

I. C. 7534,
September 1949.

INFORMATION CIRCULAR

UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

REVISED BIBLIOGRAPHY OF BUREAU OF MINES INVESTIGATIONS ON THE PRODUCTION
OF LIQUID FUELS FROM OIL SHALE, COAL, LIGNITE, AND NATURAL GAS
(TO 1949)^{1/}

By

Norma Golumbic^{2/}, Hazel C. Anderson^{2/}, and Robert C. Grass^{2/}

CONTENTS

	<u>Page</u>
Introduction	1
Reviews	2
Oil shale and shale oil	8
Coal, lignite, and tar	16
Utilization	16
Preparation	19
Carbonization	23
Properties	29
Hydrogenation (Bergius)	40
Fischer-Tropsch synthesis	45
Synthesis gas	45
Synthesis	48
Methanol synthesis	52

INTRODUCTION

In view of the widespread interest in the production of synthetic liquid fuels from solid and gaseous fuels to supplement declining reserves of petroleum, and the many requests that are now being received for information on the subject, this bibliography of Bureau of Mines publications has been compiled. It contains those papers previously listed in Information Circular 7304 plus additional items intended to make the bibliography as complete as possible up to the date of issue. The latter include those references compiled by H. M. Thorne, Petroleum and Oil-Shale Experiment Station, Laramie, Wyo., for a bibliography on oil shale and shale oil.

^{1/} The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7534." Work on manuscript completed May 1949.

^{2/} Technical Assistant, Research and Development Branch, Office of Synthetic Liquid Fuels, Bruceton, Pa.

In addition to the publications issued by the Government in printed or mimeographed form, references are included to articles written by the Bureau staff for the technical press and to cooperative reports of work done jointly with States, colleges, and industries. References are given under each section by years in chronological order, and the items in each year are arranged in alphabetical order.

Bureau of Mines bulletins, technical papers, and Minerals Yearbooks are printed and are obtainable from the Superintendent of Documents, Government Printing Office, Washington 25, D. C. at the prices indicated. If no price is given, the publication is out of print. The price of entire volumes of the Minerals Yearbook or of reprints of certain chapters may be obtained upon request. Any orders or remittances in payment for these publications should be sent directly to the Superintendent of Documents and not to the Bureau of Mines. This will prevent delay in filling orders and avoid the extra work of transmitting them from the Bureau to the Superintendent of Documents, and of obtaining receipts for funds which the Bureau of Mines cannot accept. For convenience in remitting, coupons having a face value of 5 cents are sold by the Superintendent of Documents in sheets of 20 for \$1.00. These coupons are accepted in orders for relatively small amounts.

Reports of investigations, information circulars, and copies of Congressional hearings are published in mimeographed form and may be obtained (if not out of print) without charge from Publications Section, Bureau of Mines, 4800 Forbes Street, Pittsburgh 13, Pennsylvania.

Cooperative publications present the results of investigations conducted cooperatively with various agencies. These reports and papers have been written either wholly or in part by members of the Bureau and published otherwise than by the Bureau or by journals of various technical societies or by the technical press.

As there has been a liberal distribution of all these Bureau publications to public and college libraries in the United States and to some extent in foreign countries, those reports which are now out of print may be found in the technical and large public libraries. Likewise, bound volumes of the scientific and trade periodicals in which Bureau of Mines papers appear may be consulted in libraries throughout the country. Dealers in new and second-hand books sometimes have copies of these reports for sale.

REVIEWS

1. THIESSEN, R. Under the Microscope Coal Has Already Lost Much of Its Former Mystery. Coal Age, vol. 18, No. 25, 1920, pp. 1223-1228.
2. AMBROSE, A. W. Possible Substitute for Gasoline. California Oil World, vol. 13, 1921, pp. 82 and 83.
3. OIL, PAINT, AND DRUG REPORTER. Substitutes for Gasoline as a Fuel, Described by an Expert. Vol. 99, 1921, p. 12.

4. FIELDNER, A. C., AND JONES, G. W. Comparative Engine Tests with Crude, Acid-Refined, and Silica-Gel-Refined Motor Benzol. Bureau of Mines Rept. of Investigations 2517, 1923, 17 pp. (out of print); Benzol as a Motor Fuel. Chem. Met. Eng., vol. 29, 1923, p. 543.
5. TUFFT, H. E. Subject List of Reports of Investigations Issued During 1923. Bureau of Mines Rept. of Investigations 2568, 1923.
6. FIELDNER, A. C. Has Synthetic Motor Fuel Arrived? Min. and Met., vol. 6, 1925, pp. 456 and 457.
7. - - - Personal Observations on Fuel Research in Europe. Ind. Eng. Chem., vol. 17, 1925, pp. 1046-1050.
8. - - - Significant Progress in Research on Fuels. Science in Modern Industry. Annals Am. Acad. Polit. and Soc. Sci., vol. 119, 1925, pp. 13-23.
9. - - - Recent Progress in Science in Relation to the Gas Industry. Proc. Am. Gas Assoc., 1926, pp. 871-876.
10. FIELDNER, A. C., AND BROWN, R. L. Future Trends in Automotive Fuels. Ind. Eng. Chem., vol. 18, 1926, pp. 1009-1014.
11. HORNE, J. W., AND BAUER, A. D. Comparison of Oils Derived from Coal and from Oil Shale. Bureau of Mines Rept. of Investigations 2832, 1927, 34 pp.; Fuels and Furnaces, vol. 6, 1928, p. 208.
12. FIELDNER, A. C. The Work of the Experiment Stations Division, U. S. Bureau of Mines. Min. Cong. Jour., vol. 14, 1928, pp. 484-488.
13. FIELDNER, A. C., AND EMERY, A. H. Work of the Experiment Stations of the Bureau of Mines. Bureau of Mines Inf. Circ. 6060, 1928, 29 pp. (out of print.)
14. - - - - Experiment Stations of the U. S. Bureau of Mines - Saving of Natural Resources Defined as Aim of Federal Bureau of Mines. U. S. Daily, vol. 5, June 10, 1931, p. 4; Removal of Ash from Coal Is Aim of Federal Tests, vol. 5, June 24, 1931, p. 4.
15. FIELDNER, A. C. The Bureau of Mines. The Chemist, vol. 9, 1932, pp. 366-380.
16. STORCH, H. H., AND GOLDEN, P. L. Experiments on the Synthesis of Acetylene by the Pyrolysis of Methane. Ind. Eng. Chem., vol. 25, 1933, pp. 768-771.
17. FIELDNER, A. C. 300 Years of American Fuels. Ind. Eng. Chem., vol. 27, 1935, pp. 983-988; Concrete, vol. 43, Cement Mill Sec., No. 11, 1935, pp. 39-41; vol. 44, Cement Mill Sec., No. 1, 1936, pp. 54-56 and 58.
18. FIELDNER, A. C., EMERY, A. H., AND VON BERNEWITZ, M. W. Bibliography of United States Bureau of Mines Investigations on Coal and Its Products, 1910-35. Tech. Paper 576, 1937, 145 pp.
19. WILSON, H., AND SKINNER, H. G. Equations and Quadrant Charts for Determining the Heat and Air Requirements of Continuous Driers. Jour. Am. Ceram. Soc., vol. 20, April 1937, pp. 99-111.
20. FIELDNER, A. C. Fuels of Today and Tomorrow. Universal Eng., vol. 67, No. 4, 1938, pp. 23-25; No. 5, 1938, pp. 27 and 28; No. 6, 1938, pp. 29-31.
21. STORCH, H. H. United States Coal-Oil Development. South African Min. and Eng. Jour., vol. 49, part 1, June 11, 1938, p. 494.

I. C. 7534

22. FIELDNER, A. C. Report of Committee D-3 on Gaseous Fuels. Proc. Soc. Test. Mat., vol. 39, 1939, pp. 419 and 420.
23. KASSEL, L. The Relative Values of the Four Butane-Butene-Hydrogen Equilibrium Constants. Jour. Chem. Phys., vol. 4, 1939, p. 144.
24. WARD, C. C. Review of the Literature on the Construction, Testing, and Operation of Laboratory Fractionating Columns. Bureau of Mines Tech. Paper 600, 1939, 36 pp. 10 cents.
25. FIELDNER, A. C. Report of Committee D-3 on Gaseous Fuels. Proc. Am. Soc. Test. Mat., vol. 40, 1940, pp. 327 and 328.
26. KRAEMER, A. J., AND THORNE, H. M. Petroleum Investigation. Statement from a hearing before the subcommittee of the Committee on Interstate and Foreign Commerce, House of Representatives, 76th Cong., on H. R. 290 and H. R. 7372, to promote the conservation of petroleum, to provide for cooperation with the States in preventing the waste of petroleum, to create an office of petroleum conservation, to amend the act of February 22, 1935, as amended, and for other purposes. Nov. 6-8 and 10, 1939: Manufacture and Use of Petroleum Products (A Review of Developments 1934-1938), pp. 209-286.
27. FIELDNER, A. C., AND ASSOCIATES. Fuels. Mech. Eng. Handbook, McGraw-Hill Book Co., Inc., New York, 4th ed., 1941, pp. 782-825.
28. FISHER, C. H., AND EISNER, A. Tellurium Compounds as Friedel-Crafts Catalyst. The Oxidation of Organic Compounds With Tellurium Dioxide. Jour. Org. Chem., vol. 6, No. 2, March 1941, pp. 169-174.
29. FIELDNER, A. C. Synthetic Liquid Fuels, Statement at hearings before a subcommittee of the Committee on Public Lands and Surveys, U. S. Senate, 77th Cong., 2d sess., pursuant to S. R. 53, part 4, 1942, pp. 1536-1550.
30. ROCKENBACH, L. P., AND REYNOLDS, D. A. Improved Method of Determining Benzene in Medium Temperature Light Oils. Bureau of Mines Rept. of Investigations 3619, 1942, 5 pp.
31. DAVIS, J. D. Summary of Bureau of Mines Investigations for Fiscal Year Ended June 30, 1943. Proc. Am. Gas Assoc., 1943, pp. 234-241.
32. FIELDNER, A. C. Excerpt from "Recent Development in Fuels Supply and Demands." Am. Gas Assoc. Monthly, June 1943, p. 253.
33. - - - Outlook for Coal in Supplying Liquid Fuels and Coke. Coal Age, vol. 48, February 1943, pp. 109-111.
34. - - - Recent Developments in Fuels Supply and Demand. Jour. West. Soc. Eng., vol. 48, 1943, pp. 127-147; Bureau of Mines Inf. Circ. 7261, 1943, 27 pp.
35. - - - Synthetic Liquid Fuels. Statement at hearings before a subcommittee of the Committee on Public Lands and Surveys, U. S. Senate, 78th Cong., 1st sess., on S. 1243, a bill authorizing the construction and operation of demonstration plants to produce synthetic liquid fuels from coal and other substances in order to aid the prosecution of the war, to conserve and increase the oil resources of the Nation, and for other purposes. Aug. 3, 4, 6, 9, and 11, 1943: The Production of Liquid Fuels from Coal and Lignite, pp. 160-178, 318-321, and 420-436.
36. ICKES, H. L. Coal's New Horizons. Coal Age, April 1943, pp. 54-64.

37. KRAEMER, A. J. Synthetic Liquid Fuels. Statement before hearings before a subcommittee of the Committee on Public Lands and Surveys, U. S. Senate, 78th Cong., 1st sess., on S. 1243, a bill authorizing the construction and operation of demonstration plants to produce synthetic liquid fuels from coal and other substances in order to aid the prosecution of the war, to conserve and increase the oil resources of the Nation, and for other purposes. Aug. 3,4,6,9, and 11, 1943, pp. 298-318, 436, and 437.
38. KRAEMER, A. J., AND BLADE, O. C. National Motor-Gasoline Survey. Bureau of Mines Rept. of Investigations 3735, 1943, 28 pp.
39. SAYERS, R. R. Synthetic Liquid Fuels. Statement at hearings before a subcommittee of the Committee on Public Lands and Surveys, U. S. Senate, 78th Cong., 1st sess., on S. 1243, a bill authorizing the construction and operation of demonstration plants to produce synthetic liquid fuels from coal and other substances in order to aid the prosecution of the war, to conserve and increase the oil resources of the Nation, and for other purposes. Aug. 3, 4, 6, 9, and 11, 1943, pp. 17-27, 180-195, 282-284, and 414-420.
40. SCHROEDER, W. C. Fuels and Fuel Research in Great Britain During the War. Mech. Eng., vol. 65, No. 12, December 1943, pp. 881-884 and 892; Discussion by W. T. Reid, Mech. Eng., vol. 66, No. 5, May 1944, pp. 332 and 333.
41. - - - Synthetic Liquid Fuels. Statement at hearings before a subcommittee of the Committee on Public Lands and Surveys, U. S. Senate, 78th Cong., 1st sess., on S. 1243, a bill authorizing the construction and operation of demonstration plants to produce synthetic liquid fuels from coal and other substances in order to aid the prosecution of the war, to conserve and increase the oil resources of the Nation, and for other purposes. Aug. 3,4,6,9, and 11, 1943, pp. 213-224 and 437-439.
42. STORCH, H. H. Synthetic Liquid Fuels. Statement at hearings before a subcommittee of the Committee on Public Lands and Surveys, U. S. Senate, 78th Cong., 1st sess., on S. 1243, a bill authorizing the construction and operation of demonstration plants to produce synthetic liquid fuels from coal and other substances in order to aid the prosecution of the war, to conserve and increase the oil resources of the Nation, and for other purposes. Aug. 3,4,6,9, and 11, 1943, pp. 195-208 and 268-273.
43. FIELDNER, A. C., AND SCHROEDER, W. C. Oil and Gasoline from Oil Shale and Coal. Ohio State Univ. Eng. Exp. Sta. News, April 1944, pp. 22-27; Fuel in Sci. and Practice, vol. 23, No. 2, 1944, pp. 34-36.
44. FIELDNER, A. C. Fuel Research of the Bureau of Mines, Department of the Interior. Jour. Inst. Fuel, vol. 18, No. 100, February 1945, p. 71.
45. - - - Synthetic Liquid Fuels Program. Nat. Petrol. News, sec. 2, vol. 37, No. 36, Sept. 5, 1945, pp. R709-715.
46. FIELDNER, A. C., AND FISHER, P. L. Bibliography of Bureau of Mines Investigations on the Production of Liquid Fuels from Oil Shale, Coal, Lignite, and Natural Gas. Bureau of Mines Inf. Circ. 7304, January 1945, 18 pp.

I. C. 7534

47. ICKES, H. L. Permanent Buildings Taking a Big Share of Funds for Bureau of Mines Program. Nat. Petrol. News, Tech. Sec., vol. 38, 1946, pp. R173, 174, and 176.
48. SCHROEDER, W. C. Bureau of Mines Specialist Tells ASME of German Synthetic Liquid Fuels Manufacturing. Black Diamond, vol. 115, No. 13, 1945, pp. 46-48.
49. - - - German Synthetic Oil Industry. Statement at hearings before the Special Committee Investigating Petroleum Resources, U. S. Senate, 79th Cong., 1st sess., pursuant to S. R. 36, June 19-25, 1945, pp. 349-360.
50. - - - Investigation by the U. S. Government Technical Oil Mission. Proc. 25th Ann. Meeting and Victory Jubilee, Am. Petrol. Inst., sec. III, Refining, vol. 25, 1945.
51. - - - Technical Oil Mission Studies German Petroleum Research Activities. Oil and Gas Jour., vol. 44, No. 29, 1945, pp. 112, 115, and 116.
52. STORCH, H. H. Catalysis in Synthetic Liquid Fuel Processes. Ind. Eng. Chem., vol. 37, No. 4, 1945, pp. 340-351.
53. ANDERSON, R. B. Improved Adsorption Vessel. Ind. Eng. Chem. (Anal. Ed.), vol. 18, February 1946, p. 156.
54. BUREAU OF MINES. Statistical Summary of Lignite in 1946. Mineral Market Rept. 1582, 1947, 4 pp.
55. CATTELL, R. A., WHEELER, H. P., JR., AND OTHERS. Report of Petroleum and Natural Gas Division, Fiscal Year 1944. Bureau of Mines Inf. Circ. 7358, 1946, 29 pp.
56. FIELDNER, A. C. Coal Research Activities of the Bureau of Mines. Bureau of Mines Inf. Circ. 7367, 1946, 14 pp.; Coke and Smokeless Fuel Age, December 1946, p. 276.
57. - - - Nation's Reserve of Solid Fuels and Its Relation to the Future Supply of Gaseous and Liquid Fuels. Rept. to Fed. Power Comm., Docket G-580, June 1946; Gas, vol. 22, October 1946, pp. 70-75 and 78; Gas Age, vol. 98, No. 6, 1946, pp. 37-40 and 42.
58. - - - The Application of Various Types of Solid Fuel to Synthetic Gas and Oil Production. Coal Heat, vol. 50, No. 5, November 1946, pp. 30 and 32-34.
59. - - - The National Fuel Reserves. Relation to the Future Supply of Liquid Fuels. Presented at Annual Meeting Am. Soc. Mech. Engrs. New York, Dec. 2-6, 1946; Mech. Eng., vol. 69, No. 3, 1947, pp. 221-226 and 228.
60. HOLLINGS, H. Report on the Investigation by Fuels and Lubricants Teams at the Wintershall A. G. Lutzkendorf, near Mucheln, Germany. Bureau of Mines Inf. Circ. 7369, 1946, 21 pp.
61. SCHROEDER, W. C. Production of Synthetic Liquid Fuels from Coal, Lignite, and Oil Shale. Report to the Fed. Power Comm., Docket G-580, June 1946, 7 pp.
62. YOUNG, W. H., ANDERSON, R. L., AND ISAAC, L. H. Coal - Bituminous and Lignite, with Final Statistics for 1945. Preprint from Bureau of Mines Minerals Yearbook, 1946, 86 pp. 20 cents.

63. DOHERTY, J. D. Foundation Is Being Laid in Synthetic Fuels Field. *Chicago Jour. Com.*, Nov. 11, 1947.
64. FIELDNER, A. C. Synthetic Liquid Fuels Investigations of the Bureau of Mines. *Sci. Counselor*, vol. 10, No. 1, March 1947, pp. 8-10 and 24-26.
65. FIELDNER, A. C., FISHER, P. L., AND POLLOCK, M. B. Bibliography of Bureau of Mines Investigations of Coal and Its Products, 1940-45. Bureau of Mines Tech. Paper 698, 1947, 53 pp. 15 cents.
66. LOWRY, H. H., AND ROSE, H. J. Some Observations on German Coal Research and Developments. Bureau of Mines Inf. Circ. 7422, 1947, 27 pp.
67. NEWMAN, L. L. Synthetic Oil. *Fed. Sci. Prog.*, vol. 1, 1947, pp. 11-13.
68. SAYERS, R. R. Investigation of National Resources, Statement at hearings before a subcommittee of the Committee on Public Lands, U. S. Senate, 80th Cong., 1st sess., on investigation of the factors affecting minerals, fuels, forestry, and reclamation projects, May 15, 16, and 20, 1947: Synthetic Liquid Fuels, pp. 50-90.
69. SCHROEDER, W. C. Synthetic Liquid Fuels in the United States. *Mech. Eng.*, vol. 69, December 1947, pp. 989-995; Ann. Meeting, Am. Soc. Mech. Eng., paper 47-A40, 1947, 7 pp.; *Oil and Gas Jour.*, vol. 46, No. 31, 1947, p. 128.
70. STORCH, H. H. Motor-Fuel Synthesis Process Described. *Oil and Gas Jour.*, vol. 46, No. 26, 1947, pp. 96 and 97.
71. THIESSEN, R. What Is Coal? Bureau of Mines Inf. Circ. 7397, 1947, 53 pp.
72. BOYD, J. Synthetic Liquid Fuels. Statement at hearing before a subcommittee of the Committee on Interior and Insular Affairs, U. S. Senate, 80th Cong., 2d sess., on S. 134, Jan. 29, 1948, pp. 6-8.
73. CATTELL, R. A., AND DOHERTY, J. D. Synthetic Liquid Fuels. *Producers Monthly*, vol. 12, No. 11, September 1948, pp. 21-29.
74. FIELDNER, A. C. Frontiers of Fuel Technology. *Chem. Eng. News*, vol. 26, June 7, 1948, pp. 1700 and 1701.
75. - - - Research Laboratory in North Dakota Lignite-Consuming Region. Statement before hearing before a subcommittee of the Committee on Interior and Insular Affairs, U. S. Senate, 80th Cong., 2d sess., on H. R. 2453, an act to provide for the establishment and operation of a research laboratory in the North Dakota lignite-consuming region for investigation of the mining, preparation, and utilization of lignite, for the development of new uses and markets, for improvement of health and safety in mining, and for a comprehensive study of the possibilities for increased utilization of the lignite resources of the region to aid in the solution of its economic problems and to make its natural and human resources of maximum usefulness in the reconversion period and time of peace. Feb. 19, 1948, pp. 10-13.
76. - - - Synthetic Liquid Fuels from Coal and Oil Shale. *Ohio State Univ. Eng. Exp. Sta. News*, vol. 20, No. 1, February 1948, pp. 22-28.