         | cm              |
| ft                         | feet                   | 30                         | centimeters         | cm              |
| yd                         | yards                  | 0.9                        | meters              | m               |
| mi                         | miles                  | 1.6                        | kilometers          | km              |
| <b>AREA</b>                |                        |                            |                     |                 |
| in <sup>2</sup>            | square inches          | 0.5                        | square centimeters  | cm <sup>2</sup> |
| ft <sup>2</sup>            | square feet            | 0.09                       | square meters       | m <sup>2</sup>  |
| yd <sup>2</sup>            | square yards           | 0.8                        | square meters       | m <sup>2</sup>  |
| mi <sup>2</sup>            | square miles           | 2.6                        | square kilometers   | km <sup>2</sup> |
| acres                      | acres                  | 0.4                        | hectares            | ha              |
| <b>MASS (weight)</b>       |                        |                            |                     |                 |
| oz                         | ounces                 | 28                         | grams               | g               |
| lb                         | pounds                 | 0.45                       | kilograms           | kg              |
|                            | short tons (2000 lb)   | 0.9                        | tonnes              | t               |
| <b>VOLUME</b>              |                        |                            |                     |                 |
| tsp                        | teaspoons              | 5                          | milliliters         | ml              |
| Tbsp                       | tablespoons            | 15                         | milliliters         | ml              |
| fl oz                      | fluid ounces           | 30                         | milliliters         | ml              |
| c                          | cups                   | 0.24                       | liters              | l               |
| pt                         | pints                  | 0.47                       | liters              | l               |
| qt                         | quarts                 | 0.95                       | liters              | l               |
| gal                        | gallons                | 3.8                        | liters              | l               |
| ft <sup>3</sup>            | cubic feet             | 0.03                       | cubic meters        | m <sup>3</sup>  |
| yd <sup>3</sup>            | cubic yards            | 0.76                       | cubic meters        | m <sup>3</sup>  |
| <b>TEMPERATURE (exact)</b> |                        |                            |                     |                 |
| °F                         | Fahrenheit temperature | 5/9 (after subtracting 32) | Celsius temperature | °C              |

## Approximate Conversions from Metric Measures

| Symbol                     | When You Know                     | Multiply by       | To Find                | Symbol          |
|----------------------------|-----------------------------------|-------------------|------------------------|-----------------|
| <b>LENGTH</b>              |                                   |                   |                        |                 |
| mm                         | millimeters                       | 0.04              | inches                 | in              |
| cm                         | centimeters                       | 0.4               | inches                 | in              |
| m                          | meters                            | 3.3               | feet                   | ft              |
| m                          | meters                            | 1.1               | yards                  | yd              |
| km                         | kilometers                        | 0.6               | miles                  | mi              |
| <b>AREA</b>                |                                   |                   |                        |                 |
| cm <sup>2</sup>            | square centimeters                | 0.16              | square inches          | in <sup>2</sup> |
| m <sup>2</sup>             | square meters                     | 1.2               | square yards           | yd <sup>2</sup> |
| km <sup>2</sup>            | square kilometers                 | 0.4               | square miles           | mi <sup>2</sup> |
| ha                         | hectares (10,000 m <sup>2</sup> ) | 2.6               | acres                  | acres           |
| <b>MASS (weight)</b>       |                                   |                   |                        |                 |
| g                          | grams                             | 0.035             | ounces                 | oz              |
| kg                         | kilograms                         | 2.2               | pounds                 | lb              |
| t                          | tonnes (1000 kg)                  | 1.1               | short tons             | short tons      |
| <b>VOLUME</b>              |                                   |                   |                        |                 |
| ml                         | milliliters                       | 0.03              | fluid ounces           | fl oz           |
| l                          | liters                            | 2.1               | pints                  | pt              |
| l                          | liters                            | 1.05              | quarts                 | qt              |
| l                          | liters                            | 0.26              | gallons                | gal             |
| m <sup>3</sup>             | cubic meters                      | 35                | cubic feet             | ft <sup>3</sup> |
| m <sup>3</sup>             | cubic meters                      | 1.3               | cubic yards            | yd <sup>3</sup> |
| <b>TEMPERATURE (exact)</b> |                                   |                   |                        |                 |
| °C                         | Celsius temperature               | 9/5 (then add 32) | Fahrenheit temperature | °F              |



\*1 in a 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price \$2.25, SD Catalog No. C11.10 286.

## CONTENTS

| <u>Section</u> |                                                | <u>Page</u> |
|----------------|------------------------------------------------|-------------|
| 1              | INTRODUCTION.....                              | 1           |
| 2              | PROGRAM EXECUTION.....                         | 3           |
| 3              | SAMPLE SIMULATIONS.....                        | 15          |
| 3.1            | Interactive Simulation.....                    | 15          |
| 3.1.1          | Input.....                                     | 16          |
| 3.1.2          | Output.....                                    | 16          |
| 3.1.3          | Continuation of Interactive<br>Simulation..... | 22          |
| 3.1.4          | Dump of Parts List.....                        | 22          |
| 3.2            | Batch File Submission Attached Simulation.     | 26          |
| 3.3            | Batch File Submission Detached Simulation.     | 26          |
| 3.4            | Batch Card File Submission.....                | 30          |
| 4              | INPUT DATA FORMAT.....                         | 33          |
| 4.1            | Data Format Sheet Descriptions.....            | 33          |
| 4.2            | Data Sheets.....                               | 37          |
| 5              | HEVSIM AND PARTS GENERATION.....               | 67          |
| 5.1            | Generate Core Image File.....                  | 67          |
| 5.2            | Generate Parts File.....                       | 67          |

## ILLUSTRATIONS

| <u>Figure</u> |                                                                    | <u>Page</u> |
|---------------|--------------------------------------------------------------------|-------------|
| 1             | Operational Modes and Simulation Methods Diagram.                  | 4           |
| 2             | Interactive Simulation Terminal Session.....                       | 17          |
| 3             | Vehicle Performance Simulation.....                                | 20          |
| 4             | Interactive Terminal Session Continuation.....                     | 23          |
| 5             | Parts Listing at Terminal.....                                     | 24          |
| 6             | Parts Data Directory.....                                          | 25          |
| 7             | Sample HEVSIM Control File for Batch Attached<br>Simulation.....   | 27          |
| 8             | Sample Interactive Attached Simulation Using<br>Batch.....         | 28          |
| 9             | Sample HEVSIM Control File for Detached<br>Simulation.....         | 29          |
| 10            | Sample HEVSIM Batch Test. SEV File for Detached<br>Simulation..... | 29          |
| 11            | Punched Card Listing to Execute HEVSIM.....                        | 31          |
| 12            | Summary Output from Punched Card Batch<br>Simulation.....          | 32          |
| 13            | Punched Card Listing to Generate HEVSIM Core<br>Image File.....    | 68          |
| 14            | Punched Card Listing to Generate Parts Data File.                  | 69          |

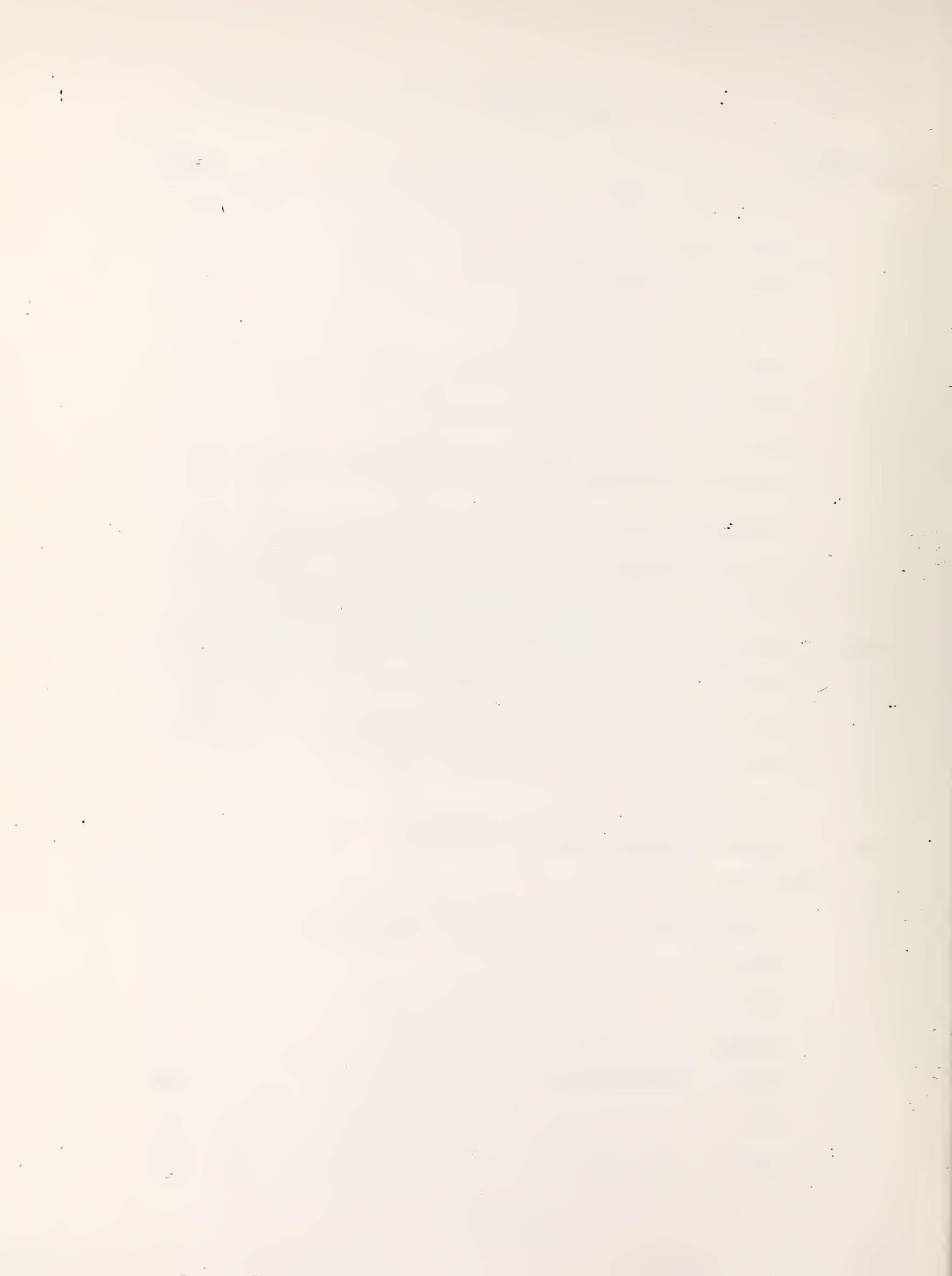
## TABLES

| <u>Table</u> |                                                    | <u>Page</u> |
|--------------|----------------------------------------------------|-------------|
| 1            | Command Names Applicable to Each Operational Mode. | 5           |



DATA SHEETS

| <u>Data Sheet</u> |                             | <u>Page</u> |
|-------------------|-----------------------------|-------------|
| 1                 | ACCESSORY.....              | 38          |
| 2                 | REAR AXLE (2 sheets).....   | 39          |
| 3                 | ENGINE (2 sheets).....      | 41          |
| 4                 | FULL CONVERTER.....         | 43          |
| 5                 | GEAR.....                   | 44          |
| 6                 | SPEED RATIO CONVERTER.....  | 45          |
| 7                 | TIRE.....                   | 46          |
| 8                 | TRANSMISSION.....           | 47          |
| 9                 | VEHICLE.....                | 48          |
| 10                | DRIVING SCHEDULE.....       | 49          |
| 11                | ROUTE.....                  | 51          |
| 12                | SHIFT LOGIC (2 sheets)..... | 52          |
| 13                | DEBUG.....                  | 54          |
| 14                | DROP.....                   | 55          |
| 15                | DUMP.....                   | 56          |
| 16                | LIMIT PRINT.....            | 57          |
| 17                | LOCKUP CONVERTER GEAR.....  | 58          |
| 18                | MODIFY.....                 | 59          |
| 19                | PRINT UNITS.....            | 60          |
| 20                | REMAP.....                  | 61          |
| 21                | SIMULATE.....               | 62          |
| 22                | TITLE.....                  | 63          |
| 23                | UNLOCK CONVERTER GEAR.....  | 64          |
| 24                | USE.....                    | 65          |
| 25                | ZERO.....                   | 66          |



## 1. INTRODUCTION

This manual describes the HEVSIM operating commands and methods available to execute a program. The methods include interactive operation, batch processing from a terminal, and batch processing using a card deck. Sample runs are presented for each method. The input data format is described and sample output data are listed.

The preference for one method of operation over another depends primarily on user convenience. For example, interactive operation typically requires more connect time at a terminal than batch processing, but offers the advantage of maximum convenience when modifying components to determine influences on fuel economy. Batch processing requires a HEVSIM control file (made up of HEVSIM operating commands and parts) which must be created before submitting the run, but offers the advantage of executing during low rate off-peak hours. The use of cards, rather than a terminal, may be more convenient for preparing a HEVSIM control file due to the enumerated column headings, especially for a user not accustomed to terminal operation. Submitting cards for execution of HEVSIM, however, usually becomes unnecessarily cumbersome once a HEVSIM control file is in a user's disk area. More conveniently, the user may submit the HEVSIM control file from a terminal. Once a HEVSIM control file is prepared, many variations may be run conveniently from the terminal.

The program is most efficient when a large scenario is being executed in such a way as to optimize data retrieval from the disk. For example, a series of \*USE commands could be used to "construct" the vehicle to be used initially. Then a sequence of alternating \*MODIFY and \*SIMULATE commands would allow the user to try ten different vehicle weights with five different rear axle ratios and so forth. This would require no further disk accesses and would accomplish some fifty trials. At that point a different driving schedule could be retrieved from the disk and

the process repeated for another fifty trials. If, on the other hand, the user alternated driving schedules for each \*MODIFY command, the program would use a great deal more time to retrieve data from the disk and therefore cost more to run.

The default time step of .05 seconds may be overridden with a \*MODIFY command to perform the same run with a longer time step in order to cut cost. (Note: Due to certain tolerances built into the program, a step of less than .05 is not recommended.)



## 2. PROGRAM EXECUTION

A description of HEVSIM execution through interactive and non-interactive operational modes will be provided in this section. Figure 1 shows the four types of simulation methods available and their association with either operational mode. The interactive mode permits the user three possible simulation methods: 1) interactive simulation in which the user is queried or directs HEVSIM, 2) attached simulation through execution of a HEVSIM control file with monitoring at the terminal; and, 3) detached simulation through submission of a batch control file. The first two methods permit switching control from one method to the other after completion of each run.

The non-interactive mode permits the submission of punched card batch control files. The card deck contains a HEVSIM control file and instructions to execute HEVSIM. The method functions in a manner similar to detached simulation, except for the use of cards instead of interactive terminal commands. In both the interactive and non-interactive modes it is assumed that HEVSIM and the required parts to be accessed are already on disk.

### SIMULATION COMMAND STRUCTURE

HEVSIM commands for both interactive and non-interactive operation will be listed and described in this section. There are many commands which have a common name and produce the same result for interactive and non-interactive operation. In non-interactive operation, however, the command names must be prefixed with an asterisk (\*) to complete the command. The applicable command names that apply to each operational mode are listed in Table 1.

The function of each command name will be described next, along with any specific mode. Hereafter, the interactive operational mode will be referred to as IA, and the non-interactive mode as NIA. By HEVSIM definition, a command name is an actual

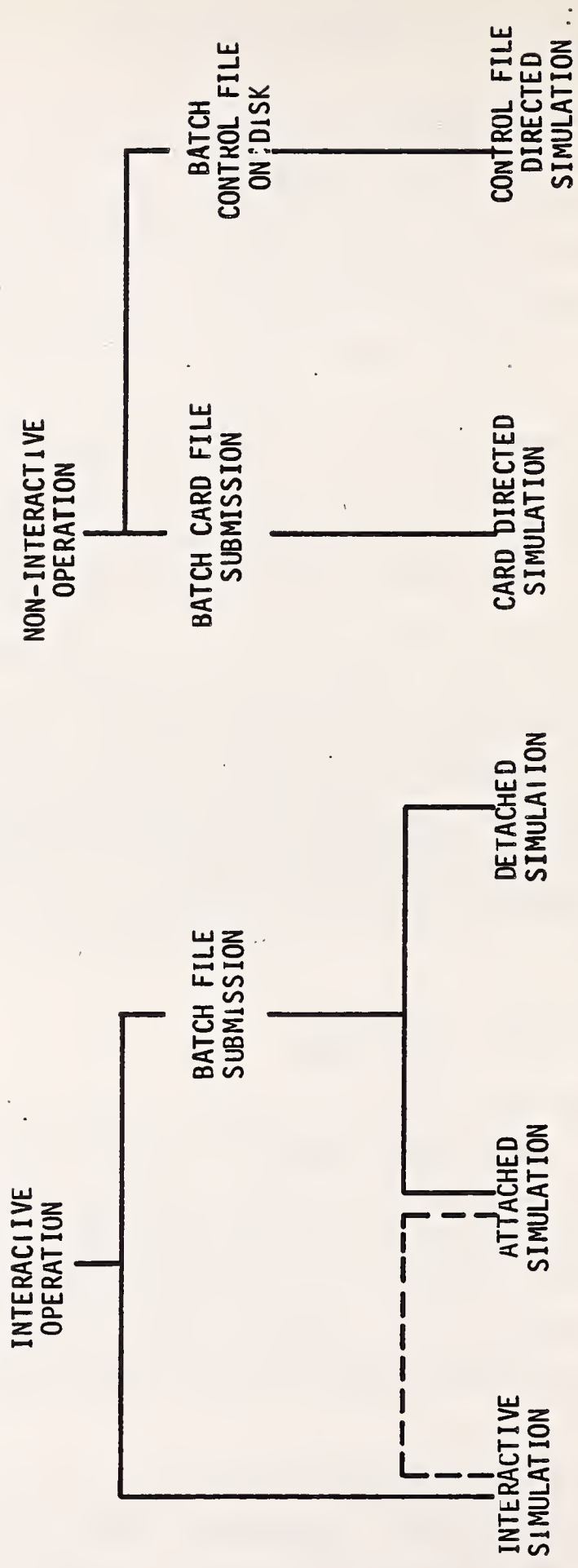


FIGURE 1. OPERATIONAL MODES AND SIMULATION METHODS DIAGRAM

TABLE 1. COMMAND NAMES APPLICABLE TO EACH OPERATIONAL MODE

| <u>COMMAND</u> | <u>INTERACTIVE</u> | <u>NON-INTERACTIVE</u> |
|----------------|--------------------|------------------------|
| ASK            | X                  |                        |
| BATCH          | X                  |                        |
| CONTINUE       | X                  |                        |
| DEBUG          | X                  | X                      |
| DELETE         | X                  | X                      |
| DIALOG         | X                  |                        |
| DIR            | X                  |                        |
| DUMP           | X                  | X                      |
| INDIRECT @     |                    | X                      |
| STOP (EXIT)    | X                  |                        |
| LIMIT PRINT    | X                  | X                      |
| MODIFY         | X                  | X                      |
| REMAP          |                    | X                      |
| RESET          | X                  |                        |
| SIMULATE       | X                  | X                      |
| STATUS         | X                  |                        |
| TITLE          | X                  | X                      |
| TTY (LPT)      | X                  |                        |
| LOCK (UNLOCK)  | X                  | X                      |
| UNIT           |                    | X                      |
| USE            | X                  | X                      |
| ZERO           | X                  | X                      |

command in the IA mode, and an asterisk immediately followed by a command name (plus specified options if any) is a command in NIA mode. During simulation in the IA mode commands are typed on the terminal, while for the NIA mode commands are card punched starting in the first column with an asterisk. In the command descriptions below, the abbreviation (cr) indicates the carriage return in IA mode. All the NIA mode command formats are specified exactly by the data format sheets in section 4.2. These descriptions will not be repeated here.

The ASK command puts HEVSIM into ASK mode. While in ASK mode, HEVSIM will cycle through all the part types, querying the user as to the particular part to use. When all parts are loaded, HEVSIM gives the user the option of going directly to the simulation or not, or going into DIALOG mode, by asking "SIMULATE (Y/N/D)". If the user elects not to simulate (N), HEVSIM will ask if various modifications are desired. When this is completed to the user's satisfaction, the user is again offered the choice. The user may cycle through the parts and modifications until the simulation parameters are as he wishes. Then he can go to the simulation (Y) or into the DIALOG (D) mode.

Use of the INDIRECT (@) command allows the user to enter HEVSIM commands from a pre-made HEVSIM control file on disk. This option is especially useful for production running. The command is used in the following fashion:

```
"@ DEV: FILE. EXT[P,PN]" (cr)
```

where DEV:FILE.EXT[P,PN] is the general file descriptor of the batch control file. The makeup of the batch control file follows exactly the batch commands defined in this manual.

The CONTINUE command is used only if an error occurs while inputting a HEVSIM batch control file. If an error occurs, the user is given the option of going into DIALOG mode and fixing the error, or skipping the faulty card and continuing with the control file. Naturally, the CONTINUE command tells HEVSIM to continue



processing the control file.

DEBUG can be used to obtain additional information beyond the run detail printout. It is very useful for debugging runs that fail. It can be operated in four modes:

(1) OFF - turns off DEBUG printout entirely;

(2) SHIFT - prints DEBUG information before and after each shift from the "start" to "stop" segments, and is good for detecting shift stutters;

(3) TIME - prints DEBUG information for the time frame specified by "start" and "stop" times;

(4) SEGMENT - prints DEBUG information from the "start" to the "stop" segments.

In the IA mode, DEBUG is activated by typing "DEBUG" (cr). VEHSIM will type "DEBUG": indicating that it is in DEBUG mode. Then enter the mode and start and stop limits. This line is read using a format of A5,2F so one must be sure to enter enough spaces between the mode and the start limit. DEBUG output format comes in four lines containing the following variables:

line 1 CUMT, CUMD, V, ACCEL, FWHEEL, FROLL, FAERO,  
FACCEL, FGRADE;

line 2 DT, NGEAR, ISEG, NRTSEG, TORQW, TR, TORQP, TORQ2,  
TORQ1, TORQF, TORQE;

line 3 PCTWOT, HIDNAM, HPBR, RPMW, DRPMW, RPMP, RPM2, RPME,  
DRPME;

line 4 NGOCAL, MAPOK.

These variables are defined in Volume III, Appendix I. If no "start" limit is given, DEBUG will start at the start of the simulation. If no "stop" limit is given, DEBUG will continue until the simulation ends or aborts. DEBUG mode will remain in effect for all SIMULATE commands until it is changed by another DEBUG command. The default value is off. The user is cautioned against using DEBUG, since voluminous printout may

result.

The shift debug output format is printed in the following order:

HSMODE, HTMODE, CUMTLS, CSTIM, TORQA, TORQAO, ATORQF, ARPME, DRPM1E, DRPMC, DTC, LCLTCH.

This data is printed only during shifting.

DELETE AND DROP allow the user to delete parts from the data base. Please be careful when using this command.

The DIALOG command places HEVSIM in DIALOG mode. This means that HEVSIM will accept commands from the terminal rather than from a disk control file.

DIR gives a directory of the data base parts data. The wild card construction is available. The directory will only be printed at the terminal if it is turned on via the TTY command. A sample terminal session showing use of DIR is given in a later section of this manual.

The DUMP command allows the user to obtain a dump of all the data currently stored in the disk parts data file. For interactive users, the model will request part type and part name information. The wildcard construction is available. A dump is a human readable form of the parts data. A dump will always come only to the print file and never to the terminal. The user has the option of obtaining a directory at the same time, and the directory will come to the terminal if the TTY is switched on via the TTY command. A sample terminal session using DUMP is provided in another section of this manual.

In NIA mode the \*DUMP command can be used with the word DIRECTORY beginning in column 19 to obtain a listing of only the names and comment fields of parts. Using only \*DUMP gives a listing of all the data in the disk parts data file.

The STOP and EXIT commands close all data base files, give the user the option of how to dispose of the print file,

and exit to the monitor. The print file disposition options are:

DELETE - delete the file  
SAVE - save the file  
PRINT - queue the file for printing

LIMIT PRINT enables the user to limit the amount of printed output he wishes to receive for the simulations that are requested. There are five options available:

- (1) "SEGME" - prints out detailed output only for the final time step for each segment of the driving schedule as well as the initial conditions step.
- (2) "MILE" - prints out detailed output at fixed mileposts along the schedule (e.g., every .1 mile) as well as the initial conditions step.
- (3) "SEC" - prints out detailed output at fixed time increments along the schedule (e.g., every 10. seconds) as well as the initial conditions step.
- (4) "OFF" - prints out detailed output at each and every time step in the simulation.
- (5) "SUMMA" - only summary sheet at end of simulation is printed. If LIMIT PRINT is off when loading parts a dump of that part will appear on the print file.

MODIFY enables the user to reset the value of a number of individual program parameters without creating a new component data set for the disk file. The MODIFY command should only be used after the USE command, which retrieves the data to be overridden. You can modify several simulation parameters.



| <u>Keyword</u> | <u>Result</u>                                                                                         |
|----------------|-------------------------------------------------------------------------------------------------------|
| AREA           | - frontal area (sq. ft.)                                                                              |
| C1             | - 1st constant in rolling resist. equation                                                            |
| C2             | - 2nd constant in rolling resist. equation                                                            |
| C4             | - bearing loss                                                                                        |
| CD             | - aerodynamic drag coefficient                                                                        |
| CYLINDER       | - number of cylinders                                                                                 |
| DIESEL         | - logical                                                                                             |
| DISPLACEMENT   | - modifies the cubic inch displacement of the engine                                                  |
| DUTYCYCLE      | - modifies the accessory duty cycle from default of 1.                                                |
| DYNA           | - turns on the dynamometer testing with a value of 1 and turns off the dynamometer with a value of 0. |
| DOWNSHIFT      | - % change in vacuum/throttle downshift level                                                         |
| FUEL           | - fuel specific gravity                                                                               |
| IDLE           | - reset the idle RPM                                                                                  |
| PHI            | - reset the wind                                                                                      |
| REAR           | - rear axle ratio                                                                                     |
| SHIFT          | - <u>available for debugging the program only</u>                                                     |
| STEP           | - time step for simulation (sec.)                                                                     |
| STROKE         | - piston stroke (in.)                                                                                 |
| TIRE           | - tire efficiency                                                                                     |
| TRR            | - front end rotating inertia (logical)                                                                |
| UPSHIFT        | - % change in vacuum/throttle upshift level                                                           |
| WEIGHT         | - gross weight of the vehicle                                                                         |
| WHEEL          | - number of wheels                                                                                    |
| WIND           | - wind velocity (WPH)                                                                                 |

In the IA mode the user is queried for a new value followed by the keyword. HEVSIM continues to ask for the new value and keyword until the query is answered by a (CR).

\*REMAP allows the user to obtain an engine map printed out at the speed and torque points that he specifies rather than at the points that were initially input. This capability provides a convenient method of comparing fuel rates, vacuums, etc., between



engines whose initial data was taken at different points in the performance map. This command is only available in the NIA mode.

RESET is executed only during an IA simulation. RESET stops the simulation and puts HEVSIM out of simulation mode. All loaded parts remain loaded. AS in the EXIT command, the user is given the option of disposing of the print file. However, since the file is to be closed and reopened, the effect of the various options are somewhat different:

APPEN - causes the new print file to be appended to the old print file, effectively saving what has been done.

DELETE - deletes the old print file.

SAVE - saves the old print file, but the closing and reopening causes the new file to overwrite the old, thereby destroying the old print file.

SIMULATE begins the actual simulation. It first checks to see that all the necessary parts have been assembled from the disk parts data file by means of USE commands or new parts data cards and allows the vehicle to reach initial conditions specified by the driving schedule itself. At the end of the simulation, more USE or MODIFY commands may be used to bring in or reset data for another simulation, and so forth, until the end of the input data is reached, at which time the program terminates execution.

The STATUS command prints out the status of the simulation parameters, including the parts that are loaded, and all modifications. To receive the status report at the user terminal, the terminal must be turned on via the TYP command. An automatic status report is generated for the print file when a SIMULATE command is given.

TITLE allows the user to specify a 60 character title which will appear on the top of every page output by the model. Each TITLE command overrides the previous one so that, if he wishes, the user may specify a different title for each simulation or the same title for all simulations performed during a single run. The date to be printed on all output may be specified here to override the actual date.

The TTY and LPT commands allow for the turning on or off of either the TTYP or LPT output while in IA mode. The initial state of the TTY is off and the initial state of the LPT is on.

LOCK and UNLOCK provide the user with the capability of "locking up" or "unlocking" the torque converter for any of the gears in the transmission. LOCKUP will render the torque converter invisible by setting the speed and torque ratios equal to unity and zeroing the input and output inertias while the vehicle is in the specified gear(s). UNLOCK can be used to "unlock" a previously "locked up" gear. All this simply means that a vehicle with locked up gears has a manual transmission and a vehicle with unlocked gears has an automatic transmission.

UNIT allows the user to specify units for the engine data printout resulting from a USE or ENGINE command in units other than those in which it was originally input on the disk data file. The available units are the same as those described in the REMAP command.

The USE command allows the user to retrieve data from the disk parts data file. The model will ask for the part typed when in the IA mode.

Valid choices are the following:

- (1) ACCESSORY
- (2) CONVERTER
- (3) DRIVING SCHEDULE
- (4) ENGINE
- (5) GEAR
- (6) REAR AXLE
- (7) ROUTE
- (8) SHIFT LOGIC
- (9) TIRES
- (10) TRANSMISSION
- (11) VEHICLE.

The program will then ask for the specific part name (the name originally stored on the disk parts data file). If ENGINE is specified, the user must specify to which gears and to which engine number the engine data will be assigned. An example of an engine is

```
"1 ENGINE      1 2 3" (cr)
```

(Note that the read format is I,A10,20I.)

Be sure to leave enough spaces after the engine name, if the name is shorter than 10 characters.) This says use ENGINE 1 for the first engine and assign to it gears 1, 2, and 3. In the case of a 3-speed car, this is the only engine that should be loaded. The program will ask for another engine, but the user should just type a (cr). In some cases two engine maps may be required if, for example, the engine calibration is different in gears 1 and 2 from the calibration in gear 3.

To load gears, use the TRANSMISSION option. The user will be asked for a transmission name or a (cr). If a transmission part has been defined, with the "TRANSMISSION" command, simply name the transmission. If not, hit the (cr) and HEVSIM will ask for and load all your gears one by one. At any point after gears are loaded the user may change a particular gear by typing "USE." In answer to the "part type" question, type "GEAR." HEVSIM will ask which gear number is to be reloaded, and then ask for the name of the gear.

ZERO command enables the user to zero the core memory data currently stored by the program, and reset program flags and pointers. In the case of accessory data the program accumulates a list of accessory tables, one for each USE command. Unless a ZERO command is issued, a new set of accessories would be added to the old set rather than replace them. To delete from core any particular accessory while in IA mode, type "ZERO name" (cr) (note 2 spaces between ZERO and name) where name is any accessory name. To zero all parts, just type "ZERO" (cr).





### 3. SAMPLE SIMULATIONS

This section will provide sample simulation cases illustrating the four methods described in the previous section. Vehicle parts for sample cases are included in Volume III, Appendices II and III.

#### 3.1 INTERACTIVE SIMULATION

An interactive simulation may be conducted using either the ASK or TELL option. The ASK option is typically more convenient, since the user is prompted for all necessary information. Although a simulation may be conducted using the TELL option, it was provided more specifically for the purpose of changing parts from a previous run to new parts for the next run. These concepts will become clear from the sample terminal sessions.

The following parts must reside on a disk before attempting to use them:

- (1) engine map data
- (2) gross vehicle data (tires and rear axle)
- (3) torque converter tables (one for drive and one for coast)
- (4) gear box data (transmission and gears)
- (5) a shift logic
- (6) a route description
- (7) a driving schedule.

Option data consists of accessory tables which are not required but may be included if desired. If a manual transmission is required, the user must specify that all gears are "locked up." This means that the speed and torque ratio for the torque converter will be set to unity. In addition, of course, an appropriate shift logic should be used.

For interactive simulation, a number of characters have been designated to perform a few key functions through a program interrupt. These are as follows:

CTRL D - TYPE OUT DEBUG INFORMATION  
CTRL E - CLOSE ALL FILES AND EXIT TO MONITOR  
CTRL N - SUPPRESS END OF DRIVING SEGMENT MESSAGES  
CTRL P - PAUSE TO MODIFY AND THEN CONTINUE SIMULATION  
CTRL S - TYPE OUT CURRENT STATUS OF SIMULATION  
CTRL O - TURN OFF SIMULATION OUTPUT EXCEPT FOR ERROR  
MESSAGE.

The CTRL abbreviation indicates the teletype terminal control key is to be depressed. A carriage return is indicated by (cr) throughout this section.

### 3.1.1 Input

A sample of an interactive terminal session input is shown in Figure 2, where user responses are underlined. Initially HEVSIM is placed in the ASK mode. After completion of loading the input data, a summary status report is typed for user review. Any modifications to the parts may then be made. Thus, the user can reset the value of a number of individual program parameters as illustrated without creating a new component data set for the disk file.

Once the parts are loaded and any required modifications have been made, the status report is repeated and the SIMULATE query may be answered affirmatively to begin execution.

### 3.1.2 Output

The default output includes end of segment time, distance, speed, CPU time in the segment, and total CPU time (these messages may be eliminated using CTRL N). The default output and the standard summary sheet groups information into five clusters, as shown in Figure 3. The first cluster shows the fuel economy, engine work per mile, average brake specific fuel consumption, and average speed. Note that if an emissions simulation were being performed, the fuel economy number would show the reciprocal of the emissions ( $\text{NO}_x$  simulations are reasonable, HC and CO not recommended) in grams per mile provided the specific gravity in the engine map is specified as 0.1198.

RUN HISTOG

HISTOG TRUCK 67(24) 15-Dec-80 15:18 JOB# 21 TTY067 DSKB : [03224,633]

\*TITLE

ENTER RUN TITLE: HEUSIM INTERACTIVE DEMO: BUS

\*OUTPUT

LPT FILE 021USM.DAT/DISP: DELETE

LPT FILE DSKB :021USM.DAT[03224,633]<100>/DISPOSE:DELETE

ENTER NEW OUTPUT FILE: BUSBUG[3,3]

\*ASK

ENTER NUMBER OF ACCESSORIES TO BE USED: 1

ENTER PART NAME FOR ACCESSORY # 1: BUS 1

ENTER PART NAME OF DRIVE CONVERTER TO BE USED: TC-100EF

ENTER PART NAME OF COAST CONVERTER TO BE USED: TC-490-C

ENTER PART NAME OF DRIVING SCHEDULE TO BE USED: TRABUSCEDA

ENTER ENGINE NUMBER (1 OR 2), PART NAME, AND GEAR ASSIGNMENTS  
: 1 6U92TA 1 2 3 4

ENTER ENGINE NUMBER (1 OR 2), PART NAME, AND GEAR ASSIGNMENTS  
:

ENTER PART NAME OF ROUTE TO BE USED: ZGRADE

ENTER PART NAME OF SHIFT LOGIC TO BE USED: U730-ST

ENTER PART NAME OF VEHICLE TO BE USED: BUS-1

ENTER PART NAME OF TIRE TO BE USED: BUS 1

ENTER PART NAME OF TRANSMISSION (OR <CR> FOR GEARS): U-730B

ENTER AXLE NAME: BUS-2

FIGURE 2. INTERACTIVE SIMULATION TERMINAL SESSION



HEUSIM TRUCK 67(24) STATUS REPORT

---

DIALOGUE MODE /TTY  
SIMULATION MODE-TRUCK  
RUN TITLE-HEUSIM INTERACTIVE DEMO: BUS  
ENGINE(1)-6U92TA  
DRIVE CONVERTER-TC-100EF  
COAST CONVERTER-TC-490-C  
VEHICLE-BUS-1  
AXLE - BUS-2  
TRANSMISSION - U-730B  
GEAR # 1-U730B-1 ASSIGNED TO ENGINE-6U92TA  
GEAR # 2-U730B-2 ASSIGNED TO ENGINE-6U92TA  
GEAR # 3-U730B-2A ASSIGNED TO ENGINE-6U92TA  
GEAR # 4-U730B-3 ASSIGNED TO ENGINE-6U92TA  
ACCESSORY # 1-BUS 1  
DRIVING SCHEDULE-TRABUSCBDA  
SHIFT LOGIC-U730-ST  
ROUTE-ZGRADE  
TIRE-BUS 1  
NO GEARS LOCKED UP  
GEARS UNLOCKED - 1 2 3 4  
LIMIT PRINT-SUMMA 0.0000000E+00  
DEBUG-OFF 0.0000000E+00 0.0000000E+00  
TTY OUTPUT-OFF  
LPT OUTPUT-ON  
NO MODIFICATIONS

SIMULATE ? (ANS Y/N/D): N

ENTER GEAR NUMBERS TO BE LOCKED UP: 3 4

ENTER GEAR NUMBERS TO BE UNLOCKED: 1 2

\*MODIFY(NEW VALUE, ITEM): .365,WEIGHT

\*MODIFY(NEW VALUE, ITEM): 5.35,REAR

\*MODIFY(NEW VALUE, ITEM):

\*LIMIT PRINT: SECON .05

TTY OUTPUT(ON/OFF): OFF

DEBUG: OFF

FIGURE 2. INTERACTIVE SIMULATION TERMINAL SESSION (continued)

HEUSIM TRUCK 67(24) STATUS REPORT

---

DIALOGUE MODE /TTY  
 SIMULATION MODE-TRUCK  
 RUN TITLE-HEUSIM INTERACTIVE DEMO: BUS  
 ENGINE(1)-6U92TA  
 DRIVE CONVERTER-TC-100EF  
 COAST CONVERTER-TC-490-C  
 VEHICLE-BUS-1  
 AXLE - BUS-2  
 TRANSMISSION - U-730B  
 GEAR # 1-U730B-1 ASSIGNED TO ENGINE-6U92TA  
 GEAR # 2-U730B-2 ASSIGNED TO ENGINE-6U92TA  
 GEAR # 3-U730B-2A ASSIGNED TO ENGINE-6U92TA  
 GEAR # 4-U730B-3 ASSIGNED TO ENGINE-6U92TA  
 ACCESSORY # 1-BUS 1  
 DRIVING SCHEDULE-TRABUSCDBA  
 SHIFT LOGIC-U730-ST  
 ROUTE-ZGRADE  
 TIRE-BUS 1  
 GEARS LOCKED UP- 3 4  
 GEARS UNLOCKED - 1 2  
 LIMIT PRINT-SECON 0.5000000E-01  
 DEBUG-OFF 0.0000000E+00 0.0000000E+00  
 TTY OUTPUT-OFF  
 LPT OUTPUT-ON  
 REAR MODIFIED FROM 4.625 TO 5.350  
 WEIGH MODIFIED FROM .2460E+05 TO .3000E+05

SIMULATE ? (ANS Y/N/D): Y

[SIMULATING]

[REACHED INITIAL CONDITIONS]

|       |            |       |       |       |       |      |      |       |      |       |      |
|-------|------------|-------|-------|-------|-------|------|------|-------|------|-------|------|
| ESEG: | 1          | CUMT: | 9.64  | CUMD: | 0.030 | MPH: | 20.0 | CPUS: | 5.12 | CPUT: | 5.18 |
| ESEG: | 2          | CUMT: | 26.98 | CUMD: | 0.126 | MPH: | 20.0 | CPUS: | 0.09 | CPUT: | 5.32 |
| ESEG: | 3          | CUMT: | 33.33 | CUMD: | 0.143 | MPH: | 0.0  | CPUS: | 1.34 | CPUT: | 6.68 |
| ESEG: | 4          | CUMT: | 40.33 | CUMD: | 0.143 | MPH: | 0.0  | CPUS: | 0.02 | CPUT: | 6.72 |
| ESCD: | TRABUSCDBA | CUMT: | 40.33 | CUMD: | 0.143 | MPG: | 3.9  | CPUT: | 6.74 |       |      |

FIGURE 2. INTERACTIVE SIMULATION TERMINAL SESSION (continued)



VEHICLE PERFORMANCE SIMULATION 15-Dec-80

\*\*\*\*\*

RUN TITLE = HEVSIM INTERACTIVE DEMO: BUS

SCHEDULE AVERAGES      FUEL ECONOMY      = 3.91 MPG  
 WORK PER MILE          = 4.48 HP-HR/MI  
 AVG SP FUEL CONS      = 0.41 LBS/HP-HR  
 AVG SPEED              = 12.7 MPH

ADDITIONAL RUN DATA

DRIVING SCHEDULE NAME = TRABUSCBA      ROUTE NAME              = ZGRADE  
 VEHICLE NAME          = BUS-1                ENGINE NAME            = 6U92TA  
 CONVERTER NAME        = TC-490-C            SHIFT LOGIC NAME      = U730-ST  
 WEIGHT (LBS)          = 30000                STROKE (INCHES)      = 5.00  
 DISPLACEMENT (CU IN) = 552.0                REAR AXLE RATIO       = 5.35      0.00      0  
 WIND VELOCITY (MPH)   = 0.0                   FUEL DENSITY (LB/GAL) = 7.10  
 AERO DRAG = 75.00 , 0.60                TIRES = 10.00 , 0.00 , 0.40 , 1.00

| TOTALS | VARIABLE (UNITS) | TOTAL<br>AMOUNT | PERCENT OF TOTAL |       |       |        |
|--------|------------------|-----------------|------------------|-------|-------|--------|
|        |                  |                 | (CRUISE          | ACCEL | DECEL | IDLE ) |
|        | TIME (SECS)      | 40.3            | 42.0             | 21.6  | 18.3  | 18.0   |
|        | DISTANCE (MILES) | 0.1             | 65.9             | 18.4  | 15.7  | 0.0    |
|        | ENERGY (HP-HR)   | 0.64            | 31.2             | 60.9  | 4.5   | 3.4    |
|        | FUEL (LBS)       | 0.26            | 35.7             | 53.7  | 5.5   | 5.1    |

ENERGY SUPPLY

HP-HR

(1) ENGINE              = 0.64  
 (2) KINETIC ENERGY   = 0.00  
 (3) POTENTIAL ENERGY = 0.00  
 (4) ROTATING INERTIA = 0.00

BREAKDOWN

PERCENT ENGINE HP-HR

(1) ACCESSORIES        = 32.83  
 (2) TORQUE CONVERTER = 1.20  
 (3) CLUTCH            = 0.00  
 (4) GEAR BOX          = 2.03  
 (5) DIFFERENTIAL     = 1.61  
 (6) TIRE SLIP         = 0.00  
       3+4+5+6         = 3.63  
       2+3+4+5+6       = 4.83  
 (7) AERODYNAMIC DRAG = 2.25  
 (8) ROLLING RESIST   = 18.06  
       SUBTOTAL 1- 8   = 59.10  
 (9) BRAKES            = 38.69  
 (10) ENGINE MOTORING = 2.21  
       SUBTOTAL 1-10   = 100.00  
 (11) OTHER ENERGY   = 0.00  
       TOTAL 1-11     = 100.00

EXIT

FIGURE 3. VEHICLE PERFORMANCE SIMULATION

The second cluster shows the totals of time, distance, engine energy, and fuel. The percent of each total is partitioned into amounts used during cruise, acceleration, deceleration, and idle. The fuel used during braking is the percentage of the total which is consumed during closed throttle decleration.

The energy supplied to the vehicle is broken down in the third cluster. Potential and kinetic energies and rotating inertia will be shown for certain types of driving schedules, such as simulating an upgrade and terminating the driving schedule at the top of a grade.

The fourth cluster lists the percent of engine work consumed by various losses, the amount of engine braking, and engine motoring. Each of the losses is broken out separately, which provides a convenient way to assess the influence of improved components.

Additional run data is presented in the last cluster, which includes key vehicle specifications and run conditions. With the exception of aerodynamic drag and tires, the additional run data is self-explanatory. The aerodynamic drag information shows the cross-sectional area and drag coefficient, while the tire information lists the linear term of the rolling resistance equation (lb/100 lb), the velocity dependent term (lb/1000 lb per MPH), and the tire friction (slippage) factor expressed as a decimal percentage.

An interactive simulation does not produce a LOG file since the terminal output is a printed copy. A HEVSIM data file, however, is generated which the user may SAVE, PRINT or DELETE after a run.

### 3.1.3 Continuation of Interactive Simulation

After the first interactive simulation has been completed, the user may wish to change a specific component, modify a component, or change to a completely different set of input parameters. Such changes are readily accomplished through the USE commands. A list of the commands necessary to change, for example, driving cycle and rear axle ratio, are shown in Figure 4.

A simulation run is terminated by typing EXIT after the summary sheet is typed on the terminals. A program-generated HEVSIM data file is recorded in the user's disk area which may be (1) APPENDED to the HEVSIM data file of the previous case, (2) SAVED, which destroys the HEVSIM data file of the previous case but keeps the record of the current case, or (3) DELETED, which eradicates the current case record. Normally, APPEND is used until after the final case when the user then selects whether to PRINT or DELETE.

### 3.1.4 Dump of Parts List

Parts data may be listed for a particular part, all the parts within a part type, or the entire parts file. A listing is accomplished through the DUMP command which queries the user, as shown in Figure 5. Wild characters may be used as required to list a group of parts.

The user also has the option to obtain a directory of all the parts within a part type or for all the data currently stored in the disk parts data file. The DIR command is demonstrated in Figure 6. Wild character use is permitted for maximum flexibility. The directory will only be typed at the terminal if the TTY switch is turned on (as shown in Figure 5). The directory which comes to the terminal is a "fast" directory, that is, only the part name will be printed. The print file directory (which automatically is printed during the DIRECTORY command) gives a full directory, that is, it includes the part name, protection, date created, the part creator's identification code, and the comment field associated with each part.

◆USE

PART TYPE: VEHICLE

ENTER PART NAME OF VEHICLE TO BE USED: BUS-1

PART TYPE:

◆MODIFY

◆MODIFY(NEW VALUE, ITEM): 3.E4, WEIGHT

◆MODIFY(NEW VALUE, ITEM):

FIGURE 4. INTERACTIVE TERMINAL SESSION CONTINUATION



♦TTY

TTY OUTPUT(ON/OFF): ON

♦DUMP

DUMP TO TTY?(ANS Y/N) Y

DO YOU WANT A DIRECTORY OF PARTS DUMPED?(ANS Y/N): Y

PART TYPE: VEHICLE

ENTER PART NAME: BUS-1

VEHIC PARTS DATA FILE DIRECTORY 7-JAN-81 DSKB :VSMVEH.BINC 03313,672

]

BUS-1

VEHICLE DATA ( BUS-1 )

STANDARD BUS

WEIGHT = 24600.0 LBS

FRONTAL AREA = 75.00 SQ FT NUMBER OF TIRES = 6

DRAG COEFFICIENT = 0.600000 CD SENSITIVITY COEFF = 1.000000

PROPSHAFT INERTIA = 0.000 FT-LB-SEC\*\*2

BEVEL GEAR = 0.975; BEVEL GEAR EFF. = 0.980

A TOTAL OF 1 VEHIC PARTS ON FILE DSKB :VSMVEH.BINC 03313,672]

FIGURE 5. PARTS LISTING AT TERMINAL

◆DIR

PART TYPE: VEHICLE

ENTER PART NAME: ◆

VEHIC PARTS DATA FILE DIRECTORY 7-JAN-81 DSKB :VSMVEH.BINL 00313,672

1

-----  
-  
2CB2G1EGMF  
2DE2H1JGMS  
TSTD  
1AD1D1DIHC  
1AD2C1DIHF  
2DD2H1GUMS  
2CDEH1NUMF  
1AD1D1DFDS  
1AD2C1CFDF  
BUS-1

A TOTAL OF 10 VEHIC PARTS ON FILE DSKB :VSMVEH.BINL 00313,672J

FIGURE 6. PARTS DATA DIRECTORY

### 3.2 BATCH FILE SUBMISSION ATTACHED SIMULATION

A simulation can be conducted at a terminal by entering a HEVSIM control file through the use of the BATCH command. A sample HEVSIM control file is shown in Figure 7. Note that the \*SIMULATE commands contains a DIALOGUE option which places HEVSIM under user control. Before the simulation begins, the user now has the option to type SIMULATE or make any desired modifications.

Figure 8 shows a sample terminal session in which the simulation was started immediately after the control file was loaded. Also shown is the use of the CTRL N interrupt character to delete the end of segment messages. The first simulation summary sheet was typed but is not shown here since it is the same as in the previous example. The second simulation using FTPR driving schedule would begin after typing the CONTINUE command. A CTRL N would also be required to turn on the end of segment messages if desired. At the end of the second simulation the user may EXIT from HEVSIM or go on with another case by switching to DIALOGUE mode to perform an interactive simulation.

### 3.3 BATCH FILE SUBMISSION DETACHED SIMULATION

Three files are needed to run HEVSIM in batch. They are as follows:

- (1) Batch control file
- (2) HEVSIM control file
- (3) HEVSIM data base file.

The batch control file is a simple four-line instruction for running HEVSIM, as shown in Figure 9: it tells HEVSIM which file in the user's area is the HEVSIM control file. A sample HEVSIM control file is also shown in Figure 10. A data base file is a binary file generated by HEVSIM (See Section 5) which contains all the parts data to run a simulation. This binary file can be read only by HEVSIM and may contain a large number of parts so that they are available for immediate use when specified in a HEVSIM control file.

```

♦OUTPUT      HEVSIM.DAT[3:3]
♦LIMIT PRINT      OFF
♦TITLE        TEST CASES OF TRUCKS AND BUSES
♦USE  6V92TA      ENGINE          1      1 2 3 4
♦USE  TRABUCCBD   DRIVING
♦USE  BUS-2       AXLE
♦USE  V730-ST     SHIFT LOGIC
♦USE  ZGRADE      ROUTE
♦USE  BUS 1       TIRE
♦USE  V-730B      TRANSMISSION
♦USE  BUS-1       VEHICLE
♦USE  TC-490-C    CONVERTER
♦USE  TC-100EF    CONVERTER
♦UNLOCK CONVERTER GEAR          1 2
♦LOCKUP CONVERTER GEAR          3 4
♦LIMIT PRINT      SEC          0.05
♦MODIFY           WEIGHT        30000.
♦MODIFY           REAR          5.35
♦SIMULATE         BUS
♦USE  TRABUCCOM   DRIVING
♦SIMULATE         BUS

```

FIGURE 7. SAMPLE HEVSIM CONTROL FILE FOR BATCH ATTACHED SIMULATION



```

*LIMIT PRINT      OFF
*TITLE           TEST CASES OF TRUCKS AND BUSES
*USE 6V92TA      ENGINE           1       1 2 3 4
*USE BUS 1       ACCESSORY
*USE BUS-2       AXLE
*USE V730-ST     SHIFT LOGIC
*USE ZGRADE      ROUTE
*USE BUS 1       TIRE
*USE V-730B      TRANSMISSION
*USE BUS-1       VEHICLE
*USE TC-490-C    CONVERTER
*USE TC-100EF    CONVERTER
*UNLOCK CONVERTER GEAR           1 2
*LOCKUP CONVERTER GEAR           3 4
*LIMIT PRINT     SEC             0.05
*MODIFY           WEIGHT          30000.
*MODIFY           REAR            5.35

END OF HEVSIM CONTROL FILE DSK ;TEST.SEV [03224,633]
*ODRI_DRI

*USE TRABUSCBD   DRIVING
*SIMULATE        BUS

[SIMULATING]
[REACHED INITIAL CONDITIONS]
ESEG:  1 CUMT:   4.58 CUMD:  0.006 MPH: 10.0 CPUS:  1.43 CPUT:  1.51
ESEG:  2 CUMT:  10.96 CUMD:  0.032 MPH: 20.0 CPUS:  1.80 CPUT:  3.33
ESEG:  3 CUMT:  28.59 CUMD:  0.130 MPH: 20.0 CPUS:  0.16 CPUT:  3.50
ESEG:  4 CUMT:  34.94 CUMD:  0.147 MPH:  0.0 CPUS:  1.20 CPUT:  4.72
ESEG:  5 CUMT:  41.94 CUMD:  0.147 MPH:  0.0 CPUS:  0.01 CPUT:  4.74
ESCD:TRABUSCBD CUMT:  41.94 CUMD:  0.147 MPG:  4.1 CPUT:  4.76

```

FIGURE 8. SAMPLE INTERACTIVE ATTACHED SIMULATION USING BATCH

```

.ASSIGN LPT:1
.RUN HISTOM
♦BATCH TEST.SEV
@DRI.DRI
.IF(ERROR) .GOTO ONE
.GOTO TWO
ONE::.CLOSE
TWO::
.DELETE HEVSIM.DAT[3,3]
.PRINT/DIS:DEL LOG2.LOG
.KJOB

```

FIGURE 9. SAMPLE HEVSIM CONTROL FILE FOR DETACHED SIMULATION

```

♦OUTPUT      HEVSIM.DAT[3,3]
♦LIMIT PRINT      OFF
♦TITLE          TEST CASES OF TRUCKS AND BUSES
♦USE  6V92TA      ENGINE          1      1 2 3 4
♦USE  TRABUCCBD   DRIVING
♦USE  BUS-2       AXLE
♦USE  V730-ST     SHIFT LOGIC
♦USE  ZGRADE     ROUTE
♦USE  BUS 1       TIRE
♦USE  V-730B     TRANSMISSION
♦USE  BUS-1       VEHICLE
♦USE  TC-490-C   CONVERTER
♦USE  TC-100EF   CONVERTER
♦UNLOCK CONVERTER GEAR          1 2
♦LOCKUP CONVERTER GEAR          3 4
♦LIMIT PRINT     SEC            0.05
♦MODIFY          WEIGHT         30000.
♦MODIFY          REAR           5.35
♦SIMULATE        BUS
♦USE  TRABUCCOM  DRIVING
♦SIMULATE        BUS

```

FIGURE 10. SAMPLE HEVSIM BATCH TEST.SEV FILE FOR DETACHED SIMULATION

Output from a batch job is written to a program-created log file for printing on a line printer. A HEVSIM data file is also created which contains additional information for the simulation. It is useful to print it if an abnormal termination of the run occurs. This HEVSIM data file is normally eliminated through the delete command in the control file, as shown by the last line in Figure 9. At the completion of a run the log file is automatically printed and retained in the user's disk area.

The print options previously described for interactive operation may also be used in batch processing.

### 3.4 BATCH CARD FILE SUBMISSION

Using a card deck input to run HEVSIM assumes that the program is already available on disk. A sample deck listing is shown in Figure 11. The card deck essentially contains a HEVSIM control file which serves as input data to run HEVSIM. The program is controlled in a manner similar to a terminal batch job, except for the use of cards.

The output summary sheet is shown in Figure 12. A 50,000-pound tractor-trailer combination unit was simulated, which is further described in the additional run data. A parts listing for this sample case is included in the Appendix to Volume III.

```

$JOB NAME[CP,FD]
$DECK SAMPLE.RUN
*LIMIT PRINT      OFF
*TITLE            SAMPLE BATCH HEVSIM TRUCK SIMULATION
*USE  LFAY2A      ACCESSORY
*USE  EN34012H2   ENGINE           1           1 2 3 4 5 6 7 8 9
*USE  COCY2       CONVERTER
*USE  CODY2       CONVERTER
*USE  SHORTHAUL   DRIVING SCHEDULE
*USE  ZGRADE      ROUTE
*USE  LM9         SHIFT LOGIC
*USE  V2DB2HIN    VEHICLE
*USE  TX5001N12   TRANSMISSION
*USE  TISTD1020   TIRE
*USE  RA8751217   AXLE
*LOCKUP CONVERTER GEAR           1 2 3 4 5 6 7 8 9
*LIMIT PRINT      SEGMENT
*MODIFY           WEIGHT         50000.
*SIMULATE         TRUCK
$DECK SAMPLE.CTL
.RUN HEVSIM
*BATCH SAMPLE.RUN
*EXIT
.PRINT TTPVSM.DAT/DISPOSE:DELETE
$TOPS10
.SUBMIT SAMPLE/AFTER: 23:00:00/TIME:01:30:00
$EDJ

```

FIGURE 11. PUNCHED CARD LISTING TO EXECUTE HEVSIM



RUN TITLE = SAMPLE BATCH HEVSIM TRUCK SIMULATION

SCHEDULE AVERAGES      FUEL ECONOMY      = 5.39 MPG  
                               WORK PER MILE      = 2.79 HP-HR/MI  
                               AVG SP FUEL CONS = 0.47 LBS/HP-HR  
                               AVG SPEED            = 32.3 MPH

ADDITIONAL RUN DATA

|                         |              |                         |                    |
|-------------------------|--------------|-------------------------|--------------------|
| DRIVING SCHEDULE NAME = | SHORTRHAUL   | ROUTE NAME =            | ZGRADE             |
| VEHICLE NAME =          | V2DB2HIN     | ENGINE NAME =           | EN34012H2          |
| CONVERTER NAME =        | CODY2        | SHIFT LOGIC NAME =      | LM9                |
| WEIGHT (LBS) =          | 50000.       | STROKE (INCHES) =       | 6.00               |
| DISPLACEMENT (CU IN) =  | 855.3        | REAR AXLE RATIO =       | 3.70               |
| WIND VELOCITY (MPH) =   | 0.0          | FUEL DENSITY (LB/GAL) = | 7.10               |
| AERO DRAG =             | 95.00 , 1.00 | TIRES =                 | 6.75 , 0.07 , 0.95 |

| TOTALS | VARIABLE (UNITS) | TOTAL AMOUNT | PERCENT OF TCTAL |       |       |        |
|--------|------------------|--------------|------------------|-------|-------|--------|
|        |                  |              | (CRUISE)         | ACCEL | DECEL | IDLE ) |
|        | TIME (SECS)      | 6697.2       | 87.8             | 4.7   | 3.0   | 4.5    |
|        | DISTANCE (MILES) | 60.1         | 91.9             | 5.9   | 2.2   | 0.0    |
|        | ENERGY (HP-HR)   | 167.85       | 85.7             | 14.0  | 0.2   | 0.2    |
|        | FUEL (LBS)       | 79.20        | 87.8             | 11.0  | 0.9   | 0.4    |

| ENERGY SUPPLY        | HP-HR    |
|----------------------|----------|
| (1) ENGINE           | = 167.85 |
| (2) KINETIC ENERGY   | = 0.00   |
| (3) POTENTIAL ENERGY | = 0.00   |
| (4) ROTATING INERTIA | = 0.00   |

| BREAKDOWN            | PERCENT ENGINE HP-HR   |
|----------------------|------------------------|
| (1) ACCESSORIES      | = 0.56                 |
| (2) TORQUE CONVERTER | = 0.03                 |
| (3) GEAR BOX         | = 2.79                 |
| (4) DIFFERENTIAL     | = 6.27                 |
| (5) TIRE SLIP        | = 4.52                 |
|                      | 3+4+5 = 13.57          |
|                      | 2+3+4+5 = 13.60        |
| (6) AERODYNAMIC DRAG | = 35.70                |
| (7) ROLLING RESIST   | = 44.77                |
|                      | SUBTOTAL 1- 7 = 94.63  |
| (8) BRAKES           | = 6.32                 |
| (9) ENGINE MOTORING  | = 0.84                 |
|                      | SUBTOTAL 1- 9 = 101.78 |
| (10) OTHER ENERGY    | = 0.00                 |
|                      | TOTAL 1-10 = 101.78    |

FIGURE 12. SUMMARY OUTPUT FROM PUNCHED CARD BATCH SIMULATION

## 4. INPUT DATA FORMAT

The precise format for data input is described here on a line-by-line basis, and is indexed to numerical card (terminal) column numbers. Data sheets may be reproduced, filled out, and submitted directly for keypunching or remote terminal processing.

### 4.1 DATA FORMAT SHEET DESCRIPTIONS

Input data for the program is punched on cards according to a specified format, and then read onto a disk or tape. The data format is provided for vehicle parts, specified procedures and utilities. The data format sheets are listed below:

| <u>PARTS DATA</u>  | <u>PROCEDURES</u>     | <u>UTILITY</u>    |
|--------------------|-----------------------|-------------------|
| (1) ACCESSORY      | (10) DRIVING SCHEDULE | (13) DEBUG        |
| (2) AXLE (REAR)    | (11) ROUTE            | (14) DROP         |
| (3) ENGINE         | (12) SHIFT LOGIC      | (15) DUMP         |
| (4) FULL CONVERTER |                       | (16) LIMIT PRINT  |
| (5) GEAR           |                       | (17) LOCKUP CONV. |
| (6) S.R. CONVERTER |                       | (18) MODIFY       |
| (7) TIRE           |                       | (19) PRINT UNITS  |
| (8) TRANSMISSION   |                       | (20) REMAP        |
| (9) VEHICLE        |                       | (21) SIMULATE     |
|                    |                       | (22) TITLE        |
|                    |                       | (23) UNLOCK CONV. |
|                    |                       | (24) USE          |
|                    |                       | (25) ZERO         |

A brief description of the parts data and procedures is provided. The utility formats are self-explanatory and their uses are discussed in Section 2.

Each line on a data sheet indicates one line of code to be punched on a card or typed on a terminal. The columns of a data field within a line are indicated with the appropriate column number. Left-justifying the data, which is always entered in

decimal form, facilitates keypunching. Alphabetic names or symbols already included on a data line must also be keypunched starting in the first column. Many of the data forms indicate repeated lines of data. For these cases, there is no need to repeat the title line, comment line, and first data line. Part names may be made up of letters and numbers only (no symbols or special characters).

Specific comments concerning the data sheets are as follows:

(1) ACCESSORY - The accessory data is specified at accessory RPM. The accessory speed, torque, and inertia are referenced to the engine through the speed ratio (SR) of the accessory gearing or pulley arrangement. The SR is equal to the accessory speed divided by the engine speed. Accessory duty cycle is a multiplying factor to account for the average accessory operating time with respect to engine operating time. The duty factor values can range from 0 to 1.0.

(2) AXLE (REAR) - the rear axle part contains data describing axle ratio, efficiency, and spin losses. If a dual axle truck is under consideration, two load efficiencies and two sets of spin loss data are specified. Header cards AXLE 1 and AXLE 2 are used for each set of spin loss data. For single axle vehicles, only one rear axle efficiency is specified (AXLE #1), and the SINGLE AXLE header card is used in place of the AXLE 1 header card. The spin loss data include up to 20 points by using two more data cards per axle.

(3) ENGINE - the engine data may be specified in any of the units as indicated by the choices for the first ENGINE card field. The preferred units, however, are RPM, TORQUE, and fuel rate in LB/HR. Engine motoring data must be included (i.e., at least one negative load point in the first LOAD POINT data field). Exhaust gas emission simulation (not recommended except for NO<sub>x</sub>) is provided for by using the above mentioned preferred units in the ENGINE data card, a fuel specific gravity of 0.1198, and entering emissions data (gm/hr) in the FUEL RATE data fields. The results of a simulation will produce the inverse of the sought after gm/mi emissions, and will show this inverse as the fuel economy in the summary sheet.



(4) FULL CONVERTER - torque converter data for both a DRIVE and a COAST converter must be provided even in the case of a manual transmission. The data cards are straightforward. Manual transmissions are considered as a locked-up torque converter.

(5) GEAR - gears must be loaded into the parts data file separately. A transmission is made up of a collection of gears which may have the same spin loss data as the entire transmission. The gear input inertia includes the rotational inertia of the input shaft and attached drive gear, while output inertia is the rotational inertia of the gear under specification.

(6) S.R. CONVERTER - serves the same function as the FULL CONVERTER. The torque converter data is specified, however, by input speed, speed ratio, and torque ratio. Essentially, this is an optional way to specify torque converter data.

(7) TIRES - all tires on a vehicle are considered to be of the same type. The coefficients C1 and C2 are rolling resistance coefficients. A second order equation is used to approximate rolling resistance force, which may be made linear by setting C2 equal to zero. The coefficients are to be specified in pounds force per 1,000 pounds vehicle weight. A tire efficiency term is a multiplicative factor which may be used to adjust for tire slip.

(8) TRANSMISSION - the transmission part is simply a list of gears used in the transmission. The gears listed must either be already in the data base as individual gear parts, or loaded as gear parts along with the transmission. The transmission part may contain a maximum of 20 gears. Once the transmission part and gears are loaded into the data base, all the gears used in the transmission are entered collectively as the transmission part during a simulation. This eliminates the string of gears to be typed in during interactive simulation. The feature of modifying a gear in the transmission still remains functional through the USE command.



(9) VEHICLE - the vehicle part contains basic characteristics of the vehicle such as weight, drag coefficient, frontal area, and number of tires on the road. The Cd sensitivity coefficient is a factor used only when investigating yaw effects in a cross wind simulation. Normally this factor is set at zero: it is further described in the mathematical analysis in Volume 1. Bevel gear ratio and efficiency can be specified for "V" drive bus drive-trains. If bevel gear information is left blank, a default value of one is used for both gear ratio and efficiency.

(10) DRIVING SCHEDULE - the course of accelerations, cruises, decelerations, and stops are specified in the driving schedule. The courses may be initiated at other than zero conditions on the INITIAL COND card; and, an application of this option would be a constant speed cruise.

Data in each SEGMENT is grouped according to which data may be specified as only one, optional, or at least one. For the latter type of data, whichever condition is satisfied first will terminate the segment.

(11) ROUTE - the route specification is used to indicate distances and driving conditions. Maximum flexibility is provided for driving conditions by allowing them to be changed from one MILEPOST to the next. The ROUTE specification and DRIVING SCHEDULE must be checked for compatibility when grades and winds are utilized. For example, one would not specify a 75. MPH speed on a 5. percent grade with a 50. MPH headwind for a 50,000 pound truck. GRADE changes must not exceed 1. percent incremental changes for heavy duty trucks. WIND SPEED may be specified as either positive or negative for head winds or tail winds, respectively. Cross-winds may also be considered, but will not be discussed at this time due to wind data limitations and the unresolved question of applicability.

(12) through (25) - data forms for the utility commands have the same effect as described in Section 2.2 and 2.3.

## 4.2 DATA SHEETS

The data sheets for parts data, procedures, and utility commands are described in this section. The format of the data sheets is similar to standard keypunch coding forms. Each part is described on a separate sheet with mandatory key words or phrases already indicated on the sheet. Each new part begins with an asterisk in column one of the first line, followed by the type of part, procedure or utility command. The remaining spaces are to be filled in with data where indicated by explanations on each form.

# DATA SHEET 1. ACCESSORY

|   |    |    |           |
|---|----|----|-----------|
| 1 | 19 | 28 |           |
|   |    |    | PART NAME |
| 1 |    |    | 80        |

COMMENT

NOTE: ENTER ALL DATA WITH A DECIMAL POINT

| 1    | 13                     | 19 | 25                                | 31            | 37 | 43 | 49 | 55 | 61 | 67 | 72 |
|------|------------------------|----|-----------------------------------|---------------|----|----|----|----|----|----|----|
| DATA | ENTER VALUE<br>INERTIA |    | SPEED<br>RATIO                    | DUTY<br>CYCLE |    |    |    |    |    |    |    |
|      |                        |    | UNITS:                            |               |    |    |    |    |    |    |    |
|      |                        |    | INERTIA (FT-LB-SEC <sup>2</sup> ) |               |    |    |    |    |    |    |    |
|      |                        |    | TORQUE (lb-ft)                    |               |    |    |    |    |    |    |    |
|      |                        |    | DUTY CYCLE (1.0 max)              |               |    |    |    |    |    |    |    |
|      |                        |    | (Default = 1.0)                   |               |    |    |    |    |    |    |    |
| 1    | 13                     | 19 | 25                                | 31            | 37 | 43 | 49 | 55 | 61 | 67 | 72 |
| 1    | TORQUE                 |    |                                   |               |    |    |    |    |    |    |    |
| 1    | ACCESS. RPM            |    |                                   |               |    |    |    |    |    |    |    |

← INCREASING RPM, FILL SPACES WITH DATA  
 POINTS AS NEEDED UP TO 20 POINTS MAXIMUM

| 1 | 13          | 19 | 25 | 31 | 37 | 43 | 49 | 55 | 61 | 67 | 72 |
|---|-------------|----|----|----|----|----|----|----|----|----|----|
| 1 | TORQUE      |    |    |    |    |    |    |    |    |    |    |
| 1 | ACCESS. RPM |    |    |    |    |    |    |    |    |    |    |

USE ONLY  
WHEN MORE  
THAN 10  
DATA POINTS  
TO BE ENTERED

DATA SHEET 2. REAR AXLE (Sheet 1 of 2)

|            |    |    |           |  |    |
|------------|----|----|-----------|--|----|
| 1          | 19 | 28 | PART NAME |  | 80 |
| *REAR AXLE |    |    |           |  |    |

NOTE: ENTER ALL DATA WITH A DECIMAL POINT  
 AXLE #1 FORWARD-REAR AXLE (or single)  
 AXLE #2 REARWARD-REAR AXLE

|      |                 |                   |                   |                 |                   |                   |                 |                   |                   |                 |                   |
|------|-----------------|-------------------|-------------------|-----------------|-------------------|-------------------|-----------------|-------------------|-------------------|-----------------|-------------------|
| 1    | 7               | 13                | 19                | 25              | 31                | 37                | 43              | 49                | 55                | 60              |                   |
| DATA |                 |                   |                   |                 |                   |                   |                 |                   |                   |                 |                   |
|      | rear axle ratio | rear axle #1 eff. | rear axle #2 eff. | rear axle ratio | rear axle #1 eff. | rear axle #2 eff. | rear axle ratio | rear axle #1 eff. | rear axle #2 eff. | rear axle ratio | rear axle #1 eff. |

Axle Speed #1      Axle Speed #2      Axle Speed #3

NOTE: USE SINGLE AXLE IF ONLY ONE AXLE. DO NOT USE AXLE 1 OR AXLE 2 TITLES.  
 USE AXLE 1 AND AXLE 2 IF DOUBLE AXLE.

|   |             |  |  |  |  |  |  |  |  |  |  |
|---|-------------|--|--|--|--|--|--|--|--|--|--|
| 1 | SINGLE AXLE |  |  |  |  |  |  |  |  |  |  |
| 1 | AXLE 1      |  |  |  |  |  |  |  |  |  |  |

SPIN LOSSES:

|             |    |    |    |    |    |    |    |    |    |    |    |    |
|-------------|----|----|----|----|----|----|----|----|----|----|----|----|
| 1           | 13 | 19 | 25 | 31 | 37 | 43 | 49 | 55 | 61 | 67 | 73 | 78 |
| TORQUE LOSS |    |    |    |    |    |    |    |    |    |    |    |    |
| INPUT RPM   |    |    |    |    |    |    |    |    |    |    |    |    |
| TORQUE LOSS |    |    |    |    |    |    |    |    |    |    |    |    |
| INPUT RPM   |    |    |    |    |    |    |    |    |    |    |    |    |





# DATA SHEET 3. ENGINE (Sheet 1 of 2)

|   |        |             |    |     |        |     |        |       |      |        |                        |
|---|--------|-------------|----|-----|--------|-----|--------|-------|------|--------|------------------------|
| 1 | ENGINE | 19          | 28 | 31  | 36     | 43  | 48     | 55    | 60   | 67     | 73                     |
|   |        | ENGINE NAME |    | RPM | PISTON | BHP | TORQUE | LB/HR | BSFC | GAL/HR | DIESEL                 |
|   |        |             |    |     |        |     |        |       |      |        | (Default: Leave Blank) |

(ENTER ONE OF ABOVE FOR EACH SET OF UNITS)

|   |         |    |    |    |    |    |    |    |    |    |  |
|---|---------|----|----|----|----|----|----|----|----|----|--|
| 1 | COMMENT | 13 | 19 | 25 | 31 | 37 | 43 | 49 | 55 | 60 |  |
|   |         |    |    |    |    |    |    |    |    |    |  |

|   |      |           |             |          |                                      |                  |            |              |    |    |
|---|------|-----------|-------------|----------|--------------------------------------|------------------|------------|--------------|----|----|
| 1 | DATA | 13        | 19          | 25       | 31                                   | 37               | 43         | 49           | 55 | 60 |
|   |      | BORE (in) | STROKE (in) | NUMB cyl | MIN ENGINE SPEED                     | MAX ENGINE SPEED | INERTIA SP | FUEL* NUMB** |    |    |
|   |      |           |             |          | (ft-lb-sec <sup>2</sup> ) (2. or 4.) |                  |            |              |    |    |

\*0.764 default if blank  
 \*Use 0.1198 for emissions  
 \*\*4. default if blank

|   |             |             |    |
|---|-------------|-------------|----|
| 1 | SPEED POINT | 13          | 18 |
|   |             | ENTER VALUE |    |

REPEAT SPEED POINT SETS AS NEEDED UP TO 20 SPEED PTS.

|   |            |    |    |    |    |    |    |    |    |    |    |    |
|---|------------|----|----|----|----|----|----|----|----|----|----|----|
| 1 | LOAD POINT | 13 | 19 | 25 | 31 | 37 | 43 | 49 | 55 | 61 | 67 | 72 |
|   |            |    |    |    |    |    |    |    |    |    |    |    |
|   | FUEL RATE  |    |    |    |    |    |    |    |    |    |    |    |
|   | THROTTLE   |    |    |    |    |    |    |    |    |    |    |    |
|   | MANIFOLD   |    |    |    |    |    |    |    |    |    |    |    |

INCREASING LOAD, FILL SPACES WITH DATA  
 POINTS AS NEEDED UP TO 20 POINTS MAXIMUM

UNITS: THROTTLE (DEGREE)  
 MANIFOLD (in. Hg.)

|   |            |    |    |    |    |    |    |    |    |    |    |    |
|---|------------|----|----|----|----|----|----|----|----|----|----|----|
| 1 | LOAD POINT | 13 | 19 | 25 | 31 | 37 | 43 | 49 | 55 | 61 | 67 | 72 |
|   |            |    |    |    |    |    |    |    |    |    |    |    |
|   | FUEL RATE  |    |    |    |    |    |    |    |    |    |    |    |
|   | THROTTLE   |    |    |    |    |    |    |    |    |    |    |    |
|   | MANIFOLD   |    |    |    |    |    |    |    |    |    |    |    |

USE ONLY WHEN MORE THAN 10 DATA POINTS TO BE ENTERED

emission rate (gm/hr) may be entered in FUEL RATE data field. See also \*notes.

DATA SHEET 3. ENGINE (Sheet 2 of 2)

|             |    |    |             |    |    |    |    |    |    |    |    |  |
|-------------|----|----|-------------|----|----|----|----|----|----|----|----|--|
| 1           | 13 | 18 | ENTER VALUE |    |    |    |    |    |    |    |    |  |
| SPEED POINT |    |    |             |    |    |    |    |    |    |    |    |  |
| 1           | 13 | 19 | 25          | 31 | 37 | 43 | 49 | 55 | 61 | 67 | 72 |  |
| LOAD POINT  |    |    |             |    |    |    |    |    |    |    |    |  |
| FUEL RATE   |    |    |             |    |    |    |    |    |    |    |    |  |
| THROTTLE    |    |    |             |    |    |    |    |    |    |    |    |  |
| MANIFOLD    |    |    |             |    |    |    |    |    |    |    |    |  |

|             |    |    |             |    |    |    |    |    |    |    |    |  |
|-------------|----|----|-------------|----|----|----|----|----|----|----|----|--|
| 1           | 13 | 18 | ENTER VALUE |    |    |    |    |    |    |    |    |  |
| SPEED POINT |    |    |             |    |    |    |    |    |    |    |    |  |
| 1           | 13 | 19 | 25          | 31 | 37 | 43 | 49 | 55 | 61 | 67 | 72 |  |
| LOAD POINT  |    |    |             |    |    |    |    |    |    |    |    |  |
| FUEL RATE   |    |    |             |    |    |    |    |    |    |    |    |  |
| THROTTLE    |    |    |             |    |    |    |    |    |    |    |    |  |
| MANIFOLD    |    |    |             |    |    |    |    |    |    |    |    |  |

|             |    |    |             |    |    |    |    |    |    |    |    |  |
|-------------|----|----|-------------|----|----|----|----|----|----|----|----|--|
| 1           | 13 | 18 | ENTER VALUE |    |    |    |    |    |    |    |    |  |
| SPEED POINT |    |    |             |    |    |    |    |    |    |    |    |  |
| 1           | 13 | 19 | 25          | 31 | 37 | 43 | 49 | 55 | 61 | 67 | 72 |  |
| LOAD POINT  |    |    |             |    |    |    |    |    |    |    |    |  |
| FUEL RATE   |    |    |             |    |    |    |    |    |    |    |    |  |
| THROTTLE    |    |    |             |    |    |    |    |    |    |    |    |  |
| MANIFOLD    |    |    |             |    |    |    |    |    |    |    |    |  |

Increasing load, fill spaces with data points as needed up to 20 points maximum  
 Units: throttle (deg) manifold (in Hg)

# DATA SHEET 4. FULL CONVERTER

|                          |    |    |    |    |       |
|--------------------------|----|----|----|----|-------|
| 1                        | 19 | 23 | 31 | 35 |       |
| FULL CONVERTER           |    |    |    |    |       |
| PART NAME                |    |    |    |    | DRIVE |
|                          |    |    |    |    | COAST |
| (enter one of the above) |    |    |    |    |       |
| 1                        |    |    |    |    | 80    |

NOTE: ENTER ALL DATA WITH A DECIMAL POINT

|      |    |    |    |    |    |  |
|------|----|----|----|----|----|--|
| 1    | 13 | 19 | 25 | 31 | 36 |  |
| DATA |    |    |    |    |    |  |

LEAVE BLANK  
IF CONSTANT  
INPUT TORQUE  
IS SPECIFIED

DIAM (inch)    CONST\*    PUMP    TURBINE  
INPUT TORQUE (ft.-lb-sec<sup>2</sup>)    INERT    INERT  
(lb-ft)    TORQUE (ft.-lb-sec<sup>2</sup>)    \*MAY BE LEFT BLANK

|               |    |    |    |    |    |    |    |    |    |    |    |
|---------------|----|----|----|----|----|----|----|----|----|----|----|
| 1             | 13 | 19 | 25 | 31 | 37 | 43 | 49 | 55 | 61 | 67 | 72 |
| INPUT TORQUE  |    |    |    |    |    |    |    |    |    |    |    |
| OUTPUT TORQUE |    |    |    |    |    |    |    |    |    |    |    |
| INPUT RPM     |    |    |    |    |    |    |    |    |    |    |    |
| OUTPUT RPM    |    |    |    |    |    |    |    |    |    |    |    |

→ INCREASING INPUT RPM, FILL SPACES WITH DATA AS NEEDED UP TO 20 POINTS MAXIMUM

|               |    |    |    |    |    |    |    |    |    |    |    |
|---------------|----|----|----|----|----|----|----|----|----|----|----|
| 1             | 13 | 19 | 25 | 31 | 37 | 43 | 49 | 55 | 61 | 67 | 72 |
| INPUT RPM     |    |    |    |    |    |    |    |    |    |    |    |
| OUTPUT TORQUE |    |    |    |    |    |    |    |    |    |    |    |
| INPUT RPM     |    |    |    |    |    |    |    |    |    |    |    |
| OUTPUT RPM    |    |    |    |    |    |    |    |    |    |    |    |

USE ONLY  
WHEN MORE  
THAN 10 DATA  
POINTS TO  
BE ENTERED







DATA SHEET 7. TIRE

|           |    |    |
|-----------|----|----|
| 1         | 19 | 28 |
| *TIRE     |    |    |
| PART NAME |    |    |

|         |    |  |
|---------|----|--|
| 1       | 80 |  |
| COMMENT |    |  |

NOTE: ENTER ALL DATA WITH A DECIMAL POINT

|                     |   |                 |    |                 |    |                                                       |    |                         |    |                 |    |    |    |
|---------------------|---|-----------------|----|-----------------|----|-------------------------------------------------------|----|-------------------------|----|-----------------|----|----|----|
| 1                   | 7 | 13              | 19 | 25              | 31 | 37                                                    | 43 | 48                      | 55 | 61              | 67 | 73 | 78 |
| DATA                |   |                 |    |                 |    |                                                       |    |                         |    |                 |    |    |    |
| ROLLING RADIUS (ft) |   | C1* (lbs/lb wt) |    | C2* (lbs/lb wt) |    | TIRE EFF. ** INERTIA (1.max)(ft-lb-sec <sup>2</sup> ) |    | WHEEL INERTIA (lb/lbwt) |    | C4*** (lb/lbwt) |    |    |    |

\*Rolling resistance coefficients. Make C2 zero for linear approximation.

\*\*Tire slip effect due primarily to road surface

\*\*\*Bearing Loss Coefficient, default value of 0.0004

DATA SHEET 8. TRANSMISSION

|                |    |                              |    |
|----------------|----|------------------------------|----|
| 1              | 19 | 28                           | 31 |
| * TRANSMISSION |    |                              |    |
| PART NAME      |    | NUMBER OF GEARS<br>(Integer) |    |

|         |    |  |  |
|---------|----|--|--|
| 1       | 80 |  |  |
| COMMENT |    |  |  |

|   | 13        | 22 | 22 |
|---|-----------|----|----|
|   | GEAR NAME |    |    |
|   | COMMENT   |    |    |
| 1 | DATA      |    |    |
| 1 | DATA      |    |    |
| 1 | DATA      |    |    |
| 1 | DATA      |    |    |
| 1 | DATA      |    |    |
| 1 | DATA      |    |    |
| 1 | DATA      |    |    |
| 1 | DATA      |    |    |
| 1 | DATA      |    |    |
| 1 | DATA      |    |    |

REPEAT  
20  
GEARS  
MAX



DATA SHEET 9. VEHICLE

|          |           |    |
|----------|-----------|----|
| 1        | 19        | 28 |
| *VEHICLE | PART NAME |    |

|         |    |
|---------|----|
| 1       | 80 |
| COMMENT |    |

NOTE: ENTER ALL DATA WITH A DECIMAL POINT

|      |   |    |    |    |    |    |    |    |    |    |    |    |
|------|---|----|----|----|----|----|----|----|----|----|----|----|
| 1    | 7 | 13 | 19 | 25 | 31 | 37 | 43 | 49 | 55 | 61 | 67 | 72 |
| DATA |   |    |    |    |    |    |    |    |    |    |    |    |

|                 |                                  |                                  |                            |                                                        |                                       |                         |                       |
|-----------------|----------------------------------|----------------------------------|----------------------------|--------------------------------------------------------|---------------------------------------|-------------------------|-----------------------|
| WEIGHT<br>(lbs) | DRAG<br>COEFF.<br>C <sub>D</sub> | CD<br>SENSI-<br>TIVITY<br>COEFF. | FRONTAL<br>AREA<br>(sq-ft) | PROP-<br>SHAFT<br>INERTIA<br>(ft-lb-sec <sup>2</sup> ) | NO. OF<br>TIRES<br>IN ROAD<br>CONTACT | BEVEL*<br>GEAR<br>RATIO | BEVL*<br>GEAR<br>EFF. |
|                 |                                  |                                  |                            |                                                        |                                       | (Default Value = 1.0)   |                       |

DATA SHEET 10. DRIVING SCHEDULE (Sheet 1 of 2)

|           |                  |    |    |
|-----------|------------------|----|----|
| 1         | DRIVING SCHEDULE | 19 | 23 |
| PART NAME |                  |    |    |

|         |  |  |  |  |  |  |  |  |  |  |    |
|---------|--|--|--|--|--|--|--|--|--|--|----|
| 1       |  |  |  |  |  |  |  |  |  |  | 80 |
| COMMENT |  |  |  |  |  |  |  |  |  |  |    |

NOTE: ENTER ALL DATA WITH A DECIMAL POINT

|   |              |                  |             |                              |       |            |                     |
|---|--------------|------------------|-------------|------------------------------|-------|------------|---------------------|
| 1 | INITIAL COND | 13               | 19          | 25                           | 31    | 37         | 43                  |
|   | TIME (sec)   | DISTANCE (miles) | SPEED (mph) | ACCELER (ft/s <sup>2</sup> ) | GEAR* | ACCESSORY* | DUTY CYCLE(% : 100) |

\*Leave Blank for Gear = 1; duty cycle = 1.0(100%)  
Default

| 1       | 13 | 19 | 25 | 31 | 37 | 43 | 49 | 55 | 61 | 67 | 73 | 78 |
|---------|----|----|----|----|----|----|----|----|----|----|----|----|
| SEGMENT |    |    |    |    |    |    |    |    |    |    |    |    |
| SEGMENT |    |    |    |    |    |    |    |    |    |    |    |    |
| SEGMENT |    |    |    |    |    |    |    |    |    |    |    |    |
| SEGMENT |    |    |    |    |    |    |    |    |    |    |    |    |
| SEGMENT |    |    |    |    |    |    |    |    |    |    |    |    |

REPEAT SEGMENT CARDS AS NEEDED UP TO 200 CARDS

SPECIFY ONLY ONE SEGMENT SPECS

OPTIONAL

SEGMENT END CONDITIONS (Specify at least one)

DATA SHEET 10. DRIVING SCHEDULE (Sheet 2 of 2)

REPEAT SEGMENT CARDS AS NEEDED UP TO 200 CARDS

| 13      | 19 | 25 | 31 | 37 | 43 | 49 | 55 | 61 | 67 | 73 | 78 |
|---------|----|----|----|----|----|----|----|----|----|----|----|
| SEGMENT |    |    |    |    |    |    |    |    |    |    |    |
| SEGMENT |    |    |    |    |    |    |    |    |    |    |    |
| SEGMENT |    |    |    |    |    |    |    |    |    |    |    |
| SEGMENT |    |    |    |    |    |    |    |    |    |    |    |
| SEGMENT |    |    |    |    |    |    |    |    |    |    |    |

CONST ACCEL (FT/S<sup>2</sup>)    CONST SPEED (MPH)    CONST % HOT    ACCEL LIMIT (FT/S<sup>2</sup>)    CONST GEAR    CONST THROT CHANGE RATE    TIME (SEC) RELATIVE    DIST (MI)    PASSING CLEARANCE (FT)    DIST (MI) ABS    TERMINAL SPEED (MPH)

SPECIFY ONLY ONE SEGMENT SPECS

OPTIONAL

SEGMENT END CONDITIONS (SPECIFY AT LEAST ONE)

REPEAT SEGMENT CARDS AS NEEDED UP TO 200 CARDS

| 13      | 19 | 25 | 31 | 37 | 43 | 49 | 55 | 61 | 67 | 73 | 78 |
|---------|----|----|----|----|----|----|----|----|----|----|----|
| SEGMENT |    |    |    |    |    |    |    |    |    |    |    |
| SEGMENT |    |    |    |    |    |    |    |    |    |    |    |
| SEGMENT |    |    |    |    |    |    |    |    |    |    |    |
| SEGMENT |    |    |    |    |    |    |    |    |    |    |    |
| SEGMENT |    |    |    |    |    |    |    |    |    |    |    |

CONST ACCEL (FT/S<sup>2</sup>)    CONST SPEED (MPH)    CONST % HOT    ACCEL LIMIT (FT/S<sup>2</sup>)    CONST GEAR    CONST THROT CHANGE RATE    TIME (SEC) RELATIVE    DIST (MI)    PASSING CLEARANCE (FT)    DIST (MI) ABS    TERMINAL SPEED (MPH)

SPECIFY ONLY ONE SEGMENT SPECS

OPTIONAL

SEGMENT END CONDITIONS (SPECIFY AT LEAST ONE)



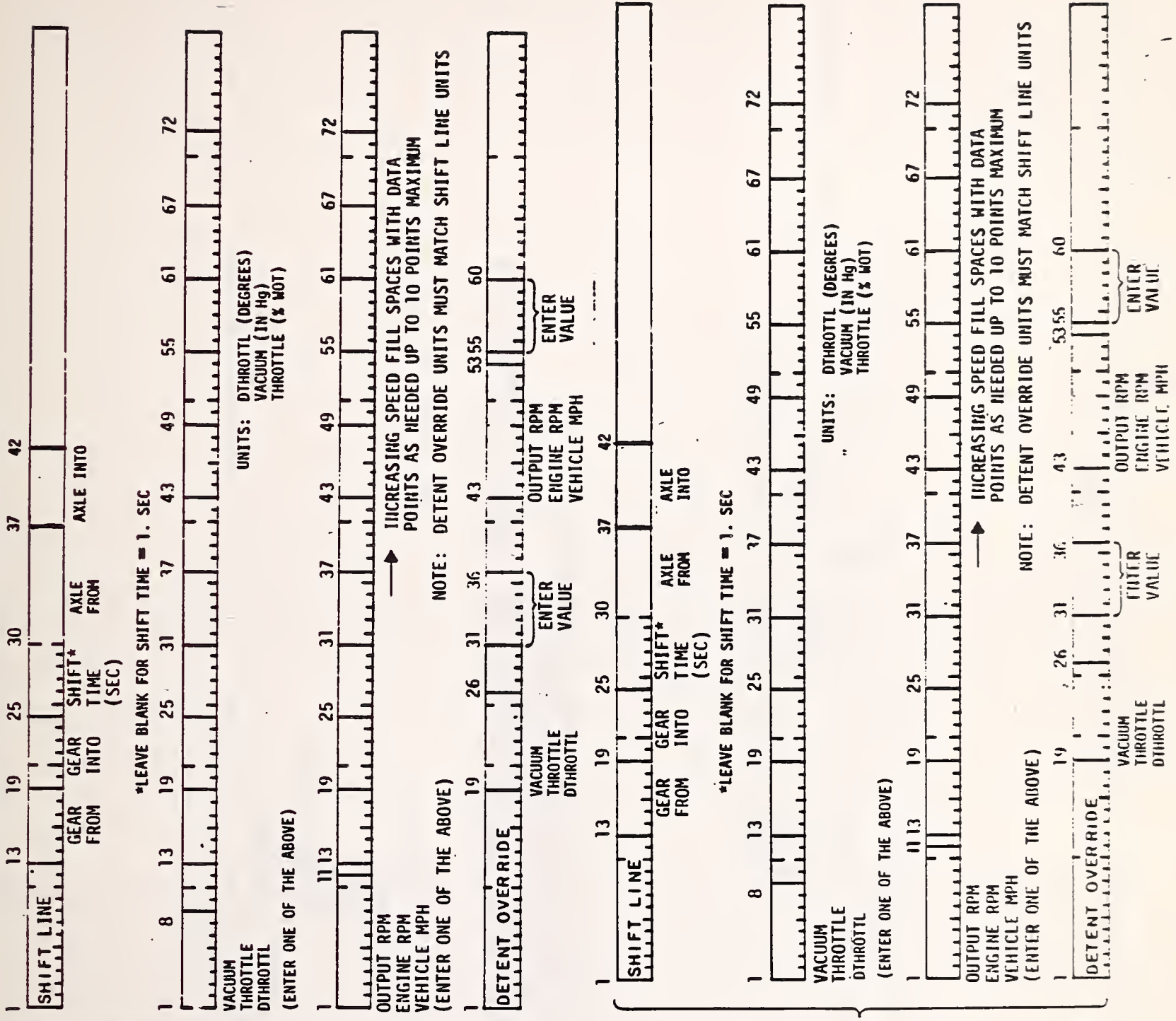




DATA SHEET 12. SHIFT LOGIC (Sheet 2 of 2)

REPEAT 3 OR 4  
CARD SETS AS  
NEEDED UP TO  
38 SETS FOR  
20 GEARS

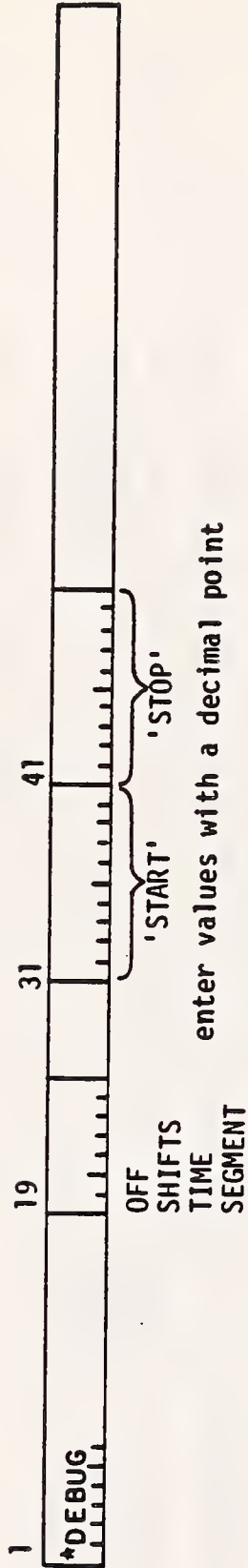
OPTIONAL  
USE ONLY  
IF NEEDED



REPEAT 3 OR 4  
CARD SETS AS  
NEEDED UP TO  
38 SETS FOR  
20 GEARS

OPTIONAL  
USE ONLY  
IF NEEDED

DATA SHEET 13. DEBUG



NOTES: FOR SHIFTS AND SEGMENT, ENTER SEGMENT NUMBERS  
 FOR TIME, ENTER VALUES IN SECONDS  
 IF NO 'START' SPECIFIED, DEBUG PRINTOUT STARTS AT BEGINNING OF RUN  
 IF NO 'STOP' SPECIFIED, DEBUG PRINTOUT CONTINUES TO END OF RUN

DATA SHEET 14. DROP

|        |   |    |    |  |
|--------|---|----|----|--|
| 1      | 7 | 16 | 19 |  |
| * DROP |   |    |    |  |

PART NAME

- ACCESSORY
- CONVERTER
- DRIVING SCHEDULE
- ENGINE
- GEAR
- ROUTE
- SHIFT LOGIC
- VEHICLE

(enter one of the above)







DATA SHEET 17. LOCKUP CONVERTER GEAR

| 1                      | 19 | 31 | 70 |
|------------------------|----|----|----|
| *LOCKUP CONVERTER GEAR |    |    |    |

LIST GEAR NUMBERS WITHOUT DECIMAL POINTS (right justify)

NOTE: GEAR NUMBERS RANGE FROM 1 to 20







# DATA SHEET 20. REMAP

|   |            |    |    |               |    |                      |    |                         |    |
|---|------------|----|----|---------------|----|----------------------|----|-------------------------|----|
| 1 | *REMAP     | 19 | 24 | 31            | 36 | 43                   | 48 | 55                      | 60 |
|   | ENGINE MAP |    |    | RPM<br>PISTON |    | BMEP<br>TORQUE<br>HP |    | LB/HR<br>BSFC<br>GAL/HR |    |

(enter one of the above for each set of units)

NOTE: ENTER ALL DATA WITH A DECIMAL POINT

|   |             |    |    |    |    |    |    |    |    |    |    |    |
|---|-------------|----|----|----|----|----|----|----|----|----|----|----|
| 1 | SPEED POINT | 13 | 19 | 25 | 31 | 37 | 43 | 49 | 55 | 61 | 67 | 72 |
|   |             |    |    |    |    |    |    |    |    |    |    |    |
|   | SPEED POINT |    |    |    |    |    |    |    |    |    |    |    |

INCREASING VALUE, FILL SPACES WITH DATA  
 POINTS AS NEEDED UP TO 20 POINTS MAXIMUM

|   |            |    |    |    |    |    |    |    |    |    |    |    |
|---|------------|----|----|----|----|----|----|----|----|----|----|----|
| 1 | LOAD POINT | 13 | 19 | 25 | 31 | 37 | 43 | 49 | 55 | 61 | 67 | 72 |
|   |            |    |    |    |    |    |    |    |    |    |    |    |
|   | LOAD POINT |    |    |    |    |    |    |    |    |    |    |    |

USE ONLY  
WHEN MORE  
THAN 10  
DATA POINTS  
TO BE ENTERED  
FOR EACH



DATA SHEET 22. TITLE

|   |        |    |  |    |     |
|---|--------|----|--|----|-----|
| 1 | *TITLE | 13 |  | 73 | / / |
|---|--------|----|--|----|-----|

RUN TITLE FOR RESULTS PRINTOUT

DATE\*  
(mo/da/yr)

\*Optional - insert to override actual date



DATA SHEET 23. UNLOCK CONVERTER GEAR

|   |                        |    |    |    |
|---|------------------------|----|----|----|
| 1 | *UNLOCK CONVERTER GEAR | 19 | 31 | 70 |
|---|------------------------|----|----|----|

LIST GEAR NUMBERS WITHOUT DECIMAL POINTS (right justify)

NOTE: GEAR NUMBERS RANGE FROM 1 TO 20

DATA SHEET 24. USE

|       |   |    |    |    |    |    |
|-------|---|----|----|----|----|----|
| 1     | 7 | 16 | 19 | 34 | 41 | 80 |
| * USE |   |    |    |    |    |    |

PART NAME

- \*ACCESSORY
- \*CONVERTER

\*DRIVING SCHEDULE

\*ENGINE - LIST ALL GEARS TO BE USED WITH THE ENGINE

\*GEAR - SPECIFY THE GEAR NUMBER THE GEAR IS TO BE USED FOR

\*ROUTE

\*SHIFT LOGIC

\*VEHICLE

LIST GEAR NUMBERS WHEN REQUIRED WITHOUT DECIMAL POINTS  
(right justified), gear numbers range from 1 to 20

(enter one of the above)

NOTE: ONE OF EACH PART ABOVE MUST BE DEFINED BY  
A USE COMMAND IN ORDER TO RUN A SIMULATION  
WITH THE FOLLOWING EXPECTATIONS:

1. ACCESSORIES ARE NOT REQUIRED.
2. TWO CONVERTERS (drive and coast) must be specified.

\*More than one of these parts may be defined.

DATA SHEET 25. ZERO

1

\*ZERO  
|||||

NOTE: THIS COMMAND RESETS THE ENTIRE PROGRAM TO ITS' INITIAL STATE  
AND ERASES ALL PARTS LOADED WITH THE USE COMMAND

## 5. HEVSIM AND PARTS GENERATION

The information provided here is not necessarily user oriented since it has to do with generation of a HEVSIM core image file and parts file. Normally a user will not have to perform these functions, or may intentionally be denied the opportunity to do so.

### 5.1 GENERATE CORE IMAGE FILE

Figure 13 shows the card deck listing to generate a sharable HEVSIM core image file with the HEVSIM source listing on magnetic tape.

### 5.2 GENERATE PARTS FILE

The deck listed in Figure 14 shows the control card setup needed to use the HEVSIM object deck (stored on a previous run as a permanent disk file) to create and store permanently on disk a new parts data file.

This deck is also used to add new parts to the currently existing old parts file (also placed on disk by a previous run). The use of a temporary data file allows the user to keep the same physical name (i.e., PARTS) for the parts file. The parts which can be loaded correspond, of course, to the parts data and procedures previously described on the data input sheets. The commands for inputting parts data contain the unique name of the part beginning in column 19 of the first card for each part. The commands are listed as follows:

\*ENGINE - indicates that engine data is to follow.

\*FULL CONVERTER - indicates that torque converter data is to follow specifying input and output torques and RPM's.

\*S.R. CONVERTER - indicates that torque converter data is to follow specifying input torque and RPM and speed and torque ratio.

\*VEHICLE - indicates that gross vehicle data ( $C_D$ , weight, etc.) is to follow.



```
$SEQUENCE XXXX
$JOB NAME[P,PN]
$PASSWORD
$DECK HEVSIM.CTL
.MOUNT MTA:VSM/REELID:HEVSIM/VID:19 TRK HEVSIM TAPE//UL
.REWIND VSM:
.COPY HEVSIM.FOR=VSM:
.COPY MAIN.MAC=VSM:
.COPY COMMS.FOR=VSM:
.COPY VSMHLP.HLP=VSM:
.DISMOUNT VSM:
.LOAD MAIN.MAC,HEVSIM.FOR
.SSAVE HEVSIM
$TOPS10
.SUBMIT HEVSIM
$EOJ
```

FIGURE 13. PUNCHED CARD LISTING TO GENERATE HEVSIM CORE IMAGE FILE

```
$SEQUENCE XXX  
$JOB NAME[P,PN]  
$PASSWORD  
$DECK PARTS.RUN  
  insert HEVSIM parts data here  
$DECK PARTS.CTL  
  .RUN HEVSIM  
♦BATCH PARTS.RUN  
♦EXIT  
  .PRINT ???VSM.DAT/DIS:DELETE  
$TOPS10  
  .SUBMIT PARTS  
$EQJ
```

FIGURE 14. PUNCHED CARD LISTING TO GENERATE PARTS DATA FILE

\*GEAR - indicates that data for a single gear is to follow.

\*ACCESSORY - indicates that data for an engine accessory is to follow.

\*SHIFT LOGIC - indicates that the shift criteria (shift lines, shift time, etc.) is to follow for all gears in the transmission.

\*TIRE - indicates that data for a tire type is to follow.

\*REAR AXLE - indicates that rear axle data is to follow.

\*TRANSMISSION - indicates that a transmission part name will follow (specifies a list of gears).

\*DRIVING SCHEDULE - indicates that data describing, in segment form, the particular driving schedule to be simulated is to follow.

\*ROUTE - indicates that data describing the physical route to be driven is to follow; the grade and road coefficient specifications are from the last data point milepost to the current one.

If a part is to be input using the same unique name as already appears in the disk data file, the request to store onto disk is ignored.

300 copies

HE 18.5 .A34

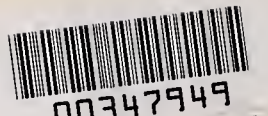
NHTSA- R

Buck, Richan

A computer p  
for heavy c

Form DOT F 1  
FORMERLY FORM





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