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# Electric/Hybrid Vehicle Simulation Program (ELVEC) User's Manual

July 1978

Prepared for:
**U.S. Department of Energy**
Assistant Secretary for Conservation
and Solar Applications
Division of Transportation Energy Conservation

Under Interagency Agreement EM-78-I-01-4209

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Prepared by:
Jet Propulsion Laboratory
Pasadena, California

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Phil Chapman
June 1978

# FOREWORD

The User's Manual provides the user with enough information to allow him to use the program which resides on National CSS Timeshare. Detailed information is conveyed by the use of several simulation examples and an explanation of the results of these examples (on a line-by-line basis) as required.

Except for a brief description of the road load equations, this User's Manual does not include descriptions of the math models.

A complete report of the ELVEC simulator is being prepared by the Vehicle Systems Modeling Task Area Team of the Electric and Hybrid Vehicle System Research and Development Project at the Jet Propulsion Laboratory. This report should be available to those wishing a complete program description by October, 1978. However, it is not necessary to possess this information in order to conduct electric and hybrid vehicle performance simulations using ELVEC. Flow charts and source listings are available for those wishing to review the coding. This information should be requested through T.A. Barber, Project Manager, Electric and Hybrid Vehicle System Research and Development Project, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91103.

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SECTION I

PROGRAM ACCESS

A. GENERAL

ELVEC is a general-purpose electric and hybrid vehicle simulation program which resides on the NCSS Timeshare system. As such, it can be accessed by a local call in most major U.S. cities. ELVEC was designed as a tool for detailed parametric studies of electric and hybrid vehicles. The simulator can be used interactively and can guide the user in a manner which requires only an elementary knowledge of computer simulation programs. This simulator can also be used in the batch mode, although not easily on the Timeshare network.

The reader will find simulation examples in Section II; Variable Dictionary List, Appendix A; Output Variables Description, Appendix B; Data Stored for Heat Engines, Appendix C; Road Load Model, Appendix D; NCSS Timeshare Phone List, Appendix E.

The remainder of this section provides the user with the information and procedures required to access the simulator.

B. USING THE NCSS TIMESHARE NETWORK

To access the network, the user needs to know:

1) The NCSS local telephone number
2) His demand terminal speed
3) The NCSS computer hostname
4) A user ID
5) A user password

Appendix E is a nationwide listing of phone numbers the user may use, depending on his geographical location. For example, from the Los Angeles area, the user dials 277-7942 (a Century City phone number), although the computer used is located in Sunnyvale, CA.

Demand terminals normally operate at the speeds indicated in Table 1-1. After dialing the phone number, obtaining the high frequency tone, and placing the telephone handset in the acoustic coupler, the user types the keyboard character that designates the speed of the terminal and the "return" key. The correct keyboard character is indicated next to the speed in Table 1-1. See Appendix E for autospeed and fixed speed phone numbers.

## C. TIMESHARE ARRANGEMENTS AND COSTS

Information regarding the use of the Timeshare network can be obtained by writing or phoning the corporate headquarters of:

National CSS, Inc.
187 Danbury Drive
Wilton, CT 06897
(203) 853-7200

Arrangements can be made with the Department of Energy and the Jet Propulsion Laboratory to transfer the ELVEC object code to a prospective user's NCSS account. This can be accomplished in a matter of minutes, after the user has arranged for an account on the network. Typical costs, including connect charges, storage charges, fixed charges, and actual CPU charges should not exceed 67 dollars an hour. Approximately 15 to 20 simulations can be performed in an hour's time.

## D. GENERAL TYPING CONVENTIONS

Each input line must end with a carriage return, which allows the current line to be transmitted. When the line has been accepted by

Table 1-1. Terminal Speed and Designator

| Speed | | Designator |
|---|---|---|
| Character/sec | Baud Rate | |
| 10 | 110 | S (Letter) |
| 30 | 300 | O (Letter) |
| 120 | 1200 | < (Back Arrow) |

the system, the input prompt ">" is printed, indicating that the system is ready to accept further input.

To correct typographical input errors (before the carriage return), use either the character-delete symbol "@" or the line-delete symbol "[". A "@" deletes the preceding character in the input line plus itself. Five consecutive @'s (@@@@@) delete the five characters immediately preceding the @'s and the @'s themselves. A "[" deletes the entire current input line and itself.

## E. TIMESHARE SIGN-ON

System and user responses are indicated in Figure 1-1. A line-by-line description is given below: (Note that user response is shown in lower case letters in all examples.)

The user types the letter O, designating a 300-Baud (30 characters per second) terminal, then types a return. The system responds as indicated on line 2. The user types line 3, where L SUNY is the computer hostname. The particular computer on which ELVEC is resident is located in Sunnyvale, CA. GRCUSER is the user identification (USER ID). The system prints lines 4 and 5. At the end of line 5, the system does a carriage return, but no line feed. This allows the user to type the password on top of line 5. This is done to prevent non-authorized personnel from determining the password should they obtain a copy of the output. The system asks for accounting information on line 6. The user types the initial letter of his first name and his last name in full.

## F. ESCAPE FROM AN EXECUTING PROGRAM

If, for some reason, the user desires to terminate execution of the program before the appropriate place to type QUIT, he can use the method outlined below:

1) Push the BREAK key - machine will echo VP, return, > (prompt)
2) Push the BREAK key <u>again</u> - machine will echo another >

3) Type KX following the prompt - machine will type KILLED! and then reinitialize the system. Then it will type the standard CSS prompt with the time, XX.XX.XX >

4) The user can then restart the program or log off.

If the user inadvertently pushes the BREAK key, the machine will stop execution and enter the VP mode as above. To restart the program with only a line or so of output lost, follow the above procedure, only type RT instead of KX.

## G. NORMAL EXIT

To exit from ELVEC after a simulation run, type QUIT or STOP. To exit from the timeshare network after a normal exit from ELVEC, type LOGOUT.

```
1  o

2  CSS ONLINE - LA2

3  >l suny grcuser
4  password:
5  [redacted]
6  A/C INFO:
7  >p.chapman
   SUNY READY AT 09.09.54 ON 23JUNE78.
   CSS.302 01MAY78
   09.10.07 SET CORE 440
   CSS.302 01MAY78
   09.10.10 SET CORE 440
   ( 448 )P 58% (000313 LEFT)

   ELVEC CAN ACCESS A NUMBER OF SETS OF VEHICLE PARAMETERS. TO USE
   ONE OF THESE, TYPE THE KEYWORD BEFORE THE VEHICLE NAME:

   ELVRIPP ... RIPP ELECTRIC (ALL ELECTRIC)
   ELVGE ..... GENERAL ELECTRIC VEHICLE (ALL ELECTRIC)
   ELVAIR .... GARRETT/AIRESEARCH VEHICLE (ELECTRIC - FLYWHEEL)
   ELVCHLD ... CHILD'S VAN (FIXED OPERATING POINT HYBRID)


20 09.10.30 >elvripp
21 EXECUTION:


   GRC ELECTRIC VEHICLE/BATTERY SIMULATION.  VERSION3.2A   8/MAY/78  -

23  SPECIFY DESIRED OUTPUT UNITS - METRIC OR ENGLISH . . .
24 >e
25 INITIATING BULK READ-
   FEDRAL CYCLE. 1372 VALUES READ.
   HIWAY  CYCLE.  766 VALUES READ.


28 CHANGES FOR THIS AND FOLLOWING RUNS-

29 WB=1300LB  WT=3288LB  ACLFAC=1.0  EFFCB=1  CDA=9.68FT2
   ATIREF=1.2  EFFBC=.85  EFFCT=.9,.9,.9,.9
31 EFFCM=0.82  EFFCD=.75  NAMCYC=J227D  NREGEN=2
   GEAR=3.757,2.169,1.404,1.0  RATIO=.29,3.9,1
   VELSCD=5.81,10.28,14.75 EFFCFW=0.622
35 CH=3.178,-0.7279,-0.05863
34 NCELLS=60 PWRHEN=7500. PDMAX=150. EFFALT=.75
36 END DATA
37 WARNING . . .THE VARIABLE DICTIONARY HAS BEEN CHANGED FOR THIS VERSION
38 (VERSION 3.2  10/MAR/78) OF ELVEC. A NEW DRIVING CYCLE IS AVAILABLE--
   MAXACL (MAXIMUM ACCELERATION BEGINNING AT SPEED VINIT). ALSO FOUR TYPES
   OF CLUTCHES ARE AVAILABLE--DIRECT COUPLING, MANUAL, TORQUE CONVERTER,
   AND CVRT. THE BATTERY STATE LIMITS CAN NOW BE SPECIFIED (BTSMIN AND
   BTSMAX).
   NAMES OF AVAILABLE HEAT-ENGINE MAPS . . .
44 BS400       ON782       GM5735      MN1600      GMVEGA140   TR7
45 TURBODSL    NADSL       IDIDSL      CWSTRATROT  NSUAUDIROT
46 BULK READ COMPLETE-
47  INPUT CHANGES FOR NEXT RUN-
48 >run
    INPUT COMPLETE FOR THIS CASE
    INPUT A 1-78 CHARACTER TITLE FOR THIS CASE-
51 >example 1.........driving cycle simulation, all electric
```

Figure 1-1. Accessing the Network

SECTION II

SIMULATION EXAMPLES

A. GENERAL

This section of the User's Manual provides eight examples of simulation runs. The actual computer printout is annotated with line numbers to clarify the explanations. These examples are just that. The components, values of variables chosen, and strategies selected are for illustrative purposes only to help the user understand how to use this simulator. One must be careful not to come to any conclusions with regard to the results of the examples.

B. EXAMPLE 1. DRIVING CYCLE SIMULATION, ALL-ELECTRIC (Figures 1-1, 2-1)

Figure 1-1 indicates how to access the network (described in detail in Section I). In order to start the program (start execution), one of four codes is used: ELVRIPP, ELVGE, ELVAIR, or ELVCHLD. These differ only in the stored default data parameters (see Table A-1, Appendix A). ELVRIPP starts the program with the Ripp electric parameters; ELVGE starts the program with the General Electric vehicle parameters; ELVAIR starts the program with the Garret AiResearch vehicle parameters; and ELVCHLD starts the program with the Energy Research & Development Corporation (Child's) van parameters. Use of line 20 indicates that the Ripp electric vehicle parameters were selected. Line 21 indicates that execution is commencing on the ELVEC program. The first question asked of the user is on line 23. In this case, the user requested English units, "E", on line 24. An "M" would have initiated the use of metric units.

On line 25, the "bulk read" process is begun. It is in this file that all the bulk data resides. First, the values of speeds for the EPA urban and highway driving cycles are read. On line 28, ELVEC prints "changes for this and following runs," indicating that this is the section of the program where the user can make changes. First, however, the rest of the bulk data is printed (the vehicle parameters — the Ripp electric vehicle in this example). Line 36 indicates that the vehicle data part of the bulk data file has been read. Lines 37 through 45 are reserved for messages to the user about the current version of the program. This section can vary in length according to how many lines are necessary to print the message. Line 46 indicates that the bulk data file reading operation has been completed by ELVEC.

Line 47 indicates that ELVEC is now ready to accept user changes to the data, and the user types RUN, without changing any of the bulk data values.

ELVEC responds on line 49, indicating that it is now starting the run and asks for the run title, which the user inputs on line 51.

Figure 2-1 shows the output for this run, starting with the title on line 1. (A complete description of ELVEC output is contained in Appendix B.) Lines 2 and 3 show the date and time of this run for record-keeping purposes.

Lines 4 through 7 are data concerning one cycle of the particular driving schedule selected by default from the bulk data file: The SAE J227a/D schedule. Information printed includes the cycle length in time and distance, road energy required without and with regenerative braking, and the maximum road power required on this cycle.

Lines 8 through 11 show the apportionment of the energy required from one cycle, in watt-hours and as a percentage of the total for the simulated vehicle on the selected driving cycle. Note that in this example no energy goes into the brakes due to regenerative braking

Lines 12 through 15 summarize the energy required from and returned to the battery and the maximum power density required from and returned to the battery.

Finally, lines 16 through 19 print the cumulative data for the simulated vehicle, running repeated cycles of the selected driving schedule until the battery is discharged. The line of asterisks indicates the completed run.

C. EXAMPLE 2. DETAILED OUTPUT (Figures 2-1, 2-2A, 2-2B)

ELVEC requests parameter changes for the next run on line 21. On line 22, the user has changed the printing flag for a detailed printout (i.e., DETAIL = 1) and the ending time of the detailed printout to 97 seconds (i.e., TFTRC = 97). (Appendix A contains the definitions of all-user selectable variables). The starting time for the detailed printout remains at the default value of zero. Then, the user types two spaces and RUN to initiate the run with this data. Note that the vehicle data has not been changed, only the detail of output was changed. Also, ELVEC always uses the most recent values of an input parameter. Previous, bulk data or default values are not restored at the end of a simulation run.

The response on line 23 indicates that ELVEC is now ready to start the run as soon as the user types a title on line 25. After the user types this line, ELVEC spaces down a few lines and, on line 26, starts the output.

Figures 2-2A and 2-2B show the detailed printing output. The left-hand column shows the time (in one-second intervals throughout the J227/D schedule) followed by the vehicle speed at that time. Next, is the acceleration of the vehicle in feet per second per second. This is followed (to the right) by the transmission gear in use (in this case, a four-speed transmission) and the road load power, which is zero during coast or idle and negative during braking. The next two columns show the output and speed of the electric motor, followed by three columns indicating the output, speed, and fuel flow of the heat engine. The final column shows the battery state. In the all-electric mode, the heat engine and battery state columns remain unchanged. Road load power is defined as the power required at the drive wheels to move the vehicle in the prescribed manner specified by the particular driving schedule selected.

D. EXAMPLE 3. ALL ELECTRIC CONSTANT SPEED (Figure 2-3)

Example 3 (Figure 2-3) shows the changes made to turn off detailed printing and initiate a constant speed run. The same vehicle parameters are being used with a constant speed of 35 mi/hr. Note that line 12 shows a 60-second "driving cycle". The energy summary on line 15 shows no energy going into the brakes because braking did not occur. Likewise, the battery parameters on line 20 indicate that no energy is returned to the battery because braking is not used during constant speed.

E. EXAMPLE 4. FXOP HYBRID CONFIGURATION (Figures 2-4, 2-5A through 2-5H)

The hybrid series configuration is called FXOP (Fixed Operating Point). In this configuration, the motor propels the vehicle and an auxiliary engine drives an alternator (or generator) which can charge the batteries. The engine can either be on or off during the simulation, depending upon the user-specified battery state variables.

The special user-defined variables particular to this configuration are indicated in Table 2-1. Other variables associated with the physical vehicle can be changed as required, as previously illustrated in this section and in Appendix A. The FXOP block diagram is illustrated in Figure 2-4.

Example 4 (FXOP Series Hybrid Simulation) is shown in Figures 2-5A thru 2-5H and is described below.

The first part of Figure 2-5A shows the new variable values for this series hybrid case. Line 10 is the means by which heat engines are scaled. The user types CHGENG, and the system prints line 11. The engine to be scaled is the BS400 (a Briggs and Stratton 400-cc displacement engine).

The horsepower in this case (element 11 of the Kathe array) is to be scaled from 13 hp to 16 hp, as seen on lines 13 thru 16. The elements of the Kathe array are defined in Appendix C, Table C-3.

Lines 26 through 37 indicate the energy distribution parameters for one J227a/D cycle. These parameters are defined in Appendix B. The user has the option of simulating additional cycles, as indicated on lines 38 thru 41. In this example, he chooses two additional cycles.

Table 2-1. FXOP Special User-Defined Variables

| Variable | Description |
|---|---|
| BTSMAX | The maximum fraction above which the battery will not be charged by the heat engine/generator BTSMAX $\leq$ 1.0 The default value of BTSMAX is 0.8 |
| BTSMIN | The battery will start to be charged by the heat engine/generator when the battery state reaches or falls below this fraction: BTSMIN $\leq$ 0.999. The default value of BTSMIN is 0. |
| NAMCLC | Name of clutch. For example, for a manually operated clutch, NAMCLC = MANUAL. |
| NAMHE | Name of the heat engine to be selected to drive the alternator or generator (see Table C-1). |
| NAMHYB | Name of this hybrid configuration. NAMHYB = FXOP |
| PWRHEN | The normal output in watts of the engine driving the generator (or alternator) which charges the batteries under charge conditions. For example, PWRHEN = 9740 (13 hp). |
| SPDHE | Speed (in radians/s) of the fixed operating point of the heat engine. If specified in rpm, include units. For example SPDHE = 3600RPM. |
| EFFALT | The efficiency of the generator (or alternator) expressed as a fraction $\leq$ 1.0. For example, EFFALT = 0.77 implies that in order to supply 7500 watts to the batteries, it would require the heat engine to develop 13 hp, if the efficiency of the generator is 77%. |

Figure 2-5B illustrates detailed output from the simulator, starting at the 265th second and ending after the 300th second in the third J227a/D cycle. Note that on the 280th second of the simulation, the heat engine turned on to charge the batteries, since the battery state dropped below 0.8 BTSMIN. Starting in Column 8 (counting from the left), the heat engine power, speed, and fuel flow are indicated, unlike an all-electric simulation. The last column of the detailed output indicates battery state. The fraction 0.794 means that 79.4% of the battery remains for use. After the brief detail output, the user requests an additional 20 J227a/D cycles, making a total of 1 + 2 + 20, or 23 cycles.

Figure 2-5C indicates that the test (simulation) was terminated when the battery was depleted in the 20th J227D cycle. The effective fuel consumption was 23.0 mi/gal.

Figure 2-5D shows that the user selected a different driving schedule (the J227B); in addition, the variable BTSMIN was set at 0.999, effectively forcing the heat engine to stay on most of the time. One J227B cycle is run, and the user requests 49 additional cycles, as seen on lines 21 thru 24.

The detailed output is seen in Figures 2-5E and 2-5F in the 50th J227B cycle between the 3529th and 3580th second. The heat engine was cycling on and off, as the battery state fell below 0.999 and rose to 1.0. At the 3540th second, the heat engine came on to charge the batteries. The output in Figure 2-5F captures the heat engine shutting down after the 3577th second. Note that there are two values at 3576 seconds. This is true for all J227-type schedules which have discontinuous power requirements at the beginning of the cruise, coast, and braking phases.

Figures 2-5G and 2-5H illustrate an FXOP constant-speed simulation, with detailed printout from the 50th through the 60th second. Normally, only 60 seconds of constant speed are simulated. In the case of hybrid vehicles, however, the user may wish to "drive" additional cycles in order to observe the changes in battery state. A cycle in this case refers to 60 seconds at constant speed.

## F. EXAMPLE 5. CBTOUT HYBRID CONFIGURATION (Figures 2-6, 2-7A, through 2-7G)

ELVEC implements a constant-battery-output parallel hybrid configuration as illustrated in Figure 2-6, and shown as examples in Figures 2-7A thru 2-7G. This strategy is such that the heat engine will come on if:

1) The required battery power density exceeds the user-specified PDMAX, the maximum allowable battery specific power density, or

2) The battery state drops below the user-specified BTSMIN, the minimum battery state allowed prior to charging.

If the heat engine is on, it will turn off if:

1) The battery state exceeds the maximum allowable state, BTSMAX.

2) The specific power density of the battery during regeneration exceeds the maximum allowable specific power density, PDMAX.

In essence, the heat engine does the load-leveling. When the motor and battery are unable to provide the necessary power, the heat engine supplies it. When the vehicle stops, there is no way to charge the battery with the engine, as in the FXOP hybrid strategy, because the motor is coupled directly to the wheels. Table 2-2 indicates the special user-defined variables for this strategy.

Table 2-2. CBTOUT Special User-Defined Variables

| Variable | Description |
|---|---|
| BTSMAX | (See Table 2-1) |
| BTSMIN | (See Table 2-1) |
| FRCHEP | Fraction of maximum power at which engine is to operate when battery is being charged. Default value is 0.6. However, the engine can operate at any power load up to its maximum if required by the driving schedule. |
| NAMCLC | (See Table 2-1) |
| NAMHE | (See Table 2-1 and Table C-2) |
| NAMHYB | Name of this hybrid configuration NAMHYB = CBTOUT |
| PDMAX | Maximum allowable battery specific power density for either discharge or charge. |

Figure 2-7A indicates that the user sets PDMAX to 95 watts/kg (a no-units indication always defaults to metric), selects a 50-hp naturally aspirated diesel engine (Table C-1, Appendix C), selects the CBTOUT hybrid strategy, and sets BTSMIN (the minimum battery state before charging occurs) to 0.75. This is indicated in lines 2 and 3 of Figure 2-7A. The entire 50th J227D cycle was also selected for detailed printout (Detail = 1, previously set, start of trace TSTRC = 6100 seconds, trace final TFTRC = 6222). Lines 10 thru 21 are the energy summary data based upon one J227D cycle. The user is asked if he wishes to drive additional cycles, and requests 49 more (line 25).

If the vehicle had gone the full 50 cycles, the detailed printout (the trace) would have appeared after line 25. However, the battery state fell to zero during the 32nd cycle, as seen by the note on lines 30 and 35. Therefore, the heat engine summary appears after line 25.

A detailed output of the first cycle is shown in Figures 2-7B, C, and D, through the 98th second. Note that the heat engine starts on the 20th second of the simulation because the power density required of the battery exceeds PDMAX. This is apparent in that the battery state was 0.981 at 20 seconds, and BTSMIN was previously set to 0.75. As can be seen from the 20th thru the 28th second, the motor power stays constant at 46.88 hp, and the heat engine provides the remainder of the required road load power to meet the acceleration portion of the driving schedule. In the cruise portion of the cycle, the road load requires 18.17 hp. The heat engine supplies 24.33 hp, of which 4.14 hp is used to drive the motor as a generator, 18.17 hp is used to meet the road load requirements, and the remainder is lost due to the efficiency factors. The battery state increases a small amount during the cruise and the coast phases. At 78 seconds when the coast phase begins, the entire engine output is used to drive the motor as a generator and 24.33 hp, less losses, is returned to the battery, as no power from either the motor or heat engine is required to move the vehicle. During braking, however, the specific power density returned to the battery exceeds PDMAX, and the engine shuts off.

Figures 2-7E and 2-7F show that during the 31st J227D cycle the battery is about depleted, and during the 31st cycle the batteries are depleted, giving an effective 26.5 mi/gal.

Figure 2-7G illustrates the simulator output for 10 seconds during a constant speed run at 35 mph. The motor is able to supply the road load power below the battery maximum allowed specific power density. Therefore, since the battery state had not dropped below 0.75 (BTSMIN = 0.75), the heat engine is off during this time period. Eventually, the battery state would drop below 0.75, and the heat engine would come on, supplying the required power to move the vehicle at 35 mph and the additional power to charge the batteries.

## G. EXAMPLE 6. FORDB HYBRID CONFIGURATION (Figures 2-8A thru 2-8D and 2-6)

ELVEC is able to simulate a modified version of the Ford Motor Company "Ford B" parallel hybrid strategy.* In this configuration (see Figure 2-6), the battery/motor provides initial vehicle acceleration. The Ford B strategy uses a direct coupling between the engine and motor. The engine valves are closed when the engine is not operating to avoid pumping losses. When the engine speed reaches a user-specified rpm, the heat engine starts. At that point, the motor may or may not stay on, depending on the following logic.

> If the battery state < BTSMIN and JBTCHG = 1, the motor is operated as a generator; or if the road load requirement > than the heat engine can supply, then the motor supplements the heat engine.

The above logic is dependent on the user specified values of FRCHEP, JBTCHG, KATHE(14) and BTSMIN.

---

*"Hybrid Vehicle for Fuel Economy", L.E. Unnewehr, J.E. Auiler, L.R. Foote, D.F. Moyer, and H.L. Stadler, Society of Automotive Engineers, No. 760121, 1976.

Figures 2-8A through 2-8D illustrate the FORDB strategy and are described below; Table 2-3 defines the special variable.

Lines 2, 3, and 4 of Figure 2-8A indicate the special user-defined parameters necessary for this parallel hybrid configuration. The user selects a turbocharged Volkswagen, 70-hp diesel engine. The vehicle parameters are those of the vehicle used to illustrate the FXOP and CBTOUT strategies. Note that for this run, ACLFAC has been set to a value of less than 1 to allow non-linear acceleration.

Lines 11 through 22 indicate the energy summary based upon one J227D cycle. The user requests 9 additional cycles at line 26; Figures 2-8B through 2-8D show the detailed output of the 10th J227D cycle.

Table 2-3. FORDB Special User-Defined Variables

| Variable | Description |
|---|---|
| BTSMAX | (See Table 2-1) |
| BTSMIN | (See Table 2-1) |
| FRCHEP | (See Table 2-2) |
| JBTCHG | Flag set to 1 if engine is allowed to recharge battery, or to 0 (zero) if recharge comes during regenerative braking. JBTCHG = 1 (default) |
| KATHE (14) | Minimum engine speed, rpm. Engine will turn on at this speed. Default is specified in the heat engine catalog array, element 14, for each engine. See Table C3. |
| NAMCLC | NAMCLC = DRCOUP only |
| NAMHYB | NAMHYB = FORDB for this strategy |
| NAMHE | (See Table 2-1 and Tables C-1 and C-2) |

The heat engine starts during the third second of the simulation when the engine speed reaches 800 rpm (KATHE (14) = 800). The motor and engine move the vehicle up the acceleration ramp. Just before cruise (1126th second), the road load requirement drops to the point where the motor is not required and so shuts off. The vehicle is propelled by the heat engine, consuming diesel fuel at the rate of 1.31 gallons per hour. During braking, energy is returned to the battery through regenerative braking (NREGEN = 2), and the heat engine turns off (BTSMAX = 1). The effective mileage is 33.4 mpg in this configuration.

## H. EXAMPLE 7. ALL-HEAT ENGINE VEHICLE (Figures 2-9A, 2-9B)

ELVEC is able to simulate an all-heat engine vehicle by setting PDMAX = 0 and NAMHYB = CBTOUT. An engine and clutch must also be selected.

Figures 2-9A and 2-9B illustrate this capability. In this example, the constant battery output strategy was chosen with a turbocharged normally aspirated Volkswagen engine with an automatic transmission. Note automatic scaling of the torque converter to match the selected engine (lines 10 - 15).

## I. EXAMPLE 8. MAXIMUM ACCELERATION AND PASSING (Figures 2-10A through 2-10F)

Wide-open throttle and passing time and distance are features of the ELVEC simulator. Table 2-4 indicates the special user-defined variables for these simulation modes. Figures 2-10A through 2-10F indicate the implementation procedures.

Figures 2-10A and 2-10B indicate the input parameters and results of simulating wide-open throttle performance of a Datson 1200 chassis with a Triumph TR7, 4-cylinder, 86-hp engine and 20-hp electric motor. The user specifies 0 to 60-mph performance, using the heat engine only (PDMAX = 0), shifting at 15, 30, and 50 mph. Figure 2-10B shows the results. The column headings are self-explanatory. For best results, the time step has been set to 0.1 seconds (DELT = 0.1) and the printing step set to 10 (NPRINT = 10). This gives one-second spacing in the output, but better calculation resolution.

Table 2-4. Wide-Open Throttle and Passing — Special User Defined Variables

| Variable | Description |
|---|---|
| BTSMAX | (See Table 2-1) |
| BTSMIN | (See Table 2-1) |
| DELT | Integration time step. 0.1 s recommended |
| DTSHFT | Time delay to shift gears. Default = 0.2 s |
| NAMCLC | (See Table 2-1) |
| NAMCYC | NAMCYC = MAXACL for wide-open throttle |
| NAMHE | Any engine |
| NAMHYB | Any configuration |
| NPRINT | Number of time steps between printing. Default is 1. 10 recommended if DELT = 0.1 |
| PDMAX | PDMAX = 0 for all-heat engine only |
| SPEED | Final speed* |
| VINIT | Initial speed* |

*For 0 to 30, VINIT = 0, SPEED = 30 mph. For passing, 30 to 48 mph, VINIT = 30 mph, SPEED = 48 mph.

Figure 2-10C is a passing-time and distance example, where the user wishes to know the time and distance to pass another vehicle (or accelerate), starting at 20.7 mph and ending at 35.2 mph. Again, this is an all-heat engine case, since PDMAX was previously set to zero.

In Figure 2-10D, the motor is allowed to work by setting PDMAX to 150 watts/kg. In Figure 2-10E, the user asks for acceleration performance from 0 to 30 mph, using both the motor and the engine. This can be compared to Figure 2-10F, where only the heat engine is allowed to work over the same range of acceleration speeds.

```
1   EXAMPLE 1..........DRIVING CYCLE SIMULATION, ALL ELECTRIC
2   DATE    06/23/78
3   TIME    09.18.04


4   TIME/  RANGE/  ROAD ENERGY   MAX ROAD  DRIVING
5    CYC   CYCLE  W/O RGN  W RGN  POWER    SCHEDULE
6    SEC    MI         WH/MI        KW

7    122   0.961   226.3  163.6    29.9    J227D


8   ENERGY SUMMARY BASED ON INPUT TO CHARGER AND FUEL TANK USING FRCTUT MODEL-
9         AERO   TIRES   BRAKES  DRVLNE MTR/CNTR STR DEV CLUTCH  HT ENG  BATT SYS

10  WH-     81      75       0       30      62       0       0       0     142
11  PRCNT 20.8    19.2     0.0      7.7    16.0     0.0     0.0     0.0    36.3


12  --------------BATTERY---------------
13  ENR OUT  ENR IN  PD OUT MX  PD IN MX
14      WH/MI              W/LB

15   306.7     46.3     31.1     26.5


16      TOTAL     ELECT CONSM    ELECT COST      FINAL STATE
17      RANGE       AT WALL      (AT 4.0C/KWH)   BATT  STR DEV
18       MI     WH/MI  WH/MI*TON     C/MI                WH

19       49.1    408      248       1.63         0.0     1000.


20  ****************************************************************************

21   INPUT CHANGES FOR NEXT RUN-
22  >detail 1  tftrc 97  run
23   INPUT COMPLETE FOR THIS CASE
24   INPUT A 1-78 CHARACTER TITLE FOR THIS CASE-
25  >example 2.........detail output of example 1


26  EXAMPLE 2.........DETAIL OUTPUT OF EXAMPLE 1
    DATE    06/23/78
    TIME    09.19.36
```

Figure 2-1. Driving Cycle Simulation, all Electric

| TIME SEC | SPEED MI/H | ACCL FT/S2 | GEAR | ROAD LD HP | ----MOTOR----- PW,HP | SPD,RPM | ----HEAT ENGINE--- PW,HP | RPM | FL,GPH | BATTERY STATE |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.0 | 2.3 | 1 | 0.0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1.000 |
| 1 | 1.6 | 2.3 | 1 | 1.22 | 1.35 | 344 | 0.0 | 0 | 0.0 | 1.000 |
| 2 | 3.2 | 2.3 | 1 | 2.44 | 2.71 | 689 | 0.0 | 0 | 0.0 | 1.000 |
| 3 | 4.8 | 2.3 | 1 | 3.66 | 4.07 | 1033 | 0.0 | 0 | 0.0 | 1.000 |
| 4 | 6.4 | 2.3 | 1 | 4.89 | 5.44 | 1378 | 0.0 | 0 | 0.0 | 1.000 |
| 5 | 8.0 | 2.3 | 1 | 6.13 | 6.81 | 1723 | 0.0 | 0 | 0.0 | 1.000 |
| 6 | 9.6 | 2.3 | 1 | 7.37 | 8.19 | 2067 | 0.0 | 0 | 0.0 | 1.000 |
| 7 | 11.2 | 2.3 | 1 | 8.63 | 9.58 | 2412 | 0.0 | 0 | 0.0 | 1.000 |
| 8 | 12.8 | 2.3 | 1 | 9.89 | 10.99 | 2757 | 0.0 | 0 | 0.0 | 1.000 |
| 9 | 14.4 | 2.3 | 2 | 11.17 | 12.41 | 1790 | 0.0 | 0 | 0.0 | 1.000 |
| 10 | 16.0 | 2.3 | 2 | 12.46 | 13.85 | 1989 | 0.0 | 0 | 0.0 | 1.000 |
| 11 | 17.6 | 2.3 | 2 | 13.77 | 15.30 | 2188 | 0.0 | 0 | 0.0 | 1.000 |
| 12 | 19.2 | 2.3 | 2 | 15.09 | 16.77 | 2387 | 0.0 | 0 | 0.0 | 1.000 |
| 13 | 20.8 | 2.3 | 2 | 16.44 | 18.27 | 2586 | 0.0 | 0 | 0.0 | 1.000 |
| 14 | 22.4 | 2.3 | 2 | 17.81 | 19.79 | 2785 | 0.0 | 0 | 0.0 | 1.000 |
| 15 | 24.0 | 2.3 | 3 | 19.20 | 21.33 | 1931 | 0.0 | 0 | 0.0 | 1.000 |
| 16 | 25.6 | 2.3 | 3 | 20.61 | 22.90 | 2060 | 0.0 | 0 | 0.0 | 1.000 |
| 17 | 27.2 | 2.3 | 3 | 22.05 | 24.50 | 2189 | 0.0 | 0 | 0.0 | 1.000 |
| 18 | 28.8 | 2.3 | 3 | 23.51 | 26.13 | 2318 | 0.0 | 0 | 0.0 | 1.000 |
| 19 | 30.4 | 2.3 | 3 | 25.01 | 27.79 | 2446 | 0.0 | 0 | 0.0 | 1.000 |
| 20 | 32.0 | 2.3 | 3 | 26.54 | 29.48 | 2575 | 0.0 | 0 | 0.0 | 1.000 |
| 21 | 33.6 | 2.3 | 4 | 28.09 | 31.22 | 1926 | 0.0 | 0 | 0.0 | 1.000 |
| 22 | 35.2 | 2.3 | 4 | 29.69 | 32.99 | 2018 | 0.0 | 0 | 0.0 | 1.000 |
| 23 | 36.7 | 2.3 | 4 | 31.32 | 34.80 | 2109 | 0.0 | 0 | 0.0 | 1.000 |
| 24 | 38.3 | 2.3 | 4 | 32.98 | 36.65 | 2201 | 0.0 | 0 | 0.0 | 1.000 |
| 25 | 39.9 | 2.3 | 4 | 34.68 | 38.54 | 2293 | 0.0 | 0 | 0.0 | 1.000 |
| 26 | 41.5 | 2.3 | 4 | 36.43 | 40.48 | 2384 | 0.0 | 0 | 0.0 | 1.000 |
| 27 | 43.1 | 2.3 | 4 | 38.22 | 42.46 | 2476 | 0.0 | 0 | 0.0 | 1.000 |
| 28 | 44.7 | 2.3 | 4 | 40.05 | 44.49 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 28 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 29 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 30 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 31 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 32 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 33 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 34 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 35 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 36 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 37 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 38 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 39 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 40 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 41 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 42 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 43 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 44 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 45 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 46 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 47 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 48 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 49 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 50 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |

**Figure 2-2A. Detail Output, Driving Cycle Simulation, all Electric**

| TIME SEC | SPEED MI/H | ACCL FT/S2 | GEAR | ROAD LD HP | ----MOTOR----- PW,HP | SPD,RPM | ----HEAT ENGINE--- PW,HP | RPM | FL,GPH | BATTERY STATE |
|---|---|---|---|---|---|---|---|---|---|---|
| 51 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 52 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 53 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 54 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 55 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 56 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 57 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 58 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 59 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 60 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 61 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 62 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 63 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 64 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 65 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 66 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 67 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 68 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 69 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 70 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 71 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 72 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 73 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 74 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 75 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 76 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 77 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 78 | 44.7 | 0.0 | 4 | 10.62 | 11.80 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 78 | 44.7 | -0.8 | 4 | 0.0 | 0.0 | 2568 | 0.0 | 0 | 0.0 | 1.000 |
| 79 | 44.2 | -0.8 | 4 | 0.0 | 0.0 | 2535 | 0.0 | 0 | 0.0 | 1.000 |
| 80 | 43.6 | -0.8 | 4 | 0.0 | 0.0 | 2503 | 0.0 | 0 | 0.0 | 1.000 |
| 81 | 43.0 | -0.8 | 4 | 0.0 | 0.0 | 2471 | 0.0 | 0 | 0.0 | 1.000 |
| 82 | 42.5 | -0.8 | 4 | 0.0 | 0.0 | 2439 | 0.0 | 0 | 0.0 | 1.000 |
| 83 | 42.0 | -0.8 | 4 | 0.0 | 0.0 | 2408 | 0.0 | 0 | 0.0 | 1.000 |
| 84 | 41.4 | -0.8 | 4 | 0.0 | 0.0 | 2377 | 0.0 | 0 | 0.0 | 1.000 |
| 85 | 40.9 | -0.8 | 4 | 0.0 | 0.0 | 2347 | 0.0 | 0 | 0.0 | 1.000 |
| 86 | 40.4 | -0.8 | 4 | 0.0 | 0.0 | 2317 | 0.0 | 0 | 0.0 | 1.000 |
| 87 | 39.9 | -0.7 | 4 | 0.0 | 0.0 | 2288 | 0.0 | 0 | 0.0 | 1.000 |
| 88 | 39.4 | -0.7 | 4 | 0.00 | 0.00 | 2259 | 0.0 | 0 | 0.0 | 1.000 |
| 88 | 39.4 | -6.4 | 4 | -62.68 | -56.41 | 2259 | 0.0 | 0 | 0.0 | 1.000 |
| 89 | 35.0 | -6.4 | 4 | -56.46 | -50.82 | 2008 | 0.0 | 0 | 0.0 | 1.000 |
| 90 | 30.6 | -6.4 | 3 | -49.98 | -44.99 | 2467 | 0.0 | 0 | 0.0 | 1.000 |
| 91 | 26.2 | -6.4 | 3 | -43.27 | -38.95 | 2114 | 0.0 | 0 | 0.0 | 1.000 |
| 92 | 21.9 | -6.4 | 2 | -36.36 | -32.73 | 2722 | 0.0 | 0 | 0.0 | 1.000 |
| 93 | 17.5 | -6.4 | 2 | -29.29 | -26.36 | 2177 | 0.0 | 0 | 0.0 | 1.000 |
| 94 | 13.1 | -6.4 | 2 | -22.08 | -19.88 | 1633 | 0.0 | 0 | 0.0 | 1.000 |
| 95 | 8.7 | -6.4 | 1 | -14.78 | -13.30 | 1886 | 0.0 | 0 | 0.0 | 1.000 |
| 96 | 4.4 | -6.4 | 1 | -7.41 | -6.66 | 943 | 0.0 | 0 | 0.0 | 1.000 |
| 97 | 0.0 | -6.4 | 1 | -0.00 | -0.00 | 0 | 0.0 | 0 | 0.0 | 1.000 |
| 97 | 0.0 | 0.0 | 1 | 0.0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1.000 |

Figure 2-2B. Detail Output, Driving Cycle Simulation, all Electric (Cont'd)

```
 INPUT CHANGES FOR NEXT RUN-
>detail 0  namcyc conspd  speed 35mph  run
 INPUT COMPLETE FOR THIS CASE
 INPUT A 1-78 CHARACTER TITLE FOR THIS CASE-
>example 3..........constant speed simulation using vehicle from example 1


EXAMPLE 3..........CONSTANT SPEED SIMULATION USING VEHICLE FROM EXAMPLE 1
DATE     06/23/78
TIME     09.27.30


TIME/  RANGE/  ROAD ENERGY   MAX ROAD  DRIVING
 CYC   CYCLE  W/O RGN  W RGN  POWER    SCHEDULE
 SEC    MI        WH/MI        KW

12   60   0.583   173.4  173.4    4.9     CONSPD


ENERGY SUMMARY BASED ON INPUT TO CHARGER AND FUEL TANK USING FRCTUT MODEL-
       AERO    TIRES    BRAKES  DRVLNE MTR/CNTR STR DEV CLUTCH  HT ENG  BATT SYS

15 WH-     43      57       0      11      24       0       0       0      77
16 PRCNT 20.4    26.6     0.0     5.2    11.5     0.0     0.0     0.0    36.2


--------------BATTERY---------------
ENR OUT  ENR IN  PD OUT MX  PD IN MX
   WH/MI                W/LB

20 235.0      0.0      5.1       0.0


      TOTAL     ELECT CONSM    ELECT COST      FINAL STATE
      RANGE      AT WALL     (AT 4.0C/KWH)   BATT   STR DEV
       MI      WH/MI  WH/MI*TON    C/MI                 WH

      92.8      368      224       1.47        0.0      1000.


*******************************************************************************
```

Figure 2-3. Constant Speed Simulation, all Electric

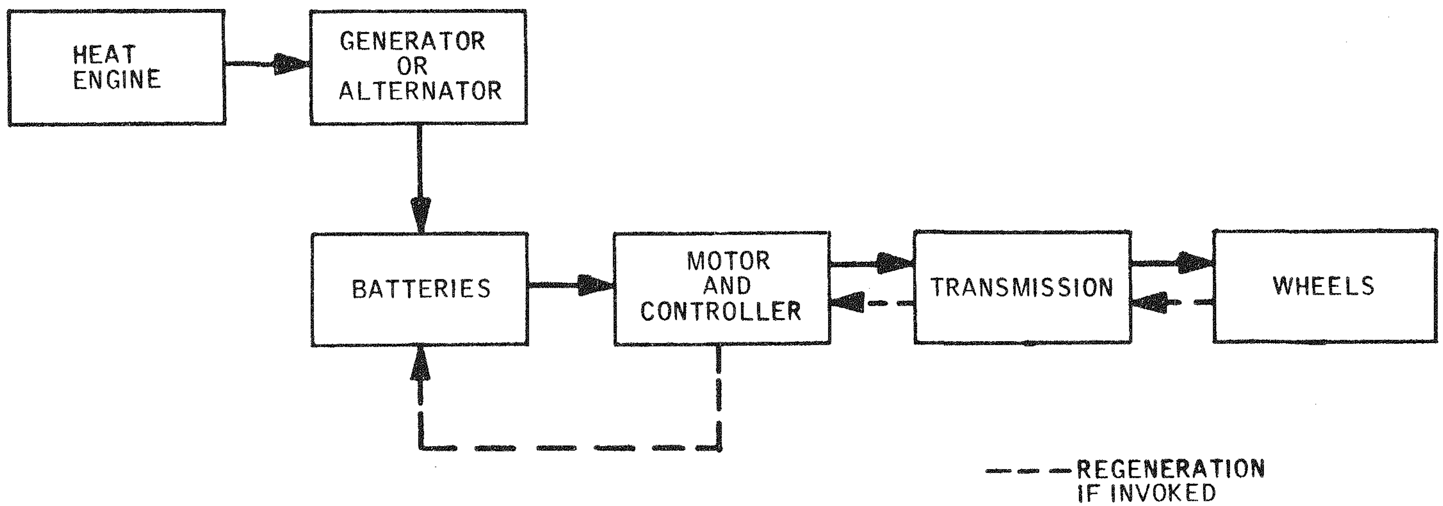



Figure 2-4. FXOP Series Hybrid Configuration

```
 INPUT CHANGES FOR NEXT RUN-
>wb 10401b  wt 51301b  atiref 1.4  cda 15.73ft2  effcm .78
>btsmax 1.0  btsmin 0.8  effalt .77  nregen 1
>namhe bs400  namhyb fxop  namclc manual  spdhe 3600rpm
>gear 3.80,2.06,1.22,0.82
>ratio 0.33,4.125,0.0
>velscd 10mph,20mph,30mph
>pwrhen 9740  detail 1  tstop 10000
>tstrc 265  tftrc 274
>chgeng
 WHICH ENGINE(TYPE =NONE= IF FINISHED)-
>bs400
 WHICH ELEMENT OF KATHE ARRAY TO BE CHANGED (1-18)-
>11
 INPUT NEW VALUE FOR KATHE(11, 1)
>16
 WHICH ENGINE(TYPE =NONE= IF FINISHED)-
>none
>run
 INPUT COMPLETE FOR THIS CASE
 INPUT A 1-78 CHARACTER TITLE FOR THIS CASE-
>fxop series hybrid simulation, j227-d driving cycle..........


FXOP SERIES HYBRID SIMULATION, J227-D DRIVING CYCLE..........
DATE    06/23/78
TIME    09.40.18


TIME/  RANGE/  ROAD ENERGY    MAX ROAD  DRIVING
 CYC   CYCLE  W/O RGN  W RGN  POWER     SCHEDULE
 SEC    MI         WH/MI        KW

 122   0.950   379.3  284.0    47.8     J227D


ENERGY SUMMARY BASED ON INPUT TO CHARGER AND FUEL TANK USING FRCTUT MODEL-
      AERO    TIRES    BRAKES  DRVLNE MTR/CNTR STR DEV CLUTCH  HT ENG  BATT SYS

WH-    132     137       90      49     112       0       27       0      291
PRCNT 15.8    16.3     10.8     5.8    13.4     0.0      3.2     0.0     34.7


--------------BATTERY---------------
ENR OUT  ENR IN  PD OUT MX  PD IN MX
     WH/MI               W/LB

 540.2      0.0     65.5      0.0
 DO YOU WANT TO CONTINUE WITH MORE CYCLES...
>yes
 HOW MANY MORE CYCLES...
>2
```

Figure 2-5A. FXOP Series Hybrid Simulation, J227D

| TIME SEC | SPEED MI/H | ACCL FT/S2 | GEAR | ROAD LD HP | ----MOTOR----- PW,HP | SPD,RPM | ----HEAT ENGINE--- PW,HP | RPM | FL,GPH | BATTERY STATE |
|---|---|---|---|---|---|---|---|---|---|---|
| 265 | 33.6 | 2.3 | 4 | 44.91 | 49.90 | 1468 | 0.0 | 0 | 0.0 | 0.841 |
| 266 | 35.2 | 2.3 | 4 | 47.47 | 52.74 | 1538 | 0.0 | 0 | 0.0 | 0.838 |
| 267 | 36.7 | 2.3 | 4 | 50.08 | 55.64 | 1608 | 0.0 | 0 | 0.0 | 0.834 |
| 268 | 38.3 | 2.3 | 4 | 52.75 | 58.61 | 1677 | 0.0 | 0 | 0.0 | 0.829 |
| 269 | 39.9 | 2.3 | 4 | 55.48 | 61.65 | 1747 | 0.0 | 0 | 0.0 | 0.824 |
| 270 | 41.5 | 2.3 | 4 | 58.28 | 64.76 | 1817 | 0.0 | 0 | 0.0 | 0.818 |
| 271 | 43.1 | 2.3 | 4 | 61.15 | 67.94 | 1887 | 0.0 | 0 | 0.0 | 0.812 |
| 272 | 44.7 | 2.3 | 4 | 64.09 | 71.21 | 1957 | 0.0 | 0 | 0.0 | 0.804 |
| 273 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 0.0 | 0 | 0.0 | 0.804 |
| 273 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 0.0 | 0 | 0.0 | 0.803 |
| 274 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 0.0 | 0 | 0.0 | 0.803 |
| 275 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 0.0 | 0 | 0.0 | 0.802 |
| 276 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 0.0 | 0 | 0.0 | 0.802 |
| 277 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 0.0 | 0 | 0.0 | 0.801 |
| 278 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 0.0 | 0 | 0.0 | 0.800 |
| 279 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 0.0 | 0 | 0.0 | 0.800 |
| 280 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 13.06 | 3600 | 1.39 | 0.799 |
| 281 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 13.06 | 3600 | 1.39 | 0.799 |
| 282 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 13.06 | 3600 | 1.39 | 0.799 |
| 283 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 13.06 | 3600 | 1.39 | 0.798 |
| 284 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 13.06 | 3600 | 1.39 | 0.798 |
| 285 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 13.06 | 3600 | 1.39 | 0.798 |
| 286 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 13.06 | 3600 | 1.39 | 0.798 |
| 287 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 13.06 | 3600 | 1.39 | 0.797 |
| 288 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 13.06 | 3600 | 1.39 | 0.797 |
| 289 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 13.06 | 3600 | 1.39 | 0.797 |

| TIME SEC | SPEED MI/H | ACCL FT/S2 | GEAR | ROAD LD HP | ----MOTOR----- PW,HP | SPD,RPM | ----HEAT ENGINE--- PW,HP | RPM | FL,GPH | BATTERY STATE |
|---|---|---|---|---|---|---|---|---|---|---|
| 290 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 13.06 | 3600 | 1.39 | 0.796 |
| 291 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 13.06 | 3600 | 1.39 | 0.796 |
| 292 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 13.06 | 3600 | 1.39 | 0.796 |
| 293 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 13.06 | 3600 | 1.39 | 0.795 |
| 294 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 13.06 | 3600 | 1.39 | 0.795 |
| 295 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 13.06 | 3600 | 1.39 | 0.795 |
| 296 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 13.06 | 3600 | 1.39 | 0.795 |
| 297 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 13.06 | 3600 | 1.39 | 0.794 |
| 298 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 13.06 | 3600 | 1.39 | 0.794 |
| 299 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 13.06 | 3600 | 1.39 | 0.794 |
| 300 | 44.7 | 0.0 | 4 | 18.17 | 20.19 | 1957 | 13.06 | 3600 | 1.39 | 0.793 |

```
DO YOU WANT TO CONTINUE WITH MORE CYCLES...
>yes
HOW MANY MORE CYCLES...
>20
```

Figure 2-5B. FXOP Series Hybrid Simulation, J227D (cont'd)

```
-----------------HEAT ENGINE-----------------
  FUEL    PWR OUT,HP  AVE EFF  ENGINE    HYBRID
MI/GAL    AVER  PEAK  PERCENT   NAME    STRATEGY

 23.0     11.5  13.1    18.7  BS400       FXOP


         TEST TERMINATED...BATTERY CHARGE TOO LOW


    TOTAL      ELECT CONSM     ELECT COST      FINAL STATE
    RANGE       AT WALL      (AT 4.0C/KWH)   BATT   STR DEV
     MI      WH/MI  WH/MI*TON     C/MI                 WH

      0.0      471       183       1.89       -0.000   1000.

NOTE-RANGE NOT MEANINGFUL FOR HYBRID VEHICLE. ABOVE FIGURES BASED ON  20 CYCLES


*******************************************************************************
```

Figure 2-5C. FXOP Series Hybrid Simulation, J227D (Cont'd)

```
*****************************************************************************

 INPUT CHANGES FOR NEXT RUN-
2 >namcyc j227b   btsmin .999   tstrc 3529   tftrc 3580   run
 INPUT COMPLETE FOR THIS CASE
 INPUT A 1-78 CHARACTER TITLE FOR THIS CASE-
>fxop series hybrid simulation, j227b, min battery .999 ..........


FXOP SERIES HYBRID SIMULATION, J227B, MIN BATTERY .999 ..........
DATE    06/27/78
TIME    14.08.47


TIME/  RANGE/  ROAD ENERGY    MAX ROAD  DRIVING
 CYC   CYCLE  W/O RGN  W RGN  POWER    SCHEDULE
 SEC    MI        WH/MI        KW

  72   0.187   283.2  172.9    13.4    J227B

ENERGY SUMMARY BASED ON INPUT TO CHARGER AND FUEL TANK USING FRCTUT MODEL-
      AERO    TIRES   BRAKES  DRVLNE MTR/CNTR STR DEV CLUTCH  HT ENG  BATT SYS

WH-      4      27      20       7      16       0       8     427       0
PRCNT  1.0     5.3     4.0     1.5     3.2     0.0     1.6    83.3     0.0


--------------BATTERY--------------
ENR OUT  ENR IN  PD OUT MX  PD IN MX
     WH/MI              W/LB

 169.1    189.3     11.2      7.2
21 DO YOU WANT TO CONTINUE WITH MORE CYCLES...
>yes
 HOW MANY MORE CYCLES...
24 >49
```

Figure 2-5D. Series Hybrid Simulation, J227B, BTSMIN = 0.999

| TIME SEC | SPEED MI/H | ACCL FT/S2 | GEAR | ROAD LD HP | ----MOTOR----- PW,HP | SPD,RPM | ----HEAT ENGINE--- PW,HP | RPM | FL,GPH | BATTERY STATE |
|---|---|---|---|---|---|---|---|---|---|---|
| 3529 | 1.0 | 1.5 | 1 | 0.90 | 1.00 | 212 | 0.0 | 0 | 0.0 | 1.000 |
| 3530 | 2.1 | 1.5 | 1 | 1.81 | 2.01 | 424 | 0.0 | 0 | 0.0 | 1.000 |
| 3531 | 3.1 | 1.5 | 1 | 2.71 | 3.02 | 636 | 0.0 | 0 | 0.0 | 1.000 |
| 3532 | 4.2 | 1.5 | 1 | 3.62 | 4.03 | 848 | 0.0 | 0 | 0.0 | 1.000 |
| 3533 | 5.2 | 1.5 | 1 | 4.53 | 5.04 | 1060 | 0.0 | 0 | 0.0 | 1.000 |
| 3534 | 6.3 | 1.5 | 1 | 5.45 | 6.05 | 1273 | 0.0 | 0 | 0.0 | 1.000 |
| 3535 | 7.3 | 1.5 | 1 | 6.37 | 7.08 | 1485 | 0.0 | 0 | 0.0 | 1.000 |
| 3536 | 8.4 | 1.5 | 1 | 7.29 | 8.10 | 1697 | 0.0 | 0 | 0.0 | 0.999 |
| 3537 | 9.4 | 1.5 | 1 | 8.22 | 9.14 | 1909 | 0.0 | 0 | 0.0 | 0.999 |
| 3538 | 10.5 | 1.5 | 2 | 9.16 | 10.18 | 1150 | 0.0 | 0 | 0.0 | 0.999 |
| 3539 | 11.5 | 1.5 | 2 | 10.10 | 11.23 | 1265 | 0.0 | 0 | 0.0 | 0.999 |
| 3540 | 12.6 | 1.5 | 2 | 11.06 | 12.29 | 1380 | 13.06 | 3600 | 1.43 | 0.999 |
| 3541 | 13.6 | 1.5 | 2 | 12.02 | 13.35 | 1495 | 13.06 | 3600 | 1.43 | 0.999 |
| 3542 | 14.7 | 1.5 | 2 | 12.99 | 14.43 | 1610 | 13.06 | 3600 | 1.43 | 0.998 |
| 3543 | 15.7 | 1.5 | 2 | 13.97 | 15.52 | 1725 | 13.06 | 3600 | 1.43 | 0.998 |
| 3544 | 16.7 | 1.5 | 2 | 14.96 | 16.63 | 1840 | 13.06 | 3600 | 1.42 | 0.998 |
| 3545 | 17.8 | 1.5 | 2 | 15.97 | 17.74 | 1955 | 13.06 | 3600 | 1.39 | 0.998 |
| 3546 | 18.8 | 1.5 | 2 | 16.98 | 18.87 | 2070 | 13.06 | 3600 | 1.36 | 0.998 |
| 3547 | 19.9 | 1.5 | 2 | 18.01 | 20.02 | 2185 | 13.06 | 3600 | 1.35 | 0.997 |
| 3548 | 19.9 | 0.0 | 2 | 4.65 | 5.17 | 2185 | 13.06 | 3600 | 1.35 | 0.997 |
| 3548 | 19.9 | 0.0 | 2 | 4.65 | 5.17 | 2185 | 13.06 | 3600 | 1.35 | 0.998 |
| 3549 | 19.9 | 0.0 | 2 | 4.65 | 5.17 | 2185 | 13.06 | 3600 | 1.35 | 0.998 |
| 3550 | 19.9 | 0.0 | 2 | 4.65 | 5.17 | 2185 | 13.06 | 3600 | 1.35 | 0.998 |
| 3551 | 19.9 | 0.0 | 2 | 4.65 | 5.17 | 2185 | 13.06 | 3600 | 1.35 | 0.998 |
| 3552 | 19.9 | 0.0 | 2 | 4.65 | 5.17 | 2185 | 13.06 | 3600 | 1.35 | 0.998 |
| 3553 | 19.9 | 0.0 | 2 | 4.65 | 5.17 | 2185 | 13.06 | 3600 | 1.35 | 0.998 |

Figure 2-5E. FXOP Series Hybrid Simulation, J227B, BTSMIN = 0.99 (Cont'd)

| TIME SEC | SPEED MI/H | ACCL FT/S2 | GEAR | ROAD LD HP | ----MOTOR----- PW,HP | SPD,RPM | ----HEAT ENGINE--- PW,HP | RPM | FL,GPH | BATTERY STATE |
|---|---|---|---|---|---|---|---|---|---|---|
| 3554 | 19.9 | 0.0 | 2 | 4.65 | 5.17 | 2185 | 13.06 | 3600 | 1.35 | 0.998 |
| 3555 | 19.9 | 0.0 | 2 | 4.65 | 5.17 | 2185 | 13.06 | 3600 | 1.35 | 0.998 |
| 3556 | 19.9 | 0.0 | 2 | 4.65 | 5.17 | 2185 | 13.06 | 3600 | 1.35 | 0.998 |
| 3557 | 19.9 | 0.0 | 2 | 4.65 | 5.17 | 2185 | 13.06 | 3600 | 1.35 | 0.998 |
| 3558 | 19.9 | 0.0 | 2 | 4.65 | 5.17 | 2185 | 13.06 | 3600 | 1.35 | 0.998 |
| 3559 | 19.9 | 0.0 | 2 | 4.65 | 5.17 | 2185 | 13.06 | 3600 | 1.35 | 0.998 |
| 3560 | 19.9 | 0.0 | 2 | 4.65 | 5.17 | 2185 | 13.06 | 3600 | 1.35 | 0.998 |
| 3561 | 19.9 | 0.0 | 2 | 4.65 | 5.17 | 2185 | 13.06 | 3600 | 1.35 | 0.998 |
| 3562 | 19.9 | 0.0 | 2 | 4.65 | 5.17 | 2185 | 13.06 | 3600 | 1.35 | 0.998 |
| 3563 | 19.9 | 0.0 | 2 | 4.65 | 5.17 | 2185 | 13.06 | 3600 | 1.35 | 0.998 |
| 3564 | 19.9 | 0.0 | 2 | 4.65 | 5.17 | 2185 | 13.06 | 3600 | 1.35 | 0.998 |
| 3565 | 19.9 | 0.0 | 2 | 4.65 | 5.17 | 2185 | 13.06 | 3600 | 1.35 | 0.998 |
| 3566 | 19.9 | 0.0 | 2 | 4.65 | 5.17 | 2185 | 13.06 | 3600 | 1.35 | 0.998 |
| 3567 | 19.5 | -0.5 | 2 | 0.0 | 0.0 | 2145 | 13.06 | 3600 | 1.35 | 0.998 |
| 3567 | 19.5 | -0.5 | 2 | 0.0 | 0.0 | 2145 | 13.06 | 3600 | 1.35 | 0.999 |
| 3568 | 19.2 | -0.5 | 2 | 0.0 | 0.0 | 2106 | 13.06 | 3600 | 1.35 | 0.999 |
| 3569 | 18.8 | -0.5 | 2 | -0.00 | 0.0 | 2066 | 13.06 | 3600 | 1.35 | 0.999 |
| 3570 | 18.4 | -0.5 | 2 | 0.0 | 0.0 | 2027 | 13.06 | 3600 | 1.35 | 0.999 |
| 3571 | 14.8 | -5.4 | 2 | -31.80 | 0.0 | 1622 | 13.06 | 3600 | 1.35 | 0.999 |
| 3571 | 14.8 | -5.4 | 2 | -31.80 | 0.0 | 1622 | 13.06 | 3600 | 1.35 | 0.999 |
| 3572 | 11.1 | -5.4 | 2 | -23.96 | 0.0 | 1216 | 13.06 | 3600 | 1.35 | 0.999 |
| 3573 | 7.4 | -5.4 | 1 | -16.03 | 0.0 | 1496 | 13.06 | 3600 | 1.35 | 0.999 |
| 3574 | 3.7 | -5.4 | 1 | -8.03 | 0.0 | 748 | 13.06 | 3600 | 1.35 | 1.000 |
| 3575 | 0.0 | -5.4 | 1 | -0.00 | 0.0 | 0 | 13.06 | 3600 | 1.35 | 1.000 |
| 3576 | 0.0 | 0.0 | 1 | 0.0 | 0.0 | 0 | 13.06 | 3600 | 1.35 | 1.000 |
| 3576 | 0.0 | 0.0 | 1 | 0.0 | 0.0 | 0 | 13.06 | 3600 | 1.35 | 1.000 |
| 3577 | 0.0 | 0.0 | 1 | 0.0 | 0.0 | 0 | 13.06 | 3600 | 1.35 | 1.000 |
| 3578 | 0.0 | 0.0 | 1 | 0.0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1.000 |
| 3579 | 0.0 | 0.0 | 1 | 0.0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1.000 |
| 3580 | 0.0 | 0.0 | 1 | 0.0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1.000 |

DO YOU WANT TO CONTINUE WITH MORE CYCLES...

>no

-----------------HEAT ENGINE-----------------

| FUEL MI/GAL | PWR OUT,HP AVER | PEAK | AVE EFF PERCENT | ENGINE NAME | HYBRID STRATEGY |
|---|---|---|---|---|---|
| 13.6 | 6.8 | 13.1 | 19.4 | BS400 | FXOP |

| TOTAL RANGE MI | ELECT CONSM AT WALL WH/MI | WH/MI*TON | ELECT COST (AT 4.0C/KWH) C/MI | FINAL STATE BATT | STR DEV WH |
|---|---|---|---|---|---|
| 0.0 | 0 | 0 | 0.0 | 1.000 | 1000. |

NOTE-RANGE NOT MEANINGFUL FOR HYBRID VEHICLE. ABOVE FIGURES BASED ON 50 CYCLES

Figure 2-5F. FXOP Series Hybrid Simulation, J227B, BTSMIN = 0.999 (Cont'd)

```
*****************************************************************************

 INPUT CHANGES FOR NEXT RUN-
>namcyc conspd   speed 35mph   tstrc 50   tftrc 60   run
 INPUT COMPLETE FOR THIS CASE
 INPUT A 1-78 CHARACTER TITLE FOR THIS CASE-
>fxop series hybrid simulation, 35 mi/hr constant speed.........


FXOP SERIES HYBRID SIMULATION, 35 MI/HR CONSTANT SPEED.........
DATE    06/27/78
TIME    14.18.38
```

| TIME SEC | SPEED MI/H | ACCL FT/S2 | GEAR | ROAD LD HP | ----MOTOR----- PW,HP | SPD,RPM | ----HEAT ENGINE--- PW,HP | RPM | FL,GPH | BATTERY STATE |
|---|---|---|---|---|---|---|---|---|---|---|
| 50 | 35.0 | 0.0 | 4 | 11.30 | 12.56 | 1647 | 13.06 | 3600 | 1.43 | 0.992 |
| 51 | 35.0 | 0.0 | 4 | 11.30 | 12.56 | 1647 | 13.06 | 3600 | 1.43 | 0.992 |
| 52 | 35.0 | 0.0 | 4 | 11.30 | 12.56 | 1647 | 13.06 | 3600 | 1.43 | 0.992 |
| 53 | 35.0 | 0.0 | 4 | 11.30 | 12.56 | 1647 | 13.06 | 3600 | 1.43 | 0.992 |
| 54 | 35.0 | 0.0 | 4 | 11.30 | 12.56 | 1647 | 13.06 | 3600 | 1.43 | 0.992 |
| 55 | 35.0 | 0.0 | 4 | 11.30 | 12.56 | 1647 | 13.06 | 3600 | 1.43 | 0.992 |
| 56 | 35.0 | 0.0 | 4 | 11.30 | 12.56 | 1647 | 13.06 | 3600 | 1.43 | 0.992 |
| 57 | 35.0 | 0.0 | 4 | 11.30 | 12.56 | 1647 | 13.06 | 3600 | 1.43 | 0.992 |
| 58 | 35.0 | 0.0 | 4 | 11.30 | 12.56 | 1647 | 13.06 | 3600 | 1.43 | 0.992 |
| 59 | 35.0 | 0.0 | 4 | 11.30 | 12.56 | 1647 | 13.06 | 3600 | 1.43 | 0.991 |
| 60 | 35.0 | 0.0 | 4 | 11.30 | 12.56 | 1647 | 13.06 | 3600 | 1.43 | 0.991 |

| TIME/ CYC SEC | RANGE/ CYCLE MI | ROAD ENERGY W/O RGN WH/MI | W RGN | MAX ROAD POWER KW | DRIVING SCHEDULE |
|---|---|---|---|---|---|
| 60 | 0.865 | 242.1 | 242.1 | 8.4 | CONSPD |

ENERGY SUMMARY BASED ON INPUT TO CHARGER AND FUEL TANK USING FRCTUT MODEL-

| | AERO | TIRES | BRAKES | DRVLNE | MTR/CNTR | STR DEV | CLUTCH | HT ENG | BATT SYS |
|---|---|---|---|---|---|---|---|---|---|
| WH- | 85 | 124 | 0 | 23 | 65 | 0 | 21 | 1023 | 68 |
| PRCNT | 6.0 | 8.8 | 0.0 | 1.6 | 4.6 | 0.0 | 1.5 | 72.5 | 4.8 |

| --------------BATTERY-------------- ENR OUT WH/MI | ENR IN | PD OUT MX W/LB | PD IN MX |
|---|---|---|---|
| 139.1 | 0.0 | 11.5 | 0.0 |

```
 DO YOU WANT TO CONTINUE WITH MORE CYCLES...
>no
```

Figure 2-5G. FXOP Series Hybrid Simulation, 35 mph Constant Speed

| ------------------ | HEAT ENGINE | ------------------ | | | |
|---|---|---|---|---|---|
| FUEL | PWR OUT,HP | | AVE EFF | ENGINE | HYBRID |
| MI/GAL | AVER | PEAK | PERCENT | NAME | STRATEGY |
| 25.4 | 18.6 | 13.1 | 18.4 | BS400 | FXOP |

| TOTAL | ELECT CONSM | | ELECT COST | FINAL STATE | |
|---|---|---|---|---|---|
| RANGE | AT WALL | | (AT 4.0C/KWH) | BATT | STR DEV |
| MI | WH/MI | WH/MI*TON | C/MI | | WH |
| 0.0 | 218 | 85 | 0.87 | 0.991 | 1000. |

NOTE-RANGE NOT MEANINGFUL FOR HYBRID VEHICLE. ABOVE FIGURES BASED ON 1 CYCLES

*******************************************************************************

Figure 2-5H. FXOP Series Hybrid Simulation, 35 mph Constant Speed (Cont'd)

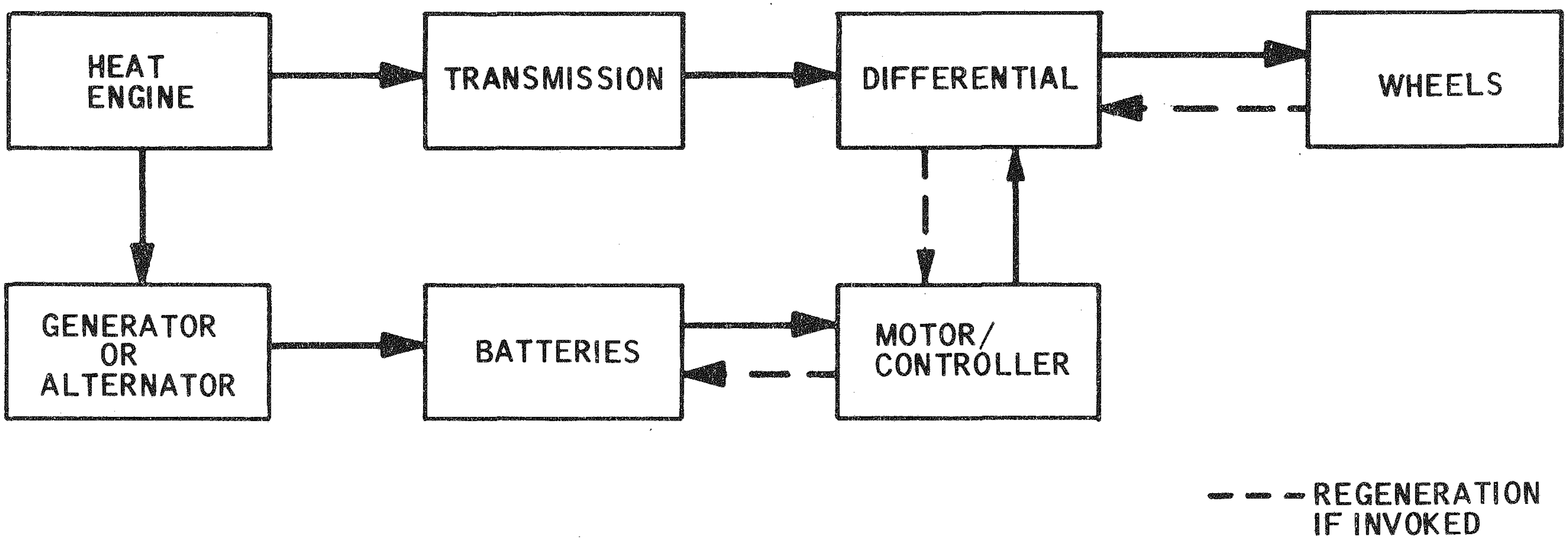



Figure 2-6. CBTOUT and FORDB Parallel Hybrid Configurations

```
 INPUT CHANGES FOR NEXT RUN-
>pdmax 95   namhe nadsl   namhyb cbtout   tstop 10000   namcyc j227d
>tstrc 6100   tftrc 6222   btsmin .75   run
 INPUT COMPLETE FOR THIS CASE
 INPUT A 1-78 CHARACTER TITLE FOR THIS CASE-
>constant battery output (cbtout) strategy, j227-d cycle..........


CONSTANT BATTERY OUTPUT (CBTOUT) STRATEGY, J227-D CYCLE.........
DATE    07/07/78
TIME    15.02.58


TIME/  RANGE/  ROAD ENERGY   MAX ROAD  DRIVING
 CYC   CYCLE  W/O RGN  W RGN  POWER    SCHEDULE
 SEC    MI        WH/MI        KW

 122   0.950   379.1  283.8    47.8    J227D

ENERGY SUMMARY BASED ON INPUT TO CHARGER AND FUEL TANK USING FRCTUT MODEL-
      AERO   TIRES   BRAKES  DRVLNE MTR/CNTR STR DEV CLUTCH  HT ENG  BATT SYS

WH-    132     137      90      49      69       0       0    1012      84
PRCNT  8.4     8.7     5.7     3.1     4.4     0.0     0.1    64.3     5.3

--------------BATTERY---------------
ENR OUT  ENR IN  PD OUT MX  PD IN MX
    WH/MI              W/LB

 232.1     76.6     43.1     13.6
 DO YOU WANT TO CONTINUE WITH MORE CYCLES...
>yes
 HOW MANY MORE CYCLES...
>49

------------------HEAT ENGINE------------------
  FUEL   PWR OUT,HP  AVE EFF  ENGINE    HYBRID
MI/GAL   AVER  PEAK  PERCENT   NAME    STRATEGY

 26.6    13.8  24.3   23.8  NADSL      CBTOUT

         TEST TERMINATED...BATTERY CHARGE TOO LOW

    TOTAL     ELECT CONSM     ELECT COST      FINAL STATE
    RANGE      AT WALL      (AT 4.0C/KWH)    BATT  STR DEV
     MI     WH/MI  WH/MI*TON     C/MI                 WH

      0.0     217       84      0.87       -0.003   1000.

NOTE-RANGE NOT MEANINGFUL FOR HYBRID VEHICLE. ABOVE FIGURES BASED ON  32 CYCLES
```

Figure 2-7A. CBTOUT Hybrid Strategy, J227D

```
 INPUT CHANGES FOR NEXT RUN-
>tstrc 0   tftrc 98   run
 INPUT COMPLETE FOR THIS CASE
 INPUT A 1-78 CHARACTER TITLE FOR THIS CASE-
>cbtout hybrid strategy, j227-d first cycle..........
```

CBTOUT HYBRID STRATEGY, J227-D FIRST CYCLE..........
DATE 07/07/78
TIME 15.06.41

| TIME SEC | SPEED MI/H | ACCL FT/S2 | GEAR | ROAD LD HP | ----MOTOR----- PW,HP | SPD,RPM | ----HEAT ENGINE--- PW,HP | RPM | FL,GPH | BATTERY STATE |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.0 | 2.3 | 1 | 0.0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1.000 |
| 1 | 1.6 | 2.3 | 1 | 1.95 | 2.16 | 323 | 0.0 | 0 | 0.0 | 1.000 |
| 2 | 3.2 | 2.3 | 1 | 3.90 | 4.33 | 647 | 0.0 | 0 | 0.0 | 1.000 |
| 3 | 4.8 | 2.3 | 1 | 5.85 | 6.50 | 971 | 0.0 | 0 | 0.0 | 1.000 |
| 4 | 6.4 | 2.3 | 1 | 7.81 | 8.68 | 1295 | 0.0 | 0 | 0.0 | 1.000 |
| 5 | 8.0 | 2.3 | 1 | 9.78 | 10.87 | 1619 | 0.0 | 0 | 0.0 | 0.999 |
| 6 | 9.6 | 2.3 | 1 | 11.77 | 13.08 | 1943 | 0.0 | 0 | 0.0 | 0.999 |
| 7 | 11.2 | 2.3 | 2 | 13.77 | 15.30 | 1229 | 0.0 | 0 | 0.0 | 0.999 |
| 8 | 12.8 | 2.3 | 2 | 15.79 | 17.55 | 1405 | 0.0 | 0 | 0.0 | 0.998 |
| 9 | 14.4 | 2.3 | 2 | 17.83 | 19.81 | 1580 | 0.0 | 0 | 0.0 | 0.998 |
| 10 | 16.0 | 2.3 | 2 | 19.90 | 22.11 | 1756 | 0.0 | 0 | 0.0 | 0.997 |
| 11 | 17.6 | 2.3 | 2 | 21.99 | 24.43 | 1932 | 0.0 | 0 | 0.0 | 0.996 |
| 12 | 19.2 | 2.3 | 2 | 24.11 | 26.78 | 2107 | 0.0 | 0 | 0.0 | 0.996 |
| 13 | 20.8 | 2.3 | 3 | 26.26 | 29.17 | 1352 | 0.0 | 0 | 0.0 | 0.994 |
| 14 | 22.4 | 2.3 | 3 | 28.44 | 31.60 | 1456 | 0.0 | 0 | 0.0 | 0.993 |
| 15 | 24.0 | 2.3 | 3 | 30.66 | 34.07 | 1560 | 0.0 | 0 | 0.0 | 0.992 |
| 16 | 25.6 | 2.3 | 3 | 32.93 | 36.58 | 1664 | 0.0 | 0 | 0.0 | 0.990 |
| 17 | 27.2 | 2.3 | 3 | 35.23 | 39.14 | 1768 | 0.0 | 0 | 0.0 | 0.988 |
| 18 | 28.8 | 2.3 | 3 | 37.58 | 41.75 | 1872 | 0.0 | 0 | 0.0 | 0.986 |
| 19 | 30.4 | 2.3 | 4 | 39.97 | 44.41 | 1328 | 0.0 | 0 | 0.0 | 0.984 |
| 20 | 32.0 | 2.3 | 4 | 42.42 | 46.88 | 1398 | 0.25 | 1398 | 0.07 | 0.981 |
| 21 | 33.6 | 2.3 | 4 | 44.91 | 46.88 | 1468 | 3.03 | 1468 | 0.38 | 0.978 |
| 22 | 35.2 | 2.3 | 4 | 47.47 | 46.88 | 1538 | 5.87 | 1538 | 0.50 | 0.976 |
| 23 | 36.7 | 2.3 | 4 | 50.08 | 46.88 | 1608 | 8.77 | 1608 | 0.67 | 0.973 |
| 24 | 38.3 | 2.3 | 4 | 52.75 | 46.88 | 1677 | 11.73 | 1677 | 0.81 | 0.970 |
| 25 | 39.9 | 2.3 | 4 | 55.48 | 46.88 | 1747 | 14.77 | 1747 | 1.01 | 0.967 |
| 26 | 41.5 | 2.3 | 4 | 58.28 | 46.88 | 1817 | 17.88 | 1817 | 1.26 | 0.964 |
| 27 | 43.1 | 2.3 | 4 | 61.15 | 46.88 | 1887 | 21.07 | 1887 | 1.54 | 0.961 |
| 28 | 44.7 | 2.3 | 4 | 64.09 | 46.88 | 1957 | 24.33 | 1957 | 1.87 | 0.959 |
| 29 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.959 |
| 29 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.959 |
| 30 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.959 |
| 31 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.959 |
| 32 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.959 |
| 33 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.959 |
| 34 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.959 |

Figure 2-7B. CBTOUT Hybrid Strategy, J227D, First Cycle

| TIME SEC | SPEED MI/H | ACCL FT/S2 | GEAR | ROAD LD HP | ----MOTOR----- PW,HP | SPD,RPM | ----HEAT ENGINE--- PW,HP | RPM | FL,GPH | BATTERY STATE |
|---|---|---|---|---|---|---|---|---|---|---|
| 35 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.959 |
| 36 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.959 |
| 37 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.959 |
| 38 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.959 |
| 39 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.959 |
| 40 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.959 |
| 41 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.959 |
| 42 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.959 |
| 43 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.959 |
| 44 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.959 |
| 45 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.959 |
| 46 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.959 |
| 47 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.959 |
| 48 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.959 |
| 49 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.960 |
| 50 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.960 |
| 51 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.960 |
| 52 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.960 |
| 53 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.960 |
| 54 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.960 |
| 55 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.960 |
| 56 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.960 |
| 57 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.960 |
| 58 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.960 |
| 59 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.960 |
| 60 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.960 |

Figure 2-7C. CBTOUT Hybrid Strategy J227D, First Cycle (Cont'd)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 61 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.960 |
| 62 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.960 |
| 63 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.960 |
| 64 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.960 |
| 65 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.960 |
| 66 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.960 |
| 67 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.960 |
| 68 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.960 |
| 69 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.960 |
| 70 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.960 |
| 71 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.960 |
| 72 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.961 |
| 73 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.961 |
| 74 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.961 |
| 75 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.961 |
| 76 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.961 |
| 77 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.961 |
| 78 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.961 |
| 79 | 44.1 | -0.9 | 4 | 0.0 | -24.33 | 1930 | 24.33 | 1930 | 1.87 | 0.961 |
| 79 | 44.1 | -0.9 | 4 | 0.0 | -24.33 | 1930 | 24.33 | 1930 | 1.87 | 0.961 |
| 80 | 43.5 | -0.9 | 4 | 0.0 | -24.33 | 1903 | 24.33 | 1903 | 1.86 | 0.962 |
| 81 | 42.9 | -0.9 | 4 | 0.0 | -24.33 | 1876 | 24.33 | 1876 | 1.86 | 0.962 |
| 82 | 42.3 | -0.9 | 4 | 0.0 | -24.33 | 1850 | 24.33 | 1850 | 1.85 | 0.962 |
| 83 | 41.7 | -0.9 | 4 | 0.00 | -24.33 | 1824 | 24.33 | 1824 | 1.84 | 0.963 |
| 84 | 41.1 | -0.9 | 4 | 0.00 | -24.33 | 1798 | 24.33 | 1798 | 1.84 | 0.963 |
| 85 | 40.5 | -0.8 | 4 | 0.0 | -24.33 | 1773 | 24.33 | 1773 | 1.83 | 0.963 |
| 86 | 40.0 | -0.8 | 4 | 0.00 | -24.33 | 1748 | 24.33 | 1748 | 1.82 | 0.964 |
| 87 | 39.4 | -0.8 | 4 | 0.00 | -24.33 | 1723 | 24.33 | 1723 | 1.81 | 0.964 |
| 88 | 38.8 | -0.8 | 4 | 0.00 | -24.33 | 1699 | 24.33 | 1699 | 1.80 | 0.965 |
| 89 | 38.8 | -6.3 | 4 | -93.96 | 7.43 | 1699 | 0.0 | 1699 | 0.0 | 0.965 |
| 89 | 34.5 | -6.3 | 4 | -84.70 | 0.0 | 1510 | 0.0 | 0 | 0.0 | 0.965 |
| 90 | 30.2 | -6.3 | 4 | -75.01 | 0.0 | 1322 | 0.0 | 0 | 0.0 | 0.965 |
| 91 | 25.9 | -6.3 | 3 | -64.97 | 0.0 | 1685 | 0.0 | 0 | 0.0 | 0.965 |
| 92 | 21.6 | -6.3 | 3 | -54.62 | 0.0 | 1404 | 0.0 | 0 | 0.0 | 0.965 |
| 93 | 17.3 | -6.3 | 2 | -44.00 | 0.0 | 1897 | 0.0 | 0 | 0.0 | 0.965 |
| 94 | 12.9 | -6.3 | 2 | -33.18 | 0.0 | 1423 | 0.0 | 0 | 0.0 | 0.965 |
| 95 | 8.6 | -6.3 | 1 | -22.21 | 0.0 | 1750 | 0.0 | 0 | 0.0 | 0.965 |
| 96 | 4.3 | -6.3 | 1 | -11.13 | 0.0 | 875 | 0.0 | 0 | 0.0 | 0.965 |
| 97 | 0.0 | -6.3 | 1 | -0.00 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0.965 |
| 98 | 0.0 | 0.0 | 1 | 0.0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0.965 |
| 98 | 0.0 | 0.0 | 1 | 0.0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0.965 |

Figure 2-7D. CBTOUT Hybrid Strategy, J227D, First Cycle (Cont'd)

```
 INPUT CHANGES FOR NEXT RUN-
>tstrc 3661   tftrc 3689   run
 INPUT COMPLETE FOR THIS CASE
 INPUT A 1-78 CHARACTER TITLE FOR THIS CASE-
>cbtout hybrid strategy, j227-d cycle, 30th cycle..........


CBTOUT HYBRID STRATEGY, J227-D CYCLE, 30TH CYCLE..........
DATE    07/07/78
TIME    15.21.22


TIME/  RANGE/  ROAD ENERGY    MAX ROAD  DRIVING
 CYC   CYCLE  W/O RGN  W RGN  POWER     SCHEDULE
 SEC    MI         WH/MI        KW

 122   0.950   379.1  283.8    47.8     J227D

ENERGY SUMMARY BASED ON INPUT TO CHARGER AND FUEL TANK USING FRCTUT MODEL-
      AERO   TIRES   BRAKES  DRVLNE MTR/CNTR STR DEV CLUTCH  HT ENG  BATT SYS

WH-    132    137      90      49      69       0       0    1012      84
PRCNT  8.4    8.7     5.7     3.1     4.4     0.0     0.1    64.3     5.3


--------------BATTERY---------------
ENR OUT  ENR IN  PD OUT MX  PD IN MX
     WH/MI              W/LB

 232.1     76.6     43.1     13.6
 DO YOU WANT TO CONTINUE WITH MORE CYCLES...
>yes
 HOW MANY MORE CYCLES...
>30
```

Figure 2-7E. CBTOUT Hybrid Strategy J227D, Detail During 30th Cycle

| TIME SEC | SPEED MI/H | ACCL FT/S2 | GEAR | ROAD LD HP | ----MOTOR----- PW,HP | SPD,RPM | ----HEAT ENGINE--- PW,HP | RPM | FL,GPH | BATTERY STATE |
|---|---|---|---|---|---|---|---|---|---|---|
| 3661 | 1.6 | 2.3 | 1 | 1.95 | -2.92 | 323 | 5.08 | 800 | 0.42 | 0.050 |
| 3662 | 3.2 | 2.3 | 1 | 3.90 | -0.67 | 647 | 5.00 | 800 | 0.42 | 0.050 |
| 3663 | 4.8 | 2.3 | 1 | 5.85 | 1.50 | 971 | 5.00 | 971 | 0.42 | 0.050 |
| 3664 | 6.4 | 2.3 | 1 | 7.81 | 3.68 | 1295 | 5.00 | 1295 | 0.44 | 0.050 |
| 3665 | 8.0 | 2.3 | 1 | 9.78 | 5.87 | 1619 | 5.00 | 1619 | 0.46 | 0.049 |
| 3666 | 9.6 | 2.3 | 1 | 11.77 | 8.08 | 1943 | 5.00 | 1943 | 0.47 | 0.049 |
| 3667 | 11.2 | 2.3 | 2 | 13.77 | 10.30 | 1229 | 5.00 | 1229 | 0.43 | 0.049 |
| 3668 | 12.8 | 2.3 | 2 | 15.79 | 12.54 | 1405 | 5.00 | 1405 | 0.45 | 0.049 |
| 3669 | 14.4 | 2.3 | 2 | 17.83 | 14.81 | 1580 | 5.00 | 1580 | 0.46 | 0.049 |
| 3670 | 16.0 | 2.3 | 2 | 19.90 | 17.11 | 1756 | 5.00 | 1756 | 0.46 | 0.048 |
| 3671 | 17.6 | 2.3 | 2 | 21.99 | 19.43 | 1932 | 5.00 | 1932 | 0.47 | 0.048 |
| 3672 | 19.2 | 2.3 | 2 | 24.11 | 21.78 | 2107 | 5.00 | 2107 | 0.49 | 0.047 |
| 3673 | 20.8 | 2.3 | 3 | 26.26 | 24.17 | 1352 | 5.00 | 1352 | 0.45 | 0.046 |
| 3674 | 22.4 | 2.3 | 3 | 28.44 | 26.60 | 1456 | 5.00 | 1456 | 0.46 | 0.045 |
| 3675 | 24.0 | 2.3 | 3 | 30.66 | 29.07 | 1560 | 5.00 | 1560 | 0.45 | 0.044 |
| 3676 | 25.6 | 2.3 | 3 | 32.93 | 31.58 | 1664 | 5.00 | 1664 | 0.46 | 0.043 |
| 3677 | 27.2 | 2.3 | 3 | 35.23 | 34.14 | 1768 | 5.00 | 1768 | 0.46 | 0.042 |
| 3678 | 28.8 | 2.3 | 3 | 37.58 | 36.75 | 1872 | 5.00 | 1872 | 0.47 | 0.040 |
| 3679 | 30.4 | 2.3 | 4 | 39.97 | 39.41 | 1328 | 5.00 | 1328 | 0.45 | 0.038 |
| 3680 | 32.0 | 2.3 | 4 | 42.42 | 46.88 | 1398 | 0.25 | 1398 | 0.07 | 0.036 |
| 3681 | 33.6 | 2.3 | 4 | 44.91 | 46.88 | 1468 | 3.03 | 1468 | 0.38 | 0.033 |
| 3682 | 35.2 | 2.3 | 4 | 47.47 | 46.88 | 1538 | 5.87 | 1538 | 0.50 | 0.030 |
| 3683 | 36.7 | 2.3 | 4 | 50.08 | 46.88 | 1608 | 8.77 | 1608 | 0.67 | 0.027 |
| 3684 | 38.3 | 2.3 | 4 | 52.75 | 46.88 | 1677 | 11.73 | 1677 | 0.81 | 0.024 |
| 3685 | 39.9 | 2.3 | 4 | 55.48 | 46.88 | 1747 | 14.77 | 1747 | 1.01 | 0.022 |
| 3686 | 41.5 | 2.3 | 4 | 58.28 | 46.88 | 1817 | 17.88 | 1817 | 1.26 | 0.019 |

| TIME SEC | SPEED MI/H | ACCL FT/S2 | GEAR | ROAD LD HP | ----MOTOR----- PW,HP | SPD,RPM | ----HEAT ENGINE--- PW,HP | RPM | FL,GPH | BATTERY STATE |
|---|---|---|---|---|---|---|---|---|---|---|
| 3687 | 43.1 | 2.3 | 4 | 61.15 | 46.88 | 1887 | 21.07 | 1887 | 1.54 | 0.016 |
| 3688 | 44.7 | 2.3 | 4 | 64.09 | 46.88 | 1957 | 24.33 | 1957 | 1.87 | 0.013 |
| 3689 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.013 |
| 3689 | 44.7 | 0.0 | 4 | 18.17 | -4.14 | 1957 | 24.33 | 1957 | 1.87 | 0.013 |

DO YOU WANT TO CONTINUE WITH MORE CYCLES...

>no

| ------------------HEAT ENGINE------------------ | | | | | |
|---|---|---|---|---|---|
| FUEL MI/GAL | PWR OUT,HP AVER | PEAK | AVE EFF PERCENT | ENGINE NAME | HYBRID STRATEGY |
| 26.5 | 13.8 | 24.3 | 23.8 | NADSL | CBTOUT |

| TOTAL RANGE MI | ELECT CONSM AT WALL WH/MI | WH/MI*TON | ELECT COST (AT 4.0C/KWH) C/MI | FINAL STATE BATT | STR DEV WH |
|---|---|---|---|---|---|
| 0.0 | 211 | 82 | 0.85 | 0.020 | 1000. |

NOTE-RANGE NOT MEANINGFUL FOR HYBRID VEHICLE. ABOVE FIGURES BASED ON 31 CYCLES

Figure 2-7F. CBTOUT Hybrid Strategy J227D, Detail During 30th Cycle (Cont'd)

```
 INPUT CHANGES FOR NEXT RUN-
>namcyc conspd   speed 35mph   tstrc 50   tftrc 60   run
 INPUT COMPLETE FOR THIS CASE
 INPUT A 1-78 CHARACTER TITLE FOR THIS CASE-
>cbtout hybrid strategy, constant speed at 35 mi/hr..........


CBTOUT HYBRID STRATEGY, CONSTANT SPEED AT 35 MI/HR..........
DATE    07/07/78
TIME    15.26.05


TIME   SPEED   ACCL GEAR ROAD LD  ----MOTOR-----  ----HEAT ENGINE---   BATTERY
 SEC   MI/H   FT/S2        HP     PW,HP  SPD,RPM  PW,HP  RPM  FL,GPH    STATE

  50   35.0    0.0   4   11.30  12.56     1531   0.0       0   0.0      0.976
  51   35.0    0.0   4   11.30  12.56     1531   0.0       0   0.0      0.975
  52   35.0    0.0   4   11.30  12.56     1531   0.0       0   0.0      0.975
  53   35.0    0.0   4   11.30  12.56     1531   0.0       0   0.0      0.975
  54   35.0    0.0   4   11.30  12.56     1531   0.0       0   0.0      0.975
  55   35.0    0.0   4   11.30  12.56     1531   0.0       0   0.0      0.974
  56   35.0    0.0   4   11.30  12.56     1531   0.0       0   0.0      0.974
  57   35.0    0.0   4   11.30  12.56     1531   0.0       0   0.0      0.974
  58   35.0    0.0   4   11.30  12.56     1531   0.0       0   0.0      0.973
  59   35.0    0.0   4   11.30  12.56     1531   0.0       0   0.0      0.973
  60   35.0    0.0   4   11.30  12.56     1531   0.0       0   0.0      0.973

TIME/  RANGE/  ROAD ENERGY   MAX ROAD  DRIVING
 CYC   CYCLE  W/O RGN  W RGN  POWER    SCHEDULE
 SEC    MI        WH/MI        KW

  60   0.875   242.1  242.1    8.4    CONSPD

ENERGY SUMMARY BASED ON INPUT TO CHARGER AND FUEL TANK USING FRCTUT MODEL-
      AERO   TIRES   BRAKES  DRVLNE MTR/CNTR STR DEV CLUTCH  HT ENG  BATT SYS

WH-     86     125       0      23      66       0       0       0     171
PRCNT 18.2    26.5     0.0     5.0    14.0     0.0     0.0     0.0    36.3

--------------BATTERY---------------
ENR OUT  ENR IN  PD OUT MX  PD IN MX
     WH/MI              W/LB

 344.9      0.0      11.5      0.0
 DO YOU WANT TO CONTINUE WITH MORE CYCLES...
>no

    TOTAL      ELECT CONSM    ELECT COST      FINAL STATE
    RANGE       AT WALL      (AT 4.0C/KWH)   BATT  STR DEV
     MI      WH/MI  WH/MI*TON    C/MI                  WH

      0.9     541      210       2.16        0.973   1000.

NOTE-RANGE NOT MEANINGFUL FOR HYBRID VEHICLE. ABOVE FIGURES BASED ON   1 CYCLES
```

Figure 2-7G. CBTOUT Hybrid Strategy, Constant Speed at 35 mph

```
     INPUT CHANGES FOR NEXT RUN-
2   >namhyb fordb   namhe turbodsl   namclc drcoup   aclfac .7   namcyc j227d
3   >frchep .6   nregen 2   jbtchg 1   btsmax 1   btsmin .8
4   >detail 1   tstrc 1098   tftrc 1195   tstop 10000   run
     INPUT COMPLETE FOR THIS CASE
     INPUT A 1-78 CHARACTER TITLE FOR THIS CASE-
    >ford-b hybrid strategy, j227-d cycle, 10th cycle..........


    FORD-B HYBRID STRATEGY, J227-D CYCLE, 10TH CYCLE..........
    DATE     07/07/78
    TIME     15.29.59


11  TIME/  RANGE/  ROAD ENERGY    MAX ROAD  DRIVING
     CYC   CYCLE  W/O RGN  W RGN  POWER     SCHEDULE
     SEC    MI        WH/MI         KW

     122   0.991   389.1  297.8    40.1     J227D

    ENERGY SUMMARY BASED ON INPUT TO CHARGER AND FUEL TANK USING FRCTUT MODEL-
           AERO   TIRES   BRAKES  DRVLNE MTR/CNTR STR DEV CLUTCH  HT ENG  BATT SYS

    WH-    139     142      81      51      46       0       0      888      52
    PRCNT  9.9     10.2     5.8     3.7     3.3     0.0     0.0     63.4     3.7


    ---------------BATTERY---------------
    ENR OUT  ENR IN  PD OUT MX  PD IN MX
         WH/MI               W/LB

22   145.8     53.3     31.5     38.6
     DO YOU WANT TO CONTINUE WITH MORE CYCLES...
    >yes
     HOW MANY MORE CYCLES...
26  >9
```

Figure 2-8A. FORDB Hybrid Strategy J227D, Detail During Cycle

| TIME SEC | SPEED MI/H | ACCL FT/S2 | GEAR | ROAD LD HP | ----MOTOR----- PW,HP | SPD,RPM | ----HEAT ENGINE--- PW,HP | RPM | FL,GPH | BATTERY STATE |
|---|---|---|---|---|---|---|---|---|---|---|
| 1098 | 0.0 | 0.0 | 1 | 0.0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1.002 |
| 1099 | 2.2 | 3.1 | 1 | 3.41 | 5.31 | 440 | 0.0 | 440 | 0.0 | 1.002 |
| 1100 | 4.3 | 3.1 | 1 | 6.60 | 0.0 | 870 | 7.34 | 870 | 0.57 | 1.002 |
| 1101 | 6.4 | 3.0 | 1 | 9.60 | 0.0 | 1289 | 10.66 | 1289 | 0.75 | 1.002 |
| 1102 | 8.4 | 2.9 | 1 | 12.41 | 0.0 | 1699 | 13.79 | 1699 | 0.89 | 1.002 |
| 1103 | 10.4 | 2.9 | 2 | 15.05 | 0.21 | 1137 | 16.51 | 1137 | 1.17 | 1.002 |
| 1104 | 12.3 | 2.8 | 2 | 17.54 | 0.39 | 1349 | 19.10 | 1349 | 1.35 | 1.002 |
| 1105 | 14.2 | 2.7 | 2 | 19.89 | 0.78 | 1556 | 21.33 | 1556 | 1.51 | 1.002 |
| 1106 | 16.0 | 2.7 | 2 | 22.11 | 1.64 | 1757 | 22.92 | 1757 | 1.63 | 1.002 |
| 1107 | 17.8 | 2.6 | 2 | 24.21 | 2.41 | 1954 | 24.48 | 1954 | 1.74 | 1.002 |
| 1108 | 19.5 | 2.5 | 2 | 26.20 | 3.10 | 2146 | 26.01 | 2146 | 1.84 | 1.002 |
| 1109 | 21.2 | 2.5 | 3 | 28.08 | 11.59 | 1382 | 19.61 | 1382 | 1.39 | 1.002 |
| 1110 | 22.9 | 2.4 | 3 | 29.87 | 12.27 | 1490 | 20.93 | 1490 | 1.49 | 1.001 |
| 1111 | 24.5 | 2.4 | 3 | 31.58 | 13.31 | 1596 | 21.77 | 1596 | 1.55 | 1.001 |
| 1112 | 26.1 | 2.3 | 3 | 33.21 | 14.30 | 1699 | 22.60 | 1699 | 1.61 | 1.001 |
| 1113 | 27.7 | 2.2 | 3 | 34.76 | 15.21 | 1800 | 23.41 | 1800 | 1.66 | 1.000 |
| 1114 | 29.2 | 2.2 | 3 | 36.24 | 16.08 | 1899 | 24.19 | 1899 | 1.72 | 1.000 |
| 1115 | 30.6 | 2.1 | 4 | 37.67 | 22.70 | 1341 | 19.16 | 1341 | 1.36 | 0.999 |
| 1116 | 32.1 | 2.1 | 4 | 39.03 | 23.43 | 1404 | 19.94 | 1404 | 1.42 | 0.998 |
| 1117 | 33.5 | 2.0 | 4 | 40.34 | 24.13 | 1465 | 20.70 | 1465 | 1.47 | 0.998 |
| 1118 | 34.9 | 2.0 | 4 | 41.61 | 24.97 | 1525 | 21.26 | 1525 | 1.51 | 0.997 |
| 1119 | 36.2 | 1.9 | 4 | 42.82 | 25.85 | 1584 | 21.73 | 1584 | 1.55 | 0.996 |
| 1120 | 37.5 | 1.9 | 4 | 44.00 | 26.69 | 1641 | 22.19 | 1641 | 1.58 | 0.995 |
| 1121 | 38.8 | 1.9 | 4 | 45.14 | 27.51 | 1697 | 22.64 | 1697 | 1.61 | 0.994 |
| 1122 | 40.0 | 1.8 | 4 | 46.23 | 28.29 | 1752 | 23.08 | 1752 | 1.64 | 0.993 |
| 1123 | 41.3 | 1.8 | 4 | 47.30 | 29.04 | 1805 | 23.51 | 1805 | 1.67 | 0.992 |

| TIME SEC | SPEED MI/H | ACCL FT/S2 | GEAR | ROAD LD HP | ----MOTOR----- PW,HP | SPD,RPM | ----HEAT ENGINE--- PW,HP | RPM | FL,GPH | BATTERY STATE |
|---|---|---|---|---|---|---|---|---|---|---|
| 1124 | 42.4 | 1.7 | 4 | 48.33 | 29.77 | 1857 | 23.93 | 1857 | 1.70 | 0.991 |
| 1125 | 43.6 | 1.7 | 4 | 49.34 | 30.48 | 1908 | 24.34 | 1908 | 1.73 | 0.990 |
| 1126 | 44.7 | 1.6 | 4 | 50.31 | 31.17 | 1957 | 24.74 | 1957 | 1.76 | 0.988 |
| 1127 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1127 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1128 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1129 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1130 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1131 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1132 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1133 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |

Figure 2-8B. FORDB Hybrid Strategy, J227D, Detail During 10th Cycle (Cont'd)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1134 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1135 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1136 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1137 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1138 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1139 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1140 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1141 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1142 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1143 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1144 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1145 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1146 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1147 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1148 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1149 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1150 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1151 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1152 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1153 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1154 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1155 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1156 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1157 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1158 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1159 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1160 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1161 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1162 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1163 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1164 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1165 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1166 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1167 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1168 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1169 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1170 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1171 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1172 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1173 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1174 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |

Figure 2-8C. FORDB Hybrid Strategy, J227D, Detail During 10th Cycle (Cont'd)

| TIME SEC | SPEED MI/H | ACCL FT/S2 | GEAR | ROAD LD HP | ----MOTOR----- PW,HP | SPD,RPM | ----HEAT ENGINE--- PW,HP | RPM | FL,GPH | BATTERY STATE |
|---|---|---|---|---|---|---|---|---|---|---|
| 1175 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1176 | 44.7 | 0.0 | 4 | 18.17 | 0.0 | 1957 | 20.19 | 1957 | 1.31 | 0.988 |
| 1177 | 44.1 | -0.9 | 4 | 0.0 | 11.78 | 1930 | 0.0 | 1930 | 0.0 | 0.988 |
| 1177 | 44.1 | -0.9 | 4 | 0.0 | 11.78 | 1930 | 0.0 | 1930 | 0.0 | 0.988 |
| 1178 | 43.5 | -0.9 | 4 | 0.0 | 11.44 | 1903 | 0.0 | 1903 | 0.0 | 0.988 |
| 1179 | 42.9 | -0.9 | 4 | 0.0 | 11.12 | 1876 | 0.0 | 1876 | 0.0 | 0.988 |
| 1180 | 42.3 | -0.9 | 4 | 0.0 | 10.81 | 1850 | 0.0 | 1850 | 0.0 | 0.987 |
| 1181 | 41.7 | -0.9 | 4 | 0.00 | 0.0 | 1824 | 0.00 | 1824 | 0.00 | 0.987 |
| 1182 | 41.1 | -0.9 | 4 | 0.00 | 0.0 | 1798 | 0.00 | 1798 | 0.00 | 0.987 |
| 1183 | 40.5 | -0.8 | 4 | 0.0 | 9.92 | 1773 | 0.0 | 1773 | 0.0 | 0.987 |
| 1184 | 40.0 | -0.8 | 4 | 0.00 | 0.0 | 1748 | 0.00 | 1748 | 0.00 | 0.987 |
| 1185 | 39.4 | -0.8 | 4 | 0.00 | 0.0 | 1723 | 0.00 | 1723 | 0.00 | 0.987 |
| 1186 | 38.8 | -0.8 | 4 | 0.00 | 0.0 | 1699 | 0.00 | 1699 | 0.00 | 0.987 |
| 1187 | 34.5 | -6.3 | 4 | -84.70 | -91.54 | 1510 | 0.82 | 1510 | 0.18 | 0.987 |
| 1187 | 34.5 | -6.3 | 4 | -84.70 | -91.54 | 1510 | 0.82 | 1510 | 0.18 | 0.991 |
| 1188 | 30.2 | -6.3 | 4 | -75.01 | -82.83 | 1322 | 9.53 | 1322 | 0.70 | 0.995 |
| 1189 | 25.9 | -6.3 | 3 | -64.97 | -77.05 | 1685 | 13.95 | 1685 | 0.90 | 0.998 |
| 1190 | 21.6 | -6.3 | 3 | -54.62 | -77.05 | 1404 | 12.32 | 1404 | 0.82 | 1.001 |
| 1191 | 17.3 | -6.3 | 2 | -44.00 | 11.38 | 1897 | 0.0 | 1897 | 0.0 | 1.001 |
| 1192 | 12.9 | -6.3 | 2 | -33.18 | 6.35 | 1423 | 0.0 | 1423 | 0.0 | 1.001 |
| 1193 | 8.6 | -6.3 | 1 | -22.21 | 9.66 | 1750 | 0.0 | 1750 | 0.0 | 1.001 |
| 1194 | 4.3 | -6.3 | 1 | -11.13 | 3.02 | 875 | 0.0 | 875 | 0.0 | 1.001 |
| 1195 | 0.0 | -6.3 | 1 | -0.00 | 0.00 | 0 | 0.0 | 0 | 0.0 | 1.001 |

DO YOU WANT TO CONTINUE WITH MORE CYCLES...

>no

| ------HEAT ENGINE------ FUEL MI/GAL | PWR OUT,HP AVER | PEAK | AVE EFF PERCENT | ENGINE NAME | HYBRID STRATEGY |
|---|---|---|---|---|---|
| 33.4 | 13.1 | 26.0 | 27.7 | TURBODSL | FORDB |

| TOTAL RANGE MI | ELECT CONSM AT WALL WH/MI | WH/MI*TON | ELECT COST (AT 4.0C/KWH) C/MI | FINAL STATE BATT | STR DEV WH |
|---|---|---|---|---|---|
| 0.0 | 90 | 35 | 0.36 | 1.001 | 1000. |

NOTE-RANGE NOT MEANINGFUL FOR HYBRID VEHICLE. ABOVE FIGURES BASED ON 10 CYCLES

Figure 2-8D. FORDB Hybrid Strategy J227D, Detail During 10th Cycle (Cont'd)

```
 INPUT CHANGES FOR NEXT RUN-
>namhe turbodsl   namhyb cbtout    namclc trqcnv
>pdmax 0   run
 INPUT COMPLETE FOR THIS CASE
 INPUT A 1-78 CHARACTER TITLE FOR THIS CASE-
>all heat engine example, j227-d cycle..........


ALL HEAT ENGINE EXAMPLE, J227-D CYCLE..........
DATE    07/07/78
TIME    15.39.49


NOTE-TORQUE CONVERTER DIAMETER HAS BEEN SCALED FROM 10.0 IN. TO  7.1 IN. TO
MATCH ENGINE POWER OF  69 HP AT A MAXIMUM SPEED OF  4999 RPM. IF YOU DO NOT
WANT TO HAVE AUTOMATIC SCALING OCCUR TYPE NO AND CARRIAGE RETURN. OTHERWISE
TYPE YES
AUTOMATIC SCALING...
>yes


TIME/  RANGE/  ROAD ENERGY    MAX ROAD  DRIVING
 CYC   CYCLE  W/O RGN  W RGN  POWER     SCHEDULE
 SEC    MI        WH/MI         KW

 122   0.991   389.1  297.8    40.1     J227D


ENERGY SUMMARY BASED ON INPUT TO CHARGER AND FUEL TANK USING FRCTUT MODEL-
      AERO    TIRES   BRAKES  DRVLNE MTR/CNTR STR DEV CLUTCH  HT ENG  BATT SYS

WH-    139     142       90      51       2       0     170    1942       6
PRCNT  5.5     5.6      3.6     2.0     0.1     0.0     6.7    76.3     0.3


--------------BATTERY---------------
ENR OUT  ENR IN  PD OUT MX  PD IN MX
    WH/MI              W/LB

  11.9      0.0      9.7       0.0
 DO YOU WANT TO CONTINUE WITH MORE CYCLES...
>yes
 HOW MANY MORE CYCLES...
>9
```

Figure 2-9A. All Heat Engine Example, J227D

```
 DO YOU WANT TO CONTINUE WITH MORE CYCLES...
>no


-------------------HEAT ENGINE------------------
  FUEL   PWR OUT,HP  AVE EFF  ENGINE    HYBRID
MI/GAL   AVER  PEAK  PERCENT   NAME    STRATEGY

 17.7    21.9  85.6   24.4  TURBODSL    CBTOUT



    TOTAL      ELECT CONSM    ELECT COST      FINAL STATE
    RANGE       AT WALL      (AT 4.0C/KWH)   BATT   STR DEV
     MI     WH/MI  WH/MI*TON     C/MI                  WH

      0.0      18        7       0.08        0.991   1000.

NOTE-RANGE NOT MEANINGFUL FOR HYBRID VEHICLE. ABOVE FIGURES BASED ON  10 CYCLES
```

Figure 2-9B. All Heat Engine Example, J227D (cont'd)

```
14.31.49 >elvripp
EXECUTION:


GRC ELECTRIC VEHICLE/BATTERY SIMULATION.  VERSION3.2A   8/MAY/78  -

 SPECIFY DESIRED OUTPUT UNITS - METRIC OR ENGLISH . . .
>e
INITIATING BULK READ-
FEDRAL CYCLE. 1372 VALUES READ.
HIWAY  CYCLE.  766 VALUES READ.


CHANGES FOR THIS AND FOLLOWING RUNS-

WB=1300LB  WT=3288LB  ACLFAC=1.0  EFFCB=1  CDA=9.68FT2
ATIREF=1.2  EFFBC=.85  EFFCT=.9,.9,.9,.9
EFFCM=0.82  EFFCD=.75  NAMCYC=J227D  NREGEN=2
GEAR=3.757,2.169,1.404,1.0  RATIO=.29,3.9,1
VELSCD=5.81,10.28,14.75 EFFCFW=0.622
CH=3.178,-0.7279,-0.05863
NCELLS=60 PWRHEN=7500. PDMAX=150. EFFALT=.75
END DATA
WARNING . . .THE VARIABLE DICTIONARY HAS BEEN CHANGED FOR THIS VERSION
(VERSION 3.2  10/MAR/78) OF ELVEC. A NEW DRIVING CYCLE IS AVAILABLE--
MAXACL (MAXIMUM ACCELERATION BEGINNING AT SPEED VINIT). ALSO FOUR TYPES
OF CLUTCHES ARE AVAILABLE--DIRECT COUPLING, MANUAL, TORQUE CONVERTER,
AND CVRT. THE BATTERY STATE LIMITS CAN NOW BE SPECIFIED (BTSMIN AND
BTSMAX).
NAMES OF AVAILABLE HEAT-ENGINE MAPS . . .
BS400       ON782       GM5735      HN1600      GMVEGA140   TR7
TURBODSL    NADSL       IDIDSL      CWSTRATROT  NSUAUDIROT
BULK READ COMPLETE-
 INPUT CHANGES FOR NEXT RUN-
>namhyb cbtout   namhe tr7   namclc manual   namcyc maxacl   delt 0.1
>vinit 0   speed 60mph   velscd 15mph,30mph,50mph   pdmax 0   nprint 10
>run
 INPUT COMPLETE FOR THIS CASE
 INPUT A 1-78 CHARACTER TITLE FOR THIS CASE-
>wide open throttle example..........



WIDE OPEN THROTTLE EXAMPLE..........
DATE    06/26/78
TIME    14.34.32
```

Figure 2-10A. Variable Selection for Wide Open Throttle, PDMAX = 0

WIDE OPEN THROTTLE PERFORMANCE

| TIME S | DIST FT | SPEED MI/HR | ACCEL GEES | LIMIT MECHNSM | BATTERY STATE | BATTERY OUTPT KW | ENGINE OUTPT HP | FLYWHL OUTPT HP | ROAD POWER HP |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 0 | 0.0 | 0.0 | | 1.00 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.00 | 4 | 6.3 | 0.27 | ENGINE | 1.00 | 0.0 | 17.8 | 0.0 | 16.0 |
| 2.00 | 18 | 11.8 | 0.23 | ENGINE | 1.00 | 0.0 | 29.2 | 0.0 | 26.3 |
| 2.64 | 30 | 15.0 | 0.23 | ENGINE | 1.00 | 0.0 | 36.3 | 0.0 | 32.6 |
| 2.84 | 35 | 14.9 | -0.01 | COAST | 1.00 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2.84 | 35 | 14.9 | 0.14 | ENGINE | 1.00 | 0.0 | 22.6 | 0.0 | 20.3 |
| 3.00 | 38 | 15.4 | 0.14 | ENGINE | 1.00 | 0.0 | 23.2 | 0.0 | 20.9 |
| 4.00 | 63 | 18.4 | 0.13 | ENGINE | 1.00 | 0.0 | 26.8 | 0.0 | 24.1 |
| 5.00 | 92 | 21.2 | 0.13 | ENGINE | 1.00 | 0.0 | 30.3 | 0.0 | 27.3 |
| 6.00 | 125 | 24.0 | 0.12 | ENGINE | 1.00 | 0.0 | 33.8 | 0.0 | 30.4 |
| 7.00 | 162 | 26.7 | 0.12 | ENGINE | 1.00 | 0.0 | 37.2 | 0.0 | 33.5 |
| 8.00 | 203 | 29.3 | 0.12 | ENGINE | 1.00 | 0.0 | 40.6 | 0.0 | 36.6 |
| 8.26 | 214 | 30.0 | 0.12 | ENGINE | 1.00 | 0.0 | 41.5 | 0.0 | 37.3 |
| 8.46 | 223 | 29.9 | -0.02 | COAST | 1.00 | 0.0 | 0.0 | 0.0 | 0.0 |
| 8.46 | 223 | 29.9 | 0.07 | ENGINE | 1.00 | 0.0 | 27.9 | 0.0 | 25.1 |
| 9.00 | 247 | 30.8 | 0.07 | ENGINE | 1.00 | 0.0 | 28.7 | 0.0 | 25.8 |
| 10.00 | 294 | 32.4 | 0.07 | ENGINE | 1.00 | 0.0 | 30.1 | 0.0 | 27.1 |
| 11.00 | 342 | 34.0 | 0.07 | ENGINE | 1.00 | 0.0 | 31.4 | 0.0 | 28.2 |
| 12.00 | 393 | 35.6 | 0.07 | ENGINE | 1.00 | 0.0 | 32.6 | 0.0 | 29.4 |
| 13.00 | 447 | 37.1 | 0.07 | ENGINE | 1.00 | 0.0 | 33.9 | 0.0 | 30.5 |
| 14.00 | 502 | 38.6 | 0.07 | ENGINE | 1.00 | 0.0 | 35.1 | 0.0 | 31.6 |
| 15.00 | 560 | 40.1 | 0.07 | ENGINE | 1.00 | 0.0 | 36.3 | 0.0 | 32.7 |
| 16.00 | 620 | 41.5 | 0.07 | ENGINE | 1.00 | 0.0 | 37.5 | 0.0 | 33.8 |
| 17.00 | 682 | 43.0 | 0.06 | ENGINE | 1.00 | 0.0 | 38.7 | 0.0 | 34.8 |
| 18.00 | 746 | 44.4 | 0.06 | ENGINE | 1.00 | 0.0 | 39.9 | 0.0 | 35.9 |
| 19.00 | 812 | 45.7 | 0.06 | ENGINE | 1.00 | 0.0 | 41.0 | 0.0 | 36.9 |
| 20.00 | 880 | 47.1 | 0.06 | ENGINE | 1.00 | 0.0 | 42.2 | 0.0 | 37.9 |
| 21.00 | 950 | 48.4 | 0.06 | ENGINE | 1.00 | 0.0 | 43.3 | 0.0 | 38.9 |
| 22.00 | 1022 | 49.7 | 0.06 | ENGINE | 1.00 | 0.0 | 44.4 | 0.0 | 39.9 |
| 22.20 | 1037 | 50.0 | 0.06 | ENGINE | 1.00 | 0.0 | 44.6 | 0.0 | 40.1 |
| 22.40 | 1051 | 49.9 | -0.03 | COAST | 1.00 | 0.0 | 0.0 | 0.0 | 0.0 |
| 22.40 | 1051 | 49.9 | 0.04 | ENGINE | 1.00 | 0.0 | 32.5 | 0.0 | 29.2 |
| 23.00 | 1095 | 50.3 | 0.03 | ENGINE | 1.00 | 0.0 | 32.9 | 0.0 | 29.6 |
| 24.00 | 1170 | 51.1 | 0.03 | ENGINE | 1.00 | 0.0 | 33.3 | 0.0 | 30.0 |
| 25.00 | 1245 | 51.8 | 0.03 | ENGINE | 1.00 | 0.0 | 33.7 | 0.0 | 30.3 |
| 26.00 | 1322 | 52.6 | 0.03 | ENGINE | 1.00 | 0.0 | 34.1 | 0.0 | 30.7 |
| 27.00 | 1399 | 53.3 | 0.03 | ENGINE | 1.00 | 0.0 | 34.5 | 0.0 | 31.1 |
| 28.00 | 1478 | 54.0 | 0.03 | ENGINE | 1.00 | 0.0 | 35.0 | 0.0 | 31.5 |
| 29.00 | 1558 | 54.7 | 0.03 | ENGINE | 1.00 | 0.0 | 35.4 | 0.0 | 31.8 |
| 30.00 | 1638 | 55.3 | 0.03 | ENGINE | 1.00 | 0.0 | 35.7 | 0.0 | 32.2 |
| 31.00 | 1720 | 56.0 | 0.03 | ENGINE | 1.00 | 0.0 | 36.1 | 0.0 | 32.5 |
| 32.00 | 1803 | 56.6 | 0.03 | ENGINE | 1.00 | 0.0 | 36.5 | 0.0 | 32.9 |
| 33.00 | 1886 | 57.3 | 0.03 | ENGINE | 1.00 | 0.0 | 36.9 | 0.0 | 33.2 |
| 34.00 | 1971 | 57.9 | 0.03 | ENGINE | 1.00 | 0.0 | 37.3 | 0.0 | 33.5 |
| 35.00 | 2056 | 58.5 | 0.03 | ENGINE | 1.00 | 0.0 | 37.6 | 0.0 | 33.9 |
| 36.00 | 2142 | 59.1 | 0.03 | ENGINE | 1.00 | 0.0 | 38.0 | 0.0 | 34.2 |
| 37.00 | 2229 | 59.7 | 0.03 | ENGINE | 1.00 | 0.0 | 38.3 | 0.0 | 34.5 |
| 37.58 | 2280 | 60.0 | 0.03 | ENGINE | 1.00 | 0.0 | 38.5 | 0.0 | 34.6 |

Figure 2-10B. All Heat Engine Wide Open Throttle

```
*******************************************************************************

 INPUT CHANGES FOR NEXT RUN-
>vinit 20.7mph   speed 35.2mph   run
 INPUT COMPLETE FOR THIS CASE
 INPUT A 1-78 CHARACTER TITLE FOR THIS CASE-
>passing performance example..........
```

PASSING PERFORMANCE EXAMPLE..........
DATE 06/26/78
TIME 14.40.04

-----------------------WIDE OPEN THROTTLE PERFORMANCE----------------------

| TIME S | DIST FT | SPEED MI/HR | ACCEL GEES | LIMIT MECHNSM | BATTERY STATE | BATTERY OUTPT KW | ENGINE OUTPT HP | FLYWHL OUTPT HP | ROAD POWER HP |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 0 | 20.7 | 0.0 | | 1.00 | 0.0 | 3.1 | 0.0 | 2.8 |
| 1.00 | 32 | 23.5 | 0.12 | ENGINE | 1.00 | 0.0 | 33.2 | 0.0 | 29.9 |
| 2.00 | 68 | 26.2 | 0.12 | ENGINE | 1.00 | 0.0 | 36.6 | 0.0 | 33.0 |
| 3.00 | 109 | 28.9 | 0.12 | ENGINE | 1.00 | 0.0 | 40.0 | 0.0 | 36.0 |
| 3.43 | 127 | 30.0 | 0.12 | ENGINE | 1.00 | 0.0 | 41.4 | 0.0 | 37.3 |
| 3.63 | 136 | 29.9 | -0.02 | COAST | 1.00 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3.63 | 136 | 29.9 | 0.07 | ENGINE | 1.00 | 0.0 | 27.9 | 0.0 | 25.1 |
| 4.00 | 152 | 30.5 | 0.07 | ENGINE | 1.00 | 0.0 | 28.5 | 0.0 | 25.6 |
| 5.00 | 198 | 32.1 | 0.07 | ENGINE | 1.00 | 0.0 | 29.8 | 0.0 | 26.9 |
| 6.00 | 247 | 33.7 | 0.07 | ENGINE | 1.00 | 0.0 | 31.1 | 0.0 | 28.0 |
| 6.94 | 294 | 35.2 | 0.07 | ENGINE | 1.00 | 0.0 | 32.2 | 0.0 | 29.0 |

*******************************************************************************

Figure 2-10C. Passing-Time and Distance-All Heat Engine

```
 INPUT CHANGES FOR NEXT RUN-
>pdmax 150   run
 INPUT COMPLETE FOR THIS CASE
 INPUT A 1-78 CHARACTER TITLE FOR THIS CASE-
>hybrid wide open throttle example..........
```

```
HYBRID WIDE OPEN THROTTLE EXAMPLE..........
DATE     06/26/78
TIME     14.41.35
```

-----------------------WIDE OPEN THROTTLE PERFORMANCE----------------------

| TIME S | DIST FT | SPEED MI/HR | ACCEL GEES | LIMIT MECHNSM | BATTERY STATE | BATTERY OUTPT KW | ENGINE OUTPT HP | FLYWHL OUTPT HP | ROAD POWER HP |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 0 | 20.7 | 0.0 | | 1.00 | 2.8 | 0.0 | 0.0 | 2.8 |
| 0.88 | 32 | 30.0 | 0.44 | ENGINE | 0.99 | 88.5 | 41.5 | 0.0 | 124.9 |
| 1.08 | 41 | 29.9 | -0.02 | COAST | 0.99 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.08 | 41 | 29.9 | 0.40 | ENGINE | 0.99 | 88.5 | 27.9 | 0.0 | 112.7 |
| 1.74 | 72 | 35.2 | 0.35 | ENGINE | 0.99 | 88.5 | 32.5 | 0.0 | 116.8 |

***********************************************************************************

Figure 2-10D. Passing Time and Distance - Hybrid Mode

```
 INPUT CHANGES FOR NEXT RUN-
>vinit 0   speed 35mph   run
 INPUT COMPLETE FOR THIS CASE
 INPUT A 1-78 CHARACTER TITLE FOR THIS CASE-
>hybrid wide open throttle example ..........


HYBRID WIDE OPEN THROTTLE EXAMPLE ..........
DATE    06/26/78
TIME    14.42.54
```

------------------------WIDE OPEN THROTTLE PERFORMANCE------------------------

| TIME S | DIST FT | SPEED MI/HR | ACCEL GEES | LIMIT MECHNSM | BATTERY STATE | BATTERY OUTPT KW | ENGINE OUTPT HP | FLYWHL OUTPT HP | ROAD POWER HP |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 0 | 0.0 | 0.0 | | 1.00 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.00 | 8 | 11.0 | 0.50 | SLIP | 1.00 | 51.3 | 0.0 | 0.0 | 50.8 |
| 1.37 | 15 | 15.0 | 0.50 | SLIP | 1.00 | 70.3 | 0.0 | 0.0 | 69.5 |
| 1.57 | 19 | 14.9 | -0.01 | COAST | 1.00 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.57 | 19 | 14.9 | 0.50 | SLIP | 1.00 | 70.0 | 0.0 | 0.0 | 69.3 |
| 2.00 | 30 | 19.7 | 0.50 | SLIP | 0.99 | 88.5 | 4.4 | 0.0 | 91.5 |
| 2.97 | 65 | 30.0 | 0.44 | ENGINE | 0.99 | 88.5 | 41.5 | 0.0 | 124.9 |
| 3.17 | 74 | 29.9 | -0.02 | COAST | 0.99 | 0.0 | 0.0 | 0.0 | 0.0 |
| 3.17 | 74 | 29.9 | 0.40 | ENGINE | 0.99 | 88.5 | 27.9 | 0.0 | 112.7 |
| 3.80 | 104 | 35.0 | 0.35 | ENGINE | 0.98 | 88.5 | 32.2 | 0.0 | 116.5 |

******************************************************************************

Figure 2-10E. Zero to 30 mph Hybrid Mode

```
 INPUT CHANGES FOR NEXT RUN-
>pdmax 0   run
 INPUT COMPLETE FOR THIS CASE
 INPUT A 1-78 CHARACTER TITLE FOR THIS CASE-
>all heat engine wide open throttle example..........
```

ALL HEAT ENGINE WIDE OPEN THROTTLE EXAMPLE..........
DATE 06/26/78
TIME 14.44.15

-----------------------WIDE OPEN THROTTLE PERFORMANCE----------------------

| TIME S | DIST FT | SPEED MI/HR | ACCEL GEES | LIMIT MECHNSM | BATTERY STATE | BATTERY OUTPT KW | ENGINE OUTPT HP | FLYWHL OUTPT HP | ROAD POWER HP |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 0 | 0.0 | 0.0 | | 1.00 | 0.0 | 0.0 | 0.0 | 0.0 |
| 1.00 | 4 | 6.3 | 0.27 | ENGINE | 1.00 | 0.0 | 17.8 | 0.0 | 16.0 |
| 2.00 | 18 | 11.8 | 0.23 | ENGINE | 1.00 | 0.0 | 29.2 | 0.0 | 26.3 |
| 2.64 | 30 | 15.0 | 0.23 | ENGINE | 1.00 | 0.0 | 36.3 | 0.0 | 32.6 |
| 2.84 | 35 | 14.9 | -0.01 | COAST | 1.00 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2.84 | 35 | 14.9 | 0.14 | ENGINE | 1.00 | 0.0 | 22.6 | 0.0 | 20.3 |
| 3.00 | 38 | 15.4 | 0.14 | ENGINE | 1.00 | 0.0 | 23.2 | 0.0 | 20.9 |
| 4.00 | 63 | 18.4 | 0.13 | ENGINE | 1.00 | 0.0 | 26.8 | 0.0 | 24.1 |
| 5.00 | 92 | 21.2 | 0.13 | ENGINE | 1.00 | 0.0 | 30.3 | 0.0 | 27.3 |
| 6.00 | 125 | 24.0 | 0.12 | ENGINE | 1.00 | 0.0 | 33.8 | 0.0 | 30.4 |
| 7.00 | 162 | 26.7 | 0.12 | ENGINE | 1.00 | 0.0 | 37.2 | 0.0 | 33.5 |
| 8.00 | 203 | 29.3 | 0.12 | ENGINE | 1.00 | 0.0 | 40.6 | 0.0 | 36.6 |
| 8.26 | 214 | 30.0 | 0.12 | ENGINE | 1.00 | 0.0 | 41.5 | 0.0 | 37.3 |
| 8.46 | 223 | 29.9 | -0.02 | COAST | 1.00 | 0.0 | 0.0 | 0.0 | 0.0 |
| 8.46 | 223 | 29.9 | 0.07 | ENGINE | 1.00 | 0.0 | 27.9 | 0.0 | 25.1 |
| 9.00 | 247 | 30.8 | 0.07 | ENGINE | 1.00 | 0.0 | 28.7 | 0.0 | 25.8 |
| 10.00 | 294 | 32.4 | 0.07 | ENGINE | 1.00 | 0.0 | 30.1 | 0.0 | 27.1 |
| 11.00 | 342 | 34.0 | 0.07 | ENGINE | 1.00 | 0.0 | 31.4 | 0.0 | 28.2 |
| 11.63 | 374 | 35.0 | 0.07 | ENGINE | 1.00 | 0.0 | 32.1 | 0.0 | 28.9 |

**************************************************************************************

Figure 2-10F. Zero to 30 mph, Heat Engine Only

# APPENDIX A

## THE VARIABLE DICTIONARY

Figures A1-A through A1-E list the simulation variables (as defined for ELVEC) which are available for the user to change. Table A-1 lists the vehicle dependent values for the Ripp and GE electrics, and the Garrett electric/flywheel vehicles.

All calculations are performed in ELVEC using the metric units defined in the right-hand column of Figure A1-A, lines 32 through 46. The user can specify different units when changing variables, but the variable units and unit format are restricted to those given in the left-hand column in the same figure. For example, if the user wishes to input a new drag coefficient-frontal area product in English units, he can type the following, where (cr) is the symbol for the "return" key (carriage return) on the terminal:

CDA 8FT2 (cr)

This value of 8.0 $ft^2$ is converted by the program to 0.743224 $m^2$, using the scale factor indicated on line 35 of Figure A1-A. Note that a space must be placed between the last character of the variable name and the first number of the variable value. A space between the last number of the variable value and the first letter of the unit name is optional.

If the user wishes to input several variable changes, he can either use the return key after each selection, or he can concatenate several variables on the same line. For example, the user can designate changes for the drag coefficient-frontal area product, vehicle weight, battery model, heat engine, and hybrid strategy by listing each change separately;

CDA 8FT2 (cr)
WT 1270.06 (cr)
MDLBAT FRCTUT (cr)
NAMHE TR7 (cr)
NAMHYB FXOP (cr)

or the user can effect the same changes by:

CDA 8FT2, WT 1270.06, MDLBAT FRCTUT, NAMHE TR7, NAMHYB FXOP (cr)

Note that no units were designated for the vehicle weight (WT), indicating that the default unit is implied, i.e., kilograms. The user could have specified 2800LB. Also note that each variable is delimited by a comma. There is no limit to the number of variable changes or the number of lines. When the user is finished specifying the changes for the next run, he types:

RUN (cr)

This is indicated on line 26 of Figure A1-A.

If the user wishes to reinstate all of the bulk data values, he can type:

RESTART (cr)

as indicated on line 25. After the user specifies the desired variable changes, and either prior to typing RUN or immediately after the simulation, he may obtain a list of the variable values for the particular simulation by typing:

LIST (cr)

An example of such a list is illustrated in Figure A-2.

When the user wishes to terminate the simulation session, he types:

QUIT (cr)

or STOP (cr)

and can then log off the network as previously indicated in Section I.

Figures A1-B through A1-E list all the variables and arrays, with their definitions. Any or all of these parameters can be changed by the user. The default values of the single variables (Non-array variables) are listed in the far right-hand columns of the figures.

Table A-1. Vehicle-Unique Parameters

| Variable Name | Vehicle | | |
|---|---|---|---|
| | Ripp Electric ELVRIPP | General Electric ELVGE | Garrett AiResearch ELVAIR |
| ACLFAC | 1.0 | 1.0 | 1.0 |
| ATIREF | 1.2 | 1.11 | 1.11 |
| CDA | 9.68 $ft^2$ | 5.8 $ft^2$ | 8.0 $ft^2$ |
| EFFCFW | --- | --- | 0.622 |
| NREGEN | 2 | 2 | 3 |
| WB | 1300 lb | 1092 lb | 1040 lb |
| WFW | --- | --- | 126 kg |
| WT | 3288 lb | 3708 lb | 3466 lb |
| EFFCT | 0.9, 0.9, 0.9, 0.9 | 0.9, 0.9, 0.9, 0.9 | 0.96, 0.96, 0.96, 0.96 |
| GEAR | 3.757,2.169,1.404, 1.0 | 1.0, 1.0, 1.0, 1.0 | 1.0, 1.0, 1.0, 1.0 |
| RATIO | 0.290, 3.90, 1.0 | 0.281, 5.48, 0.0 | 0.281, 5.48, 0.0 |
| VELSCD | 5.81, 10.28, 14.75 | 100., 100., 100. | 100., 100., 100. |
| EFFCM | 0.82 | 0.82 | 1.0 |
| CH | 3.178, -0.7279, -0.05863 | 3.3282, -0.68459, -0.021946 | 3.337, -0.57519, -0.064065 |

```
14.46.33 >print vardir data

ELVEC VERSION 3.2A          08 MAY 78

THIS VERSION INCORPORATES THE HYBRID MODEL UTILIZING HEAT-ENGINE MAPS READ
FROM THE BULK DATA FILE.  THE BULK DATA FILE NOW INCLUDES ALL OF
THE AVAILABLE HEAT-ENGINES.  THE HYBRID MODELS ARE INVOLKED BY SETTING THE
NEW INPUT VARIABLE =NAMHYB= TO ONE OF THREE STRATEGIES---
              CBTOUT    CONSTANT BATTERY OUTPUT (HEAT ENGINE PEAKING)
              FORDB     MODIFIED FORD B
              FXOP      FIXED OPERATING POINT (BATTERY PEAKING)
AS IN VERSIONS 2.0 - 2.3 A HEAT ENGINE MUST BE INVOLKED WITH THE HYBRID
OPTIONS BY SETTING THE VARIABLE =NAMHE= TO ONE OF THE HEAT ENGINES AVAIL-
ABLE (PRINTED AT THE BEGINNING OF THE RUN).

-----------------------------------------------------------------------


DICTIONARY OF KEYWORDS AND OPTIONAL UNIT-NAMES - ELVEC VERSION 3.2

KEYWORD   PROGRAM ACTION
-------   --------------
CHGENG    CHANGE ONE OF THE KATHE ARRAY VALUES FOR A HEAT ENGINE
END       EXECUTE CASE WITH CURRENT DATA
END DATA  EXECUTE CASE WITH CURRENT DATA
HELIST    LIST HEAT-ENGINE DATA FOR ALL HEAT-ENGINE MAPS AVAILABLE
             (VALUES PRINTED FOR EACH ENGINE ARE SAME VALUES AND IN
             SAME SEQUENCE AS READ FROM BULK DATA FILE)
LIST      LIST ALL PROGRAM VARIABLES AND ARRAYS AND THEIR VALUES
QUIT      TERMINATE EXECUTION
RESTART   IMMEDIATELY RE-INITIALIZE AND RESTART PROGRAM FROM BEGINNING
RUN       EXECUTE CASE WITH CURRENT DATA
STOP      TERMINATE EXECUTION
UNITNAME  (FOLLOWED BY 1-4 CHAR. UNIT-NAME FOLLOWED BY ASSOCIATED
             SCALING FACTOR) DEFINES (OR RE-DEFINES) A UNIT-NAME

UNIT-NAME MEANING            SCALING FACTOR      TO CONVERT TO INTERNAL UNIT
--------- -------            --------------      ---------------------------
DEG       DEGREES            0.017453            RADIANS
FT        FEET               0.3048              METERS
FTLB      FOOT-POUNDS        1.355866            NEWTON-METERS
FT2       FEET-SQUARED       0.092903            METERS-SQUARED
HP        HORSEPOWER         746.0               WATTS
KG        KILOGRAMS          1.                  KILOGRAMS
KPH       KILOMETERS/HOUR    0.277777            METERS/SECOND
KM        KILOMETERS         1000.               METERS
LB        POUNDS             0.453592            KILOGRAMS
M         METERS             1.0                 METERS
NM        NEWTON-METERS      1.0                 NEWTON-METERS
MPH       MILES/HOUR         0.44704             METERS/SECOND
PSF       POUNDS/SQ.FEET     4.882428            KILOGRAMS/SQ.METER
RPM       REVS/MINUTE        0.104720            RADIANS/SEC
SEC       SECONDS            1.0                 SECONDS

USER MAY DEFINE NEW UNIT-NAMES OR RE-DEFINE OLD ONES USING THE =UNITNAME=
KEYWORD.  A MAXIMUM OF 16 NEW NAMES IS PERMITTED.

-----------------------------------------------------------------------
```

Figure A1-A. Variable Dictionary

DICTIONARY OF INPUT VARIABLES - ELVEC VERSION 3.2

| VARIABLE NAME | DESCRIPTION | DEFAULT VALUE |
|---|---|---|
| ACLFAC | RATIO OF FINAL TO AVERAGE VALUE FOR EXPONENTIALLY DECREASING ACCELERATION PROFILE | 1. |
| AH20 | 20-HR AMP-HOUR RATING OF BATTERY $ | 21.54 A-H |
| AKCK | FACTOR USED IN KLECKNER MODEL $ | 4.713 |
| ATIREF | TIRE FRICTION COEFFICENT (PERCENT) | 1.3 PERCENT |
| BTSMAX | MAXIMUM ALLOWABLE BATTERY STATE - BASED ON FRACTIONAL AMOUNT OF BATTERY WEIGHT REMAINING (HOXIE AND FRACTIONAL UTILIZATION MODELS). FRATIONAL CHARGE REMAINING (KLECKNER MODEL, BASED ON 20 H RATE). | 0.8 |
| BTSMIN | MINIMUM ALLOWABLE BATTERY STATE - (SEE BTSMAX) | 0. |
| CDA | DRAG-AREA PRODUCT | 0.8993 M2 |
| DELT | DRIVING CYCLE TIME-STEP | 1. S |
| DETAIL | OUTPUT CONTROL (0=MINIMUM OUTPUT,1=INCLUDE TRACE OUTPUT) DEFAULT IS 0 | 0. |
| DTSHFT | TIME DELAY TO SHIFT GEARS DURING IN MAX. ACCEL RUNS | 0.2 S |
| ECHO | FLAG (=ON= OR =OFF= ) INDICATING WHETHER PROGRAM SHOULD REPEAT PRINT OF USER INPUTS. | OFF |
| EFCVRT | EFFICIENCY OF CONTINUOUSLY VARIABLE RATIO TRANSMISSION | 0.8 |
| EFFALT | EFFICIENCY(FRACTIONAL) OF ALTERNATOR/RECTIFIER USED WITH FXOP STRATEGY | 0.75 |
| EFFBC | EFFICIENCY OF BATTERY CHARGER(FRACTIONAL) | 0.85 |
| EFFCB | CHARGE-DISCHARGE EFFICIENCY OF BATTERY WHEN REGENERATIVE BRAKING IS USED | 1.0 |
| EFFCD | CHARGE-DISCHARGE EFFICIENCY OF BATTERY DURING NORMAL CHARGE-DISCHARGE CYCLES | 0.75 |
| EFFCFW | EFFICIENCY OF TRANSMISSION COUPLING FLYWHEEL WITH VEHICLE DRIVELINE | 0.622 |
| EFFCM | EFFICIENCY OF MOTOR(IF SET TO ZERO, THE MOTOR EFFICIENCY IS CALCULATED AT EACH TIME STEP. THIS REQUIRES THAT A DETAILED MOTOR MODEL BE PRESENT.) | 0. |
| EK | FACTOR USED IN KLECKNER MODEL $ | 0.892 |
| ENFWHL | USEABLE ENERGY IN FLYWHEEL FOR CONST. SPEED RUNS | 3.6E6 JOULES |
| FRCHEP | FRACTION OF MAXIMUM POWER AT WHICH ENGINE IS TO OPERATE WHEN BATTERY IS BEING CHARGED (FORDB AND CBTOUT STRATEGIES) | 0.6 |
| GRADE | ROADWAY GRADIENT(TANGENT OF SLOPE ANGLE, PERCENT) | 0. |
| INFORM | FLAG (=CARD= FOR CARD-FORMAT INPUT, =FREE= FOR FREE-FORMAT INPUT) | FREE |
| ITTY | INTERACTIVE MODE FLAG(0=NON-INTERACTIVE, 1=INTERACTIVE) | 1 |
| JBTCHG | FLAG SET TO 1 IF ENGINE IS ALLOWED TO RECHARGE BATTERY IN FORDB STRATEGY (OTHERWISE ALL BATTERY RECHARGE COMES DURING REGENERATIVE BRAKING) | 1 |
| MDLBAT | FLAG (=FRCTUT= FOR FRACTIONAL UTILIZATION BATTERY DISCHARGE MODEL, =HOXIE= FOR HOXIE BATTERY DISCHARGE MODEL, OTHER FOR KLECKNER MODEL) | HOXIE |
| MDLMOT | =GESPEX= FOR G E SEPARATELY EXCITED MOTOR<br>=AIRMOT= FOR AIR RESEARCH SEPARATELY EXCITED MOTOR | GESPEX |
| MOTYP | FLAG (=SERIES= FOR SERIES MOTOR, =SHUNT= FOR SEPARATELY EXCITED MOTOR) | SHUNT |

Figure A1-B. Variable Dictionary (Cont'd)

```
NAMCLC    NAME OF CLUTCH...VALID NAMES ARE-
          DRCOUP   DIRECT COUPLING
          MANUAL   MANUALLY ACTUATED
          TRQCNV   TORQUE CONVERTER
          CVRT     CONTINUOUSLY VARIABLE RATIO TRANSMISSION
NAMCYC    DRIVING SCHEDULE . . .                                J227D
             =J227A=,=J227B=,=J227C=,=J227D= (NEW SAE)
             =MAXACL FOR MAXIMUM ACLERATION RUNS
             =SAERES=,=SAEMET= (OLD SAE)
             =FEDRAL= (EPA URBAN)
             =CONSPD= (CONSTANT SPEED)
             =HIWAY= (EPA HIGHWAY)
NAMHE     NAME OF HEAT-ENGINE TO USE (USED ONLY IF NAMHYB IS SET
          TO ONE OF THE ALLOWABLE OPTIONS). MUST CORRESPOND TO
          ONE OF THE HEAT ENGINES READ FROM THE BULK DATA FILE.
NAMHYB    FLAG FOR HYBRID STRATEGY-
          =        FOR ELECTRIC OF FLYWHEEL ASSISTED VEHICLES
          = FORDB FOR MODIFIED FORDB STRATEGY
          = CBTOUT FOR CONSTANT BATTERY OUTPUT
          = FXOP FOR FIXED OPERATING POINT
NCELLS    NUMBER OF BATTERY CELLS $                             60
NKLINE    NUMBER OF CHARACTERS/OUTPUT-LINE (PROGRAM RECOGNIZES  79
             79 AND 131)
NPPPC     NUMBER OF POSITIVE PLATES/BATTERY-CELL $              9
NPRINT    NUMBER OF TIME STEPS BETWEEN OUTPUTS FOR DETAIL=1     1
NREGEN    REGENERATION FLAG (1= NO REGENERATIVE BRAKING, 2=     1
             REGENERATIVE BRAKING, 3= FLYWHEEL SYSTEM)
PDMAX     MAXIMUM ALLOWABLE BATTERY SPECIFIC POWER DENSITY      150. W/KG
          FOR EITHER DISCHARGE OR CHARGE (DURING VARIOUS HYBRID
          MODES).
PMMX2     POWER LEVEL OF BATTERY OUTPUT FOR NREGEN = 3 OPTION   1. W
          (IF UNKNOWN, THE PROGRAM ITERATES TO FIND PMMX2, BUT
             THE COMPUTATION TAKES LONGER).
PROMPT    PROMPTING SYMBOL USED BY PROGRAM (UNLESS OVER-RIDDEN
             BY SYSTEM PROMPTING)
PWRHEN    HEAT ENGINE OUTPUT POWER SETTING FOR FXOP STRATEGY    7.5 KW
RF        MOTOR FIELD RESISTANCE                                0.0164 OHMS
RI        BATTERY INTERNAL RESISTANCE/POSITIVE PLATE            0.009 OHMS
SPDHE     HEAT ENGINE SPEED SETTING FOR FXOP STRATEGY           3000. RPM
SPEED     SPEED FOR =CONSPD= DRIVING SCHEDULE                   13.41 M/S
TCIN1     TORQUE CONVERTER INPUT INERTIA                        0.108 KG-M2
TCIN2     TORQUE CONVERTER OUTPUT INERTIA                       0.0203 KG-M2
TFTRC     TIME TO TERMINATE DETAILED (DETAIL=1) OUTPUT          1500. S
TOD       TORQUE LOSS IN DIFFERENTIAL                           0. N-M
TSTOP     MAXIMUM TIME TO TERMINATE COMPUTATION                 1500. S
TSTRC     TIME TO BEGIN DETAILED (DETAIL=1) OUTPUT              0. S
VFWD      VOLTAGE DROP ACROSS FREE-WHEELING DIODE PARALLELING   1. V
             MOTOR (NOT PRESENTLY USED)
VINIT     INITIAL SPEED FOR MAX. ACCELERATION RUNS              0. M/S
VMINRG    MINIMUM SPEED AT WHICH REGENERATIVE BRAKING CAN OCCUR 0. M/S
VOC       BATTERY OPEN-CIRCUIT VOLTAGE PER CELL $               2.064 V
VSCR      VOLTAGE DROP ACROSS SILICON-CONTROLLED RECTIFIER IN   1.2 V
             CHOPPER-CONTROLLER (NOT PRESENTLY USED)
VTMIN     MINIMUM BATTERY VOLTAGE PER CELL                      1.75 V
WB        BATTERY MASS                                          589.68 KG
WFW       MASS OF FLYWHEEL ENERGY STORAGE SYSTEM (USED ONLY     100. KG
             TO COMPUTE POWER DENSITIES)
WT        GROSS VEHICLE MASS (AS TESTED)                        1391.44 KG
XMRAT     RATIO OF EFFECTIVE TO STATIC MASS FOR VEHICLE         1.05

****** $ - USED ONLY IN THE [illegible] MODEL
```

Figure A1-C. Variable Dictionary (Cont'd)

DICTIONARY OF INPUT ARRAYS - ELVEC VERSION 3.2

| ARRAY NAME | DESCRIPTION | DIMEN. |
|---|---|---|
| AF2I | COEFFICIENTS USED FOR DETAILED SIMULATION OF SERIES MOTOR TO CALCULATE THE CURRENT (I,AMPS) REQUIRED TO PRODUCE TORQUE (T,NEWTON-METERS) . . . I=AF2I(1) + T*(AF2I(2) + T*(AF2I(3) + T*AF2I(4))) (NEEDED ONLY IF EFFCM IS ZERO) | (4) |
| ARES | COEFFICIENTS USED TO CALCULATE THE EQUIVALENT FIELD AND ARMATURE RESISTANCE (R,OHMS) FOR A GIVEN MOTOR SPEED (S,RADIANS/SEC) AND CURRENT (I,AMPS) . . . R=ARES(1)+S*(ARES(2)+ARES(3)*(S/I)**2)+ARES(4)*(S/I)**2 (NEEDED ONLY IF EFFCM IS ZERO) | (5) |
| CFI | COEFFICIENTS GIVING CAPACITY FACTOR FOR TORQUE CONVERTER. (HP/(RPM**3)) CFI(1) IS CAPACITY FACTOR AT ZERO TORQUE RATIO (STALL) CFI(2),TR(2), AND SRI(1) GO TOGETHER. CFI(3) IS THE CAPACITY FACTOR AT THE COUPLING POINT CFI(4) IS THE CAPACITY FACTOR AT SRI(3)(ABOUT HALF WAY BETWEEN SRI(2) AND UNITY) | (4) |
| CH | COEFFICIENTS USED TO CALCULATE THE BATTERY SPECIFIC POWER DENSITY (PD,WATTS/KG) WHICH A BATTERY CAN MAINTAIN FOR TIME (T,SEC) . . . PD=EXP(CH(1)+CH(2)*ALOG(T/3600)+CH(3)*ALOG(T/3600)**2) | (3) |
| DENS | DENS(1)=GASOLINE SPECIFIC GRAVITY DENS(2)=DIESEL FUEL SPECIFIC GRAVITY | (2) |
| EFFCT | EFFICIENCY OF TRANSMISSION FOR EACH GEAR SPEED (FRACTION) | (4) |
| FEEQV | FEEQV(1)=GASOLINE ENERGY EQUIVALENT(DEFAULT=46.7E6 J/KG) FEEQV(2)=DIESEL FUEL ENERGY EQUIVALENT(DEFAULT=45.6E6 J/KG) | (2) |
| GEAR | TRANSMISSION GEAR RATIO FOR EACH SPEED) | (4) |
| GECON | CONSTANTS NEEDED TO MODEL THE GENERAL ELECTRIC MOTOR (SEE SUBROUTINES CNTRLR AND GEMOT FOR THE MANNER IN WHICH THE CONSTANTS ARE USED) | (14) |
| RATIO | RATIO(1)=DRIVING WHEEL RADIUS, METERS RATIO(2)=DIFFERENTIAL RATIO, INPUT-SPEED/OUTPUT-SPEED RATIO(3)=NOT CURRENTLY USED | (3) |

Figure A1-D. Variable Dictionary (Cont'd)

| | | |
|---|---|---|
| SRI | SPEED RATIO ARRAY FOR CFI AND TRI INPUTS<br>SRI(1) CORRESPONDS TO CFI(2) AND TRI(2)<br>SRI(2) IS THE SPEED RATIO AT THE COUPLING POINT<br>SRI(3) CORRESPONDS TO CFI(4) | (3) |
| TOT | TORQUE LOSS IN TRANSMISSION(FOR EACH GEAR) | (4) |
| TRI | TORQUE RATIO ARRAY FOR TORQUE CONVERTER<br>TRI(1) IS THE STALL TORQUE RATIO<br>TRI(2) CORRESPONDS TO SRI(1) (NEAR THE SPEED RATIO FOR MAXIMUM CAPACITY FACTOR)<br>TRI(3) IS THE COUPLING POINT TORQUE RATIO<br>TRI(4) IS THE TORQUE RATIO AT UNITY SPEED RATIO | (4) |
| VELSCD | SPEED AT WHICH 2ND, 3RD, AND 4TH GEARS ARE ENGAGED(M/S) | (3) |

Figure A1-E. Variable Dictionary (Cont'd) list

```
SCALED VARIABLES FOR THIS RUN-

ACLFAC          1.000000 AH20          21.539993 AKCK            4.713000
ATIREF          1.200000 BTSMAX         0.800000 BTSMIN          0.0
CDA             0.899301 DELT           1.000000 DETAIL          0.0
DTSHFT          0.200000 ECHO      OFF           EFCVRT          0.800000
EFFALT          0.750000 EFFBC          0.850000 EFFCB           1.000000
EFFCD           0.750000 EFFCFW         0.622000 EFFCM           0.820000
EK              0.892000 ENFWHL     0.360000E+07 FRCHEP          0.600000
GRADE           0.0      INFORM    FREE          ITTY               1
JBTCHG             1     MDLBAT    FRCTUT        MDLMOT     GESPEX
MOTYP     SHUNT          NAMCLC    DRCOUP        NAMCYC     J227D
NAMHE                    NAMHYB                  NCELLS            60
NKLINE            79     NPPPC             9     NPRINT             1
NREGEN             2     PDMAX        150.000000 PMMX2           1.000000
PROMPT                   PWRHEN      7500.00000  RF          0.164000E-01
RI          0.900000E-02 SPDHE        314.159912 SPEED          13.410000
TCIN1           0.108480 TCIN2      0.203400E-01 TFTRC        1500.00000
TOD             0.0      TSTOP       1500.00000  TSTRC           0.0
VFWD            1.000000 VINIT          0.0      VMINRG          0.0
VOC             2.064000 VSCR           1.200000 VTMIN           1.750000
WB            589.669434 WFW          126.000000 WT           1491.41040
XMRAT           1.030000
AF2I        0.776461E+01             -0.561570E-01            0.229324E-03
            0.0
ARES        0.797000E-01              0.0                     0.0
            0.0                       0.0
CFI         0.297192E-02              0.275950E-02            0.195205E-02
            0.102572E-02
CH          0.317800E+01             -0.727900E+00           -0.586300E-01

DENS        0.750000E+00              0.840000E+00
EFFCT       0.900000E+00              0.900000E+00            0.900000E+00
            0.900000E+00
FEEQV       0.467000E+08              0.456000E+08
GEAR        0.375700E+01              0.216900E+01            0.140400E+01
            0.100000E+01
GECON       0.414000E+00              0.170000E-02            0.730000E-01
            0.330000E-01              0.254000E-01            0.600000E-02
            0.276000E+01              0.356300E+02            0.314159E+03
            0.149200E+05              0.500500E+02            0.900600E+02
            0.412300E+01              0.488300E+01
RATIO       0.290000E+00              0.390000E+01            0.100000E+01

SRI         0.472000E+00              0.842000E+00            0.920000E+00

TOT         0.0                       0.0                     0.0
            0.0
TRI         0.245000E+01              0.155500E+01            0.998000E+00
            0.998000E+00
VELSCD      0.581000E+01              0.102800E+02            0.147500E+02

XJ          0.0                       0.0                     0.0
```

Figure A-2. Output from "List"

APPENDIX B

OUTPUT VARIABLE DESCRIPTION

This appnedix describes how the output from an all-electric simulation is calculated. Please refer to the sample output, Figure B-1. The different energies will be described mathematically, and the energy data from the sample output will be derived. Remember that all calculations are performed in the metric system, but that the output is scaled to give customary metric or English units. The variables described in this appendix are summarized in Table B-1.

1. Road energy without regeneration, $E_{NRGN}$

$$E_{NRGN} = \frac{C_1}{R} \int \left(P_{AERO} + P_{BRAKES} + P_{TIRES}\right) dt \quad \text{W.hr/mi} \qquad \text{(B1.1)}$$

where

$R$ = range covered during one cycle of the driving schedule, mi

$P_{AERO}$ = power required to overcome aerodynamic drag, watts

$P_{BRAKES}$ = power dissipated in the brakes

$P_{TIRE}$ = power required to overcome rolling resistance, watts

$C_1$ = dimensional constant

From the sample output and output from the case where NREGEN = 1,

$$E_{NRGN} = (\text{AERO} + \text{BRAKES} + \text{TIRES})/R \quad \text{W.hr/mi} \qquad \text{(B1.2)}$$

where $E_{NRGN} = (81 + 60 + 75)/0.961$ W.hr/mi

$= 224.8$ W.hr/mi

NOTE: $P_{BRAKES}$ = 60 W.hr when NREGEN = 1, otherwise $P_{BRAKES} = 0$

The difference between the computer output of 226.3 W.hr/mi (using equation [B1.1] and the hand calculation (equation [B1.2] of 224.8 W.hr/mi, a difference of 0.67% is due to the roundoff of quantities AERO, BRAKES and TIRES before they are printed.

2. Road energy with regeneration, $E_{RGN}$

$$E_{RGN} = \frac{C_1}{R} \int P_{ROAD} \; dt \qquad (B2.1)$$

where

$P_{ROAD}$ = Road load power

From the sample output,

$$E_{RGN} = E_{NRGN} - \left[E_{BATIN}/(EFFCM * EFFCT)\right] \quad W.hr/mi \qquad (B2.2)$$

where

$E_{NRGN}$ = road energy without regeneration
= 226.3 W.hr/mi

$E_{BATIN}$ = energy back to battery from regeneration
= 46.3 W.hr/mi

EFFCM = motor efficiency
= 0.82

EFFCT = transmission efficiency
= 0.9

$E_{RGN}$ = 226.3 - [46.3/(0.82)(0.9)] W.hr/mi
= 163.6 W.hr/mi

3. Energy consumption at the wall, $E_{WALL}$

$$E_{WALL} = \frac{E_{MC} - EFFCB * E_{IN}}{R * EFFBC * EFFCD} \quad W.hr/mi \qquad (B3.1)$$

where

$E_{MC}$ = energy taken from the battery to motor/controller, W.hr

EFFBC = battery charger efficiency

= 0.85

EFFCD = battery charge/discharge efficiency

= 0.75

EFFCB = charge efficiency during regeneration

= 1.0

$E_{IN}$ = energy returned to battery from regeneration, W.hr

From the sample output,

$$E_{WALL} = \frac{Eo - EFFCB * E_{BATIN}}{EFFBC * EFFCD} \quad \text{W.hr/mi} \qquad \text{(B3.2)}$$

where

$Eo = E_{MC}/R$ W.hr/mi

and

$E_{BATIN} = E_{IN}/R$ W.hr/mi

Therefore,

$$E_{WALL} = \frac{306.7 - (1.0)(46.3)}{(0.85)\ (0.75)} \quad \text{W.hr/mi}$$

$$= 408 \quad \text{W.hr/mi}$$

4. Energy cost, $E_{COST}$

$$E_{COST} = E_{WALL} \quad 4¢/1000 \quad \text{W.hr} \quad ¢/\text{mi} \qquad \text{(B.4.1)}$$

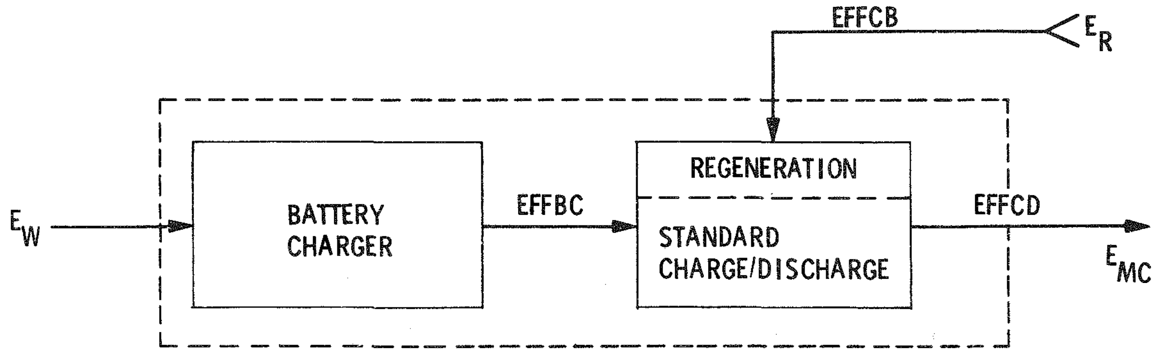
From the sample output,

$E_{COST}$ = 408 * 4¢/1000

= 1.63 ¢/mi

5. Battery System losses energy, $E_{BSL}$

Refer to the diagram below:




$E_W$ = $(E_{WALL})$ (CYCLE RANGE) = 392 W.hr

EFFBC, EFFCD, EFFCB } Efficiencies as described in Appendix A

$E_R$ = regeneration energy, W.hr

= $(E_{BATIN})$ (cycle range) = 44.5 W.hr

$E_{MC}$ = energy to motor-controller, W.hr

Also, $E_{MC} = (E_R)\,(EFFCB) + (E_W)\,(EFFBC)\,(EFFCD)$

The battery system loss is

$$E_{BSL} = E_W + E_R - E_{MC} \quad W.hr \tag{B5.1}$$

or

$$E_{BSL} = E_W + E_R - (E_R * EFFCB + E_W * EFFBC * EFFCD) \tag{B5.2}$$

or

$$E_{BSL} = E_W\,(1-EFFBC * EFFCD) + E_R\,(1-EFFCB) \quad W.hr \tag{B5.3}$$

$$= \frac{E_{MC} - E_R * EFFCB}{EFFBC * EFFCD} * (1-EFFBC * EFFCD)$$

$$+ E_R\,(1-EFFCB) \quad W.hr \tag{B5.4}$$

$$= E_{MC} \left( \frac{1}{EFFBC * EFFCD} - 1 \right) + E_R$$

$$* \left( 1\text{-}EFFCB - \frac{EFFCB}{EFFBC * EFFCD} + EFFCB \right) \qquad (B5.5)$$

and finally,

$$E_{BSL} = E_{MC} \left( \frac{1}{EFFBC * EFFCD} - 1 \right) + E_R$$

$$* \left( 1 - \frac{EFFCB}{EFFBC * EFFCD} \right) \text{ W.hr} \qquad (B5.6)$$

From the example then,

$$E_{BSL} = (306.7)\ (0.961) \left( \frac{1}{(0.85)\ (0.75)} - 1 \right)$$

$$+ (46.3)\ (0.961) \left( 1 - \frac{1}{(0.85)\ (0.75)} \right) \text{ W.hr}$$

$$E_{BSL} = 142.4 \text{ W.h}$$

6. Battery output energy, $E_{MC}$, $E_R$

$$E_{MC} = C_2/R \int MAX \left[ 0, P_{BAT} \right] dt \qquad \text{W.hr} \qquad (B6.1)$$

$$E_R = -C_2/R \int MIN \left[ 0, P_{BAT} \right] dt \qquad \text{W.hr} \qquad (B6.2)$$

where

$E_{MC}$ = energy furnished by the battery to the motor-controller, W.hr

$E_R$ = energy furnished by the motor-controller (or alternator-rectifier) to the battery, W.hr

$C_2$ = dimension constant

$P_{BAT}$ = instantaneous battery output power, watts

Table B-1. DEFINITION OF VARIABLES

| | |
|---|---|
| AERO | Energy loss due to drag, W.hr |
| $C_1$ | Constant to adjust units |
| $C_2$ | Constant to adjust units |
| CYCLE RANGE | Driving schedule range (see R below), mi |
| $E_o$ | Energy to motor-controller = $E_{MC}/R$ W.hr/mi |
| $E_{BATIN}$ | Energy back to battery from regeneration, W.hr/mi |
| $E_{BSL}$ | Battery system energy losses, W.hr |
| $E_{COST}$ | Energy cost at wall plug, ¢/mi |
| EFFBC | Battery charger efficiency, fraction |
| EFFCB | Charger efficiency, fraction |
| EFFCD | Battery charge/discharge efficiency, fraction |
| EFFCM | Motor efficiency, fraction |
| EFFCT | Transmission efficiency, fraction |
| $E_{IN}$ | Energy returned to battery (CHARGER + REGEN), W.hr |
| $E_{MC}$ | Energy to motor-controller, W.hr |
| $E_{NRGN}$ | Road energy loss per cycle, without regeneration, W.hr |
| $E_R$ | Regeneration energy, W.hr |
| $E_{RGN}$ | Road energy loss per cycle with regeneration, W.hr |
| $E_W$ | Energy wall cost, $E_W = (E_{WALL})$ (R), W.hr |
| $E_{WALL}$ | Energy consumption at wall plug, W.hr/mi |
| $P_{AERO}$ | Power required to overcome aero drag, watts |
| $P_{BAT}$ | Instantaneous battery power, watts |
| $P_{BRAKES}$ | Power dissipated in the brakes, watts |
| $P_{ROAD}$ | Power back into battery (regeneration), watts |
| $P_{TIRES}$ | Power required to overcome rolling resistance, watts |
| R | Driving schedule range for one cycle, mi |
| TIRES | Energy loss due to rolling resistance, W.hr |

```
OUTPUT VARIABLE DEFINITIONS..........
DATE     07/24/78
TIME     10.05.37


TIME/  RANGE/  ROAD ENERGY    MAX ROAD  DRIVING
 CYC   CYCLE   W/O RGN  W RGN  POWER    SCHEDULE
 SEC    MI        WH/MI         KW

 122   0.961   226.3  163.6    29.9     J227D


ENERGY SUMMARY BASED ON INPUT TO CHARGER AND FUEL TANK USING FRCTUT MODEL-
        AERO    TIRES   BRAKES  DRVLNE MTR/CNTR STR DEV CLUTCH  HT ENG  BATT SYS

WH-      81      75       0       30      62       0       0       0      142
PRCNT  20.8    19.2     0.0      7.7    16.0     0.0     0.0     0.0     36.3


--------------BATTERY---------------
ENR OUT  ENR IN  PD OUT MX  PD IN MX
     WH/MI              W/LB

 306.7     46.3     31.1      26.5


     TOTAL       ELECT CONSM     ELECT COST       FINAL STATE
     RANGE        AT WALL       (AT 4.0C/KWH)    BATT   STR DEV
      MI      WH/MI  WH/MI*TON      C/MI                   WH

      49.1     408       248        1.63          0.0     1000.


********************************************************************************
```

Figure B-1. Output Variable Definitions

# APPENDIX C

## DATA STORED FOR HEAT ENGINES

There are eleven heat engines available for use by ELVEC. The operating data for these are summarized in the following figures. Any one of these can be used when a hybrid simulation is selected.

The heat engine maps are stored as arrays within the data files of the ELVEC program. To print these arrays, the user selects the engine of interest from Table C-1. The user types HELIST, as indicated in line 1 of Figure C-1. The system asks which engine, and the user types the appropriate choice, using the proper name indicated in Table C-1. Figure C-1 (the engine map for the Honda HN1600 engine) is used as an example to describe the engine map array and associated parameters.

Line 4 indicates the engine name. In line 5, the number 197 is an index number in the array named HETAB, and indicates where the data begins for this heat engine. The next number in the row (moving to the right) indicates that there are 10 limit boundary pairs. This can be seen in Figure C-2, where the data from Figure C-1 has been rearranged into a more conventional configuration. The next number in the row indicates that there are 9 fractional rpm rows within the actual map. Again, this can be seen in Figure C-2. The next number to the right in line 5 of Figure C-1 (the number 10) indicates the number of fractional power columns in the map. The next number (to the right) is a fuel flag: 1 for gasoline, 2 for diesel.

Moving down to the next row (line 6 of Figure C-1), the 5500 indicates the maximum rpm of the engine. The following numbers are defined for this row of Figure C-1:

| Number | Definition |
|---|---|
| 5500 | Max rpm |
| 50 | Max power |
| 1.05 | Idle Fuel consumption |
| 1.00 | Torque multiplier |
| 1000 | FORDB cut-in engine rpm |
| 0.0117 | Fuel to start engine |

| Number | Definition |
|---|---|
| 0.0400 | Engine inertia |
| 800.0 | Idle rpm |
| 0.0 | Not used |

Figure C-2 gives the units in the rearranged configuration.

Starting on line 7, the numbers appearing in each row are the specific fuel consumption for this particular engine and can be correlated with the rearranged array of Figure C-2.

Each engine map is stored in this manner, and computer rearrangements are illustrated in Figures C-3A through C-13B for user information.

Certain properties of the engines can be scaled, including maximum horsepower and maximum rpm. Other properties can be changed by the user. Table C-3 lists the elements of the heat engine catalog. Any element in this list may be changed, with the exception of element No. 5, which is locked out to the user. To change an element in KATHE (Table C-3), type "CHGENG." The program will guide the user.

Table C-1. Heat Engine Map Choices

| Simulator Mfg/Designation | Displacement ($cm^3$) | HP at MAX RPM | Description |
|---|---|---|---|
| 1. Briggs & Stratton BS400 | 400 | 11 at 3600 | 1 Cyl Horizontal |
| 2. Onan ON782 | 782 | 14 at 3600 | 2 Cyl Opposed |
| 3. General Motors GM5735 | 5736 (350 CID) | 150 at 3800 | V8 (1975) |
| 4. Honda HN1600 | 1600 | 50 at 5500 | Honda CVCC |
| 5. General Motors GMVEGA140 | 2294 | 80 at 4000 | GM VEGA, 140 CID, (1975) |
| 6. Triumph TR7 | 2000 | 86 at 6000 | Slant 4 Cyl |
| 7. Volkswagen TURBODSL | 1471 | 70 at 5000 | VW Rabbit Diesel, Turbocharged |
| 8. Volkswagen NADSL | 1471 | 50 at 5000 | VW Rabbit, Diesel, Naturally Aspirated |
| 9. British Leyland IDIDSL (Rover) | 2300 | 60 at 4000 | Indirect Injection Diesel |
| 10. Curtis Wright CWSTRATROT | 983 | 75 at 4500 | Stratified Charge Single Rotor Rotary |
| 11. NSU/AUDI NSUAUDIROT | 750/Rotor (1500 Total) | 170 at 6500 | 2 Rotor Rotary |

Table C-2. Tabulation of Heat Engine Data

| Engine | HP | CID/ℓ | Idle | | Fuel | |
|---|---|---|---|---|---|---|
| | | | RPM | Fuel Flow (lb/hr) | LB/GAL | Heat Value (Btu/lb) |
| Briggs & Stratton | 11 | 0.4ℓ | 1800 | 1.04-1.6 | 6.1 | 18900 |
| Onan | 14.4 | 48 | 1200 | 1.5-2.0 | 6.1 | 18900 |
| GM 350 CID | 150 | 350 | 800 | 4.9 | 6.1 | 18900 |
| Honda CVCC | 50 | 1.6ℓ | 800 | 0.9-1.2 | 6.1 | 18900 |
| GM 140 CID | 95 | 140 | 850 | 2.2-2.7 | 6.1 | 18900 |
| VW Rabbit Diesel TC | 70 | 90 | 650 | 0.6 | 7.42 | 18390 |
| VW Rabbit Diesel NA | 50 | 90 | 650 | 0.6 | 7.42 | 18390 |
| Rover Diesel | 60 | 2.3ℓ | 650 | 1.0 | 7.42 | 18390 |
| C-W Stratified Rotary | 75 | 60 | 500 | 1.0* | 6.1 | 18900 |
| NSU Rotary | 170 | 3ℓ | 700 | 3.0 | 6.1 | 18900 |
| TR-7 Slant 4 | 86 | 122 | 950 | 2.3 | 6.1 | 18900 |

*Add 0.4 lb/hr for accessory, e.g., air conditioning

Table C-3. Kathe - The Heat Engine Catalog

| Kathe Array Element | Type | Description |
|---|---|---|
| 1 - 3 | HOLLERITH | Name of the Ith engine (up to 10 characters) |
| 4 | HOLLERITH | Not used |
| 5 | INTEGER | Location of start-of-data for Ith engine (not available for user change) |
| 6 | INTEGER | Number of fractional peak horsepower/fractional rpm pairs in the engine map |
| 7 | INTEGER | Number of fractional rpm grid points in the engine map |
| 8 | INTEGER | Number of fractional horsepower grid points in the engine map |
| 9 | INTEGER | Fuel type (1 = gasoline, 2 = diesel) |
| 10 | REAL | Maximum rpm |
| 11 | REAL | Peak horsepower |
| 12 | REAL | Idle fuel consumption (gal/hr) |
| 13 | REAL | Factor for torque required to turn nonrunning engine (FORDB only), ft-lb |
| 14 | REAL | Speed at which the engine starts (FORDB only), rpm |
| 15 | REAL | Fuel to start engine, lb |
| 16 | REAL | Engine inertia, ft-lb-$s^2$ |
| 17 | REAL | Engine idle speed, rpm |
| 18 | REAL | Not Used |

```
1   HELIST
2    WHICH ENGINE-
3   >HN1600

4   HN1600
5   KATHE(5-18, 4)        197       10        9        10        1
6     5500.0     50.0     1.05      1.00   1000.0   0.0117   0.0400    800.0       0.0

7     0.2400   0.2700   0.5100   0.6500   0.7600   0.8700   0.9500   1.0000   0.9900
      0.9600   0.1820   0.2730   0.3640   0.4550   0.5450   0.6360   0.7270   0.8180
9     0.9090   1.0000   0.1820   0.3640   0.4550   0.5460   0.6360   0.7270   0.8180
      0.9090   1.0000   0.1000   0.2000   0.3000   0.4000   0.5000   0.6000   0.7000
11    0.8000   0.9000   1.0000   1.7000   1.9000   1.5000   1.9000   2.0000   2.0000
      2.0000   2.0000   1.9600   0.9600   0.9500   0.8550   0.9750   1.0300   1.1200
13    1.1400   1.4000   1.7000   0.8600   0.7900   0.6970   0.7950   0.7850   0.8650
      0.8100   0.9750   1.4700   0.7600   0.7100   0.6100   0.6870   0.6590   0.7200
15    0.6550   0.8250   1.2700   0.6550   0.6550   0.5540   0.6200   0.5810   0.6200
      0.5850   0.7250   1.0900   0.5720   0.5470   0.5080   0.5600   0.5400   0.5500
17    0.5540   0.6650   0.9420   0.5250   0.4910   0.4680   0.5100   0.5160   0.5160
      0.5550   0.6250   0.8210   0.4990   0.4410   0.4400   0.4700   0.5050   0.5050
19    0.5250   0.6250   0.7290   0.4890   0.4430   0.4400   0.4700   0.5000   0.5060
      0.5250   0.6250   0.6640   0.4830   0.4950   0.4900   0.5500   0.5000   0.5000
21    0.5250   0.6250   0.6270
```

Figure C-1. Output from "Helist"

| LIMIT BOUNDARY | | FRACTIONAL POWER vs SPECIFIC FUEL CONSUMPTION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| hp/MAX hp | rpm/MAX rpm | .10 | .20 | .30 | .40 | .50 | .60 | .70 | .80 | .90 | 1.0 |
| .24 | .182 | 1.7 | .98 | .86 | .76 | .655 | .572 | .525 | .499 | .489 | .483 |
| .37 | .273 | – | – | – | – | – | – | – | – | – | – |
| .51 | .364 | 1.9 | .95 | .79 | .71 | .655 | .547 | .491 | .441 | .443 | .495 |
| .65 | .455 | 1.5 | .855 | .697 | .61 | .554 | .508 | .468 | .44 | .44 | .49 |
| .76 | .545 | 1.9 | .975 | .795 | .687 | .62 | .56 | .51 | .47 | .47 | .55 |
| .87 | .636 | 2.0 | 1.03 | .785 | .659 | .581 | .54 | .516 | .505 | .5 | .5 |
| .95 | .727 | 2.0 | 1.12 | .865 | .72 | .62 | .55 | .516 | .505 | .506 | .5 |
| 1.0 | .818 | 2.0 | 1.14 | .81 | .655 | .585 | .554 | .535 | .525 | .525 | .525 |
| .99 | .909 | 2.0 | 1.4 | .975 | .825 | .725 | .665 | .625 | .625 | .625 | .625 |
| .96 | 1.00 | 1.96 | 1.7 | 1.47 | 1.27 | 1.09 | .942 | .821 | .729 | .664 | .627 |

| | |
|---|---|
| ENGINE DISPLACEMENT | 1600 cc |
| HETAB INDEX | 197 |
| OF LIMIT BOUNDARY PAIRS | 10 |
| FRACTIONAL SPEED ROWS | 9 |
| FRACTIONAL POWER COLUMNS | 10 |
| FUEL FLAG (1 = GASOLINE; 2 DIESEL) | 1 |

| | |
|---|---|
| MAX rpm | 5500 |
| MAX hp | 50 |
| IDLE FUEL CONSUMPTION | 1.05 lb/hr |
| TORQUE MULTIPLIER | 1.0 |
| MIN rpm | 1000 |
| STARTUP FUEL | 0.0117 lb |
| ENGINE INERTIA | 0.0400 ft-$s^2$ |
| IDLE rpm | 800 |

Figure C-2. Engine: Honda CVCC (Rearranged Data from Figure C-1)

ENGINE: BS400

MAXIMUM POWER: 11.0 HP
MAXIMUM RPM: 3600.0
MINIMUM RPM: 1000.0
FUEL TYPE: GASOLINE

ENGINE MAXIMUM OPERATING BOUNDARY -

| RPM | POWER | FRACT RPM | FRACT POWER |
|---|---|---|---|
| 1800. | 5. | .5000 | .4590 |
| 2098. | 6. | .5830 | .5730 |
| 2397. | 7. | .6660 | .6780 |
| 2700. | 8. | .7500 | .7920 |
| 2998. | 9. | .8330 | .8680 |
| 3301. | 10. | .9170 | .9410 |
| 3600. | 11. | 1.0000 | 1.0000 |

FUEL CONSUMPTION - (LB/HP/HR)

| RPM, VALUE/ FRACTION | POWER, VALUE/FRACTION | | | |
|---|---|---|---|---|
| | 2./ .250 | 5./ .500 | 8./ .750 | 11./ 1.000 |
| 1800./ .500 | 1.6700 | 1.0700 | .9280 | .8520 |
| 2098./ .583 | 1.5900 | 1.0900 | .8900 | .7940 |
| 2397./ .666 | 1.5100 | 1.0400 | .8340 | .7400 |
| 2700./ .750 | 1.4100 | .9240 | .7520 | .6890 |
| 2998./ .833 | 1.3900 | .8970 | .7400 | .6700 |
| 3301./ .917 | 1.3600 | .8810 | .7370 | .6570 |
| 3600./ 1.000 | 1.4100 | .9050 | .7950 | .6540 |

**Figure C-3A. Engine Map, Briggs & Stratton - BS400**

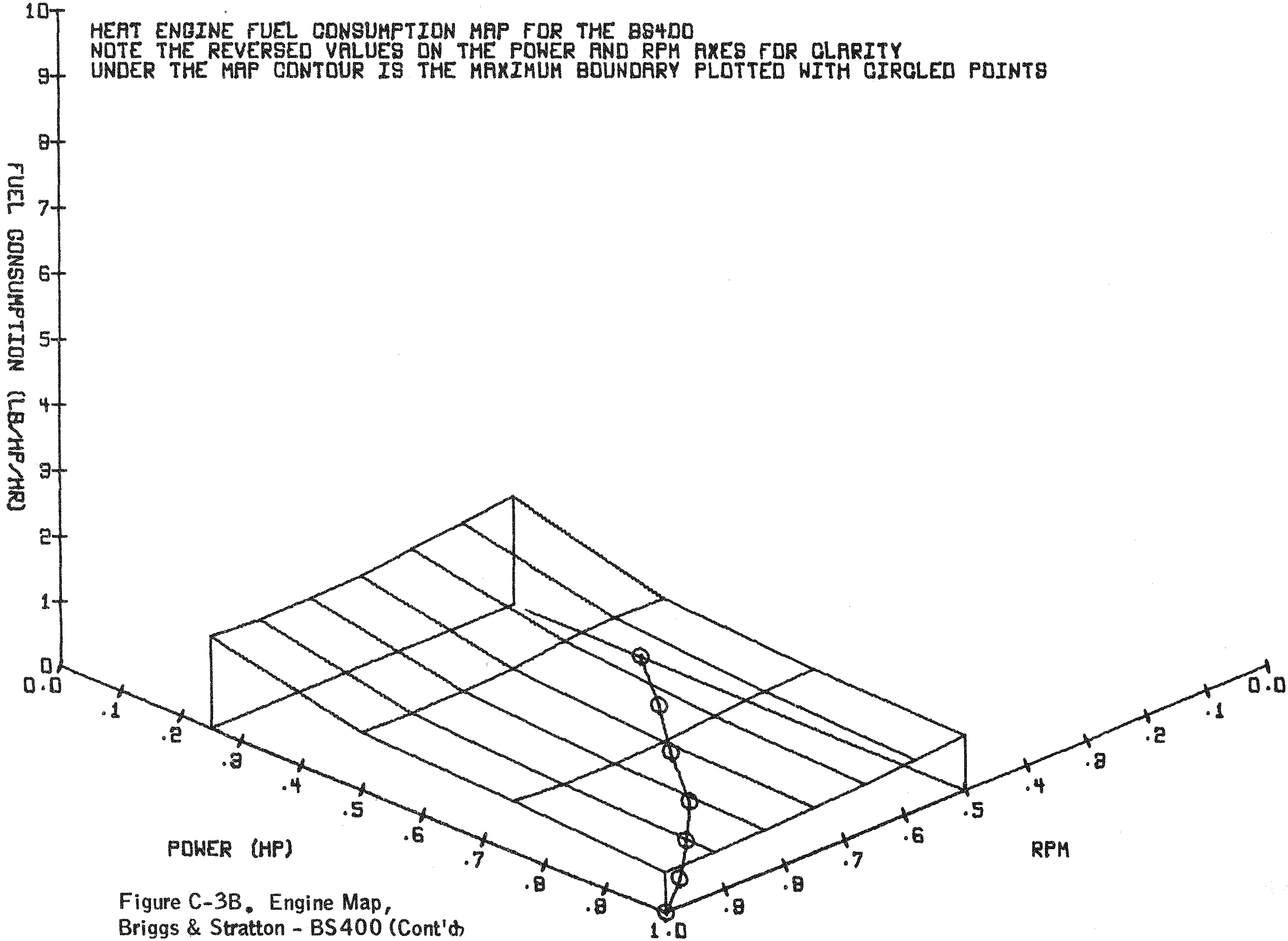



Figure C-3B. Engine Map,
Briggs & Stratton - BS400 (Cont'd)

ENGINE: ON782

MAXIMUM POWER: 14.4 HP
MAXIMUM RPM: 3600.0
MINIMUM RPM: 1000.0
FUEL TYPE: GASOLINE

ENGINE MAXIMUM OPERATING BOUNDARY -

| RPM | POWER | FRACT RPM | FRACT POWER |
|---|---|---|---|
| 1598. | 8. | .4440 | .5680 |
| 1998. | 9. | .5550 | .6420 |
| 2199. | 10. | .6110 | .7100 |
| 2397. | 11. | .6660 | .7770 |
| 2599. | 12. | .7220 | .8410 |
| 2797. | 12. | .7770 | .8990 |
| 2998. | 13. | .8330 | .9390 |
| 3196. | 14. | .8880 | .9730 |
| 3398. | 14. | .9440 | .9930 |
| 3600. | 14. | 1.0000 | 1.0000 |

FUEL CONSUMPTION - (LB/HP/HR)

| RPM, VALUE/ FRACTION | POWER, VALUE/FRACTION 4./ .333 | 7./ .500 | 10./ .750 | 14./ 1.000 |
|---|---|---|---|---|
| 1598./ .444 | 1.0500 | .9300 | .8000 | .7300 |
| 1998./ .555 | 1.1500 | .9500 | .7850 | .7000 |
| 2397./ .666 | 1.1700 | .9300 | .7700 | .7000 |
| 2797./ .777 | 1.2000 | .9250 | .7700 | .7000 |
| 3196./ .888 | 1.2500 | .9650 | .8150 | .7300 |
| 3600./ 1.000 | 1.3600 | 1.0800 | .8950 | .7600 |

Figure C-4A. Engine Map, Onan - ON782

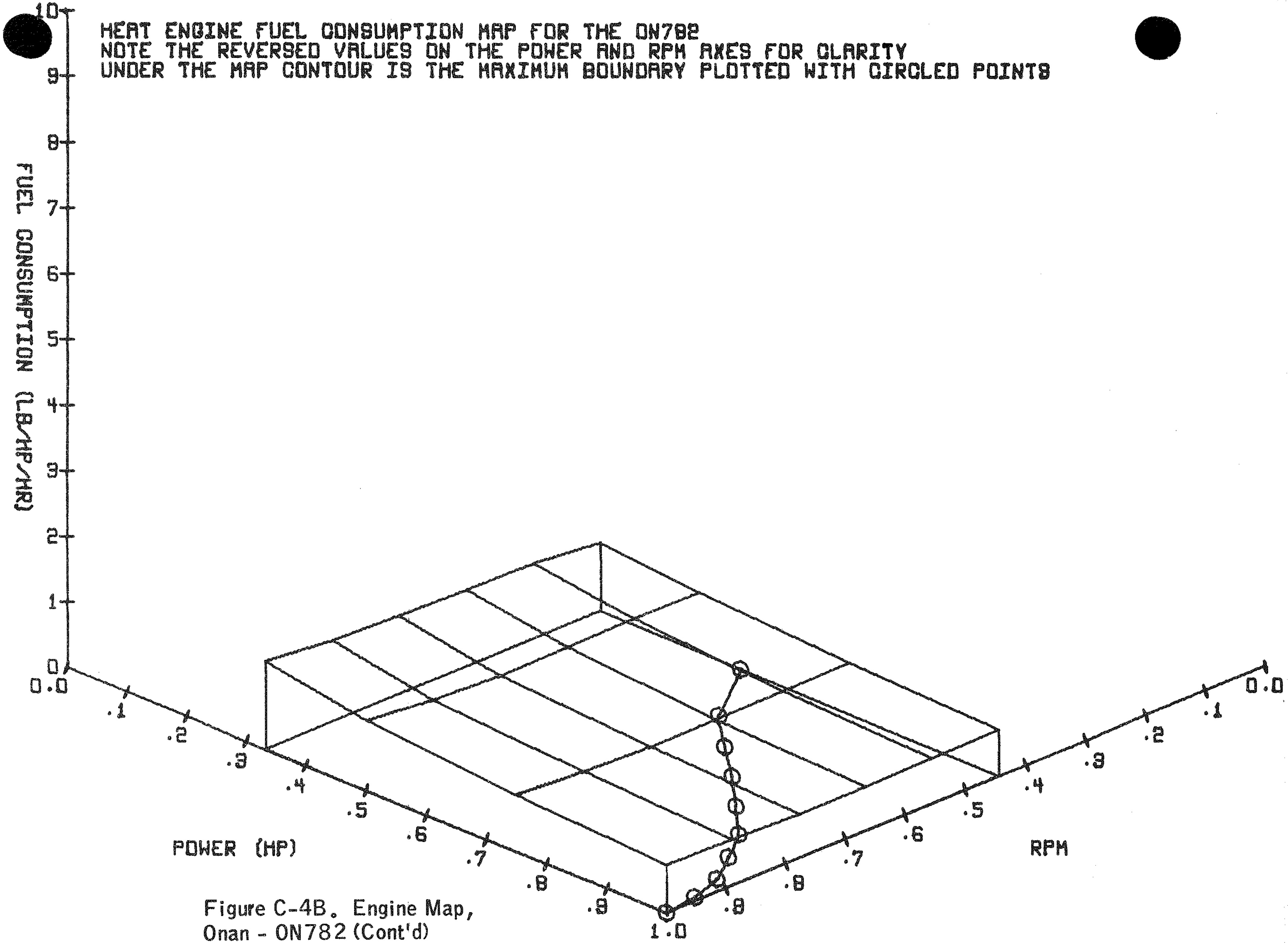



Figure C-4B. Engine Map,
Onan - ON782 (Cont'd)

ENGINE: GM5735

MAXIMUM POWER: 150.0 HP
MAXIMUM RPM: 3800.0
MINIMUM RPM: 1000.0
FUEL TYPE: GASOLINE

ENGINE MAXIMUM OPERATING BOUNDARY -

| RPM | POWER | FRACT RPM | FRACT POWER |
|---|---|---|---|
| 190. | 4. | .0500 | .0300 |
| 999. | 42. | .2630 | .2840 |
| 1299. | 58. | .3420 | .3900 |
| 1497. | 72. | .3940 | .4800 |
| 1900. | 96. | .5000 | .6440 |
| 2200. | 111. | .5790 | .7410 |
| 2800. | 132. | .7370 | .8810 |
| 3298. | 144. | .8680 | .9600 |
| 3800. | 150. | 1.0000 | 1.0000 |

FUEL CONSUMPTION - (LB/HP/HR)

| RPM, VALUE/ FRACTION | POWER, VALUE/FRACTION 4./ .030 | 15./ .100 | 37./ .250 | 60./ .400 | 90./ .600 | 112./ .750 | 150./ 1.000 |
|---|---|---|---|---|---|---|---|
| 999./ .263 | 3.4100 | .9540 | .8330 | .5690 | .5420 | .5230 | .5480 |
| 1299./ .342 | 5.3000 | 1.4800 | .6980 | .5420 | .4770 | .4630 | .5380 |
| 1497./ .394 | 3.6800 | 1.3100 | .7910 | .5120 | .5260 | .5440 | .4420 |
| 1900./ .500 | 3.9200 | 1.3600 | .7150 | .5520 | .5000 | .5110 | .5060 |
| 2200./ .579 | 3.5600 | 1.3300 | .7160 | .5300 | .5380 | .4930 | .4970 |
| 2800./ .737 | 5.0800 | 1.5700 | .8220 | .5250 | .5270 | .5320 | .5110 |
| 3298./ .868 | 4.0700 | 1.5400 | .8830 | .6940 | .5860 | .5450 | .5360 |
| 3800./ 1.000 | 5.5500 | 1.7600 | .8040 | .6920 | .6290 | .6180 | .5610 |

**Figure C-5A. Engine Map, General Motors - GM5735**

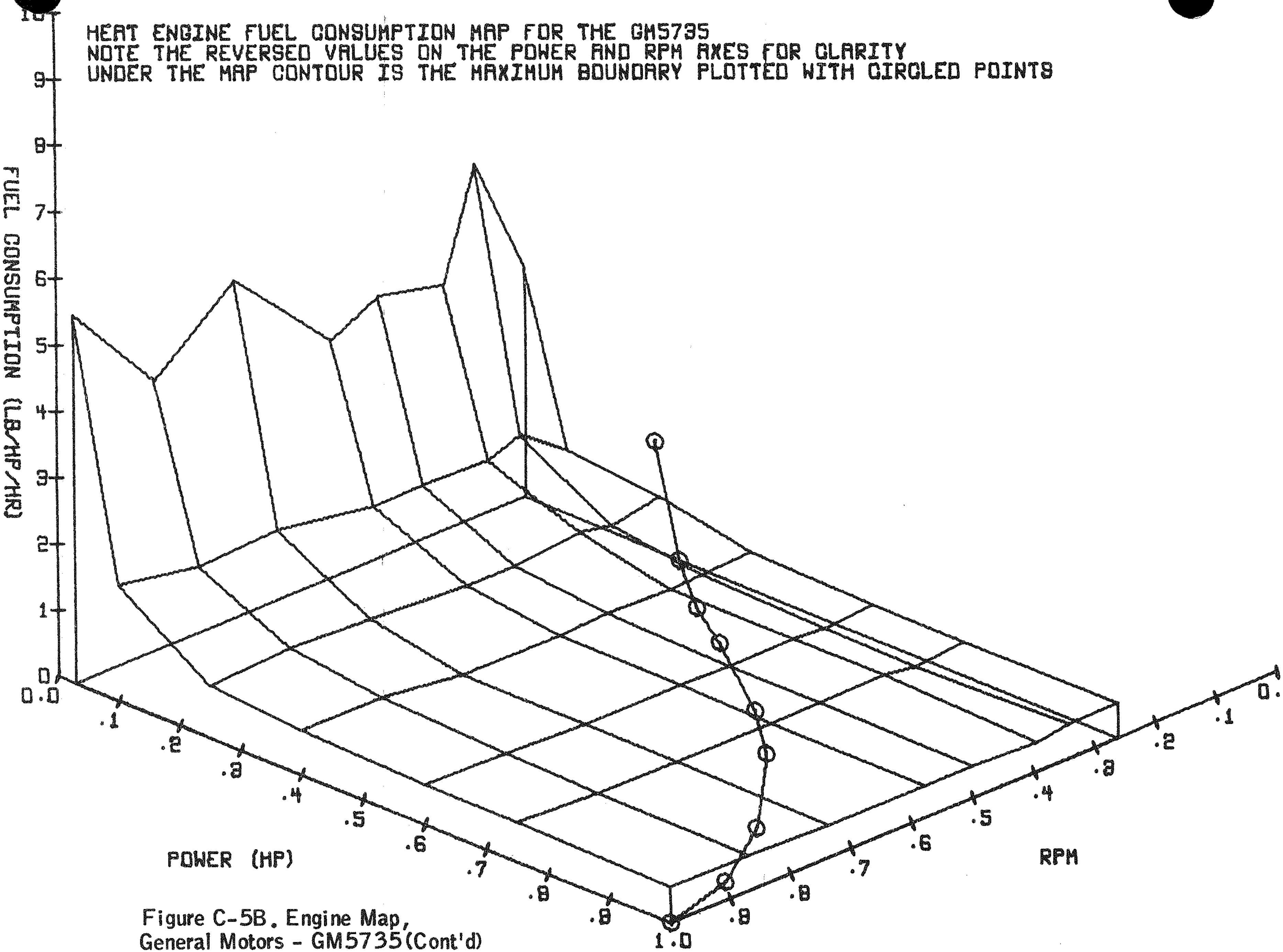



Figure C-5B. Engine Map,
General Motors - GM5735(Cont'd)

ENGINE: HN1600

MAXIMUM POWER: 50.0 HP
MAXIMUM RPM: 5500.0
MINIMUM RPM: 1000.0
FUEL TYPE: GASOLINE

ENGINE MAXIMUM OPERATING BOUNDARY -

| RPM | POWER | FRACT RPM | FRACT POWER |
|---|---|---|---|
| 1001. | 12. | .1820 | .2400 |
| 1501. | 18. | .2730 | .3700 |
| 2002. | 25. | .3640 | .5100 |
| 2502. | 32. | .4550 | .6500 |
| 2997. | 38. | .5450 | .7600 |
| 3498. | 43. | .6360 | .8700 |
| 3998. | 47. | .7270 | .9500 |
| 4499. | 50. | .8180 | 1.0000 |
| 4999. | 49. | .9090 | .9900 |
| 5500. | 48. | 1.0000 | .9600 |

FUEL CONSUMPTION - (LB/HP/HR)

| RPM, VALUE/ FRACTION | POWER, VALUE/FRACTION 5./ .100 | 10./ .200 | 15./ .300 | 20./ .400 | 25./ .500 | 30./ .600 | 35./ .700 | 40./ .800 | 45./ .900 | 50./ 1.000 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1001./ .182 | 1.7000 | .9800 | .8600 | .7600 | .6550 | .5720 | .5250 | .4990 | .4890 | .4830 |
| 2002./ .364 | 1.9000 | .9500 | .7900 | .7100 | .6550 | .5470 | .4910 | .4410 | .4430 | .4950 |
| 2502./ .455 | 1.5000 | .8550 | .6970 | .6100 | .5540 | .5080 | .4680 | .4400 | .4400 | .4900 |
| 3003./ .546 | 1.9000 | .9750 | .7950 | .6870 | .6200 | .5600 | .5100 | .4700 | .4700 | .5500 |
| 3498./ .636 | 2.0000 | 1.0300 | .7850 | .6590 | .5810 | .5400 | .5160 | .5050 | .5000 | .5000 |
| 3998./ .727 | 2.0000 | 1.1200 | .8650 | .7200 | .6200 | .5500 | .5160 | .5050 | .5060 | .5000 |
| 4499./ .818 | 2.0000 | 1.1400 | .8100 | .6550 | .5850 | .5540 | .5350 | .5250 | .5250 | .5250 |
| 4999./ .909 | 2.0000 | 1.4000 | .9750 | .8250 | .7250 | .6650 | .6250 | .6250 | .6250 | .6250 |
| 5500./ 1.000 | 1.9600 | 1.7000 | 1.4700 | 1.2700 | 1.0900 | .9420 | .8210 | .7290 | .6640 | .6270 |

Figure C-6A. Engine Map, Honda - HN1600

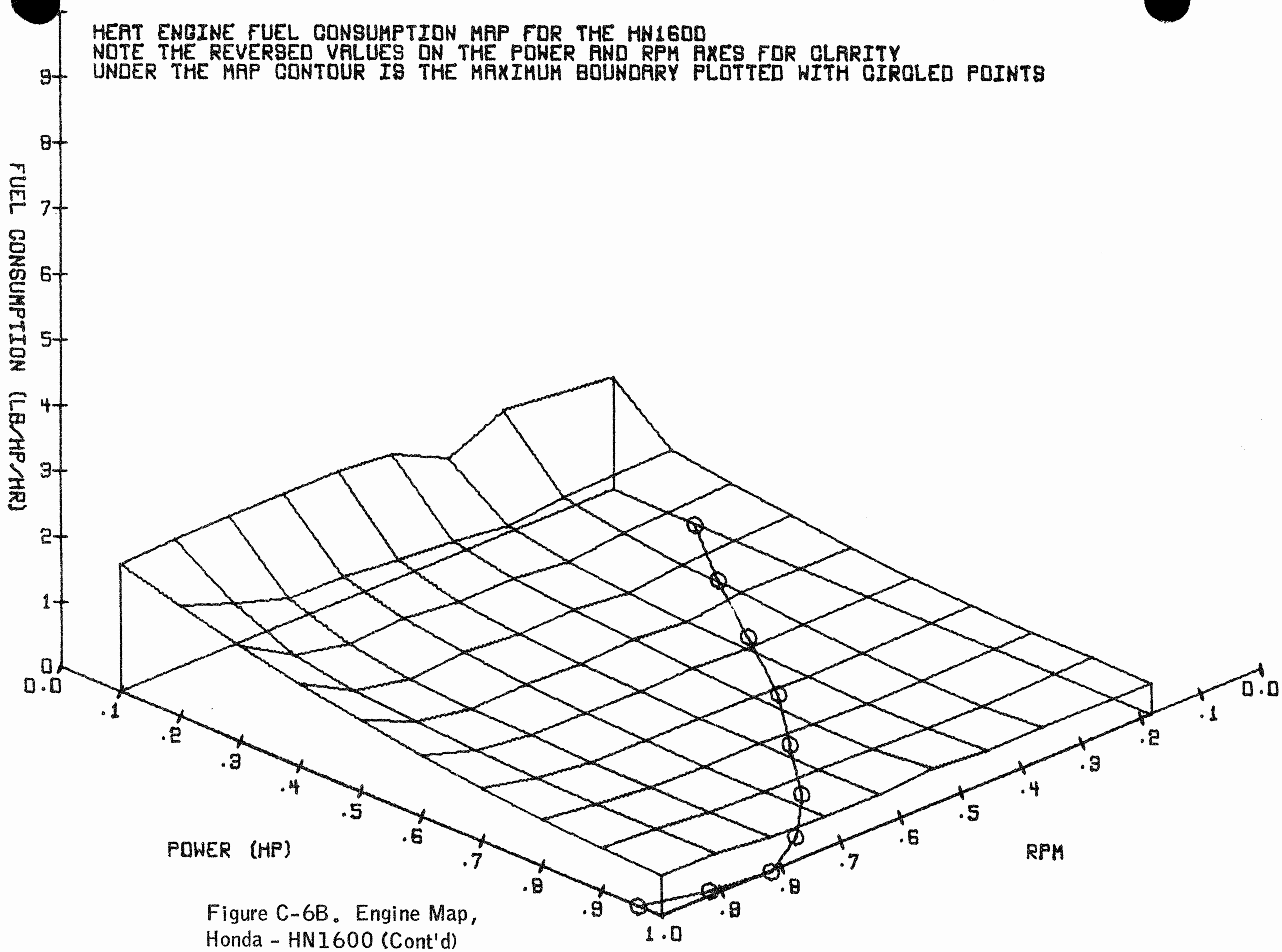



Figure C-6B. Engine Map,
Honda - HN1600 (Cont'd)

ENGINE: GMVEGA140

MAXIMUM POWER: 80.0 HP
MAXIMUM RPM: 4000.0
MINIMUM RPM: 1000.0
FUEL TYPE: GASOLINE

ENGINE MAXIMUM OPERATING BOUNDARY -

| RPM | POWER | FRACT RPM | FRACT POWER |
|---|---|---|---|
| 200. | 2. | .0500 | .0300 |
| 908. | 19. | .2270 | .2400 |
| 1364. | 28. | .3410 | .3600 |
| 1820. | 40. | .4550 | .5000 |
| 2544. | 56. | .6360 | .7000 |
| 3272. | 68. | .8180 | .8600 |
| 4000. | 80. | 1.0000 | 1.0000 |

FUEL CONSUMPTION - (LB/HP/HR)

| RPM, VALUE/ FRACTION | POWER, VALUE/FRACTION 4./ .050 | 8./ .100 | 12./ .150 | 20./ .250 | 40./ .500 | 60./ .750 | 80./ 1.000 |
|---|---|---|---|---|---|---|---|
| 908./ .227 | 2.8000 | 1.9500 | 1.3200 | .9790 | .5960 | .4610 | .5850 |
| 1364./ .341 | 3.6000 | 1.8400 | 1.4500 | 1.0400 | .6310 | .5000 | .6310 |
| 1820./ .455 | 2.8100 | 1.5200 | 1.1100 | .7760 | .5260 | .4880 | .5760 |
| 2544./ .636 | 2.8500 | 1.4500 | 1.0300 | .7300 | .5250 | .4970 | .5280 |
| 3272./ .818 | 2.6800 | 1.4900 | 1.1200 | .6400 | .6170 | .5230 | .5420 |
| 4000./ 1.000 | 2.7000 | 1.6400 | 1.1700 | .8730 | .6060 | .5530 | .5170 |

**Figure C-7A. Engine Map, General Motors - GMVEGA140**

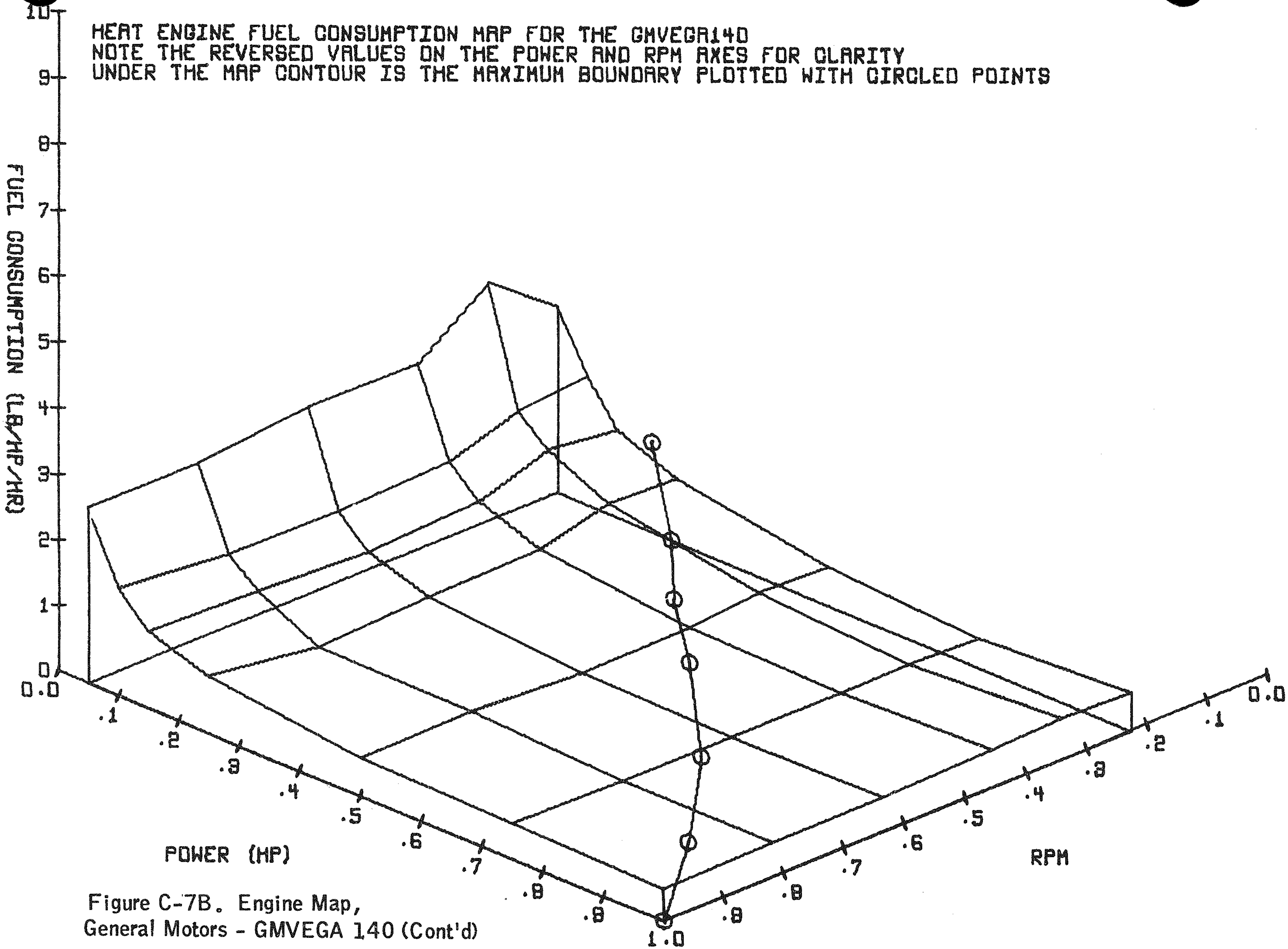



Figure C-7B. Engine Map,
General Motors - GMVEGA 140 (Cont'd)

ENGINE: TR7

MAXIMUM POWER: 86.0 HP
MAXIMUM RPM: 6000.0
MINIMUM RPM: 1000.0
FUEL TYPE: GASOLINE

ENGINE MAXIMUM OPERATING BOUNDARY -

| RPM | POWER | FRACT RPM | FRACT POWER |
|---|---|---|---|
| 996. | 14. | .1660 | .1670 |
| 1500. | 25. | .2500 | .2920 |
| 1998. | 35. | .3330 | .4140 |
| 2502. | 45. | .4170 | .5330 |
| 3000. | 55. | .5000 | .6480 |
| 3498. | 65. | .5830 | .7630 |
| 4002. | 74. | .6670 | .8650 |
| 4500. | 81. | .7500 | .9530 |
| 4998. | 85. | .8330 | .9970 |
| 5496. | 83. | .9160 | .9710 |
| 6000. | 80. | 1.0000 | .9360 |

FUEL CONSUMPTION - (LB/HP/HR)

| RPM, VALUE/ FRACTION | POWER, VALUE/FRACTION 8./ .100 | 12./ .150 | 21./ .250 | 30./ .350 | 43./ .500 | 51./ .600 | 64./ .750 | 77./ .900 | 86./ 1.000 |
|---|---|---|---|---|---|---|---|---|---|
| 996./ .166 | 1.4000 | 1.2000 | .8500 | .7000 | .6000 | .5600 | .5200 | .5000 | .5100 |
| 1500./ .250 | 1.3200 | 1.0000 | .7500 | .6400 | .5500 | .5200 | .4950 | .4900 | .5100 |
| 1998./ .333 | 1.3000 | .9700 | .7050 | .6050 | .5250 | .5150 | .4850 | .4800 | .5100 |
| 2502./ .417 | 1.3000 | .9350 | .6950 | .5950 | .5250 | .5050 | .4760 | .4700 | .5100 |
| 3000./ .500 | 1.3000 | .9100 | .6900 | .5900 | .5300 | .5000 | .4730 | .4700 | .5100 |
| 3498./ .583 | 1.3000 | .9000 | .6900 | .5900 | .5250 | .4950 | .4720 | .4700 | .5100 |
| 4002./ .667 | 1.3000 | 1.0000 | .7000 | .5850 | .5250 | .5000 | .4800 | .4700 | .5100 |
| 4500./ .750 | 1.3500 | 1.1500 | .7200 | .6200 | .5400 | .5200 | .4900 | .4850 | .5100 |
| 4998./ .833 | 1.5000 | 1.3000 | .7900 | .6600 | .5600 | .5350 | .5150 | .5000 | .5300 |
| 5496./ .916 | 1.7000 | 1.5000 | 1.1500 | .8000 | .6500 | .6000 | .5500 | .5500 | .5800 |
| 6000./ 1.000 | 2.0000 | 1.7000 | 1.4000 | 1.3000 | 1.2000 | 1.0000 | .8000 | .7000 | .6500 |

Figure C-8A. Engine Map, Triumph, TR7

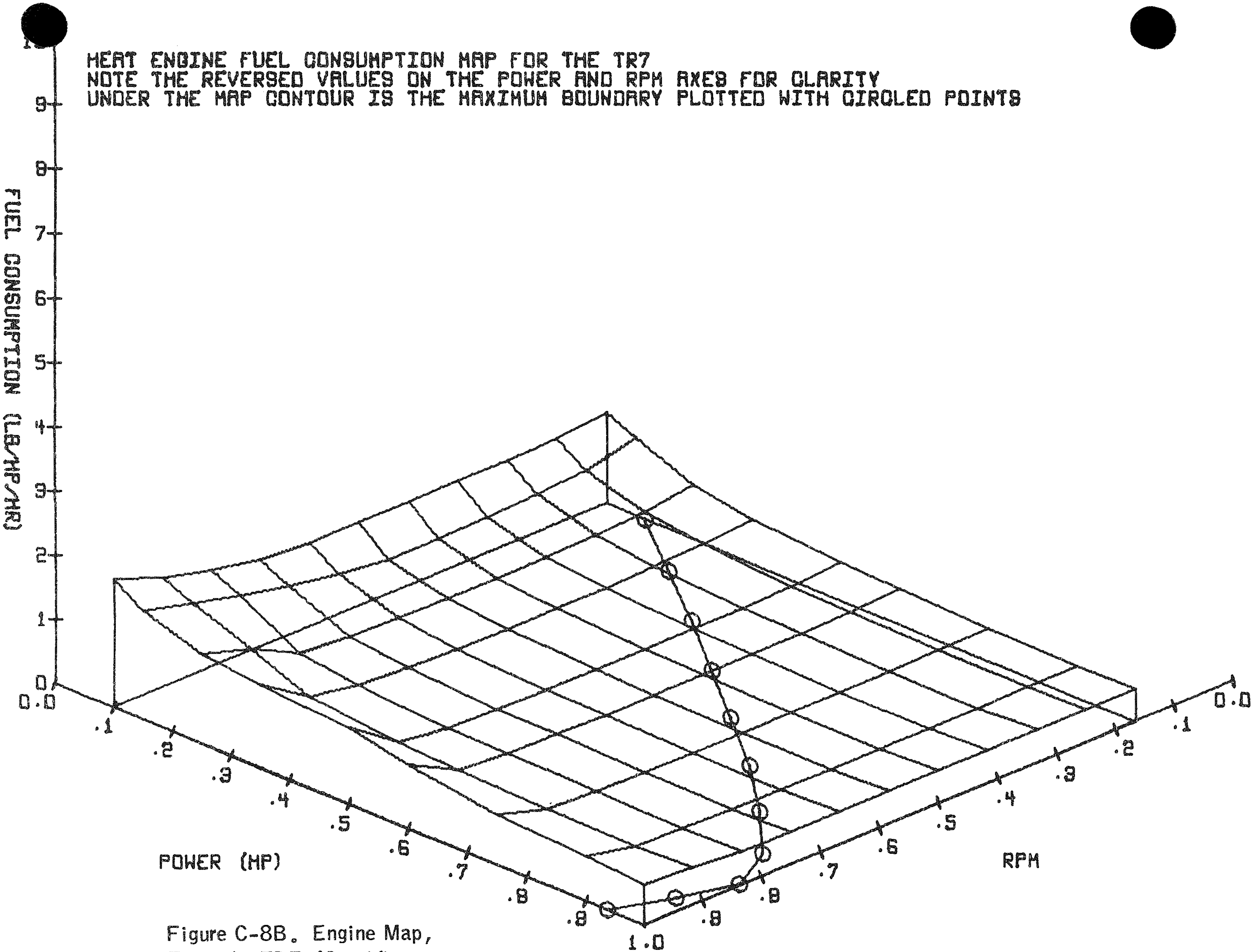



Figure C-8B. Engine Map, Triumph, TR7 (Cont'd)

ENGINE: TURBODSL

MAXIMUM POWER: 70.0 HP
MAXIMUM RPM: 5000.0
MINIMUM RPM: 700.0
FUEL TYPE: DIESEL

ENGINE MAXIMUM OPERATING BOUNDARY -

| RPM | POWER | FRACT RPM | FRACT POWER |
|---|---|---|---|
| 500. | 5. | .1000 | .0820 |
| 1000. | 12. | .2000 | .1840 |
| 1500. | 20. | .3000 | .2970 |
| 2000. | 32. | .4000 | .4710 |
| 2500. | 43. | .5000 | .6250 |
| 3000. | 53. | .6000 | .7680 |
| 3500. | 61. | .7000 | .8810 |
| 4000. | 67. | .8000 | .9630 |
| 4500. | 69. | .9000 | .9900 |
| 5000. | 70. | 1.0000 | 1.0000 |

FUEL CONSUMPTION - (LB/HP/HR)

| RPM, VALUE/ FRACTION | POWER, VALUE/FRACTION 3./ .050 | 7./ .100 | 17./ .250 | 28./ .400 | 42./ .600 | 52./ .750 | 70./ 1.000 |
|---|---|---|---|---|---|---|---|
| 1000./ .200 | 1.7600 | 1.3900 | .8600 | .6100 | .5100 | .4950 | .4950 |
| 1500./ .300 | 1.4500 | 1.2000 | .7100 | .5300 | .4600 | .4400 | .5000 |
| 2000./ .400 | 1.5600 | 1.1500 | .6100 | .4600 | .4400 | .4400 | .5000 |
| 2500./ .500 | 1.6500 | 1.1500 | .6100 | .4600 | .4400 | .4400 | .5000 |
| 3000./ .600 | 1.9000 | 1.2200 | .5900 | .4600 | .4300 | .4300 | .5000 |
| 3500./ .700 | 2.1400 | 1.7300 | .6300 | .4600 | .4300 | .4300 | .5000 |
| 4000./ .800 | 2.4700 | 1.4000 | .7100 | .5300 | .4400 | .4600 | .5400 |
| 5000./ 1.000 | 2.4000 | 1.7300 | 1.0900 | .7600 | .5900 | .5400 | .5800 |

**Figure C-9A. Engine Map, Volkswagen - TURBODSL**

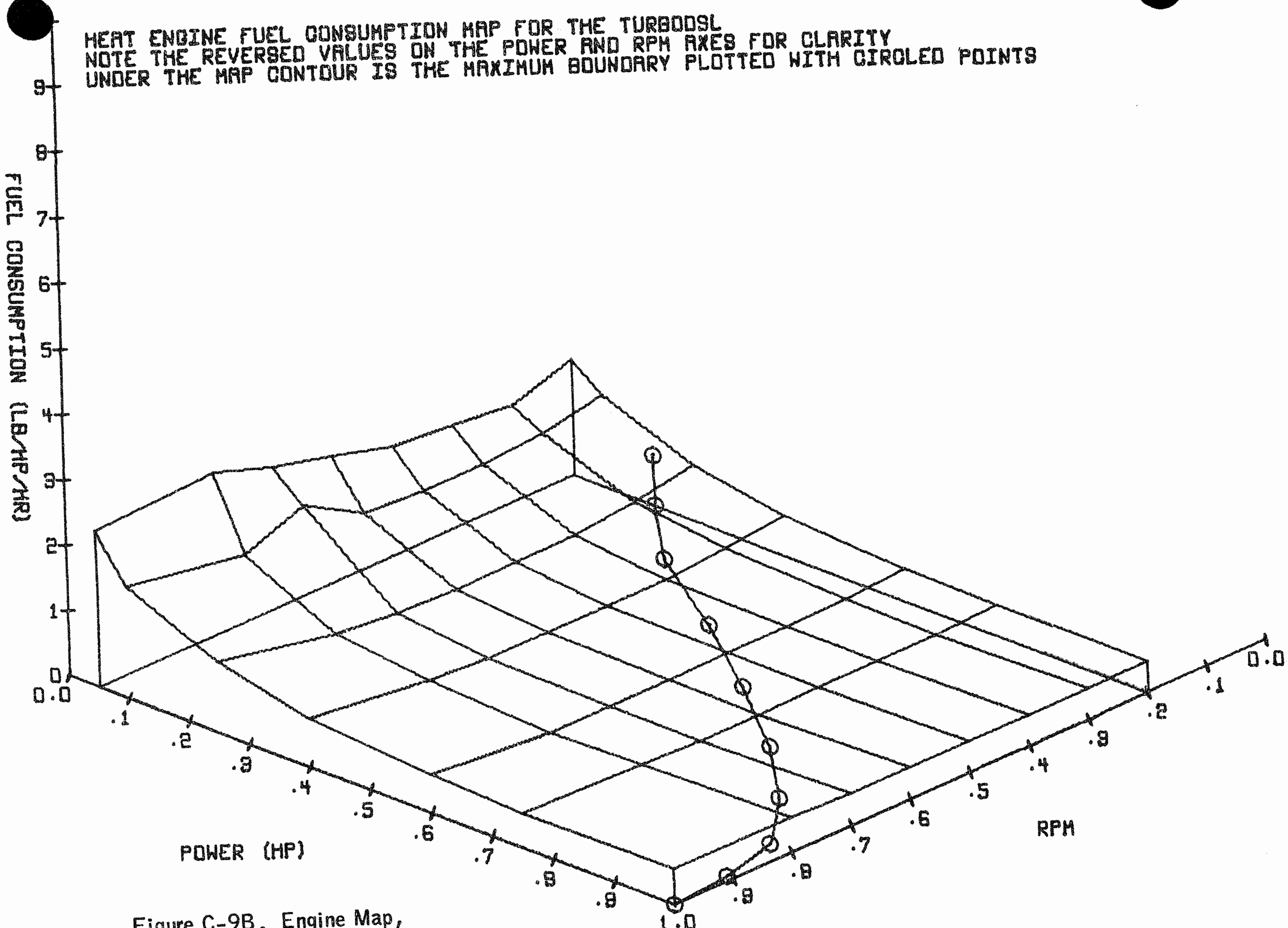



Figure C-9B. Engine Map,
Volkswagen - TURBODSL (Cont'd)

ENGINE: NADSL

MAXIMUM POWER: 50.0 HP
MAXIMUM RPM: 5000.0
MINIMUM RPM: 700.0
FUEL TYPE: DIESEL

ENGINE MAXIMUM OPERATING BOUNDARY -

| RPM | POWER | FRACT RPM | FRACT POWER |
|---|---|---|---|
| 500. | 2. | .1000 | .0560 |
| 1000. | 10. | .2000 | .2000 |
| 1500. | 14. | .3000 | .2870 |
| 2000. | 22. | .4000 | .4530 |
| 2500. | 28. | .5000 | .5600 |
| 3000. | 35. | .6000 | .7070 |
| 3500. | 40. | .7000 | .8130 |
| 4000. | 45. | .8000 | .9070 |
| 4500. | 48. | .9000 | .9680 |
| 5000. | 50. | 1.0000 | 1.0000 |

FUEL CONSUMPTION - (LB/HP/HR)

| RPM, VALUE/ FRACTION | POWER, VALUE/FRACTION 2./ .050 | 5./ .100 | 12./ .250 | 20./ .400 | 30./ .600 | 37./ .750 | 50./ 1.000 |
|---|---|---|---|---|---|---|---|
| 1000./ .200 | 1.7000 | 1.3800 | .8400 | .6100 | .5700 | .4700 | .4900 |
| 1500./ .300 | 1.6700 | 1.2300 | .6900 | .5800 | .5400 | .4900 | .4900 |
| 2000./ .400 | 1.7300 | 1.2500 | .6900 | .5300 | .4400 | .4500 | .4900 |
| 2500./ .500 | 1.7300 | 1.2400 | .7200 | .5400 | .4500 | .4300 | .4900 |
| 3000./ .600 | 1.7300 | 1.2500 | .7300 | .5400 | .4700 | .4400 | .4900 |
| 3500./ .700 | 1.8100 | 1.4000 | .7600 | .5400 | .4600 | .4500 | .4900 |
| 4000./ .800 | 2.3100 | 1.6900 | .8500 | .6000 | .4900 | .4700 | .4900 |
| 4500./ .900 | 1.8600 | 1.6500 | 1.0000 | .6800 | .5500 | .5300 | .5400 |
| 5000./ 1.000 | 2.5600 | 2.1800 | 1.1100 | .7800 | .5900 | .5400 | .5400 |

Figure C-10A. Engine Map, Volkswagen - NADSL

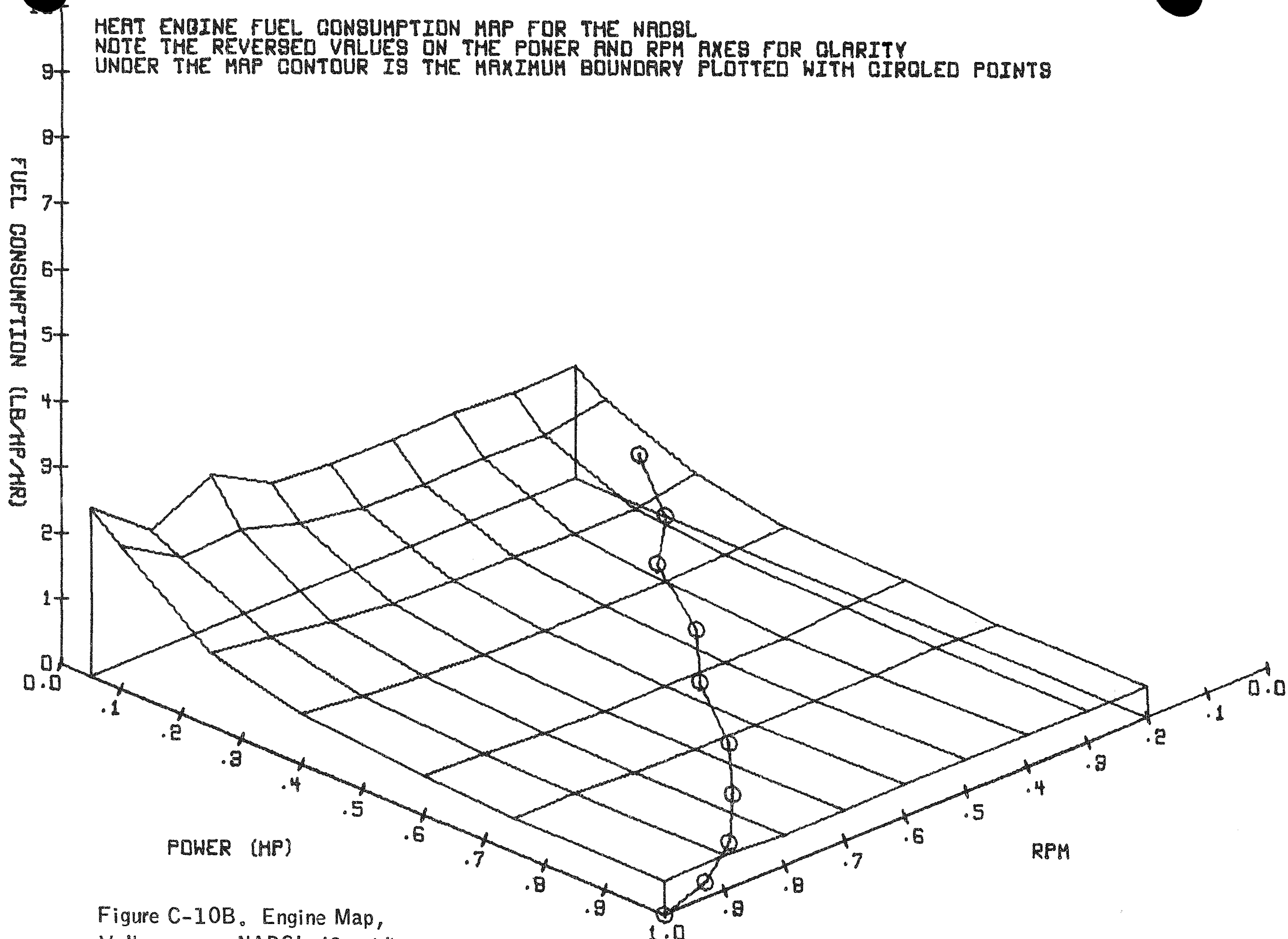



Figure C-10B. Engine Map,
Volkswagen - NADSL (Cont'd)

ENGINE: IDIDSL

MAXIMUM POWER: 60.0 HP
MAXIMUM RPM: 4000.0
MINIMUM RPM: 700.0
FUEL TYPE: DIESEL

ENGINE MAXIMUM OPERATING BOUNDARY -

| RPM | POWER | FRACT RPM | FRACT POWER |
|---|---|---|---|
| 1000. | 18. | .2500 | .3100 |
| 1500. | 28. | .3750 | .4700 |
| 2000. | 36. | .5000 | .6100 |
| 2500. | 45. | .6250 | .7500 |
| 3000. | 51. | .7500 | .8500 |
| 3500. | 55. | .8750 | .9300 |
| 4000. | 60. | 1.0000 | 1.0000 |

FUEL CONSUMPTION - (LB/HP/HR)

| RPM, VALUE/ FRACTION | POWER, VALUE/FRACTION 6./ .100 | 9./ .150 | 15./ .250 | 21./ .350 | 30./ .500 | 36./ .600 | 45./ .750 | 54./ .900 | 60./ 1.000 |
|---|---|---|---|---|---|---|---|---|---|
| 1000./ .250 | 1.2000 | 1.0000 | .7150 | .5800 | .5300 | .4790 | .4390 | .4360 | .4400 |
| 1500./ .375 | 1.0000 | .9000 | .6500 | .5600 | .4780 | .4410 | .4250 | .4310 | .4400 |
| 2000./ .500 | 1.1000 | .9000 | .6600 | .5450 | .4700 | .4370 | .4220 | .4300 | .4400 |
| 2500./ .625 | 1.1000 | .9000 | .6700 | .5600 | .4790 | .4500 | .4320 | .4250 | .4400 |
| 3000./ .750 | 1.1300 | .9500 | .7000 | .5750 | .5150 | .4790 | .4570 | .4470 | .4550 |
| 3500./ .875 | 1.1500 | 1.0000 | .8000 | .6500 | .5550 | .5200 | .4820 | .4710 | .4750 |
| 4000./ 1.000 | 1.2000 | 1.0500 | .9000 | .6750 | .6100 | .5700 | .5300 | .5000 | .5000 |

**Figure C-11A. Engine Map, British Leyland Rover - IDIDSL**

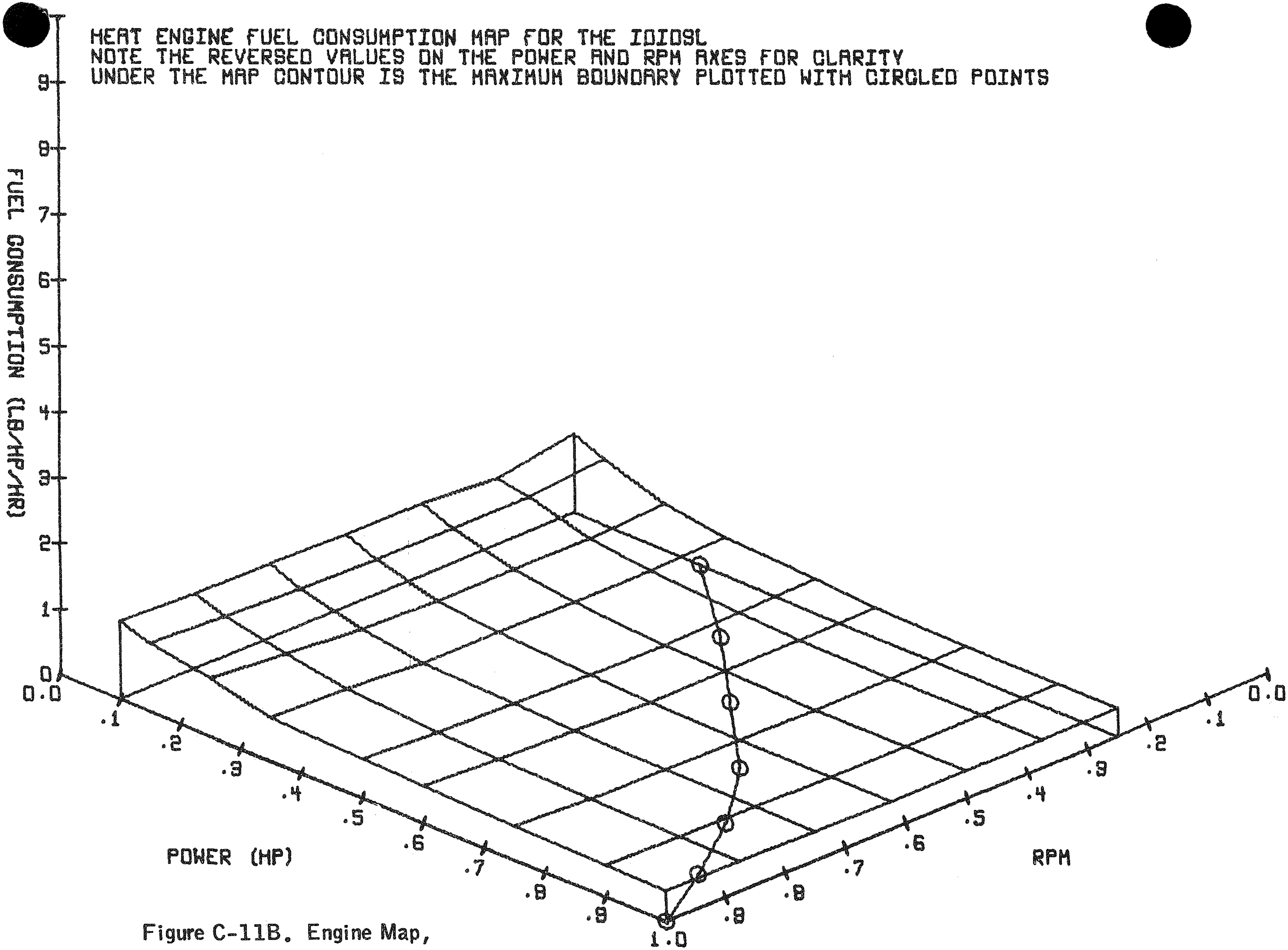



Figure C-11B. Engine Map,
British Leyland Rover - IDIDSL

ENGINE: CWSTRATROT

MAXIMUM POWER: 75.0 HP
MAXIMUM RPM: 4500.0
MINIMUM RPM: 1200.0
FUEL TYPE: GASOLINE

ENGINE MAXIMUM OPERATING BOUNDARY -

| RPM | POWER | FRACT RPM | FRACT POWER |
|---|---|---|---|
| 1197. | 15. | .2660 | .2050 |
| 1498. | 22. | .3330 | .3030 |
| 1800. | 30. | .4000 | .4060 |
| 1998. | 35. | .4440 | .4770 |
| 2497. | 48. | .5550 | .6500 |
| 3001. | 60. | .6670 | .8060 |
| 3496. | 69. | .7770 | .9330 |
| 3996. | 75. | .8880 | 1.0000 |
| 4500. | 70. | 1.0000 | .9360 |

FUEL CONSUMPTION - (LB/HP/HR)

| RPM, VALUE/ FRACTION | POWER, VALUE/FRACTION 7./ .100 | 11./ .150 | 18./ .250 | 26./ .350 | 37./ .500 | 45./ .600 | 56./ .750 | 67./ .900 | 75./ 1.000 |
|---|---|---|---|---|---|---|---|---|---|
| 1197./ .266 | 1.5000 | 1.2000 | .9000 | .7200 | .6100 | .5800 | .5500 | .5500 | .5500 |
| 1498./ .333 | 1.3500 | 1.0500 | .7600 | .6200 | .5400 | .5300 | .5000 | .5250 | .5500 |
| 1998./ .444 | 1.2000 | .9500 | .7400 | .6000 | .5300 | .5000 | .4900 | .5000 | .5500 |
| 2497./ .555 | 1.2000 | .9000 | .6950 | .5900 | .5300 | .5000 | .4870 | .4950 | .5500 |
| 3001./ .667 | 1.2500 | .9000 | .6800 | .5850 | .5300 | .4970 | .4800 | .4920 | .5500 |
| 3496./ .777 | 1.3000 | .9000 | .7100 | .6000 | .5300 | .4970 | .4920 | .5200 | .5500 |
| 3996./ .888 | 1.3500 | 1.0500 | .7600 | .6250 | .5400 | .5200 | .5200 | .5250 | .5500 |
| 4500./ 1.000 | 1.4500 | 1.2000 | .8500 | .6850 | .5700 | .5500 | .5400 | .5400 | .5500 |

Figure C-12A. Engine Map, Curtis Wright - CWSTRATROT

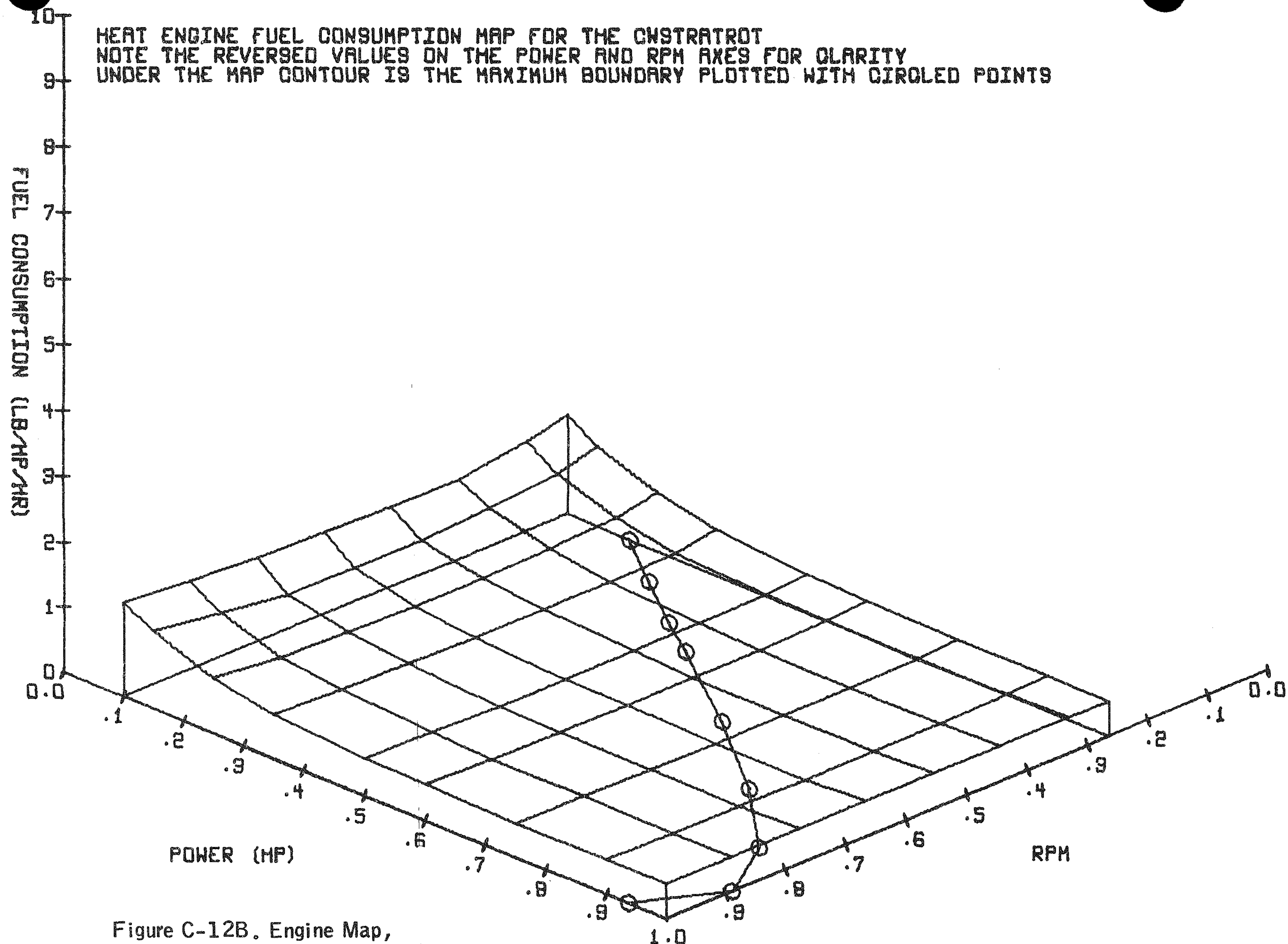



Figure C-12B. Engine Map,
Curtis Wright - CWSTRATROT (Cont'd)

ENGINE: NSUAUDIROT

MAXIMUM POWER: 170.0 HP
MAXIMUM RPM: 6500.0
MINIMUM RPM: 2000.0
FUEL TYPE: GASOLINE

ENGINE MAXIMUM OPERATING BOUNDARY -

| RPM | POWER | FRACT RPM | FRACT POWER |
|---|---|---|---|
| 1501. | 36. | .2310 | .2130 |
| 2002. | 54. | .3080 | .3200 |
| 2502. | 70. | .3850 | .4130 |
| 3003. | 88. | .4620 | .5190 |
| 3503. | 105. | .5390 | .6230 |
| 3997. | 123. | .6150 | .7290 |
| 4498. | 137. | .6920 | .8070 |
| 4998. | 150. | .7690 | .8840 |
| 5499. | 161. | .8460 | .9500 |
| 5999. | 168. | .9230 | .9910 |
| 6500. | 170. | 1.0000 | 1.0000 |

FUEL CONSUMPTION - (LB/HP/HR)

| RPM, VALUE/ FRACTION | POWER, VALUE/FRACTION 17./ .100 | 25./ .150 | 42./ .250 | 59./ .350 | 85./ .500 | 102./ .600 | 127./ .750 | 153./ .900 | 170./ 1.000 |
|---|---|---|---|---|---|---|---|---|---|
| 1501./ .231 | 1.0000 | .8800 | .7500 | .6400 | .5370 | .5200 | .4970 | .4840 | .4840 |
| 2002./ .308 | 1.0000 | .8600 | .7080 | .5940 | .5190 | .4950 | .4730 | .4620 | .4730 |
| 3003./ .462 | 1.0000 | .8600 | .6450 | .5500 | .4950 | .4660 | .4520 | .4400 | .4620 |
| 3997./ .615 | 1.0400 | .8470 | .6500 | .5500 | .4980 | .4730 | .4510 | .4490 | .4620 |
| 4998./ .769 | 1.2100 | 1.0000 | .6600 | .6050 | .5280 | .5060 | .4840 | .4800 | .4840 |
| 5999./ .923 | 1.4000 | 1.2000 | .9350 | .6490 | .5830 | .5410 | .5240 | .5190 | .5150 |
| 6500./ 1.000 | 1.7000 | 1.4000 | 1.1000 | .9100 | .6400 | .5900 | .5500 | .5400 | .5300 |

Figure C-13A. Engine Map, NSU/AUDI - NSUAUDIROT

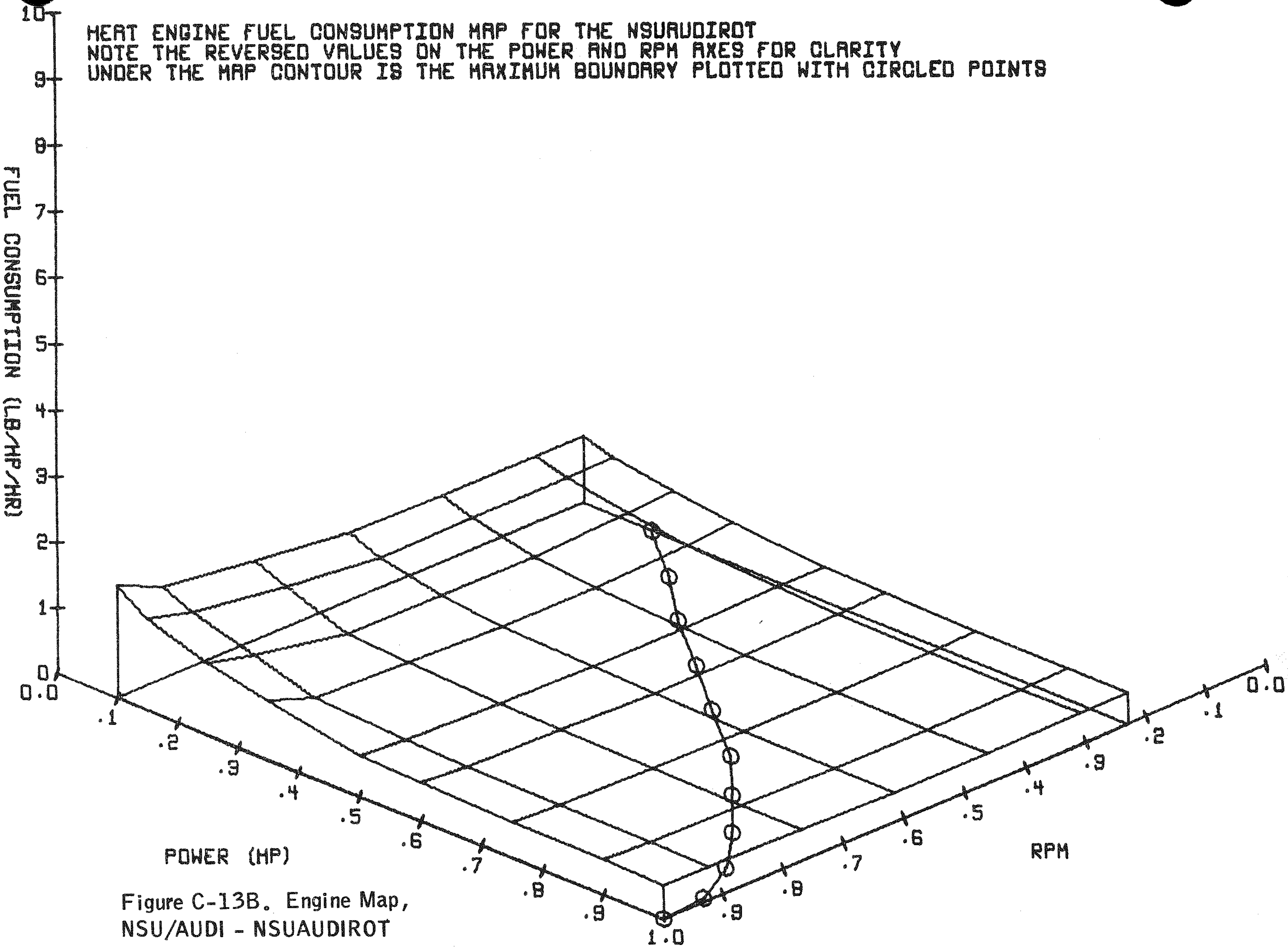



Figure C-13B. Engine Map,
NSU/AUDI - NSUAUDIROT

## APPENDIX D

## ROAD LOAD MODEL

The calculations described in this appendix are for the road load model in ELVEC. This is intended as a summary of how the road load parameters are calculated in this simulator.

### ROAD LOAD AND ITS COMPONENTS

The basic equation used to compute road load is

$$P_R = (F_A + F_T + M_V G_F + F_2 \dot{V})\ V$$

where

$P_R$ = road load (includes acceleration), W

$F_A$ = aerodynamic drag, N

$F_T$ = tire friction, N

$M_V$ = vehicle mass, kg

$G_F$ = gradient factor, N/kg

$F_2$ = vehicle effective mass, kg

$\dot{V}$ = acceleration, m/s$^2$

$V$ = speed, m/s

Aerodynamic drag is calculated, using

FA = 0.6125 * CDA * V * V

where

0.6125 = standard air density/2, kg/m$^3$

CDA = aerodynamic drag-area product, m$^2$

V = speed, m/s

Note that the resulting units are kg • $m/s^2$, which is equivalent to Newtons (N). The power lost in aerodynamic drag is calculated from PLAERO = FA * V.

Tire friction is calculated, using

$$FTR = ATIREF/100 * 9.807 * WT$$

where

ATIREF = tire friction coefficent, percent

9.807 = acceleration due to gravity, $m/s^2$

WT = vehicle mass, kg

The default value of ATIREF is 1.2 percent. The power lost in the tires is

$$PLTIRE = FTR * V$$

The gradient factor is equal to

$$G_F = \sin[\tan^{-1}(\theta/100)] * 9.808$$

where

$\theta$ = road gradient, percent

Note that $G_F$ is set to zero for all driving schedules <u>except</u> constant speed and maximum acceleration.

The vehicle effective mass is calculated from

$$F_2 = M_{Ve} + \beta_3^2 I_3$$

where

$M_{Ve} = X_m M_V$ , if the wheel, driveline, and motor inertias are set to zero; in this case $X_m$ should be set to about 1.03

$= M_V + \beta_1^2 I_1 + \beta_2^2 I_2$ , if $I_1 \neq 0$

where

$\beta_1$ = 1/driving wheel radius [BETA(1)], $m^2$

$\beta_2 = \beta_1 * r_1$ ($r_1$ is differential ratio)

$I_1$ = inertial of wheels [XJ(1)], kg-$m^2$

$I_2$ = inertial of driveline (not including motor), kg-$m^2$

The term $\beta_3^2 I_3$ is the reflected (to the wheels) mass of the rotating motor. Here

$\beta_3 = \beta_2 * r_2$ ($r_2$ is transmission gear ratio)

$I_3$ = rotating inertia of motor, kg - $m^2$

APPENDIX E

PHONE LIST

***** PHONLIST

THIS DIRECTORY INCLUDES ALL VOICE AND DATA NUMBERS FOR ALL NCSS FACILITIES. ASTERISKS IN THE FAR RIGHT COLUMN DENOTE RECENT CHANGES OR ADDITIONS.

PLEASE TYPE INFO PHONES FOR FURTHER INFORMATION.

--- ARIZONA

PHOENIX (602) 264-5490
110: 264-2718 134.5: 264-9172 300: 264-1891

TUCSON (602) 264-5490
300: 623-0318

--- CALIFORNIA

LOS ANGELES (213) 277-7511
AUTOSPEED: 277-7942 1200: 553-4271 2000: 553-7271
1200 VADIC FULL DUPLEX: 552-1674

MODESTO (408) 739-6271
AREA CODE 209 AUTOSPEED: 529-5050

MOUNTAIN VIEW (408)739-6271
AUTOSPEED: 965-9500

NEWPORT BEACH (714) 833-8370
110: 833-0531 134.5: 833-1740 300: 752-1162
2000: 752-0630

PALO ALTO (408) 739-6271
AREA CODE 415 AUTOSPEED: 321-7011

RANCHO BERNARDO (714) 297-5870
300: 484-2900

SACRAMENTO (415) 989-3930
AREA CODE 916 110: 485-1048 134.5: 481-3618
300: 481-3617

SAN DIEGO (714) 297-5870
110: 297-8252 134.5: 297-6730 300: 297-9260

SAN FRANCISCO (415) 989-3930
AUTOSPEED: 788-6800 1200: 982-2191

SAN MATEO (408) 739-6271
AREA CODE 415 AUTOSPEED: 341-7405

SANTA BARBARA (213) 277-7511
AREA CODE 805 AUTOSPEED: 963-6633

SUNNYVALE (408) 739-6271 SUNY
AUTOSPEED: 245-6051
1200: 732-9791 1200 VADIC FULL DUPLEX: 733-3420
1200 BELL 212 FULL DUPLEX: 732-1092
2000: 739-3632 2400: 735-8968 4800: 733-4870
VOICE RESPONSE: 737-2733

VENTURA (213) 277-7511
AREA CODE 805 AUTOSPEED: 643-5779

--- CANADA
MONTREAL (203) 327-9100
AREA CODE 514 AUTOSPEED: 875-5318

TORONTO (203) 327-9100
AREA CODE 416 300: 862-7511

--- COLORADO
COLORADO SPRINGS (303) 534-2720
AUTOSPEED: 598-8327

DENVER (303) 534-2720
110:573-1427 134.5: 573-1270 300: 573-1116

--- CONNECTICUT
BRIDGEPORT (203) 327-9100
AUTOSPEED: 367-8451

DANBURY (203) 327-9100
AUTOSPEED: 792-6616

HARTFORD (203) 561-3730
110: 561-2624 134.5: 561-3376 300: 561-3780

NEW HAVEN (203) 327-9100
AUTOSPEED: 772-2490

NEW MILFORD (203) 327-9100
AUTOSPEED: 354-9430

NORWALK (203) 327-9100
AUTOSPEED: 853-7915

STAMFORD (203) 327-9100 HSYS
AUTOSPEED: 327-3204 1200: 359-2801 2000: 327-9910
2400: 327-7971
1200 VADIC FULL DUPLEX: 327-9014 4800: 327-9280
VOICE RESPONSE: 327-7610

STAMFORD (203) 327-9100 M168
AUTOSPEED: 327-7100    1200: 327-2080    2000: 327-2020
2400: 327-7972    4800: 359-3428
VOICE RESPONSE: 327-7874

WATERBURY (203) 327-9100
AUTOSPEED: 574-5848

--- DISTRICT OF COLUMBIA
WASHINGTON, D.C. (703) 524-1500
AUTOSPEED: 243-8500    1200: 525-4884
AREA CODE 202    4800: 554-7734

--- DELAWARE
WILMINGTON (215) 665-1566
AREA CODE 302    AUTOSPEED: 478-4486

--- EUROPE
LONDON, ENGLAND 01-834-2223
110: 01-828-9090    134.5: 01-828-9000    300: 01-834-1288

PARIS, FRANCE 261-56-35
110: 260-43-02    134.5: 260-21-25    300: 260-25-13

--- FLORIDA
MELBOURNE (404) 659-1600
AREA CODE 305    110: 723-0091
134.5: 723-0092    300: 724-6770

--- GEORGIA
ATLANTA (404) 659-1600
110: 659-0840    134.5: 659-0990    300:659-0860
1200: 577-4628

--- ILLINOIS
CHICAGO (312) 751-2200
AUTOSPEED: 266-1790    1200: 787-7694

--- INDIANA
ZONE 2 WATS:    AREA CODE 800    AUTOSPEED: 621-8223
AUTOSPEED: 621-8229    AUTOSPEED: 621-8228

--- IOWA
ZONE 2 WATS:    AREA CODE 800    AUTOSPEED: 621-8223
AUTOSPEED: 621-8229    AUTOSPEED: 621-8228

CEDAR RAPIDS (312) 751-2200
AREA CODE 319    AUTOSPEED: 393-4813

COUNCIL BLUFFS (312) 751-2200
AREA CODE 712    300: 322-7885

--- KENTUCKY
ZONE 2 WATS: AREA CODE 800 AUTOSPEED: 621-8223
AUTOSPEED: 621-8229 AUTOSPEED: 621-8228

--- MAINE
PORTLAND (617) 868-2950
AREA CODE 207 AUTOSPEED: 774-0374

--- MARYLAND
BALTIMORE (703) 524-1500
AREA CODE 301 AUTOSPEED: 837-5929

--- MASSACHUSETTS
CAMBRIDGE (617) 868-2950
AUTOSPEED: 661-8000 1200: 492-4442 4800: 547-8379

SPRINGFIELD (617) 868-2950
AREA CODE 413 AUTOSPEED: 739-4726

--- MICHIGAN
ZONE 2 WATS: AREA CODE 800 AUTOSPEED: 621-8223
AUTOSPEED: 621-8229 AUTOSPEED: 621-8228

ANN ARBOR (313) 559-7766
300: 995-5722

DETROIT (313) 559-7766
110: 559-7612 134.5: 559-7904 300: 559-7965

--- MINNESOTA
ZONE 2 WATS: AREA CODE 800 AUTOSPEED: 621-8223
AUTOSPEED: 621-8229 AUTOSPEED: 621-8228

MINNEAPOLIS (612) 339-4801
110: 338-4803 134.5: 338-3005 300: 338-6217

--- MISSOURI
ZONE 2 WATS: AREA CODE 800 AUTOSPEED: 621-8223
AUTOSPEED: 621-8229 AUTOSPEED: 621-8228

--- NEW HAMPSHIRE
NASHUA (617) 868-2950
AREA CODE 603 AUTOSPEED: 883-9095

--- NEW JERSEY
CAMDEN (215) 665-1566
AREA CODE 609 AUTOSPEED: 962-6266

ELIZABETH (201) 965-2250
AUTOSPEED: 353-3600 1200: 355-1677

PRINCETON (201) 965-2250
AREA CODE 609	110: 799-3285	134.5: 799-2775
300: 799-3490

--- NEW MEXICO
ALBUQUERQUE (408) 739-6271
AREA CODE 505	300: 843-9652

--- NEW YORK
ALBANY (203) 327-9100 HSYS
AREA CODE 518	1200 (DATASPEED ONLY): 449-8793

ALBANY (203) 327-9100 M168
AREA CODE 518	AUTOSPEED: 462-5686

BINGHAMTON (203) 327-9100
AREA CODE 607	AUTOSPEED: 772-1915

BUFFALO (203) 327-9100
AREA CODE 716	300: 847-1710

HEMPSTEAD (212) 754-1700
AREA CODE 516	AUTOSPEED: 489-8746

NEW YORK (212) 754-1700
AUTOSPEED: 350-0900	1200: 755-9470	2000: 757-6957
1200 VADIC FULL DUPLEX: 688-6349	VOICE RESPONSE: 751-5392

POUGHKEEPSIE (203) 327-9100
AREA CODE 914	AUTOSPEED: 454-7920

ROCHESTER (716) 924-9303
110: 924-3037	134.5: 924-7175	300: 924-9338

WHITE PLAINS (203) 327-9100
AREA CODE 914	AUTOSPEED: 428-8010	1200: 428-7759
1200 VADIC FULL DUPLEX: 948-1408

--- NORTH CAROLINA
JAMESTOWN (703) 524-1500
AREA CODE 919	300: 886-4968

--- OHIO
ZONE 2 WATS:	AREA CODE 800	AUTOSPEED: 621-8223
AUTOSPEED: 621-8229	AUTOSPEED: 621-8228

AKRON (216) 771-5550
300: 434-8181

CLEVELAND (216) 771-5550
110: 696-5778 134.5: 696-0366 300: 696-5141

COLUMBUS (216) 771-5550
AREA CODE 614 300: 224-6897

DAYTON (216) 771-5550
AREA CODE 513 300: 224-8505

--- OKLAHOMA
TULSA (214) 661-3688
AREA CODE 918 300: 582-3203

--- OREGON
PORTLAND (503) 223-7255
110: 226-2395 134.5: 226-2390 300: 226-1351

--- PENNSYLVANIA
BETHLEHEM (215) 691-3616
AUTOSPEED: 691-5600

CARLISLE (215) 665-1566
AREA CODE 717 AUTOSPEED: 243-1063

PHILADELPHIA (215) 665-1566
AUTOSPEED: 665-8920 1200: 564-5961

PITTSBURGH (412) 281-6111
110:281-6842 300: 281-6127

--- RHODE ISLAND
PROVIDENCE (617) 868-2950
AREA CODE 401 AUTOSPEED: 521-5487

--- TENNESSEE
ZONE 2 WATS: AREA CODE 800 AUTOSPEED: 621-8223
AUTOSPEED: 621-8229 AUTOSPEED: 621-8228

MEMPHIS (404) 659-1600
AREA CODE 901 300: 725-1210

--- TELEX AND TWX
TELEX: 965806 TWX 110: 710-474-3540

--- TEXAS
DALLAS (214) 661-3688
110: 661-9291 134.5: 661-9274 300: 661-9257

FT. WORTH (214) 661-3688
300: 263-2113

HOUSTON (713) 621-9231
110: 741-1660 134.5: 741-2800 300: 741-2200
2000: 627-3565 1200 VADIC FULL DUPLEX: 621-1397

SAN ANTONIO (713) 621-9231
AREA CODE 512 300: 225-7424

--- UTAH
SALT LAKE CITY (303) 534-2720
AREA CODE 801 300: 364-2720

--- VIRGINIA
ARLINGTON (703) 524-1500
AUTOSPEED: 243-8500 1200: 525-4884

NORFOLK (703) 524-1500
AREA CODE 804 AUTOSPEED: 627-7423

RICHMOND (703) 524-1500
AREA CODE 804 AUTOSPEED: 644-0637

--- WASHINGTON
SEATTLE (503) 223-7255
AREA CODE 206 300: 623-4741

--- WISCONSIN
ZONE 2 WATS: AREA CODE 800 AUTOSPEED: 621-8223
AUTOSPEED: 621-8229 AUTOSPEED: 621-8228

APPLETON (312) 751-2200
AREA CODE 414 AUTOSPEED: 731-6566

MILWAUKEE (312) 751-2200
AREA CODE 414 300: 475-6818