



DIESEL ENGINE AT 120



➤ ON 17 FEBRUARY 1897, Moritz Schröter, a professor of theoretical engineering at Technische Universität, in Munich, conducted the official certification test of Rudolf Diesel's new engine. The goal of the test was to verify the machine's efficiency and hence to demonstrate its suitability for commercial development. • The 4.5-metric-ton engine performed impressively: At its full power of 13.4 kilowatts (18 horsepower) the engine's thermal efficiency was 35 percent and its mechanical efficiency reached 75 percent, resulting in a net efficiency of 26 percent. With obvious pride Diesel wrote to his wife, "Nobody's engine design has achieved what mine has done, and so I can have the proud awareness of being the first one in my specialty." Later in that year the engine's net efficiency reached 30 percent, making the machine twice as efficient as the gasoline-fueled Otto engines of the day. • Over time, that efficiency gap has narrowed, but today's diesel engines remain at least 15 to 20 percent more efficient than their gasoline-fueled rivals. Diesels have several advantages: They use fuel of a higher energy density (nearly 12 percent higher than that of gasoline); their self-ignition involves much higher compression ratios (commonly twice as high as in gasoline engines), resulting in a more complete combustion and in cooler exhaust gas; their longer stroke and lower rotational rate reduce frictional losses; they can operate with a wide range of very lean mixtures, burning refined fuel of the lowest quality; they have no throttle valves; and modern common-rail fuel injection systems can spray the fuel into their cylinders at pressures of up to 300 megapascals (up from 60 MPa 50 years ago). • But, disappointingly, in 1897 the record-setting test was not followed by rapid commercial deployment. Diesel's conclusion that he had "a thoroughly marketable machine" and that "the rest will develop automatically on its own worth" was wrong. Only in 1911 did the Danish vessel *Selandia* become the first ocean-going freighter powered by a diesel engine, and diesels dominated shipping only after World War I. Heavy railroad traction was their first land conquest, followed by heavy

road transport, off-road vehicles, and construction and agricultural machinery. The first diesel car, the Mercedes-Benz 260D, came in 1936, but diesels never made it in the United States: Even now they account for just 3 percent of all light-duty vehicles. In the European Union, about 40 percent of all passenger cars are diesels.

Diesel's initial hope was to see small engines used primarily by small, independent producers as tools of industrial decentralization, but 120 years later, the very opposite is true. Diesels are the uncontested enablers of massively centralized industrial production and the irreplaceable prime movers of globalization. Diesels power virtually all container ships and all carriers of vehicles and bulk commodities, such as oil, liquefied natural gas, ores, cement, fertilizers, and grain. They also power nearly all trucks and freight trains.

Most of the items that readers of these essays use, eat, or wear are transported at least once, and usually many times, by diesel-powered machines, often from other continents: clothes from Bangladesh, oranges from South Africa, crude oil from the Middle East, bauxite from Jamaica, cars from Japan, computers from China. Without the low operating costs, high efficiency, high reliability, and great durability of diesel engines, it would have been impossible to reach the extent of globalization that now defines the modern economy.

Over more than a century of use, diesel engines have increased both in capacity and efficiency. The largest machines in shipping are now rated at more than 81 megawatts (109,000 hp), and their top net efficiency is just above 50 percent—better than that of gas turbines, which are at about 40 percent (although in combined-cycle generation, using the exhaust gas to do work, turbines can reach 61 percent net efficiency).

And Diesel's engines are here to stay: There are no readily available mass-mover alternatives that could keep integrating the global economy as affordably, efficiently, and reliably as Diesel's machines, born 120 years ago this month. ■