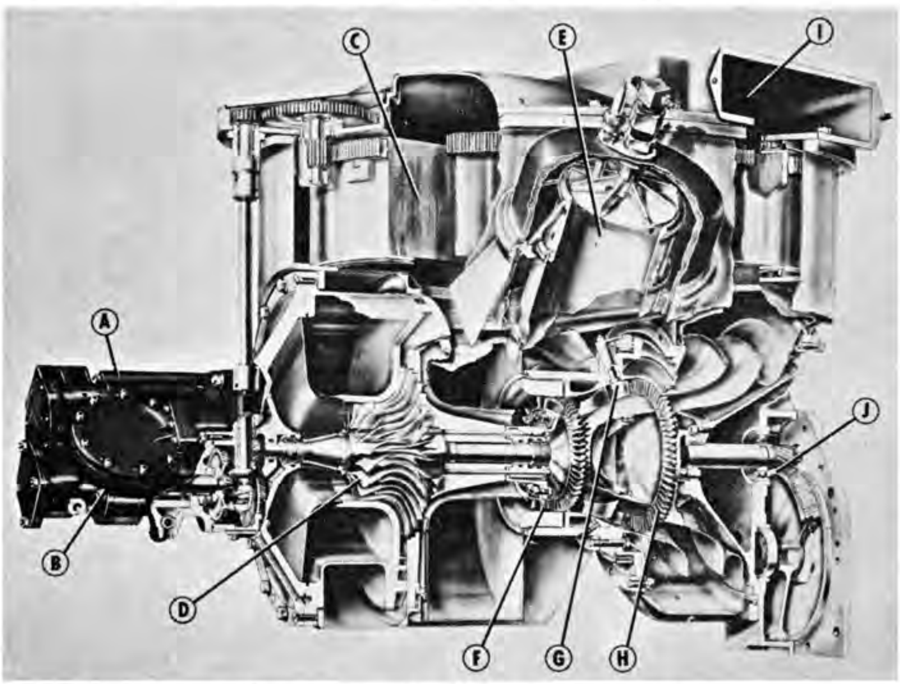
A LOOK AT THE FUTURE

CHRYSLER'S CR2A GAS TURBINE:

the "pinwheel-on-a-stick" may come sooner than we thought

Prominently displayed in the Turbo Dart's engine compartment are two barrel-like air filters behind the grille and the regenerator housing and exhaust ducts behind them. This car was used to test the CR2A experimental gas turbine on a successful cross-country engineering evaluation run.



Major components of the experimental turbine are (A) the starter-generator, (B) the fuel pump, (C) the regenerator, (D) the compressor impeller, (E) the combustion chamber, (F) the first-stage turbine which drives the compressor impeller and accessories, (G) the variable second-stage nozzle, (H) the second-stage turbine supplying power to the driveshaft, (I) one of two exhaust outlets, and (J) a single stage, 8.53-to-1 ratio, helical reduction gear which reduces power turbine rpm of 39,000-to-45,730 to a rated output of 4,570-to-5,360 rpm.

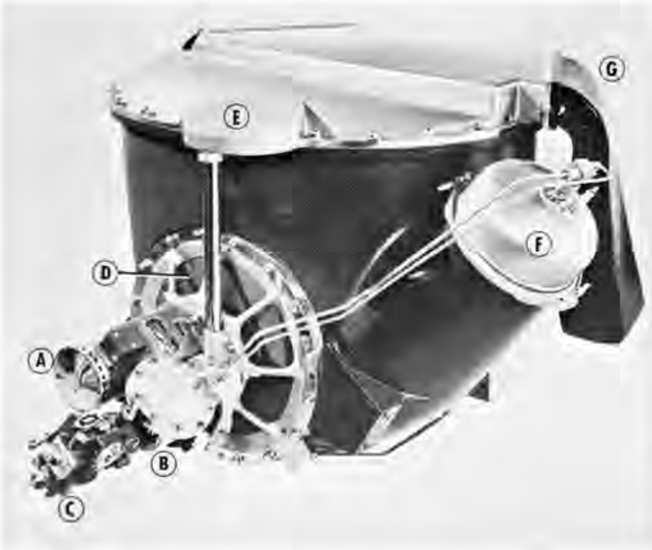
THE PISTON engine has been with us for a long time and it would be hard to expect, in view of its present stage of development, that it is going to be supplanted overnight by the gas turbine. However, the inherent advantages of the turbine are great enough to have warranted the millions of dollars in research spent on it. First and foremost is the fact that a turbine will accept almost any fuel from gasoline to kerosene, which certainly rings the economy bell. It is also an almost vibration-free powerplant. The turbine's output is continuous, as opposed to the power impulses of a piston engine, hence longer drive train life which does not need the cushioning effect of torque converters and hydraulic couplings to achieve maximum smoothness. The torque characteristics of the turbine are such that maximum torque is available for starting, or at stall point. This makes it quite akin to an engine with a built-in torque converter.

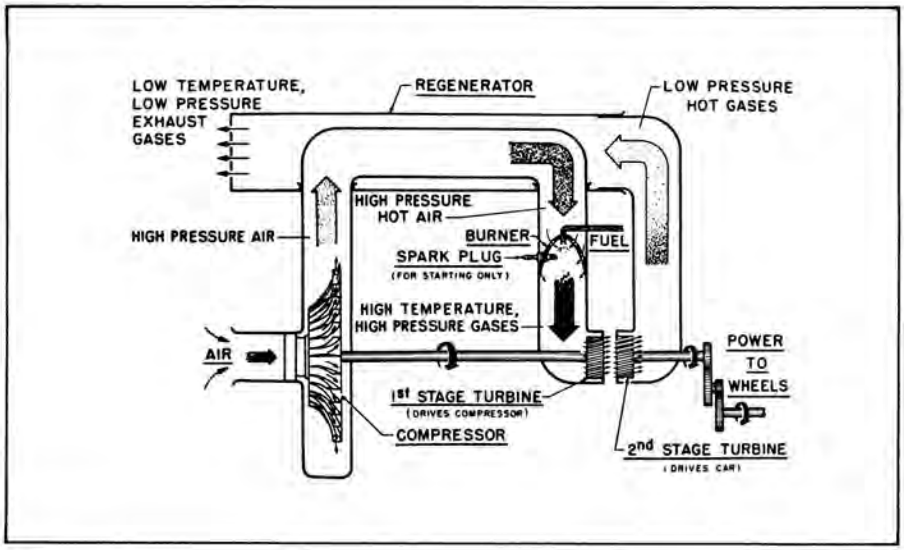
On the minus side, the turbine is far from the oversimplified conception of a "pinwheel on a stick." On the contrary, it is every bit as complex as a piston engine, and carries many built-in problems of its own. The turbine and compressor generally turn at very high speeds by current automotive standards. 30,000 to 50,000 rpm is average; gear reduction trains for accessory drives and output at those speeds are not easy to design or mass-produce. By the time several turbine stages have been incorporated to improve efficiency and reduce acceleration lag and a few extra gear trains are introduced to couple the components into a compact package, the turbine looms not only as a production but also as a service problem.

Chrysler must certainly be commended for their efforts in achieving a practical passenger car turbine. The corporation has been quite candid and honest in saying that at its present stage the turbine is still some years ahead, but that development work on its warrants a second look. While the designer of aircraft turbines operates pretty much on a cost-plus basis and feels fairly free to use exotic alloys and machining processes, the manufacturer who intends to market a turbine for passenger car use must keep his eye on cost. One of Chrysler's major breakthroughs has been to create suitable alloys that can withstand high temperatures without resorting to scarce metals at high costs.

They have also built in several features to bring fuel consumption down to very acceptable limits, even at part throttle.

Main exterior CR2A parts are (A) starter-generator, (B) fuel pump, (C) fuel control system, (D) compressor air inlet, (E) regenerator gear box, (F) combustion chamber housing a single spark plug and fuel nozzle, and (G) one of two exhaust ducts. Schematic below is worth 1,000 words in describing just what happens inside an operating CR2A gas turbine.





The gas turbine operates on a cycle which is somewhat akin to that of the piston engine. Air is taken in, compressed, and delivered to a combustion chamber where fuel is added and burned. Heat expands the gases, forcing them at high velocity against the blades of a turbine wheel after which the gases flow out of the exhaust. Intake and compression are provided by an impeller which whirls at 20,000 rpm at idle and reaches 44,600 rpm at full power. The compressor stage then delivers approximately 2.2 pounds of air per second at a pressure ratio of 4:1 to the combustion chamber.

Temperature rise due to compression amounts to approximately 300 degrees F. To save on fuel, a special heat exchanger unit called a regenerator transfers some of the waste heat from the exhaust gases to the air being fed to the combustion chamber. As a result, the temperature of the compressed air is now raised to around 1,000 degrees F. The addition and combustion of fuel in the burner section raises the temperature to 1700 degrees at the inlet of the first stage turbine, which drives the blower. By the time the gases have driven both first and second stage (power output) turbines their temperature drops to around 1200 degrees at full power. After passing through the regenerator exhaust, gas temperature has dropped to a mere 400 degrees, which certainly testifies to regenerator effectiveness (its rated efficiency is 90%). During normal cruising, the exhaust gas temperatures run at 190 degrees F, much less than that of a piston engine.

The regenerator consists of an annular matrix of large diameter which rotates very slowly in the housing. It is driven at a 2800:1 reduction ratio, and turns at a mere 18 rpm when the turbine spins at 50,000 revs. Thanks to a series of seals and partitions, exhaust gas can flow through the fine pasages in the matrix, giving off heat to the metal. As the matrix turns, the hot section then surrenders heat to compressed air flowing through it to the combustion chamber. One could liken the system to a rotating bucket wheel which picks up heat at one point and dumps it at the other end.

If the compressor impeller and the power output turbine were both anchored to the same shaft, the turbine would obviously be simpler in design. Unfortunately, it would also have a considerable acceleration lag. The turbine output depends on the amount of air brought in by the impeller, and if the impeller speed were tied to that of the power turbine we would have a case of the "tail wagging the dog." In the Chrysler CR2A gas turbine, the compressor impeller is driven by its own turbine. During acceleration, more fuel is fed to the fuel chamber raising the gas temperature. Simultaneously, a set of variable nozzles is so placed as to allow maximum output from the first stage turbine driving the impeller. Within one and a half seconds, the impeller can speed up from its 20,000 rpm idle and begin to feed increased amounts of air to the combustion chamber. The variable nozzles then direct the exhaust of the first stage against the blades of the power turbine.

The variable nozzle design adds considerably to the overall efficiency of the Chrysler turbine. It consists of a set of individually pivoted vanes disposed in ring fashion within the transition section between the two turbines. The vanes can redirect the gases so as to have either a braking effect on the power turbine blades, or provide maximum acceleration. A governor automatically points the vanes so as to achieve optimum efficiency from the turbine.

The power is relayed from the turbine through an 8.53:1 reduction gear to a modified Torque-Flite transmission from which the torque converter has been eliminated. This transmission has been modified to eliminate the neutral position, presumably so that the turbine cannot be raced without load and overspeeded (goodbye turbine). Lubrication for the accessory train at the front of the turbine is supplied through a flexible hose connection from the Torque-Flite.

The turbine-powered car is not noisy, but has a "whoosh" sound under power. Regenerator action quiets the exhaust considerably, and heat insulation around various components also contributes to sound reduction.