contact of gastric juice with an eroded surface, the following experiment was conducted:

Two small bleeding points were produced in the gastric mucosa by traumatizing it with a smooth-edged forceps. These tiny eroded areas were kept in contact with gastric juice for one-half hour. The protective mucus which accumulated rapidly in this region was sucked away frequently and fresh gastric juice applied. A sharp acceleration of acid secretion and concomitant hyperemia of the whole gastric mucosa resulted from this procedure, and these effects persisted for one-half hour after the exposure of the erosions to the action of gastric juice had been stopped. After the undisturbed lesions had become covered by mucus, the color and acid values returned to normal.

This experiment supports the idea that the acceleration of acid secretion resulting from erosions being bathed in gastric juice is one mechanism involved in the maintenance of hyperacidity in patients suffering from peptic ulcer.

It can thus be shown that when an unprotected mucosal erosion is exposed to the digestive action of gastric juice, additional tissue damage occurs and chronic ulceration results.

COMMENT

The difference between a hypersecreting stomach and actual gastritis is, as has been shown, mainly one of degree. Prolongation of inordinate hypersecretion in the stomach with the inevitable accompanying hyperemia, then, carries with it the hazard of possible structural damage to the lining of the stomach or even more likely to that of the duodenal cap, since the latter is less well protected.

Once an erosion has been effected, contact of acid gastric juice with the denuded surface would perpetuate the vicious cycle as illustrated in the experiment described.

It has been shown that situational factors resulting in emotional conflict with anxiety, hostility and resentment may induce in the stomach profound and prolonged hyperemia, hypermotility and hypersecretion. Adequate neural mechanisms exist to explain these phenomena. The reason that the patient experimented with has not acquired peptic ulcer may be that the hyperemia and hypersecretion which were observed in the presence of conflict have been relatively transitory. He is not the sort of person who harbors grudges or maintains emotional stress for prolonged periods. Usually he expressed his feelings in words or in action, and his more serious conflicts were relatively short lived. Since the occurrence of gastric hyperfunction in certain emotional settings has been demonstrated, however, and since the destructive power of excessive gastric secretion has been established, one may infer that these emotionally charged situations are involved directly in the genesis of peptic ulcer in man. Hyperacidity, gastritis, minor mucosal erosions and finally peptic ulcer occurring during the course of sustained emotional tension should not be looked on as separate clinical entities. The evidence indicates that they are all phases of the same pathologic process.

PETROLEUM, PAST, PRESENT AND FUTURE. II

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The domestically available energy source most closely related to crude oil is natural gas. The production and consumption of natural gas by states, although by no means identical to the distribution shown for crude oil in Fig. 9, follows much the same general pattern in that transportation by pipe line makes for a marked flexibility in distribution. To most of us it does not mean much when we are told that the country's proved natural gas reserves amount to some 95 trillion cubic feet.[11,12] A little figuring will show, however, that on a weight basis this is equal to about 75 per cent. of the proved reserves of petroleum. At the present rate of consumption the proved gas supply should last about thirty years, or twice as long as the oil supply. Methods are known for converting these natural gas hydrocarbons into liquid petroleum fractions. The heavier constituents can be processed by such direct methods as cracking or dehydrogenation, followed by polymerization and alkylation. Methane, however, which is the major constituent of natural gas, can best be converted into gasoline by the Fischer-Tropsch process. In that case the methane must first be reacted with steam to give a mixture of carbon monoxide and hydrogen, which is then treated with a catalyst to produce liquid hydrocarbons. Technical information is available on this process, but as yet this country has no large-scale operating experience. The process has been used commercially in Germany for some time, and a small pilot-plant unit for carrying out the Fischer-Tropsch

[11] Energy Resources Committee, "Energy Resources and National Policy," Rept. to Nat. Resources Comm., January, 1939.

[12] E. H. Poe, *Oil Gas Jour.*, July 28, 106, 1943.

synthesis is now in operation at the Bureau of Mines.[13] It would be unwise at this time, however, to make any prediction in regard to the amount of gasoline that might be produced in this manner.

A much larger potential supply of liquid hydrocarbons is obtainable from the oil shales of the United States. Most important are the Tertiary oil shales of the Rocky Mountain region, located chiefly in Colorado and Utah. Other deposits are the Devonian black shales of Indiana and Kentucky and the cannel shales of Pennsylvania and West Virginia. In 1928 these shale deposits were estimated by Dean E. Winchester as capable of producing 92 billion barrels of oil.[14] Although this is still considered the most authoritative figure, a great deal of assay work must be done before an accurate estimate of practically available oil from shale can be made. It can definitely be said, however, that the potential supply of liquid hydrocarbons from this source is high compared with known crude oil reserves.

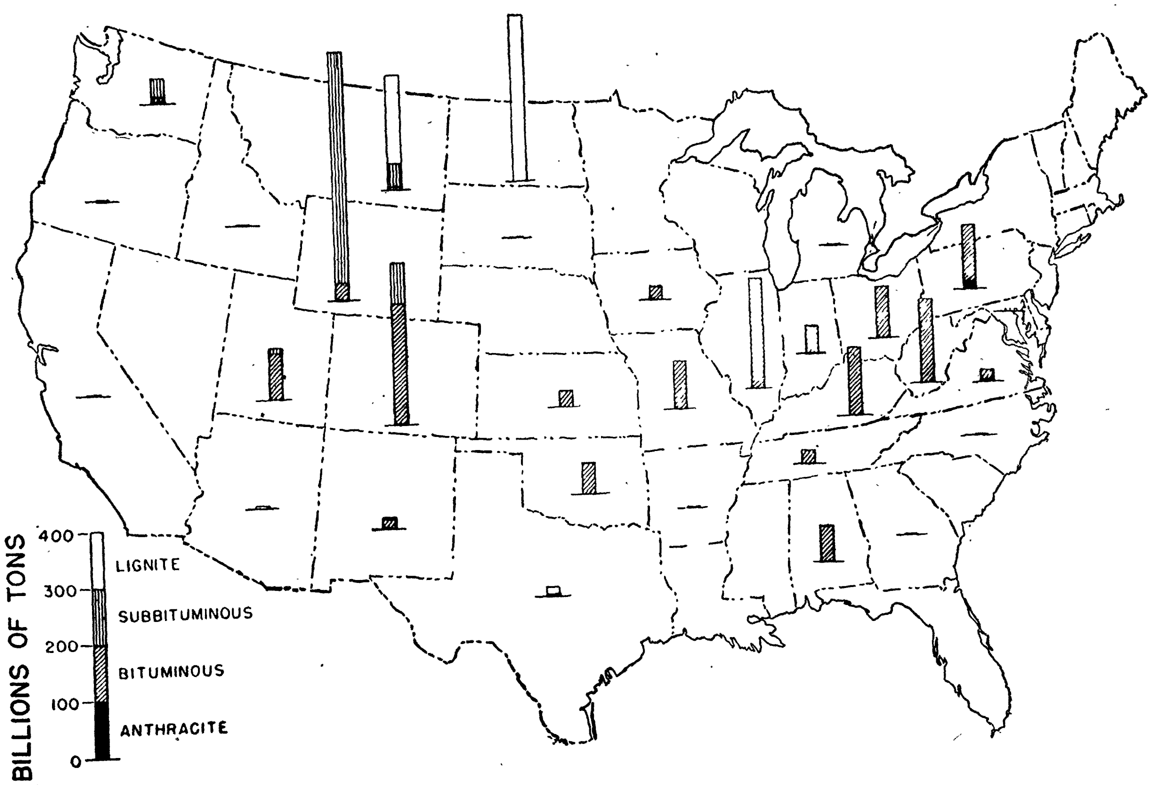

FIG. 12. Coal reserves by states as of January 1, 1937. Anthracite, subbituminous and lignite reduced to bituminous coal equivalent, according to "Energy Resources and National Policy."[11]

Oil is now being recovered from shales on a limited scale in various parts of the world by retorting under suitable conditions of temperature and pressure. From 1925 to 1929 the Bureau of Mines experimented with the recovery of oil from Colorado shales. Although no commercial scale production was undertaken, sufficient work was done to demonstrate the practicability of producing oil from this source. The oil obtained by retorting shale differs from conventional crude oil in that it has a higher percentage of unsaturated hydrocarbons, a lower percentage of gasoline, a higher wax content and relatively high content of phenolic compounds and nitrogen bases. Additional work therefore remains to be done on the development of satisfactory refining methods.[14,15]

Beyond the borders of the United States, the Canadian deposits of tar sands can also be included. These deposits spread over thousands of square miles through the central portion of the Williston Basin in the Province of Alberta. They are composed of sands saturated with oil, and figures indicate the reserves of the Athabaska deposits to range from 100 billion barrels up to many times that quantity. Pratt gives an estimate of 100 to 250 billion barrels,[5] which places Ahabaska tar sand as one of the largest potential

[13] A. C. Fieldner, statement before Joint Committee on Public Lands and Surveys, U. S. Senate, August 4, 1943.

[14] Federal Oil Conservation Board, Rept. II, p. 13, January, 1928.

[15] B. H. Weil and W. Weinrich, *Oil and Gas Jour.*, April 22, 48, 1943; April 29, 73, 1943.

sources of petroleum in North America. However, the fact that these sands must be mined to extract their tar oil content presents practical difficulties. Of the total area, variously estimated at 10,000 to 50,000 square miles, not more than 10 square miles, containing perhaps 500 million barrels of oil, can be considered workable by strip mining methods.

Aside from the development work which remains to be done on improved methods of recovery and refining, the production of oil from the tar sands as well as from shale presents a problem in waste disposal. Even though this may not be a representative illustration, an oil recovery of 13 per cent. by weight may give approximately 1.5 cubic yards of solid material as waste per barrel of oil produced. This will tend to confine at least the initial processing operations to the point of mining.

The largest potential source of liquid hydrocarbons is, without doubt, our coal reserves. Coal accounts for more than 98 per cent. of the country's known energy resources, not including water power. (All water power, developed and suitable for development in the United States, would supply less than 25 per cent. of our present total energy requirements.) These coal deposits amount to more than 3 trillion tons. As Fig. 12 shows, almost 70 per cent. of the total coal reserves lies in the semiarid plains or in the Rocky Mountains, far from present centers of population and industry. About 85 per cent. of current production is from the 30 per cent. of our reserves east of the Mississippi River. The anthracite deposits are largely confined to Pennsylvania, with lesser quantities located in Virginia and Arkansas, and only smaller amounts in Colorado and Washington.[11]

Liquid fuels may be produced from coal by various methods such as low-temperature carbonization, the Fischer-Tropsch synthesis and high-pressure hydrogenation. The two latter are of most interest from the standpoint of yields obtainable. According to Petroleum Administrator Ickes, it is possible that some 50 million barrels of gasoline may now be made annually in Germany by high-pressure hydrogenation.[16] Coal has also been hydrogenated for some time in England on a less extensive scale. In this country the Bureau of Mines has in operation a laboratory-scale pilot plant for direct hydrogenation of coal,[13] and has been working on plans for the installation and operation of industrial-scale pilot plants. In recent hearings before a joint committee of Congress, Ickes strongly endorsed a proposal for the Government to build and operate larger-scale demonstration plants for the production of oil from coal. In his words, this "is a proposal to blaze the path now for private capital to do this job when we have no more natural domestic petroleum and it becomes a question of synthetic liquid fuel or the end of the gasoline age." There is no need at this time to go into further discussion of the quality of gasoline that may be produced by these various processes or the yields obtainable from different types of coals. According to Ickes' estimate, the available coal reserves can provide the synthetic fuel we need for a thousand years and still leave enough coal for other present-day purposes.[16]

This review has been concerned only with the available raw materials which have been handed down by nature through the ages. By growing vegetable matter it would undoubtedly be possible to extend these supplies, but the potentialities of this source of energy can not readily be estimated. A discussion of some of the technical and economic aspects of this problem is presented by Burke Jacobs in the report on "Energy Resources and National Policy.[11]

As to the question of cost, it may be well to consider the figures in Table 1 which were submitted by Farish before a House Committee last year.[17] These data indicate that gasoline from such alternate raw materials can be produced at a cost sufficiently close to present prices so that with an increasing cost of crude oil we may expect a gradual upward trend rather than any abrupt increase in the cost of gasoline and related products. In this connection, the petroleum

TABLE 1

COMPARISON OF METHODS FOR MOTOR GASOLINE PRODUCTION

Process	Approx. cost per barrel motor gasoline per day[a]	Approx. tons steel per barrel motor gasoline per day	Approx. gasoline cost, cents: Direct cost, including normal overhead but excluding depreciation	Approx. gasoline cost, cents: Total cost, including normal overhead and 10 per cent. depreciation
High-pressure coal hydrogenation	$12,800	14.1	15.9	22.6
Fischer, European design starting from coal	7,600	8.9	14.7	19.2
Fischer, European design starting from natural gas[b]	4,750	6.5	6.0	8.8
Modern high-pressure hydrogenation of petroleum[c]	1,150	1.4	4.8	5.5
Modern oil refinery, $1.20/bbl.[d]	700	0.7	5.1	5.3
Modern oil refinery, $2/bbl.[d]	700	0.7	8.3	8.5

[a] 1942 costs for complete plant including all utility supply and auxiliaries.
[b] Natural gas at 5 cents per 1000 cubic feet.
[c] Crude at $1.20 per barrel.
[d] Crude price at the well.

16 H. L. Ickes, statement before Joint Committee on Public Lands and Surveys, August 3, 1943.

17 W. S. Farish, hearings before Subcommittee of Committee on Mines and Mining, U. S. House of Representatives, July 15, 1942.

industry has not so far benefited by any appreciable increase in price level. Compared to August, 1939, the start of the present war, all commodities have increased 38.3 per cent., farm products 103.1 per cent., foods 61.2 per cent. and petroleum 19 per cent.[8] As Fig. 13 shows, the petroleum industry's record is one

AVERAGE U. S. GASOLINE COST

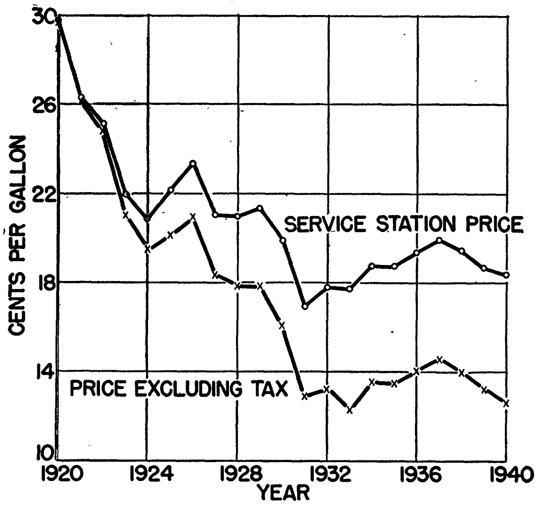

FIG. 13. Cost of gasoline in the United States (average for fifty cities.)

of decreasing costs brought about by technological improvements. This is particularly evident from the lower curve which represents the average gasoline cost in recent years, excluding the steadily mounting taxes. With a guaranteed supply of basic raw materials we should, in light of the petroleum industry's past achievements, be able to look with confidence toward the future.

It is not possible to predict the exact sequence of technical developments which lie ahead of us in this field. There is also a great deal of uncertainty in regard to the time element involved. New discoveries of crude reserves or an early termination of the war would undoubtedly relieve the present situation and delay the need for synthetic products; conversely, a prolonged war with continued heavy demands for petroleum would, in the absence of any substantial new discoveries, accelerate the need for alternate sources of supply. When the day comes, however, that the petroleum industry must turn in earnest to new sources of liquid fluids, its dependence on chemistry and engineering will become increasingly great. Whether the problem is one of recovering oil from shale, of liquefying natural gas, of working the tar sands or of hydrogenating or otherwise liquefying coal, chemistry and engineering will be called upon to work out processes which in major respects will differ from those currently in use by industry. We hardly need be concerned over the future of petroleum chemistry in general or even of the present trend toward utilization of petroleum as a chemical raw material, for these new processes will continue to yield the conventional hydrocarbons now obtained from crude oil and natural gas. In addition, such alternate processes are likely to increase the supply of hydrocarbon derivatives containing oxygen, sulfur and nitrogen which are being obtained from petroleum in such dilute concentrations that only in exceptional cases is their recovery a paying proposition.

This leads to the following general conclusions: In addition to the petroleum known to be present in the ground, large but as yet undiscovered reserves may be expected to exist in different parts of the world, including the United States. How long we can continue to locate this oil and bring it to the surface at the desired rate is an open question. At some future date, whether it be in the immediate future, in the next generation or in a much later generation, a shortage in natural petroleum will occur. In the meantime, there is nothing to indicate that this should result in any sudden change as far as our supply and consumption of gasoline and other petroleum derivatives are concerned. Progress will continue in the petroleum industry's efforts to improve the efficiency of its processes and the quality of its products. Advances in engine construction will make for better efficiency in the utilization of fuels and lubricants. Increased drilling on a world-wide basis will bring in more oil. There will be necessary adjustments in supply and demand so that oil will be moved freely from the principal centers of production to the principal centers of consumption. All this will tend to prolong the necessity, at least in time of peace, for turning to alternate sources of supply. As the need arises, synthetic products from the sources indicated will then gradually work their way into the picture.

OBITUARY

JOHN MUIRHEAD MACFARLANE

September 28, 1855—September 16, 1943

JOHN MUIRHEAD MACFARLANE, professor emeritus of botany at the University of Pennsylvania, died at his summer home, Lancaster, N. H., on September 16, twelve days before attaining his eighty-eighth birthday. He was born at Kircaldy, Scotland, and received the B.S. and D.Sc. degrees from the University of Edinburgh, where he held various academic positions, including that of professor in the Royal Veterinary College. In 1891 he was invited to speak before the American Association for the Advancement of