The Invention of the Internal Combustion Engine and the Motor Car

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Preface

This paper was written in order to examine the order of discovery of significant developments in the history of the internal combustion engine and the motor car. It is part of my efforts to put the study of social and cultural history and social change on a scientific basis capable of rational analysis and understanding. This has resulted in a hard copy book *How Change Happens: A Theory of Philosophy of History, Social Change and Cultural Evolution* and a website How Change Happens Rochelle Forrester's Social Change, Cultural Evolution and Philosophy of History website. There are also philosophy of history papers such as The Course of History, The Scientific Study of History, Guttman Scale Analysis and its use to explain Cultural Evolution and Social Change and Philosophy of History and papers on Academia.edu, Figshare, Humanities Commons, Mendeley, Open Science Framework, Orcid, Phil Papers, SocArXiv, Social Science Research Network, Vixra and Zenodo websites.

This paper is part of a series on the History of Science and Technology. Other papers in the series are:

The Invention of Stone Tools Fire The Neolithic Revolution The Invention of Pottery History of Metallurgy The Domestication of Plants and Animals History of Writing The Invention of Glass History of Astronomy Invention of Microscopes and Telescopes History of Printing The Invention of the Steam Engine History of Electricity Electric Telegraph Telephone Radio Television Photography Motion Pictures Internal Combustion Engine Motor Car Aeroplanes The History of Medicine The Discovery of the Periodic Table The Discovery of the Subatomic Particles

Other papers by Rochelle Forrester include works on Epistemology and the Philosophy of Perception such as Sense Perception and Reality and on quantum mechanics such as the Quantum Measurement Problem and The Bohr and Einstein debate on the meaning of quantum physics. Rochelle Forrester's work is also published on Slideshare, Issuu and Scribd. Rochelle Forrester is a member of the International Network for Theory of History.

Abstract

The ultimate cause of much historical, social and cultural change is the gradual accumulation of human knowledge of the environment. Human beings use the materials in their environment to meet their needs and increased human knowledge of the environment enables human needs to be met in a more efficient manner. When human knowledge of the properties of gases and vacuums grew they were able to produce an internal combustion engine that greatly improved the human need for transport. Motor cars and aeroplanes were invented and agriculture and sea transport were improved. The human environment has a particular structure so that human knowledge of the environment is acquired in a particular order. The simplest knowledge is acquired first and more complex knowledge is acquired later. This resulted in improvements to both motor cars and air transport throughout the twentieth century so that people had much better and more affordable transport by the end of the century. The growth of world trade, tourism, international migration and globalisation can partly be attributed to improved transport systems. This means human social and cultural history, has to follow a particular course, a course that is determined by the structure of the human environment.

The steam engine is an external combustion engine as the fuel is burnt outside the engine. The first internal combustion engine where fuel is burnt inside the cylinder to force a piston to move was invented in 1856 by the Italians Barsanti and Matteucci. The principle behind the internal combustion engine was the same as that behind the steam engine, namely a piston being driven by alternative phases of expanding gas and vacuums. The first internal combustion engine to be produced in substantial numbers was a gas engine built by the Belgian Lenoir in 1860. The engine lacked power and consumed a considerable amount of fuel because the fuel and air mixture was not compressed before it was ignited. In 1862 Rocas a French engineer patented a four stroke internal combustion engine which involved compression of the fuel and air mixture. The engine however was never built and in 1876 the four stroke engine was independently invented by Otto. The Otto engine produced more power and consumed considerably less fuel than the Lenoir engine.

The four stroke engine worked by the first downward stroke of the piston drawing the fuel and air mixture into the cylinder through an open inlet valve. The descending piston creates a partial vacuum in the cylinder and the valve in the cylinder closes and the piston rises, compressing the fuel and air mixture. The mixture is then ignited causing the third stroke as the piston is forced downward. It is the third stroke that gives the engine its power. The fourth stroke occurs when an exhaust valve is opened and the rising piston forces the exhaust gases from the cylinder.

In 1883 Gottlieb Daimler, who had previously worked with Otto, designed a four stroke internal combustion engine that ran on petrol or gasoline. The engine ran faster than Otto's so that it produced more power for the weight of the engine. A carburetor was used to pass air over the top of petrol to mix the petrol vapor and air which was ignited to force the piston down in the third stroke. Further improvements by Karl Benz involved an electrical induction coil for ignition of the fuel mixture.

The effect of the internal combustion engine on society was immense. Its main advantage over the steam engine was its weight to power ratio. In 1880, the Otto gas internal combustion engine weighed 440 lbs. per unit of horsepower produced; by 1900 a petrol driven internal combustion engine weighed only 9 lbs. per unit of horsepower. The weight to power ratio allowed the engine to be used to drive motor vehicles, aircraft, tractors, submarines and tanks. During the 20th century motor vehicles were to replace railways as the principal means of land transport. The ordinary citizens of developed countries enjoyed a new freedom of travel they had not previously possessed. Aeroplanes made considerable improvements in performance and safety during the 20th century. They became a new weapon of war but they also helped precipitate the enormous growth in international tourism that was to occur in the second half of the 20th century. Agricultural productivity improved greatly with the development of the tractor and other farm machinery powered by the internal combustion engine. The development of the engine also gave oil producing countries a wealth and influence in world affairs that they had not previously possessed. These social and cultural consequences of the internal combustion engine were an inevitable result of the invention of the engine and the engine was only invented after certain earlier discoveries had been made.

The steps involved in the invention of the internal combustion engine followed in a logical and necessary order. The first step was the initial invention of the engine by Barsanti and Mattucci and its development by Lenoir. Only after the engine was invented was it possible to work out the best way to operate the engine which is by the four stroke cycle system that was invented by Rochas and Otto. The use of petrol in the engine was dependent upon the earlier developments of drilling for oil which began in the United States in the 1850's and by methods of refining crude oil by distilling or thermal cracking which was developed in the 1860's.

The internal combustion engine could only be invented because of certain properties of gases and vacuums. Gases expand when heated and that a piston will move to reduce a vacuum are properties of gases and vacuums which allowed the invention of the internal combustion engine. If gases and vacuums did not have these properties the internal combustion engine could not have been invented. A further requirement for an internal combustion engine is a suitable fuel which exists in nature in the form of oil deposits. This shows how the properties of the materials in nature have had a major influence on human social and cultural history.

Motor Car

Motor driven carriages had been experimented with ever since the invention of the steam engine. The steam engine, however, was too heavy for the amount of power it produced, to allow it to drive any sort of road vehicle. It was not until the invention of the petrol fuelled internal combustion engine that there was an engine light enough and powerful enough to drive a vehicle on the road.

The four stroke internal combustion engine was invented by Nikolas Otto, but his engine ran on gas. An internal combustion engine using petrol had been built by Jean Lenoir, in 1862, but it was too heavy and lacking in power to drive a road vehicle. The creation of a more powerful internal combustion engine fuelled by petrol was achieved by Gottlieb Daimler and Wilhelm Maybach, in 1883, which, because it turned faster than the gas engine, was more powerful for its weight. The first road vehicle powered by a petrol fuelled internal combustion engine was built by Karl Benz in 1885. The car could reach a speed of 8 mph with its engine which provided less than one horsepower. The car had a very unreliable electric ignition with a battery coil and spark plugs. The car also had a gearing system involving belts between pulleys of varying size so as to provide for different forward speeds. Belts were also used to transmit power from the engine to the wheels. The vehicle only had three wheels, two at the back and one at the front. The use of a single front wheel was designed to avoid problems with normal horse carriage steering, where turning was easy enough for horses but was very difficult for people.

The steering problem was solved in 1888 when Britain's first petrol fuelled car was built by Edward Butler. Butler used the Ackermann system which involved the front wheels being connected by a rod so that they turned about a common center. This avoided skidding when the vehicle turned, making turning safer and easier. After the introduction of the Ackermann system nearly all cars had four wheels and nearly all of them used the Ackermann system.

Daimler did not produce a car for sale until 1895 as he concentrated on the production of petrol fuelled internal combustion engines. A two cylinder engine built in 1889 providing three and a half horsepower and which ran at 800 rpm became the standard engine for early cars. Daimler did produce experimental cars that introduced the modern transmission system using a friction clutch and sliding pinion gears so as to allow a range of forward speeds. This system could transmit more power than the belts used in Benz's 1885 car. In the 1890's Benz began to produce improved four wheel cars using the Ackermann system.

The standard design for motor vehicles became gradually established in the last decade of the 19th century. The engine began to be placed in the front of the vehicle as it was found this provided greater stability than placing the engine in the center or rear of the vehicle. Four wheels

on cars with the Ackermann steering system became standard. The transmission system became standardized with the introduction of the propeller shaft which ran under the car and drove the rear axle. The most common gearing system used the manually operated sliding pinion gearbox, although some cars used an epicyclic which was the predecessor of automatic transmission. The suspension consisted of four leaf springs that connected the axles to the body of the car. Pneumatic tyres were first introduced in 1895, although solid rubber tyres remained in use for commercial vehicles until around 1930. The braking system used was improved when band brakes which applied pressure to the wheel hub were replaced by drum brakes which applied pressure to the inside of a drum revolving with the wheels.

The world's first mass produced car, the Model T Ford, was introduced in 1908. Between 1908 and 1927 when production ended, 15 million Model T's were built. When a conveyor belt was introduced into the manufacturing process, in 1913, the assembly time for the chassis fell from 12 hours to one and a half hours per car. The price of the Model T fell from $850 when manufacturing began, to $260 per car.

Improvements to motor cars after World War I were limited and related mainly to improved engines, and to better comfort and safety. Hand cranking was replaced with an electric starting system and the enclosed sedan began to replace open top cars. All steel bodies became common after the 1920's. Hydraulic brakes on all four wheels became common and safety tyres with no inner tubes and instant self-sealing became common in the 1970's. Seat belts and air bags were also introduced to improve safety.

The effect of the motor car on society was immense. It gave the general public the freedom to travel when and where they liked unrestricted by time tables and with privacy not available on public transport. The urban and rural environments of developed countries were to be crisscrossed by roads, highways and motorways built specifically for motor vehicles powered by the internal combustion engine. The invention of the motor car meant the creation of a major new industry with millions of jobs. Motor cars also became a leading cause of death by accident in wealthy countries and a major cause of pollution.

The motor car could not be introduced without the prior invention of the internal combustion engine. Only that engine could provide enough power and was light enough to drive a road vehicle. Without the internal combustion engine there would have been no widespread motor car use in the 20th century. Once a reasonably efficient internal combustion engine had been invented, the rest of what was required to produce a workable motor car was quickly put together. Transmission, gearing, braking, steering and suspension systems were already well understood and all that was required was to adapt them to the motor car. This is why the standard design for the motor car became established quite quickly, within about 20 years, after Benz's first car was built in 1885. The motor car could not be invented without the internal combustion engine, which was only possible due to the properties of gases and vacuums and the existence of suitable fuels such as petrol and oil. This shows how the properties of matter and materials in

nature have had a major effect on human social and cultural history. If the properties of matter were different, for example gases did not expand when heated or it was not possible to create a vacuum, then there would have been no internal combustion engine and no motor vehicles.

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