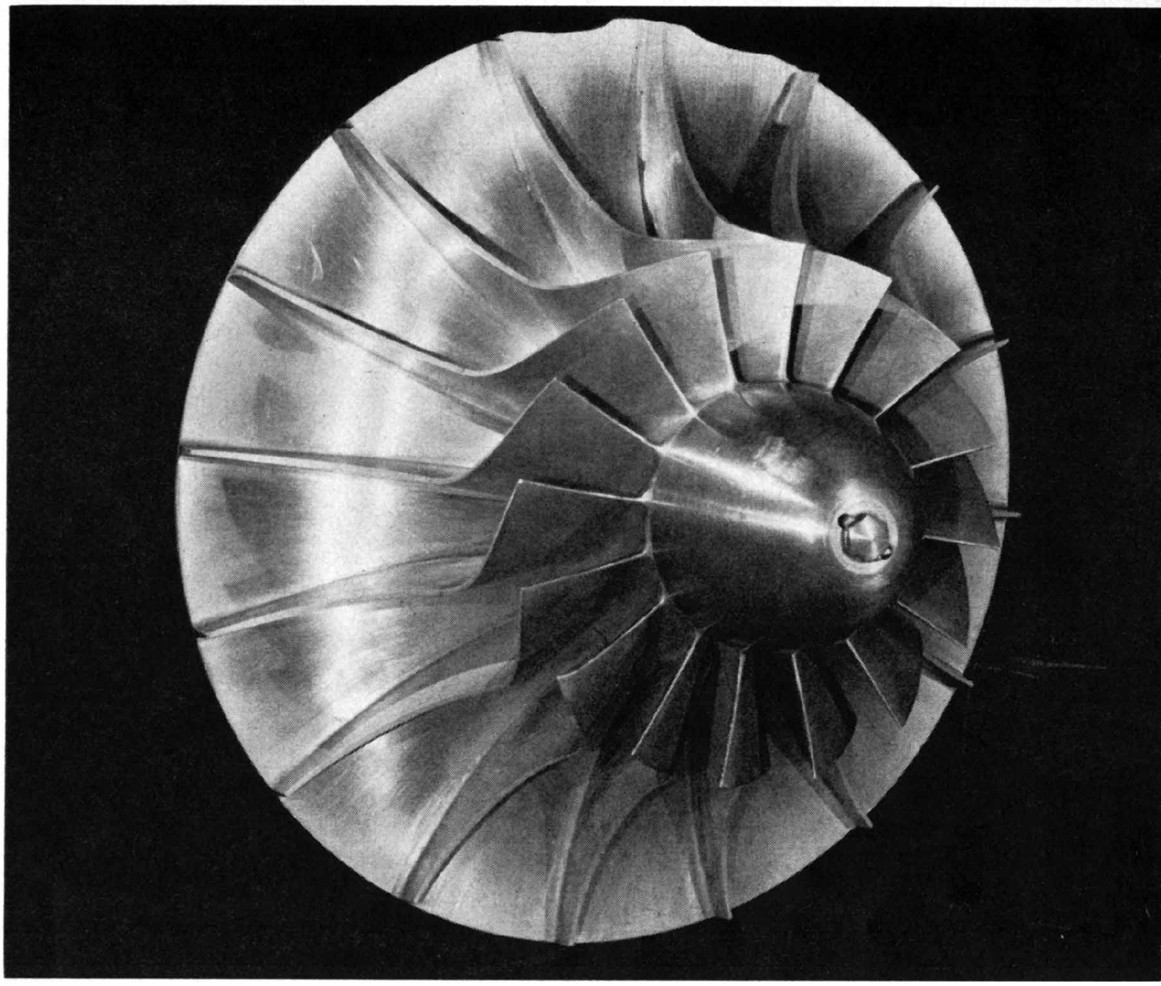


TAMING THE FAN-JET IN YOUR FUTURE

Ford engineers tackle the turbine and find some signs of promise

BY DENNIS SHATTUCK

JUST AS SUPERCHARGING is the key to impressively improved performance for the reciprocating piston engine, it also may be the key to the successful, economical gas turbine automobile engine. At least, the Ford Motor Company g.t. experts seem to think so—they're betting that this configuration will be the one to power tomorrow's trucks, and possibly cars.

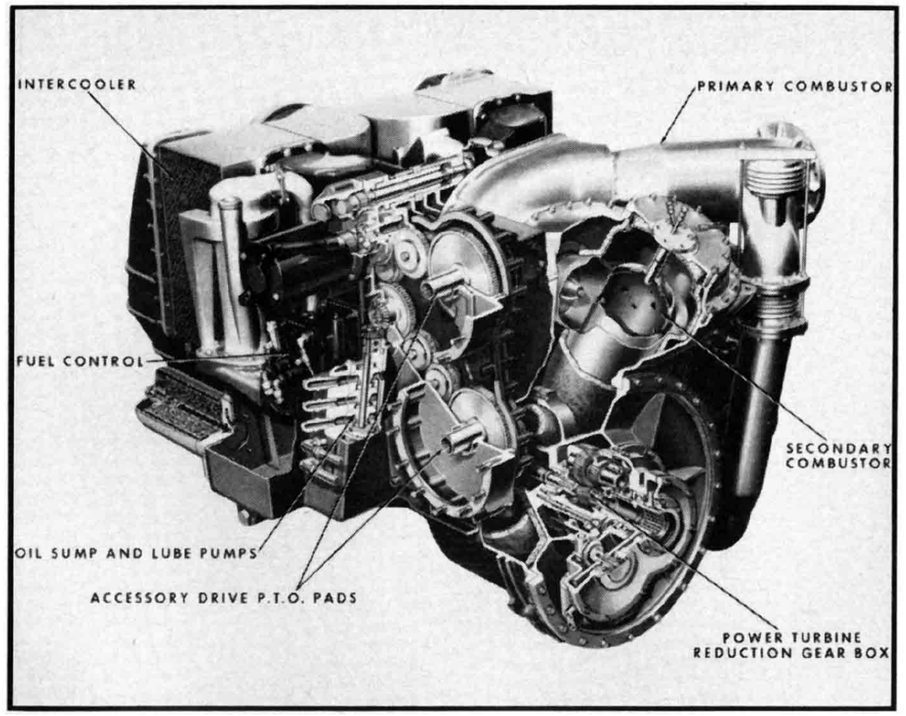
When?

C. L. Bouchard, manager of Ford's Gas Turbine Engine Department, says "8 to 10 years." Trucks, such as the Ford Engineering test vehicle we drove (pages 19-20), will be the first commercial vehicles to be so powered, Bouchard says.

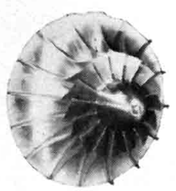
Ford has been investigating, developing and testing gas turbines since 1950. Research vehicles have included several cars and trucks, a 1955 Thunderbird, and a digital computer. Programming known factors into this latter unit, and then inserting experimental data, has helped make extensive analyses in relatively short periods of time. At Ford, the computer is a valuable and much used research tool.

The Thunderbird was used to test various transmission configurations and for a long time was equipped with a Boeing 502 g.t. for the basic power. Unmuffled (it had no regenerators), it singed ankles and shattered ears on the Dearborn test circuit. One interesting point: the g.t. needs very little in the way of a transmission, having its own built-in torque converter, and a 2-speed automatic was found to give the best performance.

An Army-Navy development contract has implemented research and resulted in Ford's Model 705, a 600-bhp engine for a variety of military installations—from a stationary power plant to a hydrofoil sea-skimmer. This project also fostered the Ford 704, a ▶



REAR AND left side cutaway shows accessory layout.



FORD TURBINE

300-bhp, commercial engine of surprisingly competitive characteristics.

The 704, in all likelihood, will be the prototype for a whole family of Ford turbines, should the use of turbine power for everyday vehicles become feasible. The 704 can be scaled up, or down, to meet a whole spectrum of power requirements.

The big problems in turbine application to wheeled vehicles are: 1) cost of the unit compared to other forms of power, 2) cost of operation, both in consumption of fuel and in longevity of service, and 3) elimination of noise and hot exhaust gases.

Ford's "supercycle," i.e., a supercharged cycle, design adds to problem No. 1, but considerably lessens No. 2 and 3. It produces more horsepower from a smaller package, too, thereby utilizing the turbine's inherent space-saving advantages. Although the 704 is not the smallest of the current specifically automotive turbines (see table), it is the best producer in terms of horsepower per pound and horsepower per cu. in. of package volume.

The supercycle is basically a 3-stage version of the conventional single-stage turbine which has only one compressor and one combustor. Ford's addition of a turbo-compressor unit pressurizes (supercharges) a second stage compressor (just like a 2-stage supercharger), to pump more air into the combustor and thereby produce more power.

On the 704 (and 705), this low-pressure compressor is driven at 36,600 rpm by a 2-phase turbine off the secondary (power) combustor. The compressor discharges into a plenum chamber which feeds the air into the intercooler. This cools the air, allowing it to become more dense, before it reaches the second compression stage at the high-pressure compressor. This twice-compressed air then passes through the recuperator, where pressure and temperature are further increased by the exhaust gases, and on into the primary combustion chamber where it is mixed with fuel and ignited, and the hot, burning gases aimed at the high pressure spool (which drives the high-pressure compressor at 75,500 rpm). Then they are packed into the secondary combustor, mixed with more fuel, and burned to produce pressure at the power wheel. After leaving the power turbine, the gases drive the low-pressure spool (which

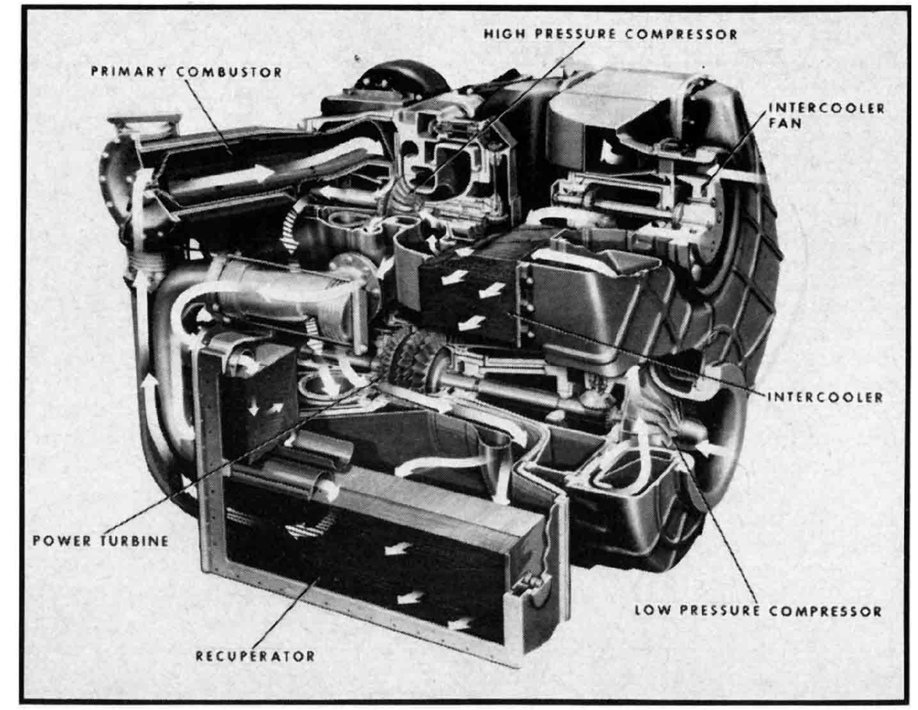
TURBINE COMPARISON

	Ford	Chrysler	GMC	Boeing
Model	704	CR-2A	Allison GMT-305	520-6
Shaft bhp	300	140	225	400
Weight, lb.	650	450	650	316
Wt./bhp	2.17	3.21	2.89	0.79
Fuel consumption (lb./hp./hr.)	0.56	0.51	0.56	0.7
Turbine inlet temp.	1700°	1700°	1700°	1790°
Exhaust temp.	600°	500°	400°	968°
Comp. ratio	16:1	4:1	3.25:1	7:1
Regen. efficiency	75%	90%	90%	n.a.
Burner efficiency	96%	95%	97%	n.a.
Turbine efficiency	85%	84-87%	85%	n.a.
Overall dim., in.	38.2 x29.3 x28.3	36 x35 x27	31 x26 x36	23.3 x16.4 x56

drives the supercharger and intercooler fan) and travel on to the recuperator where they give up heat to the incoming second-stage charge.

The power turbine shaft drives into a planetary reduction gear system which reduces the 36,600 shaft rpm to a more workable 6000 rpm. Engine accessories are driven, by spiral bevel gears, off the high-pressure spool. On the 704, this is where the oil and fuel pumps and generator are driven; on the 705, a twin power take-off is fitted.

Basically similar in operation, the 704 and 705 vary greatly in size. The 600-bhp 705 is contained in a package size of 49 x 44 x 38 in. (820 cu. in. volume vs. the 704's 317 cu. in.), remarkably small when one considers the size and weight (about three times the 705) of equivalent-bhp diesel and gasoline engines. The 705 actually is



AIRFLOW IS shown in front and right side cutaway.

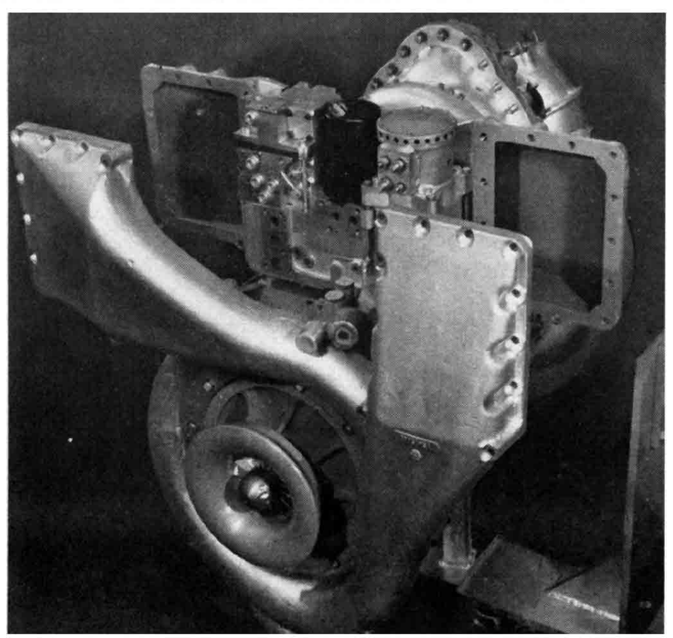
two engines in one: the main, 600-bhp unit and, with only the high-pressure section in operation, a 45-bhp auxiliary (at the two power take-offs).

For simplicity and ease of maintenance and construction, the 705 is divided into five major components. These allowed Ford engineers to develop each section separately, fully evaluating each before integrating it with the others. The next step in the 705's development, says Ford, is intensive operation and performance testing.

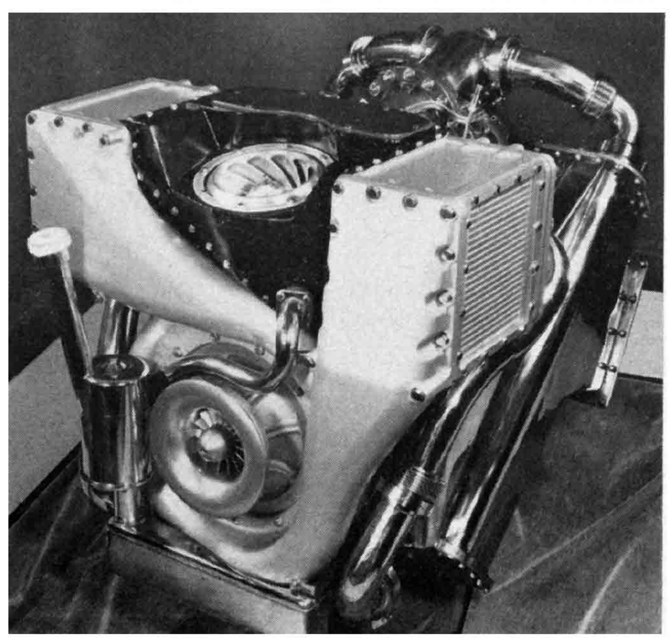
Metallurgical and aeronautical research for the 705 contributed greatly to the success of the 704. As a result of this, and the supercharger approach, the 704 components are quite small in relation to the power produced, although the rotating parts turn at a comparatively high speed. Turbine wheels, the costliest item in past gas turbine engines, are now being supplied to Ford at unbelievably low prices—less than $200 each.

The turbo-supercharging adds both to the complexity and cost of a g.t.; however, Bouchard and design/development engineer I. M. Swatman feel ►

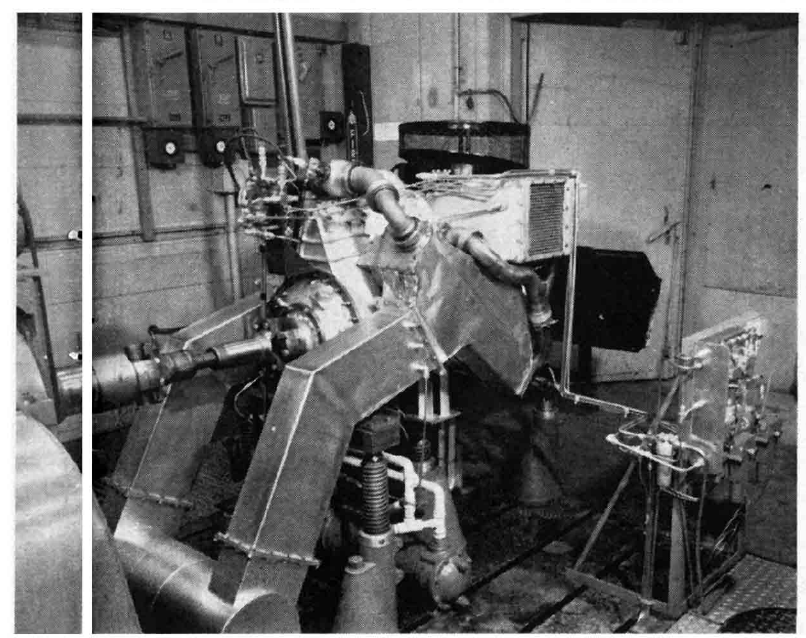
CASTINGS and compressor during build-up.



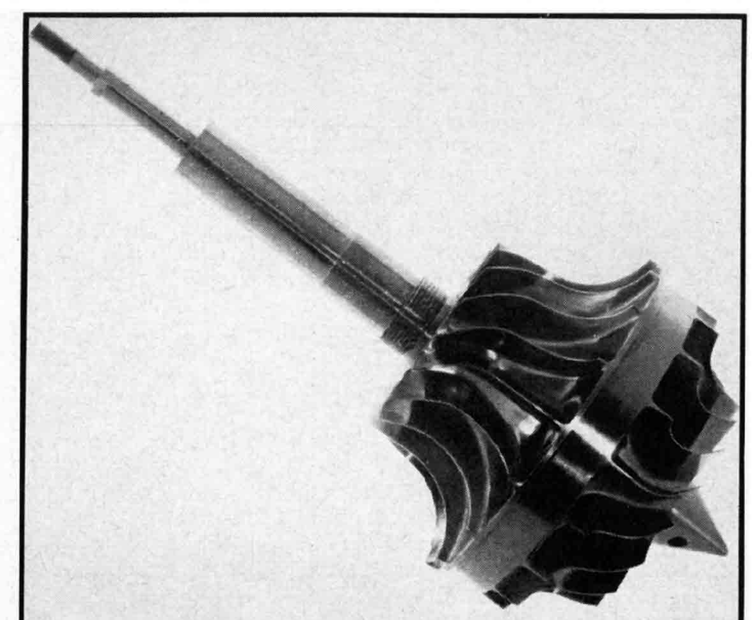
FINAL ENGINE ready to generate 300 bhp.



SPECIAL LAB used for vibration tests.



TURBINE wheel and shaft from 704.



that it is the best means of gaining the fuel economy necessary to compete with piston engines for commercial use. The 704, they say, has already achieved fuel consumption rates at least equal to, if not better than, those of diesel-powered vehicles. For this reason, they're betting on the turbine as the power to pull turnpike transports of the immediate future.

Fuel consumption is still heavy for passenger car use, although probably not much more outrageous than some of our more modern big sedans. At full rated horsepower, the 704 gulps 0.56 lb. of fuel per hour per bhp. Multiplied out, that's 168 lb., or 28.1 gal., per hour. For comparison, at 150 mph, a 400-bhp Daytona racing stocker uses approximately 33.1 gal./hr. (at 8 mpg). However, for normal highway use, the reciprocating engine is better at operating economically on part-throttle loading, so where the average car gets around 14 mpg, a g.t. probably couldn't do better than, say, 10-12 mpg.

The simple, unit construction of the 704 lends itself well to future development and Ford Engineering has a large number of test cells and labs at work on improving the various components—both individually and assembled. We witnessed one 704 test where main-shaft bearings were being evaluated. A "black box" electronic device detected any wobbling of the turbine wheel by measuring the minute electrical resistance of the air gap between the blade tips and the scroll housing. Bearing development already is satisfactory, they say, even for heavy truck use, but refinement work continues.

The Ford engineering people are cautious in predicting assembly-line application of such exotic power, but feel that they will be ready when the sales department says the public wants gas turbine engines for its cars.

Bouchard and Swatman are especially cautious about the g.t. automobile. Although the noise and exhaust problems are licked, and fuel consumption is close enough to be competitive, the engine cost is still a problem. They ask, "Would a g.t. Thunderbird, at the 'Bird's present price plus $1000 for the turbine, sell to the general public?" We don't know the answer, although we'd guess that at $5500-$6000, a g.t. car would be a pretty popular item. After all, Chrysler's sports/touring g.t. cars aren't even being sold; only leased to pre-selected "owners." ■

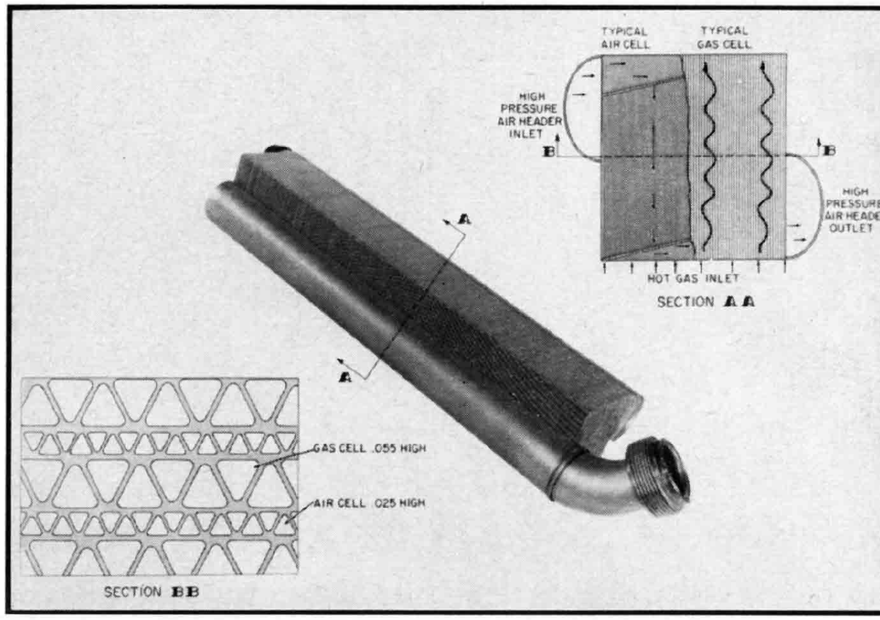


DIAGRAM OF FORD'S stationary heat exchanger (recuperator) shows in section drawings how inlet air is warmed, exhaust is cooled.

DIRECTING TURBINE program at Ford are I. M. Swatman (left), design and development engineer, and C. L. Bouchard, turbine department manager. The rotor is the heart of the 600-bhp 705 turbine in foreground.