and he will then find that the practical points he has picked up will fall into their proper places in the general laws, and that these laws will extend his vision and throw new light on all that he sees and does ever after. To study physics and chemistry is like giving sight to a blind man. It opens to him a new world of undreamed-of-beauty, meaning and possibilities.

But simply because these physical sciences are so fundamental and essential they are apt to be overlooked and neglected in the acquirement of culture. When tourists visit a Gothic cathedral many of them see nothing but the frescoes and gargoyles, and give no thought to the architectural principlos of its structure, yet the esthetic effect of the edifice is due largely to the way the structural principles are revealed in its pillars, buttresses and arches. One who fails to get that misses, not only the meaning, but much of the beauty of the building. So, too, one who, for lack of acquaintance with the physical sciences, does not see the inner meaning of the acts and processes of daily life, not only is hampered in their control, but loses the enjoyment of their significance.

CHEMISTS BELIEVE FUTURE FUEL PROBLEMS CAN BE MET

When there is one motor car to every four persons in the United States, which is now estimated as the saturation point in motor-mad America, and oil wells stop producing, what will America do for "gas". This problem wrinkled the brows of scientists gathered in Philadelphia for the seventy-second meeting of the American Chemical Society, and many schemes were suggested for keeping the wolf from the garage door.

"The United States had 100,000 motor cars twenty years ago, and today she has nearly 20,000,000," Dr. A. C. Fieldner, chief chemist of the Pittsburgh department of the U. S. Bureau of Mines explained. "The United States owns five sixths of all the motor cars and trucks in the world, anduses 80 per cent. of all the motor fuel. Nearly all of this motor fuel is gasoline made from petroleum, and the petroleum supply in the United States is definitely limited."

The engines of motor cars, Dr. Fieldner said, are very inefficient users of fuel. The mileage could be almost doubled if engines of greater gas compression were used with anti-knock gasoline, and the supply of petroleum could be made to last some years longer.

The oil wells of proven acreage in the United States are estimated to contain a billion barrels of readily available petroleum, and this supply would last only until 1936, Dr. Fieldner explained, at the present rate of consumption by inefficient engines. It is believed that more than five times as much oil or about 26 billion barrels may still be gotten out of the wells when ordinary pumping is finished. In addition to this, oil shale deposits, soft coal and lignite can supply about 700 billion barrels more when needed, according to the estimates of experts. This would make a total oil reserve of 734 billion barrles, which sounds enormous, but only about 4 per cent. of it comes from crude oil which is readily available and from which all the gasoline of commerce is made.

Gasoline used to be distilled from crude oil, but as the demand leaped with the growth of the motor car other means were used to swell the amount. A process called

"cracking" was resorted to and in 1925 petroleum yielded 35 per cent. gasoline. This is a high mark, but it is expected to be far surpassed in the future. An increase to a 55 per cent. yield, Dr. Fieldner said, would stretch the 5 billion barrels.enough to make them last until 1943 instead of 1936.

The potential gasoline source of the future lies in cracking heavy oils into just two products, gasoline and coke, in one operation, according to Dr. Gustave Egloff of Chicago. Instead of a 35 per cent. yield in ten years it will be economically necessary to get 75 per cent., he believes.

Not only does the cracking process increase the gasoline yield of crude oil but it also provides the gasoline with the sought-for anti-knock quality. This is because of the high per centage of certain kinds of unsaturated carbohydrates called olefines that are found in it. Formerly, gasoline consisting of saturated compounds was in great demand and sold at a premium, but now it is doctored with anti-knock substances or blended with cracked gasoline before sold.

The amount of cracked gasoline is continually increasing and can be used with motors of higher compressibility than ordinary gasoline, and a greater milage can be obtained. The present average compressibility of all engine models in the United States is a little more than 4 to 1, but the best anti-knock cracked gasoline is suitable for a 5½ to 1 compressibility. Dr. Fieldner believes that the automobile manufacturers will gradually modify theengines as the character of the gasoline changes, and the resulting efficiency will save fuel and make the supply last the longer. It will increase the pleasure of the motorist by the smoothness and noiselessness of the motor and save him money as well.

When it becomes necessary, Dr. Fieldner said, the gasoline supply will be augmented by alcohol from the fermentation of vegetable matter as well as from its synthesis from coal and oil gases. Ultimately, however, oil shale, soft coal and lignite must become the source of automotive fuels. Oil distilled from shale will be cracked into gasoline and other products, while coal and lignite will be carbonized into solid and liquid fuels and other by-products. New liquid combustible materials, other than alcohol, may be synthesized from combustible coal gases.

Recovery of oil shale in the United States would yield billions of barrels of oil. This oil when cracked would yield the highest grade anti-knock gasoline which would be greatly superior to that from tar oils from coal because it would be free from objectionable acids.

Motor fuels from coal may be obtained in a variety of ways in the future. At Mannhein in Germany coal and lignite are completely gasified, and methanol, synthol and other liquid combustibles are synthesized from it. In France ethyl alcohol is made from coal gas. Ethylene, a by-product of the coke ovens, is converted into alcohol by the sulphuric acid method. If this method were applied in the United States the increase of motor fuel yields from coke plants could be pushed up to 35 per cent. Ethylene from cracking stills and from oil shale plants could also be made into alcohol.

If liquid fuel becomes very scarce in spite of the efforts of scientists the electric storage battery may come back into use as motive power, especially if the long delayed discovery of a light weight battery is made. Another possibility is

that the use of a coal dust motor may come into vogue. Experimental work is being conducted with some success by German manufacturers on the Diesel engine using coal dust. In fact, Diesel's original idea was to use powdered coal fuel, and after all these years, this expedient may after all become a solution.

SYNTHETIC GERMAN PETROLEUM MAY SOLVE MOTOR FUEL PROBLEM

A new method of cheaper synthesis of a high grade motor fuel in Germany may go far toward the solution of the motor fuel problem in the future. The Berlin professor, Franz Fischer, who recently devised means of making liquid fuels synthetically from coal products, has now simplified his process so that he can dispense with costly high pressure apparatus that has stood in the way of its commercial development.

The new method produces a pleasant smelling gasoline as clear as water and one which will not harden or become gummy on exposure. The gasoline is highly volatile and is largely made up of unsaturated compounds like olefines which impart to the gasoline valuable anti-knock properties. This enables it to be used in efficient high compression motors without objectionable knocking and with great economy.

A number of valuable by-products may help to put the process on a sound commercial basis in the future. Certain substances of high boiling point condensing to heavier oils, may by the use of catalyzing agents be changed to hard paraffine. The purified crystallized substance could be used in the manufacture of candles and other paraffine products, it is claimed.

Semi-coke, a new indu try by-product for which a commercial use has not yet been found, may be used as the basis of synthesis of this new gasoline. Semi-coke is left over in the low temperature carbonization of coal in the making of tar oils. In the Fischer process water gas from which the new liquid fuel is condensed can be made from coke or semi-coke, and the latter, it is claimed, would be an ideal starting material.

Coke and coal are almost completely gasified when steam is led over them at a high temperature, and water gas, a mixture of carbon monoxide and hydrogen, is formed. If this water gas could be entirely transformed into liquid motor fuel, the problem of the wasteless transformation of solid coal into liquid fuel, the dream of the modern chemists, would be accomplished.

The Badische Analin und Soda Fabrik first succeeded in commercially synthesizing liquid fuels from this gas mixture in Germany by means of Dr. Fischer's early method, in which pressures of 1500 pounds per square inch or more were employed. By his new process, however, Prof. Fischer has succeeded in synthesizing gaseous, liquid and solid carbohydrates from carbon monoxide and hydrogen at ordinary pressure. Hitherto all reduction of carbon monoxide without pressure yielded methane, but Fischer found that by using an ironzinc oxide catalyzer more complicated products were formed. Other metals and their compounds were studied and a cobalt chromium oxide mixture was found to stimulate the formation of gaseous, liquid and solid carbohydrates, when heated to about 518 degrees Fahrenheit.

The carbon of the carbon monoxide is said to be made into carbide by the metal,