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TRANSLATIONS: Translations into English of a number of Diderot's individual works have been published but most of them so long ago as to be difficult to obtain. More recent translations include the following: *Denis Diderot: Selections*, ed. with introduction by E. Herriot (1953); *The Paradox of Acting*, trans. by W.H. Pollock (1957); *Diderot, Interpreter of Nature: Selected Writings*, trans. by Jean Stewart and Jonathan Kemp, and ed. with introduction by Jonathan Kemp, 2nd ed. (1963); *The Wigmaker's Art in the 18th Century: A Translation of the Section on Wigmaking in the 3rd Edition (1776) of the Encyclopédie . . .*, ed. by J. Stevens Cox (1965); Diderot's *Selected Writings*, trans. by Derek Coltman, and ed. with introduction and notes by Lester G. Crocker (1966); *The Nun*, trans. by Marianne Sinclair, with introduction and afterword by Richard Griffiths (1966); *The Encyclopédie of Diderot and d'Alembert: Selected Articles*, ed. by J. Lough (1969).

BIBLIOGRAPHY. A.M. WILSON, *Diderot: The Testing Years, 1713–1759* (1957), is the standard and most scholarly biography for the years covered. LESTER G. CROCKER, *Diderot, the Embattled Philosopher*, rev. ed. (1966), provides both a biographical and critical general study. JOHN (LORD) MORLEY, *Diderot and the Encyclopaedists*, 2 vol. (1878, reprinted 1923), is still of value. In the absence of a new critical edition (in preparation), the *Oeuvres complètes de Denis Diderot*, ed. by J. ASSEZAT and M. TOURNEUX, 20 vol. (1875–77); and the selected *Oeuvres* in five volumes in the "Classiques Garnier" are the best available.

(Ro.N.)

Diesel, Rudolf

Though best known for his invention of the pressure-ignited heat engine that bears his name, Rudolf Diesel was also an eminent thermal engineer, a connoisseur of the arts, a linguist, and a social theorist. As a one-man creative community, Diesel epitomized the confluence of the fine arts, the sciences, both "pure" and "social," and the creative pragmatics of mechanical engineering and invention. He described his artistic self as *ein Glückspilz* ("a lucky mushroom"); his career as an inventor as "enslavement to despair and ecstasy"; his crusade for peace and labour reform as "stubborn proselytizing by a chronic victim of petty and prejudiced nationalisms." During the last two decades of his life his informed admirers and critics alike came to regard his many-sided creative skills and his no less amazing ambivalences as stage props for one of the most memorable mechanical inventions of the 19th century.

By courtesy of the Deutsches Museum, Munich

Diesel, 1883.

Diesel's inventions, which ranged from the fantasy of a "universal sun motor" to the refinement of ice ready-frozen in restaurant table bottles, have three points in common: they relate to heat transference by natural physical processes or laws; they involve markedly creative mechanical design; and they were initially motivated by the inventor's concept of sociological needs. Diesel originally conceived the diesel engine as a facility, readily adaptable in size and costs and utilizing locally available fuels, to enable independent craftsmen and artisans better to endure the powered competition of large industries that then virtually monopolized the predominant power source—the oversized, expensive, fuel-wasting steam engine. He envisaged making his rational heat engine, to adapt his own words, as big as a hut or as small as a hat, suitable for fuels from shale oils to coal or palm oils to surplus butter. He projected the engine principle as a solvency saver for all such small but useful producers as watchmakers, jewelers, dentists and dental technicians, cobblers, toy-makers, etc. His broader goal was socio-economic justice and balance, to save the engine user from being made its "tending wage slave."

Childhood and education. Diesel was born in Paris on March 18, 1858, the only son of Theodor, a Bavarian immigrant leather craftsman, and Elise Strobel Diesel, a German-born governess and language tutor. During his Paris childhood, despite his sensitivity and his being teased as a "pretty little German pig" by chauvinistic schoolmates, Rudolf won grammar school honours and, at 12, admission to the *École Primaire Supérieure*, then the most highly esteemed secondary school in Paris.

This triumph was negated by the outbreak of the Franco-Prussian War. By the French War Ministry's decree of August 28, 1870, the Diesels, as "undesirable aliens," were rounded up by police and shipped to neutral asylum in London. Rudolf was rescued from the ensuing upset and impoverishment by a teacher-cousin in Augsburg, his father's home town. The cousin, Christoph Barnickel, wrote to invite Rudolf to enter the Royal County Trade School, where Barnickel taught, as a "deserving refugee pupil and ward."

During the ensuing three years, Rudolf again suffered derision, this time as a "pretty French pig." Nevertheless, he led his class, set an all-time high scholastic record, and, despite being a "nonnational," won a scholarship to the Technische Hochschule of Munich. In his four years there he repeated his attainment of unprecedentedly high grades. With his own earnings as an undergraduate tutor and by making and selling second-degree geometrical surfaces (ellipsoids, hyperboloids, etc.), he managed to rent himself a piano, took piano and voice lessons, attended operas, concerts, art exhibitions, and lectures in Munich. He left the Hochschule as a special protégé of Carl von Linde, its most renowned professor and pioneer in mechanical refrigeration.

Life in Paris. After two years as a mechanic and parts designer at the Sulzer Machine Works of Winterthur, Switzerland, by then self-labelled as the steam engine capital of the world, Diesel returned to Paris as a thermal engineer, installer, and salesman for the Linde Refrigeration Enterprises, then operating in five countries. On the Left, or south, Bank he found friends among international artist groups and, in more sumptuous neighbourhoods, among more affluent professional men. With his exceptional personal charms, not to mention his talents as a drawing-room artiste, he became established both as a devotee of fine arts and an internationalist.

When his father, who had earlier abandoned his leather craft to open shop as a *Heilmagnetiseur*, or "Magnetic Health Builder," exhorted his son to act more like a real German, Rudolf replied that the Diesel forebears had never been real Germans. Rather, they were all Saale Valley Slavs, or Thuringians, a gentle, poetic clan who had adopted the name Diesel from earlier Slav names, including *Dössel* and *Tüssel*, on being converted as Lutherans. Since his 13th birthday, Rudolf had been a rather devout Lutheran and believed the denomination to be symbolic of international religious liberation.

At the age of 25, Diesel married Martha Flasche, a German-raised governess he had met in the home of Ernest Brandes, an international merchant friend. The following year (1884) Martha bore a son, Rudolf, who grew up to be an abstract artist and mystic; two years later a daughter, Hedy; and in 1889 a second son, Eugen, who became a writer on, and professor of, philosophy.

During 1885 the seeker of a "power provider for global justice" set up his first shop-laboratory in Paris and began his 13-year ordeal of creating his distinctive engine.

Pacifism

A dedicated pacifist, Diesel also envisaged what he privately termed his "Black Mistress" as an implement for sustaining peace. In 1888, his second year of intensive work on the engine, the inventor barely escaped alive when ammonia gas, being tested as a fuel, exploded. Almost instantly he set out to exploit the near catastrophe as a war squelcher. He proposed to fill small, readily breakable glass vials with contact-explosive gas and supply the chemical fireworks to war ministries for use in lieu of lethal bombs and bullets. Thus, all battles could be made shams, entertaining at least to the "militant imbeciles who revel in competitive uproars." When the French Patent Office turned it down, Diesel offered his proposal to Count Georg Münster, then the imperial German consul general to Paris. The rarely smiling Count is said to have laughed aloud. By that time, however, Diesel's 30th year, his stature as a thermal engineer, inventor, and internationalist was above being the subject of derision. One cause was his extraordinary scholastic brilliance. After three gruelling and impoverishing years of preliminaries in Paris, however, Diesel was obliged to take temporary employment with the Linde Enterprises, this time in Berlin. From there, late in 1892, he gained a German development patent. On the strength of this and about a dozen trunkfuls of immaculate drawings and tabulations and on promise of eventual manufacturing rights, three sponsors, the Maschinenfabrik firm at Augsburg and the firms of Sulzer and Krupp, came to the inventor's support.

Invention of the Diesel engine. At Augsburg, on August 10, 1893, Diesel's prime model, a single ten-foot iron cylinder with a flywheel at its base, ran on its own power for the first time. The pressure needle promptly shot to 80 atmospheres, at the time the highest mechanically created pressure ever recorded. But at that point the indicator plate exploded. Again the smock-clad inventor dodged barely in time to save his head. Next, a carefully revised model ran on its own power for one minute on February 17, 1894. Expert onlookers termed that an epochal minute, a proof of momentous potentials of a still imperfect engine.

Diesel spent two more years at improvements and on the last day of 1896 demonstrated another model with the spectacular if theoretical mechanical efficiency of 75.6 percent, in contrast to the then prevailing efficiency of the steam engine—10 percent or less. Although commercial manufacture was delayed another year and even then begun at snail's pace, by 1898 Diesel was a millionaire from franchise fees, in great part international.

By 1904, when Diesel first toured the United States as an elite lecturer, his appallingly bad financial management was returning him to respectable poverty. Publication of his two-volume work on social philosophy, *Solidarismus*, did not relieve his financial difficulties; it sold fewer than 200 copies. Diesel, however, was internationally recognized as the pre-eminent pioneer of the power age and a champion of the fine arts. His engines were powering pipelines, electric and water plants, automobiles and trucks, and marine craft and soon thereafter were used in mines, oil fields, factories, transoceanic shipping, and elsewhere. But by 1912, when he toured the United States, his health was worsening; he had contracted gout and was emotionally disturbed by the overtures of World War I. Even so, the oncoming year promised to be his best.

He returned to Munich to be greeted by his three grandchildren, a welcome deluge of new engine adaptations, a reopening of the Munich Opera, and a salon art exhibition that his wife had arranged in his honour. On September 27, 1913, he set out on a brief journey to London, where he would again be honoured by an engineers' convention. Two evenings later he boarded a ferry to England in company with a longtime engineer friend, with whom he dined jovially. Later that night, his stateroom and luggage still intact, Diesel disappeared at sea and presumably drowned in the English Channel.

BIBLIOGRAPHY. EUGEN DIESEL, *Diesel: Der Mensch, Das Werk, Das Schicksal* (1937), is a sensitive and revealing profile of the inventor-philosopher as recounted by his son. RUDOLF DIESEL, *Solidarismus*, 2 vol. (1903), is the inventor's own attempt to appraise his abstruse social and economic philosophy against a background of what he recognized as a paradoxical industrial society. W.R. NITSKE and C.M. WILSON, *Rudolf Diesel: Pioneer of the Age of Power* (1965), is a detailed, authoritative biography.

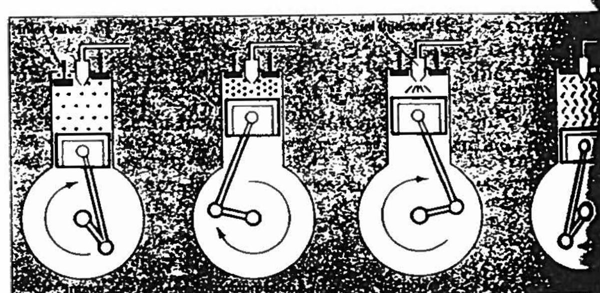
(C.M.W.)

Diesel Engine

The diesel engine is an internal-combustion engine that differs from the older gasoline engine principally in that it relies on heat generated by compressing air in the cylinder to ignite the fuel, rather than on an electric spark. To generate the required heat the diesel must produce higher compression than the gasoline engine, making it bulkier, heavier, and more expensive; it also operates at slower speeds. But it can operate on cheaper, less highly refined fuel, which gives it an advantage in many transportation and construction-equipment applications: locomotives, trucks, tractors, buses, bulldozers, graders and other heavy-duty machines, and in marine propulsion.

HISTORY

Though two English engineers had patented engines that did not depend on spark ignition, Rudolf Diesel of Germany conceived his invention as an improvement on the gasoline engine that fellow-German Nikolaus Otto had developed in 1876. Seeking to increase the efficiency of the Otto engine, it occurred to Diesel that he could do away with electrical ignition if he could compress air to so small a volume that the temperature would be above the ignition point of an appropriate fuel. The cycle of operations he conceived was set forth in his patents of 1892 and 1893 (see illustration): (1) air is drawn into the



Four-cycle diesel engine showing the sequence of cycle events.

cylinder as the piston moves away from the cylinder head (intake); (2) the air in the cylinder is compressed by the piston as it moves upward, toward the cylinder head (compression); (3) when the piston reaches the top of its stroke, the fuel charge is injected into the cylinder, where it is ignited by the high temperature of the compressed air. The fuel is injected at such a rate that the maximum cylinder pressure never exceeds the pressure attained by the compression of the air; after completion of the fuel injection, the piston continues to move away from the cylinder head in its downward or expansion stroke (power); (4) the burned fuel is forced from the cylinder by upward motion of the piston (exhaust). This is called four-cycle operation as four separate piston strokes are required; two up and two down.

In 1892–93 Diesel took out patents on an engine to operate on the cycle just described. Either powdered coal or liquid petroleum would be used as fuel. Powdered coal was included because of its ready availability as a waste material of the Saar coal mines. Diesel planned to use compressed air to introduce the coal dust into the engine cylinder but found it difficult to control the rate of injection so that the maximum pressure in the cylinder after ignition would not exceed a safe limit. After the experimental engine was wrecked by an explosion in the cylinder, Diesel gave up the idea of using coal dust and devoted his efforts to the use of liquid petroleum. He continued, however, to use compressed air to introduce the liquid petroleum into the cylinder.

The first commercial engine built on Diesel's patents was installed in St. Louis, Missouri, by a brewer, Adolphus Busch, who had seen one on display at an exposition in Munich and had purchased a license from Diesel for the manufacture and sale of the engine in the U.S. and Canada. The engine operated successfully for many years and was the forerunner of the Busch-Sulzer engine that powered many submarines of the U.S. Navy in World War I. Another Diesel engine used for the same purpose was the Nelseco, built by the New London Ship and Engine Company in Groton, Connecticut.

The diesel engine became the major power plant for submarines during World War I. It was not only economical in the use of fuel but it proved itself reliable under wartime conditions. Diesel fuel, less volatile than gasoline, was more easily stored and handled.

At the end of the war many men who had operated diesels were looking for peacetime jobs. Manufacturers began to adapt diesels for the peacetime economy. One modification was the development of the so-called semidiesel that operated on a two-stroke cycle at a lower compression pressure and made use of a hot bulb or tube to ignite the fuel charge. These changes resulted in an engine less expensive to build and maintain.

Fuel injection developments. One objectionable feature of the full diesel was the necessity of a high-pressure, injection air compressor. Not only did it require energy to drive it but the sudden expansion of the air compressed to 1,000 pounds per square inch when it entered the cylinder in which the pressure was only 500–600 pounds per square inch resulted in a refrigerating effect that delayed ignition. Diesel had needed high-pressure air in order to introduce powdered coal into the cylinder; when liquid petroleum replaced the powdered coal as fuel, a pump could be made to take the place of the high-pressure air compressor.

There were a number of ways in which a pump could be used. In England, the Vickers Company used what was called the common rail method in which a battery of pumps maintained the fuel under pressure in a pipe running the length of the engine with leads to each cylinder. From this rail (or pipe) fuel supply line, a series of injection valves admitted the fuel charge to each cylinder at the right point in its cycle. Another method employed cam-operated jerk, or plunger-type pumps, to deliver fuel under momentarily high pressure to the injection valve of each cylinder at the right time.

[...]mon [...]ethod

The elimination of the injection air compressor was a step in the right direction, but there was yet another problem to be solved: the engine exhaust contained an excessive amount of smoke, even at outputs well within the horsepower rating of the engine, and even though there was enough air in the cylinder to burn the fuel charge without leaving a discoloured exhaust that normally indicated overload. Engineers finally realized that the problem was that the momentarily high-pressure injection air exploding into the engine cylinder had diffused the fuel charge more efficiently than the substitute mechanical fuel nozzles were able to do, with the result that without the air compressor, the fuel had to search out the oxygen atoms to complete the combustion process, and since oxygen makes up only 20 percent of the air, each atom of fuel had only one chance in five of encountering an atom of oxygen. The result was improper burning of the fuel.

The usual design of a fuel injection nozzle introduced the fuel into the cylinder in the form of a cone spray, with the vapour radiating from the nozzle, rather than in a stream or jet. Very little could be done to diffuse the fuel more thoroughly. Improved mixing had to be accomplished by imparting additional motion to the air, most commonly by induction-produced air swirls or a radial movement of the air, called squish, or both, from the outer edge of the piston toward the centre. Various methods have been employed to create this swirl and squish. Best results are apparently obtained when the air swirl bears a definite relation to the fuel injection rate. Efficient utilization of the air within the cylinder demands a rotational velocity that causes the entrapped air to move continuously from one spray to the next during the injection period, without extreme subsidence between cycles.

Swirl or squish

Price's engine. In 1914 a young engineer, William T. Price, began to experiment with an engine that would operate with a lower compression ratio than that of the diesel and at the same time would not require either hot bulbs or tubes. As soon as his experiments began to show promise, he applied for patents.

In Price's engine the selected compression pressure of 200 pounds per square inch did not provide a high enough temperature to ignite the fuel charge when starting. Ignition was accomplished by a fine wire coil in the combustion chamber. Nichrome wire was used for this because it could easily be heated to incandescence when an electric current was passed through it. The experimental engine had a single horizontal cylinder with a bore (cylinder diameter) of 17 inches and a stroke (maximum piston movement) of 19 inches and operated at 257 revolutions per minute. Because the nichrome wire required frequent replacement, the compression pressure was raised to 350 pounds per square inch, which did provide a temperature high enough for ignition when starting. Some of the fuel charge was injected before the end of the compression stroke in an effort to increase the cycle timing and to keep the nichrome wire glowing hot.

OPERATION

Cycle efficiency. The thermal efficiency of any engine cycle may be expressed by the following simple equation:

$$\text{Thermal Efficiency} = \frac{E_1 - E_2}{E_1}$$

in which E_1 represents the heat energy released from the fuel during combustion and E_2 represents the heat energy rejected during the cycle. This equation states that the thermal efficiency of an engine cycle is equal to the difference between the heat supplied by the fuel and the heat rejected during the cycle divided by the heat supplied.

In the meantime many engines of the two-stroke cycle, semidiesel type were being installed. Some were used to produce electricity for small municipalities. Some were installed in water pumping plants. Many provided power for tugs, fishing boats, trawlers, and workboats.

Diesel-electric combinations. In the early 1920s the General Electric Company suggested to the Ingersoll-Rand Company, for whom Price was working, that they cooperate in the building of a diesel-electric locomotive. At that time there were many gasoline engine driven locomotives in service. A diesel-electric locomotive with Price's engine was completed in 1924 and placed in service for switching purposes in New York City.

The success of this locomotive resulted in orders from railroads, factories, and open-pit mines. The engine used in most of these installations was a 6 cylinder, 10-inch bore, 12-inch stroke, rated 300 brake horsepower at 600 revolutions, and weighing 15,000 pounds.

Marine applications. Many diesel engines were purchased for marine propulsion. The diesels, however, normally rotated faster than was desirable for large ships' propellers because the high speeds of the huge propellers tended to create hollowed-out areas within the water around the propeller (cavitation), with resultant loss of thrust. The problem did not exist, however, with smaller propellers, and diesel engines proved especially suitable for yachts, in which speed is desired. The problem was solved by utilizing a diesel-electric installation in which the engines were connected to direct-current generators that furnished the electricity to drive an electric motor connected to the ship's propeller.

There were also many installations in which the diesel was connected either directly or through gears, to the propeller. An unusual installation was a diesel-driven ferry that plied on the Hudson River between the towns of Hudson and Athens. In this installation the engine crankshaft was extended at both ends and coupled to shafting that carried a propeller at both ends of the ferry boat.

When diesel engines of larger horsepower and slower rotation speeds became available, they were installed in cargo and passenger carrying ships. Diesel engines were also installed in hospitals, telephone exchanges, airports, and other places to provide emergency power if regular electrical power was interrupted.

Emergency power

Dual fuel engines. The dual fuel engine is an internal combustion engine that can be operated as an oil diesel entirely on liquid petroleum or, without any mechanical alterations, can produce its horsepower rating on a combination of liquid fuel and natural, or artificially produced, gas. Liquid fuel is needed to perform the basic function of igniting the gas.

The gas diesel operates on gas as the primary fuel that is ignited by the introduction of a small pilot charge of liquid fuel into the cylinder shortly before the piston reaches top dead centre on its compression stroke. The amount of liquid fuel used in the gas diesel is never more than is needed for the ignition of the gas.

On April 30, 1901, the U.S. Patent Office issued to Rudolf Diesel patents that covered all the essential features of the dual fuel and gas diesel engines. In 1932 patents were issued to Victor Heidelburg that covered the advantages of the higher fuel economy made possible by the higher compression ratios that could be used.

Both patents lay unused until 1940, when the rising price of liquid fuel created a demand for natural gas that could be purchased at a very low rate on the basis of an interruptible contract. With such a contract the engine owner could switch from gas to oil and back again on short notice.

Diesel engine starting. A diesel engine is started by driving it from some external power source until conditions have been established under which the engine can run by its own power. The most positive starting method is by admitting air at 250 to 350 pounds per square inch to each of the cylinders in turn on their normal firing stroke. The compressed air becomes heated sufficiently to ignite the fuel. Other starting methods involve auxiliary equipment and include admitting blasts of compressed air to an air-activated motor geared to rotate the large engine's flywheel; supplying electric current to an electric starting motor, similarly geared to the engine flywheel; or by means of a small gasoline engine geared to the engine flywheel. The selection of the most suitable starting method depends upon the physical size of the engine to be started, the nature of the connected load, and whether or not the load can be disconnected during starting.

Fuel for diesels. Petroleum products normally used as fuel for diesel engines are distillates composed of heavy hydrocarbons, with at least 12 to 16 carbon atoms per molecule. These heavier distillates are taken from crude oil after the more volatile portions used in gasoline are removed. The boiling points of these heavier distillates range from 350° to 650° F. Thus, their evaporation temperature is much higher than that of gasoline that has fewer carbon atoms per molecule. Specifications for diesel fuels published in 1970 listed three grades: the first was a volatile distillate recommended for high-speed engines with frequent and wide variations in load and speed; the second, a distillate for high-speed engines in services with high loads and uniform speeds; and the third, a fuel for low- and medium-speed engines in services with sustained loads.

Water and sediment

Water and sediment in fuels can be harmful to engine operation; clean fuel is essential to efficient injection systems. Fuels with a high carbon residue can be handled best by engines of low-speed rotation. The same applies to those with high ash and sulfur content. The cetane number, which defines the ignition quality of a fuel, is ascertained by adjusting a mixture of cetane and *alpha*-methyl-napthalene until it has the same ignition quality as the fuel being tested. The percentage of cetane in the mixture is then the cetane number of the fuel under test. For the first two grades of diesel fuel described above the minimum cetane number is 40; for the third grade the minimum is 30, representing 30 percent cetane in the fuel.

Supercharging. The horsepower output of a diesel engine can be increased by compressing the air charge prior to its admission to the cylinder, thus increasing the weight of air available for combustion. This supercharging can be used either to increase horsepower output at sea level or to recover horsepower lost at higher altitudes due to thinner air. Supercharging can be accomplished in a number of ways: (1) by an engine-driven blower, (2) by an exhaust gas-driven compressor, or (3) by a tuned manifold that produces a phenomenon known as ramming.

In ramming, the cylinders of a multiple-pipe system are selectively connected to two or more exhaust pipes in such a way (tuned manifold) that no cylinder will be exhausted into the pipe at the same instant that another is being cleared of exhaust gases by forced fresh air. The advantage of such a precision grouping is the retention and utilization of the kinetic energy remaining within these exhaust gases and at a high level, for use as power generation when channelled to the turbine. Excessive back pressure is also prevented against the cylinder being scavenged.

THE DIESEL ENGINE TODAY

Since its success in World War II, in which it was the most prevalent power plant for armed forces equipment on the ground and at sea, the diesel engine became the conventional power source for most railroad locomotives, most heavy construction machinery, most high-powered farm tractors, and a large proportion of trucks and buses. Its weight makes it unsuitable for aircraft use, and it has had only limited (but growing) application in passenger automobiles. In general, it finds applications wherever its greater weight and cost and less smooth-running operation are offset by its lower cost of operation. An especially noteworthy application is in marine propulsion. While passenger-carrying vessels favour turbines that provide more speed and less vibration, cargo vessels, especially the largest sizes, profit from low-cost diesel power. Of 371 ships built in two recent years for the merchant fleet of the U.S.S.R., for example, 7 were propelled by steam turbines, 1 by a gas turbine, and 363 by diesel plants.

BIBLIOGRAPHY. L.V. ARMSTRONG and J.B. HARTMAN, *The Diesel Engine* (1959), a text covering the theory, basic design, and economics of the diesel engine; C.B. DICKSEE, *The High-Speed, Compression-Ignition Engine* (1940), a text covering the principles of operation and problems of compression-ignition engines running at rotative speeds required for road transport service; H.F.P. PURDAY, *Diesel Engine Design*, 5th ed. (1948), a text dealing with the functions and details of the design of engines, both large and small, and design problems such as heat flow, lubrication, and vibration stresses; A.R. ROGOWSKI, *Elements of Internal-Combustion Engines* (1953), a detailed discussion of the three stages of combustion as applied to compression-ignition engines; M.L. SMITH and K.W. STINGSON, *Fuels and Combustion* (1952), a discussion of fuel characteristics, availability, and combustion; A.J. BUCHI, *Exhaust Turbocharging of Internal Combustion Engines* (1953), a monograph on pressure fluctutation of intake air and exhaust gases, and also multiple pipe turbocharging as outlined in Dr. Buchi's patents. Other texts include: A.W. JUDGE, *Modern Smaller Diesel Engines in Theory, Construction, Operation, and Maintenance* (1969); C.C. POUNDER (ed.), *Diesel Engine Principles and Practice*, 2nd ed. (1962); and M.H. HOWARTH, *The Design of High Speed Diesel Engines* (1966).

(L.V.A.)

Dietary Laws and Food Customs

Like all other biologically and physically necessary things and acts, food and eating are always surrounded by social regulations that prescribe what may or may not be