ENGINEERING

Tornado in a Box

A new kind of engine, the gas turbine, simple, compact and economical, and operated by blowing flaming fuel against blades of wheel, may change post-war world.

By J. D. RATCLIFF

➤ UNPUBLICIZED because so much of the work has been veiled in wartime secrecy, a new kind of engine, the gas turbine, has been developed. It is the simplest and most compact engine ever invented and one of the most economical. It is already in use in scores of industrial plants and is so successful that it seems destined to be one of the things that will alter the aspect of the post-war world.

The steam engine, the steam turbine, the Diesel, the gasoline engine—successively each new means of converting fuel into moving power has created new industries and revolutionized old ones. The gas turbine seems certain to do the same.

The principle of the gas turbine is simple; it is essentially a windmill. When a stream of air blows against the blades of a windmill, the fan wheel turns and gives power to pump water or grind corn. Put the windmill wheel inside a steel cylinder and blow steam against its blades and you have the steam turbine, which drives the generators in most American electric power plants, and drives most of the world's fast ships. The gas turbine cuts out one big and expensive step. Its wheel is spun by the direct blast of the burning fuel, thus it does away with the whole elaborate steam boiler apparatus.

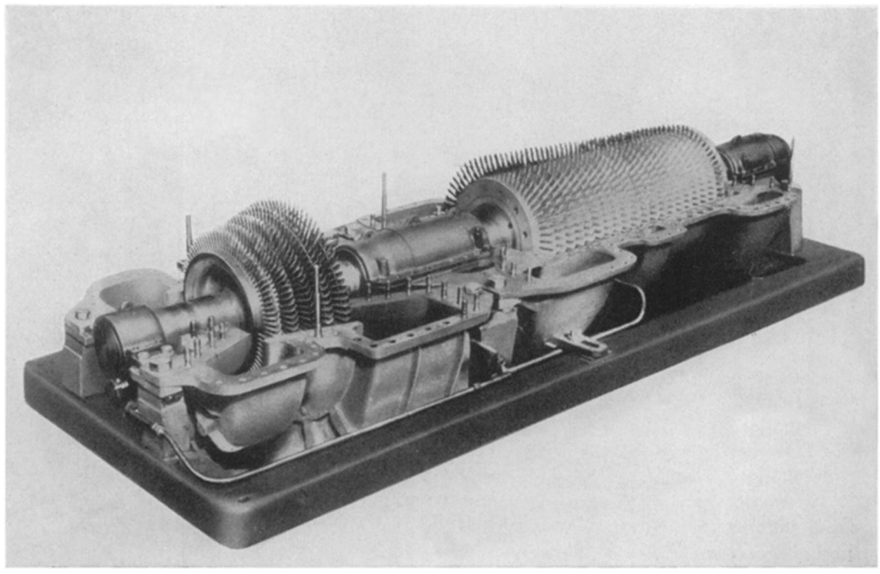
Blown Through Burner

The entire gas turbine unit is almost as simple as the principle it uses. Fuel—which may be oil, natural gas, by-product gas, perhaps even powdered coal—is caught in a blast of compressed air and blown through a burner, much like your domestic oil burner, into the turbine. The compressed air and the combustion gases, expanding mightily in the intense heat, spin the windmill. The power of the spinning shaft can either be harnessed directly to machinery or used to generate electricity.

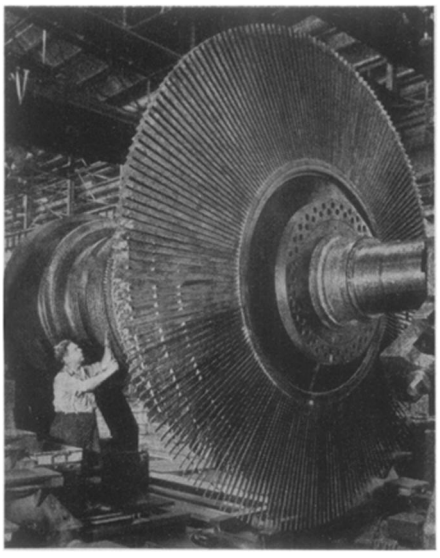
Actually, of course, a windmill compares to a gas turbine about the way a beaver dam compares to Boulder Dam—the principle is, indeed, the same, but there is considerable difference in size and in refinement of design. Gas turbine blades are not crude sails, but thousands of fins made with jeweler's precision out of alloys so expensive they might almost be called semi-precious metals. The compressor fins are shaped like miniature airplane propellor blades; rotor fins are different, but as delicate in design. Blades of both are set at the two ends of the same shaft.

This is not an inventor's dream, or something in blueprint stage. The gas turbine has arrived, unheralded, on a scale which leaves no doubt it is commercially practical. *Business Week* reported recently that there are 27 gas turbine units installed in the United States "which can be mentioned under wartime censorship," many more which cannot. Most of them produce not less than 2,000 horespower, or 1,500 kilowatts. Some of these units are used in oil refineries. Some in Europe drive generators in electric power stations. Among the corporations putting hard cash into the development of the new engine are Allis Chalmers, Westinghouse, General Electric, De Laval, and, earliest pioneer of all, the Brown Boveri Co. of Baden, Switzerland.

Future possibilities are exciting. The gas turbine may revolutionize aviation by making really big planes possible. A 2,000 horse-power gasoline engine for aviation—biggest yet built—has 14 separate cylinders and thousands of moving parts with all the mechanical complications and lubrication problems that it implies. Designers think it may be about the practical limit. But a 2,000 horse-power gas turbine unit is too small to achieve best efficiency; many units of 5,000 horsepower are in operation and designers have blueprints ready for units of 10,000 horsepower or more. Dr. Jerome C. Hunsaker, chairman of the National Advisory Committee on Aeronautics, says "the gas turbine should eliminate a host of troubles inherent in the conventional engine—among them cooling, knocking, volatile fuel (principal fire hazard), vibration, ignition and lubrication." No plane powered with a gas turbine engine is known to exist, but before censorship clamped down, Swiss manufacturers had submitted the design for an aviation turbine engine



OLD MODEL—This is the inside view of an early gas turbine developed by Brown Boveri. The blading design for the air compressor has been improved by airfoil research for use in airplanes.



STEAM TURBINE—This great rotor, made by Westinghouse Electric & Manufacturing Company, is used in a turbine generator, producing power for war industry. The construction of the gas turbine is very similar.

both to Germany and to Great Britain.

A power plant for ships which eliminates the weight, the fresh water problem, and the vast bulk of steam boilers opens up a whole new horizon for ship designers. A Liberty ship, for example, could carry 1,000 tons more cargo if it were gas turbine powered. Or more power could be packed into a hull of given size—which promises destroyers faster than anything now on the seas.

Weight, bulk and water problems are important in locomotives, too. A gas turbine railroad locomotive in use in Switzerland has proved efficient and economical. The streamliner "City of Denver" is drawn by a four-car diesel power plant. Any one of the four cars would be big enough to contain a gas turbine unit of equal power.

Only Big One Practical

What a new kind of engine might mean to the automobile industry is the subject of speculation among engineers, some of whom say a gas turbine big enough to drive an automobile would be about the size of a shoe box, would be cheap to operate, easy to maintain. This, however, is emphatically no more than speculation. In the present state of development, only big turbines are practical at all. Further refinement of design and materials may change that situation, or may confirm the present impression that small turbines are no good.

No single inventor's name is linked with the new engine. Typical of this age, the gas turbine is the sum of the contribution of many men, working in the laboratories of great corporations —notably those of Brown Boveri.

As early as 1791, engineers toyed with the idea of a turbine spun by flaming gases. But no one could develop a model which was anything more than a laboratory toy. The turbines always used up practically all their power just in feeding themselves—that is, in driving the air compressor. In 1926, the late Dr. Aurel Stodola, of Switzerland, grandfather of all turbine experts, proved mathematically that it must always be so unless some wizard produced an air compressor which would be a lot better than anyone then dreamed possible. In 1936, the same man ran the efficiency tests on the first successful experimental model.

Key Discoveries

What had happened in the intervening ten years was that two seemingly unrelated industries had made key discoveries. Metallurgists had developed metal alloys to withstand the heat and corrosion of the flaming gases. Aviation research, working out the most efficient contours for airplane wings and propellers, had discovered principles which at last made it possible for some of Dr. Stodola's pupils to design efficient blades for the compressor. Turbine design was well understood because of the work that had been done in steam.

The Diesel has been acknowledged the world's most efficient power plant. The challenger of the champion weighs about half as much as a Diesel engine of the same power; it costs less than half as much to build; it burns fuel which is half as expensive. Powdered coal would be cheaper yet. Coal at present wears out the blades too fast, but experiments in electrically removing the gritty ash particles that do the mischief are promising. The turbine has, in effect, one moving part instead of hundreds — the crankshaft, gears, pistons, cams, connecting rods, valves and pumps of the Diesel. Maintenance is correspondingly simple. The gas turbine has no need for a cooling system or for an elaborate and expensive starter.

It has no need for the elaborate electrical ignition system of the gasoline engine, and because it has no pistons and valves jerking up and down, it is, like the steam turbine, remarkably free of vibration and easy to lubricate.

Compared with the steam turbine, it saves the weight and space of boilers, as already mentioned, and instead of using vast quantities of water — five pounds of water for every pound of coal—uses none.

A well-designed Diesel power plant has an efficiency of about 35 per cent; a steam turbine plant about 30 per cent. Gas turbines now in operation deliver about 22 percent of the heat value of the fuel as usable power. Even at that the gas turbine competes economically because its first cost is less than half and because it burns the very cheapest oil. And manufacturers assert that in new models they can guarantee Diesel efficiency.

Gas turbines now installed are operating at temperatures of 1000-1200 degrees. New ones can be built to run at 1500 degrees or more. Higher temperatures give startling and wholly disproportionate gains in efficiency. The problems, which manufacturers' announcements imply has been solved, has been to get metals which would stand the terriffic heat. Dr. Moss's turbo-supercharger, which enables American planes to fly seven miles above the earth, is a turbine operated by the exhaust of the airplane engine and its blades have to stand temperatures as high as 1800 degrees. Gas turbine designers learned much from the research on the supercharger, but it did not completely solve their problem because its metals will not stand the terrific heat for more than a few hours at a time, whereas the gas turbine installed in an industrial plant or on a ship must operate for weeks and months without a shutdown.

Secret Solution

How the solution was found is still a secret as is much else about the gas turbine. But of all the new products and new processes on which the scientists, engineers and industrialists are working in wartime, none holds more exciting promise for the postwar world than the new, revolutionary, yet tested and proved gas turbine—the first really new kind of power plant in half a century. No one who looked at the gasoline engine when it was new foretold the automobile and the airplane. No one who looks at the gas turbine today can foretell its possibilities. They may be equally breathtaking.