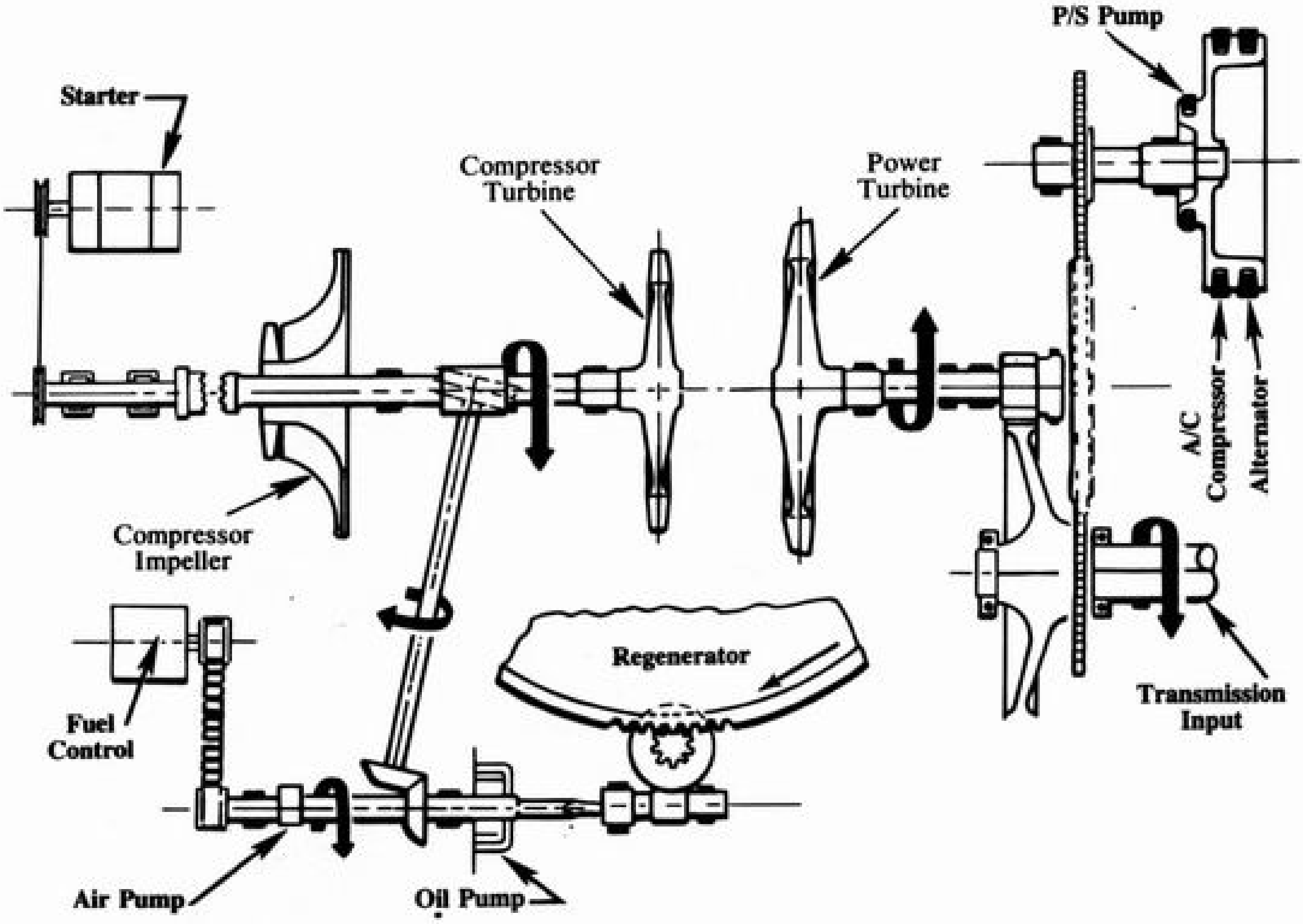
## THE SEVENTH GENERATION TURBINE ENGINE

Since the awarding of the contract, sponsorship of the program has been transferred from the EPA to the Energy Research and Development Administration (ERDA) and then to the Department of Energy (DOE), which was formed in September 1977 to consolidate the various Federal energy-related efforts.

Chrysler Corporation's sixth generation gas turbine engine was selected as most representative of the automotive gas turbine state-of-the-art at the beginning of the program, and was selected as the baseline engine for use in the development program.

Using the baseline engine, Chrysler developed and evaluated systems and components to upgrade the engine. Some of the components and concepts which were to be evaluated included combustion systems; regenerator/seal systems; integral electronic control systems; alternate turbine wheel manufacturing methods; nozzle actuators; a "free" rotor; power augmentation, including variable inlet vanes and water injection; and other efficiency improvements. Some of the components and systems were developed by Chrysler while others were developed by other subcontractors. Concepts studied and developed which were new to the automotive gas turbines were power augmentation and a "free" rotor arrangement.

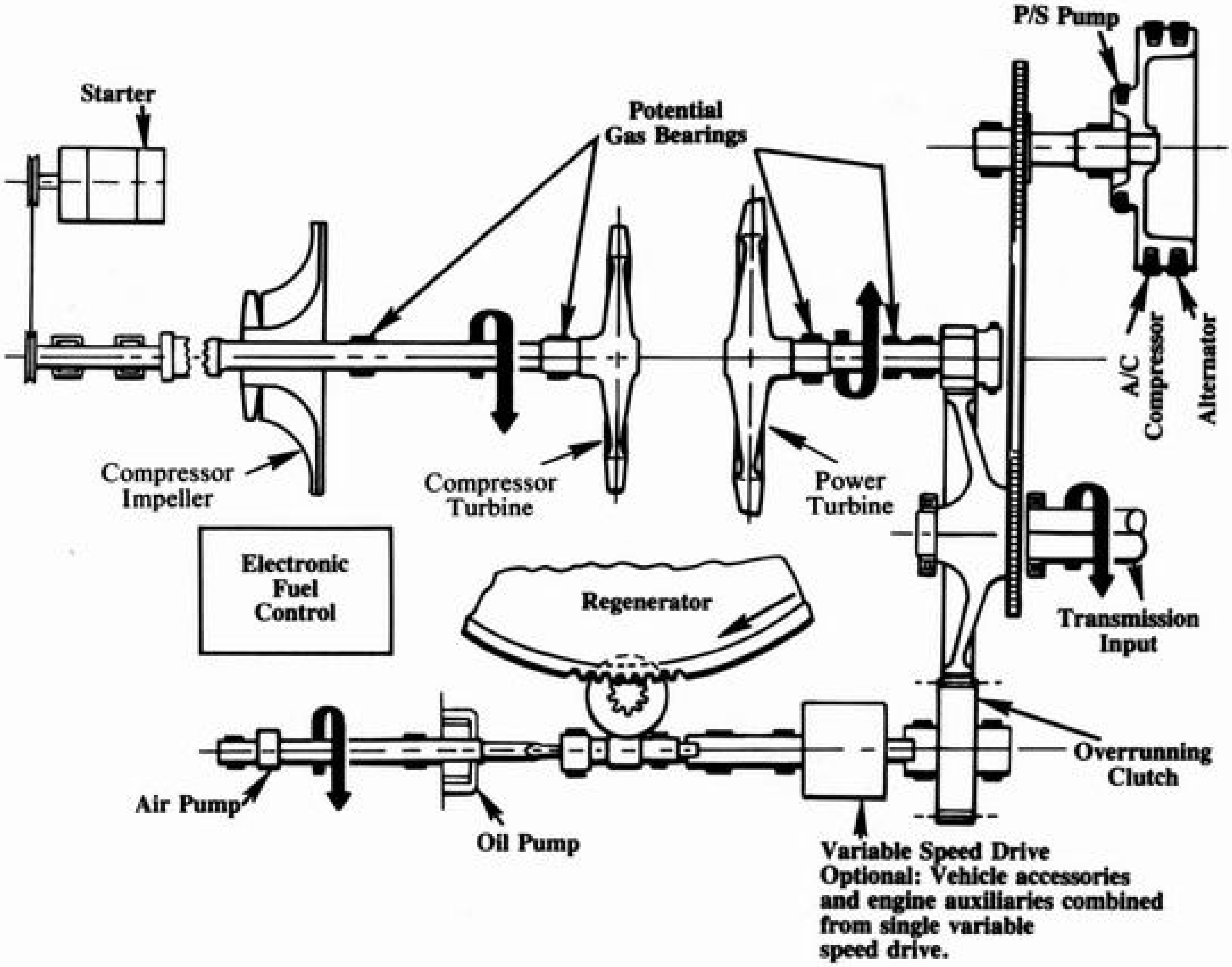
Power can be augmented by use of a water injection system and variable compressor inlet guide vanes. Under normal driving conditions the engine operates as a 104 hp (78 kW) engine and provides the higher fuel economy that is associated with lower powered engines. However, when maximum acceleration is required, performance can be increased to that of a 123 hp (92 kW) engine by use of water injection at the compressor inlet and by repositioning of the inlet guide vanes. In a gas turbine engine, power increases naturally with cooler ambient air temperatures; thus, the water injection system is needed to augment the engine power only when the ambient air temperatures exceed 60°F (15°C) so protection from freezing is not necessary.




## GEARED ROTOR CONCEPT

"Free rotor" is the identification given to a concept whereby all accessory drives (engine or vehicle) are removed from the compressor turbine shaft. The baseline engine, which uses the "geared rotor" concept, was designed with engine auxiliaries (air pump, oil pump, regenerators, fuel pump/control) driven through gearing from the compressor turbine and the vehicle accessories (alternator, power steering pump, air conditioning compressor) driven from the power turbine. Schematics of baseline "geared rotor" and "free rotor" arrangements show the differences in basic designs. Potential advantages of a "free rotor" system are:

- Improved compressor rotor response
- Reduced overall engine noise
- Simplified gas generator design
- Improved cold starting
- Ability to use gas lubricated high-speed bearings
- Improved idle fuel economy
- More efficient usage of the power turbine stage at idle.




## FREE ROTOR CONCEPT

The various improvements developed on the sixth generation engine were integrated into a new upgraded engine, called the seventh generation turbine. The seventh generation of Chrysler's gas turbine, which uses the free rotor concept, is a metal rotor technology engine, targeted to operate at about the same fuel economy as today's standard piston engines and to achieve the statutory emissions levels.

This engine development program was carried out from 1974 to 1978. In comparison with the sixth generation engine, the seventh generation engine is considerably smaller both because of its lower design horsepower, 104 versus 150 (78 - 112 kW), and its higher first stage turbine inlet temperatures, 1925° F (1052° C) versus 1850° F (1010° C). To achieve the required turbo-machinery efficiency levels in this smaller size, fundamental changes were necessary in the internal aerodynamics and design procedures. The National Aeronautical and Space Administration (NASA) is providing technical administration and support to DOE on this program.

A summary of the Chrysler/DOE turbine development program, baseline/upgraded engine comparison, and concept car/base car specifications are itemized in the following charts.

## SUMMARY OF THE CHRYSLER/DOE GAS TURBINE DEVELOPMENT PROGRAM

Contract Participants: Chrysler Corporation, Division of Transportation Energy Conservation (TEC), Department of Energy (DOE), and the National Aeronautics and Space Administration (NASA)

Contract Awarded: November 22, 1972

Purpose of Contract: To develop a gas turbine powered automobile meeting the 1978 Federal NOx emissions standards and competitive in fuel economy, performance, reliability and potential manufacturing cost with a compact size American automobile powered by a conventional piston engine.

Steps in Development of Upgraded Turbine Engine:

1. Chrysler Corporation's sixth generation gas turbine engine has established the state-of-the-art and is serving as a baseline to verify component improvements.
2. Chrysler Corporation, DOE, NASA, and other government contractors have developed and evaluated improved components.
3. Chrysler Corporation has upgraded the baseline engine by incorporating improved components and technology into a new engine.
4. Chrysler Corporation is building, testing and installing upgraded engines in vehicles for final assessment and demonstration.

Engines and Vehicles to be Provided by Chrysler Corporation:

1. Seven baseline engines. Three of these engines are installed in 1973 model Plymouth and Dodge intermediate 4-door sedans. One of the engines was delivered to NASA for upgrading and development work. The remaining three engines are at Chrysler Corporation for upgrading and development work in test cells.
2. Seven upgraded engines. Four of these engines will be used in test cells for design verification and development. The remaining two will be installed in compact size production cars (modified 1976 Dodge Aspens) and one in a Turbine Concept Car.

Components and Concepts to be Evaluated and Developed:

Combustion systems; regenerator/seal systems; control systems; turbine wheels; transmission system; a free rotor; power augmentation; linerless insulation; and efficiency improvements.

## ENGINE COMPARISON

| Specifications | Baseline Engine (6th Generation) | Upgraded Engine (7th Generation) |
|---|---|---|
| Power | 150 hp (112 kW) | 104 hp (78 kW) Base<br>123 hp (92 kW) Augmented |
| Engine Weight | 650 lb (295 kg) | 500 lb (227 kg) |
| Vehicle Test Weight | 4300 lb (1950 kg)<br>(1973 Intermediate) | 3500 lb (1588 kg)<br>(1976 Compact) |
| 0-60 mph Time | 12 seconds | 13 1/2 seconds |
| Turbine Inlet Temp. | 1850° F (1010° C) | 1925° F (1052° C) |
| Idle Fuel Flow | 10 lb/h | (2.0 kg/h) |

Configuration

| | | |
|---|---|---|
| Housing | 3-piece | 1-piece |
| Regenerator | 2 Metal | 1 Ceramic |
| Accessory Drive<br>Engine (Regen., O/P)<br>Vehicle (P/S, A/C, Alt.) | Gas Generator<br>Power Turbine | Power Turbine<br>(Free Rotor) |
| Control | Hydromechanical | Electronic |
| Transmission | 3-speed Automatic | 3-speed Automatic |
| Torque Converter | 11 3/4 in. (298 mm) diameter | 10 3/4 in. (273 mm) diameter - Lock-Up at 2-3 shift |