The Diesel engine and it's development

A historical timeline

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1673 *Christian Huygens,* a Dutch scientist, produces the first know heat engine from his inspiration of a cannon. *Mr. Huygens* place a cannon vertically, and used a piston instead of a cannonball. The cannon had exhaust valves near the top and the piston was attached to a weight by means of rope and pulley. He calculated that a .5 kg of gun powder could lift 1360 kg piston over nine meters. But the absence of a reliable fuel hampered its development.

1801 French chemist *Phillipe Lebon* develops a usable coal gas. Shortly after he patents a coal gas fired internal combustion engine.

1804 *Richard Trevithick* built the first, albeit crude, locomotive using a steam engine mounted on a wagon riding steel rails.

1807 The Malayan fire piston, originally from southeast Asia, is brought to Europe. It was a air pump type tube, when compressed would heat up the air and ignite a small clump of tinder.

1820 *William Cecil*, 28 year old *Fellow of Madeleine College*, Cambridge, is the first to build an engine to run continuously. It uses a mixture of hydrogen and air (1:3) but soon abandons it when he is ordained in the Anglican church.

1821 *James Watt* improves the efficiency of *Newcomen*'s reciprocating pump to become the most efficient (4%) prime mover using pistons and expanding steam. The engine become the most popular at the time and lasted for quite a while.

1824 *Sadi Carnot* published his theory on the thermodynamic cycle of the heat engine. From it, *Rudolph Diesel* would design his engine.

1825 'Curacao' built in Dover, England becomes the first practical steamship to sail. It is bought by the Netherlands Navy. It was a wooden hull, 445 tonnes, paddle-wheeler with two engines developing 110 kW each.

1829 *George Stephenson* builds the 'Rocket'. The first practical locomotive which made ten trips a day over a 2.4 km hauling a 13

tons at about 24 km/h for the *Liverpool & Manchester Railway*.

1860 The first production engine is patented in Paris. *Jean Joseph Etienne Lenoir* builds around 500 of these 7:1 air gas ratio engine. But they were prone to problems due to their electric ignition.

1864 *Nicolaus August Otto* and *Eugen Langen* form the *N.A. Otto & Cie.* In 1867 they premiere their first working model. At first, the one cylinder "coffee grinder" design, with it's horrible racket, scares away the *Paris Exposition 1867* judges. But they realized it was the most efficient engine of the exposition, and the engine took first prize.

1872 With many back orders for their successful engine, *Otto & Cie* established a new plant. They called it Gasmotoren-Fabrik-Deutz after the Deutz neighborhood of Koln, Germany. They hire a production manager, *Gottlieb Daimler* and an assistant *Wilhelm Mayback*. These three men, some of the greatest engineers who ever lived, now where under one roof.

Shortly after, *Otto* "comes up" with the four strokes of an internal combustion engine; intake, compression, ignition/expansion, and exhaust were all assigned a "stroke".

1876 *Otto*'s new design is built. The one cylinder, flame ignited prototype is "handed over" to *Mayback* who develops it for production. It becomes know as the "Deutz A" engine. With an efficiency of over 16% and quiet operation, it is issued a patent insuring it almost a virtual monopoly.

1878 *Dugald Clerk*, a Scot, is granted a patent which lays down the groundwork for the two stroke compression engine design. It is demonstrates at Kilburn, England in 1879.

1879 *Karl Benz* expands on *Clerk*'s ideas, and establishes Benz & Cie in Manheim to develop the engine idea. Deutz's stranglehold on Germany sees to it that a patent is not granted to Benz's ideas.

1880 The 137 meter, 5,247 tonnes 'Arizona' is the first steam powered vessel to win the mythical "*Blue Ribband*". The *White Star Line* steel hulled ship reached 32 km/h with her John Elder & Company 's 4,679 kW compound steam engines.

1882 *Daimler* quits Deutz because of some contentious issues over patents with *Otto. Mayback* join *Daimler* to research the possibility of a light weight, higher speed, internal combustion engine.

1886 Deutz stranglehold on the basic patent of the internal combustion engine is reversed. A patent attorney for *Geruber Korting* finds a prior patent, laying out the exact cycles of the internal combustion engine. The French transportation engineer, *Alphonse Beau de Rochas,* had filed it on January 16, 1862.

1886 *Benz'*s biggest problem, the magneto design, is remedied by *Robert Bosch*. The final prototype, the three wheeled 'Dogcart', is a success.

1889 *Rudolph Diesel*, with his French connections, is the only German engineer invited to give a his paper, "*Revue Technique de l'Exposition Universelle*" at the International Engineering Congress.

1892 *Rudolph Diesel* draws his theories into a design, but it is decline a patent in Europe, at first. On appeal his "not original" idea is patented on February 28. It was a design using much higher pressure to achieve *Carnot*'s ideal heat cycle. Sometime later, *Diesel* is granted a patent in the United States for the new engine.

1893 *Benz*'s engine the 'Standhur' (Upright clock) runs continuously at the Paris Expositions. The beginning of a long "work day" for it.

1893 *Rudolph Diesel* rewrites his manuscript "*The theory and construction of a rational heat engine to replace steam engine and contemporary combustion engine*" to "*Eines rationellen Warmenmotor*" describing his theory of a heat engine with an estimated 70-80% efficiency. He is severely criticized by his peers, the leading edge German engineers.

1893 In July, *Rudolph Diesel*, assistant *Lucian Vogel*, and his father in law, *Heinrich Buz* at the *'Ausgburb Machine Works'* begin experimenting with *Rudolph Diesel's* the new prime mover.

1894, February 17, *Diesel's* experimental engine runs at 88 rpm for about one minute, the first time ever, about 9 months after first "test firing".

1897, February 17, the *Diesel*'s engine runs on its own. The water cooled, ringed piston, fuel injection, single cylinder engine ran on cheap kerosene. It was a total success. It produced 13.1 kW at 154 rpm, and achieved 26.2% efficiency.

1897 *Mirrlees, Watson & Yaryman* of Glasgow, among others, sign a deal to build the new prime mover from *Rudolph Diesel*.

1897 *Immanuelle Lauster*, at *'Machinenfabrik Augsburg'*, designs and build the first twin cylinder prototype Diesel engine. It develops 44 kW at 180 rpm, this is achieved by increasing the size of the bore and stroke as well as other refinements.

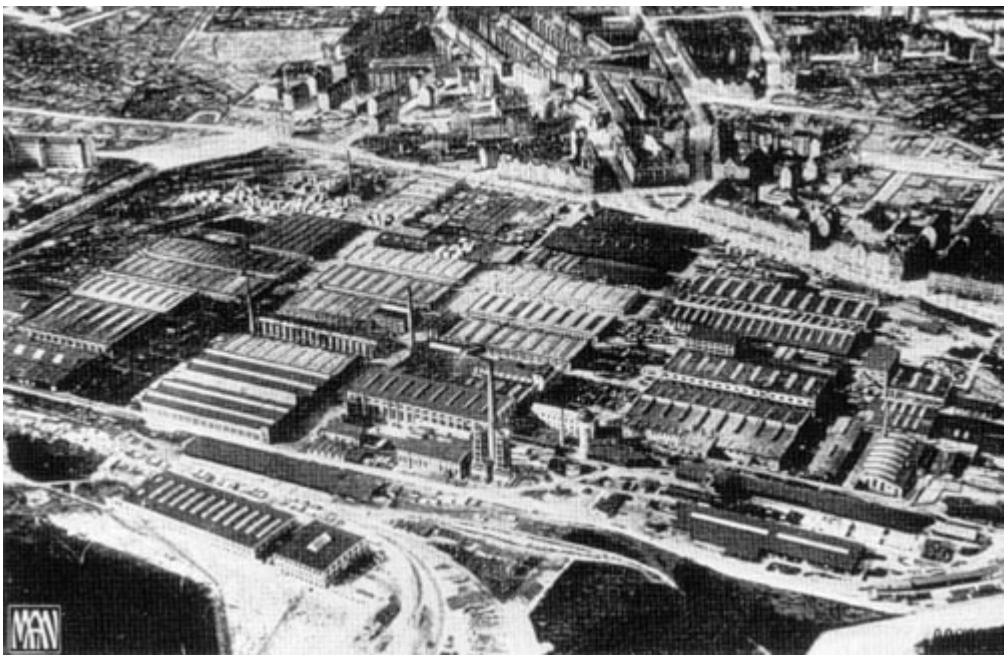
1898 June 10, Sulzer starts building it's first *Diesel* engine A four stroke, 260mm cylinder, developing 14.7 kW.

1898 Burmeister & Wain (B&W) of Kohaven, Denmark retain rights to build the Diesel engine. As do *Aldophus Busch* (Budweiser beer in US) who sets up

the Adolphus Busch's Diesel Motor Company of America. Vickers Sons & Maxim Ltd of England and Gebruder Howalt-Werf are among others. Sweden financiers *Marcus Wallenberg* and *Oscar Lamm* set up AB Diesel Motorer. *Emanuel Nobel*, Swedish-Russian nephew of *Alfred Nobel*, acquires the rights to build the *Diesel* engine and promptly establishes the Russian Diesel Company of Nuremberg.

1898 The first commercial *Diesel* engine is sold to Aktiengesellschaft Union, a matchmaking company in Kempten near Ausgburg, Germany. It is one of *Lauster*'s twin cylinder design. It is delivered in January and started up on March 5. After fifteen years it still ran perfectly, without any major repairs.

1898 After a successful exhibition of their engines, side by side, at the Munchen Power and Works Exhibit, Machinenfabrik Augsburg and Nurnberg decide to continue their partnership. The partnership's name is shortened in 1904 to Machinefabrik Augsburg-Nurnberg, better known today as M.A.N.



1898 In order to manage the explosive growth of the *Diesel* engine. *Rudolph Diesel*'s establishes a company to manage the licensing of the design. The new venture buys all patents and is tasked with the further developments and management of the new engine. It is called the General Diesel Corporation, and is founded on September 17. *Rudolph Diesel* is paid a sum of 3.5 million German marks.

1900 The *Diesel* engine takes the "Grand Prix", the highest prize, at the 1900 Paris Exposition. The exhibition was attended by 50 million people.

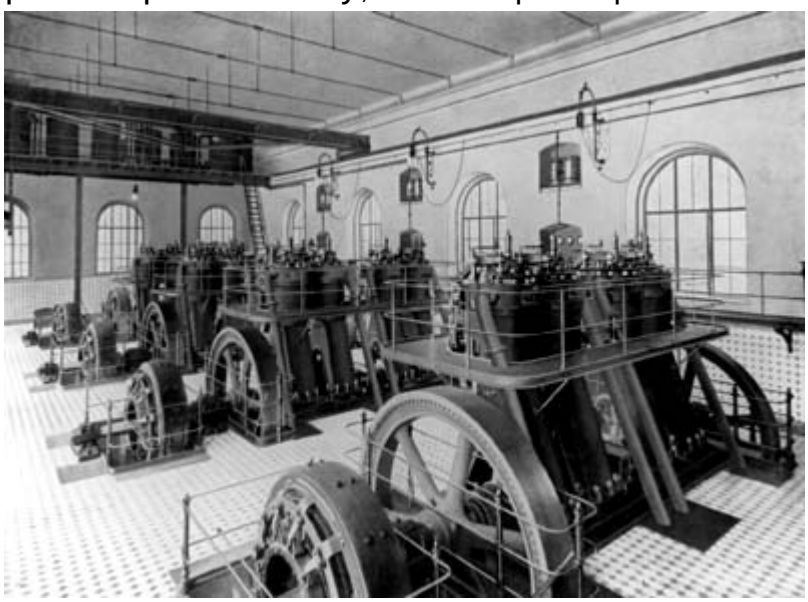
1902 *Adolphus Busch*'s company build the first *Diesel* engine in the United States. It is a three cylinder, 55 kW model, which first ran in April. Fewer than 100 were sold, most of them without profit.

1903 Sulzer begins engine manufacturing in Winterthur, Switzerland. Three years later, they offer a range of 12 engines with power from 11 to 440 kW.

1904 *KW Hagelin*, engineer in charge of *Nobel*'s marine division, oversees the building of 'Vandal'. A 74.5 meter long, shallow draft tanker with a cargo capacity of 800 tonnes. A revolutionary design at the time. Three generators, driven by 3 cylinder AB Diesels, supplied 88 kW each, at 240 rpm. These generators supplied power to 75 kW reversible DC motors. A setup almost identical to today's locomotives.

1904 Ancient Etablissment Sautter-Harle of Paris, licensed by *Diesel* in 1899, builds the first opposed piston, reversing engine. The four stroke engine develops 19 kW and was installed in the 38 meter Canal Ship 'Petit Pierre', which also boasted a variable pitch propeller. The firm's next engines, larger versions of the previous design, were delivered to the French navy for installation into their submarines.

1904 M.A.N. installs four diesel engines with a total 1800 kW turning at 160 rpm in the Kiev Municipal Transport Authority, the first power plant of its kind. It is in operation until 1955.



1904 Sulzer installed their first diesel engine in a ship, the freight boat 'Venoge'. It was much like the 'Vandal', but Sulzer was dissatisfied with the electric motor, the only way to get reverse. They go on to develop their two stroke, reversing engine. One year later...

1905 The first two stroke, and the first direct reversible engine (as opposed to starting in reverse) is built by Sulzer. It had four cylinders with a bore of 175 mm and stroke of 250 mm producing 66 kW. It is on exhibit at the *Milano World Exposition* in 1906.

1907 *Rudolph Diesel*''s patent in Europe expires. A flood of new engine building begins.

1907 Nobel Brothers builds the first four stroke reversible engine.

1909 In 1907, Benz & Cie entices a young Lebanese engineer, *Prosper L'Orange*, from Deutz. He goes on to design the precombustion chamber. Making the *Diesel* engine run smoother and quieter, but with a slight loss of fuel economy.

1910 The 'Fram' receives it's 132kW engines from AB Diesel Motorer of Sickla, Sweden. The ship carries *Roald Amundsen* to the Antarctic. He becomes the first man to reach the South Pole on December 14, 1911. AB goes on to adopt the Polar trademark.

1911 Sulzer builds a larger version of their 1905 engine, ushering in the age of the large slow speed two stroke engine; quite a bit larger. The one cylinder, with a meter diameter piston turns at a leisure pace of 150 rpm. It produces an astounding 1472 kW. Shortly after, they begin building a four cylinder version to produce 2760 kW.

1912 Burmeister & Wain build the first ocean-going motor ship, the 'Selandia', for the Danish East Asiatic Company. It starts a revolution in shipping and ship design. It is launched on November 4 and has two, four stroke, reversible engines developing 932 kW each at 140 rpm. On the other hand, Hamburg Sud cargo liner, the Monte Penedo, is the first ship to be powered by two stroke engine. The two Sulzer engines developed a combined 1250 kW at 160 rpm.

"I read your history of diesel engines . Being an engineer myself and Swedish I couldn't resist noting that you mentioned M/S Selandia. Built 1972, having 3 deiselengines of 55 something MW. Selandia had one 12-cylinder and two 9-cylinder Götaverken engines. At the same time Swedish shipping company Broströms built M/S Nihon with 8 more MW, with two 10 cylinder doing average speed of 32 knots on its maiden voyage around the world . Consuming 320 metric ton of fuel per 24 hours she had no traditional separators but 8 centrifuges that took out most of the impurities in the fuel. I have many friend that worked on this ship and I have been working as service personal on this ship myself.

Yours sincerely, Hans-Olof Hansson , Gothenburg , Sweden"

1912 The first *Diesel* locomotive is built. The 80 tonne locomotive is built by Sulzer, Krupp, an the Prussian & Saxon State Railway. The first revenue earning locomotive is built by ASEA for Sweden's Melersta Sodermanslands Railway in 1913.

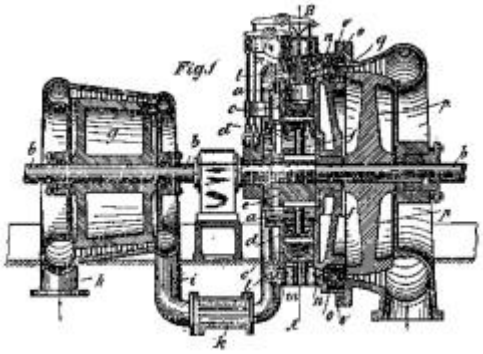
1912 The *Diesel* patent expires in the US. New companies spring up to build their versions of the engine. Allis-Chalmers and Nordberg in Milwaukee, Fairbanks-Morse in Beloit and Worthington Cudahy - all in Wisconsin, heart of the dairy states, a popular place for German immigrants. As well Busch-Sulzer set up shop in St Louis, and Winton in Cleveland.

1912 Sulzer tinkers with their 1S100, an experimental engine. It has a bore of 1 meter and holds the title, engine with the largest bore, for almost 60 years.

1913 *Hugo Junkers*, an aeronautical engineer, builds a four cylinder lightweight *Diesel* engine for an aircraft. Shortly after, a six cylinder was producing 368 kW at 2400 rpm.

1914 Sulzer develops piston cooling and scavenging for their two stroke engine.

1914 The *Diesel* powered German U-boat, U-9, meets and sinks the British cruisers Aboukir, Cressey, and Hogue off the Dutch coast in less than one hour. The *Diesel* powered submarine could no longer be ignored.



1915 Swiss engineer *Dr. Alfred J. Büchi,* Chief Engineer of Sulzer Brothers Research Department, proposes the first prototype of a turbocharged diesel engine. He had been working on the design since 1909. Even with a 40% increase in an engine's efficiency, his idea was not well received.

1916 *Hugo Junkers* unveils the Jumo, a six cylinder opposed piston aircraft engine. It is installed in the Dornier Do18 flying boat. The Deutsche Lufthansa Do18 break the long distance flight record to Caravellas, Brasil from the English Channel.

1919 In 1909, *Jonas Hesselman* of AB Diesel Motorer and *Harry Leissner* at Lujussne-Woxna were working on a solid fuel injection system. It is not until 1919 that *Prosper L'Orange* brings it all together. He successfully incorporates fuel injection in Benz's one cylinder, smooth running engine.

1919 *Sir Harry Ricardo* pioneers the swirl chamber, a slightly different combustion chamber than *Mr. L'Orange* 's design.

1920 Enterprise, in the US, builds it's first engine, it later becomes a division of DeLaval.

1922 Benz & Cie's stationary engine division becomes it's own company. It becomes the Motoren-Werke Manhein AG better known as MWM.

1923 General Electric, American Locomotive and Ingersoll Rand collaborate to produce a *Diesel* powered switcher engine. It works around the clock at New York Central's yard, operating for only ten cents per kilometer. A refined model becomes the first commercially produce units, they are bought by the Jersey Central Railroad remaining in service at the Bronx yard for 30 years.

1923 Peugeot installs the first *Diesel* engine in their car.

1924 Benz & Cie introduces their transport truck, the 5K3. M.A.N. introduces it's competition five month later.

1924 The newly formed Electro-Motive Company, a spin off of Motive Power, a division of the Union Pacific Railroad, headed by *WR McKeen*, introduces their 59 passenger coach. It is powered by a Winton engine and costs about half the normal cost of running a steam equivalent.

1925 The Caterpillar Company is the result of a merger of Holt Manufacturing Company of Stockton, California and the C. L. Best Gas Traction Company of San Leandro, California.

1926 Daimler and Benz merge. The new company is called Daimler-Benz, it changes later to Mercedes - Benz. They introduce the new 5K3 model which includes the new, *Robert Bosch* designed, glow plugs.

1927 Continuing on *Fritz Lang*'s injection system, *Robert Bosch* simplifies and improves the fuel injection system for it's debut in the Mercedes Benz OM5 truck. By now most of the world's freight moves by *Diesel* powered truck.

1929 In Indianapolis, *Clessie Cummins* manages to fit his 6.25 liters Diesel engine into a 1925 Packard, seven passenger car. He drives it to New York for the Auto Show where he gets the "cold shoulder" officially- but Ford and GM executives ask for private demonstration.

1929 Kawasaki and Mitsubishi of Japan sign licensing agreements with M.A.N. Kawasaki later signs agreements with Mitsui.

1929 General Motor buys the Adam Opel AG Company, in the 1930s, the largest car producer in Europe.

1930 General Motors Corporation buys the Electro-Motive Company and the Winton Engine Company. The result is Electro Motive Division (EMD) and a new aggressive campaign to slay the "fiery dragon of railroading" - the steam locomotive. They build the GM #103, a four unit, 59 meter long behemoth, painted in "grimy black" with a yellow stripe and "GM" stylized on the front. Sixteen driving axles deliver to the rails 4000 kW of power. They also support

the 408,000 kg, the heaviest locomotive ever.

1931 *Clessie Cummins* installs his *Diesel* in a race car. It runs at 162 km/h in Daytona, and 138 km/h in Indianapolis where it places 12th.

1931 Caterpillar introduces the 1C1 *Diesel* engine crawler tractor. Although more expensive, they sell about 10,000 units, 90% of these having *Diesel* engines. The Cleveland Tractor Company and International Harvester follow the example shortly after.

1932 In Manchester England, L Gardner & Sons' *Hugh and Joseph Gardner*, inspired by *Mr. Cummins,* install a Gardner 4LW *Diesel* in a 1925 Bentley Saloon. With a top speed of 128 km/h, they enter the car in the *1933 Monte Carlo Rally*. They are encouraged to build a new lightweight engine, although the new idea was not readily accepted.

1932 *CL Cummins* installs a *Diesel* engine in a Mack 10 tonne bus. They proceed to drive across the US, 5181 km, in 78 hours 10 minutes. Faster than any other form of transport - train and such, and all for $21.80 in fuel cost.

1932 The Flying Hamburger garnishes newsreel and tabloid attention because of its radical design and performance. The Zeppelin Aircraft Works used wind tunnel testing to determine the styling of the Flying Hamburger. While the two 300 kW Mayback V12 engines, propelled the train to 198.5 km/h, it's regular service speed was around 160 km/h.

1933 Unlike Cummins and Gardner, Daimler-Benz built cars as opposed to converting existing one to *Diesel* power. They took the risk and introduced the 'Manheim', powered by a noisy version of their truck engine. It is not well received at the *1934 Berlin Auto Show*. Undaunted, they redesign the idea and introduce the 260D. With it's combination of medium size sedan look and excellent fuel economy, it becomes a commercial success.

1934 M.A.N. Begins development on their exhaust gas turbine.

1934 May 26, the Pioneer Zephyr, modeled after the Flying Hamburger, breaks all speed and distance records on it's run between Denver, Co. and Chicago, Il. The all stainless steel train averages 125 km/h over the 1633 km journey.

1935 B&W builds the first four stroke engine to burn Heavy Fuel Oil.

1938 General Motors forms a new division - Detroit Diesel Engine Division, they mostly build the popular 71 Series engine for the war efforts.

1950 M.A.N. unveils the first four stroke supercharged engine to reach 45% efficiency.

1954 Cummins unveils PT (pressure-time) fuel injection system.

1958 The Peugeot 403 is introduced. The four cylinder Diesel powered car revives the car maker, battered from the second world war. The engine uses

the licensed *Ricardo* swirl chamber design. In April 1970, the Lille Peugeot Plant builds it's millionth *Diesel* engine.

1968 The first resilient mounts are used in engine installations by B&W.

1970 The U.S. government passed the Clean Air Act.

1972 Opel introduces the Opel GT coupe. It is the company's first *Diesel* powered car. They install a small turbo charger to their new 2 liter engine; it develops 70 kW. On June 1 and 2, the Opel GT breaks 18 international speed records with it's top speed of 197.5 km/h.

1972 Burmeister & Wain launched the new "Selandia" for the same customer as the original "Selandia". It serves to illustrate the dramatic pace of ship and engine development. The new Selandia is two and a half times longer, twice as wide, at 50 km/h, is two and half times faster. It's three *Diesel* turbo charged, two stroke engine produced a total of 55,200 kW.

1973 The Brown, Boveri and Company introduce the supercharger, known as the Comprex AWS. A mechanically driven air pump, based on a German patent developed under the supervision of *Professor Max Berchtold* at the *Swiss Federal Institute of Technology* in Zurich.

1975 Mercedes introduces the 300D. The in-line five cylinder *Diesel* engine was radical for it's time. The 3005 cc developed 59 kW at 4000 rpm, and it boast an overhead chain driven camshaft. The Bosch fuel pump delivered fuel to a *Prosper L'Orange* styled combustion chamber and started and stopped with a turn of a key.

1976 Volkswagen adapts various popular technology to introduce it's four cylinder *Diesel* engine. The four cylinder, 1471 cc, producing 37 kW at 5000 rpm is installed in their Golf. The engine is coupled to a front wheel drive assembly. Its advertising claims state it's the quickest accelerating *Diesel* car.

1976 Mercedes stuns the automotive world by building the fastest car. The *Diesel* powered C-111 set the new speed record at 253 km/h, averaged over 24 hours. The engine is equipped with a small Garret Airsearch turbo charger to produce 147 kW at 4200 rpm from only three liters of displacement.

1977 GM's Oldsmobile division introduce their sedan with an 89 kW, pushrod V8 *Diesel* engine. It is adapted form a standard gas counterparts. They soon offer the engine in the 1978 GMC and Chevrolet pick ups. With the energy crisis of the seventies, it sparks an automotive revolution, where gas engine had previously dominated. Companies which had never marketed the efficient *Diesel* powered cars began to do so.

1977 The ERDA's Energy Research Center in Oklahoma backs ups research by other independent researchers, confirming the dramatic fuel savings of the efficient Diesel engine comparatively to its gas counterparts. Figures of 43%, 25%, 35% in savings are declared, as well the cleaner burning Diesel gains popularity because of its lower emissions.

1977 Murphy Diesel of Milwaukee agrees to market MWM engines.

1984 MAN and B&W merge to become MAN B&W Diesel A/S, Copenhagen.

1987 The QE 2 goes into refit to remove it's steam systems to install the world's largest *Diesel* Electric propulsion plant. Nine four stroke MAN engines deliver 179 MW.

1988 MAN B&W acquires the French engine maker SEMT Pielstick.

1998 P&O Nedlloyd accept delivery of the 6,674 teu container ship P&O Nedlloyd Southampton. The first ship to be powered by the 12 cylinder Sulzer RTA96C with an output of 65,880 kW.

1999 Not to be outdone, the B&W 12K98MC-C with an output of 68,640 kW is sold by the Dutch engine maker.

1999 *Martin Leduc* creates Martin's Marine Engineering Page, a website dedicated to the prime mover and it's application in ships and the marine world.

2000 MAN B&W aquires ALSTOM's Diesel engine business consisting of the long established Mirrlees Blackstone, Ruston and Paxman brands.

2003 M.A.N. introduces the ME engine. The slow speed two stroke engine does away with the traditional camshaft, replacing it with electronically controlled actuators.

Help me out ! do you know of any good source of info on certain technology benefiting the Diesel or any other prime mover ? Email me.

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