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FLYWHEEL/DIESEL HYBRID POWER DRIVE: URBAN BUS VEHICLE SIMULATION

Glenn S. Larson Harry Zuckerberg

U.S. DEPARTMENT OF TRANSPORTATION RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION TRANSPORTATION SYSTEMS CENTER CAMBRIDGE MA 02142



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A flywheel/diesel hybrid power drive configuration for urban transit bus application is investigated, using a computer simulation model. The hybrid uses continuously variable ratio transmissions and a control subsystem to optimize fuel consumption in an "on-off" mode of engine operation. The system is projected to use 50% less fuel than a diesel-alone in urban driving cycles having more than 4 stops per mile. Regenerative braking is used, contributing to fuel consumption improvement. The computer simulation model developed as a major tool for this investigation is described in detail.

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PREFACE

The work covered by this report is part of an Urban Mass Transportation Administration program which is concerned with fuel conservation in urban transit buses. The program is based on the use of a systems approach to develop propulsion design concepts consistent with environmental, safety, operational and economic objectives. This document reports on a Transportation Systems Center study of a flywheel/diesel hybrid power drive concept suitable for an urban transit bus. A primary tool of the investigation was a computer simulation model developed by the Center during the program and described in detail in this report. This model should be useful in further studies of flywheel/heat engine analyses for vehicle propulsion application over various drive cycles.

The authors are also indebted to Alan McDonald of Purdue University for helpful comments and suggestions, and to Detroit Diesel Engine personnel for valuable information regarding diesel on-off operation.

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SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The Transportation Systems Center has evaluated, as part of the Urban Mass Transportation Administration's fuel economy efforts, the practicality of a flywheel/diesel hybrid power drive concept for urban transit bus propulsion. A computer simulation model was developed as the major tool of this investigation.

The proposed subsystem is a moderately sized diesel engine in series with a relatively large flywheel. The model incorporated a friction clutch between the engine and the flywheel and a continuously variable ratio transmission between the flywheel and the rear axle drive wheels. This hybrid configuration shows considerable promise for fuel efficient propulsion of urban transit buses.

The flywheel/diesel power drive configuration, with the onoff engine operating mode, is projected to have a reduction in fuel consumption of at least 50% (in gallons per mile) below the diesel-alone fuel consumption for urban bus driving cycles having more than 4 stops per mile. This stems from the following:

- The diesel engine, used in the hybrid, is operated (onmode) in regions of minimum specific fuel consumption during a much greater portion of its operating time than in conventional drives. Also, the engine is not operating (off-mode) during the time the flywheel has sufficient stored energy to power the transit bus over a number of driving cycles. Transients in fuel consumption are minimized during the time the flywheel is used as an oversize starter in starting the engine up (on-mode). The on-off engine operation mode practically eliminates engine idling which is a major source of low fuel economy during city driving.
- The flywheel power drive portion of the hybrid subsystem is used in a regenerative braking mode by storing the recoupped vehicle kinetic energy in the flywheel during deceleration. This recouping of energy is appreciable

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during the multi-stop operations of transit buses. The recoupped energy also tends to increase the length of time the diesel engine is in the off-mode condition. This leads to additional fuel economy, as well as minimizing brake wear.

The required diesel engine in this application can, potentially, be rated at a lower horsepower than the conventional diesel transit bus engine, leading to further reductions in fuel consumption and weight.

A number of developments are needed to achieve an acceptable hybrid power drive, principally in the areas of continuously variable ratio transmissions (CVRT) design, improved bearings, and seal effectiveness.

RECOMMENDATIONS

A system design of a flywheel/diesel power drive (series configuration, on-off engine operation mode) should be conducted encompassing all the system elements in order to optimize the power transfer from power source to drive wheels with respect to minimizing fuel consumption within the constraints of safety, environmental effects, and acceptable driveability. This will entail engineering design of the diesel engine, CVRT, flywheel and gear train. An additional study should include life cycle cost analyses of the overall system and each of the subsystems.

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1. INTRODUCTION

This report describes the results of a Transportation Systems Center investigation, conducted under Urban Mass Transportation Administration sponsorship, of the practicality of a flywheel/ diesel hybrid power drive for urban transit bus propulsion. A simulation model, developed in the program, was the major tool used in the investigation and is described in detail in the report.

1.1 BACKGROUND

A fundamental deficiency of the current urban transit bus diesel engine and transmission assembly is that the power unit is operated much of its time in the less-efficient regions of its performance envelope. During urban traffic use the diesel engines are operated in an intermittent mode or duty cycle, characterized by many cycles per mile consisting of acceleration, short cruise, deceleration, and idle segments. During the acceleration segment there is a large speed variation as well as a large variation in drive power required. In the cruise segment the speed is almost constant with sufficient engine power development to account for the air drag and ground rolling friction losses. During deceleration, the engine provides some form of braking to slow the bus vehicle. The idling segment is the most inefficient of all operating modes because fuel is wasted while doing no useful work. The fuel consumption for such a duty cycle is higher than desired.

The national fuel conservation effort has brought together the voluntary action of manufacturers and operators to promulgate fuel efficient or energy saving features for truck and bus vehicles. Typical of these, are the following:

- o Weight reduction options;
- Aerodynamic design improvements that reduce the wind and ground effect drag of the buses;

- o Use of radial ply tires that reduce rolling resistance;
- Redesign of diesel engines that develop rated power at reduced engine speeds;
- Use of turbochargers that improve the efficiency of diesel engines;
- o Demand actuated fan clutches that disengage the engine cooling fan when it is not needed.

Case studies of major trucking operators reveal fuel savings ranging from 15 to 20% through the use of the above measures (References (1), (2). Similar fuel savings ranging from 10 to 15% may be estimated for the bus operators.

Additional fuel savings would be attainable with effective energy management and matching of the diesel engine to its duty cycle. This suggests that there are a number of potentials which can be considered for reducing urban bus fuel consumption. One potential is in the use of a Continuously Variable Ratio Power Drive Transmission (CVRT) concept which is capable of sustaining the diesel engine operation within its optimum performance envelope. A simulation study of such an approach has predicted that the use of an available CVRT in a present day urban bus would increase the bus fuel economy (in mpg) by as much as 30%.*

More improvement in fuel economy can be achieved with the alternate approach of using a hybrid power drive concept which will support deceleration energy recovery along with optimum engine operation.

^{*}H. Zuckerberg, "Performance Characteristics of a Diesel Powered Urban Bus Equipped with Sundstrand Hydromechanical Transmission," material on file with Kentron Hawaii, Limited, Transportation Systems Center, 55 Broadway, Cambridge MA 02142.

1.2 STUDY APPROACH

The objective of this study was to determine the potential of a flywheel/diesel power drive concept for urban transit bus propulsion. The approach taken to meet the objective was in accordance with the following tasks:

- Provide information showing the potential viability of flywheel hybrid power drives for bus propulsion.
- 2. Estimate the improvement in fuel economy that could be achieved through use of flywheel hybrid propulsion.
- Identify the problem areas which will be encountered in the development of flywheel hybrid power drives.
- 4. Delineate the initial phases necessary for an urban bus flywheel hybrid propulsion system development.

These tasks were performed within the following guidelines:

- 1. Engines designed to operate at peak efficiency;
- Power transmissions designed for compatibility with peak engine efficiency;
- Accessory power drives designed for compatibility with peak efficiency.

The most significant characteristic of the proposed flywheel/ diesel power drive subsystem is a moderately sized engine in series with a relatively large flywheel. The interfaces between the engine and flywheel and between flywheel and rear axle drive wheels, are CVRTs and possibly fluid clutches. The use of CRVTs with flywheel/diesel hybrids permits the combining of the best features of the flywheel and the diesel to provide an attractive transit bus power drive subsystem.

Many "hotel" accessories (air conditioning, heating and ventilating) can provide optimum output within their peak efficiency regime when operated at near constant input speed. Within the time frame projected for the development of a prototype bus vehicle concept, (i.e., 1985), it is likely that an optimized package of "hotel" accessories having a constant input speed

specification will be available for operation off the hybrid "power drive or off a separate power source.

Because of the uncertainty in the characteristics of future "hotel" loads, comparisons between hybrid propulsion and standard diesel propulsion in this report are made on the basis of no air conditioning, heating or ventilation.

2. HYBRID SYSTEM CONSIDERATIONS

2.1 HYBRID SYSTEM SELECTION

In configuring a heat engine hybrid power drive, four major selections must be made:

Type of engine

Power drive configuration (series or parallel)

Type of energy storage

Operation mode of the engine

A discussion of these follows.

The diesel was chosen as the heat engine for this study because of its demonstrated superiority to other available engines in the areas of maintenance and fuel economy. Other engines such as the gas turbine or the Stirling may prove superior to the diesel at a later date when they are developed for bus operation.

Hybrid power drive configurations are often grouped into two broad classes, series and parallel, as illustrated in Figure 2-1. In the series configuration, the energy passes directly through the various energy conversion and energy storage devices as it flows from the prime source to the drive wheels. This permits a wide latitude in the degree of prime source decoupling from the drive wheels, which results in greater flexibility of diesel engine operation. In the parallel configuration of hybrids, the energy flow still has a path through energy conversion and storage devices but there is also a (parallel) path of mechanical power transmission to the drive wheels. The decoupling potential is less than in the series configuration, which limits the engine flexibility. However, the transmission losses in the mechnical drive path can be lower than those in the series configuration. Although the size and weight of some of the components can be less in parallel hybrid configurations there are more components.

The series configuration was selected because, having less components it is less complex than the parallel. In addition, the

- A. SERIES CONFIGURATION
- (i) PRIME ENERGY SOURCE/FLYWHEEL HYBRID



- **B. PARALLEL CONFIGURATION**
 - (i) PRIME ENERGY SOURCE/FLYWHEEL HYBRID





FIGURE 2-1. SCHEMATIC DIAGRAM OF HYBRID POWER DRIVE SUBSYSTEMS

particular series configuration chosen is more fuel efficient than a parallel configuration and allows on-off operation of the diesel engine, whereas the parallel configuration requires essentially continuous operation.

Continuous, constant speed operation of the heat engine is attractive because it provides the possibility of finding the best operating engine speed to minimize fuel consumption and/or exhaust emissions. However, a particular setting of constant speed operation is only applicable to a particular phase of a driving cycle. Because of this, the heat engine is sized to meet the maximum power requirement for the continuous operational mode, and the speed-power operation is adjusted to meet the lower power levels as required. The energy savings, if any, that are realized by this method of control, stem from the slow variations in engine speeds that are possible. The design challenge is to configure the control system so that the engine speed and power changes take place in such a manner that no vehicle acceleration demands are imposed upon the engine.

Another engine operational mode is possible in which the engine is turned on and off in response to the state-of-charge of the energy storage device. The energy storage device discharges as energy is extracted for propulsion. When the energy storage device has been discharged to its minimum operational level, the heat engine is turned on to charge it up. When the storage device reaches its maximum charge limit, the heat engine is turned off and disengaged. This on-off operation of the heat engine allows for essentially complete decoupling of the engine from the wheel loads and, therefore, minimum fuel consumption. For this reason, the on-off operation of the heat engine was chosen.

Energy can be stored in batteries, flywheels and hydraulic accumulators. A state-of-the-art review of these methods determined that only flywheels could be characterized well enough to be accurately modeled in a simulation program. In addition, flywheels are superior to the others in charge and discharge power densities and in cycle life.

A functional diagram of the selected hybrid power drive -system is shown in Figure 2-2. This particular type of hybrid drive subsystem has not received extensive attention in prior studies. Only two previous studies and experimental trials are related. These are described in References 3 and 4. In this concept the flywheel/diesel hybrid drive train is dominated by the flywheel. The diesel engine is used only to charge up the flywheel. In terms of performance (acceleration, cruising speed and energy economy), the proposed subsystem can be a satisfactory substitute for currently manufactured transit bus power drive train subsystems. The flywheel can provide high power density levels to propel vehicles at the desired speeds and accelerations. With a bilateral transmission, a flywheel assembly can store vehicle kinetic energy developed during the deceleration phase which can be used during the next acceleration phase, thereby increasing the energy efficiency of the transit bus. In addition, the proposed systems should have the operating life compatible with service-life requirements of the complete bus vehicle drive system.

2.2 HYBRID POWER DRIVE OPERATION MODES

The proposed vehicle drive subsystem is shown schematically in Figure 2-2. The diesel engine is used primarily to charge the flywheel, when required. Power is supplied to the flywheel through a Continuously Variable Ratio Transmission (CVRT) which adjusts its ratio automatically to maintain the engine operation at its best power-speed profile while the flywheel speed varies between its minimum and maximum values. Figure 2-3 illustrates the optimum power-speed profile for a typical bus diesel engine.

Other modes of operation for the hybrid concept are illustrated in Figure 2-4. When the flywheel is fully charged, the engine is automatically turned off. Later, when the energy in the flywheel reaches a specified lower threshold level, the engine is started up by the flywheel. Once turned on, the engine brings the flywheel to full charge.



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FIGURE 2-2. SELECTED HYBRID POWER DRIVE - SERIES CONFIGU-RATION - ON-OFF ENGINE OPERATION



FIGURE 2-3. 8V-71N ENGINE PERFORMANCE CHARACTERISTICS

A - POWER DRIVE SUBSYSTEM STARTUP



Note: For the simulation program the CVRT between the engine and the clutch was not included.

FIGURE 2-4. FLYWHEEL/DIESEL HYBRID POWER DRIVE MODE OF OPERATION

Another CVRT with reversing capabilities is used for transmitting power to the drive wheels from the flywheel. The need for a CVRT between the flywheel and the drive wheels is emphasized by the incompatibility of the flywheel and vehicle speed regimes. For example, at vehicle standstill, after charging, the flywheel speed is maximum while the vehicle speed is zero. As the urban bus begins to accelerate, the flywheel slows down. During the cruising phase with the bus travelling at steady speed, the flywheel gradually slows down due to the extraction of energy. During the deceleration phase, as the vehicle slows down, the flywheel speeds up because of the kinetic energy imparted to it.

The engine can be operated without CVRT coupling to the flywheel. In this case, a clutch must be used and the engine operation will not be optimal, resulting in higher fuel consumption.

To establish which approach is better, a trade-off analysis between the clutch and CVRT must be made, considering maintenance costs and power drive efficiency.

2.3 PRELIMINARY ENGINEERING ASSESSMENT OF THE FLYWHEEL/DIESEL HYBRID CONCEPT

The purpose of this section is to document the development of a "proof of principle" engineering assessment method for determining the fuel conservation potential of the selected flywheel/diesel hybrid concept. The method is based on the balance of energy flows from and to the flywheel energy storage subsystem. The analysis is predicated on the determination and use of average efficiency values of each of the drive components.

Upon completion and acceptance of this assessment method, a computer simulation model was used as a tool to develop component functional specifications of the selected power drive hybrid concept. In the computer simulation program, performance and efficiency maps of the power drive components are used. The accuracy of the simulation model output depends greatly upon the accuracy of these maps. The maps which have been used are considered to

be the best available. A detailed computer listing of the simulation modeling is presented in Section 3 of this report.

The preliminary assessment, which follows, estimates the road load power requirement for a drive cycle considered to be realistic from an energy requirement viewpoint. Estimates are then made of the average efficiency of each component when operated over the chosen drive cycle. Then, through energy balance relationships, the fuel consumption per mile is calculated.

2.3.1 Dynamic Road Power Demand

The instantaneous dynamic power demand manifested at the drive wheels of an urban bus vehicle during any drive cycle is expressed by

$$P_{i} = P_{A} + P_{D} + P_{F} + P_{G}$$
 (2-1)

where

- P_i = Instantaneous power at the drive wheels due to vehicle losses incurred while in motion.
- P_A = Power loss or gain due to vehicle inertia effects either during an acceleration or deceleration phase:
- $P_{\rm D}$ = Power loss due to air resistance on the vehicle;
- P_F = Power loss due to tire/ground resistance and wheel/axle bearing losses;
- P_G = Power loss or gain due to vehicle negotiating an elevation change in the road profile - (in terms of grade slope in percent). During this study, this loss will be neglected.

The power loss in kilowatts for straight line motion, consists of the translational acceleration effects of the vehicle mass and the rotational acceleration effects of the rotating elements of the power drive train and is expressed by

$$P_{A} = K_{A}(GVWR) (ACC) (V) + K_{RA} \sum_{i=1}^{n} I_{i} \alpha_{i} \omega_{i}$$
(2-2)

where ${\rm K}_{\rm A}$ and ${\rm K}_{\rm RA}$ are parameters to assure dimensional compatibility

GVWR = Rated Gross Vehicle Weight; 1bs ACC = Acceleration; mph/s V = Velocity mph I_i = Moment of inertia; slugs ft² α_i = Rotational acceleration; rad/sec² K_A = 9.07 x 10⁻⁵ K_{RA} = 135 x 10⁻⁵

For preliminary analyses the rotational effects are approximated as 10% of the translational effects. Thus

 $P_{\Delta} = 1.10K_{\Delta} (GVWR) (ACC) (V)$ (2-3)

where

GVWR = Normal Gross Rated, Vehicle weight; pounds. ACC = Linear acceleration of vehicle; mph/sec. V = Resultant vehicle velocity; mph. K_A = Parameter to assure dimensional compatibility. = .0907 x 10⁻³

The power loss in kilowatts due to the air resistance on the vehicle is expressed by

$$P_{\rm D} = K_{\rm D} C_{\rm D} S V^3 \tag{2-4}$$

where

C_D = Air drag coefficient
S = Vehicle frontal area; sq. ft.
V = Vehicle resultant velocity; mph

 K_D = Parameter to assure dimensional stability K_D = 5.089 x 10⁻⁶

Equation (2-4) is rewritten as follows:

$$P_{\rm D} = 5.089 \times 10^{-6} C_{\rm D} {\rm SV}^3$$
 (2-5)

The power loss in kilowatts due to the drive wheel/ground rolling friction and wheel/axle bearing losses is expressed by

$$P_{E} = K_{E} (f) (GVWR) (V)$$
(2-6)

where

f = Wheel/ground rolling friction coefficient K_F = Parameter to assure dimensional stability K_F = 1.9885 x 10⁻³

Many values of the rolling friction and bearing loss coefficient have been quoted and measured under controlled conditions by various authors as noted in the technical literature. It would appear that during real life conditions many vehicles may not maintain the tire pressures consistent with those used in the tests, and there may not be compatibility of the route surface conditions with that of the tests and a host of other mismatches. Based on available data the following expression for f was developed:

$$f = .005 + 30 \times 10^{-6} V + .25 \times 10^{-6} V^2$$
(2-7)

The resulting power loss in kilowatts due to rolling friction is expressed by

$$P_{\rm F} = 1.99 \times 10^{-3} (.055 + 30 \times 10^{-6} \text{V} + .25 \times 10^{-6} \text{V}^2) \text{ (GVWR)} \text{ (V)} \text{ (2-8)}$$

The power loss in kilowatts due to the negotiating of a grade in the road profile, is expressed in terms of the slope in percent.

$$P_{G} = 1.99 \times 10^{-3} \left((GVWR) \left(\sin(\tan^{-1}\gamma/100) \right) \right) V$$
 (2-9)

where γ = slope in percent.

2.3.2 Balance of Energy Flow

Figure 2-5 is a schematic of the drive chain of a flywheel/ diesel powered urban transit bus, equipped with a system for recovering energy when the vehicle is slowing down. The overall energy balance of the power drive subsystem during any kind of drive cycle and time interval is (see Figure 2-5):



FIGURE 2-5. HYBRID FLYWHEEL PROPULSION SUBSYSTEM WITH REGENERATION

 $E_{FW} + E_{MT} + E_{PD} + E_{DES} + E_{BR} - BE_{DE} - E_{REG} = 0$

where

E_{FW} = Net flywheel energy extracted
E_{MT} = Losses in mechanical transmission chain
E_{PD} = Energy consumption due to vehicle inertia acceleration, due to air drag, due to ground traction rolling resistance and due to road gradient = E_A + E_R + E_G
E_{DES} = Flywheel energy loss during diesel engine start up

E_{BR} = Energy wasted in friction braking

- E_{DE} = Energy provided to flywheel from diesel engine; β = 0 if the engine is in the off mode and β = 1 during engine charging.
- E_{REG} = Energy provided to flywheel from regenerated energy mechanism.

Estimates of Component Efficiencies

The efficiency of the mechanical transmission chain from the flywheel to drive wheels is based on the following engineering estimates:

 $\gamma (REAR AXLE) = .91$ $\gamma (CVRT) = .77$

2.3.3 Drive Cycle Delineation

Power and energy relationships were determined with respect to a particular stop-and-go urban driving schedule. In order for the simulation model to provide reasonable values for the hybrid subsystem component specifications and for comparison with alternative concept approaches it was necessary to establish a reference drive cycle. Drive cycle candidates, (shown in Figure 2-6) were taken from the TRANSBUS and Small Bus Specifications (References 5 and 6), work by Renner (Reference 7), and measurements made by TSC in the Boston area. The limit drive cycles shown may be considered as the upper and lower bounds of national urban drive cycles when considered from an energy point of view. In real-world transit operations, buses are subjected to varying acceleration and/or cruising velocities within any one drive cycle as well as with



ITEM	NOMENCLATURE	UPPER BOUND	LOWER BOUND	STUDY DRIVE CYCLE
(A)	ACCELERATION MODE (CONSTANT ACCELERATION)	3.5 mphps	2.0 mphps	2.5 mphps
(C)	CRUISE MODE (CONSTANT VELOCITY)	35 mph	20 mph	25 mph
(D)	DECELERATION MODE (CONSTANT DECELERATION)	3.4 mphps	2.5 mphps	2.5 mph
(DW)	DWELL TIME AT BUS STOP	20 seconds	10 seconds	20.4 sec.

FIGURE 2-6. URBAN TRANSIT BUS DRIVING CYCLE

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variation in the number of stops per mile. However, from the standpoint of determining the performance behavior and comparisons of different power drive subsystems such as a "standard transit bus" with a "hybrid bus", the use of simple repetitive drive cycles can provide data of sufficient accuracy for the purpose of the present study.

The simple trapezoidal-shaped drive cycle used in this study was taken as an average of the upper and lower bounds shown in Figure 2-6. This drive cycle was assumed repetitive over any number of stops. It should be noted that the dwell time in the stop region is 20.4 seconds to take into account exiting and entering passengers as well as traffic delays.

2.3.4 Determination of Fuel Usage

The fuel usage may be determined in the following manner: The typical high heat value (HHV) of diesel fuel (ranging from 18,500 to 20,000 BTU per 1b, Reference 6) is estimated at 19,250 BTU per 1b, or, (since 2511.5 BTU = 1 HPHR and 1 gallon = 6.8 1bs), 187,632 HP-SEC/GAL. Fuel usage was determined from

 $mpg = (HHV)\xi_{F}/E_{DF}$

where

ξ_E = Thermodynamic conversion efficiency of a diesel engine and is a function of the operating range of engine speed and power.

Average estimated values for component efficiencies were used in the determination of energy flows.

Since the diesel engine is to operate along its optimum fuel usage line (see Figure 2-3), it is estimated that the thermodynamic conversion efficiency is

 $\xi_{\rm F} = .35$

The efficiency of the standard bus transmission chain is based on the following average values (Abstracted from the technical literature):

η	(rear axle)	=	.91
η	(automatic transmission)	==	.85
η	(torque converter)	=	.80

The process of estimating fuel consumption is as follows (Refer to the Energy Balance Diagram in Figure 2-7):

- Determine the energy expended per cycle by integration of the power drive cycle. Any energy of regeneration is added to the flywheel energy.
- Extract this energy expended from the flywheel. Track the flywheel rotational speed.
- Determine when flywheel speed drops to minimum threshold level (a function of the velocity of the bus).
- Turn engine on to recharge the flywheel. Determine the time for full flywheel charge. The start up energy of the engine must be taken into account.
- 5. Determine the fuel used during the on-cycle operation of the engine.
- 6. Repeat the process until the accumulated mpg levels out.

The preliminary estimates of fuel usage for an urban hybrid bus of 30,000 and 34,000 weights are illustrated in Figure 2-8.

The performance characteristics for a typical urban bus of similar size and weight are also estimated for comparison with those of the hybrid bus. The energy balance diagram for the diesel bus is illustrated in Figure 2-9, and the comparison is illustrated in Figure 2-8. The comparison of the preliminary assessments of fuel usage between the hybrid and standard transit buses showed sufficient promise for the hybrid to justify the development of an accurate computer performance simulation model.

Prof. A.T. McDonald had developed an Engineering Limit Performance of Transit Buses which is included herein as Appendix C. The results of the computer simulation program discussed in this report are consistent with the findings of Prof. McDonald.







FIGURE 2-8. FUEL MILEAGE AS A FUNCTION OF STOPS PER MILE (ESTIMATED DATA USING ENERGY BALANCE ANALYSIS)



FIGURE 2-9. ENERGY BALANCE DIAGRAM - STANDARD BUS IN URBAN DRIVE CYCLE

2-19/2-20

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3. COMPUTER SIMULATION PROGRAM

3.1 INTRODUCTION

The present study was initiated to compare the performance of hybrid power drive subsystems with a standard transit bus heatengine power drive subsystem. The guidelines for the hybrid flywheel power drive subsystem include the following:

- Use the same baseline bus configuration and the same diesel power plant.
- o Replace the torque converter and transmission with the following:

A flywheel kinetic energy unit and engine/flywheel clutch

A flywheel/transmission clutch

A continuously variable ratio hydromechanical transmission.

- o Select a flywheel size capable of storing enough energy to power the urban transit bus over a series of stop-andgo-drive cycles along a simulated scheduled route, with the diesel engine in the "OFF" mode.
- Engage the flywheel with the 'STOPPED' diesel engine to start the engine.
- Use the diesel engine to recharge the flywheel when required.

3.2 SYSTEM OPERATING PRINCIPLES

3.2.1 Configuration and Engine Operation Mode Options

The series hybrid concept was selected as the baseline configuration to be pursued for simulation and evaluation because of its simplicity of assembly and simple control system logic. There are a number of operation modes possible with the series hybrid. Two of the more interesting ones are:

(a) Continuous Engine Operation Mode

- Keep the diesel engine continuously running at constant speed and power except during braking.
- Use flywheel power to fulfill demand power.
- Regenerate to flywheel during braking.
- Balance over a selected number of cycles per bus route.
- (b) On-Off Engine Operation Mode
 - Operate the diesel engine in an on-off mode. Initially bring flywheel up to maximum rated speed, then shut off engine.
 - Use flywheel energy to power the transit bus over its drive cycle. Limit the spin-down of the flywheel to a minimum threshold speed which will permit the engagement and start-up of the engine without the complete loss of flywheel energy and which should occur near the point of braking.
 - Regenerate to the flywheel during braking.
 - Use flywheel power to start engine and use engine power to bring flywheel speed up to maximum rated speed during stop segment of drive cycle.

Intuitively, the on-off mode operation should develop better fuel economy than the continuous mode. Therefore, the baseline concept of the initial study phase (the diesel engine/flywheel hybrid concept) employed the on-off mode of engine operation.

3.2.2 On-Off Engine Operation Mode

In this mode of operation the heat engine is started and warmed-up before initiating the route run. The engine clutch is engaged to "rev-up" the flywheel to its maximum operational speed. The engine operation control system logic will cause the engine clutch to disengage and the engine to be turned off when the flywheel reaches its maximum rpm. The transit bus is then ready to begin revenue operations. During the traverse of a number of driving cycles, energy is extracted from the flywheel causing it to spin-down. The control logic will sense the threshold minimum speed of the flywheel and cause the engine clutch to re-engage and, thus, cause the flywheel to turn the engine over and start-up. This will further extract energy from the flywheel and cause additional spin-down. The energy extracted from the flywheel during the 'powering' of the transit bus and engine restart, must not cause the flywheel speed to drop below its critical minimum speed where the flywheel will be ineffective. A schematic diagram of a typical series on-off engine power drive subsystem is shown in Figure 3-1.



FIGURE 3-1. SERIES ON-OFF ENGINE OPERATION SCHEMATIC

3-3

3.3 PROGRAM

3.3.1 Subsystem Description

The computer simulation program used in this work is an adaptation of the University of Wisconsin hybrid vehicle computer program which was developed under the sponsorship of the U.S. Department of Transportation Office of University Research (Reference 3).

The TSC computer program is sufficiently flexible to permit any vehicle configuration to be simulated and to allow rapid evaluation of subsystem components as well as alternate configurations. Basically, the program consists of three parts; input, simulation and output.

The input element accepts the following information: Vehicle configuration masses and moments of inertia. Vehicle power drive subsystem component characteristics; e.g., heat engine data; gear box, flywheel, CVRT transmission, rear axle gearing and drive wheel characteristics.

Driving cycle characteristics for vehicle route; e.g., total length, number of stops, roadway grade, and wind conditions.

The simulation element of the program accepts input information controlling the simulation time step, time interval for storing simulation results, and operational control parameters. All simulation calculations and comparisons with necessary vehicle system operating constraints are performed within this element and the calculation results are output at the specified time intervals for the output element.

The output element accepts the simulation results and output specifications to produce printouts in a variety of formats. Summaries, tabular outputs and graphic plots of the desired simulation parameters are possible. A flywheel hybrid vehicle power drive subsystem layout to be simulated for this study is shown in Figure 3-2. A schematic organization of the simulation program is illustrated in the block diagram of Figure 3-3. The equations of motion of the vehicle basic to the simulation program were delineated in Section 2-3. Representative input data are given in Figure 3-4.

The simulation program is started with an initialization step. After proper initialization, the reflected flywheel rotor element of the flywheel package is assumed spinning at 2,100 rpm (the basic flywheel is rotating at 11,000 rpm, and the engine and transmission "sees" the reflected rotor inertia at the gear box). The on-off mode of operation requires the engine to be turned off when the 'reflected' flywheel is fully charged; that is spinning the drive shaft at 2,100 rpm. Thus, after initialization, the heat engine is in the 'off' condition and the engine clutch disengaged.

The transmission clutch is engaged and the transit bus begins the driving cycle with calculations performed for time increments of 0.10 seconds. For each time increment, the 'automatic driver' compares the current vehicle speed (at the beginning of the time increment) with the required speed at the end of the time increment (from the driving schedule), and then determines the required drive shaft torque to bring the transit bus to the desired speed. The required torque is provided by the energy extracted from the flywheel. The extraction of energy from the flywheel causes the flywheel to slow down.

As previously noted, the engine is in the "off" mode when the flywheel is fully charged to 2,100 rpm drive shaft speed. When the reduction in flywheel speed due to energy extraction reaches the minimum threshold value (a function of vehicle speed, see Figure 3-5) the engine clutch is engaged and the engine operates in the "on" mode. Fuel is consumed only when the engine is in the "on" mode. Fuel consumption is calculated based on the fuel rate provided as input data.



FIGURE 3-2. COMPONENT LAYOUT DIAGRAM OF HYBRID POWER DRIVE TRAIN SUBSYSTEM



FIGURE 3-3. SIMPLIFIED SYSTEM BLOCK DIAGRAM

Typical Data

TVT FFF TABL	P					
12+13	22+03	22.39	22.39	22.33	22,39	22+39
11+14	16-23		11-12		11+19-	
7.12	13+69	5.60	5.60	5.60	5.60	5-60
					2.80	
3.24	11.45	.00		.00	.05	+00
		E				
0.22	10.00	1,000	3+50	1.1.10		11.17
9.50	16.04	11+12	17,7-			11°17
10.00		55222	62532	62722		6.4.
20+45	20.11	44+77	44.77	44 17	44.77	44077
						63•69
11+14	13 + 42	15+21	14+65	14-65	14+65	14.65
7•12			7+32	7.32	7.32	7+32
5+13	9-64	12.55	3.66	3.66	3.66	3.66
6.17	8.57	12.00	7.32	7.32	7.32	7:32
	9.72					•
15.20	12.01	*/.35	20.00	20 20	20.00	20.20
10460	12-01	14:30	C2*C7	 	. <u> </u>	
20149		1011/	123.52		20+26	
12013	10.55	1/ • 4 3	1/+21		30+19	30+13
11+1+	11:05	12021	13-13	10.10	- C + _ U	10.10
7+12	8.85	9+91	12+16	3 • 95	9.05	9+05
5:13	7.04	8:85	11731	4:52	4.5	4.52
3 • 24	6 • 48	7.76	11.51	- 0 C	+ 0 0	+ 00
6 • 17	6.01	7.01	12755	9105	9.05	3.08
9+20	7+59	8+67	12:55	18.10	18+10	18+10
13-30	9*75	10.73	13145	36+19	36+13	35113
20.46	14 - 34	15 • 14	15+58	72.39	72.39	72.39
12+13	17.36	15+34	15-16		43.1C	43.10
11+14	9.98	10.08	10.90	21.55	21.55	21+55
	7+12	7*67				
5+13	5.85	6.56	8.41	5.33	5.29	5.39
6.17	4046	4.05	7.77	10.77	10.77	10.77
15.50	7.70	0.494	0.142	61100	41+00	61.00
	/ 37	1 * 2 6	9.70	93+10	43+10	43+10
20.49	11.12	11.51	15.15			
12+13	15+59	8,51	7 • 2 /	5.4C	20+00	50+00
	<u> </u>				20-00-	
7 • 12	6 • 4 5 -	5•18	4.51	5+38	12.50	12+50
5+13	4+94	4.85	47.20		- 6,25-	6 • 25
3 • 2 4	3.42	3.91	3.79	5.40	+00	• 00 •
5 \$ 1 7	5.93	5.60		5:42	12:50	
9+20	8+55	7.26	6.29	7.45	25.00	25.00
		10				
20,46	23.92	16.04	15.40	13.73	100.00	100,00
	11.57	11.72 -			54.20	54.00
11014	7.53	7.60	3.21	9,94	28.45	28.45
7.12						
5.12	4.6/	4.47	5.45	7 22	7 4 4	7.11
0-10		7.07	J * 1 J	142.2	/ • 1 1	/ * 1 1

FIGURE 3-4. INPUT DATA - DIGITAL SIMULATION OF A 30,000 LB HYBRID BUS (Sheet 1 of 6) CVRT EFFICIENCY AS A FUNCTION OF SPEED AND TORQUE

ILSEL WITH	FLYWELEL					
3•24	4.89	4,95	5.77	7 + 83	• 0 0	• 0 0
6+17	6 15	6+23	7:04		14.23	
9.20	7.56	7.56	8.25	9.46	28.45	28.45
15+30	10+83	10753	10.34	11.45		56+90
20.46	19.41	17.55	16+60	16.28	113.81	113.81
12013	15.00	15.32	15+50	15-83	15914	63+81
11+14	10.37	10.10	10.59	11.68	13.3:	31+90
7.12						15+95
5 • 13	7.03	6.55	7 . 23	2.81	11.68	7 • 9 %
3•84			7 . 23			
6:17	8.25	7.92	3-54	0.8%	11.51	13+95
			9125			
15+30	12.81	12.51	12.84	13.34	13,79	63.81
					13.93	
12:13	18+08	18.04	13+43	18.38	12.33	70+71
7:12	10-18	9.84	10+33	11.41	13.43	17+63
						
3 • 2 4	8.69	8,29	8+33	10+07	12.16	+ 00
				<u>-11+37</u>		
2+20	11.40	11+19	11.80	12.72	14.15	35+36
		-14+40	14-95			70 • 71
20 * 46	22.40	22+05	81.96	22.11	55°CƏ	141.42
12113	20.08	12 (1 2 .3 1	21+32	25.00		6-110
11 • 14	14+26	14+46	15.24	16+27	17.73	19-37
7:12	11,83	11+31	12.51	13.82	15.40	17.05
5+13	10.65	10.53	11.15	12.64	14.28	15+93
3+24	10+14	10:05	10.79	12.27	13.95	15+70
6 • 17	11+48	11.52	12.32	13.61	15.23	16.98
<u>3120</u>	12-52	13.03	13-23	-5-02	10,00	18+27
15-30	16.02	16.25	17-27	18.13	19.42	20-79
20+46	23.68	24+12	24071	20:27		27.34

FIGURE 3-4. INPUT DATA - DIGITAL SIMULATION OF A 30,000 LB HYBRID BUS (Sheet 2 of 6)

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FIGURE 3-4. INPUT DATA - DIGITAL SIMULATION OF A 30,000 LB HYBRID BUS (Sheet 4 of 6)

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.122E CO							
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FIGURE 3-4. INPUT DATA - DIGITAL SIMULATION OF A 30,000 LB HYBRID BUS (Sheet 5 of 6) MISCELLANEOUS PARAMETERS: SEE APPENDIX D

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FIGURE 3-4. INPUT DATA - DIGITAL SIMULATION OF A 30,000 LB HYBRID BUS (Sheet 6 of 6)



VEHICLE SPEED ~ MPH



The calculations are carried through the drive shaft, CVRT transmission, rear axle and to the drive wheels. The dynamics of the vehicle are then determined and energy losses are integrated for each time increment of the driving cycle. The whole process then repeats until the end of the driving cycles constituting the route length.

Representative output data are illustrated in Figure 3-6.

The computer simulation program can be exercised for any drive cycle, any route length and/or any number of bus stops.

3.3.2 Hybrid Power Drive Simulation Results

The hybrid computer program was exercised for the series configuration with the engine operating in the on-off mode. In most of the cases the lower limit driving cycle illustrated in Figure 2-6 was used. The gross vehicle weight was 30,000 pounds. Enough variation in driving cycle and vehicle weight was studied to obtain an understanding of the effect of these variables. The computer runs were generated with variation in flywheel moment of inertia from 8 to 17 ft-1b-sec² (reflected to drive shaft) and for 6, 8 and 10 stops per mile.

When due consideration is given to fuel consumption, flywheel weight and frequency of on-off cycles, a flywheel moment of inertia of 14 lb-ft-sec² appears to be a reasonable initial design value.

Figure 3-7 illustrates the results of some simulation runs. The fuel consumption (gpm) decreases slowly with increasing values of flywheel moments of inertia over the entire range studied. For a fixed maximum flywheel rotational speed and fixed diameter, the flywheel weight varies linearly with moment of inertia. As shown in Appendix B, the flywheel system weight is approximately 2,200 pounds for a (reflected) inertia of 14 ft-1b-sec².

A comparison of fuel consumption performance of the hybrid power drive (inertia =14) with the baseline bus fuel consumption

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FIGURE 3-6. OUTPUT DATA - DIGITAL SIMULATION OF A 30,000 LB HYBRID BUS WITH A MODIFIED EPA DRIVING CYCLE (Sheet 3 of 5)

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FIGURE 3-6. OUTPUT DATA - DIGITAL SIMULATION OF A 30,000 LB HYBRID BUS WITH A MODIFIED EPA DRIVING CYCLE (Sheet 4 of 5)

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FIGURE 3-7. FUEL CONSUMPTION AS A FUNCTION OF FLYWHEEL MOMENT OF INERTIA

performance is shown in Figure 3-8. The hybrid bus shows sufficient improvement in fuel economy over the standard bus to warrant a design study culminating in an integrated hybrid power drive subsystem design.

Other analyses have been made using the computer simulation program from which the following can be predicted:

- 1. The diesel engine power may be reduced to approximately 100 horsepower (lower limit). This will result in a modest weight reduction of about 1,000 pounds in the hybrid propulsion subsystem, and a reduction in fuel consumption and exhaust emissions.
- For other driving cycles representative of urban bus operation, the ratio of fuel consumption of the hybrid to fuel consumption of the baseline bus will not differ radically from the data shown in Figure 3-8.
- 3. A parallel hybrid configuration will show very little improvement in fuel economy (if any) over the series configuration. It will be less attractive because of its increased complexity and maintainability due to additional components.
- 4. The continuous mode of engine operation will not show any significant advantage over the on-off mode studied in this report.







APPENDIX A PREVIOUS FLYWHEEL AND HEAT ENGINE STUDIES

Flywheel Background

Robert Clerk (Reference 9) describes the early history of flywheel applicability to a number of vehicles including the flywheel-powered Howell Torpedo of 1885.

Most of these historical applications used steel flywheels. They illustrate the many advantages of flywheel energy storage even though the performance was very poor according to present technology. The advantages include:

- 1. Rapid charge/discharge capability;
- 2. Unlimited depth of discharge and number of cycles;
- 3. Simplicity, no maintenance, and infinite self life;
- Flexibility, i.e., input/output can be electrical (AC or DC), hydraulic, or mechanical, or any combination; and
- 5. Autonomy from ambient environment.

But these early flywheels also had a number of very important disadvantages, which inhibited flywheel development until the present. Clerk described these disadvantages as:

- 1. Relatively poor energy storage per pound;
- 2. Poor efficiency, i.e., short rundown time, and
- 3. The ever-present hazard of catastrophic failure.

Although modern technology has provided an order of magnitude improvement in steel flywheel energy density and efficiency, the hazard problem has gotten proportionately worse. In spite of its present limitations, the flywheel is being introduced in an increasing number of applications throughout the world, including small road and non-road vehicles, buses, a variety of electrical power supplies, hoists, aircraft catapults, trains, and earthmoving vehicles. The first major vehicular application of flywheels was the Oerlikon Electrogyro bus, used in European and African transit services in the 1950's. The buses were technically successful and economically feasible. However, long waits between recharges and difficulties imposed on the vehicle operators forced a gradual withdrawal of these buses from service.

Lockheed has worked on a program to demonstrate flywheel propulsion systems in San Francisco using a dual mode vehicle operating either from energy sypplied by the flywheel or from energy supplied by trolley wires (Reference 10). Initial analysis suggested an effective electric vehicle with increased route flexibility. Lockheed has also examined several flywheel and flywheel hybrid concepts in detail for the Environmental Protection Agency (Reference 11). These studies centered on the hybrid configuration of a small flywheel with a slightly reduced engine, e.g., about 50 percent of a normal power plant. This system was found to offer only minor advantages over the conventional automobile drive system in terms of economy and emissions. Furthermore, the high performance was limited to a small number of cycles because the small flywheel was quickly discharged. The study also found that a pure flywheel drive system was impractical for a conventional American automobile. The biggest drawback was the size of the drive system necessary to give a 5000-lb vehicle a 200-mile range. However, special purpose vehicles with a limited range were found to be excellent candidates for flywheel power systems.

Garrett Research* is currently testing flywheels as an element of a regenerative braking system for the New York subway system (Reference 12). Large flywheels absorb braking energy during stops and give it up upon demand during accelerations or emergencies. The Garrett tests indicate the regenerative system could reduce electrical energy demands by nearly 30 percent and, in addition, provide sufficient power for the trains to reach the next station in the event of a power failure.

^{*}Garrett Research and G.E. are presently involved in alternate flywheel storage systems studies for urban transit buses under UMTA sponsorship.

In addition to the flywheel power units just described, other variations of flywheel-driven vehicles are feasible as transportation alternatives. A more comprehensive look at the field of flywheel hybrids follows.

Aerospace Hybrid Study Review (1976 Draft)

The most recent study of hybrid propulsion was performed by the Aerospace Corporation (Reference 13). Both heat engine/ battery and heat engine/flywheel propulsion systems were simulated, using a computerized model. The object of the study was to assess the potential of hybrid power drives in reducing energy consumption while still fulfilling Federal emission regulations. Only nickel-zinc batteries and steel flywheel storage means were considered sufficiently advanced to be included in a comparative study. Lead-acid batteries, hydraulic energy storage and composite flywheels were rejected as either inadequate or incompletely understood.

Three vehicles were considered: a 2,500 pound automobile; a 4,000 pound automobile; and a 6,000 pound van. The vehicles were configured to have the performance characteristics shown in Table A-1. In each case, the hybrid energy consumption was compared with published measurements of representative spark-ignition powered vehicles, manufactured to meet Federal emission standards of 1975/ 1976 model year.

TABLE A-1. PHYSICAL CHARACTERISTICS OF HYBRID VEHICLES

Vehicle Loaded Weight* (lb)	Tire Radius (ft)	Tire Pressure (psi)	Drag Area (ft ²)	Drag Coefficient (Dimensionless)
2500	0.98	25	19.0	0.45
4000	0.99	25	21.2	0.45
6000	1.22	40	35.0	0.76

Loaded weight (includes 300 lb for occupants and luggage in cars, and 1000 lb for driver and payload in van).

Series and parallel power drive configurations were studied "with the control routine depicted in Figure A-1. This is one example of a continuous, variable speed mode of engine operation.



FIGURE A-1. Aerospace Study Control Routine

In this routine the power at the flywheel (or generator) is maintained at a fixed value up to a given vehicle speed. The shift from fixed power takes place only when the vehicle load (as determined at the engine transmission) exceeds the fixed power level. Then the power output is increased, following the increasing road load requirement. No other control routine was studied. The on-off type of heat engine operation, although considered attractive, was rejected because of unknown factors influencing the system lifetime and control system complexity.

Three types of driving cycles were selected for use in the comparative evaluation, namely, the EPA Urban, the EPA Highway and the U.S. Postal. Only the Postal is of interest for bus propulsion system evaluation. This is illustrated in Figure A-2.



A - 5

The hybrid power drive examined in greatest detail was the series type configuration. For the heat engine/battery hybrid, it included: a conventional 1975 model year General Motors 140 CID, 4-cylinder, spark-ignition engine utilizing air injection, EGR, and oxidizing catalyst for emission control; nickel-zinc storage batteries with a specific energy density of 22 w-hr/lb;* an AC electric generator; a series-wound DC drive motor; and a solidstate chopper control to regulate battery power to the DC drive motor. For the heat engine/flywheel hybrid it included: a conventional 1975 model year General Motors 140 CID, 4-cylinder, spark-ignition engine; a 1.09 foot diameter, 25,600 rpm, steel flywheel; a continuously variable transmission; and a control system to regulate power flow. The flywheel system included a guard ring, vacuum housing and vacuum pump to support a pressure of 5 mm Hg.

The effects of a parallel configuration and of regenerative braking were determined separately. For the hybrid heat engine/ battery parallel configuration, it was estimated that the required heat engine output shaft energy (exclusive of battery recharge energy, and accessory/engine auxiliary drive energy) would be 70 percent of that required in the series configuration, regardless of driving cycle. This figure was based on the improved efficiency of an automatic mechanical transmission compared with the combined efficiencies of the generator/drive motor set. For the hybrid heat engine/flywheel parallel configuration, the automatic transmission efficiency was fixed at 90 percent.

Regenerative braking was treated parametrically. Ten and fifteen percent energy recovery values were used for comparative purposes for the Urban Driving Cycle, and fifteen and thirty

[&]quot;Lead-acid batteries were found to be too heavy for the requirements of the study. Nickel-zinc batteries were used in the expectation that they (or their equivalents) will be available.

percent for the Postal Driving Cycle. The percent energy recovery refers to the percent of total driving cycle energy recovered and delivered into the energy storage system by the regenerative braking system. This energy recovery amount was then used to reduce the energy required from the heat engine for recharging the energy storage system.

A brief examination was made of the type of performance that might be expected from an advanced design, high-speed plasticreinforced composite flywheel.* The intention was to provide greater energy storage capability than was available with the metal rotor and, thereby, improve the vehicle operating range whenever the on-board heat engine was not providing full recharge energy to the flywheel.

It was assumed for purposes of rotor sizing that a guard ring was not required, thereby allowing a maximum possible rotor diameter for a vertical power shaft mounting of the flywheel in the hybrid vehicle. The resulting design for the Kevlar rotor was 2 feet in diameter with a speed of 42,000 rpm.

An initial evaluation showed totally unacceptable performance because of excessive parasitic losses related to aerodynamic drag, bearing drag, seal drag, and vacuum pump power requirements. Hence, a large amount of engine power was required to keep the wheel recharged, and this resulted in energy consumption much higher than that of a conventionally-powered car.

Lowering the pressure in the flywheel housing to reduce windage losses only caused a large increase in pump power requirements. Therefore, a further step was made: assuming improved seals to hold pressures in the rotor housing down to 10^{-3} mm Hg without requiring an increase in pump power requirements over those needed to sustain 5 mm Hg pressure. Even this liberal

This part on composite flywheels is copied essentially verbatim from the Aerospace report (Ref. 13).

assumption did not produce results equivalent to those for the - case of a steel rotor. It appears that high-speed composite wheels are not viable for the heat engine/flywheel hybrid vehicle, unless parasitic losses can be reduced to much lower levels.

The results of the Aerospace study of interest to our present bus propulsion study are listed in Table A-2. This tables shows the energy consumptions of the hybrids as a percentage of the energy consumption of the conventional-powered vehicles for variations in regeneration energy. In all cases shown here all energy is supplied by the on-board fuel. For those cases in which utility energy is used, the reader is referred to the many plots in the Aerospace study.

Table A-2 shows energy consumption reductions of as much as 43% for heat engine/battery hybrids. In contrast, for the heat engine/flywheel hybrids, the comparable reductions were as large as 55%. The parallel mode always shows greater reductions in energy consumption, although, for the Multi-Stop Postal Cycle, the reductions of parallel over series are insignificant.

The Aerospace study considers hybrid vehicle data from the most significant government and privately sponsored investigations. A synopsis containing a brief description of major components of the power drive is given for each hybrid automotive vehicle system design that has been examined in recent years (11 systems). Only nickel-zinc battery and steel flywheel energy storage devices were considered for use in these designs. A tabular review of these systems is included at the end of this appendix as Table A-4.

A review of components which could be used in hybrid power drive sybsystems was made in the Aerospace study and by TSC, and is included in Appendix B.

The majority of the designs that was reviewed evolved from the work sponsored by EPA in the period 1970-1972 and was primarily aimed at achieving major reductions in exhaust emissions rather than reductions in fuel consumption. Only two of the studies had configurations and projected fuel economies that are

A - 8

TABLE A-2. % ENERGY CONSUMPTION (GALLONS PER MILE) HYBRID RELATIVE TO CONVENTIONAL Postal Cycle

TYPE HYBRID	VEHICLE WEIGHT POUNDS	REGENERATION %	ENERGY CONS	SUMPTION % PARALLEL
BATTERY	2500	0	75	69
		15	71	66
		30	67	63
	4000	0	70	65
		15	66	62
		30	62	58
	6000	0	71	66
		15	66	62
		30	62	57
FLYWHEEL	2500	0	60	57
		15	57	55
		30	54	52
	4000	0	58	55
		15	55	52
		30	52	50
	6000	54	54	51
		50	50	47
		47	47	45

Source: Ref. 13.

of interest to our present study. These are the studies of the University of Wisconsin and the Technical School at Aachen, West Germany. Descriptions of these systems and some of the results achieved follow.

University of Wisconsin Hybrid Automobile - Design and Simulation*

An automobile, based on a 3,000 pound chassis and equipped with a powerplant incorporating a high-speed energy-storage flywheel, has been analyzed, designed and built by the University of Wisconsin under contract to the U.S. Department of Transportation (Ref. 3). Design and fabrication of the vehicle have been augmented by computer simulation studies of fuel economy and emissions.

A reciprocating piston, spark ignition gasoline engine, calibrated for minimum emissions, is connected through a clutch to the flywheel. When the flywheel speed drops below a predetermined value, the engine is turned on and run at full throttle for maximum efficiency. The engine is shut off when the flywheel reaches a maximum design speed. A four-speed manual shift transmission is used in combination with a hydrostatic power-split, continuously-variable transmission to allow for proper matching of the flywheel. Power is transferred partly through a hydrostatic transmission (pump and motor) and partly through a mechanical gear train. The system is designed to absorb regenerative braking energy during vehicle deceleration.

Basic specifications for the flywheel are:

- 1. Usable energy storage of 2/3 hp-hr
- 2. Maximum windage loss of 1 hp
- 3. Overspeed protection
- 4. Locked bearing protection

Verbatim from Reference 13.

5. Alloy steel construction

6. 250 ft-1b torque capability.

Principal features of the CVRT are:

- 1. A ratio range of 3.5:1
- 2. Torque control
- 3. 400 ft-1b torque capability
- 4. Designed for 80 mph maximum vehicle speed

Vehicle acceleration and regenerative braking are controlled through the CVRT by varying the hydrostatic pressure. Although a production vehicle would have automatic controls, the demonstration vehicle will be manually controlled.

A computer simulation was developed by the University of Wisconsin to predict the fuel economy and other performance characteristics of the flywheel vehicle. Table A-3, based on 1976 emission standards, shows comparative predictions for three different types of 3,000 pound vehicles and includes a breakdown of energy disbursement in each case. A potential improvement of 58% (in mpg) over the conventional car is shown by the near-term flywheel car. This predicted improvement is based on the ability to operate the engine at a brake specific fuel consumption (BSFC) of 0.50 lb/hp-hr. The ability to shut the engine off when the flywheel is not being recharged and the use of regenerative braking also contribute to saving energy.

An examination of the calculated energy losses shows the greatest losses occur in the CVRT. The arrows in Table A-3 designate those components, including the transmission, that the University of Wisconsin feels can be significantly improved in efficiency.

Technical School at Aachen, West Germany Hybrid Van - Design and Test

Development of this hybrid drive system with flywheel energy storage has been sponsored by the West Germany Federal Ministry of

ITEMS	STANDARD 1976 2.3 LITER VEHICLE (HP. SEC.)		1976 FLYWHEEL 2.3 LITER VEHICLE (HP. SEC.)	POTENTIAL FROM CONTINUED R & D (HP. SEC.)
Road Load	3700		3702	3702
Rear Axle	470		536	536
Transmission	648		648	200*
		F1ywhee1	855	400 ·
Deceleration and Brakes	<u>2555</u>	CVT	1809	●●● *006
Total (+) Work	7373	FW Gears	172	172
		Charge Pump	634	100
		Excess Brakes	50	50
Idle & Coast Fuel .25#	*1111	Engine Clutch	66	66
		Engine Inertia	93	93
		Engine Start	99	66
Total Work	8484		8664	6318
Fuel for (+) Work	1.655#		1.202#	0.876#
Fuel Total	1.905#		1.202#	0.876#
(+) BSFC	0.808#/HP-HR		0.50#/HP-HR	0.50#/HP-HR
Mileage	24.0 MPG		38.0 MPH	52.0 MPG
Improvement			58%	117%
*Equivalent Work Computed at .808#/H	IP-HR			*A Single CVT Package will Replace Both Units

EPA CYCLE ENERGY CONSUMPTION BY UNIVERSITY OF WISCONSIN TABLE A-3.

A-12

Data Source: Reference 3.
Research and Technology since 1973. The ability to recover energy during vehicle braking and to operate the heat engine at improved efficiency account for the reduction in fuel consumption over that of a conventional power drive.

A schematic of the parallel configuration power drive is shown in Figure A-3. The major components are an electric-motor/ generator, a heat engine, a differential gear train, a flywheel primary energy storage system, and a battery secondary energy storage system. Modulation of the speed and torque of the motor/ generator controls the torque and speed of the drive shaft leading



FIGURE A-3. SCHEMATIC OF THE TECHNICAL SCHOOL AT AACHEN HYBRID DRIVE WITH FLYWHEEL COMPONENT (Ref. 13)

to the wheels during vehicle motion, as well as energy recharging of the battery and the flywheel when the vehicle is stationary. Power from the battery is only used for producing the necessary motor torque and speed. Power from the flywheel is used to augment heat engine power for vehicle acceleration.

A 2100 kilogram Volkswagen van was used for road tests on the installed hybrid drive train. The vehicle top speed is 70 km/hr; the system start-up time is about 20 seconds and the -heat engine normally runs at about 3,500 rpm.

Road test results are shown in Figure A-4, which shows fuel consumption against the dynamic factor (a term developed to correlate the energy requirements of various types of driving cycles) for a conventional van and the hybrid van. The dynamic factors corresponding to various driving cycles are noted on the plot. A reduction in fuel consumption of about 40% is shown (with as much as 45% at the larger dynamic factors). Between 10% and 30% of the energy available for recovery during dynamic braking was actually recovered. For the case of 30% energy recovery efficiency, a 45% reduction in fuel consumption was achieved. Of this reduction, about 30% was attributed to recuperation of braking energy and 70% to improved operating efficiency of the heat engine.

Development work to optimize the system should reduce fuel consumption by 50% for a wide range in driving cycles.

The University of Florida Diesel/Battery Bus

The Mechanical Engineering Department of the University of Florida (Gainsville) has built a hybrid bus under the direction of Dr. Vern Roan (Reference 14). The basic vehicle is a modified Electrobus, Model 20. This bus is propelled by a 50 horsepowerelectric motor and normally its energy source is a lead-acid battery pack. The batteries were resituated and a diesel engine and an ac generator were mounted in the normal battery position at the rear of the bus.

The diesel engine was sized so that it operates continuously at near rated load. The bus can be run on battery power alone, if desired. The sizing of the batteries and the diesel engine was accomplished with the aid of a computer simulation program. The total weight of the battery installation was quoted as 3,700 pounds.

Other elements of the system are the generator, the rectifiers and the controls. Two three-phase ac generators were chosen in order to minimize size and weight for a given power output.

A-14



FIGURE A-4. FUEL CONSUMPTION FOR 2100 Kg VEHICLE AS A FUNCTION OF THE DYNAMIC FACTOR

Each generator charges a single battery pack weighing 1850 pounds. The total power output is 30 kW. Two bridge rectifiers are used to provide two independent voltage sources for charging the propulsion batteries. The control for the generator voltage is solidstate but the battery control system for the propulsion motor is composed of electromagnetic relays as in the normal Electrobus. There is controlled dynamic braking but no attempt was made to store energy through regeneration.

The computer simulation allowed study of the system response to various driving cycles. The generator output was varied and time of operation to discharge was analyzed. A typical analysis is shown in Figure A-5, which corresponds to the driving cycle of Figure A-6. On the pure electric mode the vehicle was predicted to travel 1.7 hours on this driving cycle (about 20 miles) but with increasing generator power the predicted time of operation increases until, at 28 kW, the simulation shows the bus running all day.

The hybrid bus of the University of Florida has gone through an initial road test program in which it closely followed the drive pattern of a diesel bus in revenue service on a transit route in Gainsville, Florida. Preliminary results from these tests indicate a 40% improvement in fuel economy over the standard bus.

Continuously Variable Ratio Transmission Devices

A very important component in the power drive connecting the flywheel energy storage device to the drive wheels is the transmission unit. It is necessary to match the energy required by the drive wheels to the energy extracted from the flywheel energy storage unit. There must be a smooth transition between the two to avoid excessive energy losses in the flywheel.

The Continuously Variable Ratio Transmission (CVRT) represents the most promising mechanical means to meet such transition requirements. A state-of-the-art review of CVRT's has been conducted at TSC.* Two primary CVRT types appeared to have the

Zuckerberg, H., "State of-the-Art Review of Continuously Variable Ratio Transmissions (CVRT) Subsystems," KHL-TSC-76-1411, June 1976





4

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FIGURE A-6. SPEED AS A FUNCTION OF TIME CHART - DRIVING CYCLE #1, 6 STOPS PER MILE

necessary viability; i.e., the hydromechanical and the traction drive types.

The hydromechanical transmission concept offers the best near-term (by 1980) CVRT for application with the hybrid power drive subsystem. The traction CVRT drive is considered to be the best long-term CVRT (by 1985) and beyond. An appreciable development effort will be necessary to bring the traction type CVRT to fruition.

Conclusions From Past Work

Very few of the hybrid drives that have been built to date show less fuel consumption than the heat engine-only drive when compared over the same drive cycle. In most cases, they have been developed for reasons other than enhanced fuel economy.

The multi-stop drive cycle, typified by urban bus operation, is a promising application of hybrids. This is especially true of the heat engine/flywheel because of its potential ability to use regenerated braking energy.

The parallel configuration requires more components and has more control complexity than the series configuration. In multistop operation the difference in energy efficiencies between the parallel and series configurations will be small (a few percent).

Regeneration can potentially reduce fuel consumption by 10% to 15% in multi-stop drive cycles.

Improvements in flywheel materials and fabrication technology promise weight reduction. However, since higher rotational speeds are required for such weight reduction, careful design studies must be made to determine the effect on parasitic losses, bearing life, seal effectiveness and safety.

Present lead-acid batteries when operated at the power levels required in automotive and bus driving, would have a cycle lifetime that is probably too short from an operational cost standpoint. On-going developments on these and other battery types project significantly better performance within five years. Present knowledge of hydraulic energy storage and re-use is not sufficient to generate a heat engine/hydraulic simulation comparable to that with flywheel energy storage. TABLE A-4. DETAIL REVIEW OF HYBRID SYSTEMS BY AEROSPACE CORPORATION (Sheet 1 of 15)

I. HEAT ENGINE/BATTERY SYSTEM

D -

Organization	Petro-Electric, Ltd.	Mercedes-Benz
Objectives and Goals	Develop standard-size prototype car which meets FCCIP requirements	Develop a hybrid diesel electric bus

Power Train Elements

Configuration	Parallel	Series
Heat Engine	Continuous operation, variable power, Mazda rotary, 70 cu.in., 9.4/1 compression ratio, 4- barrel carburetor, 130 HP max @ 7000 rpm, 115 ft-1b max torque @ 4000 rpm, weight 273 1b	OM 314 diesel engine, 232 cu.in., 4-cylinder, 65 HP @ 2200 rpm, operated for range extension of vehicle during highway driving
Emission Control System	Thermal reactor and EGR	Information not provided (INP)
Electric Traction Motor	DC shunt, separately ex- cited motor, 120 volts, 115 amps continuous or 600 amps surge, 20 HP continuous rating, 60 HP max @ 5500 rpm, 190 ft-1b max torque, weight 240 1b	DC shunt, separately ex- cited motor, 120 HP contin- uous rating, 201 HP max, 4800 rpm max motor speed, motor weight with driving gear, 1330 lb
Electric Power Conditioning and Control	INP*	Combined pulse width and pulse frequency modulation max pulse frequency, 250 Hz min pulse duration 1 ms, max current - 600 amps
Electric Power Generator	INP	3-phase generator with rectifier
Batteries	8 Gould, 12-volt, lead- acid batteries; voltage 48 or 96; 90 amp hours at 10-hr rate; 600 amps max current; weight 300 lb	Supplied by VARTA; rated voltage 380 volts; 5-hour cap city discharge 275 A-hr; storage capacity 104 kw-hr, weight 3.86 tons
Transmission	Manual 1973 Vega - lst gear ratio 3.0/1.0 2nd gear ratio 1.85/1.0 3rd gear ratio 1.0/1.0	None
Data Source: Reference *INP = Information not	e 13 present.	

TABLE A-4. CORPORATION	DETAIL REVIEW OF HYBRID (Sheet 2 of 15)	SYSTEMS BY AEROSPACE	
I. HEAT ENGINE	I. HEAT ENGINE/BATTERY SYSTEM (continued)		
Organization	Petro-Electric, Ltd. (continued)	Mercedes-Benz (continued)	
Objectives and Goals			
Differential	Gear ratio 5.0/1.0	Single reduction gear between electric traction motor & wheels	
Performance			
Emissions HC CO NO _x	0.38 gr/mi, 40 mi, EPA test 2.42 gr/mi, 40 mi, EPA test 0.76 gr/mi, 40 mi, EPA test	INP	
Acceleration	0-60 mph, 17.5 sec @ 4950 lb	<pre> 2.25 mph/second from stop due to standees</pre>	
Fuel Economy	8.75 mi/gal, EPA Urban Cycle	INP	
Noise	70 db (A) max	INP	
Max Speed	INP	43.5 mpg	
Gradeability	INP	11% @ 13.7 mph	
Range	INP	34.2 mi with stops every 0.25 mi on batteries only. All-day operation in hybrid mode	
Payload	INP	66 - 110 passengers	

TABLE A-4. DETAIL REVIEW OF HYBRID SYSTEMS BY AEROSPACE CORPORATION (Sheet 3 of 15)

I. HEAT ENGINE/BATTERY SYSTEM

ORGANIZATION TRW Systems, Inc.

Objectives and Goals (1) Select and analyze performance of hybrid vehicle designs, (2) Define relative weights and costs, (3) Get data on catalysts, (4) Develop an accumulator, (5) Meet 75/76 emission goals.

Power Train Elements

Configuration	Parallel	Series
Heat Engine	Continuous operation, var- iable power, 71 Chevrolet Vega, 2300 cc (140 CID), 90 HP (max), aluminum block	INP
Emission Control System	Hydrocarbon accumulator of activated carbon cat- alytic converter with copper oxide on aluminum pellets	INP
Electric Traction Motor	Series DC, 30 HP at 7200 rpm, 180 terminal volts, 145 amps at 22.5 ft-1b continuous duty, 9-inch diameter frame GE BT 2338, 15-1/2 inches long, 150 lb	Series DC, 65 HP at 4650 rpm, 235 terminal volts, 235 amps at 74 ft-lb con- tinuous duty, 12-1/2 inch diameter frame GE CD 280/ 2508, 21 inches long, 325 lb
Electric Power Con- ditioning and Control	200 VDC rectifier	240 VDC rectifier
Electric Power Generator	Salient pole alternator with slip rings, 10 kw @ 12,000 rpm, 95% effi- cient, rpm range 1200- 12,000, 3-phase contin- uous duty, 40 lb, 8-in. diameter, 4 in. long, 400 Hz base speed	Salient pole alternator with slip rings, 58 kw @ 4000 rpm, 95% efficient, rpm range 4000-12,000, 3-phase, continuous duty, 160 lb, 10-in. diameter, 19 in. long, 400 Hz top speed
Batteries	INP	INP
Transmission	Electromechanical trans- mission; 2:1, 0 to 42.5 mph; 1.5:1, 42.5 to 55 mph; 1:1, 55 to 85 mph; planetary geartrain	INP

TABLE A-4. DETAIL REVIEW OF HYBRID SYSTEMS BY AEROSPACE CORPORATION (Sheet 4 of 15) I. HEAT ENGINE/BATTERY SYSTEM Organization TRW Systems, Inc. (continued)

Objectives and Goals

Differential	INP	INP
Performance		
Emissions HC CO NO _X	EPA Urban Cycle, gr/mi <u>Cold</u> <u>Hot</u> 2.84 .29 46.8 3.26 3.84 .32	INP
Acceleration	Designed for 440 ft in 10 sec	INP
Fuel Economy	INP	INP
Noise	INP	INP
Max Speed	85 mph calculated at dry weight	85 mph calculated at dry weight
Gradeability	INP	INP
Range	INP	INP
Payload	INP	INP

TABLE A-4. DETAIL REVIEW OF HYBRID SYSTEMS BY AEROSPACE CORPORATION (Sheet 5 of 15)

I. HEAT ENGINE/BATTERY SYSTEM

Organization	Minicars, Inc.	General Motors Corp.
Objectives and Goals	Determine relative reduction in exhaust emissions obtainable from a heat engine/battery hybrid car compared to same vehicle powered by heat engine alone.	Basic in-house research to explore use of low emission Stirling engine in a hybrid car.
Power Train Elements		
Configuration	Series hybrid, elements in line	Series, 1189 pounds
Heat Engine	Continuous operation, variable power Corvair engine, 6-cylinder opposed, clock-wise rotation, 164 cu.in. displacement, 8/1 compression ratio, single venturi carburetor with idle, main, and power jets, and an accelerator pump, heat air intake and manifold legs	Continuous operation, fixed power, Stirling engine (GPU-3), converted Army design with hydraulic controls single-cylinder, 8 HP at 3000 rpm, hydrogen working fluid at 1000 psi using combustion air blower.
Emission Control System	INP	INP
Emission Control System Electric Traction Motor	INP Lear-Siegler G22-3, 24V, 300 amp, 9.7 HP rated, shunt motor-generator, 94 lb, 2000-6500 rpm range	INP AC induction motor, 3-phase 24 VDC, 20 HP over 3:1 speed ratio
Emission Control System Electric Traction Motor Electric Power Conditioning and Control	INP Lear-Siegler G22-3, 24V, 300 amp, 9.7 HP rated, shunt motor-generator, 94 lb, 2000-6500 rpm range Modulated with both shunt field control and varia- ble armature voltage, throttle delay mechanism	INP AC induction motor, 3-phase 24 VDC, 20 HP over 3:1 speed ratio Variable frequency and voltage, all solid state, modulating inverter fre- quency and amplitude control
Emission Control System Electric Traction Motor Electric Power Conditioning and Control Electric Power Generator	INP Lear-Siegler G22-3, 24V, 300 amp, 9.7 HP rated, shunt motor-generator, 94 lb, 2000-6500 rpm range Modulated with both shunt field control and varia- ble armature voltage, throttle delay mechanism (see Electric Traction Motor)	INP AC induction motor, 3-phase 24 VDC, 20 HP over 3:1 speed ratio Variable frequency and voltage, all solid state, modulating inverter fre- quency and amplitude control 3-phase alternator, 19 kv nominal, 5500 rpm

TABLE A-4. DETAIL REVIEW OF HYBRID SYSTEMS BY AEROSPACE CORPORATION (Sheet 6 of 15)

I. HEAT ENGINE/BATTERY SYSTEM

Organization	Minicars, Inc.	General Motors Corp.
	(continued)	(continued)

Objectives and Goals

Transmission	Automatic transmission, 2.0/1 stall ratio at 1400 rpm, 1.82/1 low and reverse, 1/1 high gear	Planetary gear set
Differential	3.57 axle gear ratio	3.45/1.0
Performance		
Emissions	DHEW Cycle, Constant Volume Sampling (engine air-fuel ratio set at 16.5 to 1.0)	With 25 to 1 air-fuel ratio, and 1200°F heated combustion air
HC CO	3.15 gr/mi 29.6 gr/mi 1.0 gr/mi	HC (c6) 0.03 gr/hp-hr CO 0.5 gr/hp-hr NO _x 3.3 gr-hp-hr
Acceleration	0-60 mph, 23.2 sec on 3000-1b car (5.64 mph/sec peak); 32.1 sec on 4000- 1b car (4.20 mph/sec peak)	0 - 30 mph in 10 sec
Fuel Economy	Internal combustion engine: 14.5 mpg at 15 mph, 10.3 mpg at 30 mph, 12.6 mpg at 50 mph; hybrid: 11.8 mpg at 15 mph, 8.8 mpg at 30 mph, 12.4 mpg at 50 mph; no all-electric mode pos- sible	30-40 mpg at 30 mph, engine-only operation
Noise	INP	INP
Max. Speed	75 mph	55 mph with heat engine and batteries, 30 mph with heat engine alone

TABLE A-4. DETAIL REVIEW OF HYBRID SYSTEMS BY AEROSPACE CORPORATION (Sheet 7 of 15)

I. HEAT ENGINE/BATTERY SYSTEM

Organization	Minicars, Inc. (continued)	General Motors Corp. (continued)
Gradeability	INP	INP
Range	≈ 200 miles on heat engine; believed 2-5 miles on batteries only	Heat engine: 30-40 miles at 55 mph; electric power only: 15-30 miles at 30 mph
Payload	INP	3200 lb, with 2 passengers

load

TABLE A-4. DETAIL REVIEW OF HYBRID SYSTEMS BY AEROSPACE CORPORATION (Sheet 8 of 15)

- I. HEAT ENGINE/BATTERY SYSTEM
- Organization The Aerospace Corporation
- Objectives and Goals (1) Establish through computerized analysis and hardware data the design feasibility and potential for major reductions in exhaust emissions through use of hybrid heat engine/battery vehicles, (2) Establish general design goals for components & subsystems in the vehicle power train.

Power Train Elements

Configuration	Series	Parallel
Heat Engine	Continuous operation, var- iable power, 93 HP spark ignition engine operating at best brake specific fuel consumption of 0.5 and weighing 335 lb, for powering 4000-lb full- size hybrid family car	Continuous operation, var- iable power, 84 HP spark ignition engine operating at best brake specific fuel consumption of 0.5 and weighing 319 lb for power- ing 4000-lb full-size hybrid family car
Emission Control System	Lean carburetion (A/F= 22), oxidizing catalyst, exhaust gas recirculation	Lean carburetion (A/F=22), oxidizing catalyst, exhaust gas recirculation
Electric Traction Motor	Forced-air cooled, 8000 rpm, 64 HP, DC, shunt- wound with step voltage and field control weigh- ing 337 pounds. 90% peak efficiency, 80% average efficiency	Forced-air cooled, 8000 rpm, 35 HP, DC, shunt-wound with step voltage and field control weighing 250 lb. 90% peak efficiency, 80% average efficiency and capability of 3:1 short- term overload
Electric Power Conditioning and Control	Step voltage augmented with field control and armature current sensing, 12.5 lb motor controller, 18 lb AC rectifier, 3 lb generator controller, 99.5% control system efficiency	Step voltage augmented with field control and armature current sensing, 12.5 lb motor controller, 9 lb AC rectifier, 2 lb generator controller, 99% control system efficiency
Electric Power Generation	12,000 rpm alternator, rated at 51 kw, weighing 80 lb with rated effi- ciency of 90% and average efficiency of 80%	12,000 rpm alternator rated at 7 kw weighing 18 lb with rated efficiency of 90% and average efficiency of 80%

TABLE A-4. DETAIL REVIEW OF HYBRID SYSTEMS BY AEROSPACE CORPORATION (Sheet 9 of 15)

I. HEAT ENGINE/BATTERY SYSTEM

Organization

The Aerospace Corporation (continued)

Objectives and Goals

	Batteries	38 amp-hr lead-acid or nickel-zinc with capacity of 8.36 kw-hr, weighing 398 lb and required to deliver 92.5 kw, 10 shallow charge-discharge cycles (3.5% of capacity max) per vehicle mile	38 amp-hr lead-acid or nickel zinc, with capacity of 8.36 kw weighing 460 lb and required to deliver 92.5 kw, 10 shallow charge- discharge cycles (3.5% of capacity max) per vehicle mile
	Transmission	transmission not necessary	Modified conventional 3-speed automatic, rated at 64 HP, 90% efficiency, weighing 59 lb
	Differential	95% efficiency, total rear axle drive weighing 80 lb	95% efficiency, total rear axle drive weighing 80 lb
P	Performance		
	Emissions HC CO NO _X	Calculated for DHEW* Urban Driving Cycle 0.361 gr/mi 0.494 gr/mi 0.504 gr/mi	Calculated for DHEW* Urban Driving Cycle 0.323 gr/mi 0.442 gr/mi 0.451 gr/mi
	Acceleration	O-60 mph in 13 sec, peak acceleration of 5 mph/sec	O-60 mph in 13 sec, peak acceleration of 5 mph/sec
	Fuel Economy	Calculated ll mpg over DHEW Urban Driving Cycle	Calculated 12.5 mpg over DHEW Urban Driving Cycle
	Noise	INP	INP
	Max Speed	80 mph	80 mph
	Gradeability	40 mph on 12% grade for 8 miles	40 mph on 12% grade for 8 miles
	Range	200 miles	200 miles
	Payload	Min. of 300 lb, passengers and luggage	Min. of 300 lb, passengers and luggage
	*U.S. Department of Hea	lth, Education & Welfare, fo	rerunner of EPA cycle.

TABLE A-4. DETAIL REVIEW OF HYBRID SYSTEMS BY AEROSPACE CORPORATION (Sheet 10 of 15)

I. HEAT ENGINE/BATTERY SYSTEM

Organization University of Wisconsin

Objectives and Goals Urban Vehicle Design Competition - 1972 -High fuel economy, low emissions

Power Train Elements

Configuration	Parallel
Heat Engine	Continuous operation, vari- iable power, Wankel, 53 HP (power train also functions in other modes with engine off)
Emission Control System	INP
Electric Traction Motor	DC, continuous rating of 18 HP
Electric Power Conditioning and Control	manual control
Electric Power Generator	INP
Batteries	Lead-acid, run between 50% and 90% full charge, 450 lb, 36 volts
Transmission	l:l gear ratio
Differential	Gear ratio 1:1 to 1:2 depending on drive mode
Performance	
Emissions	Simulated LA4-1370 sec driving cycle, 60% efficient power train, no emission controls or devices
HC CO NO _X	.559 gr/mi 27.7 gr/mi 1.26 gr/mi

TABLE A-4. DETAIL REVIEW OF HYBRID SYSTEMS BY AEROSPACE CORPORATION (Sheet 11 of 15)

I. HEAT ENGINE/BATTERY SYSTEM

Organization	University of Wisconsin
	(continued)

Objectives and Goals

Acceleration	0.3 g (11 ft/s ²)
Fuel Economy	Simulated LA4-1370 sec, 60% efficient power train, 21.6 mpg

Noise

Max Speed

Gradeability

Range	Mode 1, 5-10 miles (sim-
	ulated); Modes 2, 3 INP
	(probably limited by gas
	tank size only)

Payload

INP

INP

INP

INP

TABLE A-4. DETAIL REVIEW OF HYBRID SYSTEMS BY AEROSPACE CORPORATION (Sheet 12 of 15)

II. HEAT ENGINE/FLYWHEEL SYSTEM

Objectives and Goals(1) Determine through analysis feasibility of flywheel system as a low- emission propulsion system, (2) Demonstrate and evaluate performance of full-size flywheelsConduct proof-of-principle tests of the "superfly- wheel" concept and evaluate earcher of the "superfly- wheel" concept and evaluate earcher of the superfly- wheel" concept and evaluate earcher of the superfly- wheels to reduce automotive emissions.Power Train ElementsContinuous operation, var- iable power, medium-size V-8, 350 CID engine char- derived from literature sourcesPower Train ElementsContinuous operation, var- iable power, medium-size V-8, 350 CID engine char- derived from literature sourcesEmission Control SystemExhaust recirculation and Engelhard oxidizing catalystTransmissionHydrostatic power- splitting, 238-1b Sundstrand Version 8CControl System <td< th=""><th>Organization</th><th>Lockheed Missiles and Space Company</th><th>Johns Hopkins University Applied Physics Laboratory</th></td<>	Organization	Lockheed Missiles and Space Company	Johns Hopkins University Applied Physics Laboratory
Prover Train ElementsConfigurationSeriesHeat EngineContinuous operation, var- iable power, medium-size V-8, 350 CID engine char- acteristics scaled from 176 HP for full-size 4300- Ib carOn-off operation, 94 HP, S spark ignition engine for 	Objectives and Goals	 Determine through analysis feasibility of flywheel system as a low- emission propulsion system, Demonstrate and evaluate performance of full-size flywheels 	Conduct proof-of-principle tests of the "superfly- wheel" concept and evaluate through analysis the use of such flywheels to reduce automotive emissions.
ConfigurationSeriesSeriesHeat EngineContinuous operation, var- iable power, medium-size V-8, 350 CID engine char- acteristics scaled from 176 HP for full-size 4300- lb carOn-off operation, 94 HP, : spark ignition engine for 4300-lb car, characterist: derived from literature sourcesEmission ControlExhaust recirculation and Engelhard oxidizing catalystINPTransmissionHydrostatic power- splitting, 238-lb Sundstrand Version 8CHydrostatic power-splittinControl SystemINPINPFlywheelTapered steel disk with rim flange, 6.52-inch radius, 24,000 rpm, 86 lb weight for rotor only; usable energy storage of 0.5 HP-hr (max of 1.0 HP- hr), shaft mounted in- line with engine, total flywheel system weight of 187 lb.Reinforced plastic composition Storage in the system weight of 255 lb.DifferentialINPINPBatteriesNANA	Power Train Elements		
Heat EngineContinuous operation, var- iable power, medium-size V-8, 350 CID engine char- acteristics scaled from 176 HP for full-size 4300- lb carOn-off operation, 94 HP, 5 spark ignition engine for 4300-lb car, characterist derived from literature sourcesEmission Control SystemExhaust recirculation and Engelhard oxidizing catalystINPTransmissionHydrostatic power- splitting, 238-lb Sundstrand Version 8CHydrostatic power-splittinControl SystemINPINPFlywheelTapered steel disk with rmi flange, 6.52-inch radius, 24,000 rpm, 86 lb weight for rotor only; usable energy storage of 0.5 HP-hr (max of 1.0 HP- hr), shaft mounted in- line with engine, total flywheel system weight of 187 lb.Reinforced plastic compost S.3-inch-thick bar with sp diameter of 24 inches, 32 rpm, 163-lb rotor weight, 7.1 HP-hr energy storage, 3.5 min. recharge time, system weight of 255 lb.DifferentialINPINPBatteriesNANA	Configuration	Series	Series
Emission Control SystemExhaust recirculation and Engelhard oxidizing catalystINPTransmissionHydrostatic power- splitting, 238-1b Sundstrand Version 8CHydrostatic power-splittingControl SystemINPINPFlywheelTapered steel disk with rim flange, 6.52-inch radius, 24,000 rpm, 86 Ib weight for rotor only; usable energy storage of 0.5 HP-hr (max of 1.0 HP- hr), shaft mounted in- line with engine, total flywheel system weight of 187 1b.Reinforced plastic composition S.3-inch-thick bar with splitting system weight of 255 1b.DifferentialINPINPBatteriesNANA	Heat Engine	Continuous operation, var- iable power, medium-size V-8, 350 CID engine char- acteristics scaled from 176 HP for full-size 4300- lb car	On-off operation, 94 HP, 357 spark ignition engine for 4300-lb car, characteristics derived from literature sources
TransmissionHydrostatic power- splitting, 238-1b Sundstrand Version 8CHydrostatic power-splittingControl SystemINPINPFlywheelTapered steel disk with rim flange, 6.52-inch radius, 24,000 rpm, 86 1b weight for rotor only; usable energy storage of 0.5 HP-hr (max of 1.0 HP- hr), shaft mounted in- line with engine, total flywheel system weight of 187 1b.Reinforced plastic composition S.3-inch-thick bar with splitting time system weight of 187 1b.DifferentialINPINPBatteriesNANA	Emission Control System	Exhaust recirculation and Engelhard oxidizing catalyst	INP
Control SystemINPINPFlywheelTapered steel disk with rim flange, 6.52-inch radius, 24,000 rpm, 86 lb weight for rotor only; usable energy storage of 0.5 HP-hr (max of 1.0 HP- hr), shaft mounted in- line with engine, total flywheel system weight of 187 lb.Reinforced plastic composition 	Transmission	Hydrostatic power- splitting, 238-1b Sundstrand Version 8C	Hydrostatic power-splitting
FlywheelTapered steel disk with rim flange, 6.52-inch radius, 24,000 rpm, 86 lb weight for rotor only; usable energy storage of 0.5 HP-hr (max of 1.0 HP- hr), shaft mounted in- 	Control System	INP	INP
Differential INP INP Batteries NA NA	Flywheel	Tapered steel disk with rim flange, 6.52-inch radius, 24,000 rpm, 86 lb weight for rotor only; usable energy storage of 0.5 HP-hr (max of 1.0 HP- hr), shaft mounted in- line with engine, total flywheel system weight of 187 lb.	Reinforced plastic composite, 5.3-inch-thick bar with spin diameter of 24 inches, 32,000 rpm, 163-1b rotor weight, 7.1 HP-hr energy storage, 3.5 min. recharge time, system weight of 255 lb.
Batteries NA NA	Differential	INP	INP
	Batteries	NA	NA

TABLE A-4. DETAIL REVIEW OF HYBRID SYSTEMS BY AEROSPACE CORPORATION (Sheet 13 of 15)

II. HEAT ENGINE/FLYWHEEL SYSTEM

Organization	Lockheed Missiles and	Johns Hopkins University
	Space Company (cont.)	APL (cont.)

Objectives and Goals

Performance

Emissions	Calculated for 4300-lb car over EPA Urban Cycle, hot start	Calculated for 4300-lb car over EPA Urban Cycle, hot start
HC CO NO _X	0.378 gr/mi 1.12 gr/mi 1.21 gr/mi	0.127 gr/mi 1.97 gr/mi 0.692 gr/mi
Acceleration	*	*
Fuel Economy	Calculated 10 mpg over EPA Urban Driving Cycle	Calculated 14.4 mpg over EPA Urban Driving Cycle
Max Speed	*	*
Gradeability	*	*
Range	*, 200 mi	*, 200 mi
Payload	*, 1700 lb max	*, 1700 lb max

*Specified in "Vehicle Design Goals - Six Passenger Automobile," EPA Advanced Automotive Power Systems Program, Revision C, May 28, 1971. TABLE A-4. DETAIL REVIEW OF HYBRID SYSTEMS BY AEROSPACE CORPORATION (Sheet 14 of 15)

II. HEAT ENGINE/FLYWHEEL SYSTEM

Organization	University of Wisconsin	Technical School at Aachen, West Germany
Objectives and Goals	 Study & evaluate methods for improving fuel utilization efficiency in autos emphasizing advanced power plant concepts, (2) Complete a demonstration flywheel vehicle and test its fuel consumption and emission characteristics 	Development and demonstra- tion of vehicle power train designed to reduce fuel consumption in urban traffic
Power Train Elements		
Configuration	Parallel	Parallel
Heat Engine	2.3 liter, Spark ignition engine operating on-off at wide- open throttle and cali- brated for low emissions and fuel consumption. Clutch connects engine to flywheel for recharging	Continuous operation, Wankel rotary, max power of 15 kw, max speed of 523 rad/sec, weight of 28 kg, operates normally at 366 rad/sec
Emission Control System	INP	INP
Transmission	Four-speed manual - in conjunction with University of Wisconsin designed CVT hydrostatic power splitting unit with 400 ft-1b capability and 3.5 to 1.0 speed ratio range	INP (Direct mechanical link to vehicle drive wheels via differential controlled by electric motor torque.)
Control System	Hydrostatic system linked to CVT transmission and sensitive to position of accelerator pedal and use of brake pedal	INP (Electric motor torque and speed are mechanical input to control of drive shaft output torque and speed.)
Flywheel	AiResearch steel design with 2/3 HP-hr energy storage and 250 ft-1b torque capability	Moment of inertia of 0.621 kg-m ² , max speed of 1832 rad/sec, weight of 50 kg

TABLE A-4. CORPORATION	DETAIL REVIEW OF HYBRID (Sheet 15 of 15)) SYSTEMS BY AEROSPACE
II. HEAT ENGINE	FLYWHEEL SYSTEM	
Objectives and Goals	University of Wisconsin (continued)	Technical School at Aachen, West Germany (continued)
Objectives and Goals		
Differential	INP	INP
Batteries	NA	Energy content of 4.1 kwh, weight of 150 kg
Electric Motor		Power output of 11 kw, max speed of 701 rad/sec, weight of 65 kg
Performance		
Emissions	Designed to meet model year 1976 emission standards of HC = 1.5 gr/mi CO = 1.5 gr/mi NO _x = 3.1 gr/mi	INP
Acceleration	INP	Max. acceleration of 1.2 m/sec, max. deceleration of 1.4 m/sec reaches 50 km/hr in 10.8 sec (with flywheel operating, up to 100 kw can be delivered to drive shaft)
Fuel Economy	Calculated 38 mpg for 3000-1b car	O.ll ltr/km (reduced fuel consumption up to 45% com- pared to conventional vehicle)
Max Speed	80 mph	70 km/hr*
Gradeability	INP	INP
Range	INP	INP
Payload *By road test for 210	INP DO kg vehicle, test cycle not	INP specified

A-35/A-36



APPENDIX B SELECTED POWER DRIVE SUBSYSTEM COMPONENT REVIEW AND FLYWHEEL SIZING

B.1 COMPONENT REVIEW

B.1.1 Aerospace Review of Components

Aerospace Corporation made a review of components which could be used in hybrid power drives (Ref. 13). It was found that stateof-the-art heat engines, electric motors, electric generators and controls are satisfactory for hybrid propulsion. However, cost and weight reductions are possible with development and higher levels of production. On the other hand, substantial development is needed in batteries, flywheels and continuously variable transmissions.

B.1.2 Batteries

Specific power, specific energy, cycle life and cost are the most important parameters in battery selection. Power and energy parameters are plotted in Figure B-1 along with performance requirements for various vehicles configured for hybrid operation. Lead-acid batteries do not meet the specific energy or power requirements of any of the hybrid vehicles shown. Nickel-cadmium batteries are better adapted but are too expensive and use materials that are too scarce. Nickel-zinc batteries are very promising provided they can be developed in the time-frame desired. It does not appear that development of molten salt batteries is crucial for practical hybrid power trains. The development of molten salt batteries does not appear to be as important to future hybrid power trains as the battery types described above.

B-1



FIGURE B-1. COMPARISON OF BATTERY PERFORMANCE CAPABILITIES AND VEHICLE REQUIREMENTS

B.1.3 Transmission*

Several types of continuously variable transmissions were investigated for possible application in the heat engine/flywheel vehicle power train. Included in these are the mechanical (straight gear ratio), the hydrostatic, the multiple V-belt (variable pitch sheaves), the traction drive and the hydromechanical transmission. Because of numerous limitations (size, weight cost, durability and/or efficiency), the most promising candidates appear to be either the traction drive or the hydromechanical transmissions.

B.2 TSC REVIEW OF COMPONENTS

TSC findings are similar to those of the Aerospace Corporation. The areas where the most development is needed are batteries, flywheels, continuously variable transmissions and hydraulic accumulators.

B.2.1 Battery Energy Storage

In contrast to the need for high energy density batteries for electric vehicles, the emphasis in hybrid battery design is on high power density to handle the high peak power involved in acceleration, regenerative braking, grade climbing, and highspeed passing maneuvers. The heat engine supplies the primary energy requirements but displaces space and weight that is otherwise available for batteries in the battery-powered vehicle. Therefore, the hybrid battery must provide the same or greater power delivery capability as the electric vehicle battery at half or less than half its weight. The energy storage requirements for the hybrid battery are less severe than those for electric vehicles.

Experimental car experience has demonstrated that conventional aqueous storage batteries can marginally meet hybrid vehicle power and energy density requirements, and battery studies have indicated

*Verbatim from the Aerospace study.

that further improvements in each of these parameters are possible. Cycle life under the high charge/discharge rates of hybrid operation poses the largest technical problem remaining to be solved for all battery systems.

Lead-acid, nickel-cadmium and nickel-zinc batteries have been used in experimental and analytical hybrid vehicle designs to date, with limited success. A brief summary of the different types of batteries that can be considered as potential candidates for powering transit vehicles is presented herein. Much of the information was obtained from certain of the References,* and the various proceedings of the Intersoc Energy Conversion Engineering conferences as well as the Electric Vehicle Conference Proceedings.

The lead-acid battery is considered promising on the basis of cost and materials availability but is marginal from a weight point of view. The lead-acid type has an open circuit potential of approximately 2 V, a theoretical energy density of 76 Whr/1b, and achieved energy densities of 10-24 Whr/1b and power densities of 40 to 90 W/1b. This battery type has a high current capability, can operate over a wide temperature range, has good charge retention, high efficiency, long life, and low cost for materials and manufacturing.

The attainable energy density of lead-acid batteries is dependent on the discharge rate as illustrated in Figure B-2. This rate dependency is caused primarily by mass transport and ionic diffusion limitations.

Present cycle life of the lead-acid batteries is of the order of 300-500 for high energy density designs at deep depths of discharge. Further developments promise cycle lives up to 1000 in the near term. It is possible to increase life by compromising on energy density. One question which should be addressed is the

*H. Zuckerberg and C. Salmi, "A Bibliography on Hybrid Power Drive Subsystems," material on file with Kentron Hawaii, Limited, Transportation Systems Center, 55 Broadway, Cambridge MA 02142.



FIGURE B-2. EFFECT OF DISCHARGE RATE ON ENERGY-DENSITY OF LEAD-ACID BATTERIES

economic trade-offs between the use of light, high energydensity batteries with short life and the use of heavier, longer-life designs.

As can be deduced from the information in the technical press, a substantial effort is in progress to develop better lead-acid batteries.¹⁵ Typical avenues for improvements include:

- a. Lightweight cases with shortened intercell connector path lengths;
- b. New laminar grid design where the active material is sandwiched between grid segments which may meet the high charge and discharge current needs of electric power drives for longer cycles; there may not be any improvement in energy density.
- c. The use of other types of grid alloys, such as using lead with calcium and tin, and fabricated by wrought processes instead of casting. (Wrought processes will develop a better microstructure which should be stronger and more corrosion resistant. This should lead to thinner and lighter grids and thus a higher energy density.).
- d. Further development and improvement of the automotive maintenance-free lead-acid batteries. With the newer lead-calcium-tin grids, the oxygen over-voltage is low enough that gassing is negligible at normal charging voltages.
- e. The use of potassium perchlorate as the electrolyte instead of sulphuric acid in order to improve the energy density.

It is possible that energy densities of at least 50 Whr/1b for long distance duration may be achieved within the next 5 years along with power densities of the order of 100 watts/1b.

Nickel-Zinc Battery

The nickel-zinc battery unit has an open circuit potential of 1.7 V, a theoretical energy density of 140 Whr/1b and an achieved energy density of over 30 Whr/1b. This battery unit is of great interest since:

- a. The theoretical and practical energy density is considerably better than the lead-acid battery unit;
- b. It has good high-rate capability;
- c. It can be sealed;
- d. The cost of materials is reasonable.

Much research is needed to improve the cycle life of this type of battery unit. One possible direction is the development of improved separators which are essential to long life.

Nickel-Cadmium (Ni-Cad) Battery

The Ni-Cad battery has an open circuit potential of 1.3 V and a theoretical energy density of at least 100 Whr/lb depending on state of charge. Ni-Cad cells permit very high power drain, and have satisfactory cycle life. Though the Ni-Cad system has excellent potential, the main drawback to its use is the limited world supply of cadmium and its high cost.

Metal-Air Batteries

Metal-air batteries use a metal for the negative electrode and a gas electrode, using oxygen from the air, for the positive side. High energy-density metal-air batteries have severe thermal problems since this type of battery system overheats quite readily.

Research has concentrated on the zinc-air types. The many problems surrounding this concept, including passivation of the electrodes, thermal problems, etc., are discouraging further application of this type. Iron-air, aluminum-air and lead-air systems have been looked at. Iron-air seems to be one of the more promising types but it still has not reached the stage which is encouraging.

High Temperature Batteries

High temperature batteries offer both high power density and high energy density ratings. High energy is achieved by using reactants of low equivalent weight and high electron difference. High power capability is achieved by use of low resistance electrolyte materials such as fused salts and, by operating at elevated temperature which increases the exchange current density.

Research efforts have been applied toward the development of the following types among others:

Sodium-sulfur system Potassium-sulfur system Lithium-sulfur system

The above types show excellent promise, especially if they can be made to operate in the vicinity of 70°-100°C. However, severe engineering problems must be solved to achieve the necessary confidence and safety for public use.

B.2.2 Flywheel Energy Storage

The very high power densities and moderate energy densities achievable with flywheels provide a good match to the requirements of hybrid vehicles. In separate tests, Lockheed determined that the power density of a steel flywheel rotor could exceed 5000 W/lb, and the Johns Hopkins Applied Physics Laboratory (APL) obtained 28 W-hr/lb rotor energy density in subscale experiments with bar-type filamentary flywheels. It should be recognized that the weight added by the housing, power coupling system, bearings and ancillary components detracts from the overall energy and power density of the complete storage system assembly. Since the rotor is the most critical component, most work done to date has concentrated on improving its performance.

B - 8

The Lockheed work concentrated on metal flywheels of various materials and configurations. Pierced and solid disk and conical and constant stress exponential cross-section designs were examined. Materials considered included maraging steel, 1020 and 1040 steel, 4340 steel, and 2021-T81 and 2024-T851 aluminum. Several experiments were also conducted with E-glass and S-glass bar type composite wheels. On the basis of minimum weight and cost, Lockheed selected 4340 steel in a modified exponential constant-stress disk configuration as the best among the combinations analyzed. Two 46-1b wheels designed to operate at 24,000 rpm were built and tested. One of these was tested to destruction after spindown and acoustic tests were conducted. Disintegration occurred at a speed in excess of 35,000 rpm at a stored kinetic energy level of 1.1kW-hr which represents an energy density of 26.1 W-hr/1b for the 20.4-in. diam., 42.4-1b wheel.

Work at APL was confined to an investigation of composite wheels using boron, graphite, E-glass, and R-glass filaments. A large number of early tests were performed on small rod configurations using epoxy, RTV, acrylic and tube-supported mounting systems to evaluate the ultimate performance of the materials and to verify the operation of the test instrumentation. In these tests, a 0.004-in. diameter boron filament weighing 0.00035 lbs/in displayed the highest energy density of all the materials tested at 48 W-hr/lb without failing. For reasons of lower ultimate cost, subsequent 1-1b bar tests were limited to graphite/polyester, graphite/epoxy, and S-glass/epoxy composites. In the best of a series of five tests, a 30-in. diam. S-glass epoxy wheel exhibited a 28 W-hr/1b energy density. APL found that flywheel failures occurred at 71% of the static tensile stress failure levels measured for S-glass/epoxy composites and at 81% of those measured for graphite/epoxy systems. The premature failure stress is attributed to fabrication practices used in the preparation of the experimental specimens which resulted in fiber misalignment and cut surface fibers.

The containment ring required for the metal rotors will probably be much heavier than that for composite rotors in order to resist the large chunks which are characteristic of the failure of homogeneous rotors. Lockheed found that a 192-1b steel ring was required to contain a 0.86-hp-hr steel rotor burst and that a 167-1b composite ring could contain a 0.46-hp-hr burst. APL did not perform burst containment tests of full-scale wheels, but found that the 1/4"-thick rings used in their bar test series successfully contained the bursts of the experimental composite wheels. They concluded that the very low energy which apparently transfers to the containment ring is due to the fact that the composite rotors dissipate a significant portion of their kinetic energy by microfracture of vaporization of the matrix material. As part of their test series, APL observed that bursts of the graphite/epoxy composite rotors produced greater deformation of the containment ring than did bursts of S-glass epoxy composites. This difference was attributed to the rate at which disintegration occurs in the two materials.

The sustaining power required to maintain the rotor within its operational speed range also detracts from the overall performance of flywheel energy storage systems. Both Lockheed and APL system designs use a mechanical coupling between the rotor and drive system; both rotor housings are evacuated to a vacuum of $10^{-2} - 10^{-3}$ torr to reduce windage losses to a negligible level. However, the required support bearings and vacuum seals can be responsible for sustained power losses up to 3 hp at the maximum stored energy level, according to Lockheed calculations and measurements. These parasitic losses are similar in effect to, but much higher than, the self-thermal losses of high-temperature battery systems.

Many other investigators (Reference 16) have been studying the use of various materials and design concepts to maximize the utility of the flywheel energy storage subsubsystem. Sizing of Flywheels

Discussion

The hybrid power drive subsystem concept considered herein uses the series on-off engine operation mode. This concept requires that the flywheel, for efficient subsystem operation, serve a double duty:

```
Case I - Oversize Starter
Case II - Energy Storage Accumulator
```

The sizing of the flywheel should include the above cases with the higher value being selected for use in the design concept.

Case I - Flywheel as Engine Starter

The flywheel is to be used as a starter for the engine in the on operation mode.

Flywheel Inertia Criteria in On-Off Operation Mode

Let	Engine Speed	= N _E in rpm
	Engine Torque	= T _E in ft-1bs
	Gear Ratio to Reflect	Flywheel Inertia
	to Drive Shaft	$= (GR_{FW/E})$
	Flywheel Speed	= N_{FWD} at drive shaft in rpm
	Flywheel Torque	= T _{FW} in ft-1bs
	Engine Inertia	= I _E in 1b-ft-sec/rpm
	Flywheel Inertia	= I _{FW} in 1b-ft-sec/rpm

Assume Engine to be Started by Flywheel

Engine acceleration due to clutch torque, T_C

$$\dot{N}_{\rm F} = T_{\rm C}/I_{\rm F}$$
 in rpm/sec (B-1)

Flywheel deceleration due to clutch torque, T_C

$$\dot{N}_{FWD} = T_C / I_{FW} (GR_{FW/E})^2$$
 in rpm sec (B-2)

Assume Synchronizing Speed = N_S

Synchronizing time
$$t_{S} = \frac{N_{S}}{N_{E}} = \frac{N_{S} \cdot I_{E}}{T_{C}}$$
 (B-3)

Solving for N_S by Combining Equations (B-1) through (B-3)

$$N_{S} = N_{FWD} [I_{FW} (GR_{FW/E})^{2}] / [I_{E} + I_{FWD} (GR_{FW/E})^{2}]$$
 (B-4)

Let the Energy Originally Stored in the Flywheel be:

$$(\text{ENERGY})_{\text{FW}} = \frac{1}{2} I_{\text{FW}} (\text{GR}_{\text{FW}/\text{E}} \cdot \text{N}_{\text{FWD}})^2 \qquad (B-5)$$

After Clutch Engagement and Subsequent Engine Start-Up

The final energy =
$$\frac{1}{2} [I_E + I_{FW} (GR_{FW/E})^2] (N_S)^2$$
 (B-6)

$$(\text{ENERGY})_{FW} = \frac{1}{2} [I_{FW} (\text{GR}_{FW/E})^2] [N_{FWD}^2] \left\{ \frac{I_{FW} (\text{GR}_{FW/E})^2}{I_E^+ I_{FW} (\text{GR}_{FW/E})^2} \right\} \quad (C-7)$$

Energy Lost in Synchronization:

LOST ENERGY_{FW} = (ENERGY)_{FW} - (ENERGY)_{FINAL} (B-8)

Ratio to original =
$$\left[\frac{I_E}{I_E + I_{FW}(GR_{FW/E})^2}\right]$$
 (B-9)

To minimize loss,
$$I_{FW}(GR_{FW/E})^2 > I_E$$
 (B-10)

Let

Minimum drive shaft speed for engine-flywheel clutch engagement = N_{DSTS}
Critical minimum drive shaft speed = N_{DSMS}

(Below this speed, flywheel will not have sufficient energy stored to accomplish anything.) From Equations (B-7) through (B-9):

$$I_{FW}(GR_{FW/E})^2 = I_E / \left[\left(\frac{N_{DSTS}}{N_{DSMS}} \right)^2 - 1 \right]$$
 (B-11a)

The maximum rated flywheel speed (at the flywheel) is set at:

$$N_{FW} = 11,000 \text{ rpm}$$

The following limiting values are established for this study:

Thus

$$I_{FW}(GR_{FW/E})^2 = 3.267 I_E$$
 (B-11b)

For the types of engines used in this program:

$$I_E = 14 \ 1b - in - sec^2$$

typical of current Detroit Diesel engines.

Then from Equation (B-11):

$$I_{FW}(GR_{FW/E})^2 = .1222 \text{ lb-ft-sec/rpm}$$
 (B-12)

<u>Case II - Sizing of Flywheel as an Energy Storage Accumulator</u> During Driving Cycle(s)

Drive Wheel Power Requirements

P_{RDRES} = power loss due to road resistance in lb-ft/sec VGW = vehicle gross weight in 1b ACC = initial vehicle acceleration in mph/s g = gravity constant = 32.1739 ft/sec² = air drag coefficient - non dimensional CD = vehicle frontal area in square feet AF V = vehicle velocity in mph = road resistance coefficient - non dimensional μ Air Drag Power $P_{DRAG} = .002556 (C_D) (A_E) (V^3)$ (B-13)Road Resistance Power $P_{\text{RDRES}} = \mu(VGW)(V)$ = $[.005+5.45(1.466V)^{2.5}](10^{-7})(VGW)(V)$ (B-14)Acceleration Power $P_{ACCE} = (VGW/G) (1.4667(ACC)) (V)$ (B-15) Drive Wheel Power $P_{WH} = P_{ACCE} + P_{DRAG} + P_{RDRES}$ (B-16) Net engine power at engine flywheel = P_{ENG} P_{ENG} = GROSS ENGINE POWER - ENGINE ACCESS. POWER $= P_{FWIN}$ Flywheel charging power Power extracted from flywheel = P_{FWOUT} Transmission efficiency involved in charging $n_{\rm C}$ Flywheel power drive efficiency = η_D

Let

Engine on-off coefficient β = 0 engine off β = 1 engine on

The net horsepower P_{FWOUT} extracted from the flywheel shaft is the difference between the vehicle power requirement and the power supplied by the engine:

$$P_{FWOUT} = (P_{WH}/\eta_D) + P_{A/C} - \beta(P_{ENG} \times \eta_C)$$
 (B-17)

 $P_{A/C}$ = power requirement for air conditioning, etc.

During deceleration the power regenerated at the flywheel shaft is defined by:

$$P_{\text{REG}} = (P_{\text{DECEL}})(n_{\text{R}})$$
(B-18)

= β

where n_R is the average regeneration transmission efficiency.

The change in β from 0 to 1 is set to occur when the flywheel speed drops to a minimum of 50% of maximum rated speed. Let

Total time during which power is expended = t_E sec

Energy expended,
$$E_{EXP} = (P_{FWOUT})(t_E)(3.766 \times 10^{-7})$$
 (B-19)
in kW-hr

Energy Storage

$$E_{EXP} = \frac{1}{2} I_{FW} (W_0^2 - W_1^2)$$
 (K) (B-20)

where W_0 = flywheel speed fully charged in rpm W_1 = minimum flywheel threshold speed in rpm Assume W_1/W_0 = .50 Let I_{FW} = flywheel moment of inertia in lb-ft-sec² $K = (2\pi/60)^2$ Then E_{EXP} = (.004112)(I_{FW})(W_0^2) (B-21) Equating Equations (B-19) and (B-21) and solving for I_{FW} yields:

$$I_{FW} = (7.825 \times 10^{3}) (P_{FWOUT}) (t_E) W_0^2 \text{ in } 1b - ft^2$$
 (B-22)

Correcting for flywheel installation losses, $\phi_{LOSS} = .707$

$$I_{FW} = (1.105 \times 10^4) (P_{FWOUT}) (t_E) / W_0^2 in 1b - ft^2$$
 (B-23)

Assume Δt_E = time increment wherein power is expended N_{CY} = number of cycles during time t_E

Then
$$t_E = (N_{CY}) (\Delta t_E)$$
 (B-24)

Finally
$$I_{FW} = (1.105 \times 10^4) [(P_{FWOUT}) (\Delta t_E) / W_0^2] (N_{CY})$$
 (B-25)

Correcting Equation (B-25) to be reflected at the drive shaft .

$$I_{FW} = (36) [(P_{FWOUT})(\Delta t_E)/W_{DS}^2](GR_{FW/E})(N_{CY})$$
(B-26)
in 1b-ft-sec/rpm

where W_{DS} = drive shaft rpm

 $GR_{FW/E}$ = gear ratio between engine and flywheel

The weight of the flywheel rotor corresponding to the moment of inertia calculated from Equation (B-25), can be determined using the following empirical relationship.

$$W_{ROTOR} = K_W(I_{FW}) \tag{B-27}$$

where

$$K_W = .70$$

For the Case I driving cycle, and assuming

$$N_{CY} = 3$$

 $E_{EXP}/CYCLE = .628 \times 10^{6}$
TOTAL $E_{EXP} = 1.884 \times 10^{6}$
 $W_{0} = 11,000 \text{ rpm}$

From Equation (B-25)

 $I_{FW} = (1.105 \times 10^4) (1.884 \times 10^6) / 121 \times 10^6 = 172.05 \text{ lb-ft}^2$ From Equation (B-26)

 $I_{FW} = 14 \ 1b - ft - sec/rpm$

From Equation (B-27)

 $W_{\rm ROTOR} = 172.05/.70 = 246$ lbs

The miscellaneous hardware weight consisting of shafting, bearings, housing, containment ring, etc. is estimated at 5 times ^WROTOR.

The miscellaneous installation weight consisting of transmission between engine and flywheel, housing, supports, etc. is estimated as a fixed quantity at 724 pounds.

The total flywheel installation subsystem weight is estimated as follows:

Rotor weight		=	246	1bs
Miscellaneous	hardware weight	=	1,230	1bs
Miscellaneous	installation weight	=	724	<u>lbs</u>
	TOTAL		2,200	1bs



APPENDIX C ENGINEERING LIMIT PERFORMANCE OF TRANSIT BUSES OVER URBAN DRIVE CYCLES

This appendix consists of an Engineering Limit Performance of Transit Buses developed by Professor A.T. McDonald, Purdue University, School of Engineering



FIGURE C-1. TRACTIVE POWER REQUIREMENTS FOR TRANSIT COACH



FIGURE C-2. PROFILE OF TRACTION POWER AS A FUNCTION OF TIME FOR CYCLE C AT 8 STOPS PER MILE



FIGURE C-3. MAXIMUM PRACTICAL FUEL ECONOMY LIMIT FOR OPERATION WITHOUT STOPS AS A FUNCTION OF CRUISE SPEED



FIGURE C-4. ENGINEERING LIMIT FUEL ECONOMY WITH REGENERATION FOR TRANSIT COACH OPERATING ON CYCLE C AS A FUNCTION OF NUMBER OF STOPS PER MILE (1 of 2)



FIGURE C-4. ENGINEERING LIMIT FUEL ECONOMY WITH REGENERATION FOR TRANSIT COACH OPERATING ON CYCLE C AS A FUNCTION OF NUMBER OF STOPS PER MILE (2 of 2)



FIGURE C-5. ENGINEERING LIMIT FUEL ECONOMY W1THOUT REGENERATION FOR TRANSIT COACH OPERATING ON CYCLE C AS A FUNCTION OF NUMBER OF STOPS PER MILE (1 of 2)



LNET ECONOWA (wbd)

(2 of 2) FIGURE C-5. ENGINEERING LIMIT FUEL ECONOMY WITHOUT REGENERATION FOR TRANSIT COACH OPERATING ON CYCLE C AS A FUNCTION OF NUMBER OF STOPS PER MILE (2 of 2)

APPENDIX D COMPUTER PROGRAM NOMENCLATURE Subroutine name: AUTOHB

Type of subroutine: Component subroutine

Description: Subroutine to simulate the driver and to determine new vehicle velocity and the new desired driveshaft torque for the next point in the driving cycle.

ΑΕΡΑ	-	acceleration required to reach next cycle velocity
DELT	-	time difference between next cycle point and
		current time
GR	-	gear ratio from engine to rear wheels
RATKLS	-	rear axle torque loss
TMAX	-	maximum steady state engine torque
T9ICDN		new required driveshaft torque
T911GR	-	equivalent rear axle gear ratio
VEPA	-	required cycle velocity
VVDF	-	vehicle road load
VVDFD	-	vehicle road load
VVDMI	-	inertial vehicle mass
VVIDRR	-	time radius
VVOS	-	vehicle velocity

Subroutine name: CONTHB

Type of sub	routi	ne: control subroutine
Description:		Subroutine to control the engine and
		flywheel torque depending on the operating
		modes of the hybrid car.
DF		flywheel speed
DFSTOP	-	flywheel speed at which engine shuts off
DFSTRT	-	flywheel speed at which engine starts
ENGSTP(1)	-	maximum flywheel speed
FINTRQ		torque from engine (or starter motor) to flywheel
IENGIN		mode of operation of engine-flywheel system
		2. Engine charging flywheel
		 Flywheel starting engine Engine off
TOWI		
ISMI	-	engine on-oir. 0-oir, -r-on.
ISW2	-	torque flow from flywheel to engine. 0-no, -l-yes
PAON	-	engine speed (rpm)
RFINR	-	system inertia (l/RIF or l/RIEPIF)
VVOS	-	vehicle speed (mph)

D-3

Subroutine name: CVTGNU

~	Type of sub	routi	ne: Component subroutine
	Description	:	Subroutine to calculate flywheel torque
			losses in the CVT, clutch, and driveshaft.
	Alcvt	-	ratio of hydraulic pump input speed to CVT
			input speed.
	CVTLS	-	torque loss in CVT
	CVTSCL	-	CVT scale
	CVTTRQ	-	torque at driveshaft which will be transmitted
			to flywheel
	GNU	-	CVT efficiency
	ICLUCH	-	clutch indicator, 0 if open, 1 if closed or slippin
	IGEAR	-	shift indicator. 0 if neutral
	R	-	ratio of driveshaft speed to flywheel speed
	RMIN	-	minimum system ratio
	RP	-	the CVT ratio
	RPP	-	the new transmission ratio
	SPDIN	-	driveshaft speed
	SPUMP	-	input speed of hydraulic pump
	TC	-	output torque of CVT
	TCLULS	-	torque loss in clutch at flywheel
	TCVTLS	-	equivalent torque loss in CVT at flywheel
	TLPUMP	-	charge pump loss at flywheel
	TMAX	-	maximum engine torque
	TTRIN	-	torque in shaft between the 4-speed transmission
			and CVT
	T9IC	-	driveshaft torque
	T9IN	-	driveshaft speed

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Subroutine name: DSTORQ

Type of subroutine: Component subroutine Description: Subroutine to calculate driveshaft torque and the next desired torque command and brake setting

BS	-	brake setting
ICLUCII	-	clutch indicator, 0 if open, 1 if closed or
		slipping
IGEAR	-	gear shift indicator
RP	-	CVT ratio
TMAX		maximum steady state engine torque
TNUM	-	rear axle torgue
TS	-	throttle setting
T8IlGR	-	nominal rear axle ratio
T9IC	-	driveshaft torque
T9ICDN	-	new required driveshaft torque
T9ON	-	rear axle speed
VVI2BR	-	brake constant

Subroutine name: ENGINI

Type of subroutine: Initialization

Description: Subroutine used for initializing engine.

- FINTRQ torque from engine (or starter motor) to flywheel.
- ISW1 engine on-off. 0 off, -1 on.
- ISW2 torque flow from flywheel to engine. 0 no, -1 yes.
- PAOC engine shaft torque
- PAOFR fuel consumption rates (1b. 1 hr.)
- PPOB engine vacuum (in -Hg)
- SSTORQ STEADY STATE TORQUE

Subroutine name: ENGWHL

Type of su	brouti	ne: Component subroutine
Descriptio	n:	Subroutine to integrate flywheel speed
		and engine speed.
Input vari	ables:	
CVTTRQ	-	torque at driveshaft which will be transmitted
		to the flywheel
DT	-	time increment (= .05 sec.)
EDRAG	-	engine drag coefficient
EGAIN	-	engine gain
ENGTORQ	-	torque supplied by engine at a given speed and
		throttle setting. Taken from throttle map.
FINTRQ	-	torque from engine (or starter motor) to
		flywheel.
IENGIN	-	Mode of operation of engine flywheel system.
		 Engine charging flywheel Flywheel starting engine Engine off
ISW1	-	engine on-off. 0-off, -1-on.
ISW2	-	torque flow from flywheel to engine. 0-no, -l-yes.
PAOC	-	engine shaft torque
PAON	-	engine speed
PERLOS	-	% loss in flywheel gears
R	-	ratio of driveshaft speed to flywheel speed
RFINR	-	System inertia (1/RIF or 1/RIEPIF)
RIEINV	-	inverse of engine inertia
TCLSS	-	torque loss in four speed transmission reflected
		to the flywheel

ENGWHL Subroutine Page 2

TCLULS	-	torque loss in the clutch at the flywheel
TCVTLS	-	equivalent torque loss in CVT at flywheel
TLPUMP	-	charge pump loss at flywheel
T9IN	-	Driveshaft speed (between CVT & rear axle)
		corrected for tire growth
Output Varia	ables	:
A(1)	6 5	power generated by engine
A(2)	-	power required by road load
A(3)	-	power lost in CVT
A(4)	-	power lost in clutch
A(5)	**	power lost in excess braking
A(6)	e m	power output from system
A(7)	-	power lost in rear axle
A(8)	-	power lost in starting the engine
A(9)	-	power lost to flywheel friction
A(10)		power lost in flywheel gear
AA(1)	-	power lost in transmission gears
AA(2)	-	power used by transmission charge pump
Other progra	am va:	riables:
DFINT	-	change in flywheel speed over the integration
		period
DFDOT	-	flywheel acceleration
DTF	-	time increment for integrating flywheel acceleration
ENTORQ	-	torque on flywheel to accelerate engine
ESDOT	-	derivative of engine speed

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ENGWHL Subroutine Page 3

- FLYGRL flywheel gear loss
- NDT number of times flywheel power out is calculated before average is taken and integrated for energy out.
- RGNTRQ regenerative braking torque

TFTORQ - torque on flywheel demanded by drivetrain also includes torque for accelerating engine

-

Subroutine name: EPAVEL

Type of subroutine: System computation Description: EPAVEL retrieves the appropriate velocity as a function of time and supplies it to the automatic driver.

Input variables:

IVEPA (]) -	cvcle	velocities	at 1	second	intervals
----------	-----	-------	------------	------	--------	-----------

TIME - time from start of driving cycle (sec.)

Output variables:

- DELT time difference between next cycle point and current time.
- ICYEND used as a flag to indicate the end of the cycle.

VEPA - next required cycle velocity

Other program variables:

DELMIN	-	automatic drive minimum lead time
DT	-	time of one clock pulse
FLOAT(I)	-	treat the integer variable I as a real variable
NVEPA	-	number of velocities specified in driving
		cycle

IVEL

KPLACEvariables used to pack and unpack two cycleKREMvelocities per word of core

Subroutine name: FSPEED

Type of subroutine: Interpolation Description: Subroutine to provide interpolation for engine parameters.

Subroutine name: GRSHFT

Type of subroutine:	Component	subi	coutine		
Description:	Subroutine	to	simulate	gear	shift

AEPA	-	acceleration required to reach next cycle velocity
DT	-	time of one clock pulse
ICLUCH	-	clutch indicator, 0 if open, 1 if closed or slipping
IGEAR	-	current gear zero if neutral
INEXT	-	the next transmission gear
NGEAR	-	number of gears
R	-	ratio of driveshaft speed to flywheel speed
RMAX	-	maximum allowable transmission system ratio
RMIN		minimum allowable transmission system ratio
RP	-	the CVT ratio
RPMAX	-	maximum allowable CVT ratio.
RPMIN	-	minimum allowable CVT ratio
RPP	-	the new transmission ratio
STIME	-	time interval between checks for shift
TIMINT	-	time interval
TRMAX	-	maximum overall gear ratio (flywheel to drive-
		shaft) for the current gear
TRMIN	-	minimum overall gear ratio (flywheel to drive-
		shaft) for the current gear.
T9ICDN	-	new required driveshaft torque

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Subroutine name: HYBLSS
Type of subroutine:
                    Computing Subroutine
Description:
                     Subroutine to calculate energy losses
                     in the hybrid car.
Input variables:
A (1)
+
                same as ENGWHL
AA (6)
CVTTRO
            - torque at driveshaft which will be transmitted
                to the flywheel
DELTA
                integration time increment (sec.)
            -
RATKLS

    rear axle torque loss

T9IC
            - driveshaft torgue (between CVT and rear axle)
T9IN
            - driveshaft speed
VVDF
            - vehicle road load force at the road interface (1b)
VVOS
            - vehicle speed (mph)
Output variables:
C(1)
¥
                same as ENGWHL but substitute energy for power.
C (6)
Other variables:
          - 2 DELTA/5252
DELCON
RACON - vehicle speed (ft/sec)
```

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```

Type of subroutine: Initialization

- Description: This subroutine reads in all maps and tables needed by the system computation routines. It reads in all constants that are required and calculates other constants as necessary. It sets the ADC and DAC conversion constants. It also calculates acceleration limits of the vehicle, accounting for weight transfer.
- ADDCON(9) ADC conversion constants
- AVIB air pressure (psi)
- AVIM air density (lb/ft^3)
- AVIR air temperature (°F)
- AlCVT ratio of hydraulic pump input speed to CVT input speed.
- COMM(I) title cards
- CVTSCL CVT scale

DACCON(10) - DAC conversion constants

- DELMIN automatic drive minimum lead time (sec)
- DT value of one clock pulse (sec)
- EDRAG engine internal drag coefficient

EFFTAB(I,J,K) - CVT torque loss table (ft-lb)

EGAIN - engine gain

- ENGFUL(I) engine fuel consumption map (BSFC vs. rpm)
- ENGSTP(1) maximum flywheel speed (rpm)
- ENGSTT(I) minimum flywheel speed vs. vehicle speed
 (rpm vs. mph)

INCNHB Subroutine Page 2

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ENGTRQ(1)	-	engine torque map (it-1b vs. rpm)
ENGVAC(I)	-	manifold vacuum map (in Hg vs. rpm)
EPS	-	used to test for constant engine speed (rpm)
FDRAG	-	flywheel drag
FUELWT	-	weight of l gallon of fuel (lb)
FUIDL	-	fuel consumption at idle (lbm/hr)
GAIN	-	gain for VEDYNH
GEREFF(I)	-	table of gear efficiencies for each gear of
		the manual transmission
GRATIO(I)	-	table of gear ratios for the manual transmission
HRPSEC	-	hours per second
IOUT	-	number of clock pulses allowed between outputs
IVEPA	-	driving cycle velocities at 1 second intervals
LOADEQ	-	road load calculation control
MAXLIN	-	lines per page
NDIM(2)	-	number of variables used in joint probability
		density
NGEAR	-	number of gears
NSPEED	-	number of speed increments in throttle map
NTIMES	-	number of velocities
NVEL	-	number of velocities
NVEPA	-	number of velocities specified in driving cycle
PERLOS	-	% loss in flywheel gears
PMAX(1)	-	maximum torque for PRBDHB (ft-1b)
PMAX(2)	-	maximum engine speed for PRBDHB (rpm)
RAEFTB(I,J)	-	rear axle efficiency table
RASCAL	_	rear axle scale

INCNHB Subroutine Page 3

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RIE	-	rotary engine inertia (lbm-ft ²)
RIEINV	-	inverse engine inertia
RIEPIF	-	engine inertia plus flywheel inertia
RIF	-	flywheel inertia
RMAX	-	maximum allowable transmission system ratio
RMAXAS(I)	-	maximum overall gear ratio (from flywheel to
		driveshaft) for gear I
RMIN	-	minimum allowable transmission system ratio
RMINAS(I)	-	minimum overall gear ratio (from flywheel to
		driveshaft) for gear I
RPMAX	-	maximum allowable CVT ratio
RPMIN	-	minimum allowable CVT ratio
SPDING	-	speed increment for reading throttle map (rpm)
TIMING	-	not used
TMAX	-	maximum steady state engine torque (ft-lb)
TRQIDL	-	engine torque at idle (ft-lb)
TVICRL	-	road load torque at driveshaft (ft-lb)
TVIJCT	-	polar moment of torque converter turbine (lbm-ft ²)
TVIJRA	-	polar moment of rear axle gears (lbm-ft ²)
TVIJTR	-	polar moment of transmission gears (lbm-ft ²)
JVIJTW	-	polar moment of tires and wheels (lbm-ft ²)
T8INV(10)	-	driveshaft speed as a function of vehicle
		speed (rpm vs. mph)
T811GR	-	nominal rear axle ratio
VACIDL	-	manifold vacuum at idle (in-Hg)
VACMAX	-	maximum manifold vacuum (in-Hg)
VELINC	-	velocity increment (mph)

INCNHB Subroutine Page ⁴

VINT(1)	-	increment in torque for PRBDHB (ft-1b)
VINT(2)	-	increment in engine speed for PRBDHB (rpm)
VMIN(1)	-	minimum torque for PRBDHB (ft-lb)
VMIN(2)	-	minimum engine speed for PRBDHB (rpm)
VVIAMX	-	maximum vehicle acceleration accounting for
		weight transfer without tire slippage
VVIAS	-	maximum vehicle acceleration accounting for
		weight transfer with tires slipping.
VVIDRR	-	tire rolling radius (ft)
VVIFUM	-	coefficient of static tire friction (g's)
VVIFUS	-	coefficient of slipping tire friction (g's)
VVILFR (-	frontal area (ft ²)
VVIM	-	vehicle mass (lb)
VVIMDR	-	weight on drive wheels (lb)
VVIMI	-	inertial mass of vehicle (lb). The read in
		value of VVIMI is not used - it is calculated
		instead.
VVISH	-	height of vehicle center of gravity (in)
VVISWB	-	wheel base (in)
VVILCD	-	drag coefficient
VVILCF	-	tire constant friction coefficient
VVILRF	-	rolling friction coefficient
VVI2BR	-	brake constant (usually static weight of vehicle)

Subroutine name: INGRHB

Type of	subrouti	ne: Initialization
Descript	ion:	Subroutine to initialize the hybrid car
		after the engine is in steady state.
AVIO	-	grade angle (rad)
AVIS	-	windspeed (mph)
EMISE	-	emissions (not used)
EMISF	-	emission rate (not used)
FUELE	-	cumulative fuel consumed (1b)
ICLOCK	-	cumulative number of clock pulses
ICLOKO	-	time at previous output of variables
ICLOK1	-	ICLOCK at completion of last integration
ICLUCH	-	clutch indicator, 0 if open, 1 if closed or
		slipping
ICYCLE	-	number of times the program has iterated
IENGIN	-	mode of operation of engine - flywheel system
		2. Engine charging flywheel
		3. Flywheel starting engine
TCEAD		4. Engine oli
IGEAR	-	current gear
INDIC	-	output indicator
INEXT	-	the next transmission gear
IPDX(I,J) –	integer table of probability density distribution
ISEQ	-	shift indicator
ITICYC	-	ICLOCK at start of driving cycle
NGI	-	current gear number
NGIOLD	-	gear at previous iteration

INGRHB Subroutine Page 2

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NGT (I)	-	number of samples above maximum engine speed
NGT (2)	-	number of samples above maximum torque
NLINE	-	number of lines on current page
NLT (1)	-	number of samples below minimum engine speed
NLT (2)	-	number of samples below minimum torque
PAOFR	-	fuel consumption rate (lb/hr)
PAOFRO	-	previous value of PAORR
RP	-	the CVT ratio
RPP	-	the new transmission ratio
TIMAVG(I)	-	timer averages
TIME	-	time from start of driving cycle (sec.)
TIMLEN(I)	-	timer lengths
TIMMAX(I)	-	timer maximum
T8DN	-	uncorrected driveshaft speed
T9ICDO	-	old desired driveshaft torque
T9IN	-	driveshaft speed
T9I1GR	-	effective rear axle ratio
T90N	-	rear axle speed
VEPA	-	next driving cycle velocity
VVOA	-	vehicle acceleration
VVOAO	-	previous value of VVOA
VVOD	-	vehicle distance traveled
vvos	-	vehicle speed (mph)
vvoso	-	previous value of VVOS
WHLOLD	-	previous value of wheel slip indicator

Type of subroutine: Computing subroutine

Description: This subroutine integrates vehicle acceleration, vehicle speed and fuel rate to get vehicle velocity, distance traveled and fuel expended respectively. Velocity is set to zero if it becomes negative in this subroutine.

Input variables:

FUELE	-	fuel expended
ICLOCK	-	value of system clock
ICLOK1	-	last value of system clock
PAOFR	-	new fuel rate
PAOFRO	-	old fuel rate
VVOA	-	new vehicle acceleration
VVOAO	-	old vehicle acceleration
VVOD	-	last distance traveled
VVOS	_	last vehicle speed

Output variables

1.10

FUELE	- new	fuel consumed
ICLOK1	- cur:	rent value of system clock
PAOFRO	- old	fuel rate for next iteration
VVOAO	- old	acceleration for next iteration
VVOD	- new	distance
VVOS	- new	velocity
VVOSO	- old	speed for next iteration

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INGRTH Subroutine

Other variables:

- DELTA integration time factor
- HPPSEC hours per second

Subroutine name: INVRHB

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Type of	subrouti	ne: Initialization
Descript	ion:	Subroutine to initialize the variables
		for the hybrid car simulation.
BS	-	brake setting
CVTTRQ	-	torque at driveshaft which will be transmitted
		to flywheel
DELMIN	-	automatic drive minimum lead time
DF	-	flywheel speed (rpm)
DFDOT	-	flywheel acceleration (rpm/sec)
ESDOT	-	engine acceleration (rpm/sec)
ESDOTO	-	previous value of engine acceleration
FINTRQ	-	torque from engine (or starter motor) to flywheel
GNU	-	CVT efficiency
ICLOCK	-	cumulative number of clock pulses
ICLOK1	-	ICLOCK at completion of last integration
ICYEND	-	end of driving cycle indicator
IENGIN	-	mode of operation of engine-flywheel system
		 Engine charging flywheel Flywheel starting engine Engine off
IENGNO	-	state of engine on last iteration
IOLD1	-	old value of switch l
IOLD2	-	old value of switch 2
ISHIFT	-	ICLOCK at start of last shift
ISW1	-	engine on-off. 0 - off, -1 - on.
ISW2	-	torque flow from flywheel to engine. 0-no, -1-yes
INVRHB Subroutine Page 2

NGL	-	current gear number
NGIOLD	-	gear at previous iteration
NREC	-	output record number
R	-	ratio of driveshaft speed to flywheel speed
RIEINV	-	inverse of engine inertia
RIF	-	flywheel inertia
RFINR	-	<pre>system inertia (l/RIF or l/RIEPIF)</pre>
TBOIGI	-	tran s mission gear ind e x
TBOIGR	-	tran s mission gear ratio
TCLULS	-	torque loss in clutch at flyweel
TCVTLS	-	equivalent torque loss in CVT at flywheel
TIMAVG(I)	-	timer averages
TIME	-	time from start of driving cycle (sec.)
TIMLEN(I)	-	timer lengths
TIMMAX(I)	-	timer maximums
TS	-	throttle setting
TVEPAO	-	time of previous driving cycle speed
T9IN	-	driveshaft speed
VANALG	-	analog car speed
VAR(10)	-	extra space for variables
VEPAO	-	previous driving cycle speed
VVOA	-	vehicle acceleration (ft/sec ²)
VVOS	-	vehicle speed (mph)

Subroutine name: JPBHYB

Type of subroutine: Output Description: Subroutine to printout gross results of the simulation for a complete run of the driving cycle.

- CFMPG corrected fuel consumption connected for energy left in the flywheel (mpg)
- EFRIC The sum of ELENIN and energy lost to flywheel friction
- ELEFT energy left in the flywheel

ELENIN - energy lost to engine inertia

- FUMPG fuel consumption (mpg)
- INT increment in torque intervals for printout

- ITORQ1 start of torque interval (for printout)
- ITORQ2 end of torque interval (for printout)
- N2 number of speed intervals (for printout)
- SUMJ(I) totals of joint probability distribution for each
 speed interval
- X(J) dummy array for tape or disc output

Subroutine name: MONKEY

Type of	subr	outine: Interpolation
Descript	ion:	Subroutine to interpolate input torque
		loss of a hydrostatic power split trans-
		mission.
ABS(I)	-	absolute value
R	-	ratio of driveshaft speed to flywheel speed
RMAX	-	maximum allowable transmission system ratio
RMIN	-	minimum allowable transmission system ratio
RP	-	the CVT ratio
S	-	driveshaft speed
STAR (9,7	,9)	transmission torque loss for specific driveshaft
		torque driveshaft speed and transmission ratio.
т	-	output torque of CVT

TLOS - torque loss in CVT

Subroutine name: NUTRAL

Type of subroutine: Component subroutine Description: Subroutine to calculate torque in rear axle due to drivetrain spin losses with transmission in neutral. CVTR - ideal CVT ratio RAR - effective rear axle ratio RAS - rear axle speed TAXLE - rear axle torque Subroutine name: OTCNHB

Type of subroutine: Output

Description: Subroutine to output constants for hybrid car on a disc for performance analysis. Subroutine name: OTPTHB

Type of subroutine: Output

Description: Subroutine to output hybrid system variables on a line printer for evaluation.

- BSFC brake specific fuel consumption
- FMPGC accumulative fuel consumption (mpg)
- FOBHP flywheel output horsepower
- NLINE number of lines on current page
- OBHP observed brake horsepower
- RIENG mode of operation of engine flywheel system
 - 2. Engine charging flywheel
 - 3. Flywheel starting engine
 - 4. Engine off
- TBD1EF overall transmission efficiency
- T9D1 rear axle efficiency

Subroutine name: OTVRHB

Type of subroutine: Output Description: Subroutine to output variables for the hybrid car on a disc for performance analysis. Subroutine name: PRBDHB

Type of subroutine: Computing subroutine This subroutine calculates the joint Description: probability density distribution of engine speed versus steady state torque over a given driving cycle. Input variables: VAL(1) current steady state torque VAL(2) current engine speed gain Output variables: IPDX(20,20) - new probability distribution NGT(1) number of samples above maximum engine speed -NGT(2) - number of samples above maximum torque NLT(1) number of samples below minimum engine speed -NLT(2) number of samples below minimum torque -Other varialbes: INTI - torque index INT2 engine speed index ----VINT(1) size of torque interval VINT(2) size of engine speed interval -VMAX(1) maximum torque -VMAX(2) maximum engine speed VMIN(1) minimum torque -

VMIN(2) - minimum engine speed

Subroutine name: RAEFFH

Type of subroutine: component subroutine Description: Subroutine to calculate rear axle torque loss.

IGEAR	-	gear	shift	indic	ator
RASCAL	-	rear	axle	scale	
RATKLS	-	rear	axle	torque	loss
T9IC	-	drive	eshaft	torqu	e
T9I1	-	rear	axle	effici	ency
T9IlGR	-	rear	axle	ratio	equivalent
T90C	_	rear	axle	output	torque.

Subroutine name: RAXLOS

Type of subroutine: Interpolation Description: Subroutine to interpolate rear axle torque losses

RALS - rear axle torque loss STRA (11, 11) - rear axle torque loss table

Subroutine name: RDEPA

Type of sub	orouti	ne: Input
Description	1:	RDEPA reads and stores the driving cycle
		velocities at one second intervals.
Input varia	ables:	
IVEPA(I)	-	cycle velocities at one second intervals
ITEMP	-	intermediate variable for reading the cycle
		points from the cards (26 points per card)
N	-	number of cycle points
NREAD	-	number of cards to read in cycle velocities
NREM	-	number of points to read from last card
IDATA		
ITEMP		
ITEMP1	-	variables used to pack and unpack two cycle
KPLACE		velocities per word of core
KREM		

Subroutine name: READRA

Type of subroutine: Input Description: Subroutine to read in the rear axle efficiency table STRA (I,J) - rear axle torque loss table.

Subroutine name: SIMHBD

Type of subroutine: Control Description: Mainline of the simulation, including a proper calling sequence for the rest of the routines. ATORQS(NFUEL) engine torque used in performance analysis DF - flywheel speed EPS - used to test for constant engine speed

ESPEED (NFUEL) engine speed used in performance analysis FINTRO torque from engine (or starter motor) to flywheel FOBHP flywheel output horsepower time used in performance analysis FTIME (NFUEL) ICLOCK cumulative number of clock pulses ICLOKO time at previous output of variables ICLOK1 ICLOCK at completion of last integration number of times the program has iterated ICYCLE end of driving cycle indicator ICYEND INDIC output indicator INISWT logic variable 0 - initialization of engine speed complete. Car in first. 1 - engine being initialized. Car in neutral. logic variable 0 - engine not in steady state IREADY 1 - engine in steady state NTIMEP time since last printout OBHP observed brake horsepower

- PAOC engine shaft torque
- PAOFR fuel consumption rate (lb/hr)

SIMHBD Subroutine Page 2

PAON	-	engine speed (rpm)
PPOB	-	engine vacuum (in Hg)
RATE	-	flywheel speed
RATKLS	-	rear axle torque loss
SSTORQ	-	steady state engine torque
TFTORQ	-	total flywheel input torque
TIME	-	time from start of driving cycle
T9IC	-	driveshaft torque
T9I1GR	-	effective rear axle ratio
T9OC	-	rear axle output torque
VAL(1)	-	current steady state torque
VAL(2)	-	current engine speed

Subroutine name: TGG15H

Type of subroutine:		ne: Component subroutine
Description:		Subroutine to determine the effective
		rear axle ratio and driveshaft speed
		taking into account tire growth.
Input variab	les:	
vvos	-	vehicle speed
Output varia	lbes	
T9IN	-	actual driveshaft speed
T9IlGR	-	equivalent rear axle ratio
Other variab	les:	
DIFF	-	difference between current vehicle speed
		and vehicle speed at lower interpolation
		points
T8DN	-	uncorrected driveshaft speed
T8DNHI	-	upper interplation point
T8DNLO	-	lower interpolation point
T8INV(J)	-	table of driveshaft speeds
T8IlGR	-	Nominal rear axle ratio
VVIDRR	-	time radius

Subroutine name: TREFFH

Type of subroutine: Component subroutine Description: This subroutine calculates the torque loss in the 4 speed transmission.

GRATIO(I) - table of gear ratios of the manual transmission
GEREFF(I) - table of gear efficiencies for each gear of
the manual transmission

IGEAR - current gear

- TCLSS torque loss in the 4 speed transmission reflected to the flywheel
- TORQ torque in shaft between 4 speed transmission and CVT.

Subroutine name: TURKEY

Type of subroutine:	Input
Description:	Subroutine to read in hydrostatic power-
	split transmission efficiency table.
STAR(I,J,K) -	transmission torque loss for specific
	driveshaft torque, driveshaft speed and
	transmission gear ratio

Input Torque		Inpu	it Speed	Transm	mission	Gear	Ratio
	ft-lbf		rpm				
I		J		K			
1	-200	1	0	1	.224		
2	-100	2	600	2	.293		
3	- 50	3	1200	3	.362		
4	- 25	4	1800	4	.431		
5	0	5	2400	5	.500		
6	25	6	3000	6	.569		
7	50	7	3600	7	.638		
8	100			8	.707		
9	200			9	.776		

Subroutine name: VAL

Type of subroutine: Interpolation Description: Function subroutine to evaluate by 2-dimensional linear interpolation the value of a point bounded by four points of known values.

Subroutine name: VEDYNH

Type of subroutine: System computation Description: This subroutine determines the vehicle acceleration based on the difference between the force driving the vehicle and the resistive forces. It also tests for conditions of tire spinning or skidding.

Input variables:

AVIO	- wind speed (mph)
TBOIGI	- gear index
TBOIGR	- transmission gear ratio
T9IlGR	- equivalent rear axle ratio
т9ос	- rear axle output torque (ft-lb)
VVIBBR	- brake setting
VVOS	- vehicle speed (mph)
Output varia	bles:
VVDF	- vehicle road load force at tire road interface (lb)
AOAA	- vehicle acceleration (mph/sec)
Other program	n variables:
AVIM	- air density (lb/ft ³)
AVIS	- wind speed (mph)
LOADEQ	- used in a logical manner to determine whether
	road load equation or D.S. torque table is used
R	- ratio of driveshaft speed to flywheel speed
SINAVO	 sine approximation for grade angle
TVICRL(16)	- road load torque at driveshaft
TVIJCT	- polar movement of inertia of torque converter
	turbine (lbm-ft ²)

VEDYNH Subroutine Page 2

TVIJRA	- polar moment of inertia of rear axle (lbm-ft ²)
TVIJTR	- " " transmission (lbm-ft ²)
TVIJTW	- " " rear wheels (lbm-ft ²)
TVIMJ	- total rotary inertia of drivetrain reflected
	to rear wheels.
VVDFBR	- total resistive force acting on vehicle including
	brakes
VVDFN	- net force available to accelerate the vehicle
VVDMI	- total inertial mass of vehicle
VVIAMX	- maximum acceleration based on maximum coefficient
	of tire friction (g's)
VVIAS	- maximum acceleration based on sliding coefficient
	of tire friction (g's)
VVIDRR	- tire radius
VVIFUM	- coefficient of static tire friction
VVIFUS	- coefficient of slipping tire friction
VVILFR	- frontal area (ft ²)
VVIM	- vehicle mass (lb)
VVIMAX	- maximum vehicle acceleration
VVIICD	- drag coefficient
VVIICF	- tire coulomb friction coefficient
VVIlRF	- coefficient of rolling friction
WHLSLP	- used in R.T. simulation to control tire slip
	noise generator.

APPENDIX E PROGRAM LISTING OF COMPUTER SIMULATION

		• • •	
	11	• • • • • • • • • • • • • • • • • • •	
	21	SUBROUTINE_SIMHBD	
	31	C+ DIGITAL MAINLINE FOR HYBRID CAR	
	- 41 -	C=+++ R+R+RA01KE 2/18/75	
	51	 MODIFIED ON 12 NOV 1976 	
	61	# MODIFIED & APRIL 1977 TO PUT RUN NUMBER ON OUTPUT TAPE	
	7:	•	
	81	COMMON RIE, TMAX, VACMAX, VVIMI, VVILER, VVI2BR, VVI2CD, VVIM, VVI1RF	COMMOND1
	9;	COMMON VVIMDR, VVIDRR, AVIB, AVIR, TBIIGR, AVIM, VVIFUM, VVUFUS	COMMOND2
	101	COMMON VVISHB, VVISH, VVIAS, VVIAS, VVIICE, TVIJCT, TVIJRA	COMMONO3
	11;	COMMON TVIJTWASCALEFADELMINAFUELWTATIDLEADT	COMMOND4
	121	COMMON NYEPA, RIEINY, HRPSEC, MAXLIN, EPS, NGEAK, IOUT, IPRNT, LOADEG	COMMONUS
	131	DIMENSION TRINV(11), IVEPA(3000)	COMMON 0
	141	DIMENSION VMIN(2), VMAX(2), VINT(2), NDIM(2)	COMMONO/
	151_	DIMENSION DACCON(15) ADCCON(15)	LOMMONUS
	165	DIMENSION TVICKL(16)	Commonus
	171	COMMON TEINY	COMMONIA
	18:	COMMON IVEPA, YMIN, YMAX, VINT, NUTH, UALCON, AULCON, TVICKL	COMMONITS
	191	COMMON TIME, NRUNJINDIC, NRECJNY DELJILLACKJILLAND, TSJBJOBH JING	COMMONIE
	201	COMMON STEREJESUDIAFACLAFADNAFFODJADCJADN	COMPONIS -
	<u> </u>	COMMON TOIC TOINT BUNG TOCH TOUR AVEN AVEN AVEN AVEN TVIN TVUNE VUNET DARRE	CAMMAN15
	221	COMMON INITING TO AN TO AN TO ANT OF AND A TO ANT AND A TO ANT	Common 16
	241 -	COMMON TOPERSTITUTE TO TELEVIE AND TO THE OLDERA VANAL & PASERDA VVAAD	CammaN17
	251	CAMMAN WASOLOSI TALOSIT. ISSUESSA ISALSSATALISFA	Common 18
	261		Common19
	271	DIMENSION FTIME (60) ESPEED (60) ATABAS (60) VAR (10) X(225) NVALT (15)	CammaN20
	28:-	OTMENSION VAL (2) ANITIZ) ANOTIZ) A TEOX (20, 20) A TEPETO (20) A TIMMAX (5)	COMMON21
	291	DIMENSION TIMLEN(5) TIMAVG(5)	Camman22
1.0	301	COMMON VAR, X, NVOLT, VAL, NLT, NGT, IPOX, ISPEED, TIMMAX, TIMLEN, TIMAYG	COMMON23
	311	EQUIVALENCE (FTIME(1) x (46)) (ESPEE0(1) x (106)) (ATOROS(1) x (166))	COMMON24
	32:	COMMON IQLD1, IQLD2, IQLD3, ISW1, ISW2, ISW3, IENGNO, IENGIN	COMMON25
	331	COMMON EINTRO, FINTRO, RIF, RFINR, DFOOT, GNU, FGNU, TROIDL, TOICO, R, DF	Common26
	341	DIMENSION COMM (26), ENGTRQ (20), ENGFUL (20), ENGVAC (20), ENGSTT (20)	COMMON27
	35î	DIMENSION ENGSTP (20) = EFFTAB (9,9,9) = RAEFTB (11,11)	Common28
	361	COMMON COMM, ENGTRO, ENGTUL, ENGVAC, ENGSTT, ENGSTP, EFFTAB	CommoN29
	371	DIMENSION A (10) JC(1D)	COMMON3Q
	381	COMMON ALC, FUIDL, VACIDL, NOPEEO, NVEL, NTIMES, 6POINC, VELINC, TIMINC	COMMON31-
	391	COMMON TFTORQ;RIEPIF;CYTTRQ;ISIM;TSNEW;BSNEW;TSICDN;T9ICDO	COMMON32
	4D1"	COMMON RPJRPPJFOBHPJTCVTLGJTCLULGJRPMINJRPMAXJTTJTCJT	Common39
	411	COMMON RASCALJENTORQJEDRAGJEGAINJEORAGJRAEFTBJRATKLGJDTF	COMMON34-
an an an angar	42:	OIMENSION GRATIO(1D)	COMMON35
	431	COMMON_GRATIO; RMIN; RMAX; ICLUCH; CVTSCC	COMMONIS
	441	DIMENSION GEREFF(1D)	COMMON
	451	COMMON /EFFGER/GEREFF	COMMON
	461	COMMON /rLYEFF/PERLOS	COMMON
-	471	DIMENSION CC(1D), AA(10)	Contract
	481	COMMON /SUMVAR/CC/AA	Common
	421	COMMON /OKLUSS/TCLES/TTHIN	Fowner
	201	COMMON /FUMPCU/ILPUMP	
	211	LUMMUNY ME GYEMPU (13) JCPMP (13) JKNJ CP MPGJKNENJ KWAP	
	821	SENSE SWITCH INFORMATION	
	991	A PERPERATED THEOREM	

			1. PRINTY AUTPUT	
	86.			
	251			
	201		J. WINDUP OPERATION	
	57;		66 AUTOMATIC RUNNING	
	581			
	591	Ceene	RUNINDICATOR	
	601		NRUN = O	
	441	- 1	CANTINUE	
			THITTAL TTE ALL CONCRANTS AND TADLES	
	061		INITIALLE ALL CONSTANTS AND TABLES	
	031		CALL INCOME	
	643	Ceees	INITIALIZE VARIABLES	
	65;		CALL' INVRHB	
	661		NRUN=NRUN+1	
-	671		WRITE(16) NRUN	
	481		INDICHO	
	- 201			
	071			
	791		PUELE. # 0.0	
	713		RN # 1+0	
	721		G0 T0 60	
	731			
	741	10	CONTINUE	
			TERSENCE CHITCH 11 (1.12	
	791			
	701		CALL PRINTY	
	771	12	CONTINUE	
	781	C===	UPDATE SYSTEM CLOCK	
·· ·	791		ICTBCK+ICTBCK+1	
	801		TIME=ICLOCK+DT	
	·	1	AUTOMATIC DRIVER	
	821		CALL FRAVEL	
	051			
	0.93		CALCHART ACTUAL DOINE CHART TARDUC	
	941	Ceeee	CALCULATE ACTUAL DRIVESHAFT TORGOE	
	853		CALL DSTORQ	
	86;		CALL CONTHB	
	871	Canad	HORSEPOWER	
	881		6BHP + FINTRO-PAGN/5252+0	
	891		PACC - SSTARG - FINTRG	
	901		PARER = 0.0	
	011		15/51NTPD1 20.50.30	
	211	20	The Initial Solution	
	921	30		
	93 <u>i</u>		CALCULATE FUEL CONSUMPTION	
	94;	+ EN	GFUL(I) STARTS AT PAGN - 800 RPM	
	95:		PA6FR«68HP&FSPEED(ENGFUL,N8PEED,SPDINC,PA0N+800+0)	
	961	50	CONTINUE	
	971		T98Ca(T91C-BATKI 6)+T911GR	
	0.0	Casas	VENTCLE DYNAMICS	
	- 201	Canad		
	331		CALL VEUINM	
	1001	C+++4	SUBROUTINE TO SHIFT GRANS	
	1011		CALL GREHFT	
	102:	Crees	TRANSMISSION EFFICIENCY	
	103:		CALL CVTGNU	
	104		CALL TREFEHITTRINATOICAIGEARATCLSSAGRATIO)	
-	TAR		INTEGRATION SUBREUTINE	
	1001	Certife		
	1091			

.

	* *		
		1091 CARAN TIRE GRAWTH SUBROUTINE	
		111: T96N = T9IN/T9I1GR	
	•	1121 CHART AKLE EFFICIENCY	· · · · · · · · ·
		113: CALL RAFFFH	
		1141 CHART JOINT PROBABILITY DISTRIBUTION	
		115: VAL (1)=SSTORQ	
		116: VAL (2) • PARN	
		1171 CALL PREDHE	
		1181 ICYCLE#ICYCLE#1	
1		1191 NTIMEP + ICLOCK-ICLOKO	
	1000 100	1201 C CHECK FOR END OF DRIVING CYCLE	
		1211 . ICYEND IS SET IN EPAVEL	
		1221 IF (ICYEND+1)55,90,90	
		123: C+-++ CHECK FOR BUTPUTS	
		1241 55 IF(NTIMER+16UT)10,85,85	· · · · · · · · · · · · · · · · · · ·
		1251 •	
		1261 • • INITIALIZATION SECTION •	
		1271 60 CONTINUE	
		1281 CALL ENGINI	
		1291 •	
		1301 REPEAT 75, WHILE DF & EPS	· · · · · · · · · · · · · · · · · · ·
		1311 CALL ENGWHL	
		1321 75 CONTINUE	
		133) •	
		1341 IF (SENSE SWITCH 3) 77,78	
		135; 77 CONTINUE	
	-	1361 • DF(0) IS INCBEASED FROM 900 TO 2200 RPM IN WINDUP	
	1	137: CALL WINDUP	
		138; PAON = 88HP = PAOFR = 0.0	
		1391 78 CONTINUE	
		1401 CALL ENGINI	
		1411 CALL: INGRHB	
		1421 •	
		143; • • END OF INITIALIZATION •	*
		1443 •	
		145; • • BUTPUT SECTION •	
	_	1471 BD CONTINUE	
		1481 CALL BTPINB	
		1491 CALL BIVENB	
		1501 ICLOKDEICLBCK	
	1	1221 - PUD OF DUIPUI SECTION -	
		1621	
		A DECTN TEDMINATIAN SEPTIAN A	
		1581 - 90 CONTINUE	

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 1601
 CALL JPBHYB

 1611
 CALL 0TVRH8

 1633
 END FILE 16

 1641
 • END TERMINATION SECTION •

 1651
 • END FILE 16

 1701
 REWIND 16

 1721
 RETURN

 1731
 END

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		•	
	11 4	ease AUTOHB ease	
	21	SUBREUTINE AUTOHB	,
	31 0	R.R.RADTKE 1/29/75	
	41 4	MODIFIED ON 14 OCT 1976	
	51 •		
	61	COMMON RIEJTMAX, VACMAX, VVIMI, VVILFR, VVI20R, VVIICD, VVIMI, VVIRF	LOMPIONUL
	71	COMMON VVIMOR, VVIDRR, AVIB, AVIR, ISIIGR, AVIP, VVIP UG, VVIP US	DMMENUS
	81	COMMON VVISH, VVIAMA, VVIAS, VVIICE, TVIJCT, TVIJTR, TVIJRA	
	31	COMMON TYIJTWASCALEFADELMINAFUELWIATIDLEAUT	JOMMONU4
	101	COMMON NYEPA, RIEINV, HRPSEC, MAXLIN, EPB, NGEAR, IOUT, IPKNI / LOADEG	
	11: _	DIMENSION TBINV(11), IVEPA(3000)	
	121	DIMENSION VMIN(2), VMAX(2), VINT(2), NDIM(2)	
	131	DIMENSION DACCON(15) ADCCON(15)	LOMMONUO
	148	DIMENSION TVICEL(16)	LOMMONUS
	15;	COMMON TEINV	COMMONIQ
	161	COMMON IVEPA, VMIN, VMAX, VINT, NDIM, DACCON, ADCCON, TVICRL	
	17;	COMMON TIME, NRUN, INDIC, NREC, NFUEL, ICLOCK, ICLOKD, TS, BS, OBHP, TORG	
	181	COMMON SSTORQ, ESDOT, PAOC, PAON, PPOB, TAOC, TAON	LOMMONI 3
	19;	COMMON T91C, T91N, T8DN, T90C, T90N	
	2DJ 🗌	COMMON TAIL, TAILGR, VVBS, VVBS, VVBD, AVIO, AVIS, TYIMJ, VVDF, VVDMI, PABER	COMMON15
	21:	COMMON FUELE, ITICYC, ICLOKI, ISHIFT, WHLSLP, WHLOLD	COMMONIS
	221	COMMON ICYEND, NLINE, ICYCLE, NGI, NGIOLD, VEPA, VANALG, PAOPRO, VVOAO	LOMMENT7
	231	COMMON VVOSO,DELTA,DELT,ISEQ,IGO,EDDOTO,IGEAR	COMMON18
	541 _	EQUIVALENCE (DIST, VVOD) (8\$, VVIBBR)	COMMON19
	251	DIMENSION FTIME (60) / ESPEED (60) / ATOROS (60) / VAR (10) / X(225) / NV0LT (15)	COMMONZO
	261	DIMENSION VAL(2),NLT(2),NGT(2),IPDX(20,2D),ISPEED(20),TIMMAX(5)	COMMONEL
1	271	DIMENSION TIMLEN(5)ATIMAVG(5)	COMMON22
	281	COMMON VAR, X, NVOLT, VAL, NLT, NGT, IPDX, ISPEED, TIMMAX, TIMLEN, TIMAVG	COMMENZS
	291	EQUIVALENCE (FTIME(1) (X(46)) (ESPEED(1) (X(106)) (ATOROG(1) (X(166)))	COMMON24
	301	COMMON IOLD1, IOLD2, IOLD3, ISW1, ISW2, ISW3, IENGNO, IENGIN	COMMONZO
	311	COMMON EINTRO, FINTRO, RIF, RFINR, DFDDT, GNU, FGNU, TROIDL, TYICD, R, DF	COMMON26
	32;	DIMENSION COMM(26) ENGTRO(20) ENGFUL(20) ENGVAC(20) ENGSTT(20)	COMMON27
	33;	DIMENSION ENGSTP(20), EFFTAB(9,9,9), RAEFTB(11,11)	COMMEN28
	341	COMMON COMM, ENGING, ENGPUL/ENGVAC, ENGSTT, ENGSTP, EFFTAB	COMMENCE
	35;	DIMENSION A(10),C(1D)	COMMONIQ
	361	COMMON AAC, FUIDL, VACIDL, NSPEED, NVEL, NTIMES, SPDINC, VELINC, TIMINC	COMMONS1
	371	COMMON TETORO, RIEPIF, CYTTRO, ISIM, TSNEW, BSNEW, TRICON, THICOO	COMMONJ2
	381 "	COMMON RP, RPP, FOBHP, TCVTLS, TCLULS, RPMIN, RPMAX, IT, TC, TF	COMMONSS
	391	COMMON RASCAL, ENTORO, FORAG, EGAIN, EDRAG, RAEF TB, RATKLS, DTF	
	401	DIMENSION GRATIO (10)	
	411	COMMON GRATIO, RMIN, RMAX, ICLUCH, CVTSCL	LOMMONJO
	421	COMMON /ACCELN/AEPA	COMMON.
	43;	COMMON/CVTTORQ/CVTMAX	
	442 4		
	45: 4	DETERMINE VEHICLE ACCELERATION REQUIRED TO REACH NEXT CYCLE VELOCITY.	
	461	AEPA - (YEPA+VVSS)/DELT	
	471 (•	
	481	VVDFD+VVDF	
	49;	IF (VEPA < 0.1 > VVOS) VVDFD + 0.0	
	501		
	511	GR=VVIDRR/T9I1GR	
	52;	TNUM=AEPA+VVDMI=1+4667+VVDFD	
	531	•	
	541	TEICDNATNUMAGRARATKLS	
	55;	IF(T9ICDN < CVTMAX) RETURN	•
	561	T9ICDN # CVTMAX	
	571		
	58:	RETURN	
	591	END	a sign and the state of monotonic

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1.107

11 23 31 45 51 61 71 81 91	CPUMP CONCURPENDENCE OF CONCURP CONCURP CONCURP CONCURP CONCURP CONCURP CONCURP CONCURPT CONC	······			
101 111 121 131 141 151 161 171 181 191 201	<pre>IF(SPEED *EG* 0*0) TL05 * 0*2*5166; RETURN I*(SPEED/500*)*1 IF(I * 1) I * 1 IF(I * 8] I * 8 IP*I*1 SM*500*(I*1) PL05 * HPL0SS(I) * 0*002*(SPEED*SM)*(HPL0SS(IP)*HPL0SS(I)) TL05 * 875*333*PL0S/SPEED RETURN END</pre>				
		· · · · · · · · · · · · · · · · · · ·			
		,			

E - 7

		* * '		
	11		**** CONTHB ****	
	21		SUBROUTINE CONTHO	
	- 31	C++++	SUBROUTINE TO CONTROL ENGINE AND PLYMAEL TORGUE	
		C****	K # # * KAUTKE 1/27/7D	
	21			
	01	+ 17	NGA 7310	
	- 11		COMMON DIE THAT WACHAY WUTHT WUTHED WITSBAWUTTED WUTH VUTTED	CAMMANO
	01		COMPON RAES INARSYACDASSYATDISYALD STATE COMPANYILLD SATING	CemmeNO2
			COMMON VIIMURATIURAJAVIDJAVISJOJAVIASJAVINAVILLUUTAVILUUTAVI	COMMONOS
	101			Common/04
			COMMON AVISTA DICTNO HODCE MANY DELATITA FOR NGEAR TAUT TODNY A RACE	CAMMANOR
	161		COMPONENT AND	Commen 4
	131		DIMENSION (DIMILI///CEALGOUD)	COMMANO?
	- 121		DIMENSION VALNESSYARA(2)SVINI(2/SADIA(2)	CAMMANOR
			DIMENSION DECONISSIAUCCONISSI	CAMMANOS
	101		PAMMAN TRINU	COMMONIO
	4.4		CRMNRN TVERA WMIN WAY WINT NDIM DACCAN ADCCAN. TVICP	CAMMAN11
	101		CRAMAN TIME NRUN INDIC NDEC NEUEL ICLACK ICLAKA TO ACARDA TABA	COMMON 12
	121		COMMON STADDISCOT DISC MAN, DES TISC TICK	- CAMMAN1 9
	201		COMMON SCIENCESUCIERALIERAUNIFECTION	CRMMAN14
	226		COMMON TAILSTAINTADNALSUVALSUVALSUVALSUVALSUVALSUVALSUVALSUV	PECAMMAN1A
	221			CAMMAN14
	241		COMMON TOLESI I I I I I I I I I I I I I I I I I I	- CAMMAN17
	571		COMMON VECCO.CE TA. DELT. 1850. 160.500810. ISEAD	CAMMANIA
	241			Cemmen19
	221		CONTACENCE (UISISYVOU/S(GSVV)IDDA), ATABAS/401, VID/101, V/225), NVALT/41	SICRMMEN20
	-561			CAMMAN21
	201		AIMENGIAN TIME ENERGY THAT A CALL AND A CALL	Common 22
-	221	• · · · · · · · · · · · · · · · · · · ·	CAMERSION TIMERAUST TIMERAUST	Commen23
	301		CONTUNE TARYANAGE / FIME/ALANLIANG/ALCOPEDA/11/2/1061/.//TABOS/11/2/44	Common24
	371	· · -	CONTACTIC (FINC(1))A(0) (COPECATI)A(CO)) (CANAGA)	CAMMAN25
	321		CAMMAN FINTON FINTON DI BEIND AFAAT AND FANDARD TOTOLATAICD PADE	Common 26
	331		TIMENSIAN CAMMIZAS ENGTOCIZAS ENGENICAS ENGLACIZAS ENGLAS	CAMMAN 27
	351		OIMENSIAN ENGSTD/201 FEFTR(9,9,9) BAFFTR(11,11)	Common 28
	361	• •• •••	CAMMAN CAMM.FNGTRO.FNGEIL /FNGVACAFNGSTT/FNGSTP.FFETAB	COMMON29
	371			CemmeN30
=	- 381		COMMON AAC, FUTOLAVACTOLANSPEEDANVELANTIMESASPOINCAVELINCATIMINC	CemmeN31
	391		CAMMAN TFTARDARIEDIFACVITEDAISIMATSNEWARSNEWATGICONATGICDB	Cemmen32
	-401		COMMON BP , ROP , FABHP , TOVTI & TO IL & RPHIN , RPHAX , TT , TC , TF	- CemmeN33
	411		COMMON RASCAL / ENTORO / FORAG / EGAIN / EDRAG / RAEFTB / RATKLS / DTF	COMMON34
	421		DIMENSIAN GRATIC(10)	COMMON35
	431		COMMON GRATICARMINARMAXATCIUCHACVISCI	COMMONIA
	441		COMMON /EPASH/VCRUS/OUM(B)	
	451		ann an tar Manu ranaaaAnnas	
	-461		TF (IENGIN-a)5,15,25	
	471	5	CONTINUE	
- ·	481		OFSTOPPENGSTP(1)	
	491		IF (VV85 +GT+ VCRUS+0+1) DESTOP + 2080+0	
	501	-	IF (OF=DFSTEP) 10, 30, 30	
	511	10	IENGIN#2	
	521		ISW1 = 01 ISW2 = +1	
	53:		FINTRO-FSPEED (ENGTRO, NSPEED, SPDINC, PAGN-800.D)	•

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* *	* *	* *	**** CVTGNU ****		
	- 51	•	SUBRAUTINE CVTGNU		
	3.	C	SUBROUTINE TO CALCULATE OVE EFECTENCY		
1	- 61	Taure.	B.B. BADTKE 1/28/75		
	- 21	4t	CAMMAN RIF. TMAX, VACMAX, VVIMI, VVII FR, VVI2BR, VVIICD, VVIM, VVIIRF	COMMOND1	
	Ă		CAMMEN VYIMDE, VYIDER, AVIB, AVIE, TELIGE, AVIM, VVIEUM, VVIEUS	COMMOND2	· · · · · · · · · · · · · · · · · · ·
			CAMMAN VYISUBAVYISUAVYIAMYAVYIASAVYIICEATVIJCATVIJIRATVIJRA	COMMOND3	
	63			CAMMANDA	
	01		CAMMAN NUCLA BIETNY HODSC MAY IN FRS NGFAR THUT TPRNTAL BADER	CAMMANDS	
	401		DIMENSIAN TRINUITING VERY (3000)	CAMMAN 6	
	141		DIMENSION UMINICAL UMAY (AL. VINT (AL. NDIM (AL	COMMOND7	
	131	···· ···	DIMENSION DACCONVIST ADCONVIST	COMMONDS:	
	121			CAMMAND9	
	1.51			CAMMAN10	
	121		COMMON TOTAL WITH WAY, VINTANDIM, DACCOM, ADCCOM, TUTCH	CAMMAN11	
	121		COMMAN TIRE NOTING THE TO THE STOLE STOLE AND THE STOLEN STOLEN.	CAMMANT 2	
	103		CAMMAN CSTADD. FCAT, DIAC, DIAN, DAR. TACK, TANN	CAMMAN13	
	111-		CAMMAN TOTA TOTAL TONA TOTAL TOTAL TOTAL TOTAL	CAMMAN14	
	101		COMMON STILLING UNDER VIEL AVIE AVIE, TUTA , VUEL VUEL BASED	CAMMAN15	
	171			COMMONIO	
	201		COMMON PUELEDITICULILURITONICIURIANCOLPANDUCU	CAMMAN17	
	411			CAMMENTS'	
	221		CONTRACTOR CONTRACTOR STATES AND A CONTRACTOR	COMMONIO COMMONIO	
	231		EWDIVALENCE (DIGIJVUD)/(03/V)IDDRJ DIMENTAN ETIMEIAN EGOBERIANA ATARASIANA VID/IDA V/2251 NVALT/18)	CAMMANED	
	571		DIMENSION FILMETOUJESFEEDTUJJATUMUGUDJATANIDIJATAEAJANUUTIA	CammaN21	
	221		DIMENSION VAL(C)INCI(C)INCI(C)IITDA(CUICUIIITEED(CUITIAAAA)	COMMON22	
	201		CAMENA VAR V. NY VAR V. VAL NY T. NGT. TORY, TOREED. TIMAY, TTMIEN. TIMAVG	CAMMAN23	
	201		CONTRACTOR TARYASINGLISTALSTLISTALSTLISTALSTALGENESINGASINGLASTALGENESING	CAMMAN24	
	201		CAMMAN TALENCE (FILMELIJA(TOTALESTEDUIJAATDOTALENCEN	CAMMAN25	
	271		CAMMEN CINTED SINTED DIE DEINE DENNE SUNAFICHENDIEUN TOICH P.DE	COMMON26	
	301		COMPONE LANERAGY INTRUSKIFYKFINGED (JOB) - SNGVICIDAL FNGET (20)	COMMON27	
- 1	211		DIMENSION COMMICS/JENGIAG(CO/JENGPOCICS/JENGPAG(CO/JENGOLI(CO/	COMMON28	A
	381		DIMENSION ENGSIF(ED)SEF IMD/3/3/3/3/RAEFID/4//////	CAMMAN29	
	331			CAMMANSO	
	341		CAMENAL ALCHUIGHT AND AND AND AND AND ANT MER. APPTING VET THE TIMENC	COMMON31	
	301		COMMON TEADO, DICOIE ALIQUINATEDINATEDINITEGIOFUTUCIALITATE	COMMON92	
	301		CAMMAN DD.000.FABUD.TOUTI 8.TOUH S.RDMIN.DDMAY.TT.40.TS	CAMMAN33	
	3/1		CANNAN DASCAL ENTROD. ENDAG. FGAIN. ENDAG. DAFFTR. DATH 6.DTP	CAMMAN34	
	301		CUMBUR RAGEALINIGRAJEURANJEURANJEURANJERAFIOJEKIELOJUP	COMMON35	
	321		CANNENT CRATTER DATE TO TAUT TO THE CONSCIENCE	CANNANSA	
	401			9911101190	
	74.8		COMMEN / DECOSTICESTINI		
	781				
	431				
	221		CONTONY CT ONW/CY IMAA		
	401	Conter	TNRUTTVARTADIES		
	401	6	TAFARAGEAD CAR IS INA ZERA IF NEUTRALA		
	7/1	C	ICHICH-CHUTCH INDICATAR D IF APEN. 1 IF CLASED AP SUPPING.		
	401	Coord	TGINARADIVE SAFT SPEN		
	501		TAIL DRIVESHAFT TRADIE		· · -·
	51+		RMIN MINIMUM SYSTEM RATIO		
	521	C	Research OF DRIVESHAFT SPEED TO FLYWHEEL SPEED		
	531	C	THE BUTPUTS ARE		

541	C====	CVTTROIORQUE AT DRIVESHAFT WHICH WILL BE TRANSMITTED TO) FLYWHEEL
551	C====	TCVTLS EQUIPMENT TORQUE LOSS IN CVT AT FLYWHEEL	
561	C+	TCLUES TORQUE LOSS IN CLUTCH AT FLYWHEEL	
871	10000	GNDCVT FFFICIENCY	
		CVTI Sama TROUIS LASS IN CVT	
20,		CALEBRACE EDGS TH CAL	· · · · · · · · · · · · · · · · · · ·
221			
601		IF (IGEAR) 603003	
611	3	CANTINUE	
621		IF(ICLUCH) 40,40,5	
631	5	IF (R+RMIN) 50, 50, 10	
641	10	CONTINUE	
651		CLUTCH CLASED, NAT SLIPPING	
0/1			
001		IF (LYTTRU + LVIMAX & 0.0) LVITHU # #EVTMAA	
691		Ge Te 20	
701			
711	50	CONTINUE	
721	C+++*	CLUTCH SLIPPING	
731		CVTTRDeTSIC	
		TO UL RE(PHIN-P) CUTTRO	
-423			····
10	EV		
_ 701		SFUINEISAN	
7/1		TC#CVTTRU#CVTSEL	
78;		CALL MONKEY (TC/SPDIN/RP/RRMIN/RPMAX/EFFTAG/CVTLS)	
79;		SPUMP=(T9IN/RP)+A1CVT	
801		CALL COPUMP (SPUMP, TLPUMP)	•
81		TLPUMP+TLPUMP+RPP+AICYT	
821		CVTL BECVTLS/CVTSCL	
		TOVI SECUTI SERP	the second of the second s
04.			
071		TENNEL BERKETCIED	and the second
901		ICHT - AGG(IZICHT)	
801		GNU#TEMP/(TEMP+CVILS)	
87		RETURN	
881			
891	60	CONTINUE	
901	Coner	GEAR BOX IN NEUTRAL	
91	·	CVTL BADAD	the second s
92	*0		
- 05		CHITCH NETTIGACED	
931		CUTTOR . ONL - SCULP - SCUTC - SUDUND - TEDIN - 0.0	
941		CALING + AND + LECORS + LEALPR + LENAWH + LENAW + 0.0	
951		KETURN	
961		END	
-			

··· · · · ·

11	*	**** DSTORQ ****	
21		SUBROUTINE DSTORD	
31	C====	SUBROUTINE TO CALCULATE OBIVESHAFT TORQUE AND NEXT THROTTLE AND B	RAKE
41	C====	R*R*RADTKE 1/28/75	
5;		COMMON RIE, TMAX, VACMAX, VVIMI, VVILER, VVI2BR, VVI1CD, VVIM, VVI1RF	COMMONO1
61		COMMON VYIMDR, VVIDRR, AVIB, AVIR, TOILGR, AVIM, VVIFUM, VVIFUS	COMMOND2
71		COMMON VYIEWB, VVISH, VVIAMX, VVIAS, VVIICE, TVIJCT, TVIJTR, TVIJRA	COMMOND3
81		COMMON TYIJTWASCALEFADELMINAFUELWTATIDLEADT	EOMMON04
91		COMMON NYEPA, RIEINV, HRPSEC, MAXLIN, EPS, NGEAR, IBUT, IPRNT, LBADEG	COMMONOS
101		CIMENSION TRINV(11), IVEPA(3000)	COMMON 6
		DIMENSION VMIN(2) VMAX(2) JVINI(2) NUIM(2)	COMMONU/
121		DIMENSION DALCON(15) ADCCON(15)	CammaNOG
131		DIMENSION TATCKLEIO)	Commonuo
1.57		COMMON TELNY	Cammani 1
		COMMON' TIME NEUNATION NOTE AND THAT TO COMPACE ON THE SECONDARY TO BE AND THE	CAMMAN12
171		CAMMAN STADA STADA C DARN OPRATARCATARN	Commonia
- 181		COMMON TOICATOINATADNATORCATOON	CommoN1+
191		COMMON T911, T911GR, VV65, VV6A, VV0D, AVIO, AVIS, TV1MJ, VV0F, VVDMI, PAOF	RCOMMON15
201		COMMON FUELE, ITICYC, ICLOKI, ISHIFT, WHLSLP, WHLOLD	COMMONIS
211		COMMON ICYEND, NLINE, ICYCLE, NGI, NGIOLD, VEPA) VANALG, PAOFRO, VVOAD	COMMON17
221		COMMON VVOSD, DELTA, DELT, ISEQ, IGO, ESOOTD, IGEAR	COMMONIS
231		EQUIVALENCE (DIST/VV00)/(85/VVI8BR)	COMMON19
241		DIMENSION FTIME(6D), ESPEED(6D), ATOBG6(60), VAR(10), X(225), NYQLT(15	COMMONZO
251		DIMENSION VAL(2)/NLT(2)/NGT(2)/IPDX(20/2D)/IEPEED(2D)/TIMMAX(6)	COMMON21
261		DIMENSION TIMLEN (5) ATIMAYG(5)	COMMONZZ
271		COMMON VAR, X, NVOLT, VAL, NLT, NGT, IPOX, ISPEED, TIMMAX, TIMLEN, TIMAYG	EDMMON23
591		EQUIVALENCE (FTIME(1), X(46)), (ESPEEU(1), X(106)), (ATORUS(1), X(106))	Commonice Commonice
591		COMMON IDLD1/IDLD2/IDLD3/ISWI/ISW3/ICNGND/IENGIN	COMMONED
301		COMMON LANTRUSTINTRUSTITS AT INKJUT DO IS GNUST GNUSTINU IS INCLUST STUDY SUP	COMMONES COMMON27
331	te-pe agenage	DIDENSION COMPLEGISENGIAGEC/SENGRALED/SENGRALED/SENGRITED/	CAMMAN28
321		CAMMAL CHOST (LOTECT INCLASSIONAL CONSTANT)	CAMMAN29
331		DIBENSIAN (10) -C(10)	Common30
351		COMMON AAC, FUIDLAVACIDLANSPEEDANVELANTIMESASPOINCAVELINCATIMINC	Common31
361	We can a section a	COMMON TETARGARIEPIFACVITEGAISIMATSNEWABENEWATSICONATPICOO	COMMON32
371		COMMON RP, RPP, FOBHP, TCVTLS, TCLULS, RPMIN, RPMAX, TT, TC, TF	COMMON33
381		COMMON RASCALJENTORD, FORAD, EGAIN, EORAG, RAEFTB, RATKLB, DTF	COMMON34
391		DIMENSION GRATIO(10)	COMMON35
401		COMMON GRATIO, RMIN, RMAX, ICLUCH, CVTSCL	COMMON36
411	4		
421	Cotot	SET ACTUAL ORIVESHAFT TORQUE	
431		TAICALAICDN	
221	•	LALLULAIE BRANE BETTING	
401		TELTOICON LEA DADIERE A STOICON/VVI280	
401		S. FLATARIA APPA AARI AB A BIATARIALIIIBBU	
	-	IF(IGEAR > D < ICLUCH) RETURN	· · · · · · · · · · · · · · · · · · ·
691	C++++	CAR IN NEUTRAL OR CLUTCH OPEN.	
501		IF(BS > D.2) RETURN	-
511	C	EXCESS BRAKING NOT REQUIRED. VEHICLE COASTS.	
521		CALL NUTRAL (T90N, 1.0) RP, TNUM)	
53;		T9IC . TNUM	
54	1	RETURN .	
5.9	1		

E-12

	AAAA ENGINI AAAA			
	SUBBOLITINE ENGINE		-	
	SUBRAUTINE USED FAR INITIALIZING ENGINE			
	RID RATKE 1/29/75			
	MADIFIED AN 14 ACT 1934			
1		· — · · ·-		
	CAMMAN RIF. THAY. VACHAY. VVINT. VVII FR. VVI288. VVII CO. VVIN. VVIIRE	CAMMANOS		
	CAMMAN WYMAD WYTAD AVTBAAVTD AVTDAAVTD AVTA VYTEIM WYTEIM	CAMMONO2		
3 ·	CAMMAN VVICUBAVVICUVVIANAVVVICAAVVICEAVVICEAVVICUSVVICUS	Campano2		
		COMMONOS		
	COMMON ISIGNIGACAES SUCCEMENT OCCUPITION CONTACT TO A CONTACT AND CONTACT	CONFIGNOS		
	DIMENSIAN RELAXISTING AND	COMMONUS		
		LOMMON D		
31				
	OTHENSION DALLON (ID) ADCCON(ID)	COMMONUO		
51	DIMENSION TAICHE (16)	COMMENUS		
21	COMMON TEINV	COMMONIO.		
	COMMON IVEPA, VMIN, VMAX, VINT, NDIM, DACCON, AUCCON, TVICKL	COMMONII		
53	COMMON TIME, NRUN, INDIC, NREC, NFUEL, ICLOCK, ICLOKO, TS, BS, OBHP, TORG	COMMON15.		
21	COMMON SSTORD, ESDOT, PADC, PADN, PPOB, TAOC, TAON	COMMON13		
D1	COMMON TAIC, TAIN, TOON, TAON, TAON	COMMON14		A DESCRIPTION OF A DESC
11	COMMON T911, T911GR, VVQS, VVOA, VVOD, AVIO, AVIS, TVIMJ, VVDF, VVDMI, PAOFR	COMMON15		
51	COMMON FUELE, ITICYC, ICLOKI, ISHIFT, WHLSLP, WHLOLD	COMMON16		
31	COMMON ICYEND, NLINE, ICYCLE, NGI, NGIBLD, VERA, VANALG, PABFRO, VVBAO	COMMON17		
44	COMMON VVOSQJDELTAJOELTJISEGJIGOJEBOBTOJIGEAR	COMMON18-		
51 .	EQUIVALENCE (DIST,VV00)/(BS,VVIBBR)	COMMON19		
51	OIMENSION FTIME(60), ESPEED(60), ATOBQS(60), VAR(10), X(225), NV0LT(15)	COMMON20		
71	DIMENSION VAL(2), NLT(2), NGT(2), IPDX(20, 20), ISPEED(20), TIMMAX(5)	Commen21		
81	DIMENSION TIMLEN (5) TIMAYE (5)	COMMON22-		
91	COMMON VAR, X, NVOLT, VAL, NLT, NGT, IPDX, ISPEEO, TIMMAX, TIMLEN, TIMAYG	COMMON23		
01	<pre>""EQUIVALENCE (PTIME(1),X(46)),(ESPEED(1),X(106)),(ATQRQS(1),X(166))</pre>	C8MM8N24		and a state of product means an even
11	COMMON 10L01, 10L02, 10L03, ISW1, ISW2, ISW3, IENGNO, IENGIN	COMMON25		
21	COMMON EINTRO, FINTRO, RIF, RFINR, DFDOT, GNU, FGNU, TROIDL, TSICD, R, DF	COMMON26		
31	DIMENSION COMM(26), ENGTRQ(20), ENGFUL(20), ENGVAC(20), ENG6TT(20)	COMMON27		
1	DIMENSION ENGSTP (20) / EFFTAB (9,9,9) / RAEFTB (\$1,11)	COMMON28-		
51	COMMON COMM, ENGTRO, ENGFUL, ENGVAC, ENGSTT, ENGSTP, EFFTAB	COMMON29		
51	OIMENSION A(10) AC(10)	COMMON30		· · · · · · · · · · · · · · · · · · ·
71	COMMON AAC, FUIDLAVACIDLANSPEEDANVELANTIMESASPDINCAVELINCATIMING	COMMON31		
81 · ·	COMMON TETORO, RIEPIF, CVTTRO, ISIM, TSNEW, BENEW, T9ICON, T9ICO	COMMON32		
9 1	CAMMAN RP. PPP. FABHP. TOVI S. TOLULS. RPMIN, RPMAX, TT. TC. TF	COMMON33		
	COMMON RASCAL AFNTORO FORAD EGAINAFORAD RAFFTBARATKI SADTF	COMMON34-		
	DIMENSIAN GRATIA(10)	CommoN35		
	CAMMAN GRATIA RMIN. RMAYATCI UCH. CVTSCI	CAMMAN36		
21	CANON CONTRACTANTALEECCIACTOC			
1	RRHDADASNATDOTOL (5252.			
7 E				
1				
1				
	FLOD & AWCIDP			
	15%1*0			
- 1	150271			
1	MAGC . SETCHQ . 0.0			
+1	RETURN			
51	END	*		

			4.41			
		71Î		**** ENGHHL ****		
		- 21	-	SUBROUTINE ENGWHL		
		31	C===?	SUBROUTINE TO INTEGRATE PLYWHEEL SPEED AND ENGINE SPEED		
		-41	C++++	R . R . RADTKE 2/19/75		
		51	-	COMMON RIE, TMAX, VACMAX, VVIMI, VVILER, VVI28R, VVIICD, VVIIRF	COMMONO1	
		61		COMMON VVIMDR, VVIDR, AVIB, AVIR, TSIIGR, AVIM, VVIFUM, VVIFUS	COMMOND2-	
		71		COMMON VYISWB, VVISH, VVIAMX, VVIAS, VVI1CE, TVIJCT, TVIJTR, TVIJRA	COMMOND3	
		~ 8i		COMMON TVIJTW, SCALEF, DELMIN, FUELWT, TIDLE, DT	COMMOND4	
		91		COMMON NVEPA, RIEINV, HRPSEC, MAXLIN, EPS, NGEAR, IOUT, IPRNT, LOADEQ	COMMOND5	
		101		DIMENSION TAINY (11) / IVEPA (3DDD)	COMMON 6	
		111		DIMENSION VMIN(2), VMAX(2), VINT(2), NDIM(2)	COMMOND7	
	to	181	that would be readed on the	DIMENSION DACCON(15) ADCCON(15)	COMMONDS -	
4		131		DIMENSION TVICKL(16)	COMMBN09	
		141		COMMON TEINY	COMMON10	
		151		COMMON IYEPA, VMIN, VMAX, VINT, NDIM, DACCON, ADCCON, TVICRL	Commen11	
		161		COMMON TIME, NRUN, INDIC, NREC, NFUEL, ICEBCK, ICLOKO, TS, BS, BBHP, TORG	COMMON12	
		171		COMMON SSTORG/ESDOT/PADC/RADN/PPOB/TAOC/TAON	COMMON13	
		181		C8MM6N T91C, T91N, T80N, T98C, T96N	COMMON14"	
		191		_COMMON_T9I1,T9I1GR,VV0S,VV0A,VV0D,AV30,AVIS,TYIMJ,VVDF,VVDMI/PAOFR	COMMON15	
		20;		COMMON FUELE, ITICYC, ICLOKS, ISHIFT, WHLSLP, WHLDLD	COMMON16	
		211		COMMON ICYENDINLINE, ICYCLE, NGI, NGIOLD, VERA, VANALG, PAOFRO, VVOAD	COMMON17	
		221		COMMON VVBSO,DELTA,DELT,ISEG,IGO,EBDOTD,IGEAR	COMMON18-	
		231		EQUIVALENCE (DIST/VVOD)/(85/VVIBBR)	COMMONIS	
	ter anter under Mandarder 4	241		"DIMENSION FTIME(6D), ESPEED(6D), ATORQS(6D), VAR(10), X(225), NVOLT(10)	COMMONED	I and the same the plant of the contract Product and the second second second second second second second second
		521		DIMENSION VAL(2), NLT(2), NGT(2), IPOX(20,20)) ISPEED(20), TIMMAX(5)	COMMOD21	
		261		DIMENSION TIMLEN(5), TIMAVG(5)	COMMONZZ	•
_		271		COMMON VAR, XANVELT, VALANLT, NGT, IPDX, ISPEED, TIMMAX, TIMLEN, TIMAVG	COMMON23	
		281		EQUIVALENCE (FTIME(1), X(46)), (ESPEED(1), X(106)), (ATOROSII), X(106))	COMMONIZE	
		591		COMMON IDLDI, IDLD2, IDLD3, ISW1, ISW2, ISW3, ILNGNO, ILNGIN	COMMONED	
		301		COMMON EINTRG, FINTRG, RIF, NFINR, DFDGT, GNU, FGNU, TRGIDL, TSICD, RDF	COMMONIZE	
ß		311	-	DIMENSION COMM(20) ENGTRG(20) ENGTUCA 20) ENGVAC(20) ENGSTI(20)	Commone/	and a summer of the state of the line of
		351		DIMENSION ENGLIP (20) EFTAB (37373) (ALT 1011)	Commonico	
		331		COMMON COMMIENDING, ENGPULIENGVALIENGSTIJENGSTPJEFFTAD	COMMONES	
		341		COMMENSION A (10) (10)	CAMMAN31	
		321		COMMON ALLY DIDLY ALLULYNSFELDIN Y SNEW, SSTEW, SST	CAMMAN32	
		301		COMMEN DE GOORTEFITIES (VILME SIDE DE SUCCESTICUMI) TEOR	Common33	·
		3/1		COMMON REFRETTORIEST CONFICULATION CONTINUE CONTINUE CONTRACTORIEST	CAMMON34	
		301		COMPONENT ADALLENINGRY PRASEDAINEDRACHAGE TORATECOTT	CAMMAN35	
		201		CAMMAN GRATA RMIN RMAY TOTUCH CVISC	COMMON36	
		411				
		491		CAMARY /SUMVAR/CEAAA	· · · ·	
		431		COMMON /FLYEFF/PERLOS		
		441		COMMON / GRUDSS/TCLSS/TTRIN		
		451		COMMON /PUMPCG/TLPUMP		
		461		COMMON /ENGW/FNDT, NDT		
		471		COMMON/HOTEL/THATEL		
		48:				
		491				
		501	+ 79	IN IS THE SHAFT VELOCITY AFTER THE CVT		
		511			•	
		521	1000	FORMAT(/19H++INPUT TO ENGWHL++,2X,5HTIME+,F.2)		
		531	1010) FORMAT(6X,4HISW1,6X,4HISW2,5X,6HFINTRQ,5X,6HTCVTLS,5X,6HTCLUL6,		

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1 6X, 5HTCL6S, 6X, 5HRF[NR, 7X, 4HSUM1, 7X, 4HSUM2, 5X, 6HCVTTRG) 1020 FORMAT(2(7X, 13), 8E11.3) 1030 FORMAT(5X, 6HENTORG, 5X, 6HTFTORG, 5X, 6HRGNTRG, 6X, 5HESDOT, 6X, 5HDFDOT, 17X, 4HPADN, 9X, 2HDF) 1040 FORMAT(7511.3) 1050 FORMAT(7) 541 551 -10 561 571 581 591 601 611 621 . A(1)*A(6)*A(8)*A(9)*A(10)*AA(1)*AA(2)*ÄA(6)*DFINT*0.0 EGIS * (*15#2)*EGAIN SUM1 * TCVTLS * TCLUES * TCLBS * TLPUMP * THOTEL SUM2 * FINTRQ * SUM1 621 631 641 651 661 671 681 PERI = PERLOS = 1.0 IFISENSE SWITCH 21 100,110 IFISENSE SWITCH 2/ 100/110 100 CONTINUE PRINT 1000/TIME PRINT 1020/ISW1/ISW2/FINTRG/TCVTLS/TCLULS/TCLSS/RFINR/SUM1/SUM2/ 1 CVTTRG PRINT 1030 69; 70; 71; 72; 73; 731 751 • 761 771 781 791 • 110 CONTINUE CO 50 I = 1,FNDT ENTORG = EGIS*(DF=PAON) TFTORG = SUM2 - R*CVTTRG = ENTORG*(=ISW1) 801 811 821 831 841 IF TFTORG & O, THEN . . TFTORG # +TFTORG/PER1 FLYGRL * +TFTORG*PERLOS . 851 . STHERWISE, FOR POSITIVE TFTORG 861 . IF (TFTORG .GE. 0.0) TFTORG . TFTORG.PER1.PER1. FLYGRL . FLYGRL .PERT 871 881 . OFDOTETFTORG+RFINE-DF+FDRAS 891 OF+DF+OFD0T+DTF R = T9IN/OF IF(IENGIN+2)20,30,20 901 911 921 931 94] 95] -----. 20 ESDOT=ENTORG+RIEINV+EORAG+PAON PAON#PAON+ESDOT+DTF IF(IENGIN .EQ. 4) PAON # 0.0 961 971 IF (PAON) 25,40,40 98 25 PABN=0+0 G8 T8 40 99 1001 101: 102: 103: 104: CONTINUE PAON=DF ESDOT=DFDOT 30 40 CONTINUE A(1)=A(1)+PADN 105: A(6)=A(6)-(TFTBRG=FINTRG)+DF 1061 A(8)=A(8)+ENTORQ+OF

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+	* * *	* *				
	1071		A(9)=A(9I+DF+DF			
	108;		A(10)=A(10)+DF+FLYGRL			
	1091		DFINT # DFINT + DF			
	1101		IP (SENSE SWITCH Z) 200,210			
	1111	200	CONTINUE			
	1121		WTRE WALLE TO FREM BUT BOOMEDUC BY INTERNAL			
	_1131	6 KU	NTRE VALUE IS FROM THE PREVIOUS DI INTERVAL			
	1141	•	PRANE LAND CHEADO HERADO BONEDO CODAT DEDAT DIAN DE			
	1151		PRINT LOROSENTORUS TP TORUS RUNTRUSE SUGTS DE DUTS PAONS DE			
	110	210				
	11/1	00	CONTINUE		And a state framework that some state is a state of	
4	1101	*	PONTOR - LONGVITOR A SUMALABERA			
·	- 1201		$\mathbf{T} = \{\mathbf{X} \in \mathbf{T} \mid \mathbf{T} \in \mathbf{V} \in \mathbf{T} : \mathbf{T} \in \mathbf{T} $	· · · · · · · · · · · · · · · · · · ·		
	1211		$\frac{1}{1}$			
Reasonable contraction and	- 1231		CANTAGE SWITCH &/ SOUNDLY			
	1221	300	DONIA 1050			
	1241					
	125.					
	1261		DEF. DEINT/ENDT			
	1271	* AD	D BACK INTA FINTRA THE ACCESSORY LOADS SEE SUBRAUTINE ACCESS.			
	1281		A(1) = A(1)=1.08=FINTRO/FNDT			
	1291					
	1301		A(3) a DFF+TCVTLG		· · ·	
	1311		A(4) # DFF+TCLULS			
· · · · · · · · · · · · · · · · · · ·	1321		A(6) # A(6)/FNDT			- 4
	1331		A(8) + A(8)+(+ISW1)/FNDT			
	1341		A(9) A(9) +FDRAGZ(RFINR+FNDT)	· · · · · · · · · · · · · · · · · · ·		
	1351		A(10) # A(10)/FNDT			
	1361		AA(1) 9 DFF+TCLSS			
• 1	1371		AA(2) # DFF#TLPUMP			
	1381		AA(6) = DFF+RGNTRG			
	1391		RETURN			
	1401		END			
				* · · · · · · · · · · · · · · · · · · ·		
- W H						
--	--	--	---------------------------------------	--	---------------------------------------	--
11						
- 21		SUBROUTINE FRACALC (RVFL + TUTIME)				
- 31						
1	A 97	NAV 1976				
- 21		CAMAN DIF. THAY . VACHAY . VVIMI . VVII EP. VVI2BP VVI CO VVIM VVI PF	COMMON	01		
		CONNON REFINANTACIONATIONATION AVIERATIECA VIICUS VIICUS VIICU	COMMON	V1		
- 21		COMMON VIIONAVIONAVIDAVINAVINAVINAVINAVINUVINDEVIND	COMMON	02		
. 71		COMMON VIISWOJVVISHJVVIAMAJVVIASJVVIICFJTVIJCTJTVIJINJTVIJNA	COMMON	03		
81		COMMON TVIJTWASCALEPADELMINAFUELWTATIDLEADT	TOMMON	04		
- 71		COMMON NYEPA; RIEINY; HRPSEC; MAXLIN; EPS; NGEAR; 18UT; 1PRNT; LBADEQ	COMMON	05		
101		OIMENSION TEINV(11)/IVEPA(30D0)	COMMON	6		
111		OIMENSION VMIN(2), VMAX(2), VINT(2), NDIM(2)	COMMON	07		
121		DIMENSION DACCON(15) JADCCON(15)	COMMON	08		
131		OIMENSION TVICEL(16)	COMMON	09		
141		COMMON TEINV	COMMON	10	at realized and a set	
151		COMMON IVERAAVMINAVHAXAVINTANDIMADACCONAAOCCONATVICEL	COMMON	11		
161		COMMON TIME NRUNA INDICANRECANFUELATCI SCKAICI SKOATSABSABBHRATORD	COMMON	12		
17.		CAMMAN STADA FSDAT BAAC BAAN DAAR TAAC TAAN	CAMMAN	13		
		COMMAN' TOTAL TOTAL TON TON TOAL TOAL	COMMON	1.4		
101		COMMAN TALETIC VUR TURE TOUR TOUR TURE AVER AVER TUTE TUVE TUVE VUNT BARE	BCSHMON	16		
			CAMMAN	14		
201		CONTROL TOUCHT LICENTIATED TO A MARCH AND THE TO A MARCH AND THE TOUCHT	COMMON	10	•	
_ 211		COMMON ILTENDANLINEALTELEANGIANGIALDAAVERAAVANALGARAATKOAVVOAV	Comman	-/		
221		COMMON VEDSOJUELTA, DELTA ISEGA IGOAESDOTDA IGEAR	LOWHON	18		
531		OIMENSION FTIME(60), ESPEED(6D), ATORGS(60), VAR(10), X(22B), NVOLTI15	ICOMMON	20		
241		OIMENSION VAL(2), NLT(2), NDT(2), IPDX(20, 20), ISPEED(20), TIMMAX(8)	COMMON	£1		
521		OIMENSION TIMLENIS) JTIMAVG(5)	LOMMON	22		
561	•	COMMON VAR,X,NVOLT,VAL,NLT,NGT,IPDX,ISPEEO,TIMMAX,TIMLEN,TIMAVG	COMMON	23		
27:		EQUIVALENCE (FTIME(1), X(46)), (ESPEED(1), X(106)), (ATOROG(1), X(166)) COMMON	24		
281		COMMON IDLD1, IDLD2, IDLD3, ISW1, ISW2, ISW3, IENGND, IENGIN	-COMMON	25		
291		COMMON EINTRO, FINTRO, RIF, RFINR, DFDOT, GNU, FGNU, TRGIDL, T9ICD, R, DF	COMMON	26		
301		OIMENSION COMM(26), ENGTRQ(20), ENGFUL (20), ENGVAC(20), ENGSTT(20)	Cammon	27		
311		OIMENSION ENGSTP (20) EFFTAB (9,9,9) RAEFTB (11,11)	COMMON	28		
321		COMMON COMMA FNGTRO A ENGELL A ENGVACA ENGSTA ENGSTPA EFETAB	COMMON	29	•	· · · · · · · · · · · · · · · · · · ·
33.		OTMENSION A(10)-C(10)	COMMON	30		
- 34		TORMANTA C FUIDL VACTOL NROFED NVEL NTTHERASDOINC VELINCATIMINC	COMMON	91		
341		COMMEN ALLER TOLETACIOLISOFILISETALICENTIALE DISTOLACITUS				
301		COMMON /EPASH/ VCNU3/ACEL/DECEL/TA/TC/TD/Dente/JATENST				
301	C	DEPHONE THE VELACIAN THE VEHICLE MUST DEACH IN AN ACC.				
3/1		RETURNS THE VELOCITY THE VEBILLE MUST REACH IN 191 SECT				
301		TNRUS FRAM DOCAL IN COMMAN TO WEDUE-COULSING COCCO				
		INPUT FROM RDEPA IN COMMON IS VCRUS+CRUISING SPEED				
391	C+++4	INPUT FROM RDEPA IN COMMON IS VCRUB.CRUISING SPEED ACEL-ACCELERATION			· ·· · ·	· ····································
39: 401	C++++	INPUT FROM RDEPA IN COMMON IS VCRUB.CRUISING SPEED ACEL-ACCELERATION DECEL-DECELERATION		······································	-	
39: 401 411	C++++ C++++ C++++	INPUT FROM RDEPA IN COMMON IS VCRUB+CRUISING SPEED ACEL+ACCELERATION OECEL-DECELERATION TA-TIME THE ACCELERATION CYCLE ENDS			-	
39: 401 411 481	C**** C**** C****	INPUT FROM RDEPA IN COMMON IS VCRUB.CRUISING SPEED ACEL-ACCELERATION OECEL-DECELERATION TA-TIME THE ACCELERATION CYCLE ENDS TC-TIME THE CRUISING CYCLE ENDS		······	· · · · · · · · ·	· · · · · ·
391 401 411 481 431	C++++ C++++ C++++ C++++	INPUT FROM RDEPA IN COMMON IS VCRUB.CRUISING SPEED ACEL-ACCELERATION OECEL-DECELERATION TA-TIME THE ACCELERATION CYCLE ENDS TC-TIME THE CRUISING CYCLE ENDS TD TIME THE DECELERATION CYCLE ENDS		··· ··· · · · · · · · · · · · · · · ·		
39: 401 411 421 431 441	C++++ C++++ C++++ C++++ C++++ 6	INPUT FROM RDEPA IN COMMON IS VCRUB.CRUISING SPEED ACEL-ACCELERATION OECEL-DECELERATION TA-TIME THE ACCELERATION CYCLE ENDS TC-TIME THE CRUISING CYCLE ENDS TD TIME THE DECELERATION CYCLE ENDS TD TIME THE DECELERATION CYCLE ENDS TIDLE-TIME AT BUS STOP			· · · · · · · · · · · · · · · · · · ·	
39: 401 411 481 481 481 481		INPUT FROM RDEPA IN COMMON IS VCRUB.CRUISING SPEED ACEL_ACCELERATION OECEL-DECELERATION TA-TIME THE ACCELERATION CYCLE ENDS TC.TIME THE ACCELERATION CYCLE ENDS TD TIME THE DECELERATION CYCLE ENDS TIOLE-TIME AT BUS STOP TE-TIME FOR ONE CYCLE .TD + TIDLE			· · · · · · · · · · · · · · · · · · ·	
39: 401 411 421 431 445 461		INPUT FROM RDEPA IN COMMON IS VCRUB.CRUISING SPEED ACEL-ACCELERATION OECEL-DECELERATION TA-TIME THE ACCELERATION CYCLE ENDS TC-TIME THE CRUISING CYCLE ENDS TD TIME THE DECELERATION CYCLE ENDS TIDTIME THE DECELERATION CYCLE ENDS TIOLE-TIME AT BUS STOP TE-TIME FOR ONE CYCLE .TD + TIDLE TUTIME . FTIME .TU FROM RDEPA			· · · · · · · · · · · · · · · · · · ·	
391 401 421 431 4451 4451		INPUT FROM RDEPA IN COMMON IS VCRUB-CRUISING SPEED ACEL-ACCELERATION OECEL-DECELERATION TA-TIME THE ACCELERATION CYCLE ENDS TC-TIME THE CRUISING CYCLE ENDS TD TIME THE DECELERATION CYCLE ENDS TD TIME THE DECELERATION CYCLE ENDS TIOLE-TIME AT BUS STOP TE-TIME FOR ONE CYCLE OTD + TIDLE TUTIME O PTIME - TU FROM RDEPA			· · · · · · · · · · · · · · · · · · ·	· · · ·
391 401 411 431 445 451 451 457 451 451		INPUT FROM RDEPA IN COMMON IS VCRUB.CRUISING SPEED ACEL=ACCELERATION OECEL=DECELERATION TA-TIME THE ACCELERATION CYCLE ENDS TC-TIME THE CRUISING CYCLE ENDS TD TIME THE CRUISING CYCLE ENDS TD TIME THE ACCELERATION CYCLE ENDS TD TIME THE ACCELERATION CYCLE ENDS TIOLE-TIME AT BUS STOP TE-TIME FOR ONE CYCLE #TD + TIDLE TUTIME # PTIME = TU FROM RDEPA CELERATION PHASE				· · · · ·
391 401 411 431 4431 4451 4561 457 457 457		INPUT FROM RDEPA IN COMMON IS VCRUB CRUISING SPEED ACEL=ACCELERATION OCCEL=DECELERATION TA=TIME THE ACCELERATION CYCLE ENDS TC=TIME THE CRUISING CYCLE ENDS TD TIME THE DECELERATION CYCLE ENDS TIOLE=TIME AT BUS STOP TE=TIME FOR ONE CYCLE OTD + TIDLE TUTIME FOR ONE CYCLE ONE CYCLE OTD + TIDLE TUTIME FOR ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE FOR ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE FOR ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE FOR ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE FOR ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE FOR ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE FOR ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE FOR ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE FOR ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE FOR ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE FOR ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE FOR ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE FOR ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE FOR ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE FOR ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE ONE CYCLE FOR ONE CYCLE O		······································	· · · · · · · · · · · · · · · · · · ·	· · · · · · · ·
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391 401 441 443 445 445 456 457 457 457 457 501		INPUT FROM RDEPA IN COMMON IS VCRUB.CRUISING SPEED ACEL=ACCELERATION OECEL=DECELERATION TA-TIME THE ACCELERATION CYCLE ENDS TC-TIME THE CRUISING CYCLE ENDS TD TIME THE DECELERATION CYCLE ENDS TD TIME THE DES STOP TE.TIME FOR ONE CYCLE #TD + TIDLE TUTIME # PTIME - TU FROM RDEPA CELERATION PHASE IF(TUTIME < TA) RVEL # RVEL + ACELINVEL # RVEL#ID.OJRETURN UISE PHASE IF(TUTIME < TC) RVEL # VCRUBINVEL # RVEL#10.DJRETURN		······································	· · · · · · · · · · · · · · · · · · ·	
39:1 411 421 443 445 445 457 551 551		INPUT FROM RDEPA IN COMMON IS VCRUB CRUISING SPEED ACEL=ACCELERATION OECEL=DECELERATION OECEL=DECELERATION TA TIME THE ACCELERATION CYCLE ENDS TC TIME THE CRECELERATION CYCLE ENDS TIOLE-TIME AT BUS STOP TE TIME FOR ONE CYCLE OTD + TIDLE TUTIME OFTIME AT BUS STOP TE TIME FOR ONE CYCLE OTD + TIDLE TUTIME OFTIME OT OF FOM RDEPA CELERATION PHASE IF (TUTIME < TA) RVEL O RVEL + ACELINVEL O RVELODOJRETURN UISE PHASE IF (TUTIME < TC) RVEL O VCRUGINVEL O RVELODOJRETURN CELERATION PHASE			· · · · · · · · · · · · · · · · · · ·	
39:14 411 421 442 44 44 44 44 44 44 44 44 44 55 52 52	C+++++ C+++++ C+++++ C+++++ C+++++ C+++++ C+++++ C+++++ C++++++	INPUT FROM RDEPA IN COMMON IS VCRUB CRUISING SPEED ACEL-ACCELERATION OECEL-DECELERATION OECEL-DECELERATION TA-TIME THE ACCELERATION CYCLE ENDS TC-TIME THE ACCELERATION CYCLE ENDS TD TIME THE DECELERATION CYCLE ENDS TD TIME THE DECELERATION CYCLE ENDS TIOLEFINE AT BUS STOP TE TIME FOR ONE CYCLE OTD + TIDLE TUTIME OFTIME AT BUS STOP TE TIME FOR ONE CYCLE OTD + TIDLE TUTIME OFTIME ATA) RVEL OTD + ACELINVEL ORVELOIDOJRETURN UISE PHASE IF(TUTIME (TC) RVEL ORVEL ORVELOIDOJRETURN S STOP PHASE IF(TUTIME (TC) RVEL ORVELONDIRETURN S STOP PHASE				· · · · · · · · · · · · · · · · · · ·
3911 442 444 444 444 444 44 44 44 45 55 55 55 55	C**** C*** C*** C*** C*** C*** C*** C*** C* C	INPUT FROM RDEPA IN COMMON IS VCRUB.CRUISING SPEED ACEL=ACCELERATION OECEL=DECELERATION OECEL=DECELERATION TA-TIME THE ACCELERATION CYCLE ENDS TC-TIME THE ACCELERATION CYCLE ENDS TD TIME THE ACCELERATION CYCLE ENDS TD TIME THE ACCELERATION CYCLE ENDS TD THE THE ACCELERATION CYCLE ENDS TOTATIME THE ACCELERATION CYCLE ENDS TOTATIME THE DUS STOP TEATINE FOR ONE CYCLE #TD + TIDLE TUTIME # PTIME • TU FROM RDEPA CELERATION PHASE IF(TUTIME < TA) RVEL # RVEL + ACELINVEL # RVEL#ID.OJRETURN UISE PHASE IF(TUTIME < TC) RVEL # VCRUBINVEL # RVEL#ID.DJRETURN S TOP PHASE IF(TUTIME .GE. TD) NVEL # RVEL # D.OJRETURN				
391 441 444 444 444 444 4467 490 11 490 11 55 55 5 5 5 5 5 5		INPUT FROM RDEPA IN COMMON IS VCRUB CRUISING SPEED ACEL-ACCELERATION OECEL-DECELERATION TATIME THE ACCELERATION CYCLE ENDS TC-TIME THE CRUISING CYCLE ENDS TD TIME THE DECELERATION CYCLE ENDS TD TIME THE DECELERATION CYCLE ENDS TIOLE-TIME AT BUS STOP TE-TIME FOR ONE CYCLE OTD + TIDLE TUTIME OF PIME OT UPROM RDEPA CELERATION PHASE IF(TUTIME < TC) RVEL = RVEL + ACELINVEL = RVEL=ID=0JRETURN UISE PHASE IF(TUTIME < TC) RVEL = VCRUSINVEL © RVEL=ID=0JRETURN S STOP PHASE IF(TUTIME GE TD) NVEL = RVEL > D=0JRETURN CELERATION PHASE	· · ·		· · · · · · · · · · · · · · · · · · ·	
391 4411 448 448 448 448 448 448 448 448 4		INPUT FROM RDEPA IN COMMON IS VCRUB CRUISING SPEED ACEL=ACCELERATION OECEL=DECELERATION OECEL=DECELERATION TA TIME THE ACCELERATION CYCLE ENDS TC TIME THE ACCELERATION CYCLE ENDS TD TIME THE DECELERATION CYCLE ENDS TIOLEFINE AT BUS STOP TE TIME FOR ONE CYCLE OTD + TIDLE TUTIME OFTIME AT BUS STOP TE TIME FOR ONE CYCLE OTD + TIDLE TUTIME OFTIME AT A RVEL OTD + TIDLE TUTIME OFTIME ATA RVEL OTD + ACELINVEL ORVELOIDOJRETURN UISE PHASE IF(TUTIME (TC) RVEL VCRUGINVEL ORVELOIDOJRETURN S STOP PHASE IF(TUTIME (GE TD) NVEL ORVEL OF OJRETURN CELERATION PHASE RYELFRVELOECEL			· · · · · · · · · · · · · · · · · · ·	· · · · · · · · · · · · · · · · · · ·
391 4411 448 448 448 448 448 448 448 448 4		INPUT FROM RDEPA IN COMMON IS VCRUB CRUISING SPEED ACEL=ACCELERATION OECEL=DECELERATION OECEL=DECELERATION TA TIME THE ACCELERATION CYCLE ENDS TC TIME THE ACCELERATION CYCLE ENDS TD TIME THE DUS STOP TE TIME THE AUS STOP TE TIME FOR ONE CYCLE OTD + TIDLE TUTIME OF PHASE IF(TUTIME < TA) RVEL ORVEL + ACELINVEL ORVELODIRETURN UISE PHASE IF(TUTIME < TC) RVEL VCRUBINVEL ORVELODIRETURN S STOP PHASE IF(TUTIME & GEO TD) NVEL ORVEL DOOJRETURN CELERATION PHASE IF(TVEL & GECEL IF(RVEL OFCEL IF(RVEL & GECEL) NVEL OF OOJRETURN	· · · · ·		· · · · · · · · · · · · · · · · · · ·	
391 401 421 445 445 445 457 455 555 555 555 555 555	C+++++++++++++++++++++++++++++++++++++	INPUT FROM RDEPA IN COMMON IS VCRUB CRUISING SPEED ACEL=ACCELERATION OECEL=DECELERATION OECEL=DECELERATION TA TIME THE ACCELERATION CYCLE ENDS TC TIME THE ACCELERATION CYCLE ENDS TD TIME THE DECELERATION CYCLE ENDS TD TIME THE DECELERATION CYCLE ENDS TIOLEFIIME AT BUS STOP TE TIME FOR ONE CYCLE OTD + TIDLE TUTIME OF PIME OTU FROM RDEPA CELERATION PHASE IF(TUTIME (TA) RVEL = RVEL + ACELINVEL = RVEL=ID=0JRETURN UISE PHASE IF(TUTIME (TC) RVEL = VCRUBINVEL © RVEL=ID=0JRETURN S STOP PHASE IF(TUTIME GE TD) NVEL = RVEL = D=0JRETURN CELERATION PHASE RVEL=RVEL=OECEL IF(RVEL = 000) NVEL = RVEL = 0.0JRETURN NVEL=RVEL=1000			· · · · · · · · · · · · · · · · · · ·	
3911 448 445 445 445 445 455 55 55 55 55 55 55 5	C ••••• C •••• C ••••• C •••• C ••• C •• C ••	INPUT FROM RDEPA IN COMMON IS VCRUB CRUISING SPEED ACEL=ACCELERATION OECEL=DECELERATION OECEL=DECELERATION TA TIME THE ACCELERATION CYCLE ENDS TC TIME THE ACCELERATION CYCLE ENDS TD TIME THE DECELERATION CYCLE ENDS TD TIME THE DECELERATION CYCLE ENDS TIOLEFINE AT BUS STOP TE TIME FOR ONE CYCLE OTD + TIDLE TUTIME OPTIME OTU FROM RDEPA CELERATION PHASE IF(TUTIME < TC) RVEL ORVEL + ACELINVEL ORVELOIDOJRETURN UISE PHASE IF(TUTIME < TC) RVEL VCRUGINVEL ORVELOIDOJRETURN S STOP PHASE IF(TUTIME < CC) NVEL ORVEL ODOJRETURN CELERATION PHASE RVELORVELOECEL IF(RVEL 000) NVEL OCOJRETURN NVELORVELOOC	· · · · · · · · · · · · · · · · · · ·		· · · · · · · · · · · · · · · · · · ·	

		• •	
	11	• **** EPAVEL ****	
	21	SUBROUTINE EPAVEL	
	31	• 16 NOV 1976	
	21	COMMON DIE MAY, VACHAY, VVIMI, VVII EP, VVIDER, VVIICO, VVIM, VVIIPE	COMMONOS
	21	COMMON REFINANTALINATION TO STATE OF TIME VIEWS VIEWS	COMMONO2
			COMMONOS
	· 41	CAMBON TVI ITWISCAL FEADEL MINAFUEL WTATIOL FADT	CRMMONO&
	91	COMMON NYEDAARIEINYA HEPSECAMAXLINA EPSANGEARA IOUTA IPRNTALBADEG	Cemmeno5
	101-	DIMENSIAN TAINY (11) ATVEPA (3000)	COMMON 6
	111	DIMENSION VMIN(2) VMAX(2) VINT(2) NDIM(2)	COMMON07
	121-	DIMENSION DACCON(15) ADCCON(15)	COMMONOS
-	131	DIMENSION TVICEL (16)	COMMONOS
	141	COMMON TOINY	COMMONIQ
1	151	COMMON IVERAJVMINJVHAXJVINTJNDIMJDACCONJADCCONJTVICRL	Commonii
	161	COMMON TIME, NRUN, INDIC, NREC; NFUEL; ICLBCK, ICLBKO; TS, 85, 88HP, TORG	COMMONIE
	171	COMMON SSTORQJESDOTJPAOCJPAONJPPOBJTAOCJTAON	COMMON13
1	181	COMMON T9IC, T9IN, T8DN, T90C, T90N	COMMON14
	191_	COMMON T911, T911GR, VY05, VV0A, VY0D, AVIG, AVIS, TVIMJ, VVDF, VVDMI, PAD	FREDMMON15
í	105	COMMON FUELES ITICYCS ICLORISISHIFTS HHLLLPS WHLDLD	
	211_	COMMON ICYENDINLINE, ICYCLE, NGIJNGIDLD, VEPA, VANALG, PAOP ROJ VVDAO	
-	221	COMMON VYDSOJDELTAJDELTA JELTA ISEWA I GOJE SUDIOJA UČAR	COMBNIO .
	231		CAMMAN21
	29) 35.	DIMENSION VALCEJING (CINGIS)	CAMMAN22
	201	CAMAN VERY VINCE T. VIL . NI T. NOT. TODY, TOFFD, TTMAY, TTMI FN. TTMAYR	CAMMAN23
	271	FOUTVALENCE (FITHE(1), Y(AS)), (FSPEED(1), X(106)), (ATARAB(1), X(166))	1)CommoN24
	281	COMMON TOLDY, TOLDY, TOLDY, ISWA, ISWA, IENGNO, TENGIN	Common25
	291	COMMON FINTRO FINTRO RIFARFINR, OF DOTA GNUA FGNUA TRGIDLA TOICDAR OF	CBMMBN26
	301	DIMENSION COMM(26) / ENGTED (20) / ENGFUL (20) / ENGVAC(20) / ENGOTT (20)	C6MM6N27
	311	DIMENSION ENGSTP(20), EFFTAB(9,9,9), RAEFTB(11,11)	COMMON28
	321	COMMON COMM, ENGING, ENGFUL, ENGVAC, ENGSTT, ENGSTP, EFFTAB	Common29
:	331	DIMENSION A(10) (10)	COMMON30
	341	COMMON ALC, FUIDL, VACIOL, NSPEED, NVEL, NTIMES, SPDINC, VELINC, TIMINC	COMMONS1
:	351	COMMON TETORO, RIEPIF, CVTTRO, ISIM, TSNEW, BSNEW, TSICON, T9ICOO	COMMON32
	361	COMMON RP, RPP, FOBHP, TCVILS, TCLULS, RPMIN, RPMAX, II, TC, TP	COMMON33
	371	COMMON RASCALJENTOROJFORAGJEGAINJEDRAGJRAEFTBJRATKLGJOTF	COMMON34
	381		
	371	ITIME	
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	451	IF(II - NVFPA) 16,16,4	
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	471	IIENVEPA	
	481	ICYEND=1	
	491	10 CONTINUE	
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	511	KREM=II=Z=KPLACE	
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	331	IFIRREM (EQ. 0) VEPA & U.10IDATACIRCIURN	
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	301	ANTI INTEL A ITEMPI + IDATA2+4096	
	58+	VEPA +(ITEMP1 + IDATA8+4096)+0+1	
-	591	RETURN	5 State 1949 - 174
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	11		AAAA GRSHFT AAAA					
-	21		SUBROUTINE" GRSHFT					
	11	C	SUBBRUTINE TO SHIFT GEARS					
		Casalla			 			
	21.		NARTESCA ALLA ACTION					
	51		HODIFIED ON TA OCI TASE					
	61			~			•	
	71		COMMON RIE, TMAX, VACMAX, VVIMI, VVILFR, VVI2BR, VVIICD, VVIM, VVIIRF	COMMOND1				
••	81	-	COMMON VYIMDRAVVIDRRAVIBAAVIRATBIIGRAAVIMAVVIEUMAVVUEUS	COMMONO2	 			
			CAMMAN VVISUB.VVISU.VVIAMY.VVIAS.VVIICE.TVI ICT.TVI ITD.TVI IDA	CRMMENO3				
	21			COMMONOS -	 			
1	UI.		COMMON TRIJIWASCALE ADELMINA FUELWIA TIDLEADI	LOMMONUA				
_ 1	11		COMMON NVEPA/RIEINV/HRPSEC/MAXLIN/EPS/NGEAR/IOUT/IPRNT/LOADEG	COMMONDS				
- 1	21		DIMENSION TRINV(11), IVEPA(30DD)	COMMON ⁻ 6	 			
1	31		DIMENSION VMIN(2) VMAX(2) VINT(2) NOIM(2)	COMMON07				
ī	41		DIMENSION DACCON(15) ADCCON(15)	CRMMRN08	 			
- 2	21			COMMONOO				
	21		DIMENSION IVICALIDI	COMPONDS				
1	01		COMMON TELNY	COMMENIA				
1	71		COMMON · IVEPA/VMIN/VMAX/VINT/NDIM/DACCON/ADCCON/TVICRL	COMMONII				
1	81		COMMON TIME, NRUN, INDIC, NREC, NFUEL, ICLOCK, ICLOKD, TS, BS, OBHP, TORO	COMMON12	 			
Ť	91		COMMON SSTARDAESDOTAPACCARAONAPPOBATAOCATAON	COMMON13				
·	21		CAMMAN TOTAL TOTAL TOTAL TOTAL TOTAL TOTAL	COMMONIA -	 			
5	41		COMPONE TALE TATAON WAS AND	COMMONIE				
C	11		COMMON 1911,1911GR, 4405,440A,4400,A410,A413,14,MJ,440F,440HIJPA0FE	COMMONIO				
5	21		COMMON FUELE, ITICYC, ICLOKS, ISHIFT, WHLSLP, WHLSLD	COMMONIO"				
2	31		COMMON ICYEND, NLINE, ICYCLE, NGI, NGIOLD, YEPA, YANALG, PAOFRO, VVOAO	COMMON17				
- ž	41		COMMON VVOSOADELTAADELTAISEGAIGOAESDOTOAIGEAR	COMMON18	 			
5	É.		FOUTVALENCE (DICT.VVOD) (RS.VVI880)	COMMON19				
	21		EDUITACIAN CTIDISTUDISTUDIATA ARADOCIANTANA VIDIAN VIDEN VIDEN VIDEN	COMMON20	 			
¢	<u>91</u>		DIMENSION FILME (OD) JESPEED (OD) JAIOKUS (OD) JVAR (ID) JX(EED JJNVOLI (10)	Commonicu				
2	71		DIMENSION VAL(2)/NLT(2)/NGT(2)/IPDX(2D/2D)/ISPEED(20)/TIMMAX(5)	COMMODZI		•		
2	81		DIMENSION TIMLEN(5) TIMAVQ(5)	COMMON22-				
2	91		COMMON VARAXANVALTAVALANI TANGTA IPDXA ISPEEDATIMMAXATIMLENATIMAVG	COMMON23				
. 5			FOULVALENCE (FILME (1), Y/46)), (FREED(1), Y(106)), (ATREDE(1), Y(166))	CRMMAN24	 			
			COMPARING TO A TO BE TO BE TO A TOWN TOWN TO A TOWN TO A TOWN	COMMON25				
. 3	11		COMMON TOEDISTOEDESTOEDESTENSSTENDSTENDINGSTENDING	COMMONICO	 			
3	21		COMMON EINTRO, FINTRO, RIF, RFINR, DFDOT, GNU, FUNU, TROIDL, TOICD, RADF	COMMENZO				
3	31		DIMENSION COMM(26), ENGTRQ(20), ENGFUL(20), ENGVAC(20), ENGSTT(20)	COMMONZ7				
3	41		DIMENSION ENGSTP(20) EFFTAB(9,9,9) RAEFTB(11,11)	COMMON28-	 			
3	51		CAMMAN COMM. ENGTRO. ENGELU . ENGVAC. ENGETTAENGSTP. FEFTAB	COMMON29				
	21			COMMONSO .	 			
-	21		CAMPAN IS FULL AND A CONTRACT NOTED AND ANTHES CONTRACT INC. THINK	Cannan34				
3	11		COMMON AJC, FUIDLAVACIDLANSPEEDANVELANTIMESASPDINCAVELINCATIMINC	COMMONSI				
3	81		COMMON TFTORGARIEPIFACYTERGAISIMATSNEWABSNEWATRICDNATSICDO	COMMON32				
3	91		COMMON RP/RPP/FOBHP/TCVTLS/TCLULS/RPMIN/RPMAX/TT/TC/TF	COMMON33				
A	01		COMMON RASCAL, ENTORO, FORAG, EGAIN, EDRAG, RAEFTB, RATKLG, DTF	COMMON34-	 			
	11		DIMENSION CRATICIAN	CAMMAN35				
	1			CAMMANSA	 			
	CI.		COMMON GRAIIOJRMINJRMAXJICLUCHJCAISCE	CONHOMOO				
4	31		COMMON /SWIFT/ RMINAS(1D)/RMAXAS(10)					
4	41		COMMON "/GRINIT/INEXT		 	_		
	51		COMMON JACCELNJAEPA					
	60		COMMON TOST AV TROTME TROTH		 			
1	1	-	COUNCY ACCENTATION IN TRANS					
- 4	11							
4	81	C	THE INPUTS TO THIS SUBROUTINE ARE					
4	91	Coper	R-+RATIO OF DRIVESHAFT SPEED TO FLYWHEEL SPEED					
	Di	C	IGEAR+CURRENT GEAR. ZERO IF NEUTRAL.		 			
ē		Conne	PDMINMINITALIM ALL BWARLE CVT PATIA					
	1.		REPART TANANA ALGORADE OTI RELA		 			-
5	12	64444	KMMAX+**MAXIMUM ALLOWABLE EVI KALIO					
5	31	C	RMIN-+++HINIMUM ALLOWABLE TRANSMISSION SYSTEM RATIO					

	9 (P) 19 (L +		PHAY
	271	0	THE ANTING ADE
	001	0	THE SUIFNIS AND TRANSMISSION GEAR
	201		TOPARATALINE INT DATA
	3/1		DOD
	291		RERESSINE NEW IRANDHIDDION RAILO
	221	•	18 (105) D. 40 40 00
	601		IP (IGEAR) 103103CU
	611	C	GEAR BOX IN NEUTRAL
	150		
	631	5	STIME#0#
	641	10	STIME#STIME+DT
	651		IF (STIME +LE+ TBOTMS) RETURN
	661		
	671		IGEAR # INEXT
	68;		IF(IGEAR +GT+ NGEAR) IGEAR + INEXT + NGEAR
	69;		ICLUCH+1
	701	20	IF (R+RMIN) 55,55,25
	711	25 1	IF (R=RMAX) 30,30,60
	721	30	CONTINUE
	731	C	CALCULATE BATID LIMITS IN CURRENT GEAR
	741		TRMIN=RMINAS(IGEAR)
	751		TRMAX=RMAXAS(IGEAR)
	761		IF (R+TRMIN) 35,35,40
	771	35 1	CONTINUE
	781		DOWNSHIFT
	791		INEXT+IGEAR+1
	801		ICLUCH . IGEAR . O
	-81 i		G6 T6 5
	821		
	831	40 7	CONTINUE
	RAT		IF (R-TRHAY) 50,50,45
	851		UPSHIFT
	844	AR	INFYTETGFARES
	- 47.		TOUCH - TAFAR - O
	0/1		GA TA S
	40.		
	071		CANTINUE
	01.		CALFULATE TOANENISCIAN GEAD DATIR
	241		PBD=CDITIS/CCIDI
	- 221	Ernan	NEFTURAL OLI GENT
	23)	C	PPAD/000
	741	-	
	321		REIVEN
	301		CANTER
	971	00	LONTINUE
	761	Casaa	- TO PESS IMAN UINIDAU KAIIO
1	22		
	100		REFERENCE ()
	1011		REFRENIN REFRENIN
	1021		IF LATAI 36/30/37
	103	C	ALLELERATION NOT REQUIRED: OPEN LEUTCH)
	104	90	
	105		IFITYILUN > 0+0) THICDN # 0+0
	1061		KETUKN

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'n

1071	•
1081	59 CONTINUE
1091	C++++ACCELERATION REQUIRED. SLIP CLUTCH.
1101	ICLUCH # 1
1111	RETURN
1121	
1121	40 CONTINUE
	OD CONTENDE
1141	CONNOR GREATER THAN MAXIMUM RATIO (SHOULD BE IMPOSSIBLE)
1151	IGEAR®NGEAR
-1161	RPP+GRATID (NGEAR)
1171	RP = RPMAY
118:	RETURN
1.0.	END
1721	

.

11	• •	FINERAL ROOFFOLGERY
<u><u> </u></u>	C	FUNCTION FEFELV(ARRATINIVALIN(JVAL)
		SUBROUTINE TO PROVIDE INTERPOLATION FOR ENGINE PARAMETERS
41	C	RERERADTRE 1/29/75
51		DIMENSION ARRAY(1)
61		I +VAL/VALINC
71		REMAVALAVALINCAI
81	_	101+1
31	•	
101		IF(I • GE• N) FSPEED • ARRAY(N)] RETURN
111	٠	
121 131 141		FSPEED=ARRAY(I)+REM+(ARRAY(I+1)+ARRAY(I))/VALINC RETURN END

			* *		
		11		**** MYBL55 ****	
_		21		SUBRBUTINE HYBLSS	
		31	C+	SUBROUTINE TO CALCULATE HYBRID ENERGY LOSSES	
2-111-00		- <u>6 -</u> -		THIS VERSION OF HYBESS IS ONLYFOR THE DIGITAL SIMULATION	
		R.	C	RABADAKE 1/30/75	
				ATTACKET AT BOTTO	
		21	•	COMMON OTE BALV, ULAMAN, UUTAT, UUTEED, VUTED, VUTED, VUTAD, VUTADE	CANNANOI
		11		COMMON KIESIMAASYALMAASYATMISYATTERFATTERFATTERF	Commonios
		81		COMMON VAIMORAVVIDARAAVIBAAVIRAIBIIGRAAVIMAAVIPUDAAVIPUD	
		9£.,		COMMON VYISWBAVVISHAVVIAMBAVVIASAVVIICEATVIJCTATVIJKA	COMMONUS
	1	.01		COMMON TYIJYW, SCALEF, DELMIN, FUELWT, TIDLE, DT	COMMONO4
	1	11		COMMON NYEPA/RIEINY/HRPSEC/MAXLIN/EPG/NGEAR/IOUT/IPRNT/LOADEQ	COMMONOS
	······	21		DIMENSION TBINV(11), IVEPA(3000)	COMMON 6
		31		DIMENSION VMIN(2) VMAX(2) VINT(2) NDIM(2)	COMMON07
		4.1		DIMENSION DACCON(15) ADCCON(15)	CammaNDa
		R .			CAMMAN09
					CRAMENIO
	1	DI		COMMON TEINY	COMMONIA
	1	71		COMMON IVEPA, VMIN, VMAX, VINTANDIMA DACCONANUCCON, TVICKL	
	- 1	,81		COMMON TIME, NRUN, INDIC, NREC, NFUEL, ICLDEK, ICLDKO, TS, BS, DBHP, TORG	LOMMONIC
	1	91		COMMON SSTORG/ESDOT/PAOC/RADN/PPOB/TADC/TADN	COMMON13
	2	201		COMMON T91C, T91N, T8DN, T90C, T90N	COMMON14
		11		COMMON T911, T911GR, VVOS, VVOA, VVOD, AVID, AVIS, TYIMJ, VVDF, VVDMI, PABFR	COMMON15
		21-		COMMON FUELEA ITICYCATCLOKIAISHIFTAWHLSLPAWHLOLD	COMMON16
	-	21		COMMON TOYENDANI INFATOYOLEANGTANGTOLDAVEPAAVANALGAPAOFROAVVOAD	COMMON17
				TRAMAN VVASDADELTA DELTA ISEA IGA ESDATDA IGEAR	COMMON18
		8.		FOUTVALENCE (DIST-VVAD) (AS+VVIABP)	CAMMAN19
	9			DIVENCENCE (DISTUTION CONTONICAL ATABASIAN, VAPIAN, VI225), NUALTIES	CAMMAN20
		O.		DIMENSION FILLEGUI/COFED/COTATONOCOTATIONALIS	CammaN21
		· · · ·		DIMENSION VALIGIANEI (CIANGIALIAIDALEDALEDALEDALEDALEDALEDALEDALEDALEDALE	Common/22
				CAMENDIAN TINGTATI THE AGE TONY TONE TONY TONES, THE FALTHAVA	CAMMAN22
	4	2	· · · · · · · · · · · · · · · · · · ·	COMMON VARAXANVOLIAVALANLIANGIAIPECOAIAPECOAIAMAAAAIAMENAAAAA	Commoni24
		0			COMMONICE
		11		COMMON TOLDI / TOLDI / TOLDI / TONI / TOMON / TOLDI /	COMMENTS
		121		COMMON E ENTRUS FINIRUS RIFS RFINRS OF DO 13 GNUS FONDS I RUIDES I SI CUSRIDE	Commonizo
	2	33		DIMENSION COMM(26), ENGRA(2D), ENGRUL (20), ENGVAC (20), ENGST (20)	COMMONE
		941."		DIMENSION ENGSTP (20) / EFFTAB (3, 7, 7) / RAEFTB (11, 11)	COMMENZE
		95:		COMMON COMMJENGTRQJENGFULJENGVACJENGSTTJENGSTPJEFFTAB	COMMON29
		36;		DIMENSION A(10) / C(10)	COMMON30
		371		COMMON AIC, FUIDL, VACIDL, NOPEED, NVEL, NTIMES, SPDINC, VELINC, TIMINC.	COMMON31
	2	381		COMMON TFTORGARIEPIFACVTTRGAISIMATSNEWABSNEWAT9ICDNAT9ICD0	COMMON32
		191		COMMON RP, RPP/FOBHP/TCVTLS, TCLULS, RPMIN, RPMAX, TT, TC, TF	COMMON33
		01-		COMMON RASCAL / ENTORO / FORAG / EGAIN / EDRAG , RAEFTB / RATKLS / DTF	COMMON34
		11		DIMENSION GRATIC(10)	COMMON35
	1	21		CAMMAN GRATTA BATA BATA TO UCH CVISCI	COMMON36
		7 % 8 6 18 4			
					CAMMAN
					00111011
		101			
		101		COMMON /ER/VVDFN	
	'	471			
		481		DATA CONST/0.00533333/	
		49 t			
	1	5D (. DEL	TA # DT/2	
	1	511		DELCON = DELTA/2626.0	
-		52:	4 CON	NST = 22/15/275	
		53:		RACON # VVB8+CONST	

A(1) + A(1) + DELCON	
A(2)=VYDF+RACON+DELTA	
A(3) #A(3) #DELCON	
A(4)=A(4)+DELC6N	
A(5) + +T9IN+DELCON+(T9IC+CVTTRQ)	
IF(T91C > D+D) A(5) = 0+0	
A(6)=A(6)+DELCON	
A(7) +RATKLS+T9IN4DELCON	
A(8) = A(8) = DELCEN	
A(9)=A(9)=DELCON	
A(10)=A(10)=DELCON	
AA(1) #AA(1) #DELCON	
AA(2)=AA(2) +DELCON	
IF(AEPA > Q.D1)	
1 AA(7) # VYDFN#RACON#DELTAJ	
2 AA(3) # VYDF #RACON#DELTA	
IF (VV05 \$ VCRUS=0+02)	and a complete state of the sta
1 AA(4) . VYDF .RACONODELTA	
IF (AEPA & OODI)	
1 AA(5) = VVDF &RACON&DELTA	
AA(6) #AA(6) #DELCON	
D0 20 1+1,10	
$C(I)_F C(I)_E A(I)$	
CC(1)=CC(1)+AA(1)	
D CONTINUE	
RETURN	
END	ie -
	A(1) *A(1) *DELCON A(2) *VYDF*&ACON*DELTA A(3) *A(3) *DELCON A(4) *A(4) *DELCON A(4) *A(4) *DELCON A(5) * =T91N*DELCON (T91C*CVTTRQ) IF(T91C * D*D) A(5) * 0*0 A(6) *A(6) *DELCON A(5) * =T91N*DELCON A(6) *A(6) *DELCON A(6) *A(6) *DELCON A(10) *A(10) *DELCON A(10) *A(10) *DELCON A(10) *A(10) *DELCON A(10) *A(10) *DELCON A(10) *A(10) *DELCON A(2) *A(2) *DELCON A(2) *A(2) *DELCON A(2) *A(2) *DELCON A(2) *A(3) * VYDF *RACON*DELTA IF(VYDS * VCRUS=0.02) 1 AA(5) * VYDF *RACON*DELTA IF(AEPA * 0*D1) 1 AA(5) * VVDF *RACON*DELTA IF(AEPA * 0*D1) 1 AA(5) * VVDF *RACON*DELTA A(6) *AA(6) *DELCON D0 20 TI\$1;10 C(1) *A(1) CC(1) *A(1) C

	· •	* * '				
	1	1 *		**** INCNHB ****		
	2	1	SUBRO	JTINE INCNHB		
	- 3	1 CH	SUBROL	JTINE TO INITIALIZE CONSTANTS FOR SIMULATION OF HYBRID CAR		
		1 6-	HEA'R RARARI	NDTKE 1/28/75		
	5	î • -	MODIFIED) FOR DIESEL ON 13 OCT 1976		
	6	1.4	MODIFIED	FER PRODUCTION RUNNING ON 1 MAR 1977		
	7	1 .				
		i -	COMMON	RIE TMAX VACHAX VVIMI VVILFR/VVI2BR/VVIICO, VVIM/VVIIRF	COMMOND1	
	ĕ		COMMO	VVIMOR VVIDER AVIA AVIA TALIGE AVIM VVIEUM VVIEUS	COMMOND2	
		;	CRRHAM	UVIGUB VVISU VVIAMY, VVIAS, VVIACE TVIJCT, TVIJTATVIJRA	CammaND3	
	44		CAMMA	TVI STWASCALEFADEL MINAFIEL WTATIOLFADT	CAMMAND4	
	15	!	CARMAN	INVERATE TAVE HODGEC MAYLIN, FRS. NEFARITAUT, TRANTIL CAREG	CAMMANO5	
	10		DIMEN	A ASERANTEINFERENCES AND ASERANTE STATEMATE AND A ASERANTE AND A ASERANTE AND A ASERANTE AND A ASERANTE AS	CAMMAN A	
·		·		SIGN (SINVIII) IVER AUDUV	CAMMENOT	
	- 37	1	DIMEN	510N YAIN(2/)YAAX(2))YAN((2))NUTA(2)	CAMMANDE	
	10		DIMEN		Commonio	
	10	1	DITIEN	TOR TVICKE(16)	Commonito	
	17	1	Common	N TRINY	COMMONIU	
	18	1	Common	I IVEPA, VHIN, VHAX, VINT, NDIH, DACCON, AUCCON, TVICKL	COMMONI1	
	19	1	Common	TIME, NRUN, INDIC, NRECANFUEL, ICLOCK, ICLORD, TS, BS, OBHP, TORG	COMMONIZ	
	20	1	Common	SSTORUSESDOTSPADCSPADNSPPOBSTADCSTADN	COMMONIS	
	- 21	1	COMMO	T91C, T91N, T8DN, T98C, T98N	COMMON14	
	25	1	COMMO	1_12111111110H1AAB21AABY1AABD14A1B1VA1214IWD1AADH1AADW11by9bk	COMMONIO	1
	- 33	\$	COMMÕI	N FUELE, ITICYC, ICLOKI, ISHIFT, WHLSLP, WHLOLD	COMMON16	
	24	1	COMMO	V ICYENDINLINEJICYCLEJNGIJNGIOLDIVEPALYANALGIPAOFROJVOAO	COMMON17	
	25	1	COMMO	N VYOSD/DELTA/DELT/ISEQ/IGO/ESDOTO/IGEAR	COMMON18	
	26	1	EQUIV	ALENCE (DIST/VV8D)/(BS/VVIBBR)	COMMON19	
	27	1	DIMEN	SION FTIME(60)/ESPEED(60)/ATORGS(60)/VAR(10)/X(225)/NYOLT(15)	CemmeN2D	
	21	i	DIMEN	SIGN VAL (2) NET (2) NGT (2) TPOX (20, 20) JISPEED (20) JTIMMAX (5)	COMMON21	
	29	1	DIMEN	SIGN TIMLEN(5) TIMAVQ(5)	COMMON22	
	30	1	COMMO	VAR, XANVOLT, VALANLT, NGTA IPDXA ISPEEDATIMMAX, TIMUENATIMAVG	COMMON23	
	31	i	EQUIV	LENCE (FTIME(1), X(46)), (ESPEED(1), X(106)), (ATORQS(1), X(166))	COMMON24	
	32	i	COMMON	10LD1; 10LD2; 10LD3; 15W1; 15W2; 15W3; 1ENGNO, 1ENGIN	COMMON25	
	33	12	COMMO	FINTRO, FINTRO, RIF, RFINR, OF DOT, GNU, FONU, TROIDL, T91CD, R, DF	COMMON26	
	34		DIMEN	TAN CAMMIZATIENGTRO (20) JENGFUL (20) JENGVAC (20) JENGSTT(20)	COMMON27	
	35		DIMEN	SIAN ENGSTP(20) (FFFTAB (9,9,9) (RAEFTB(11,11))	COMMON28	
	14	·	COMMO	N COMMAENGTROAENGFULAENGVAEAENGSTTAENGSTPAEFFTAB	COMMON29	· • ·
	17		DIMEN	SIAN 4/10)+C(10)	CemmeN30	
		1	COMMO	AAF. FUTOL AVACTOL ANSPERDANVELANTIME BASPOTNCA VELINCATIMINC	C6MM6N31	
	34		CAMMA	TETARO, RIEPIFACUTTROAISIMATENEW, BENEWATGICON, TOICOS	COMMON32	
		f	CAMMA	TOP ODP FARUPITOTICS TOTUES RPMIN RPMAY TTATATITE	CRMMAN33	
		1	CAMMA	DASCAL SENTADO EDDAG EGAIN EDDAG PAFETB DATE	CRMMRN34	
	- 14	i	DIMEN	TRACE/SATURGED AND SATURATION CONSISTENT FOR A RECOVER	CAMMAN35	
			CAMMA		CRMMRN3A	
	5		EDUTY	A CALIDANIANA ILOCATOL		
		7 6	COMMO	NECKE (TONIGIEGOIN) ONLY (TAN)	•	
			COLLING N	TAN ACOCTITING LUID AAAAAAAA	CAMMAN	
	+0		COMMO		CAMMAN	
	- 5		COUND		COMMON	
	48				CONNON	
	45		CONTRA		COMMON	
	50	18	COMMO		COMMON	
		1	COMMO			
	50		COMMO			

6 EQUI 71 DJMEI 91 104 FORM. 91 105 FORM. 91 106 FORM. 11 106 FORM. 12 109 FORM. 11 106 FORM. 11 106 FORM. 11 112 FORM. 12 1000 FORM. 1010 FORM. FORM. 1000 FORM. FORM. 1010 FORM. FORM. 1010 FORM. FORM. 10105 FORM. FORM. 10100 FORM. FORM. 10100 FORM. FORM. 10100 FORM. FORM. 10100	VALENCE (ICOMM, COMM) NSION ENGTR (20) AT(8E10.3) AT(8E10.3) AT(14F5.1) AT(17F6.1) AT(17F6.1) AT(12F8.1) A	
Image Image Image <th>NSIGN ENGTR (20) AT (8510.3) AT (8510.3) AT (12F5.1) AT (12F6.1) AT (13A6) AT (13A6) AT (10.3F10.1,110) AT (12F8.1) AT (2F8.1) AT (</th> <th></th>	NSIGN ENGTR (20) AT (8510.3) AT (8510.3) AT (12F5.1) AT (12F6.1) AT (13A6) AT (13A6) AT (10.3F10.1,110) AT (12F8.1) AT (2F8.1) AT (
104 FORM, 105 FORM, 106 FORM, 107 FORM, 108 FORM, 110 FORM, 1112 FORM, 112 FORM, 112 FORM, 112 FORM, 112 FORM, 110 FORM, 1000 FORM, 1000 FORM, 1015 FORM, 1015 FORM, 1015 FORM, 1010 FORM, 1015 FORM, 1050 FORM, 1050 FORM, 1050 FORM, 1050 FORM, 1060 FORM, 1070 FORM, 1070 FORM, 1120 FORM, 1120 FORM, 1120 FORM, 1120 FORM, 1120 FORM, 1120 FORM, <tr< th=""><th>AT(8E10.3) AT(8F3.1) AT(12F5.1) AT(13A6) AT(13A6) AT(2F8.1) AT(3510.3&F10.1&I10) AT(3510.3&F10.1&I10) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(9HENGSTF(1)) AT(4X,6HSPDINC,2X,6HNSPEED) AT(9HENGSTF(1)) AT(4X,6HSPDINC,2X,6HNSPEED) AT(9HENGSTF(1)) AT(4X,6HSPDINC,2X,6HNSPEED) AT(9HENGSTF(1)) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(2HREAR,4X,6HSPDINC</th><th></th></tr<>	AT(8E10.3) AT(8F3.1) AT(12F5.1) AT(13A6) AT(13A6) AT(2F8.1) AT(3510.3&F10.1&I10) AT(3510.3&F10.1&I10) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(9HENGSTF(1)) AT(4X,6HSPDINC,2X,6HNSPEED) AT(9HENGSTF(1)) AT(4X,6HSPDINC,2X,6HNSPEED) AT(9HENGSTF(1)) AT(4X,6HSPDINC,2X,6HNSPEED) AT(9HENGSTF(1)) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(2HREAR,4X,6HSPDINC	
105 FORM 105 FORM 105 FORM 109 FORM 109 FORM 109 FORM 100 FORM 100 FORM 100 FORM 100 FORM 100 FORM 100 FORM 100 FORM 100 FORM 105 FO	AT(8110) AT(12P6.1) AT(12P6.1) AT(12P6.1) AT(12P6.1) AT(2F6.1) AT(3F0.3,F10.1,110) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(9HENGTRG(1)) AT(9HENGTRG(1)) AT(9HENGTRG(1)) AT(9HENGTT(1)) AT(4X,6HTMINC,4X,6HNTIMES) AT(9HENGSTP(1)) AT(4X,6HTMINC,5X,5HFUIDL) AT(3HENGSTP(1)) AT(4X,6HTRGIDL,5X,5HFUIDL) AT(4X	
106 FORM 109 FORM 109 FORM 110 FORM 209 FORM 209 FORM 1000 FORM 1000 FORM 1000 FORM 1010 FORM 1010 FORM 1050 FORM 1120 FORM 1120 FORM 1120 FORM 1130 FORM	AT(16F5.1) AT(12F6.1) AT(12F6.1) AT(250.3/F10.1/IO) AT(3510.3/F10.1/IO) AT(3510.3/F10.1/IO) AT(3510.3/F10.1/IO) AT(12F8.1) AT(4X,6HSPDINC,2X,6HNSPEED) AT(14) AT(4X,6HSPDINC,2X,6HNSPEED) AT(9HENGFRQ(1)) AT(9HENGFRQ(1)) AT(9HENGFTQ(1)) AT(9HENGFTQ(1)) AT(9HENGFTQ(1)) AT(4X,6HTMINC,4X,6HNTIMES) AT(9HENGSTT(1)) AT(4X,6HTMINC,4X,6HNTIMES) AT(9HENGSTT(1)) AT(4X,6HTMINC,5X,5HFUIDL) AT(4X,6HCVTMAX) AT(14X,6HCVTMAX) AT(14X,6HCVTMAX) AT(24H REAR AXLE EFF. TABLE)	
109 FORM 110 FORM 110 FORM 204 FORM 209 FORM 1000 FORM 1010 FORM 1010 FORM 1010 FORM 1010 FORM 1050 FORM 1150 FORM	AT(12P6.1) AT(13A6) AT(210.3, 110) AT(3510.3, F10.1) AT(3510.3, F10.1) AT(3510.3, F10.1) AT(12F8.1) AT(14) AT(4X, 6HSPDINC, 2X, 6HNSPEED) AT(14) AT(4X, 6HSPDINC, 2X, 6HNSPEED) AT(9HENGTRQ(1) AT(9HENGTRQ(1) AT(9HENGTRQ(1) AT(9HENGTRQ(1) AT(9HENGSTT(1)) AT(4X, 6HTCHIMINC, 4X, 6HNTIMES) AT(9HENGSTT(1)) AT(4X, 6HTCHIMINC, 4X, 6HNTIMES) AT(9HENGSTT(1)) AT(4X, 6HTCHIMINC, 4X, 6HNTIMES) AT(9HENGSTF(1)) AT(4X, 6HCVTHAX) AT(14HTCHIDL, SCALEF) AT(14X, 6HCVTMAX) AT(14HCVT EFF. TABLE) AT(24H REAR AXLE EFF. TABLE)	
110 FORM 112 FORM 112 FORM 209 FORM 990 FORM 1000 FORM 1000 FORM 1010 FORM 1015 FORM 1015 FORM 1050 FORM 1150	AT(13A6) AT(250.3,F10) AT(3510.3,F10.1,110) AT(12F8.1) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPT(1)) AT(4X,6HST(1)) AT(4X,6HST(1)) AT(4X,6HTMINC,4X,6HNTIMES) AT(9HENGSTF(1)) AT(4X,6HTMIDL,5X,5HFUIDL) AT(3HENGIDL,5X,5HFUIDL) AT(4X,6HCVTMAX) AT(4X,6HCVTMAX) AT(4X,6HCVTMAX) AT(2H REAR AXLE EFF. TABLE)	
112 FORM 204 FORM 390 FORM 1000 FORM 1000 FORM 1010 FORM 1010 FORM 1010 FORM 1050 FORM 1050 FORM 1052 FORM 1052 FORM 1062 FORM 1062 FORM 1062 FORM 1062 FORM 1062 FORM 1062 FORM 1060 FORM 1060 FORM 1060 FORM 1070 FORM 1120 FORM 1120 FORM 1120 FORM 1120 FORM 1120 FORM 1120 FORM 1150 FORM 120 FORM	AT(E10.3,10) AT(3510.3,F10.1,10) AT(3510.3,F10.1,10) AT(4%,6HSPDINC,2%,6HNSPEED) AT(E10.3,18) AT(9HENGTRG(1)) AT(9HENGTRG(1)) AT(9HENGTRG(1)) AT(9HENGTTG(1)) AT(9HENGSTT(1)) AT(4%,6HTMINC,4%,6HNTIMES) AT(9HENGSTP(1)) AT(4%,6HTMINC,5%,5HFUIDL) AT(3HENGIDL,5%,5HFUIDL) AT(3HTAIDL) AT(4%,6HTRGIDL,5%,5HFUIDL) AT(3HTAIDL) AT(4%,6HTRGIDL,5%,5HFUIDL) AT(3HTAINY) AT(5HTAINY) AT(2H REAR AXLE EFF. TABLE)	
204 FORM 209 FORM 209 FORM 1000 FORM 1010 FORM 1010 FORM 1030 FORM 1030 FORM 1050 FORM 1050 FORM 1050 FORM 1050 FORM 1050 FORM 1060 FORM 1120 FORM 1120 FORM 1120 FORM 1130 FORM 1130 FORM 1140 FORM 1140 FORM 1150 FORM 1150 FORM 1150 FORM 1150 FORM	AT(3510.32F10.12110) AT(12F8.1) AT(4X,6HSPDINC,2X,6HNSPEED) AT(4X,6HSPDINC,2X,6HNSPEED) AT(5HENGTRG(1)) AT(9HENGFRG(1)+SCALEF) AT(9HENGFRG(1)+SCALEF) AT(9HENGSTR(1)) AT(4X,6HTEMINC,4X,6HNTEMS) AT(9HENGSTF(1)) AT(4X,6HTEMINC,4X,6HNTEMS) AT(9HENGSTF(1)) AT(4X,6HTEMINC,4X,6HNTEMS) AT(4X,6HTEMINC,4X,6HNTEMS) AT(4X,6HTEMINC,4X,6HNTEMINC) AT(4X,6HTEMINC,4X,6HNTEMINC) AT(4X,6HCTEMAX) AT(5HTAINY) AT(4X,6HCTEF.TABLE) AT(2H REAR AXLE EFF. TABLE)	
209 FORM 990 FORM 1000 FORM 1010 FORM 1015 FORM 1030 FORM 1030 FORM 1050 FORM 1050 FORM 1050 FORM 1050 FORM 1052 FORM 1065 FORM 1065 FORM 1065 FORM 1065 FORM 1065 FORM 1125 FORM 1125 FORM 1125 FORM 1130 FORM 1130 FORM 1130 FORM 1130 FORM 1140 FORM 1150 FORM 1150 FORM 1150 FORM 1150 FORM 1150 FORM 1150 FORM	AT (12F8.1) AT (H1) AT (4X, 6HSPDINC, 2X, 6HNSPEED) AT (6X, 6HSPDINC, 2X, 6HNSPEED) AT (6HENGTRQ(1)) AT (6X, 6HORTQ(1) & SCALEF) AT (9HENGFUL(1)) AT (4X, 6HTCINC, 4X, 6HNTIMES) AT (9HENGSTT(1)) AT (4X, 6HTRQIDL, 5X, 5HFUIDL) AT (4X, 6HCIDL, 5X, 5HFUIDL) AT (4X, 6HCVTMAX) AT (5HTAINY) AT (4X, 6HCVTMAX) AT (2H REAR AXLE EFF. TABLE)	
990 FBRM 1000 FBRM 1010 FBRM 1010 FBRM 1015 FBRM 1040 FBRM 1050 FBRM 1050 FBRM 1050 FBRM 1050 FBRM 1060 FBRM 1060 FBRM 1060 FBRM 1060 FBRM 1070 FBRM 1100 FBRM 1120 FBRM 1120 FBRM 1130 FBRM 1140 FBRM 1140 FBRM 1140 FBRM 1150 FBRM 1150 FBRM 1150 FBRM 1120 FBRM	AT(H1) AT(4X,6HSPDINC,2X,6HNSPEED) AT(14):0.3/18) AT(9HENGTRG(1)) AT(14HENGTRG(1)) AT(9HENGTRG(1)) AT(9HENGTP(1)) AT(9HENGSTT(1)) AT(4X,6HYELINC,4X,6HNTIMES) AT(9HENGSTF(1)) AT(4X,6HTRGIDL,5X,5HFUIDL) AT(3HENGIDL,5X,5HFUIDL) AT(3HTRGIDL,5X,5HFUIDL) AT(4X,6HCYTMAX) AT(5HTAINY) AT(4X,6HCYTAX) AT(2H REAR AXLE EFF. TABLE)	
1000 FORM 1000 FORM 1010 FORM 1010 FORM 1010 FORM 1030 FORM 1030 FORM 1050 FORM 1050 FORM 1052 FORM 1052 FORM 1052 FORM 1060 FORM 1060 FORM 1060 FORM 1070 FORM 1070 FORM 1120 FORM 1120 FORM 1120 FORM 1130 FORM	AT (4%, 6HSPDINC, 2%, 6HNSPEED) AT (E10.3, 18) AT (9HENGTRQ(I)) AT (9HENGFUQ(I)) AT (9HENGFUQ(I)) AT (4%, 6HYELINC, 4%, 6HNYEL) AT (9HENGSTT(I)) AT (4%, 6HTRIDL, 5%, 5HPUIDL) AT (4%, 6HTROIDL, 5%, 5HPUIDL) AT (4%, 6HCYTMAX) AT (5HTRIDL SCALEF) AT (4%, 6HCYTMAX) AT (5HTRINV) AT (2H REAR AXLE EFF. TABLE)	
1000 FORM 1000 FORM 1015 FORM 1030 FORM 1050 FORM 1050 FORM 1050 FORM 1052 FORM 1054 FORM 1055 FORM 1065 FORM 1065 FORM 1065 FORM 1065 FORM 1100 FORM 1120 FORM 1120 FORM 1120 FORM 1130 FORM 1130 FORM 1150 FORM	AT(ELO.3718) AT(SHENGTRG(I)) AT(SHENGFU(I)) AT(SHENGFU(I)) AT(SHENGFU(I)) AT(SHENGSTT(I)) AT(SHENGSTT(I)) AT(SHENGSTF(
1010 FORM. 1010 FORM. 1040 FORM. 1050 FORM. 1050 FORM. 1050 FORM. 1050 FORM. 1050 FORM. 1050 FORM. 1051 FORM. 1052 FORM. 1054 FORM. 1065 FORM. 1065 FORM. 1065 FORM. 1000 FORM. 1100 FORM. 1100 FORM. 1110 FORM. 1120 FORM. 1130 FORM. 1140 FORM. 1150 FORM. 1200 FORM.	AT(SHENGTRQ(I)) AT(SHENGTRQ(I)) AT(SHENGTRQ(I)) AT(SHENGTRQ(I)) AT(SHENGTRQ(I)) AT(SHENGSTP(I)) AT(SHENGSTP(I)) AT(SHENGSTP(I)) AT(SHTRQIDL,SX,SHFUIDL) AT(SHTRQIDL,SKALEF) AT(SHTQIDLSKALEF) AT(SHTQIDLSKALEF) AT(SHTQIDL) AT(SHTQIDLSKALEF) AT(SHTQIDLSKALEF) AT(SHTQIDLSKALEF) AT(SHTQIDLSKALEF) AT(SHTQIDLSKALEF) AT(SHTQIDLSKALEF)	
10130 FBRM 1040 FBRM 1050 FBRM 1050 FBRM 1050 FBRM 1052 FBRM 1052 FBRM 1065 FBRM 1065 FBRM 1065 FBRM 1070 FBRM 1100 FBRM 1120 FBRM 1120 FBRM 1120 FBRM 1120 FBRM 1130 FBRM	AT (GHENGILG()) AT (GHENGTUL()) AT (GHENGSTT()) AT (AX,GHYELINC, 4X,GHNTUMES) AT (GX,GHTIMINC, 4X,GHNTIMES) AT (GHENGSTP()) AT (GHENGSTP()) AT (GHTROIDL, SX, SHFUIDL) AT (GHTROIDL, SCALEF) AT (GHTROIDL, SCALEF) AT (GHTRINY) AT (G	
1040 Form 1050 Form 1052 Form 1052 Form 1054 Form 1055 Form 1060 Form 1065 Form 1065 Form 1060 Form 1060 Form 1070 Form 1100 Form 1100 Form 1110 Form 1120 Form 1120 Form 1120 Form 1130 Form 1130 <td>AT (AX, GHVELINC, AX, AHNVEL) AT (AX, GHVELINC, AX, AHNVEL) AT (9HENGSTT(I)) AT (9HENGSTP(I)) AT (9HENGSTP(I)) AT (4X, GHTRQIDL, 5X, SHFUIDL) AT (13HTRQIDL=SCALEF) AT (4X, GHCVTMAX) AT (5HT&INV) AT(14HCVT EFF. TABLE) AT(24H REAR AXLE EFF. TABLE)</td> <td></td>	AT (AX, GHVELINC, AX, AHNVEL) AT (AX, GHVELINC, AX, AHNVEL) AT (9HENGSTT(I)) AT (9HENGSTP(I)) AT (9HENGSTP(I)) AT (4X, GHTRQIDL, 5X, SHFUIDL) AT (13HTRQIDL=SCALEF) AT (4X, GHCVTMAX) AT (5HT&INV) AT(14HCVT EFF. TABLE) AT(24H REAR AXLE EFF. TABLE)	
1050 F0RM 1050 F0RM 1054 F0RM 1054 F0RM 1054 F0RM 1065 F0RM 1065 F0RM 1065 F0RM 1065 F0RM 1070 F0RM 1000 F0RM 1100 F0RM 1100 F0RM 1125 F0RM 1125 F0RM 1130 F0RM 1130 F0RM 1130 F0RM 1140 F0RM 1140 F0RM 1150 F0RM	AT (9HENGSTT (1)) AT (9HENGSTT (1)) AT (9HENGSTP(1)) AT (4%)6HTROIDL,5%,5HFUIDL) AT (4%)6HTROIDL,5%,5HFUIDL) AT (13HTROIDL•SCALEF) AT (14%,6HCVTMAX) AT (5HTBINV) AT (5HTBINV) AT (24H REAR AXLE EFF• TABLE)	
1052 FORM. 1054 FORM. 1050 FORM. 1060 FORM. 1070 FORM. 1070 FORM. 1070 FORM. 1070 FORM. 1070 FORM. 11070 FORM. 1100 FORM. 1120 FORM. 1120 FORM. 1120 FORM. 1120 FORM. 1120 FORM. 1120 FORM. 1130 FORM. 1140 FORM. 1150 FORM. 1120 FORM. 1120 FORM. 1200 FORM. 1210 FORM. 1220 FORM. <	AT(4X,6HTIMINC,4X,6HNTIMES) AT(9HENGSTP(I)) AT(4X,6HTRQIDL,5X,5HFUIDL) AT(4X,6HCVTMAX) AT(5HTAINV) AT(5HTAINV) AT(2H REAR AXLE EFF. TABLE)	
1054 FORM, 1060 FORM, 1062 FORM, 1065 FORM, 1080 FORM, 1080 FORM, 11080 FORM, 11080 FORM, 1100 FORM, 1110 FORM, 1120 FORM, 1120 FORM, 1120 FORM, 1120 FORM, 1120 FORM, 1130 FORM, 1140 FORM, 1150 FORM, 1180 FORM, 1190 FORM, 1210 FORM, 1210 FORM, 1210 FORM, 1220 FORM, 1220 FORM, 1220 FORM, 1220 FORM,	AT(9BENGSTP(1)) AT(4X,6HTRQIDL,5X,5HFUIDL) AT(4X,6HTRQIDL.5X,5HFUIDL) AT(4X,6HCVTMAX) AT(4X,6HCVTMAX) AT(5HT&INV) AT(14HCVT EFF. TABLE) AT(24H REAR AXLE EFF. TABLE)	
1060 FORM, 1065 FORM, 1065 FORM, 1070 FORM, 1080 FORM, 1100 FORM, 1100 FORM, 1110 FORM, 1120 FORM, 1120 FORM, 1120 FORM, 1120 FORM, 1120 FORM, 1120 FORM, 1130 FORM, 1200 FORM, 1220 FORM, </td <td>AT(4X,6HTRQIDL,5X,5HFUIDL) AT(13HTRQIDL+SCALEF) AT(4X,6HCVTMAX) AT(5HT8INV) AT(14HCVT EFF• TABLE) AT(24H REAR AXLE EFF• TABLE)</td> <td></td>	AT(4X,6HTRQIDL,5X,5HFUIDL) AT(13HTRQIDL+SCALEF) AT(4X,6HCVTMAX) AT(5HT8INV) AT(14HCVT EFF• TABLE) AT(24H REAR AXLE EFF• TABLE)	
1062 FØRM, 1065 FØRM, 1070 FØRM, 1090 FØRM, 1100 FØRM, 1110 FØRM, 1120 FØRM, 1130 FØRM, 1140 FØRM, 1150 FØRM, 1140 FØRM, 1150 FØRM, 1120 FØRM, 1200 FØRM, 1210 FØRM, 1220 FØRM, 1220 FØRM, 1220 FØRM, 1220 FØRM, 1220 FØRM, </td <td>AT(13HTROIDL®SCALEF) AT(4%)6HCVTMAX) AT(5HT8INV) AT(14HCVT EFF® TABLE) AT(24H REAR AXLE EFF® TABLE)</td> <td></td>	AT(13HTROIDL®SCALEF) AT(4%)6HCVTMAX) AT(5HT8INV) AT(14HCVT EFF® TABLE) AT(24H REAR AXLE EFF® TABLE)	
1065 FORM. 1070 FORM. 1090 FORM. 1090 FORM. 1100 FORM. 1100 FORM. 1110 FORM. 1120 FORM. 1120 FORM. 1120 FORM. 1120 FORM. 1120 FORM. 1120 FORM. 1130 FORM. 1200 FORM. 1210 FORM. 1220 FORM. 1220 FORM. 1220 FORM.	AT(4X)6HCVTMAX) AT(5HTAINV) AT(14HCVT EFF. TABLE) AT(24H REAR AXLE EFF. TABLE)	
1070 FORM. 1080 FORM. 1080 FORM. 1000 FORM. 1100 FORM. 1110 FORM. 1120 FORM. 1130 FORM. 1140 FORM. 1150 FORM. 1150 FORM. 1150 FORM. 1150 FORM. 1170 FORM. 1180 FORM. 1190 FORM. 1200 FORM. 1210 FORM. 1220 FORM.	AT(5HT&INV) AT(14HCVT EFF. TABLE) AT(21H REAR AXLE EFF. TABLE)	and an
11 1080 FORM 11 1090 FORM 1100 FORM 1110 FORM 1125 FORM 1125 FORM 1130 FORM 1130 FORM 1130 FORM 1130 FORM 1150 FORM 1150 FORM 1150 FORM 1150 FORM 1190 FORM 1190 FORM 1200 FORM 1200 FORM 1200 FORM 1200 FORM 1200 FORM 1200 FORM 1200 FORM 1200 FORM 1200 FORM	AT(14HCVT EFF. TABLE) AT(21H REAR AXLE EFF. TABLE)	
2: 1090 FBRM 3: 1100 FBRM 4: 1110 FBRM 5: 1120 FBRM 6: 1125 FBRM 7: 1126 FBRM 9: 1140 FBRM 0: 1150 FBRM 1: 1160 FBRM 4: 1180 FBRM 4: 1180 FBRM 4: 1180 FBRM 4: 1200 FBRM 7: 1210 FBRM 8: 1200 FBRM 9: 1230 FBRM	AT(21H REAR AXLE EFF. TABLE)	
3: 1100 FBRM. 4: 1110 FBRM. 5: 1120 FBRM. 6: 1125 FBRM. 6: 1126 FBRM. 9: 1130 FBRM. 9: 1140 FBRM. 9: 1150 FBRM. 9: 1150 FBRM. 9: 1170 FBRM. 11: 1 6%. 2: 1160 FBRM. 3: 1170 FBRM. 3: 1180 FBRM. 5: 1200 FBRM. 6: 1200 FBRM. 6: 1200 FBRM. 6: 1200 FBRM. 9: 1230 FBRM.		
1110 FORM. 1120 FORM. 1125 FORM. 1126 FORM. 1120 FORM. 1210 FORM. 1220 FORM.	AT (BHOTVICKLO)	
1120 FORM. 1125 FORM. 1130 FORM.	AT (3%,7HVMIN(1),3%,7HVMAX(1),3%,7HVIN(1)	
1123 FORM 1130 FORM 1140 FORM 1150 FORM 1120 FORM 1210 FORM 1220 FORM 1220 FORM 1220 FORM 1220 FORM	ATLIAN/THYMINIC//JA/THYMAAIC//JAA/THYINIIC/	
1120 F0RM 1140 F0RM 1150 F0RM 1120 F0RM 1210 F0RM 1210 F0RM 1210 F0RM 1220 F0RM 1220 F0RM 1220 F0RM	AT(3044+14CK11A UN113) EP-FT-250/KFN/ AT(3044+14CK11A UN113) EP-FT-250/KFN/	1741
9: 1140 F0RM 0: 1150 F0RM 1: 150 F0RM 3: 1170 F0RM 3: 1170 F0RM 5: 1190 F0RM 5: 1200 F0RM 6: 1200 F0RM 8: 1220 F0RM 9: 1230 F0RM	AT(9X,3001E)	44/41 CC
1150 FORM 11 160 FORM 11 160 FORM 1100 FORM 1100 FORM 1100 FORM 1100 FORM 1200 FORM 1200 FORM 1200 FORM 1200 FORM 1200 FORM	AT(7X, SHRIF)	and the second
1: 1 6X, 2: 1160 FORM 3: 1170 FORM 4: 1180 FORM 5: 1190 FORM 5: 1200 FORM 6: 1200 FORM 8: 1220 FORM 8: 1220 FORM	AT (5X, 5HVVIMIA & XA 6HVVILFRA 4XA 6HVVI2BRA #XA	6HVVIICD/
2: 1160 FORM 3: 1170 FORM 4: 1180 FORM 5: 1200 FORM 5: 1200 FORM 71 1210 FORM 8: 1220 FORM 9: 1230 FORM	4HVVIM, 4X, 6HVVI1RF, 4X, 6HVVIMDR, 4X, 6HVVIDR	R) the transmission of the second
3: 1170 FORM 4: 1180 FORM 5: 1190 FORM 6: 1200 FORM 7: 1210 FORM 8: 1220 FORM 9: 1230 FORM	AT(6X,4HAVIB,6X,4HAVIR,4X,6HT8I1GR)	
4: 1180 F8RM 5: 1190 F8RM 6: 1200 F8RM 7: 1210 F8RM 8: 1220 F8RM 9: 1230 F8RM	AT (4X, 6HVVIFUM, 4X, 6HVVIFUS, 4X, 6HVVISWB, 5X	J5HVYISH/AX/6HVVIICF)
5: 1190 FBRM 5: 1200 FBRM 7: 1210 FBRM 8: 1220 FBRM 9: 1230 FBRM	AT (4%,6HTVIJCT, 4X,6HTVIJTR, 4X,6HTVIJRA, 4X	6HTVIJTW)
6: 1200 FORM 7: 1210 FORM 8: 1220 FORM 9: 1230 FORM	AT (4X, 6HSCALEF, 4X, 6HFUELWT, 4X, 6HDELMIN)	
7] 1210 FORM 8: 1220 FORM 9: 1230 FORM	AT (4X, 6HTBDTMS, 5X, 5HTBDTH, 6X, 9HGAIN (=DT))	
8: 1220 FORM 9: 1230 FORM	AT (5%, SHNGEAR)	
91 1230 FBRM	AT(SHURATIO(I))	
A A A A FORM	IAT (JHKMINAS(I))	
1 1240 FORM		ست با الما المربقة المربعة المسابق من المربق المربق المربق المربق
21 1260 FORM	ATTAX. CUPERIASY	
21 -1270-FRPM		and the state of the
41 1280 FARM	AT (5X, SHRPMIN, 5X, SHRPMAX, 7X, 3HEP6)	
5: 1290 FARM	AT (5X, 5HEDRAG, 5X, 5HEGAIN, 5X, 5HEDRAG)	
61 1300 FORM	AT (4X, 6HRASCAL, 4X, 6HCVTSCL)	1994 - Min J. (1997)
		and the second s
-64 (5) 57 (<u>15</u> (· · · · · · · · · · · · · · · · · · ·

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	107;	1310 FORMAT(6%,4HISUT,4%,6HLDADEG)	
	108;	1320 FERMAT(8%,2HOT,7%,3HOTF)	
-	1091	1325 FORMAT(10HTBUIMS=DIFFD3)	
	1101	1330 PERMAT(29HCBNSTANTS COMPUTED IN INCHME)	
	111;	1340 FORMAT(3A)/HNDIM(1)/3A)/HNDIM(2/30A)/HAVINJOA/4HAVIDJ	the state of the second s
	112;	1 OKI HHRMANJAKI HHRMAAJAKI DIRILINI JAAJ OOBLEFIT / 1950 - Roomatiky Kuudeer, kuvitany sy suvita (4.445.01.71.71.34007)	
	1131	1350 FUNDALIAASOMMENT CIDALIASOMATANA AASAH NUTAA AASAH NUTAASAH NUTAA	
	****	TERE FORMATTIANCOUNTRY COMPANY	
	1161	1F(SENSE BWITCH 6) 2.1	
	1171	1 CONTINUE	
	1181	• ZERG-BUT COMMENT ARRAY	
	1191	00 6/1 - 1/52	
	1201	ICOMM(I) = OW	
	1211	6 CONTINUÉ	
	1221	C READ CVT EFFICIENCY TABLE	
	1231	PRINT 1080	
	1241	CALL TURKEY(EFFTAB)	
	1251	• TOP OF PAGE	
	1261	PRINT 990	
manual of service come of the service of the	1271	C++++ READ IN REAR AXLE EFFICIENCY TABLE	
	1591	PRINT 1070	
	1531	CALL REAURA (RALFID)	
	1301	C URIVESHAFT RESISTIVE IDRUGE ROAD EDAD DATA	
	131;		
	1321		•
	1391	PRINT TOWNERS MAD	·
	1351	READ 112 ABPOINCANSPEED	
	1361	PRINT 1000	
	137:	PRINT 1005, SPDINC, NSPEED	
	138;	READ 104/(ENGTR (I)/IN1/NSPEED)	
	139	PRINT 1010	
	140;	PRINT 1047 (ENGTR (1) TO17 NSPEED)	
	141;	C READ FUEL CONSUMPTION MAPS	
	1421	READ 104; (ENGFUL (II; I=1; NSPEED)	
_	143:	PRINT 1030	
	1441	MKINI 104/(ENGFUL(I)/I01/NSPEED)	
	1408	COMPACT CAUNTER CONTROL PARAMETERS	
	1401	REAU JAGJYELINUJNYEL Reini Jaga	
	14/3	PRINT LORD VELTNE NVEL	
	1401		
	150		
	1515	PRINT 104. (ENGSTI()) AT=1.NVEL)	
	152		
	153	SAVE NVEL	
· *** ****	154	NVELSAVE . NVEL	
	155	READ 112, TIMINC, NTIMES	
	1561	PRINT 1052	
	157	PRINT 1005, TIMINC, NTIMES	
	1581	READ 104; (ENGSTP(1); INTIMES)	
	159	PRINT 1054	

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W W				
	1601		PRINT 104, (ENGSTP(I), I+1, NTIMES)	
	161;	C+===	ENGINE TORQUE AT IDLE	
;	162;		READ 104, TRGID , FUIDL	
	163;		PRINT 1060	
1	164:		PRINT 104, TRGID , FUIDL	
•	1651		READ MAX CVT BUTPUT TERQUE	A second s
	1661		READ 104+CVTMAX	
	4 4 7 4		DOINT 1045	·······
1	10/1			
	1001		PRINT INT/CVIERA	
	1691	C	DRIVE SHAFT SPEED AS A FUNCTION OF VEHICLE SPEED	
;	170;		READ 107, TSINV	
	171:		PRINT 1070	
	172:		PRINT 209, TRINV	
-	1731	C	READ IN DEFINITION OF CROSS CORRELATION	
	1741	-	READ 104-UMIN(1)-UMAY(1)-UNI(1)	
	4 7 7 4 4 7 5 4		DOTNY 1110	
			TRANT 4490. BD1NT 466 OMTRIAS, OMAVIAS, OTREIAS	
	1/01			
	1771		READ IORAVMIN(2)AVENAX(2)AVINT(2)	
	1781		PRINT 1140	
	179;		PRINT 104, VMIN(2), VMAX(2), VINT(2)	
1	180:		NDIM(1)=(VMAX(1)=VMIN(1))/VINT(1)+1	
	1811	·····	NDIM(2) # (VMAX(2) = VMIN(2) //VINT(2) +1	
	1821		ENGINE INERTIA UNITS SAME AS FLYWHEEL	
· ··· ;	1831		ENGINE INFOTTA	
	1 0 4 4			
	4074			
	1001			*
	1901		PRINT 1047RIE	
	187:	C+++7	INVERSE ENGINE INERTIA	
	188;		RIEINV = 1.0/RIE	
	189;	C	AIR PRESS, AIR TEMPAREAR AXLE RATIO	
	190:		READ 104, AVIB, AVIR, TBIIGR	
	1911		PRINT 1160	ferror of the second
	192:		PRINT 104 AVIBAAVIRA TAI1GR	
	1021	Colora	CALCULATE ATP DENSITY	
	4 7 9 8	6		
	1341			
	1951	C	SET THE BIND SPEED TO ZERD	
	190:		AVISEO	
	1971	C+	TIRE PARAMETERS	· · · · · · · · · · · · · · · · · · ·
	198;		READ 104, VVIFUM, VVIFUS, VVISHB, VVISH, VVI1CF	
	199;		PRINT 1170	
	2001		PRINT 104, VVIFUM, VVIFUS, VVISWB, VVISH, VVI1CF	
	2011	C+	POLAR MOMENTS	and the second
	202:	-	READ 104 TVIJCTA TVIJCA TVIJRA TVIJRA	
	2031		PPINT 1180	
	2041			
	2041	- 49 - 12.	FRINT LUTE VIOLISIVIOIRS ATTACAS ATTACAS A	
	C05;	0000	LENGTH OF TIME FOR DATA TIME DETWEEN SHIFTS IN SECONDS	
	206:		READ 104, TBDTMS, TBDTH, GAIN	
	207:		PRINT 1200	
	2081		PRINT 104, TBDTMS, TBDTH, GAIN	
	209:	+ 18	P OF PAGE	
	2101		PRINT 990	
	2111		PEAD 105-NICEAP	
	2121		DENU 1000 DELA	
	ere:		ENTITI TERM	

	2131		PRINT 105, NGEAR	
	2141		READ 1084 (GRATIB(I) I = 14NGEAR)	
	215:		PRINT 1220	
	216:		PRINT IOR, (GRATIO(I), I=1, NGEAR)	
	2171		READ 104/(RMINAS(I)/I=1/NGEAR)	
	2181		PRINT 1230	· · · · · ·
	2191		PRINT 104/(RMINAS(1)/1=1/NGEAR)	
	2201		READ 1044 (RMAXAS(T) / I + 1, NGEAR)	
	2211		PRINT 1240	
	2221		PRINT (04./PMAXAS(1))II=1.NGEAR)	
	223.		PEAD 104./GEFEEF(1).1=1.NGEAR)	
	224+		PRINT 1250	
	2251		PRINT 104. (GEREFELT), 1=1, NGEAR)	
	224.			
	2271			
	2281			
	2201			
	220+			
	2211			
	2321		DEAD TIGH. DDMIN. DDMIY.EDG	
	2221			
	5331		PDINT 104.0DMIN.DDMIY.EDC	
	235.		READ 104 FORGERAIN-FORA	
	2341			
	2371		PRINT 104-FORAG-FGAIN-FORAG	
	2381			
	2391		PRINT 1300	
	2401		PRINT TO A PASCAL ACVISCI	
	2441			
	2421		PRINTIAIO	a ser allocation and a series and
	2431		PRINT 105. TOUTAL BADED	
	244+		RMIN = DPMINGRATIA(1)	
	248+		RMAY - RPMAYERRATIS(NGFAR)	•
	2441			
	2471	C	READ 104-DTAOTE	
	2481		PRINT 1320	
	2491		PRINT 104 DTADTE	
	2501		FNDT = NDT = DT/DTE + 0.5	and the second
	2511		CORRECT TODTMS IF LESS THAN DT	
	2521		IF (TBOTMS & DT) TTBOTMS # DTT WRITE (108/1325) TBDTMS	
	2531	C	HOURS PER SECONO	
- · · · · · ·	2541		HRPSEC=1+/3600+	
	2551	C	LINES PER PAGE	
	2561	•	MAXLINe48	
	2571			
	2581	PR	DUCTION RUNS START HERE	
	2591			·
	2601	2	CONTINUE	
	2611	C	READ IN COMMENT CARDS	
	2621	1 1	READ 110, (COMM(I), I = 1,13)	
	2631		PRINT 1360	
	2641		PRINT 1107 (C8MM(1), I = 1,13)	
	2651	C====	READ IN DRIVING CYCLE	
1 Birl unter				

2661	CALL RDERA	
2671	TOP OF PAGE	
2681	PRINT 990	
5921		
2701	RESTORE NVEL	
2711	NVEL = NVELSAVE	
272;	READ FLYWHEEL INERTIAUNITS: LB-FT-SEC/RPM	
273:	READ 104 RIF	- and the data of the second second
274;	PRINT 1125	
2751	PRINT 1126	
2761	PRINT 1130	
2771	PRINT 104, RIF	
2781	RIEPIF = RIE + RIF	
2791	C DRAG CUNSTANTS	
2801	READ 104; VVIMI, VVILFR, VVI2BR, VVI1CD, VVIM, VVIIRF, VVIMDR, VVIDR	
281;	PRINT 1150	
2821	PRINT 100, VVIPI, VVILER, VVI20R, VVI1CD/VVIP, VVIIRF, VVIDR, VVIDR	
5831	• ENGINE SCALE, FUEL WEIGHT,	
2841	READ 104, SCALEF, FUELWT, DELMIN	
285;	PRINT 1190	
2861	PRINT 104/9CALEF/FUELWT/DELMIN	
2871		
288;	HULTIPLY TARQUE VALUES BY THE SCALE FACTOR.	
5831		
5901	DE 10 I = INSPEED	
5911	ENGINUE ENGTR (I) SCALEP	
2921	SU CONTINUE	
2931		
2341	TROID A TRAIN ABOUNDER	
2951	REIDE - IKUID - SCALEF	
2901	PRINT LODE	
29/1	FRINI 1049 [RGIDE	
2001	UTENSEUTENSEUTENSEUTENSEUTENSITEST	
2001	VVIALA VIELGAVVIMDAVVIGB//VVIMA/VVIGB/VVIELGAVVISH))	
3001		
3034		
3021	PRINT 104 NOTHISISNOTHISISNOTHISISSENTAVIS	
3051		
3041	BENT 204 UDBREFTUTING. UVIARIENDTINDT	
3061		
307	TE(NDIM(1) \$ 20 - 88- NDIF(2) = 201	
3081	1 BUTPUT(102), INDIM(1) AND/OR NDIM(2) EXCEED 20 IN INCOMBIA	
308	2 PAUSE	
310		
3111	4 THAN NOT USED IN PROGRAM, BUT IS SET TO ZERO.	
3121	TMAX = 0+0	
3131		
3141	RETURN	
3151	END	
0101		

* * * 1	* * *	**** INGRHB ****	
	-	SUBROUTINE INGRHO	
3		SUBROUTINE TO INITIALIZE CAR AFTER ENGINE IS IN STEADY STATE	
	1	8-8-RADTKF 1/30/75	
ŝ	1.4		
6	1 + 18	NOV 1976	· ·····
7	1 +		
8	1	COMMON RIE, TMAX, VACHAX, VVIHI, VVILER, VVI2BR, VVI1CD, VVIH, VVI1RF	COMMONO1
9	11	COMMON VVIMDR, VVIDRR, AVIB, AVIR, TBIIGR, AVIM, VVIFUM, VVIFUM,	COMMOND2
10	1	COMMON VVISWB, VVISH, VVIAMA, VVIAS, VVIICE, TVIJCT, TVIJTR, TVIJRA	LOMMONUS
11	1	COMMON TVIJTWSSCALEFSDELMINSFUELWTSTIDLESOT	
12	1	COMMON NVEPA, RIEINV, HRPSEC, MAXLIN, EPG, NGEAR, IBUT, IPHNT, LDADEG	COMMENUE
13	1	DIMENSION TRINV(11), IVEPA(3000)	COMMON 6
14	1	DIMENSION VMIN(2) VMAX(2) VINT(2) NDIM(2)	Common 07
15	1	DIMENSION DACCON(15) ADECON(15)	
10	1	DIMENSION TVICKL(16)	
17		COMMON TOINY	
18		COMMON IVEPA VMIN, VMAX, VINT, NDIM, DALCON, ADCON, TVICKL	Commonia -
		COMMON TIME, NRON, IND IC, NRECAN DEL, ILLOCK, ILLORD, TS, DS, DSHP, TORG	COMMENTS
20	1	COMMON SSTERUJESDETJPACLJKADNJPPOBJTADCJTADN	
21	1	LEMMON TOICS TOINS TRUNC TO A VIE AVER TUTE TUTE TUTE TO THE AVER	
20	1		Camman14
24		COMMON FUELESTILLUS ILLORISIONIFIAMALSLESMALULU	CAMMAN17
67	1	COMMON VACALORIALINESICICESINGISIGISCESINGISCESINGISCESING	Camman18
	· · · · · · · · · · · ·		Common 19
27	:	DIMENSION FTIME (60) FEREFOLGOL ATARAS (60) VAR (10) X(225) NVALT(15)	Common20
28	;	DIMENSION VALUED NITIES AND CLAIPDX (20,20) AISPEED (20) ATIMMAXIB	COMMON21
29	1	DIMENSION TIMLEN(5) TIMAVG(5)	COMMON22
	1	COMMON VARAXANVOLTAVALANLTANGTAIPDXAISPEEDATIMMAXATIMLENATIMAYG	COMMON23
31	ī.	EQUIVALENCE (FTIME(1), X(46)), (ESPEE0(1), X(1D6)), (ATORGS(1), X(166))	COMMON24
32	1	COMMON IOLDI, IOLDZ, IOLOJ, ISWI, ISW2, ISW3, IENGNO, IENGIN	COMMON25
33	1	COMMON EINTRG, FINTRG, RIF, RFINR, DFDOT, GNU, FGNU, TRGIDL, T9ICD, R, DF	COMMON26
34	1	DIMENSION COMM(26) JENGTRO(20) JENGFUL(20) JENGVAC(20) JENGGTT(20)	Common27
35	1	DIMENSION ENGSTP(20) JEFFTAB(9,9,9) JRAEFTB(11,11)	CBMMBN28
36	1	COMMON COMM, ENGTRO, ENGFUL, ENGVAC, ENGSTT, ENGSTP, EFFTAB	COMMONES
37	1	DIMENSION A(10) C(1D)	
38	I	COMMON AAC, FUIDL, VACIDL, NSPEED, NVEL, NTIMES, SPDINC, VELINC, TIMINC	CommoN31
39	1	COMMON IF IGRUARIENIFICYITRUJISIMITSNEWINSNEWIJICDNIJICDD	COMMON32
40	1		Commen 33
		COMMON RASLALISENTORGIPDRAGIEGAINIEDRAGIRAGITOIRAIREBIDT	COMMON36
46	1	CAMPAN CRATECONN, DAIN, TELICU, CVTCCI	Common34
	1	COMMON BRAILDSKEINSKMAASIGLOCHSCYTSCC	COMBINE
44			CAMMAN
LA		TRAMAN ZGRI ASSZTELSS TTEL	CAMMON
40	1	COMMON /GRINIT/INEXT	NEW
4.8	1 4	Anti-iniz kuittisis sijindi	
49	1	AVID = AVIS = 0.0	
	12	EMISE . EMISE . D.O	the second second
51	1	ICLOKD#+(IBUT+1)	
52		ICLOK1 + ICLOCK + 0	
53	11	ICYCLE + ISEG + ITICYC + 0	

* * *	***		
	• 2		
0		ICAUINE	
2			
5			
	21	NGT(1) W NGT(2) W NET(1) W NET(2) W O	
0		NEINEMAALINTO - TURN	
6		PADERO = PADER = FUIDL	
6	31	RP - RPMIN	
6	<u>+</u>	RPP U GRATIO(1)	
6	51	TIME # 0.0	
6		TBON = TYIN F TYON E 0.0	
6	71	THIGRETEILGR	
6	51	TPICDE = 0.	
6	21	VEPA & ORO	•
	21	VARA = VYGAO = VVGD = VVGBO = 0.0	
7	11	VVBS # 0+0	
7		WHLBLD = 0.0	
7	31	DO 6 Melalo	
7	• • • • • • • • • • • • • • • • • • •	A(M) = AA(M) = C(M) = CC(M) = 000	
7	91 9	CONTINUE	
70			
/	1		
	51	1PDX(1,J) = 0	
7	10 10	CONTINUE	
8			
8	11	(IMAAA(I) = IIMERK(I) = IIMMAX(I) = 000	
8	21 10	CONTINUE	
8	33	CALL LONING	
5		CALL CVIGNU	and a summarial data and a sub-standard surveying data
8	51	CALL TREFFICITRINATALCALGEARATCEOSAGRATION	
8	61	CALL RAEFTH	
8	/1	LALL VEDINH	
	81 *		
8	21	INCAK . P	
9	11	RETURN	
9	c i	UNU	

	+		. eeee ingrih eeee		
	- 41		CHIDGHITTHE THRETH		
	51		CHORDALINE INTECONTE CACIEN ANDIANES		
	- 44		SUDROUTUE TO INICORALE SISTEM VARIABLES		
		(REFERENCE STOLLA	CONNONIOS	
	91		COMMON RIE, THAX, VACHAX, VVIHI, VVILER, VVI20R, VVIICD, VVIH, VVIIR	COMMONUL	
	61		COMMON VVIMDR, VVIORR, AVIB, AVIR, TBILGR, AVID, VVIEDH, VVIED	COMMENUZ	
	- 71		COMMON VVISWB/VVISH/VVIAMX/VVIAS/VVIICE/TVIJCT/TVIJTR/TVIJRA	COMMON03	
	- 8 t		COMMON TVIJTWASCALEFAOELMINAFUELWTATIOLEAOT	COMMONO4	
	91		COMMON NVEPA, RIEINV, HRPSEC, MAXLIN, EPS, NGEAR, IOUT, IPRNT, LOAOEG	COMMONOS	
	101		DIMENSION TRINV(11), IVEPA(3000)	COMMON 6	
	11:		DIMENSION VMIN(2), VMAX(2), VINT(2), NOIM(2)	COMMON07	
	121		DIMENSION DACCON(15) ADCCON(15)	COMMONOS	
	131		DIMENSION TVICRL(16)	COMMON09	
	141		COMMON TAINV	COMMONIQ	
	151		CAMMAN TVERAS VMTNS VMAXS VINTS NOTMS DACCANS ADCCANS TVICKL	COMMON11	
	141		CAMMAN TIME . NRUN INDIC NRECANFUEL . ICLACKAICLAKO . TS. 85,08HP . TORO	COMMON12	
	191		CAMMAN STADD FSORT PARC. PARN PPRB TARC TARN	COMMON13	
	14			COMMON14	
	101		COMMON TOTAL TOTACH VVASAVVASAVVASAVVASAVISAVIS.TVIMIAVDEAVDEAVDATAPARE	CAMMAN15	
	171			CAMMAN16	
	201		COMMON TRELEVITICTSILLORISINGTI INCLETIOLOUD	CAMMAN17	•
	211			CAMMEN12	
	CC1			Cammania	
	631			CRUMAN20	·
	241		DIMENSION FILME (DU) ESPECICUJA IDAGICO DU VARI U) I (ACADINADE 113)	Commonizy	
	501		UIMENSION VAL(2), NLI(2), NUI(2), IPUA(EU,20), ISPEED(20), IIMMAA(B)	Connene:	
	501		UTHENSION TIMEN(3) TIMAYU(3)	Commence	
	271		COMMON VAR, X, NVOLT, VAL, NLT, NGT, IPDX, ISPEEU, TIMMAX, TIMEN, TIMAVO	LOMMONZJ	
	591		EUUIVALENCE (FTIME(1), X(46)), (ESPEED(1), X(106)), (ATORUS(1), X(186))	Commonice	
	521		COMMON IDLD1, 10L02, 10LD3, 15W1, 15W2, 15W3, 1ENGNO, 1ENGIN	COMMONED	
	301		COMMON EINTRO, FINTRO, RIF, RFINR, OFDOT, GNU, FGNU, TROIDL, TYICO, R, DF	LOMMONZO	
	311		OIMENSION COMM(26), ENGTRG(20), ENGFUL (20), ENGVAC(20), ENGST (20)	Commone/	
	321		OIMENSION ENGSTP (20) JEFFTAB (9,9,9) JRAEFTB (11,11)	COMMONZO	
	331		COMMON COMMJENGTROJENGFULJENGVACJENGSTTJENGSTPJEFFTAB	COMMONZY	
· and · man r age a party	341		DIMENSION A(10) C(10)		
	35;		COMMON AIC, FUIOL, VACIDL, NSPEEO, NVEL, NTIMES, SPDINC, VELINC, TIMINC	COMMON31	
	361		COMMON TFTORQ,RIEPIF,CYTTRQ,ISIM,TSNEW,BSNEW,T9ICON,T9ICOO	COMMON32	
	371		COMMON RR, RPP, FOBHP, TCVTLS, TCLULS, RPMIN, RPMAX, TT, TC, TF	COMMON33	
	381		COMMON RASCAL;ENTORO;FORAG;EGAIN;EORAG;RAEFTB;RATKL6;DTF	COMMON34	
	391		OIMENSION GRATIO(10)	COMMON35	
	401		COMMON GRATIO, RMIN, RMAX, ICLUCH, CVTSCL	COMMONS6	
	411				
	421	-	NTIMEPAICLACK		
	431		DELTAN (NTIMEPNICLOKI) +OT++B		
	441		VVBS+VVBS+(VVBA0+VVBA)+DFLTA		
	48		$IF(VVAS \leq 0.0) VVAS = 0.0$		
	66		VV80+VV80+(VV8S0+VV8S)+OFLTA+HRPSFC		
	47		FUEL F & FUEL F & (PARFROSPARFR) & OF1 TASHRPEFC		
	4.81				
	401		VV8S0_VV8S	,	
	80			-	
	81				
	- 821				
	831		END	•	
			LITH .		

1: e eese INVRHB ****	
2: SUBROUTINE INVRHB	
31 C+ SUBROUTINE TO INITIALIZE VARIABLES FOR SIMULATION HYBRID CAR	
4: C+-++R+R+R+R+R+TKE 1/30/75	
5: COMMON RIE, TMAX, VACMAX, VVIMI, VVILFR, VVI2BR, VVIICD, VVIM, VVIIRF	COMMONOÍ
6 COMMON VVIMORAVVIORRAAVIBAAVIRATBI1GRAAVIMAVVIFUMAVVIFUS	COMMONO2
71 CAMMAN VVISUBAVVISUAVVIAMXAVVIASAVVIICEATVIJCTATVIJTRATVIJPA	CAMMANO3
CAMMAN TVI ITWISCALEFIDELMINIPIELWTITIDEFIOT	CAMMANOA
G. CAMMAN NUCAL DICTNUL LODGER MAY IN EDG. MEER TO LINE TODAT A ADEO	CAMMANOR
S COMMON NYERAKIEINYARASECHAALINJERSINGERNIGUTIFRHIJEGADEW	
101 DIMENSION TRINV(11)/IVEFA(3000)	
11; UIMENSION VMIN(2) / VMAX(2) / VINT(2) / NDIH(2)	COMMONUZ
121 OIMENSION DACCON(15) ADCCON(15)	COMMONUS
131 DIMENSION TVICEL(16)	COMMONOS
14: COMMON TAINV	COMMONIQ
15: COMMON IVEPA/VMIN/VMAX/VINT/NDIM/DACCON/ADCCON/TVICRL	COMMONII
161 COMMON TIME, NRUN, INDIC, NREC, NFUEL, ICCOCK, ICLOKO, TS, BS, OBHP, TORG	COMMON12
171 COMMON STORQ/ESOOT/PADC/PADC/PADC/TAON	COMMON13
18: COMMON T9IC, T9IN, T8DN, T9C, T90N	COMMON14
191 COMMON TOTI TOTIGR, VVOS, VVOD, AVID, AVIS, TVIM I. VVDF, VVDMI PA	AFRCOMMON15
20. CAMMAN FUELEATTICYCATCLAKIAISHIETAWHISLEAWHI ALD	COMMON16
24 CAMMAN TOYEND. I THE TOYELE NOT NOTAL D. VERANINAL C. RARERO, VAAO	Common 17
CII COMMON ICTERUSTICITESICITESICITATION COMPACTIVATION	
22; COMMON VVOSUSDELTASDELTSEUSTGOSEDOTUSTGEAR	Cennelle
23) EQUIVALENCE (DISTAVYDD)/(DSAVYIODR)	COMMONIA S
24] DIMENSION FTIME(60), ESPEED(60), AIGROS(80), VAR(10), A(220), AVOLI	10)COmmoney
25: OTHENSION VAL (2) ANLT (2) ANDT (2) A TPDA (20) A TSPEED (20) A THEMAX (5)	COMMONES
26; DIMENSION TIMLEN(5), TIMAVG(5)	COMMONZE
27: COMMON VAR, X, NVOLT, VAL, NLT, NGT, IPDX, ISPEED, TIMMAX, TIMLEN, IMAVG	LOMMONES
28] EQUIVALENCE (FTIME(1),X(46)), (ESPEED(1),X(106)), (ATOROS(1),X(16	6) JCOMMONZ9
29: COMMON IOLDI, IOLDI, IOLDI, ISWI, ISWI, ISWI, ISWI, IENGIN	COMMONED
30; COMMON EINTRO, FINTRO, RIF, RFINR, DFDOT, GNU, FGNU, TROIDL, TOICD, R, DF	COMMONZO
31: DIMENSION COMM(26),ENGTRG(20),ENGFUL(20),ENGVAC(20),ENGSTT(20)	COMMON27
32: OIMENSION ENGSTP(20), EFFTAB(9,9,9), RAEFTB(11,11)	COMMON28
33: COMMON COMM;ENGTRO;ENGPUL;ENGVAC;ENGSTT;ENGSTP;EFFTAB	COMMON29
34; DIMENSION A (10) / C (10)	COMMON 30 -
35: COMMON ALC, FUIDL, VACIDL, NOPEED, NVEL, NTIMES, SPDINC, VELINC, TIMINC	COMMON31
361 COMMON TETARQARIEPIFACVTTROAISIMATSNEWABSNEWATSICDNATSICDO	COMMON32
371 COMMON RPARPAFOBHPATCYTI SATCLULSARPMINARPMAXATTATCATF	COMMON33
- 381 CAMMAN PASCAL FINTARO FORAG. EGAIN FORAG. RAEFTB, RATKI SADTF	COMMON34
26 DIMENCIAN COLICITATION	CemmeN35
Comman Grate PMIN, PMAY, TOUCH, CVTSC	Camman36
AII EGUIVALENCE (VAR(4))IVEFAU//VAR(5/)VEFAU/	
43: 55=0.	
44; ICLOCK = ICLOKI = ICYEND = ISHIPT = 0	
45; I8LD1 = 18LD2 = 18LD3 = 0	
46: NGI = NGIOLD = NREC = 0	
471 TIME = TS = VANALG = VEPAO = VV8A = 0.0	
48; VV65=0+	
49; D0 5 I=145	
50: TIMMAX(I) = TIMLEN(I) = TIMAVG(1) = 0.0	
51; 5 CONTINUE	
52: VAR(2)=50.	
531 TVEPAOF DELMIN	

1

e e e e e e e	RFINR+1+/RIF				
551	FINTRO=TROIDL				
561	PAON # O+				
571	ESDOTETROIDLERIEI	NV			
58;	ISW1=0				
591	ISW24=1 TENGINH4				
801	IENGINUI				
621	T91N = T98N = 0.0				
631	DF # 775.0				
641	DFDOT = 0.0				
651	CVTTRO . TCLSE	TCLULS - TCVTLS - TLF	PUMP # GNU = R # 0	•0	
661	RETURN				
	ENV				
9/1					
9/1					
0/4					
•					
0/1			· · · · · · · ·		

	- 11		**** JPBHYB ****		
	51		SUBROUTINE UPBHYB		
	31	Cross	TERMINATION SUBROUTINE		
	- 4	Cee++	R + R + RADTKE 3/5/74		
	5:		COMMON RIE, TMAX, VACMAX, VVIMI, VVILFR, VVI2BR, VVIICD, VVIM, VVIARF	COMMOND1	
	61		COMMON VYIMDR, VVIDRR, AVIB, AVIB, AVIB, AVIM, VVIFUM, VVIFUS	COMMONO2	
	71		COMMON VYISHBYVYISHYVYIAMXYVVIASYVVI1CF, TVIJCT, TVIJTB, TVIJRA	COMMOND3	
	81		COMMON TYIJTWASCALEFACELMINAFUELWTATIDLEACT	COMMONOA	
	91		COMMON NVEPA, RIEINVAHRPSFC, MAXLINAEPSANGEAR, IBUTA TPRNTALOADEQ	COMMON05	
	101		QIMENSIAN TRINV(11) / IVEPA(3000)	COMMON 6	
	111		QIMENSION VMIN(2), VMAX(2), VINT(2), NDIM(2)	COMMONO7	
	121		DIMENSION DACCON(15) ADCCON(15)	COMMON08-	
	131		OIMENSIAN TVICEL (16)	COMMONO9	
· · · ·	141		COMMON TOTAL	COMMON10	
	151		CAMMAN IVERA. WITN. WMAX. VINTANDIM. DACCON. ADCCON. TVICRI	CammaN11	
	161		COMMON TIME NRUNAINDICANECANEDELAICEOCKAICIOKOATSABSABBPATORO	COMMONIZ	
	171		CAMMAN SSTADD FSDAT PARC BAAN PPAR TARC TAAN	COMMON13	
	1		CAMMAN TOIL.TOIN.TON.TON.TON.TONN	CAMMON14	
	101		CAMMAN TOTATORY VVALVVALVVALVVALAVIA.AVIA.TVIMI.VVDEVVDMIAPARER	CAMMON15	,
	201			CAMMANIA	
	211		CAMMAN TOPENDING TOPES F.NGTA NATA D.VERA VANA G.DARERO.VVAAD	CAMMAN17	
	221		CAMMAN WARAS DELTA, SELT, ISEA, IGA, ESDATO, IGA, PARALAS FARANAN	CAMMAN18-	
	221			CAMMAN19	
	241		DIMENCIAN FINE (AN. FODEDIAN) ATARASIAN, VARIAN, VI225), NUAL TITA	CAMMAN20	
	551		OTHERSTOR VALUES AND THE CONTRACT OF TRACTOR AND THE ACCURATE	CAMMAN21	
	201		OTHERSTON ARTELINCITEDINGLEDING CONTRACTOR	CAMMAN22	
	201		PAMAN VED V.NULT VI.NI TO AND TONY TODESDATIMALY TIMENATINAVE	CAMMAN23	
	2/1		COMMON YARJANYOCIJYACJALIJAGJITEODESIGECEVILINAAJITEODIJIOAYO	CAMMANSA	
	201		EQUIVALENCE (FIJMELIJJALGO)//(COPELULJJALLOO)//(AIGNUGLIJALJOD//	CRMMRN25	
	531		COMMON TOLDS I DECAS I SWITTEWESTEWESTEWEND LENGTON (TOLDA TO DECAS OF TO DECA	CAMMANSA	
	301		COMMON EININGSFININGSKIFSKFINKSDFODISGNOSFGNOSFGNOSFGNOSFGNOSFGNOSFGNOSFGNOS	COMMON23	
	311		DIMENSION COMM(20))ENGING(20))ENGPOLIZO))ENGPALIZO)	COMPONEY	
	321		DIMENSION ENGSTP(2D) JEFF [AB(3) 3) 3) RAEF [D(1)]11)	COMMONSO	
	331		COMMON COMMAENGTRG, ENGROLLENGVALLENGSTIJENGSTIJEFFTAB	COMPONE 2	
	341		DIMENSION A(1D) C(10)	COMMONIQ	
	321		COMMON AAC, FUIDL, VACIDL, NSPEED, NVEL, NTIMES, SPDIDC, VELINC, TIMINC	COMMONIS	
	361		COMMON TETBRUSKIEPIPSCVTRUSISIMITSNEWSBAREWSTRICDASTSCOO	Commonia	
	371		COMMON REARPAR OBARA TOURS TOURS SEMINARMANATTA TO TO	COMMONIS	
	381		COMMON KASCALJENTORUJEDKAGJEDAINJEDKAGJKAEP TOJKATKEDJDIP	COMPORT	
	39;		DIMENSION GRATIO(10)	COMMON 30	
	401		COMMON GRATIO, RMIN, RMAX, ICLUEN, CATSCE	Componee	
	411		DIMENSION SUMJ(2D)		
	451		DIMENSION CE(10), AA(10)	COMMON	
	431		EBMMBN /SUMVAR/CC,AA	Common	
	443		COMMON/SIGPS/NSIGP		
	40;		COMMON /EPASH/ VERUS/ACEL/DECEL/DE/DJ/ID/DD/RILNGT		
	46		COMMON/WER/FURG(12)/CFMP(12)/KN/CFMPG/KWEN/KWPP		
	471	*			
	481	199	PORMAT (/22DX/13A6//22DX/13A6//)		
	491	200	FURMATI 41X, 36HUBINT PROBABILITY DENSITY (PER CENT)		
	501	201	FORMAT(//, 39X, 43HENGINE STEADY STATE TORQUE VS, ENGINE SPEED)		
	511	505	PORMAT(2/, 1X, 6HTORQUE, 44X, 13HSPEED INTERVALS//1X, 9HINTERVALS)		
	521	203	FORMAT(WD)		
	53:	204	FORMAT(8%,2016)		

241	200 FORMATI 1740 HIGRACCAVATAAATATATATATA	
55;	206 FORMAT(1\$\$1331H=313320F6+d)	
561	207 FORMAT(/45%/I5/38H SAMPLES FELL BELOW THE MINIMUM TORQUE/	
571	1 7,5%, 15,36H SAMPLES EXCEEDED THE MAXIMUM TORQUE,	Address of the second of the second sec
581	2 1.5X IS 374 SAMPLES FELL BELOW THE MINIMUM SPEED.	
	2 JEV. 15. AND CANDIES FUEFARD THE MAYIMIM SPEEN	
231	3 //3A/13/33H SAMPLES CALCOUR THE MAATHON GREEVE	
601	208 FORMAT(5X, 17, 37H ITERATIONS TOOR PLACE OVER THE CYCLE?	
611	209 FORMAT(8H TOTALS J20F6+2)	
621	210 FORMAT(10x,42HCUMULATIVE FUEL CONSUMPTION FOR EACH MILEI)	
631	2100 FORMAT(10X, AHMILE, 5X, 11HUNCORRECTED, 17X, 9HCORRECTED)	
444	3440 FROMATION . 54.3. BY . 54.3. Y. SUMOR B. 57. 5. Y. 4400MI. 47. 56. 3. Y. SUMPR B.	
001		
661	211 FORMAT(10X) SHOISTANCE # F7 4/2X, DHMILES)	
671	212 FORMAT(12X,46HONE SAMPLE TAKEN OURING EACH PROGRAM ITERATION)	
68:	213 FORMAT(10X,17HROAD LOAD ENERGY://12(2H =)/F9(2)	
49	214 FORMAT(102, 19HENFRGY LAST IN CVII.11(2H +)/F9.2)	
	STE REDMATING SAUENEDRY LEGT IN THE CHITCHINA, 7/24 -1.59.21	
701	210 FORDALLICATEDENERGI CUGI IN THE CEUTHINGTIER FURTHER, 21	
711	210 PORMAI (104) JUHENERGY LOST IN EALESS GRAAT HUI AAD CH - 78 F STET	
721	217 FORMAT(10X, 27HENERGY GENERATED BY ENGINE 137(2H +) JFD+ 23 A3	
731	18HHORSEPOWER SECONDS)	
741	218 FORMAT(10X,24HENERGY LEFT IN FLYWHEEL; X,8(2H ,),F9.2)	
75	219 FORMATINON STHENERGY LAST TO FLYWHEEL FRICTION 44(2H +)+ F9.2)	
761	220 FROMATING, STHENEDGY AUTOUT FRAM SYSTEM PRWERDLANTI, 2(2H -), F9.2)	
/01	200 FORMATION STRENEND OUTPUT FROM SISTED FORMER 200	
771	221 FORMATIJUX, 25HENENGT LOST IN REAR AALEIJOICH DIJESIET	
781	222 FORMAT(10X) 35HENERGY LOST IN STARTING THE ENGINE (33(CH +)) F9+C)	
791	225 FORMAT(10X, 30HENERGY LOST TO ENGINE INERTIA: X,5(2H -),F9.2)	
801	226 FORMAT(10X,29HENERGY LOST IN FLYWHEEL GEAR1,6(2H -),F9.2)	
	227 FORMAT (10X, 34HENERGY LAST IN TRANSMISSION GEARS 1, X, 3(2H +), F9+2)	
= 24	228 FREMATION, ACHENERGY USED BY TRANSMISSION CHARGE DUMPLAY, F9.2)	
	200 FROMATING ACTIVITIES (1997)	
031	250 FORMATION INTERICE MEIGHTIFF TITATALDATINE DOWNING FR. 21	
841	260 FORMAT(10%)41HENERGY RECOVERED IN REGENERATIVE BRAKINGSJF7.21	
851	262 FORMAT(10X,24HACTUAL FLYWHEEL INERTIA1,F9+8,X,9HLB+FT 500)	
861	300 FORMAT(H1)	
871	1000 FORMATISX, SHACCEL, 4X, 6HCRUISE, 5X, 5HDECEL, 12X, 8HBUS STOP/2X,	
8.8	1 BHNG STARS 44 AH ENGTH)	
	1002 FROMATINY, OUTMOUSCOLL, AV. BUIMOUSLAV, BUIMOUSCOLL, 44V. BUISECI, 24.	
071	TORE FORMAL (34) SHORE SECTION SHORE STATISTICS OF THE SECTION	
901	1 IDW(PER MILE)/3X/7H(MILED)/	•
911	1003 FORMATT3F10+3#F20+3#I10#F10+3)	
921		
93	PRINT 300	
941	PRINT 1994 (COMM(1) + T=1+24)	
05	BRINT 200	
300		
	PRINI 604	a second a second s
- 97 (PRINT COC	
981	ISPEED(1)#VMIN(2)	
991	TNT=VINT(2)	
100	NL1M=NOIM(2)	
101	OB 5 TARINI TM	•
103		
102		
103	a CONTINUE	
104:	NCONDIM(¢) 91	
105	PRINT 204/(ISPEED(I)/I+1/N2)	
106	PRINT 204, (ISPEE0(1), 1+2, NLIM)	

· · ·	107		PRINT 203	
	1071		TTORO1 = VMTN/1)	
	1001			
	1031			
	1101			
	1111			
	1141		10 200011340	
	1131		DO 20 IEIANI	
	1141		ITBR02+IJBR01+INT	
	1151		De 15 Jalanz	10 C C C C C C C C C C C C C C C C C C C
	1161		X(J)+FLBAT(IPDX(I,J))+100+/FLBAT(ICYCLE)	
	1171			
	118:		15 CONTINUE	
	1191		PRINT 206, ITORQ1, ITORQ2, (X(J), J01, N2)	
	1201		ITERG1=ITERG2	and a second
	1211		20 CONTINUE	
	1221	·····	PRINT 205	·····
	1231		PRINT 203	
	1241		PRINT 2094 (SUMJ(J) Jefen2)	
	1251		PRINT 300	
	1241	-	PRINT 203	a company parts, represent the company/or parts and
	1001			
	12/1			
	1201		PRINI GIG	
	1521		PRINT 2073 (NLT(1)) NG1(1) / 16682)	
	1301		PRINT 203	
	1311		PRINT 230, VVIM	
	1321		COMPUTE ACTUAL FLYWHEEL INERTIA IN LBOFTOFT	
	1331		RI = RIF+32+174+60+0/(6+28#18+25+0)	
	1341		PRINT 262,RI	
	1351		PRINT 203	
	136;		PRINT 211, VOD	
	1371		PRINT 1000	
	138;		PRINT 1002	
	139;		PRINT 1003, ACEL, VCRUS, DECEL, TIDL, NSTOP, RTLNGT	
	1401		PRINT 203	
	1411		PRINT 210	
• •	1421	•	PRINT 2100	
	1431			
	1441		SUTPUT FUEL CONSUMPTION	······································
	1451			
	1461		De 25 N W LARN	
	1471		VN B N	-
	1481	-	TE(N FGA BN) VN B VVAD	
	1491		PRINT 2110. VN. EMPRINI. 1. OVEMPRINI. CEMPINIA 1. OVERMOIN	
~ -	1501		25 CANTALS AND THE ALL STATES AND ALL STATES	
	1		ES CONTAIDE	
	1221		BDINE 203	
	1041			
	103		EFELL - ALGHERIL/JAOA40	
	1341			
	1551		ELENINFERKICOC(9)	
	1561		PRINT 21/JC(1)	
_	1571		C(6)=C(6)+CC(6)	
	158;		PRINT 220, C(6)	
	1591		PRINT 260,CC(6)	

-	1601	PRINT 218,ELEFT		
	161:	PRINT 203		
	1621	PRINT 213, C(2)		
	163:	PRINT 203	***********	
	1641	PRINT 216, (5)		
	1651	PRINT 221/C(7)		ate
	1661	PRINT 214, C(3)		
	1671	PRINT 228, CC(2)		
	1681	PRINT 227, CC(1)		
	169:	PRINT 215, C(4)	1 sauth to mint the local and the set of 1	
	170:	PRINT 226, C(10)		
	1711	PRINT 219, C(9)		
	1721	PRINT 225, ELENIN		
	1731	PRINT 222, C(8)		
	1741	PRINT 300		
	175;	RETURN		
	1761	END		
	- · · ·		44 ·	

		CONTRACTOR OF A	
31		SURPRUTINE MANKEY (T.S.P. PMIN. PMAY. STAP. TLAS)	
3,		ATEM HAUSENBAUER 5/1975	
41		DIMENSION STAR(9,7,9)	
5		DIMENSION TIT(2) TS(2)	
		TAPABS(T)	
71		IF(TA+25+) 11/11/12	
8	111	ID+1	
91		TMD=0.	
10;		TPD+25+	
11;		G8 T8 20	
121	15	IF (TA=50+) 13,13,14	
131	13	IDe2	
\$41		TMD • 25 •	
151			
161			
	17	10-3	
101	1.	TMDaBOA	
201		TPD=100	
211		G0 T0 20	
221	16	10+4	
23		TMD=100,	
241		TPD=200+	
25	20	CONTINUE	
261		IF (T) 25,81,21	
271	21	IBID+4	
281	L .		
29			
30	30		
32		THEFTED	
33	1	TPROTMD	
		CONTINUE	· · · · · · · · · · · · · · · · · · ·
35	1	1PP#1+1	
36	i –	J#1+{S/600.)	
37			
38:	: -	TF(J 4 1) J 4 1	
39	1	IF(J > 6) J # 6	
40			
41	1	SM#600+4J	
42	I.		
9.3	Į.	KINIFIRMAAFKUINI/Q0 Majiriini/Q0	· · · · · ·
94 1.5	•	PATTURE CONTENT OF A CONTENT	
		IF(R & RMIN) K + 1	
40	1	IF(R > RMAX) K = 8	
48			
49	1	RP=(K+RINT)+RMIN	
50	1	RMSRPORINT	
51	1	D8 46 LL=1,2	
52	1	LeK+LL-1	

* * * *	8 8 MalaMMat	
55)	TLT(MH) * STAR(IJMJL) + (T+TM)+(STAR(IPP)MJL)+STAR(IJMJL))/(1	P=TM)
561	45 CONTINUE 	
58)	TLOS = TS(1) + (R=RH)+(TS(2)=TS(1))/(RP=RM)	
60I	END	
	age a la company de la comp	
	•	
		,
		The Africa on a contract successful to a second
		·
* * * *		
21	SUBROUTINE NUTRAL (RAS, RAR, CVTR, TAXLE)	
31	C+++++TOM HAUSENBAUER 9/1975	
4)	COMPANDUMENTO CALCULATE TORQUE IN REAR AXLE DUE TO DRIVETRAL	N
61	e arth Fages with thrughtsolog th graine	
71	• GBTLS • 0.	
5)		
10:	• IF (CVTR) 10/5/10	··· ···
11)	# 5 TDST = 0;	
12)	• GO TO 151	. 1 Apple 700 1
13)	TE RATIS # 2	
151	* TAXLE * •RAR*(TDST+RATLS)	
161		
171		<u>.</u>
181	IF (LYTH ONLO UOU) TUST P, BOU/LYTH Tayle =	
201	RETURN	

11			
21		SUBROUTINE OTPTHB	
3:	C	SUBROUTINE TO OUTPUT HYBRID SYSTEM VARIABLES	
	Cynee	R • R • R • R • D 7 5	
51	. 11	FEB 1977	
61	1.1	COMMON RIE, TMAX, VACMAX, VVIMI, VVILFR, VVI2BR, VVIICD, VVIM, VVIIRF	CammaND1
71		COMMON VVIMDR, VVIDRR, AVIB, AVIR, TSTIGR, AVIM, VVIFUM, VVIFUS	CAMMAND2
81		COMMON VYISH& VVISH& VVIAMX VVIASA VVIACE TVIJCT TVIJTRA TVIJRA	CAMMANO3
9		COMMON TVIJTWASCALEFADELMINAFUELWTATIDLEADT	CAMMANDA
10:		COMMON NVEPAARIEINVAHRPSECAMAXLINAEPSANGEARAIOUTATPRNTALOADEG	CAMMANDS
111		DIMENSIAN TRINV(11), TVEPA(3DDD)	CAMMAN 6
		DIMENSION WIN(2), VMAX(2), VINT(2), NDIM(2)	CAMMAND7
131		DIMENSION DACCON(15) ADCCON(15)	CAMMANOS
			CAMMAND9
121		CAMMAN TAINU	Cemman1D
		COMMON TYPESA, VMTNI, VMAV, VTNIT, NDTM, DACCAN, ADCCAN, TVACDI — — — — — — — — — — — — — — — — — — —	Common t
101		CAMMAN TICFAY TO NY TRAFT NO INTERNO INTERCONFECTORY IVICK	CAMMANIS
1/1		COMMON STREETED AS DIAL DIAL DIAL DIAL TACK TILLORDISSIDDANSIDKA	
101		CAMMON SSIERUJESUDIJFACLJFADNJFFOSJACLJIADN	Common 13
171		COMMON 1712/1710/1600/1700/1700	
201		COMMON FILLS ISIIGKAVADSAVADAAVADAVADAVADAVADAVASAVADAVADAV	COMMONIA
		COMMON FORLES IT ICTC / ICLOR IS IS A IT A MACSLA WALGED	
221		COMMON ILTENDINLINE ILTELDINGIDLDINE PAIVANALGIPADERUNAVEAU	Lommon17
23;		COMMON VYOSOJDELTAJDELT, ISEU, IGOJEDDOTDJIGEAR	
241		EGUIVALENCE (DIST/VVBD)/(BS/VVIBBR)	Lommoniy
201		DIMENSION FTIME (6D) & ESPEED (6D) & ATORUS (6D) & VAR (10) & (223) ANOLT (15)	Lammaney
261		DIMENSION VAL(2), NLT(2), NGT(2), IPDI(20, 20), ISPEED(20), TIMMAX(5)	COMMONEL
27;		DIMENSION TIMLEN(5) JTIMAYG(5)	COMMONES
28:		COMMON VAR, X, NVOLT, VAL, NUT, NUT, IPDX, ISPEED, TIMMAX, TIMLEN, TIMAYG	COMMONES
291		_EQUIVALENCE (FTIME(1),X(46)),(ESPEED(1),X(1D6)),(ATORGB(1),X(166))	COMMONES
30:		COMMON IDLD1, IBLD2, IBLD3, ISW1, ISW2, ISW3, ILNGND, IENGIN	COMMONED
311		COMMON EINTROJFINTROJRIFJRFINRJDFDDTJGDUJFGNUJFROIDLJTJICUJRJDF	
321		DIMENSION COMM(26), ENGTRG(20), ENGFUL(2D), ENGVAC(2D), ENGSTT(2D)	COMMON27
331		DIMENSION ENGSTP(2D), EFFTAB(9,9,9), RAEFTB(11,11)	COMMONICS
341		COMMON COMM, ENGING, ENGPULJENGVAC, ENGSTIJENGSTP, EFFTAB	COMMONES
351		DIMENSION A(1D) C(1D)	COMMONIO
361		COMMON AAC,FUIDL,VACIDL,NSPEED,NVEL,NTIMES,SPDINC,VELINC,TIMINC	COMMON31
37:		COMMON TFTORO,RIEPIF,CYTTRO,ISIM,TONEW,BONEW,TOICDN/T9ICD0	COMMON32
38		COMMON RP, RPP, FOBHP, TCVTLS, TCLULS, RPMIN, RPMAX, TI, IC, TF	C6MM6N33
39:		COMMON RASCAL/ENTORO,FDRAG,EGAIN/EDRAG,RAEFTB/RATKLG/DTF	COMMON34
401		DIMENSION GRATIO(1D)	COMMON38
411		COMMON GRATIO, RMIN, RMAX, ICLUCH, CVTSCL	Cemmen36
42;		COMMON/FUEL/FMPGC	
431		COMMON/MPG/FMPG(15), CFMP(15), RN, CFMPG, RWEN, RWHP	
441	-	COMMON/ERASH/DUM(8), RTLNGT	
45:			
461	90	FORMATT101,2DX,13A6,/,21X,13A6)	
471	102	FORMAT (/49X,6(H+), THVEHICLE, 8(H+), 2X,6(H+),6HENGINE,6(H+),X,2H++,	
68		1 4HFUEL, B=, 2X, 6HACCUMU, X, 5HCORR-, X, 6(H-), 8HFLYWHEEL, 5(H-), X,	
491		2 6H-REAR-, 2X, 13H-DRIVE TRAIN-, X, 2HGE, X, 2HBR)	
50	- 103	FORMAT (3X, AHTIME, 2X, SHDIST, 2X, SHSPEED, 3X, AHACCEL, 2X, SHSPEED, X,	
511		1 6HTORQUE, X, 5HPOWER, X, 7HINSTANT, 2X, 6HLATIVE, X, 5HECTED, X, 5HSPEED, X,	
521		2 6HTORQUE, X, 6HOUTPUT, X, 6HWHEELS, 4X, 2HTR, 3X, 2HRA, 2X, 2HMO, X, 2HAR,	
53		3 X/2HAK)	

· · · · · · · · · · · · · · · · · · ·	MA. V.
341 104 FORMATICAJ3H(SEC)ZAJ4H(M])JJAJ3H(MFR)JAJ7H(MFR/SEC)JAJ9H(RF	
	2HF.)
	F7.16
601 . IF BRAKE APPLIED, BUTPUT LETTER B.	
611 IB • 4W	·····
621 IF(BS > 0.0) IB + 4HB	
631 •	· · · · · · · · · · · · · · · · · · ·
64: RWEN - T90N+T90N+TVIJTW/ 3227396.0	
65: • J227396.0 • 2+33000+60+J2:174/(2+PI • 2+PI)	
661 RWHP • T30C+T90N/5232.0	
71: RIFNG IFNGIN	
72: FMPGC+0.0	
731 IF (FUELE) 4, 4, 3	
74: 3 FMPGC=VV00+FUELWT/FUELE	
75; 4 CONTINUE	
761 ELEFT • 0F+0F+RIF/10504+0	
771 CFMPG + FMPGC+C(1)/(C(1)+ELEFT)	
78; IF(CFMPG 4 0+0) CFMPG 4 0+0	
791 IF(CFMPG & 50+0) CFMPG @ 50+0	
DI IFIVVD K KNI ENG(PN) a EMBCCI	
A31 2 CEMPCRN) = CEMPCI	
841 3 RN 9 RN + 1 0	
851 •	a second and a second sec
861 IF(ICYEND = 0)	
871 1 FHPG(RN) P FHPGCJ	
881 2 CFMP(RN) = CFMPG	
901 NLINERLINEAL	.
22. E FANTANIC	
951 PRINT 103	the and the reconstruction of definition of the set of the set
961 PRINT 10k	
971 NLINE#1	· · · · · · · · · · · · · · · · · · ·
981 20 CONTINUE	
993 PRINT 1053 TIME, VV00, VV06, VV0A, PAON, SSTBRO, OBHP, PAOR, FMPGC,	
1001 1 CFMPG, OF, TFTORG, FOBMP, RWMP, TBOLEF, T901, IENGIN, IGEAR, IB	
101t RETURN	

11		AAAA ATVRHB AAAA	
21	-	SUBROUTINE OTVRHB	
31	Cases	SUBROUTINE TO OUTPUT HYBRID VARIABLES	
41	Co	RaRaDTKE \$/30/75	
51			
61	a 17	1/77 LA SAMERSA	
71	- **		
······································		CAMMAN RIF. THAY, VACHAY, VVINT, VVII FR. VVI PRRAUVI CO. VVIN. VVIDR	CammaNO1
91		COMMON VVINOR VVIOR AVIR AVIR TATIGR AVIM VVIEW VVIENS	CRHMANO2
		TRAMAN VICUR, VVICU, VVILVVILA, VVILA, VVILA	Campanos
111		CAMMAN TYLETAS CALEFADEL MINAFILE WIATOLFAD	CAMMANOA
121	· ··· ··	CAMMAN NVEBA DIFINU HOBECCAMAYIN, FERANGEAD, TAUT, TADATA AADEO	CAMMANOS
121		DIMENSIAN TEINVIIII IVERSEISIAALINSEPSINGERSIBUISIPRATSEBADES	CAMMAN 4
		DIMENSIAN UMIN(2), UMAY(2), VINT(2), NDIM(2)	CammeN07
161		DIMENSION AACCONTINA AACCONTINA AACONTINA	CammaNOS
			CAMMANOS
131			CAMMONIO
4.8.4		CONMON' IVINA VMINAVAVAVANTANDIMAGECANA DECANA VICO	CAMMAN11
101		COMMON TEPRATHINATORASTINIANUTATORCONSCIONSTULIA	CommoN12
201		COMMON FINELNAUXINOILINALING DELITILOCKITLOCUITIODIDAPITURA	Commonse
201		COMMON SGIERUSESUDISFAULSFAUNSFFUSSIAULSIAUN	CAMMANIA
211		COMMON TRICATIONALISUNALISUNA AVIA AVIA AVIA TUTAT VVARAVANALISUALI	
241			
231		COMMON PUELE ITICT/ICLOKI/ISHIPI/WHLSLP/MLSLD	
241		COMMON I LYENON LINE I LYCLE, NGI NGI BLO, VERA YANALG, PADPRO, VVBAO	
201		COMMON VVBBOJOLITAJDELTJISENJIGOJESDOTOJIGEAR	Commonia
501		EQUIVALENCE (DIST & YVBO) & (BS & VVIBBR)	Commonia
271		DIMENSION FTIME (60) / ESPEE0 (60) / ATORGS (60) / VAR (10) / X(225) / NVOLT (15	ICOMMONZO
185		DIMENSION VAL(8) ANLT(2) ANDT(2) A IPDX(20,20) A ISPEED(20) A TIMMAX(5)	COMMONEL
591		DIMENSION TIMLEN(5) TIMAVO(5)	COMMON/22
301		COMMON VAR, X, NVOLT, VAL, NLT, NGT, IPDX, ISPELD, TIMMAX, TIMLEN, TIMAVG	COMMONAS
311			
321		EQUIVALENCE (FTIME(1),X(46)),(ESPEE0(1),X(106)),(ATBROS(1),X(166)	COMMONZA
331			
341		COMMON ISLDI, ISLOS, ISLOS, ISWI, ISWS, ISWS, IENGNO, IENGIN	COMMONZO
351		COMMON EINTRO, FINTRO, RIF, RFINR, DFDOT, GNU, FGNU, TROIDL, TOICC, R, DF	COMMONZO
361		OIMENSION COMM(26), ENGTRQ(20), ENGFUL(20), ENGVAC(20), ENGSTT(20)	COMMON27
37;		DIMENSION ENGSTP(20) JEFFTAB(9,9,9) JRAEFTB(11,11)	COMMONES
381		COMMON COMM, ENGTRO, ENGFUL, ENGVAC, ENGSTT, ENGSTP, EFFTAB	COMMON29
391		DIMENSION A(10) C(10)	COMMONJO
401		COMMON" AAC, FUIDL, VACIOL, NSPEED, NVEL, NTIMES, SPDINC, VELINC, TIMINC	COMMONAL
411		COMMON TFTORQ/RIEPIF/CVTTRQ/ISIM/TSNEW/BSNEW/TRICDN/T9ICDO	COMMON32
423		COMMON RE, RPP, FOBHP, TCVTLS, TCLULS, RPMIN, RPMAX, TT, TC, TF	COMMON33
43;		COMMON RASCAL,ENTORO,FORAG,EGAIN,EORAG,RAEFTB,RATKL6,DTF	COMMON34
443		OIMENSIBN GRATIB(10)	COMMON35
451		COMMON GRATIO, RMIN, RMAX, ICLUCH, CVTSCL	COMMON36
461		DIMENSION B(25)	
473		EQUIVALENCE (B(1))X(1))	
481		COMMON/FUEL/FMPGC	
491		OIMENSION CC(10), AA(10)	
501		COMMON /SUMVAR/CC/AA	COMMON
51:		COMMON/MPG/FMPG(15),CFMP(15),RN,CFMPG,RWEN,RWHP	
52:	٠		· · · · · · · · · · · · · · · · · · ·
53:		PULSE = Q+Q	•
	T		taking and stress of the stress of the stress of the stress of the stress

541	F(IENGIN .EG. 2) PULSE . 1.0	
551 +		
561		
3/1	F(FAPGE 8 0:0) GFA # 1:0/FAPGE	
591	IGPM = G&D	· · · · · · · · · · · · · · · · · · ·
601	F(CFMPG > 0+0) CGPM + 1+0/CFMPG	
611 • -		
621	0(1) = TIME	
631 . VEH	CLE DATA	•
641	(2) • YV8D	
651	(3) • YAB2	
661 - ENG		
67 <u>1</u> • ENG	ING VALA	
491	(C6) = PARC	
701)(7) # ОВЫR	
711 + FLY	NEEL DATA	
721	(8) = DF	
731	(9) • TFTORQ	
41	(IO) = FOBHP	
/51 +		
<u></u>	1/51/ 9 18PA	
AL & REA	R WHEFL DATA	
	(13) # RWWP	
101	0(14) • RWEN	
117 * ENG	NE ON/OFF PULSE	
151	(15) • PULSE	
831 + PUE	, DATA	
541	0107 V FMPUC	
861	1/1/ • Wrn 1/18) - CEMOG	
871	119) • CGRM	
881	(20) . RABER	
891 .		
901	3(21) • CC(6)	
911	8(22) • T9IN	· · · ·
921 •		
331 + NUN	ACD LOCATIONS	
991	(C3) • D(E4) • D(CD) • U(U	
961	RITE(14) B	
971 +		
981	RETURN	
991		

 * *			
11		ARA PREDHE ARA	
 21		SUBROUTINE PRODUC	
- 51	Conse	SUBRAUTINE TA CALCULATE THE ISTNE DOBLARTITY DELETY AS THE VADIA	a) ca
 - 21		DAN GIRLEY OCCUPATE THE SOUNT FRODADIETTY DENSITY OF THE TAKEN	
	68484	UAN RAFELLEN E//4	
- 51		COMMON RIE, TMAX, VACMAX, VVIMI, VVILER, VVI2BR, VVI1CD, VVIM, VVI1RF	C8MM6ND1
 61		COMMON VVIMDR& VVIDRR&AVIB&AVIR&TBI1GR&AVIM&VVIFUM&VVIFUS	CBMM6ND2
71		COMMON VVISHBAVVISHAVVIAMXAVVIASAVVIICEATVIJCTATVIJIRATVIJRA	CAMMANO3
 - 61		CANNAN TVI (TW. SCALEE DELMIN. SHELW, TTD) S.DT	CAMMONDA
		COMMON TRIGER/SCALEF/SCALEF/SCALEFITIESCONT	
 31		COMMON NYEPAJKIEINVJHKPSELJMAXLINJEPAJNGEAKJIBUTJIPKNTJEBADEW	Commenue
101		DIMENSION TRINV(11), IVEPA (3DOQ)	COMMON 6
111		DIMENSIBN VMIN(2), VMAX(2), VINT(2), NDIM(2)	COMMBN07
 12:		DIMENSION DACCON(15) ADCCON(15)	COMMONOS
131		DIMENSIAN THICH (14)	CAMMANOS
 101		Autoration Interction	CAMMANIA
141		COMMON TELNY	LOWWEN10
151		COMMEN IVEPAJVMINJVMAXJVINTJNDIMJDACCENJADCÇENJTVICRL	COMMONI1
 161		COMMON TIME,NRUN;INDIC;NREC;NFUEL;ICLOCK;ICLOKo;TS;BB;BBHP;TBRO	COMMON12
171		COMMON SSTORDAESDOTAPAOCAPAONAPPOBATAOCATAON	Common13
 141		CAMMAN THIC. THIN. THON. THAC. THAN	CAMMAN1A
101		COMMAN TALL TALL TO NO LOUGH WAR AVE AVE AVE AVE TVENT AVE VENT AND	CAMMANIS
 121		COMMON 1311,1311GR, VUB3, VVGA, VVGD, AVIO, AVIS, TYIMJ, VVDP, VVDMI JFAOFR	COMMONIO
201		COMMON FUELE/ITICYC/ICLDK1/ISHIFT/WHLSLP/WHLSLD/	COMMENIE
21:		COMMON ICYENDINLINE, ICYCLE, NGIINGIOLD, YEPA, YANALG, PAOFRO, VVOAO	COMMON17
 221		COMMON VYOSO, DELTA, DELTA ISEQ, IGO, ESDOTO, IGEAR	COMMON18
231		FRUIVALENCE (DISTAVYAD) + (BSAVYIBBR)	COMMON19
 241		DINELONG AND PERMETANA CONCENTANA ATADACIANA VADIANA VIDIZA ANVALTIEN	CammaN20
571		DIMENSION FILME(OU)/EDFED(OU)/ATDROS(OU//WRKID)/ATEC//WOLIAIO/	COMMONEY
 521		DIMENSION VAL(2) INLT(2) INGT(K) IPDA(20) 2011 ISPEED(2011) IMMAA(3)	LOMMONEI
261		DIMENSION TIMLEN(5) TIMAVG(5)	COMMONZZ
271		COMMON VAR;X;NVOLT;VAL;NLT;NGT;IPDX;ISPEED;TIMMAX;TIMLEN;TIM4VG	COMMON23
 281		EQUIVALENCE (FTIME(1)) X(66)); (ESPEED(1)) X(1D6)); (ATORQS(1)) X(166))	COMMON24
291		CAMMAN TALDS, TALDS, TALDS, TSW1, TSW2, TSW3, TENGNA, TENGIN	CAMMAN25
 671		COMMON TOLUTITOLOGI TOLUGATONIA DENERAMINASI TOLOGI TOLOGI TOLOGO DE DE	CAMMAN34
301		COMMON EANTRESPININGSRIPSRINKSDEDOTSGNOSFGNOSINGIDESTSICOSKSDE	
311		DIMENSION COMM(26) JENGTRQ(20) JENGFUL(20) JENGVAC(20) JENGTT(20)	COMPONE?
321		DIMENSION ENGSTP(2D) JEFFTAB(9,9,9) JRAEFTB(11,11)	COMMONSE
331		COMMON COMM, ENGTRO, ENGFUL, ENGVAC, ENGSTT, ENGSTP, EFFTAB	COMMON29
 341		DIMENSION ALLOY CLID)	Camman30
351		CAMMAN ALC. FUIDL VACIDL NRPEED NVEL NTIMES SPDING VELING TIMING	Common 31
 301		CONTRA ACTIVITY TALING ANTRA CONTRACTOR CONTRACTOR TATANA ANTRA ANTRA	CAMMAN 39
301		COMMON IN IDREARIEFILACAT INCAL INCAL SUCH DOUGHINICHALAND	Commonue
371		COMMON REARPAROBAPATOVILAAICLULGARMMINARMAXAJIAICAIM	Lommonaa
 381		COMMON RASCALJENTOROJEDRAGJEGAINJEDRAGJRAEFTBJRATKLSJDTF	COMMON34
391		DIMENSION GRATIO(10)	CBMMBN35
 -201		COMMON GRATIO, RMIN, RMAX, TELUCH, CVTSCL	COMMONSA
441			
 741	L++++	THIS CONDECTIVE ALL OUT LEFE THE LEASE DEEDERT THE PERIOD	
421	Chese	THIS SUBROUTINE CALCULATES THE JOINT PRODADILITY DENSITY OF THE	
431	C+++*	SPECIFIED FUNCTIONS DURING THE DRIVING CTLLE. THE PROGRAM	54 C
 441	C+++*	VARIABLES ARE AS FOLLOWS,	
451	Course	INPUT VARIABLES	
 641	6	VALUTIN	
47.	Conner	VAL 23 A CONCENT VALUE OF SECAND SPECIFIED VALUES	
 7/1		THELEPTTY UNALL VICTOR OF OCCUR AFECTIVE ABSTROFE.	
481	6	A A A A A A A A A A A A A A A A A A A	
491	C====	NUT(I) ++ HUMBER OF SAMPLES BELOW SPECIFIED MINIMUM FOR EACH VARIAD	LLP
 501	C = = = =	NGT(I)===NUMBER OF SAMPLES ABOVE SPECIFIED MAXIMUM FOR EACH VARIAD	
511	Crees	IPDX(1,J) . INTEGER TABLE OF PROBABILITY DENSITY DISTRIBUTION.	
 52			
82.	6	VMTNETAL-COCCUTCATION AND TAKING CACU VADIARIES	
231	00000	ANTIATIA-OFFICIENTED MINIMAN NOK CARM ANTIAREA	· · · · · · · · · · · · · · · · · · ·

541 C VMAX(I)BRECIFIED MAXIMUM FOR EACH VARIABLE, 551 C VINT(I)SPECIFIED INTERVAL LENGTH FOR EACH VARIABLE. 561 C INTITABLE INDEX FOR FIRST VARIABLE. 571 C+ INTITABLE INDEX FOR SECOND VARIABLE. 581 C+- THE JOINT PROBABILITY DENSITY IS DETERMINED AS A PERCE	INTAGE AT THE
59; COOOF END OF THE CYCLE IN JPBHYBO 40: A	
611 + DETERMINE RANGE OF VALUES	
63: IF(VAL(1), GT. VMAX(1)) NOT(1) # NGT(1) + 1	E
64: IF(VAL(2) ,LT. VMIN(2)) NLT(2) + NLT(2) + 1, RETURN	
601 IP (VAL(2) OUTO VMAX(2)) NUT(2) U NUT(2) V IJ RETURN	
671 C DETERMING THE TABLE INDICES FOR EACH OF THE VARIABLES 681 C BY THE INTERVAL IN WHICH THE VALUES FALL.	AS DETERMINED
69: 70: 70: 71: 70: 71: 71: 71: 71: 72: 72: 72: 72: 72: 72: 73: 74: 74: 74: 74: 74: 74: 74: 74	
731 RETURN 741 END	

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11 •	eeee PRINTV +eee	
21	SUBROUTINE PRINTV	
3: 4	MOOIFIED 2 NOV 1976	
<u>#</u> E *	CAMPAN DIE PHLY VIENLY VUINT DUTIER VUIRDE DUTIES VUIN DUTIES	Caunalia
31	COMMON RIESTMASSYALMASSYALMASSYALMASYAVILPRSVAILPRSVAILPRSVAILOSSYAVILOSSYAVIL	COMMONUL
<u>81</u>	COMMON VVIMORIVVIORAJAVIBJAVIBJTBIIGRJAVIMJVVIFUBJVIFUBJ	COMMONUZ
71	COMMON VVISWB/VVISH/VVIAMS/VVIAS/VVILCE/TVIJCT/TVIJTR/TVIJRA	COMMONOJ
81	COMMON TYIJTWISCALEFIDELMINAFUELWTITIDLESUT	COMMONOS
91	LOHMON NYEPA, KIEINV, HRPSEC, MAXLIN, EPS, NGEAK, IGUT, IPRNT, LOADEG	COMMONDO
101	DIMENSION TRINV(11), IVEPA(3000)	COMMON 6
111	OTMENSION VMIN(2), VMAX(2), VINT(2), NDIM(2)	COMMONO7
121	DIMENSION DACCON(15) ADCCON(16)	COMMONOS
131	DIMENSION TVICEL(16)	COMMONQO
141	COMMON TRINV	COMMON10
15;	COMMON IYEPA, VMIN, VMAX, VINT, NDIM, DACCON, ACCCON, TVICRL	COMMON11
161	COMMON TIME, NRUN, INDIC, NREC, NFUEL, ICLOCK, ICLOKD, TS, BS, OBMP, TORO	COMMONIZ
171	COMMON SSTORQJESDOT, PAOC, PAON, PPOB, TAOC, TAON	COMMON13
18;	COMMON' TRIC, TRIN, TEDN, TRON, TRON, TRON	COMMON14
191	COMMON T911, T911GR, VVOS, VVOA, VYOD, AVIO, AVIS, TYIMJ, VVDF, VVDMI, PAOF	RCOMMON15
105	COMMON FUELE, ITICYC, ICLOSI, ISHIFT, WHLELP, WHLOLO	COMMON16
21:	COMMON ICYENDINLINEIICYCLEINGIINGIOLOIVEPAIYANALGIPAOFROIVVOAD	COMMON17
551	COMMON VVOSD/DELTA, DELT, ISEG, IGO, ESOOTO, IGEAR	COMMON18
231	EQUIVALENCE (DIST/VV00)/(BS/VVIBBR)	COMMON19
241	01MENSION FTIME(60) & ESPEED(60) & ATBROS(60) & VAR(10) & X(225) & NVOLT(15) COMMON2Q
251	DIMENSION VAL(2)/NLT(2)/NGT(2)/IPOX(2D/2D)/ISPEED(2D)/TIMMAX(5)	COMMON21
261	DIMENSION TIMLEN(5), TIMAYG(5)	COMMON22
271	COMMON VÁR, XANVOLTA VALANLTANGTA IPDXA ISPEEOATIMMAXATIMLENATIMAVG	COMMON23
281	EQUIVALENCE (FTIME(1) x (46)) x (ESPEED(1) x (106)) x (ATOROS(1) x (166)	COMMON2A
291	COMMON IOLD1, 10LD2, 10LD3, ISW1, ISW2, ISW3, IENGNO, IENGIN	COMMON25
301	COMMON EINTRO, FINTRO, RIF, RFINR, DFOOT, GNU, FGNU, TROIDL, TOICD, R, DF	COMMON26
311	OIMENSION COMM(26), ENGTRO(20), ENGFUL (20), ENGVAC(20), ENGGTT(20)	COMMON27
321	QIMENSIAN ENGSTP(2D) FEFTAB(9,9,9) RAEFTB(11/11)	COMMON28
331	COMMON COMMAENGTRO, ENGEULAENGVACAENGETAENGETAEFEFTAB	COMMON29
341	OTHENSIAN A(10) C(10)	COMMONSO
351	CAMMAN ASC. FUTOL VACIOLANSPEROANVELANTIMESASPOINCAVELINCATIMINC	COMMONSI
341	CAMMAN TETRODELEDIE CUTTEDAISIMATSNEW BSNEW TOLCONATOLOGA	CAMMAN32
37:	COMMON RP. DPP. FORHP. TOVI S. TOLUL S. RPMIN. RPMAX.TT.TC. TF	COMMAN33
	COMMON RASTAL FITTERA FORAS, EGAIN, FORAS, RAEFTS, RATH STOTE	COMMON34
39,	OTMENSIAN GRATIA(10)	Common35
	CAMMAN GRATA, DMAY, TOLION, CVTRC	CAMMON34-
401		
	CAMAGE /GUTPT/ DATAS/JAAIN)	
761	DIMENTAL CODESCION	CAMMAN
······	CAMAGA (FERER (10)	COMMON
771	COMMON / FLYCE/VERTF	CAMMAN
401		
401	DIMENSION LE(10)/AA(10)	COMMON
471	COMMON /SUMVAR/EL/AA	LONDON
481	COMMON /GEARAI/AICVT	
491	COMMON /DELAY/TBDTMS/TBDTW	
50;	COMMON/ACCELN/AEPA	
51:	COMMON /PR/VVDFN	
52:	COMMON / GRINIT/INEXT	

53: •

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		* *		FREMAT/UC1	
-		991 881	900	FORMATING, F.J. 2.27. JUTGING A FARARY AND FARARY AND	
		201	330	19.9.79.7910101101-7202222777027700770072220000000000	
	-	871	- 1000	FARMAT(SHDANA,F5,44,SHT8DNB,F5,24,SHT9INE,F5,24,SHT9IL+,F5,3)	
		581	1020	FARMAT (SHPAACE+F5, 2X, 7HT9ICDN++F5,2X+5HT9ICE+F5,2X+5HT9AC++F5)	•
		591	1030	FORMAT(H++48X+3HDF=+F6)	
		601	1050	FORMAT (6HVVDM1=+F7,2X,6HVVIM1=+F6,2X,6HTVIMJ=+F6,1,2X)	
		611	-	1 THSSTORQ#, F5,2X, THENTORQ#, E12.5,8X, THTFTORQ#, E12.5,8X,	
		621		2 7HCVTTRQ=, E12+5)	
		631	1070	FORMAT(4HGNU=,F4+3,2X,5HVEPA=,F5+1,2X,3HRP9,F5,2,	
		641		L 2X/4HRPR+2F5+2/2X/2HR+/F5+2/2X/5HAEPA+/E9+3/2X/	
		65;	1	2 58VVDF=,E11.4,3X,68VVDFN#,E11.4,2X,7HRATKLS=,E10.3)	
		661	•		
		671		PRINT 980	
		681		PRINT 990, TIME, T911GR, IGEAR, INEXT, ICLUCH	
		691		PRINT 1000, PAGN, TBON, TYIN, TYIL	
		701		PRINT 1020, PABLATAILON, TAILATAGL	
		713		PRINT 1030,00 P	
		761		PRINT TOODY ADDITY ATDITY TOTO SO TO ASEN TA ASENT	
		131		DETIDN	
		101		PIA.	

	11		AAAA RAEFFH AAAA		
	21		SUBROUTINE RAEFFH		
	31	C+++*	SÜBRƏÜTİNE TƏ CƏMPUTE REAR AXLE TƏRQUE LƏSS		
	- 41	Cenee	R+R+RADTKE 3/3/75		
	5;		COMMON RIE, TMAX, VACMAX, VVIMI, VVILER, VVI2BR, VVIICD, YVIM, VVI1RF	CammeNQ1	
	61		COMMON VVIMOR, VVIDRR, AVID, AVIR, TOILGB, AVIM, VVIFUM, VVIFUS	COMMOND2 "	
	71		COMMON VVISH, VVIAN, VVIAS, VVIAC, TVIJCT, TVIJTR, TVIJRA	COMMONO3	
	83		COMMON TVIJTWASCALEFADELMINAFUELWTATIDLEADT	CammanD4 -	
			COMMON NYEPAJKIEINY MRPSEC, MAXLIN, BPS, NGEAR, IOUT, IPRNT, LOADEG	LOMMONDO	
	101		DIMENSION TAINY(1)//YEVA(3000)	COMMON O	
	4.24			CAMMANOR -	
	131		DIMENSION DACCON(15)/AUCCON(15)	CAMMANOS	
	141	· · · · ·		CAMMANIO -	
	151		COMMON IVERA VMINA VMAXA VINTANDIMA DACCONA ADCCONA TVICEL	Camman11	
	181		COMMON TIME ANRUNAINDICANRECANFUELAICLOCKAICLOKOATSABBABBHPATORO	COMMON12-	
	171		COMMON STORQ/ESDOT/ PAGC, PAGN, PPOBA TAGC, TAGN	COMMON13	
	181		COMMON T9ICAT9INATODNAT9BCAT90N	COMMON14 "	
	191		COMMON T911, T911GR, VVOS, VVOA, VVOD, AVIO, AVIS, TYIMJ, VVDF, VVDMI, PAOFR	Camman15	
-	201		COMMON FUELE, ITICYC, ICLOKS, ISHIFT, WHLSLP, WHLOLD	COMMON16	
	211		COMMON IGYEND, NLINE, ICYCLE, NGI, NGIOLD, VEPA, VANALG, PAOFRO, VVOAD	COMMON17	
	551		COMMON VYDSO/DELTA, DELT/ ISED, IGO/ESDOTD/ IGEAR	COMMONIS-	,
	231		EQUIVALENCE (DIST, VVOD), (BS, VVIBBR)	COMMON19	
	241		DIMENSION FTIME(60), ESPEED(6D), ATORUS(60), VAR(10), X(220), NVOLT(10)	COMMONEU	
	251		DIMENSION VAL(2), NIT(2), NIT(2), IPDA(60, 40), ISPEED(20), TIMMAX(8)	CANNONCI	
	201		UTERSION TIMERICONTING AND TRAVELOP	Camman22	
	5/1		TERMINAL ENERTYPETAR / FEVILANELANELANELANELANELANELANELANELANELANE	COMMAN24	
	291		CAMMAN 101 D14101 D2.101 D3.15W1415W241SW341ENGN041ENGIN	CammaN25	
	301		COMMON EINTRO, FINTRO, RIF, REINR, DEDOT, GNU, FGNU, TROIDL, TOICD, R, DE	COMMON26	
	311		DIMENSION COMM(26), ENGTRO(20), ENGFUL (20), ENGVAC (20), ENGSTT(20)	Commen27	
•	321		DIMENSION ENGSTP (2D) & EFFTAB (9,9,9) & RAEFTB (11,11)	COMMONES	
	331		COMMON COMMAENGTRO, ENGPULAENGVACAENGSTTAENGSTPAEFFTAB	CômmaN29	
	341		DIMENSION A(10) C(10)	COMMON90 -	
	351		COMMON ALC, FUIDL, VACIDL, NSPEED, NVEL, NTIMES, SPDINC, VELINC, TIMINC	COMMON31	
	361		COMMON TFTORG, RIEPIF, CVTTRG, ISIM, TSNEW, BSNEW, TSICON, TYICDO	COMMON32	
	371		COMMON RP, RPY, FOBHP, TEVILS, ICLUES, RPMIN, RPMAX, JT, IC, IP	COMMENSS .	
	381		LOMMON RASCALSENTORGSPORADSEGAINSEDRAGSRAGFIDSRATELDSDIF	CammaN35	
	371		DIMENSION BRAID(10)	COMMONSO	
	411		Animold ABA11ASUMAVA14PARASIARE	4011101100	
**	421				
	431	Cene.	CAR IN NEUTRAL		
	441	•	T911 = O+	-	
	451		IF(IGEAR 4 1) T98C # T91C/T911GRJ RETURN		
	461				
	47:	+ CAI	R NOT IN NEUTRAL		
	481		TRF#ABS(T91C)		
	49:		TRATER ASCAL		
	501		IP(TR > 1000+0) TR # 1000+0		
	21:		171NL = 171N 175/791N - 4000-01 791NL = 4000-0		
	53		CALL RAYLOS/TRATGINE ARAFFTRARATKLS)		
	331		FUEL REVEALATION STREAMER TONNELLEST		

Top of

 541
 RATKLS=RATKLS/RASCAL

 551
 C====
 COMPUTE' EFFICIENCY

 561
 TEMP=TRF=RATKLS

 573
 IF(TEMP=TRF=RATKLS)

 581
 IF(TEMP=Q=0.0)

 591
 9

 601
 790C=(T9IC=RATKLS)=T1

 613
 RETURN

 621
 END

IF (TEMP 2 0.0) T911 - TEMP/TRF T98C=(T9IC-RATKLS)+T911GR . ----------- ----____ SUBROUTINE RÁXLOS(T/S/STRA/RALS) DIMENSION TS(Z)/STRA(11/11) I=(T/100)+1 IF(I > 10) I = 10 - ---- --IP=I+1 TP=100+1 TM = TP=300+0 J=(\$/400)+1 ____ IF(J \$ 10) J = 10 SP=400+J SM = SP#0000 DØ 1 MHEI2 H=J+MH=1 TS(MM)+VAL(T2TM2TP2STRA(Ĭ2H)2STRA(IP2M)) RALB=VAL(S2SM2SP2TS(1)2TB(2)) RETURN END ----1 -----

	6 6		
11	•	SUBPOUTINE DOCTA	
¢ j		SOBROLITE RDEFA	
		PEADS TH EDAT DAYA	
	. 17	NAV 1974	
	1 <u>*</u> 1		
71		COMMON RIF, THAX, VACMAX, VVIMI, VVILER, VVI2BR, VVIICO, VVIM, VVIAR	CammanO1
		COMMON VYIMDRAVVIDRAAVIDAAVIRATBIIGRAAVIMAVVIFUMAVVIFUS	COMMOND2
91		COMMON VVISWBAVVISHAVVIAMXAVVIASAVVI1CFATVIJCTATVIJTRATVIJRA	Commonds
101		COMMON TYIJTWASCALEFADELMINAFUELWTADUMMYADT	COMMON 4
111		COMMON NYEPA, RIEINY, HRPSEC, MAXLIN, EPS, NGEAR, IOUT, IPRNT, LOADEQ	COMMONOS
12:		DIMENSIAN TAINV(11), IVEPA(3DOO)	COMMON 6
13;		DIMENSION VMIN(2) VMAX(2) VINT(2) NDIM(2)	COMMOND7
141		DIMENSION DACCON(15) ADCCON(15)	COMMONOS
151		DIMENSION TVICRL (16)	COMMONDO
161		CBMMBN TSINV	COMMONIO
171		COMMON IVEPA, VMIN, VMAX, VINT, NDIM, DACCON, ADCCON, TVICRL	COMMONII
181		COMMON TIME, NRUN, INDIC, NREC, NFUEL, ICLOEK, ICLOKD, TS, BS, OBHP, TORG	COMMON12
191		COMMON SSTERUJESDOTJPABCJPADNJPPOBJTADCJTADN	
201		COMMON TOIC, TOINITSUNATORCALORN ANTO ANTO ANTO ANTO ANTO ANTO ANTO ANT	COMPONIS ·
211		COMMON 1911, 1911, GAY YUGAYUGAYUGAYUGAYUGAYUGAYUGAYUGAYUGAYUGA	CONNONSO
221		COMMON TOPENTS ILLEGISTERSTIFT AND APARTALUY	CAMMAN17
231		COMMON VACADADE TALDETALESCALEGALESDATALESTATATA	Common18
251	1	CONTON AND DECIMPTED AND A REAVERED	Camman19
261		DIMENSION FTIME (6D) + ESPEED (6D) + ATARGS (4D) + VAR (1D) + X(225) + NV0LT(15)	CemmeN20
27:		DIMENSION VAL (2) NI T(2) NGT(2) / IPDX(2D/20) / ISPEED(20) / TIMMAX(5)	CommoN21
281		DIMENSION TIMEN(5) TIMAVG(5)	Common22
29		COMMON VAR, XANVOLTA VALANLTANGTA IPDXA ISPEEDATIMMAXATIMLENATIMAVG	COMMON23
3D 1	·	EQUIVALENCE (FTIME(1), X(46)), (ESPEED(1), X(1D6)), (ATORQS(1), X(166))	COMMON24
311		COMMON IDLD1, IDLD2, IDLD3, ISW1, ISW2, ISW3, IENGNO, IENGIN	COMMON25
321		COMMON EINTRO, FINTRO, RIF, RFINR, DFDOT, GNU, FGNU, TROIDL, T9ICD, R, DF	COMMON26
33;	1	DIMENSION COMM(26), ENGTRO(2D), ENGFUL(2D), ENGVAC(20), ENGSTT(20)	COMMON27
341	3	DIMENSION ENGSTP(2D) JEFFTAB(9,9,9) JRAEFTB(11,11)	COMMONZE
35:	1	COMMON_COMM,ENGTRO,ENGFUL/ENGVAC/ENGSTT/ENGSTP/EFFTAB	COMMON29
361		DIMENSION A(1D), C(1D)	COMMENSO
371		COMMON AAC, FUIDL, VACIDL, NSPEED, NVEL, NTIMED, SPDINC, VELINC, TIMINC	COMMONIAL
381		COMMON / EPASH/ VERUSJACELJDECELJTAJTCJTDJTJDEJTEJRIENGT	×
371			
404			
421		ACEL SACCEL SPATTEN/MPH/SEC)	
431		VCRUS_CRUISING VELACITY MRH	
- 44		DECEL-DECELERATION FT/SEC++2 ON INPUTA MPH/SEC ON OUTPUT IN EPASH	and the second sec
451		NSTOP-NUMBER OF STOPS PER MILE	
46	-c	RTLNGT=ROUTE LENGTH(MILES)	
47	1 .		
48	C .	TA TIME ACCELERATION STOPS	
49	: C	TC TIME CRUISING STOPS	
50:	: C	TD TIME DECELERATING STOPS	
51		TIDLE-TIME AT BUG STOP	
52	t •	TE TIME FOR ONE CYCLE PTIDLE+TD	
_ 53	1.4	DENUTH*LENGTH OF EACH CYCLE(MILES)	

	541			
	551	100	FORMAT(3F8.3,18,2F8.3)	
	561	98.0	FORMAT(2)	
	5/1	330	FORMATIZIARTA VALA FOLLOWSIN	,
	581	1000	FORMAT(5%/5HALCEL/4%/6HCRUIDE/5%/5HUECEL/J6%/8HBUB STOP/64%	
	691		1 SHNO STOPS/4X/6HLENGTH)	
	601	1002	FORMAT(3%,9H(MPH/SEC),3%,5H(MPH), 3%,10HFT/SEC/SEC,11%,5H(SEC),2%,	
	611		L 10H(PER MILE)+3X+7H(MILES))	
	491	1001	5 AUNTEUN ULLETTUNT/ULLETT/	
	120	1004	PORMAL (ST 10 SF 20 SF 10 F 10 F 10 F 2 SV 20	
	631	1004	PORMAT(BAJ2HTAJ8X/2HTC/8X/2HTD//A/SHDTO/BAJ2HTE/2K/BHNG BIDPS)	
	641	1005	FORMAT(5(5x,5H(SEC)),3x,7H(TOTAL))	
	651	1006	FORMAT(6F10+3)	
	661	1007	FORMAT (7X, 3HL TA, 7X, 3HL TC, 7X, 3HL TO, 4X, 6H ILNGTH, 5X, 5H IT IME, 5X,	
	471		SUTTMAY)	
		1005	- VULLURAT Redukt/2010-31	
	001	1008		
	693	1010	PORMAT(X413(17048)017)	
	70:	1015	FORMAT(6BNVEPA=, 15)	
	711	1020	FORMAT(16H++ENO EPA DATA++)	
	721	1025	FORMAT (IRDEPAL EXCEEDS 3000 VALUES!)	
	921			
	731	•	READ ADDIACT NERVES OFER NETRO OT NOT TIDE	
	_ / 41		REAU JUDIALELIVERUSS DECENTRICHTITTOLE	
	751		PRINT 980	
	761		PRINT 990	
	771		PRINT 980	
	781		PRINT 1000	
	791		PRINT 1002	
	121		BOTH TOOL ACTI VCDUC, OFFEL, TIDEC, NOTAD, PTLNAT	
	801		PRINT 1003, ACELIVERUSJOECELITIDEENSTOFICTURI	
	811		NTOTAL # TSTOPS # NSTOP#RILNOT	
	821		OLNGTH = 1.0/FLBAT(NSTOP)	
	83:	C	CONVERTS DECEL TO MPH/SEC	a register i strationalizer i -
	841		DECEL # DECEL#15+0/22+0	
		~ · ·	TABVCPUSZACE	
	0.51			
	_001			
	871		TC = 0+5=(DTD=DTD=DECEL + IA=TATALEL)	
	- 88;		TC = (3600.0+0LNGTH -TC)/VCRUS + TA	
	891		TOUTCHOTD	
	901		TE P TD + TIDIE	
			PRINT 980	· · · · · · · · · · · · · · · · · · ·
	241			•
	761			
	-231		PRINT 1000	
	- 941		PRINT 1006, TAJTCJTDJOTDJTEJTSTOPS	
-	95:			
	961		ILNGTH # NTATAL#OLNGTH	
-	97.		TTIME & NTRTAL STE	
	- 00		1174-9 0 84071 9710	
	221			
	1001		LIC - LTA & VLHUS-(TC-TA)/JODU-U	
	1011		LTO = LTC + 0.500ECEL+DTO+DTD/3600.0	
	1021		PRINT 980	
	103		PRINT 1007	
	104		PRINT 1008. I TANI TONI TON IL NOTHALTIMEATIMAX	
	105			
	1021		ERINI 260	
	106			
* 1	107 BVCL = 0+0			
-------	--	-------------------------------------		
-	1081 PTIME = 0.0			
	1091 DB 5 I = 1,3000			
	1101 IVEPA'(I) = 0			
	111: 5 CONTINUE			
	1121 •			
- ···	1131 DO 32 I PINTOTALAL			
	116: IO CENTINUE			
	117: IPTIME # PTIME # PTIME + 1.0			
	118: TUTIME • PTIME • TUT			
	1191 •			
	1201 • TERMINATE IF PTIME EXCEEDS TIMAX			
	1211 IF(PTIME > TIMAX) G0 T0 33			
		and the second second second second		
	1251 KREM IPTIME = 24KPLACE			
	1261 IF (KREM 4 1) IVEPA(KPLACE) = NVEL+4096 + ITEMP1			
	127: ITEMPI + NVEL			
	1281 IF(PTIME + 1+0 4 TRI G8 TH 10	-		
	1291 32 CONTINUE			
	1331 IF(KREM Á O) IVEPA(KPLACE) * ITEMP1			
	1341			
	1351 NVEPA # PTIME # 1+0			
	1361 NN NVEPA/2			
	137; PRINT 1015, NN			
	1381 PRINT SEU			
	1331 IF (NN 8 3000) WRITE (1023) WRITE (1023) TOES / PAULE			
	1+31 IF(K > NN) K = NN			
	1441 PRINT 1010/(IVEPA(I)/I#J/K)			
	145; 60 CONTINUE	·		
	146: PRINT 980			
	1471 PRINT 1020	-		
	1481 KETUKN			
	1421 FUO			

1; • • • • • • • • • • • • • • • • • • •	EADRA ++++
2: SUBROUTINE READRA(SIKA)	
4: 1000 FORMAT(1187-2)	
5: 1001 FORMAT(1X,11F7+2)	
61 D0 1 J#1411	
7: READ 1000, (STRA(I,J), [91,11)	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
B; PRINT 1001, (STRA(1, J), 101, 11)	
101 RETURN	
111 END	
	· · · · · · · · · · · · · · · · · · ·
· · · · · · · · · · · · · · · · · · ·	
SUBRAUTINE TREFEN (TARA) SPEED	IGEARATCL 6SAGRATIA)
3: DIMENSION GEREFF(10)	
4 COMMON /EFFGER/GEREFF	
5: DIMENSION GRATIO(10)	
61 IF (IGEAR) 4/4/11	
71 11 LONTINUE EFEEGEDEFE/(GEAD)	· · · · · · · · · · · · · · · · · · ·
91 IF(TORQ)1/2/2	
101 ITCLSS=(TORQ=(TORD/EFF))+GRATI	B(IGEAR)
11: 00 70 3	
12: 2 TCL6S+TORG+(1+EFF)+GRATIO(IGE	AR)
15: RETURN	
161 4 TCLSS+0	
17: RETURN	
18: END	
an an an an an an an an an an an an an a	
	· · · · · · · · · · · · · · · · · · ·
	URKEY
3: COMMONSUBROUTINE TO READ THE ARRAY	ISTAR! FROM HYDROSTATIC POWER SPLIT
A: C TRANSMISSION TORQUE LOSS	DATA CARDS
51 C++++TOM HAUSENBAUER 5/1975	
6: DIMENSION STAR(9,7,9)	
AL DA 1 K a 1.9	····
91 DB 1 1 m 1,9	
101 READ 20 (STAR(1) J.K) 01077	
111 PRINT 2, (STAR(1, J,K), J=1,7)	
12: 1 CONTINUE	
131 C FORMAT(7P10+2)	· · · · · · · · · · · · · · · · · · ·
15: END	
	AL
3: VALs(XeX1)+(45eA1)/(X5EX1)F41	4
AT RETURN	
5: END	
and the second sec	

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	- 1 ž	1.	AAAA TAGISU AAAA	
		-		
		C	SUBRUYINE PARTONINE FEFERINE DEAD AVEC DATES AND D.C. COFED.	
			SUDRUTINE TO DETERMINE EFFECTIVE REAR AALE RATIO AND DOSS SPEED	
	- 21	Leeue	DAN KAPELEN 107/3	
	21	· MQ1	DIFIED 24 DEC 1976	
	01	· MAJ	I RANGE OF TRINVI 40 MPH	
	71	*		
	01		COMMON RIE, TMAR, VACMAR, VVIMI, VVILFR, VVI2BR, VVIICD, VVIM, VVIIRP	COMMONU1
			COMMON VVIMDR, VVIDRR, AVIB, AVIB, TBIIGR, AVIM, VVIFUM, VVIFUS	COMMONDS
	101		COMMON VVISWB, VVIAM, VVIAS, VVIACE, TVIJCT, TVIJTR, TVIJRA	Cammanus
	111		COMMON TYIJTWASCALEFADELMINAFUELWTATIDLEADT	COMMON04
	121		COMMON NVEPA, RIEINV, HRPSEC, MAXLIN, EPS, NGEAR, IOUT, IPRNT, LOADEG	COMMONDO
	131		DIMENSION JBINV(11), IVEPA(3000)	COMMON 6
	141		DIMENSION VMIN(2),VMAX(2),VINT(2),NDIM(2)	CammaN07
	15;		DIMENSION DACCON(15) ADCCON(15)	Cammanda
	161		DIMENSION TVICEL(16)	Cammon 09
	171		COMMON TOINV	CammaN10
	18;		COMMON IVEPA, VMIN, VMAX, VINT, NDIM, DACCON, ADCCON, TVICRL	Camman11
	191		COMMON TIME, NRUN, INDIC, NREC, NFUEL, ICLOCK, ICLOKD, TS, BS, OBHP, TORG	Cemmen12
	201		COMMON SSTORQJESDOTJPAGCJRADNJPPOBJTAGCJTADN	COMMON13
	211		COMMON T9IC, T9IN, T8DN, T90C, T90N	Cammon14
	221		COMMON T911, T911GR, VVDS, VVOA, VVOD, AVIO, AVIS, TVIMJ, VVDF, VVDMI, PASF	Câmman 15
	231		CAMMAN FUELE, ITICYC, ICLOK1, ISHIFT, WHLSLP, WHLOLD	COMMON16
	241		CAMMAN ICYENDANLINEAICYCLEANGIANGIALDAYEPAAYANALGAPAAFROAVVAAD	CemmeN17
	251		COMMON VYOSO, DELTA, DELT, ISEG, IGO, ESDOTD, IGEAR	CemmeN18
	261		EQUIVALENCE (DIST/VVOD)/(BS/VVIBBR)	COMMON19
	271		DIMENSION FTIME (6D), ESPEED (6D), ATORQS (60), VAR(1D), X(225), NVOLT(15)	C8MM8N20
	185		DIMENSION VAL(2), NLT(2), NGT(2), IPOX(20, 20) JISPEED (20), TIMMAX(6)	COMMON21
	291		DIMENSION TIMLEN(5), TIMAVO(5)	CemmeN22
	301		COMMON VAR, X, NVOLT, VAL, NLT, NGT, IPDX, ISPEED, TIMMAX, TIMLEN, TIMAYO	CommoN23
	311		EQUIVALENCE (FTIME(1), X(46)), (ESPEED(1), X(1D6)), (ATORQS(1), X(166))	Cemmen24
	321	· ·	COMMON IOLD1, IOLD2, IOLD3, ISW1, ISW2, ISW3, IENGNO, IENGIN	C8MM6N28
	331		COMMON EINTRO, FINTRO, RIF, RFINR, DFDOT, GNU, FGNU, TROIDL, TOICO, R, DF	Common26
	341		DIMENSION COMM(26) ENGTRQ(20) ENGFUL (20) ENGVAC(20) ENGSTT(20)	COMMON27-
	351		DIMENSION ENGSTP(20) & EFFTAB (9,9,9) & RAEFTB(11,11)	COMMON28
	361	· ··· –	COMMON COMMAENGTROAENGFULAENGVACAENGSTTAENGSTPAEFFTAB	CommaN29
	371		DIMENSION A(10) C(10)	Camman3Q
	381		COMMON AACAFUIDLAVACIDLANSPEEDANVELANTIMESASPDINCAVELINCATIMINC	Cemmen31
	391		COMMON TFTORGARIEPIFACYTTRGAISIMATSNEWABSNEWAT9ICONAT9ICOO	COMMON32
	401		COMMON RPARPPAFOBHPATCYTLSATCLULSARPMINARPMAXATTATCATF	Common33
	411		COMMON RASCAL + ENTORO + FORAG + EGAIN + EDRAG + RAEFTB + RATKLE + DTF	Cemmen 34
	421		DIMENSION GRATIA(10)	CammaN35
	431		CAMMAN GRATIGARMINARMAXAICIUCHACVISCL	CommoN36
	44.1		FOULVALENCE (VAVVAS)	
	451			
	- 461	Cases	"THIS SUBROUTINE DETERMINES A TCORRECTED! DRIVESHAFT SPEED AND AN	
	471	Cases	'EQUIVALENT! REAR AXLE RATIO BASED ON A TABLE OF DRIVESHAFT SPEED	
	481	Cases	AS A FUNCTION OF VEHICLE SPEED OBTAINED FROM EXPERIMENTAL DATA	
	491			
	50:	Cress	THE PROGRAM VARIABLES ARE AS FOLLOWSA	
	51:		INPUT VARIABLES	
-	-52:	Cours	VV8SFAFAVEHICLE SPFED.	
	531		AUTPUT VARIABIES	
	440	-		

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	11		THE ALTON AT A STATE AND A STA		
	51		SUDROUTINE VEUTNH		
	31	C====	SUBRBUTINE TO SIMULATE VEWICLE ACCELERATION AND BRAKING DYNAMICS		
	48	C****	DAN KAPELLEN 10/73		· · · · · · · · · · · · · · · · · · ·
	51				
	61		COMMON RIE, TMAX, VACMAX, VVIMI, VVILFR, VVI20R, VVIICD, VVIM, VVI1RF	COMMONO1	
	71		COMMON VVIMDR, VVIDRR, AVIB, AVIR, TSI1GR, AVIM, VVIFUM, VVIFUS	COMMONO2	
· ·	81		COMMON VVISWBAVVISHAVVIAMXAVVIASAVVIICEATVIJCTATVIJTRATVIJRA	CBMM8N03	
			CAMMAN TVT ITWASCALEFADEL MINAEUELWTATIDLEADT	CAMMANOA	
			COMMON NUCLA DICTNU NODCOC MAY IN COS NOTA THIS TODATA AND T	CAMMANOS	
	10.		CONDUCTION PRIMITIAN INCOCO CONDUCTION PRIMITIANI PROVINCE CONDUCTION CONTRACTOR CONTRA TOR CONTRAC	COMMON 4	
	111		UTHENDIDA TAINV(11)/IVEFA(3000)	COMMON 0	
	151		DIMENSION VMIN(2) & VMAX(2) & VINI(2) & NDIM(2)		
	131		OIMENSIBN OACCBN(15) ADCCBN(15)	COMMONUS	
	141		DIMENSION TVICEL(16)	COMMONU9	
	15;		COMMON TEINV	COMMON10	
	161		COMMON IVEPA, VMIN, VMAX, VINT, NDIM, DACCON, ADCCON, TVICRL	COMMON11	
	171		COMMON TIME, NRUN, INDIC, NREC, NFUEL, ICLOCK, ICLOKO, TS, BS, OBHP, TORO	COMMON12	
	18:	-	COMMON STORQ ESOOT PABC , RAON , PPOB , TAOC , TAON	COMMON13	· · · · ·
	191		COMMON T91C, T91N, TBDN, T98C, T98N	COMMON14	
	201		CAMMAN 1911. T911GR. VVAS. VVAL VVAO. AVTA. AVIS. TVIM I. VVOF. VVOMI PARFR	COMMON15	
	211		CAMMAN FILL FITTCYC. TCLAVA. TCHTFT. WHICLE MANH ALD	CAMMAN16	
			CONTRACTORENT ANTAL A CALCARY AND A MADE	CAMMAN17-	
	284			CammaN1 E	
	231		CONTON AAOSUDELTAIDELTIISEMIIGOESUOTUIIGEAN	COMMONTO	
	541		EQUIVALENCE (DIST/VV00)/(DS/VVIDBR)	COMMONIA	
	251		OIMENSION FTIME (60) & ESPEED (60) & ATOROS (60) & AR(10) & X (20) & NVOLT(10)	COMMONEU	
	261		DIMENSION VAL(2), NLT(2), NGT(2), IPOX(20, 20), ISPEED(20), TIMMAX(5)	COMMODEL	
	27:		DIMENSION TIMLEN(5) aTIMAVG(5)	COMMONSS	
	281		COMMON VAR, X, NVOLT, VAL, NLT, NGT, IPDX, ISPEEO, TIMMAX, TIMLEN, TIMAYG	COMMON83-	
	291		EQUIVALENCE (FTIME(1), X(46)), (ESPEE0(1), X(106)), (ATORQS(1), X(166))	COMMON24	
-	301		COMMON IOLD1, IOLD2, IOLD3, ISW1, ISW2, ISW3, IENGNO, IENGIN	COMMON25	
	911		COMMON FINTROAFINTROARIF, RFINRAOFDOTAGNUAFGNUATROIDLAT9ICDARADF	Common26	
	321		DIMENSION CRMM(26) - ENGTRO (20) - ENGEUL (20) - ENGVAC(20) - ENGSTI (20)	CammaN27	
	321		DIMENSION ENGEDIZON SEETAR(9,9,9) ADAFETR(11,11)	CAMMAN28	
	- 391		CARMAN CANCENCEDO CONCENTRACIÓN CONCENTRACIÓN CONCENTRACIÓN DE CONCENTRACIÓN	CAMMAN29-	
	391		COMPONE CONTRACTOR OF OF DEPENDENCE PROBABILITE RECEPTING	CAMMAN30	
	321		OTHENSION A(10) ((10)	COMMONSU -	
	36:		COMMON AJC, FUIDL, VACIDL, NSPEED, NVEL, NTIMED, SPDINC, VELINC, IMINC	COMMONIAL	
	37:		COMMON TETORO, RIEPIF, CVTTRO, ISIM, TSNEW, BSNEW, TSICON, TSICON	COMMONJE	
	381		COMMON RP, RPP, FOBHP, TCVTLS, TCLULS, RPMIN, RPMAX, TT, IC, TF	COMMONIS	
	391		COMMON RASCALJENTORQJEDRAGJEGAINJEORAGJRAEFTBJRATKLSJDTF	COMMON34	
	-401		DIMENSION GRATIO(10)	COMMON 36	
	411		COMMON GRATIO, RMIN, RMAX, ICLUCH, CVTSCL	COMMON36	
	421		FOUTVALENCE (VAR (3) + GAINA DEL TAT)		
	431		COMMON /PR/VVOEN		
	444		EDITVALENCE (VAVAS)		
	-144		THIS CHIPRANTINE DESCONTINES THE VEHICLE ACCELERATION BASED ON THE -		
	401	Cerry	ARE DOROUTING DETERMINES ING THERE A REACE AND THE DESISTING		
	4/8	40000	VIFICACINE DE MEET INE FORGE DRIVING ING THELE AND THE RESISTING		
	481	CHOAD	FORCES. IT ALSO TESTS FOR CONDITIONS OF TIRE SPINNING ON SKIDDING	1.0	
	491		• INPUT VAKIABLES ••		
	501	C+++*	VVOS VEHICLE SPEED (MPH) .		
	511	C++++	T98C-REAR AXLE BUTPUT T©RQUE (FT=LB).		
	52:	C	VVIBBR OR BS-BRAKE SETTING (0 TO 1)		
	531	C++++	TB01GR-TRANSMISSION GEAR RATIO SQUARED.		
		· · · · · · ·			

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	541	C T9I1GR-EQUIVALENT REAR AXLE RATIO.	
	55;	C AVIS-WIND SREED (MPH)	
	561	C GRADE ANGLE (RAD)	
	571	OUTPUT VARIABLES	
	58;	C# VVOA-VEHICLE ACCELERATION (MPH/SEC)	
	591	C VVDF-VEHICLE ROAD LOAD FORCE AT TIRE ROAD INTERFACE (LB).	
	601	C WHLSLP- USED IN R. T. SIMULATION TO CONTROL TIRE SLIP NOISE GENERATOR.	
	611	• •• PROGRAM CONSTANTS••	
	621	C VVIM-VEHICLE MASS (LB).	
	631	C VVILFR-FRONTAL AREA (SQ- FT-)	
	64:	C VVIICD-DRAG COEFFICIENT.	
	65;	C VVIIRF-COEFFICIENT OF ROLLING FRICTION.	
	661	CPPP VVIFUM-CDEFFICIENT OF STATIC TIRE FRICTION (G'S).	
	671	C VVIFUS-COEFFICIENT OF SLIPPING TIRE FRICTION (GIS).	
	681	C VVIMAX-MAX VEHICLE ACCEL (G'S). CALCULATED IN INCNHB	
	691	CONTRACTOR AND VEHICLE ACCEL WITH WHEEL SPIN(GIS) CALCO IN INCOME	
	701	COPPO VVI2BROBRAKE CONSTANTO (LB).	
	711	COOP TVIJCTATVIJTAATVIJAATVIJA POLAR MOMENT OF INERTIA OF TOROUC	
	721	CO CONVERTER TURBINE, TRANSMISSION, REAR AXLE, AND REAR WHEELD	
	73;	C RESPECTIVELY(LBM-FT++2).	1 · ·
	741	C LOADEQ-A USED IN A LOGICAL. MANNER TO TO DETERMINE WHETHER	
	75:	C LOADEG- USED TO DETERMINE IF ROAD LOAD EQUATION IS OF TABLE IS USED.	
	761	C-++- OTHER PROGRAM VARIABLES-	
	771	CORPORATION FOR GRADE ANGLES	
	78;	CO IVINGOIDIAL KOIARY INERIIA OF ORIVEIRAIN REFEELED TO BEAR WHEELED	
	79:	COOPE VUDERE ISTAL RESISTIVE PORCE ACTING ON VEHICLE INCLUDING BRARESS	
	-001	LOTT VUPNING FOR AVAIADE IN SCIENCE / (19)	
	011	Content And the second state of a second state of the second state	
	001	CONTRACTOR AND AND AND THE AVAID USE BE SINE FUNCTIONA	
	841		
	85:		
	86:	40 CONTINUE	
	871	TO SET IF LOADEG TS 12 USE ROAD LOAD EQUATION - IF ZERO USE D.S. TORQUE TABLES	
	88:	1F(LCADEQ)45445446	
	891	45 I • V/10+D + 1+0	
	901	7912=•97	
	°911	TEM • V+(1+1)+10+0	
	92;	DRTORK=TVICRL(I)+(TVICRL(I+1)=TVICRL(I))+REM/10.	
- the second sec	93;	VVDF=DRTQRK+T9I1GR+T912/VVIDR	
	941	G0 T0 47	
	95:	46 CONTINUE	
	961	VVAV # V + AVIS	
	97:	VVDF=00334294+VVIICD+VVILFR=AVIM+VVAV+VVAV +	
	98:	2 VVIIRF+VVIM+(1++VVIICF+V)+VVIM+SINAVO	
	991	47 CONTINUE	
	1001	COMM ADD RESISTIVE FORCE TO BRAKING FORCE TO ODIGIN TOTAL REDISTIVE FORCES.	
	1011	COMPOSITION THE HYBRID CAR THE BRAKING FORCE IS INCLUDED IN TOOC	
	1021	VVUFOREVVUP	
	103	UNDER-TORE VYTODE VUDERD	
	1041	CALCULATE TA TATAL DATA VITO FOR A RETUR DE LA CALCULATE A TATAL	
	1041	Cares BEAR MUEELS.	
		La compose de la	

	+ +			
	11		*** VEDYNH ****	
	21		SUBROUTINE WEDANH	
	31	Ceese	SUBROUTINE TO SIMULATE VEHICLE ACCELERATION AND BRAKING DYNAMICS	
	41	C****	DAN KAPELLEN 10/73	
	51	•		
	61		COMMON RIE, TMAX, VACMAX, VVIMI, VVILFR, VVI20K, VVI1CD, VVIM, VVI1RF	COMMONOI
	71		COMMON VVIMOR/VVIDRR/AVIB/AVIB/TEI1GR/AVIM/VVIFUM/VVIFUS	COMMONOZ
	81		COMMON VVISHBAVVISHAVVIAMXAVVIAGAVVI1CEATVIJCTATVIJTRATVIJRA	COMMONO3
	91		COMMON TVIJTW/SCALEF/DELMIN/FUELWT/TIOLE/DT	COMMONO4
	10:		COMMON NYEPA,RIEINV;HRPSEC;MAXLIN;EPS;NGEAR;IOUT;IPRNT;LOADEQ	Campanos
	111		DIMENSION TRINV(11), IVEPA(3000)	Cemmen 6
	12:		OIMENSIBN VMIN(2),VMAX(2),VINT(2),NOIM(2)	CBMMBN07
	131		DIMENSION DACCON(15) ADCCON(15)	Commonos
	141		DIMENSION TVICRL(16)	Camman09
	15:		COMMON TAINY	Common10
	161		COMMON IVEPA, VMIN, VMAX, VINT, NDIM, DACCON, ADCCON, TVICRL	COMMON11
	171		COMMON TIME, NRUN; INDIC, NREC; NFUEL; ICLOCK; ICLOKO; TS; BS; OBHP; TORQ	Common12
	181	-	COMMON_SSTORGJESDOT, PAOC, RADN, PPOB, TAOC, TAON	COMMON13
	191		COMMON T9IC, T9IN, T8DN, T96C, T96N	Cemmen14
· · ·	201		¨COMMON Τ9ΙΊ,Τ9Ι1GR,VVOS,VVOA,VVOO,AVIO,AVIS,TYĪMŪ,VVDF,VVDMI,PAOFR	COMMON15
	211		COMMON FUELE, ITICYC, ICLOK1, ISHIFT, WHLSLP, WHLOLD	Cemmen16
	221		-COMMON-ICYENO,NUINE,ICYCLE,NGI,NGIOLD,YEPA,YANALG,PABFRO,VVDAO	Common 17
	23:		COMMON VVOSO, CELTA, CELTA ISEG, IGO, ESDOTO, IGEAR	COMMON18
	241		EQUIVALENCE (DIST/VVOD)/(BS/VVIBBR)	Cemments
	251		OIMENSION FTIME (60), ESPEED (60), ATORGS (60), VAR (10), X(225), NYOLT (15)	Cemman20
•	261		OIMENSIBN VAL(2), NLT(2), NGT(2), IPOX(20,20), ISPEED(20), TIMMAX(5)	CemHe321
	27:		OIMENSION TIMLEN(5) / TIMAVG(5)	CemmeN22
	~281		COMMON VAR, X, NVOLT, VAL, NLT, NGT, IPDX, ISPEEO, TIMMAX, TIMLEN, TIMAYG	COMMONS3
	29:		EQUIVALENCE (FTIME(1), X(46)), (ESPEED(1), X(106)), (ATEROS(1), X(166))	Cemmen24
	301		COMMON ICLO1, ICLD2, ICLD3, ISW1, ISW2, ISW3, IENGNO, IENGIN	COMMON25
	311		COMMON EINTRO, FINTRO, RIF, RFINR, OFOOT, GNU, FGNU, TRODL, T91CO, R, DF	Cemman26
	321	· · · ·	OIMENSIAN CAMM(26) ENGTRO(20) ENGFUL (20) ENGVAC(20) ENGSTT(20)	COMMBN27
	331		DIMENSION ENGSTP(20) = EFFTAB(9,9,9) = RAEFTB(11,11)	Cemman28
	-341		COMMON COMM, ENGING, ENGFUL, ENGVAC, ENGSTT, ENGSTP, EFFTAB	COMMON29
	351		DIMENSION A(10) (C(10)	Cemmen30
	361	· ·	COMMON AAC, FUIDLAVACIDLANSPEEDANVELANTIMESASPDINCAVELINCATIMINC	Cemman31-
	371		COMMON TETREGARIEPIEACVITEGAISIMATSNEWABSNEWATSICONATSICO	COMMON32
	381		COMMON RP, RPP, FOBHP, TCVTLS, TCLULS, RPMIN, RPMAX, TT, TC, TF	Cemman33
	391		COMMON RASCALSENTOROSEDRAGSEGAINSEORAGSRAEFTBSRATKLSSOTF	CammaN34
	-101		DIMENSION GRATIO(10)	Cemman35
	411		COMMON GRATIDARMINARMAXAICLUCHACVISCL	CemmeN36
	12		FOULVALENCE (VAR (3), GAIN, OFLITAT)	i si si sis
	431		COMMON ZPRZVVOFN	
·	441		EQUIVALENCE (VAVVOS)	
	451			
	164	-C++++	"THIS SUBROUTINE DETERMINES THE VEHICLE ACCELERATION BASED ON THE -	
	471		DIFFFRENCE BETWEEN THE FORCE DRIVING THE VEHICLE AND THE RESISTIVE	
	481	Canan	FORCES. IT ALSO TESTS FOR CONDITIONS OF TIRE SPINNING OR SKIDDING	10 · · · · ·
	491		INPUT VARIABLES.	
	501	Crees	VV8S+ VEHICLE SPEED (MPH)+	· · · · · ·
	511	Creas	T98C-REAR AXLE SUTPUT TORQUE (FT-LB).	
	-52	Contra	VVIBER OR BS-BRAKE SETTING (0 TO 1)	
	531	C+++	TB01GR+TRANSMISSION GFAR RATIO SQUARED.	

54	Coose TYTIGREGUIVALENT REAK AXLE RATID.		
55	C AVIS-WIND SREED (MPH)		
20	Coord GRADE ANGLE (RAD)		
57	* Y*OUIPUT VARIADLES**		
	LANNE VYDA-YEHILE ALLELERATION (MEMOSEL)		
53	- CHART YUD YURILLE KDAD LUAD FORLE AT TIKE RDAD INTERFALE ILDI.		
60	Comme and the state of the stat	at address - base	
01	• ••FROMAN CONSIANIS•		
	Correction And And Crosses and		
63	COOPER VYILL REFRONTAL AREA (SWE F10)0		
	Const VVILDECRAG COEFFICIENTS		
65	CARACTERISTIC CONTRACTOR AND AND AND AND AND AND AND AND AND AND		
00	Const Wirderetterterter a constant the Frician (G'S),		
67	Come VVIPUSECDEFFICIENT OF SCIEPING TRE FRICISON (GIS):		
60	Coose Vyinaxemax Vehicle Aleel (B'3) CALULAIED IN INCHIO		
69	Coose VVIADORAA VEHICLE ALLEL WITH WHEEL SPIN(GID) CALL IN INCOME		
. 70	COMMENT AVIZOR BRAKE CONSTANTS (LOJS)		
71	COMPANY AND THE PROPERTY OF THE AND AND AND AND AND AND AND AND AND AND		
. 76	COMPERIER TURDINES INANDAISSIONS READ AALES AND READ HAREES		
73	COOPER RESPECTIVELT (LUMOPTICAL) MANIER TO TO DETEND		1.1
	CASSS LAADEWSA USED IN A LOGICAL MANNER IN TO VEIERNINE WHETHER		
75	Come DADER BREDIN VETERNINE IF RAN LOAD ENDIENDATION IS OF TABLE, IS USED		
	CALLS CINCK FRUCKAN VARIASLESSEN FRU COADS AND 5.		
7/	, CEPT SINAYGASING AFFRONIDATION FUR GRADE ANGLE.		
70	Come lyingeidial rotary incrite of origeidaly relacing in dear preserved		
/ 3	CARTY YOURDRY IGIAL RESISITYE PERCE ACTING ON TERICE INCOURNE DRAKES		
82	Const Alberteld's Heating Hass of Astrock (d.s.)		
81	CARRY APPRAYIMATE GRADE ANGLE TO AVAID USE OF SINE FUNCTION.		
84	SINAVORAVICA(1.=AVIC(4.))		
85	WHI SI PBO.		
86	40 CONTINUE		
87	Const IF LOADEQ IS 12 USE ROAD LOAD EQUATION. IF ZERO USE D.S. TORQUE TABLES		
88	IF (LOADEQ) 45, 45, 46		
89	46 I = V/10+0 + 1+0		
90	T912#+97		
91	REM # V-(1+1)+10+0		
92	DRTORK#TVICKL(I)+(TVICKL(I+1)=TVICKL(I))*REM/10.		
93	VVDF=DRTQRK+T9I1GR+T9I2/VVIDRR		
94	G0 T0 47		
	46 CONTINUE		
96	VVAV V V AVIS		
97	VVDF=.03342944VVI1CO4VVILFR+AVIM+VVAV+VAV +		
98	; 2 VVI1RF+¥VIM+{1++VVI1CF+V}+VVIM+SINAVB		
99	47 CONTINUE		
100	C ADD RESISTIVE FORCE TO BRAKING FORCE TO OBTAIN TOTAL RESISTIVE FORCES.		
101	I CARANA FOR THE MYBRID CAR THE BRAKING FORCE IS INCLUDED IN TOBC		
102	YVDFBR*VYDF		
103	CO DETAIN NET FORCE AVAILABLE TO ACCELERATE THE VEHICLE.		
104	YYDPNaT9DC/YYJDRWeYVDFBR		
105	I COOPE CLUCULATE TO TOTAL ROTARY INENTIA OF THE UNIVERAIN AS SEEN AT THE		
106	I COMMAN REAR WHERES:		

		· ·
1071		T9I = T9I1GR+T9I1GR
108:		TB01GR # ReR
109:		TVIMJa(TVIJCT+TVIJTR)+TB01GR+T9I + TVIJRA+T9I + TVIJTW
1101	· C	DETERMINE THE INERTIAL MASS SETUE VEHICLES
4 4 4 4	G	
4444		
1161		AADAT A YAATU A TATUDAAADABABABABABABABABABABABABABABABABAB
1191	Leeve	VELENTING VEHICE ALLELERATIONS
1141		AABYAADLU \AADWI
115:		
116:	Ceree	DETERMINE IF THERE ARE ANY CONSTRAINTS ON THE CALCULATED ACCELERATION
117:		
118:		1F(VVBA) 51,50,52
119:	Ceres	IF ACCEL IS NEGATIVE CHECK IF TIRES ARE SKIDDING.
1201	51	1F (VV0A/32.1739+VV1FUM) 55/56/56
1211	55	CONTINUE
1221		Well St. Pest.
1231		VVAA=_VV15/15=32.179
124.	Cooss	TE TIDES ADE SKIDDING SET DEFENTE THAT ACCUREING UNDER SUDING CONDITIONS
4951	54	TANTANIC AND ANY ANY ANY ANY ANY ANY ANY ANY ANY ANY
1041	6	CONTINUE
1201	Conne	CUDAR AFERING AFERING SECTOR REPAIRS ARING MENT THE STELL
1271		1 / · · · · · · · · · · · · · · · · · ·
158	23	VVDA V/DELTAT
1291		RETURN
1301	Ceesa	FOR POSITIVE ACCEL DETERMINE IF WHEELS ARE SPINNING.
131;	52	IF (VV0ARVVJAMX+32.1739) 50,50,62
1321	62	CONTINUE
1331		WHLSLPssla
1341	C	IF WHEELS ARE SPINNING SET ACCEL TO MAX POSSIBLE UNDER SLIP.
135:	-	VV0A=VV1A8e32+1739
1361	50	CONTINUE
137	Centra	CHANGE VEHICLE ACCLERATION FROM FISECISEC TO MPHISEC.
138		VVAA=VVAA= 681818
129		RFTIRA
1401		

E - 59

	11	eeee WINDUP eeee	
	21	SUBRUTINE WINDUP	
	31	•	
	<u>+</u> +	9 FEBRUARY 1977	
	51	·	CANNALIGAT
	61	COMMON RIESTMAXSVACMAXSVVIMISVVICERSVVICOSVVICOSVVIMIVAL	COMMONO2
	71	COMMON VEIMORAVIDRAJAVIBJAVIRJAVIRJAVIGJAVIGJAVIGUAVIFUGJAVIFUGJ	CAMMANO2
			Cammanoa
	- 71	CAMMON INIGAL OF INVIDESCE MAY IN. FRS. NGFAR. TAUT. I PRNT. I BADEO	CAMMANOS
	101		COMMON 6
	121	DIMENSION VMIN(2), VMAX(2), VINT(2), NDIM(2)	CommoN07
1	131		COMMONOS
	141	DIMENSIAN IVICEI (16)	Camman09
	151	COMMON TÔINY	Cemmen10
	-161	COMMON TYERAS VMINS VMAXS VINTS NO IMS DACCONS ADCCONS TYICRL	COMMONII
	17:	COMMON TIME, NRUN, INDIC, NREC, NFUEL, ICLOCK, ICLOKO, TS, BS, OBHP, TORG	COMMON12
	181	COMMON STORQ, ESDOTA PAOC, PAON, PPOB, TAOC, TAON	Common13
	191	COMMON T9IC, T9IN, TBON, T90C, T90N	Common14
	201	COMMON T9I1, T9I1GR, VVOS, VVOA, VVOD, AVIO, AVIO, TVIMJ, VVDF, VVDMI, PAO	FRCOMMON15
	211	COMMON FUELE, ITICYC, ICLOK1, ISHIFT, WHLSLP, WHLOLO	Common16
	22:	COMMON ICYEND, NUINE, ICYCLE, NGI, NGIOLD, VEPA, VANALG, PABPPO, VVOAO	COMMON17
	23:	COMMON VYOSO, DELTA, DELT, ISEQ, IGO, ESDOTO, IGEAR	COMMON18
·	241	EQUIVALENCE (DIST, VVOD) (BS, VVIBBR)	COMMON19
	25:	DIMENSION FTIME (60) ESPEED (60) ATOROS (60) AVAR (10) AX (220) AVOLTI	DICOMMONZO
	261	DIMENSION VAL (2), NLT (2), NGT (2), IPDX (20, 20), ISPEED (20), TIMMAX (5)	Lomman 21
	271	DIMENSION TIMLEN (5) JTIMAYG(5)	LOMMONEZ
	281	COMMON YAR, X, NYOLT, YAL, NLT, NGT, IPDX, ISPEED, TIMAX, TIMLEN, IIMAYO	
	531	EQUIVALENCE ($PTIME(1)_{2}X(40)$) (ESPEED(1))X(100)) (ATORUS(1))X(100)	//LUMMEN28
	301		CommoN24
t i	311	DIMENSION CAMPICAL ENGEDICAL ENGENICAL ENGETICAL	CAMMAN27
	321	DIMENSION ENGETHIOLOGY EFFICIENCE (14.14.14.14.14.14.14.14.14.14.14.14.14.1	Common28
		COMMAN COMMA FIGTRO FIGTI SENGVACA FIGST FIGST FIGST FIGTRA	Common 29
	351	DIMENSION A(10) ((10)	
· · ·	361	COMMON AACAFUIDLAVACIDLANSPEEDANVELANTIMESASPOINCAVELINGATIMING	Cemmen31
	371	COMMON TFTORG, RIEPIF, CVTTRG, ISIM, TSNEW, BSNEW, T9ICDN, T9ICDO	COMMON32
	38;		
	391	1000 FORMAT (H1,6/,49HFUEL EXPENDED TO REV UP FROM EPS TO ENGETP AT TO	0.0
	-901	1 9H FUELE 0, F7.5, X, 2HLB1	
	411	•	
total and have a	421	DT2 • DT/2•0	
	431	PADERO • FUIDL	
	441		
d	_451	KFINR 9 1.07KIEPIF	
ur -	491		
	- 478	REFEAT 10 WHILE UP & ENGETF(1)	-
	701	ARHP = FINTROADAN/RESSAO	
	501	PARTR = FORFED (FORFUL ANSPEED SPOTNCAPARNARDO) ARBUR	
	511	FUELE = FUELE + (PAGER) + PAGER) + DT2+HRPSEC	
	- 521	PASERO - PASER	
	531	CALL ENGUML	
	64		
	- 55t		
	56:	PRINT 1000-FUELE	· ··· ··· · ·
	57:	RETURN	
	581	END	

APPENDIX F REFERENCES

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