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BUREAU OF MINES

BIBLIOGRAPHY OF THE FISCHER-TROPSCH SYNTHESIS AND RELATED PROCESSES

(In Two Parts)

I. REVIEW AND COMPILATION OF THE LITERATURE ON THE PRODUCTION OF SYNTHETIC LIQUID FUELS AND CHEMICALS BY THE HYDROGENATION OF CARBON MONOXIDE

By H. C. Anderson, J. L. Wiley, and A. Newell

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Foreword

The importance of the chemistry of carbon monoxide in industrial processes such as production of synthetic liquid fuels, and of chemicals (particularly alcohols) has been increasing rapidly during the past decade. Although the staff of the Bureau of Mines has produced a critical review of Fischer-Tropsch and related syntheses (J. Wiley & Son, 1951), continued development of such synthetic liquid fuel processes demanded an exhaustive bibliography containing abstracts of all relevant publications. The need for this was especially evident in work on the production of synthesis gas and hydrogen from coal and byproduct hydrocarbon gases. It is anticipated that this bibliography will serve the needs of all experimenters in the field of chemistry of carbon monoxide.

BIBLIOGRAPHY OF THE FISCHER-TROPSCH SYNTHESIS AND RELATED PROCESSES

(In Two Parts)

1. REVIEW AND COMPILATION OF THE LITERATURE ON THE PRODUCTION OF SYNTHETIC LIQUID FUELS AND CHEMICALS BY THE HYDROGENATION OF CARBON MONOXIDE[1]

By

H. C. Anderson,[2] J. L. Wiley,[3] and A. Newell[4]

Introduction

THIS REVIEW contains abstracts of the technical literature and patents dealing with the history, development, and commercial application of the Fischer-Tropsch synthesis and related processes for the hydrogenation of carbon monoxide and the production of synthetic fuels and chemicals. Attempt has been made to include abstracts of all the published information on the above subjects as well as of the captured foreign documents collected and classified as TOM and FIAT reels and CIOS, FIAT, and BIOS reports.

The material in this review is divided into two sections—literature (part I) and patents (part II)—each with a comprehensive subject index. A numerical patent list by countries will appear in part II. The abstracts in each section are arranged alphabetically by author or patentee with further chronological arrangement under each author or group of authors. Secondary authors and patentees as well as assignees are cross-indexed to the main entry. In serial articles or reports the complete series appears in the alphabetical arrangement according to the author of the first member of the series. Succeeding members as well as secondary authors are entered as cross-references. Titles of the periodicals are used as the authors in anonymous references. By following the above procedure, no author index is required.

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JOURNAL REFERENCES

Abbreviations	*Journal titles*
Acad. Sci. Petrograd	Petrograd academie science.
Acqua e Gas	Acqua e Gas.
Acta Cryst	Acta Crystallographica.
Acta Physicochim. U. R. S. S.	Academy of Sciences of the U. S. S. R.
Advances Chem. Ser	Advances in Chemistry Series —
Akad. Verlagsgesell., Leipzig	Akademische Verlagsgesellschaft m. b. H. Verlagsbericht Leipzig.
Allgem. Oel- u. Fett-Ztg	Allgemeine Oel- und Fett-Zeitung.
Allgem. Osterr. Chem. u. Tech.-Ztg	Allgemeine Österreichische Chemiker und Techniker-Zeitung.
Am. Chem. Soc., — Meeting Abs	American Chemical Society, — Meeting Abstracts.
Am. Gas Assoc. Monthly	American Gas Association Monthly.
Am. Gas Jour	American Gas Journal.
Am. Inst. Chem. Eng	American Institute of Chemical Engineers.
Am. Inst. Min. and Met. Eng	American Institute of Mining and Metallurgical Engineers.
Metals Technol	Metals Technology.
Tech. Pub	Technical Publication.
Tech. Proc	Technical Proceedings.
Am. Paint Jour	American Paint Journal.
Am. Perfumer Essent. Oil Rev	American Perfumer and Essential Oil Review.
	American Petroleum Institute. *See* Bull. Am. Petrol. Inst.; Proc. Am. Petrol. Inst.
Am. Petrol. News	*See* National Petroleum News.
Am. Soc. Mech. Eng	American Society of Mechanical Engineers *See also* Mech. Eng.; Trans. Am. Soc. Mech. Eng.
Anal. Chem	Analytical Chemistry.
Anales asoc. quím. argentina	Anales de la asociatión quimíca argentina.
Anales soc. españ. fís. y quím	Anales de la sociedad española de fisica y química.
Angew. Chem	Angewandte Chemie.
Ann. chim	Annales de chimie (Paris).
Ann. chim. applicata	Annali di chimica applicata.
Ann. chim. phys	Annales de chimie et de physique.
Ann. combust. liquides	Annales de l'office national des combustibles liquides.
Ann. mines	Annales des mines.
Ann. mines et carburants	Annales des mines et des carburants.
Ann. Physik	Annalen der Physik.
Ann. Rept. Progress Chem., (Chem. Soc. London).	Annual Reports on the Progress of Chemistry (Chemical Society of London).
Ann. Rev. Petrol. Technol	Annual Review of Petroleum Technology (London). *See also* Rev. Petrol. Technol.
Anthracite Inst. Bull	Anthracite Institute Bulletin.
Anyagvizsgálók Közlönye	Anyagvizsgálók Közlönye.
Anz. Maschinenw	Anzeiger Maschinenwesen.
Apoth. Ztg	Apotheker Zeitung.
Apparatebau	Der Apparatebau.
Arch. Eisenhüttenw	Archiv für das Eisenhüttenwesen.
Arch. Math. Naturvidensk	Archiv for Mathematik og Naturvidenskab.
Arch. Metallkunde	Archiv für Metallkunde.
Arch. Wärmewirt	Archiv für Wärmewirtschaft.
Armed Forces Chem. Jour	Armed Forces Chemical Journal.
Asphalt Teer Strassenbautech	Asphalt und Teer Strassenbautechnik.
Assoc. franç. techn. pétrole	*See* Bull. assoc. franç. techniciens pétrole.
Assoc. Tech. Services	Associated Technical Services.
ASTM	American Society for Testing Materials.
Atti cong. intern. chim. — Cong., (City), (Year).	Atti del congresso internazionale di chimica, —th Congress, (city) (year).
Atti cong. nazl. chim. ind	Atti del congresso nazionale di chimica industriale.
Atti cong. nazl. chim. pura applicata	Atti del congresso nazionale di chimica pura ed applicata —th Congress, (city).
Australia Council Sci. Ind. Research, Bull	Australia, Commonwealth of, Council for Scientific and Industrial Research, Bulletin.
Australian Chem. Inst. Jour. and Proc	Australian Chemical Institute Journal and Proceedings.
Australian Jour. Sci	Australian Journal of Science.
Australian Jour. Sci. Research	Australian Journal of Scientific Research.
Auszüge Deutscher Patent-Anmeldungen	Auszüge Deutscher Patent-Anmeldungen.
Automobil tech. Ztschr	Automobiltechnische Zeitschrift.
Bányász. Kohász. Lapok	Bányászati és Kohászati Lapok.
Ber. deut. chem. Gesell	Berichte der deutschen chemischen Gesellschaft.

Abbreviations	*Journal titles*
Ber. Gesell. Kohlentech	Berichte der Gesellschaft für Kohlentechnik.
Ber. Inst. physik. Chem., Akad. Wiss. Ukr. S. S. R.	Berichte des Instituts für physikalische Chemie, Akademie der Wissenschaften der Ukrainischen S. S. R.
Bergbau	Bergbau.
Bergbau Arch	Bergbau Archiv.
Bergbau u. Energiewirtsch	Bergbau und Energiewirtschaft.
Bib. Sci. Ind. Repts	Bibliography of Scientific and Industrial Reports.
Biochem. Ztschr	Biochemische Zeitschrift.
BIOS Rept	British Intelligence Objectives Subcommittee Reports.
Bitumen, Teere, Asphalte, Peche	Bitumen, Teere, Asphalte, Peche.
Blast Furnace Steel Plant	Blast Furnance and Steel Plant.
Bol. inst. sudamer. petrol (Montevideo)	Boletin del instituto sudamericano del petroleo (Montevideo).
Braunkohle	Braunkohle.
Braunkohlenarch	Braunkohlenarchiv.
Brennstoff-Chem	Brennstoff-Chemie.
Brennstoff- u. Wärmewirt	Brennstoff- und Wärmewirtschaft.
British Abs	British Abstracts.
British Chem. Abs	British Chemical Abstracts.
British Coal Utilisation Research Assoc., Monthly Bull.	British Coal Utilisation Research Association, Monthly Bulletin.
Bul. Chim. Soc. Româna Științe	Buletinul de Chimie pură și Aplicăta Societătea Româna de Științe.
Bull. acad. roy. Belg	Bulletin de l'académie royale de Belgique.
Bull. acad. sci. U. R. S. S	Bulletin de l'académie des sciences de l'Union des Républiques Soviétiques Socialistes.
Bull. Am. Petrol. Inst	Bulletin of American Petroleum Institute.
Bull. assoc. franç. techniciens pétrole	Bulletin de l'association française des techniciens du pétrole.
Bull. assoc. tech. fonderie	Bulletin de l'association technique de fonderie.
Bull. Chem. Soc. Japan	Bulletin of the Chemical Society of Japan.
Bull. Imp. Inst	Bulletin of the Imperial Institute.
Bull. Inst. Phys. Chem. Research (Tokyo)	Bulletin of the Institute of Physical and Chemical Research (Tokyo).
Bull. Liverpool Eng. Soc	Bulletin of Liverpool Engineering Society, Inc.
Bull. mat. grasses inst. colonial Marseille	Bulletin des matières grasses de l'institut colonial de Marseille.
Bull. Math. Biophysics	Bulletin of Mathematicl Biophysics.
Bull. sci. école polytech. Timișoara	Bulletin scientifique de l'école ploytechnique de Timișoara.
Bull. soc. belge ing. ind	Bulletin de la société belge des ingénieurs et des industriels.
Bull. soc. chim	Bulletin de la société chimique de France.
Bull. soc. chim. belg	Bulletin de la sociétés chimiques belges.
Bull. soc. encour. ind. nat	Bulletin de la société d'encouragement pour l'industrie nationale.
Bureau of Mines Bull	Bureau of Mines Bulletin (United States).
Bureau of Mines Inf. Circ	Bureau of Mines Information Circular (United States).
Bureau of Mines Minerals Yearbook	Bureau of Mines Minerals Yearbook (United States).
Bureau of Mines Rept. of Investigations	Bureau of Mines Report of Investigations (United States).
Bureau of Mines Tech. Paper	Bureau of Mines Technical Paper (United States).
Bureau of Mines Transl	Bureau of Mines Translation (United States).
Bureau Standards Jour. Research	*See* Nat. Bureau of Standards Research Journal.
Bus and Coach	Bus and Coach Operators' Journal.
Business Week	Business Week.
Butterworth's Sci. Publication	Butterworth's Scientific Publication.
Cashiers phys	Cahiers de physique.
Calif. Oil World	California Oil World.
Canadian Chem. and Met	Canadian Chemistry and Metallurgy.
Canadian Chem. Process Ind	Canadian Chemistry and Process Industries.
Canadian Jour. Research	Canadian Journal of Research.
Canadian Jour. Tech	Canadian Journal of Technology.
Canadian Min. and Met. Bull	Canadian Mining and Metallurgical Bulletin.
Canadian Min. Jour	Canadian Mining Journal.
Carburants nat	Carburants nationales.
Carnegie Inst. Technol., Coal Research Lab. Contrib.	Carnegie Institute of Technology, Coal Research Laboratory Contributions.
Chaleur et Ind	Chaleur et Industrie.
Chem. Abs	Chemical Abstracts.
Chem. Age	Chemical Age (London).
Chem. and Eng. News	Chemical and Engineering News.
Chem. and Ind	Chemistry and Industry.
Chem. and Met. Eng	Chemical and Metallurgical Engineering.
Chem. en Pharm. Tech	Chemische en Pharmaceutische Techniek.
Chem. Eng	Chemical Engineering.
Chem. Eng. and Min. Rev	Chemical Engineering and Mining Review.
Chem. Eng. Cong. World Power Conf	Chemical Engineering Congress and World Power Conference.
Chem. Eng. Progress	Chemical Engineering Progress.
Chem. Fabrik	Chemische Fabrik.
Chem. Ind	Chemische Industrie.
Chem. Inds	Chemical Industries.
Chem.-Ing.-Tech	Chemie-Ingenieur-Technik.
Chem. Week	Chemical Week.

Abbreviations	*Journal titles*
Chem. Markets	Chemical Markets.
Chem. News	Chemical News.
Chem. Obzor	Chemicky Obzor.
Chem. Products	Chemical Products.
Chem. Rev	Chemical Reviews.
Chem. Rev. (Japan)	Chemical Review (Japan).
Chem. Tech	Chemical Technology.
Chem.-tech. Rundschau	Chemisch-technische Rundschau.
Chem.-tech. Ubersicht	Chemisch-technische Ubersicht.
Chem. Trade Jour	Chemical Trade Journal and Chemical Engineer.
Chem. Weekblad	Chemisch Weekblad.
Chem. Zentralb	Chemisches Zentralblatt.
Chem.-Ztg	Chemiker-Zeitung.
Chemie, Die	Die Chemie.
Chim. et ind	Chimie et industrie.
Chim. ind. agr. biol	Chimica nell'industria, nell agricoltura, nella biologia e nelle realizzazioni corporative.
Chimica e industria	La Chimica, e L'industria.
CIOS	Combined Intelligence Objective Sub-committee Reports.
Clay Minerals Bull	Clay Minerals Bulletin.
Coal Age	Coal Age.
Coal and Colliery News	Coal and Colliery News.
Coal Carbonisation	Coal Carbonisation.
Coal-Heat	Coal-Heat.
Coal Technol., Am. Inst. Min. Eng., Tech Pub	Coal Technology, American Institute of Mining Engineers, Technical Publications.
Coke	Coke.
Coke and Chem. (U. S. S. R.)	Koks i Khimiya, U. S. S. R. (Coke and Chemistry).
Coke and Gas	Coke and Gas.
Coke Smokeless-Fuel Age	Coke and Smokeless-Fuel Age.
Colliery Eng	Colliery Engineering.
Colliery Guard	Colliery Guardian.
Colloid Chem	Colloid Chemistry.
Combustibles (Zaragoza)	Combustibles (Zaragoza).
Combustion	Combustion.
Compt. rend	Comptes rendus hebdomadaires des séances de l'académie des sciences.
Compt. rend. acad. sci. U. R. S. S	Comptes rendus (Doklady) de l'académie des sciences de l'U. R. S. S.
Compt. rend., Cong. Chauffage ind., — Cong	Congrès du chauffage industriel Comptes rendus du— Congrès.
Compt. rend., Cong. chim. ind., —me, Paris	Comptes rendus, Congrès de chimie industrielle, —me, (City).
Conf.-rapports sur les combustibles	Conférence–rapports sur les combustibles.
Conf. réunion soc. belg. étude pétrole, dérives et succédanes, Brussels, 1947.	Conférence réunion société belge pour l'études pétrole, dérives et succédanes, Brussels, 1947.
Cong. chim. ind., —th Cong	Congrès de chimie industrielle, —th Congress, (City).
Cong. mondial pétrole, 2me Cong., Paris — sec., Phys. Chim. Raffinage.	Congrès mondial du pétrole, —me Cong., (City) (date) (in five sections—Section 2, Phys. Chim. Raffinage). *See also* Proc. World Petrol. Cong.
Consolidated Eng. Corp. Recordings	Consolidated Engineering Corporation Recordings.
Cours conf	Cours conference.
Crucible	Crucible.
Cuerpo de Ingenieros de Minas	Cuerpo de Ingenieros de Minas.
Current Sci	Current Science (India).
Deut. Chemiker	Deutscher Chemiker.
Deut. Gesundhw	Deutsche Gesundheitswesen.
Deut. Molkerei-Ztg	Deutsche Molkerei-Zeitung.
Dingl. poly. Jour	Dinglers Polytechnisches Journal.
Disc., Faraday Soc	Discussions of the Faraday Society.
Doklady Akad. Nauk S. S. S. R.	Doklady Akademii Nauk Soyuza Sovetskikh Sotsialisticheskikh Respublik. *See also* Comptes rendus (Doklady) de l'academie des sciences de l'U. R. S. S.
Echo mines et met	Echo des mines et de la métallurgie.
Elektrotech. Ztschr	Elektrotechnische Zeitschrift.
Energia termica	Energia termica.
Eng. Jour	Engineering Journal, Journal of the Engineering Institute of Canada.
Engineer	Engineer (London).
Engineering	Engineering.
Erdöl u. Kohle	Erdöl und Kohle.
Farbe u. Lack	Farbe und Lack.
Farben, Lacke, Anstrichstoffe	Farben, Lacke, Anstrichstoffe.
Federal Sci. Progress	Federal Science Progress.
Festschrift 100-jähre Bestehen Tech. Hochschule zu Karlsruhe.	Festschrift 100-jähre Bestehen Technische Hochschule zu Karlsruhe.
Fette u. Seifen	Fette und Seifen.
Feuerungstech	Feuerungstechnik.
FIAT	Field Information Agencies Technical.

Abbreviations	*Journal titles*
Finska Kemistsamfundets Medd	Finska Kemistsamfundets Meddelanden.
Food	Food.
Food Manuf	Food Manufacture.
Food Technol	Food Technology.
Foreign Petrol. Technol	Foreign Petroleum Technology.
Forschungen u. Fortschr	Forschungen und Fortschritte.
Forschungsarb. Gebiete Ingenieurw	Forschungsarbeiten auf dem Gebiete des Ingenieurwesens.
Fortschr. chem. Forsch	Forschritte der chemischen Forschung.
Fortune	Fortune.
Frankfurter Ztg	Frankfurter Zeitung.
Fuel	Fuel in Science and Practice.
Fuel Abs	Great Britain Department of Science and Industrial Research, Fuel Research Station, Fuel Abstracts.
Fuel Econ	Fuel Economist.
Fuel Econ. Rev	Fuel Economy Review.
Fueloil & Oil Heat	Fueloil & Oil Heat.
Gas	Gas.
Gas Abs	Gas Abstracts, Institute of Gas Technology.
Gas Age	Gas Age.
Gas Age-Record	Gas Age-Record.
Gas and Oil Power	Gas and Oil Power.
Gas Jour	Gas Journal.
Gas Research Board Inf. Circ	Gas Research Board Information Circular.
Gas Times	Gas Times.
Gas- u. Wasserfach	Gas- und Wasserfach.
Gas, Wasser, Wärme	Gas, Wasser, Wärme.
Gas World	Gas World.
Gaz. Cukrownicza	Gazeta Cukrownicza.
Gazz. chim. ital	Gazetta chimica italiana.
Génie civil	Génie civil.
Geol. en Mijnbouw	Geologie en Mijnbouw.
Ges. Abhandl. Kenntnis Kohle	Gesammelte Abhandlungen zur Kenntnis der Kohle.
Gesundh.-Ing	Gesundheits-Ingenieur.
Giorn. bibliografia tecnica intern	Giornale di bibliografia tecnica internaziole.
Giorn. chim. ind. applicata	Giornale di chimica industriale ed applicata.
Glückauf	Glückauf.
Gosudarst. Nauch.-Tekh. Izdatel'stve	Gosudarstvennoĭ Nauchno-Tekhnicheskoe Izdatel'stve.
Gulf	Gulf Research & Development Co., Patent Survey on the Synthine Process and Related Syntheses.
Gulf Research & Development Co., Chemistry Division Rept.	Gulf Research & Development Co., Chemistry Division Report.
Hamburger Tech. Nachrichten	Hamburger Technische Nauchrichten.
Handbuch der Gasindustrie	Handbuch der Gasindustrie.
Heat Engineering	Heat Engineering.
Helv. Chim. Acta	Helvetica Chimica Acta.
Het Gas	Het Gas.
Hornický Věstnik	Hornický Věstnik.
Ind. agr. aliment	Industries agricoles et alimentaires (Paris).
Ind. Chemist	Industrial Chemist and Chemical Manufacturer.
Ind. Chim	L'Industrie Chimique.
Ind. Chim. belge	Industrie chimique belge.
Ind. Eng. Chem	Industrial and Engineering Chemistry.
Ind. Eng. Chem., anal. ed	Industrial and Engineering Chemistry, analytical edition.
Ind. Eng. Chem., news ed	Industrial and Engineering Chemistry, news edition —.
Ind. Research Service	Industrial Research Service.
Industria chimica	Industria chimica.
Industria (Milan)	L'Industria (Milan).
Industria y quím	Industria y química (Buenos Aires).
Ing. Vetenskaps Akad. Handl	Ingeniörs Vetenskaps Akademien Handlingar.
Ingegnere	L'Ingegnere (Milan).
Ingenieur	Ingenieur.
Ingeniøren	Ingeniøren.
Inst. Fuel (London) Bull	Institute of Fuel (London) Bulletin.
Inst. Fuel, Wartime Bull	Institute of Fuel, Wartime Bulletin.
Inst. Gas Eng. Pub	Institution of Gas Engineers, Publication.
Inst. Ind. Chem. Fuels, Polytechinicum, Milan.	Institute of Industrial Chemical Fuels, Polytechinicum, Milan.
Inst. Min. Eng	Institution of Mining Engineers.
Inst. Petrol. Rev	Institute of Petroleum Reviews.
Internat. Chem. Eng	International Chemical Engineer.
	International Conference on Bituminous Coal. *See* Proc. Internat. Cong. Bituminous Coal.
Internat. Cong. Appl. Chem	International Congress of Applied Chemistry.
Internat. Cong. Pure Appl. Chem., — Cong., (Place) (No.).	International Congress of Pure and Applied Chemistry, — Congress.

Abbreviations	*Journal titles*
Internat. Ztschr. Metallog	Internationale Zeitschrift für Metallographie.
Ion	Ion.
Iron and Coal Trades Rev	Iron and Coal Trades Review.
Iron and Steel (London)	Iron and Steel (London).
Iron and Steel Inst. (London), Carnegie Schol. Mem.	Iron and Steel Institute (London), Carnegie Scholarship Memoirs.
Iva	Iva.
Izvest. Akad. Nauk S. S. S. R., Otdel. Khim. Nauk.	Izvestiya Akademii Nauk Otdelenie Khimicheskikh Nauk.
Japan. Jour. Eng	Japanese Journal of Engineering.
Jour. Am. Chem. Soc	Journal of the American Chemical Society.
Jour. Appl. Chem. (U.S.S.R.)	Zhurnal Prikladnoĭ Khimii, U.S.S.R. (Journal of Applied Chemistry).
Jour. Appl. Phys	Journal of Applied Physics.
Jour. Chem. Education	Journal of Chemical Education.
Jour. Chem. Eng. (China)	Journal of Chemical Engineering (China).
Jour. Chem. Ind. (U.S.S.R.)	Zhurnal Khimicheskoĭ Promyshlennosti, U.S.S.R. (Journal of Chemical Industry).
Jour. Chem. Met. Min. Soc. South Africa	Journal of the Chemical, Metallurgical and Mining Society of South Africa.
Jour. Chem. Phys	Journal of Chemical Physics.
Jour. Chem. Soc	Journal of the Chemical Society (London).
Jour. Chem. Soc. Japan	Journal of the Chemical Society of Japan.
Jour. chim. phys	Journal de chimie physique.
Jour. Chinese Chem. Soc	Journal of the Chinese Chemical Society.
Jour. Colloid Sci	Journal Colloid Science.
Jour. four élec	Journal du four électrique et des industries électrochimiques.
Jour. Franklin Inst	Journal of the Franklin Institute.
Jour. Fuel Soc. Japan	Journal of the Fuel Society of Japan.
Jour. Gasbeleucht	Journal für Gasbeleuchtung.
Jour. Gen. Chem. (U.S.S.R.)	Zhurnal Obshcheĭ Khimii, U.S.S.R. (Journal of General Chemistry).
Jour. Imp. Coll. Chem. Eng. Soc	Journal of the Imperial College Chemical Engineering Society.
Jour. Ind. Eng. Chem	Journal of Industrial and Engineering Chemistry.
Jour. Indian Chem. Soc	Journal of the Indian Chemical Society.
Jour. Inst. Fuel	Journal of the Institute of Fuel.
Jour. Inst. Petrol	Journal of the Institute of Petroleum.
Jour. Inst. Petrol. Technol	Journal of the Institution of Petroleum Technologists.
Jour. Iron Steel Inst. (London)	Journal of the Iron and Steel Institute (London).
Jour. Junior Inst. Eng. (London)	Journal of the Junior Institution of Engineers, Inc. (London).
Jour. Math. Phys., Mass. Inst. Tech	Journal of Mathematics and Physics, Massachusetts Institute of Technology.
Jour. Metals	Journal of Metals.
Jour. Oil & Colour Chemists' Assoc	Journal of the Oil & Colour Chemists' Association.
Jour. Path. Bact	Journal of Pathology and Bacteriology.
Jour. pharm. chim	Journal de pharmacie et de chimie.
Jour. Phys. and Colloid Chem	Journal of Physical and Colloid Chemistry.
Jour. Phys. Chem	Journal of Physical Chemistry.
Jour. Phys. Chem. (U.S.S.R.)	Zhurnal Fizicheskoĭ Khimii, U.S.S.R. (Journal of Physical Chemistry).
Jour. phys. radium	Journal de physique et le radium.
Jour. prakt. Chem	Journal für praktische Chemie.
Jour. Proc. Australian Chem. Inst	Journal Proceedings of Australian Chemical Institute.
Jour. Research Inst. Catalysis	Journal of the Research Institute for Catalysis.
Jour. Roy. Tech. Coll. (Glasgow)	Journal of the Royal Technical College (Glasgow).
Jour. Ross. Phys.-Chem. Soc	Zhurnal Russkogo Fiziko-Khimicheskogo Obshchestva (Journal of the Russian Physical-Chemical Society).
Jour. Sci. Ind. Research (India)	Journal of Scientific & Industrial Research (India).
Jour. Soc. Auto. Eng	Journal of the Society of Automotive Engineers.
Jour. Soc. Chem. Ind. (Japan)	Journal of the Society of Chemical Industry (Japan).
Jour. Soc. Chem. Ind. (London)	Journal of the Society of Chemical Industry (London).
Jour. soc. ing. automobile	Journal de la société des ingénieurs de l'automobile.
Jour. South African Inst. Eng	Journal of the South African Institution of Engineers.
Jour. Tech. Phys. (U. S. S. R.)	Journal of Technical Physics (U. S. S. R.) (Zhurnal Teknicheskoĭ Fiziki (U. S. S. R.).
Jour. usines gaz	Journal des usines à gaz.
Jour. Western Soc. Eng	Journal of the Western Society of Engineers.
Kainer	Die Kohlenwasserstoff-Synthese nach Fischer-Tropsch, F. Kainer; Springer-Verlag, Berlin, 1950.
Khim. Mashinostroenie	Khimicheskoe Mashinostroenie (Chemical Machine Construction).
Khim. Prom	Khimicheskaya Promyshlennost (Chemical Industry).
Khim. Referat. Zhur	Khimicheskiĭ Referativnyĭ Zhurnal.
Kkim. Tverdogo Topliva	Khimiya Tverdogo Topliva (Chemistry of Solid Fuels).
Khimstroĭ	Khimstroĭ (Journal for Projecting and Construction of the Chemical Industry in U. S. S. R.)
Kiev Tekh. Inst. Kozhevenno-Obuvnoi Prom	Universite d'état de Kiev Kozhevenno-Obuvnaya Promyshlennost S. S. S. R.

Abbreviations	*Journal titles*
Kislorod (Oxygen)	Kislorod (Oxygen).
Klepzig's Textil-Ztschr	Klepzig's Textil-Zeitschrift.
Klin. Wochschr	Klinische Wochenschrift.
Kohle u. Erz	Kohle und Erz.
Kolloid-Beihefte	Kolloid-Beihefte.
Kolloid-Ztschr	Kolloid-Zeitschrift.
Koppers Review	Koppers Review.
Kraftstoff	Kraftstoff.
Kunststoffe	Kunststoffe.
Labour's Pub. Dept. London	Labour's Publications Department London.
Lamp	Lamp.
Leben u. Umwelt	Leben und Umwelt.
Lesokhim. Prom	Lesokhimicheskaya Promyshlennost.
Machinery Market	Machinery Market.
Magyar Kém. Lapja	Magyar Kémikusok Lapja (Journal of the Hungarian Chemical Society).
Magyar Mérnők-Építészegy et Kőzlőnye	Magyar Mérnők- és Építészegylet Kőzlőnye (Journal of the Hungarian Society of Engineers and Architects).
Mat. grasses	Les Matières grasses.
Mech. Eng	Mechanical Engineering.
Mechanization	Mechanization.
Mededeel. Koninkl. Vlaam. Acad. Wetenschap., Belg. Klasse Wetenschap.	Mededeelingen van de Koninklijke Vlaamsche Academie voor Wetenschappen, Letteren en Schoone Kunsten, van Belgie, Klasse der Wetenschappen.
Mem. Faculty Sci. Eng., Waseda Univ. (Tokyo).	Memoirs of the Faculty of Science and Engineering, Waseda University, Tokyo, Japan.
Mem. Inst. Chem., Ukrain. Acad. Sci	Memoirs of the Institute for Chemistry, Academy of Science of the Ukrainian S. S. R.
Mém. poudres	Mémorial des poudres.
Mem. Ryojun Coll. Eng	Memoirs of the Ryojun College of Engineering.
Mém. services chim. état (Paris)	Mémorial des services chimiques de l'état (Paris).
Mém. soc. ing. civils France	Mémoires de la société des ingénieurs civils de France.
Metallbőrse	Metallbőrse.
Metallurg (U. S. S. R.)	Metallurg (U. S. S. R.) (Metallurgist).
Metallurgia	Metallurgia.
Métallurgie	Métallurgie.
Metallwirtschaft	Metallwirtschaft.
Metano	Metano (Padua).
Métaux & corrosion	Métaux & corrosion.
Métaux, corrosion, usure	Métaux, corrosion, usure.
Mfg. Perfumer	Manufacturing Perfumer.
Mfr. Record	Manufacturer's Record.
Michigan State Coll. Agr., Eng. Expt. Sta., Bull.	Michigan State College of Agriculture and Applied Science, Engineering Experiment Station Bulletin.
Min. and Met	Mining and Metallurgy.
Min. Cong. Jour	Mining Congress Journal.
Min. Eng	Mining Engineering.
Min. Jour. (London)	Mining Journal (London).
Mineral Ind	The Mineral Industry.
Mines, carrières	Mines, Carrières, grandes entreprises.
Mines Mag., Colorado	Mines Magazine, Colorado.
Mitt. Forsch.-Anstalt. Gutehoffnungshütte Oberhausen A.-G.	Mitteilungen aus den Forschungs-Anstalten von Gutehoffnungshütte Oberhausen Aktien-Gesellschaft.
Mitt. Kaiser Wilhelm-Inst. Eisenforsch. Dusseldorf.	Mitteilungen aus den Kaiser Wilhelm-Institut für Eisenforschung zu Düsseldorf.
Mitt. Kohlenforsch.-Inst. Prag	Mitteilungen des Kohlenforschungs-Instituts in Prag. (German edition of Zprávy Ústavu Vědecky Výzkum Uhli v Praze).
Modern Plastics	Modern Plastics.
Mon. produits chim	Moniteur des produits chimiques.
Montan. Rundschau	Montanistische Rundschau.
Motorwagen	Motorwagen.
Nafta (Yugoslavia)	Nafta (Yugoslavia).
Nat. Advisory Comm. Aeronau. Repts., Tech. Mem. Notes.	National Advisory Committee for Aeronautics, Reports, Technical Memorandum and Technical Notes.
Nat. Bureau of Standards, Research Jour	National Bureau of Standards, Research Jornal.
Nat. Petrol. News	National Petroleum News.
Natural Gasoline Assoc. of America	Natural Gasoline Association of America.
Nature	Nature (London).
Nature, La	La Nature.
Naturwissenschaften	Die Naturwissenschaften.
Natuur. Tijdschr	Natuurwetenschappelijk Tijdschrift (Belgium).
Neftyanoe Khoz	Neftyanoe Khozyaĭstvo (Petroleum Economy).
Neue Giesserei, Tech. Wiss. Beihefte	Neue Giesserei, Technisch-Wissenschaftliche Beihefte, Metallkunde und Giessereiwesen.
New Zealand Dept. Sci. Ind	New Zealand Department of Scientific and Industrial Research.

Abbreviations	*Journal titles*
Nippon Kinzoku Gakukai-Shī	Nippon Kinzoku Gakukai-Shī.
Notiz. chim.-ind	Notiziario chimico-industriale.
Novosti Tekhniki	Novosti Tekhniki (Technical News).
Nuclear Sci. Abs	Nuclear Science Abstracts.
Nucleus	Nucleus.
Nuovo cimento	Nuovo cimento.
Oel u. Kohle	Oel und Kohle.
Oel u. Kohle Erdoel Teer	Oel und Kohle, Erdoel und Teer.
Official Gaz	Official Gazette of the United States Patent Office.
Ohio State Univ., Eng. Expt. News	Ohio State University Engineering Experiment Station News.
Oil and Soap	Oil and Soap.
Oil Gas Jour	Oil and Gas Journal.
Oil, Paint and Drug Reptr	Oil, Paint and Drug Reporter.
Oil Weekly	Oil Weekly.
Öle, Fette, Wachse, Seife, Kosmetik	Öli, Fette, Wachse, Seife, Kosmetik.
Olearia	Olearia.
Oliën, Vetten Oliezaden	Oliën, Vetten en Oliezaden.
Org. Chem. Ind. (U.S.S.R.)	Organic Chemical Industry (U.S.S.R.) (Promyshlennost Organicheskoĭ Khimii).
OSRD Rept	Office of Scientific Research & Development (United States).
Österr., Chem.-Ztg	Osterreichische Chemiker-Zeitung.
Österr. Ing.-Archiv	Osterreichisches Ingenieur-Archiv.
Paint Manuf	Paint, Varnish, Lacquer, Enamel and Colour Manufacture.
Paliva	Paliva.
Parfumerie	Parfumerie.
Peintures, pigments, vernis	Peintures, pigments, vernis.
Pennsylvania State Coll., School of Mineral Ind.	Pennsylvania State College, School of Mineral Industry.
Petrol. Eng	Petroleum Engineer.
Petrol. et Remplacement	Petroleum et Remplacement.
Petrol. Press Service	Petroleum Press Service.
Petrol. Processing	Petroleum Processing.
Petrol. Refiner	Petroleum Refiner.
Petrol. Technol	Petroleum Technology.
Petrol. Times	Petroleum Times.
Petrol. World and Oil Age	Petroleum World and Oil Age.
Petrol. Ztschr	Petroleum Zeitschrift für die gesamten Interessen der Erdöl-Industrie und des Mineralöl-Handels.
Petroleum (London)	Petroleum (London).
Pharm. Ztg	Pharmazeutische Zeitung.
Pharmazie	Die pharmazie.
Phil. Mag	Philosophical Magazine.
Phys. Rev	The Physical Review.
Phys. Ztschr	Physikalische Zeitschrift.
Physiol. Rev	Physiological Reviews.
Planovoe Khoz	Planovoe Khoziaĭstvo.
Podzemnaya Gazifikatsiya Ugleĭ	Podzemnaya Gazifikatsiya Ugleĭ (Underground Gasification of Coal).
Power Plant Eng	Power Plant Engineering.
Prirodnuie Gazui	Prirodnuie Gazui.
Proc. Am. Gas Assoc	Proceedings of the American Gas Association.
Proc. Am. Petrol. Inst	Proceedings of the American Petroleum Institute.
Proc. Ann. Coal Conf	Proceedings of the Annual Coal Conference, — Conference.
Proc. Cambridge Phil. Soc	Proceedings of the Cambridge Philosophical Society.
Proc. Chem. Soc	Proceedings of the Chemical Society (London).
Proc. Coal. Min. Inst. of America	Proceedings of the Coal Mining Institute of America.
Proc. Imper. Acad. (Tokyo)	Proceedings of the Imperial Academy (Tokyo).
Proc. Indian Acad. Sci	Proceedings of the Indian Academy of Science.
Proc. Indian Sci. Cong., — Cong	Proceedings of the Indian Science Congress, — Congress.
Proc. Internat. Conf. Bituminous Coal	Proceedings of the International Conference on Bituminous Coal, — Conference.
Proc. "Koninkl. Akad. Wetenschappen Amsterdam".	Proceedings of the "Koninklijke Akademie van Wetenschappen te Amsterdam".
Proc. Natl. Acad. Sci. U. S.	Proceedings of the National Academy of Science of the United States.
Proc. Phys. Math. Soc. Japan	Proceedings of the Physico-Mathamatical Society of Japan.
Proc. Phys. Soc. (Japan)	Proceedings of the Physical Society (Japan).
Proc. Phys. Soc. (London)	Proceedings of the Physical Society (London.)
Proc. Pure Applied Chem., — (city) —th Internat. Cong.	Proceedings Pure Applied Chemistry, — (city) —th International Congress.
Proc. Roy. Soc. (London)	Proceedings of the Royal Society (London).
Proc. Roy. Soc. (South Wales)	Proceedings of the Royal Society (South Wales).
Proc. South Wales Inst. Eng	Proceedings of the South Wales Institute of Engineers.
Proc. World Eng. Cong., — (city)	Proceedings of the World Engineering Congress, — (city).

Abbreviations	*Journal titles*
Proc. —d World Petrol. Cong	Proceedings of the —d World Petroleum Congress.
	Promyshlennost Organicheskoĭ Khimii *See* Org. Chem. Ind. (U. S. S. R.)
Przegląd Chem	Przegląd Chemiczny.
Przegląd gorniczo-hutniczy	Przegląd gorniczo-hutniczy.
Przegląd Gorniczy.	Przegląd Gorniczy.
Przegląd Mechaniczny	Przegląd Mechaniczny.
Przegląd Tech	Przegląd Techniczny.
Przemysl Chem	Przemysl Chemiczny (Chemical Industry).
Przemysl Naftowy	Przemysl Naftowy (Petroleum Industry).
Przemysl Rolny i Spożywczy	Przemysl Rolny i Spożywczy (Agricultural and Food Industry).
Pubs. assoc. ing. faculte polytech. Mons	Publications de l'association des ingenieurs de la faculte polytechnique de Mons.
Quart. Jour. Indian Chem. Soc	Quarterly Journal of the Indian Chemical Society.
Quart. Revs. (London)	Quarterly Reviews (London).
Rass. min. met. chim	Rassegna mineraria, metallurgica e chimica.
Rec. trav. chim	Recueil des travaux chimiques des Pays-Bas.
Recherches et inventions	Recherches et inventions.
Refiner and Nat. Gasoline Mfr	Refiner and Natural Gasoline Manufacturer.
Reichsamt Wirtschaftsausbau	Reichsamt Wirtschaftsausbau.
Rept. to Federal Power Commission	Reports to the Federal Power Commission.
Repts. Imperial Fuel Research Inst., Japan	Reports of the Imperial Fuel Research Institute, Japan.
Research	Research (London).
Research Council Alberta (Canada) Ann. Rept.	Research Council of Alberta (Canada) Annual Reports.
Rev. carburants France	Revue carburants France.
Rev. chim. ind. (Paris)	La Revue chimie industrielle (Paris).
Rev. combust. liquides	Revue des combustibles liquides.
Rev. Gén. Gaz	Revue Générale du Gaz.
Rev. ind. minérale	Revue de l'industrie minérale.
Rev. indust	La Revue industrielle.
Rev. inst. franç. pétrole et Ann. combustibles liquides.	Revue de l'institut française du pétrole et Annales des combustibles liquides.
Rev. mét	Revue de métallurgie.
Rev. Modern Phys	Reviews of Modern Physics.
Rev. Petrol. Technol	Reviews of Petroleum Technology (London).
Rev. pétrolifère	Revue pétrolifére.
Rev. Phys. Chem. Japan	Review of Physical Chemistry of Japan.
Rev. prod. chim	Revue des produits chimiques.
Rev. quím. ind	Revista de química industrial.
Rev. sci	Revue scientifique.
Rev. univ. mines	Revue universelle des mines.
Riv. catasto servizi tecn. erar	Rivista catasto servizi tecn. erar.
Riv. combustibili	Rivista dei combustibili.
Riv. ital. petrolio	Rivista italiana del petrolio.
Riv. ital. essenze. profumi, piante offic., olii vegetali, saponi.	Rivista italiana essenze profumi, piante officinali, olii vegetali, saponi.
Rundschau deut. Tech	Rundschau deutscher Technik.
Saggiatore	Saggiatore.
Sbornik Nauch.-Issledovatel. Rabot Kiev Tekh. Inst. Kozhevenno-Obuvnoi Prom.	Sbornik Nauchno-Issledovatel'skogo Rabot Kiev Tekhnika Institut Kozhevenno-Obuvnaya Promyshlennost.
Schweiz. Aero Rev	Schweizer Aero Revue.
Schweiz. Apoth. Ztg	Schweizerische Apotheker Zeitung.
Schweiz. Arch. angew. Wiss. u. Tech	Schweizer Archiv für angewandte Wissenschaft und Technik.
Schweiz. Bauztg	Schweizerische Bauzeitung.
Schweiz. elektrotech. Ver., Bull	Schweizerischer elektrotechnischen Vereins, Bulletin.
Schweiz. Techztg	Schweizerische Technikerzeitung.
Schweiz. Ver. Gas- u. Wasserfach., Monats-Bull.	Schweizerischer Verein von Gas- und Wasserfachmännern, Monats-Bulletin.
Sci. American	Scientific American.
Sci. and Culture	Science and Culture (India).
Sci. and Ind. Research Council, Alberta, (Canada), Repts.	Scientific and Industrial Research Council, of Alberta (Canada), Reports.
Sci. et ind., Tech. ind. pétroles	Science et industrie, Technique industries pétroles.
Sci. Lubrication	Scientific Lubrication (London).
Sci. Papers Inst. Phys. Chem. Research (Tokyo).	Scientific Papers of the Institute of Physical and Chemical Research (Tokyo).
Sci. Petrol	Science of Petroleum (Oxford University Press, London).
Sci. Repts. Tôhoku Imp. Univ	Scientific Reports of the Tôhoku Imperial University.
Sci. Repts. Tokyo Imp. Univ	Scientific Reports of the Tokyo Imperial University.
Science	Science.
Science Councilor	Science Councilor.
Seifen-Öle-Fette-Wachse	Seifen-Öle-Fette-Wachse.
Seifensieder-Ztg	Seifensieder-Zeitung.

Abbreviations	*Journal titles*
Siebert Festschr	Siebert Festschrift.
Sitz. der heidelberg. Akad. Wiss	Sitzungsberichte der heidelberger Akademie der Wissenschaften.
Soap	Soap.
Soap Sanit. Chemicals	Soap and Sanitary Chemicals.
Soc. of Automotive Engineers	Society of Automotive Engineers.
South African Ind. Chem	South African Industrial Chemist.
South African Min. and Eng. Jour	South African Mining and Engineering Journal.
Southern Power and Ind	Southern Power and Industry.
Sparwirtschaft	Sparwirtschaft.
Stahl u. Eisen	Stahl und Eisen.
Stal	Stal.
Studi ric. comb	Studi e richerche sui combustible.
Süddeut. Apoth.-Ztg	Süddeutsche Apotheker-Zeitung.
Süddeut. Molkerei Ztg	Süddeutsche Molkerei Zeitung.
Suomen Kemistilehti	Suomen Kemistilehti.
Surveyor	Surveyor.
Svensk Kem. Tid	Svensk Kemisk Tidskrift.
Syn. Org. Chem	Synthetic Organic Chemicals
T. A. C. Rept	Technical Advisory Committee Report
Tech. Blätter	Technische Blätter (Dusseldorf)
Tech. Eng. News, M. I. T	Technical Engineering News, Massachusetts Institute of Technology.
Tech. ind. chim	Technique des industries chimiques.
Tech. Mitt. Krupp	Technische Mitteilungen Krupp. A. Forschungsberichte. B. Technische Berichte.
Tech. moderne	Technique moderne.
Techn.-Wetenschap. Tijdschr	Technisch-Wetenschappelijk Tijdschrift.
Technik, Die	Technik, Die.
Teer	Teer.
Teer u. Bitumen	Teer und Bitumen.
Tek. Tid	Teknisk Tidskrift Upplaga D. Mekanik, Skeppsbyggnadskonst och Flygteknik jämte Automobile-och Motorteknik.
Tek. Ukeblad	Teknisk Ukeblad.
Teknillinen Aikakauslehti	Teknillinen Aikakauslehti (Technical Review).
Teoriya i Prakt. Met	Teoriya i Praktika Metallurgii
Tetsu-to-Hagane	Tetsu-to-Hagane.
Tids. Kjemi Bergvesen	Tidsskrift for Kjemi og Bergvesen.
TIIC Rept	Technical Industrial Intelligence Committee Report.
TOM Reel	Technical Oil Mission Reel —.
Trans. Am. Inst. Chem. Eng	Transactions of the American Institute of Chemical Engineers.
Trans. Am. Inst. Min. and Met. Eng	Transactions of the American Institute of Mining and Metallurgical Engineers.
Trans. Am Soc. Mech. Eng	Transactions of the American Society of Mechanical Engineers.
Trans. Am. Soc. Metals	Transactions of the American Society for Metals.
Trans. Am. Soc. Steel Treating	Transactions of the American Society for Steel Treating.
Trans. — Ann. Anthractie Conf., Lehigh Univ	Transactions — Annual Anthracite Conference, Lehigh University.
Trans. Canadian Inst. Min. and Met	Transactions of the Canadian Institute of Mining and Metallurgy and of the Mining Society of Nova Scotia.
Trans. Electrochem. Soc	Transactions of the Electrochemical Society, Inc.
Trans. Faraday Soc	Transactions of the Faraday Society.
Trans. Indian Inst. Metals	Transactions of the Indian Institute of Metals.
Trans. Inst. Chem. Eng. (London)	Transactions of the Institution of Chemical Engineers (London).
Trans. Inst. Marine Eng	Transactions of the Institute of Marine Engineers.
Trans. Karpov Chem. Inst	Transactions of the Karpov Chemical Institue.
Trans. World Power Conf., Chem. Eng. Cong	Transactions of the World Power Conference, Chemical Engineers' Congress.
Trans. World Power Conf., Fuel Conf	Transactions of the World Power Conference, Fuel Conference.
Trudy Leningrad. Khim. Tekhnol. Inst	Trudy Leningradskogo Khimiko-Tekhnologicheskogo Instituta.
U. O. P. Co., Lib. Bull	Universal Oil Products Co., Library Bulletin.
U. O. P. Co., Survey Foreign Petrol. Literature.	Universal Oil Products Co., Survey of Foreign Petroleum Literature.
U. S. Industrial Chemical News	United States Industrial Chemical News.
U. S. Naval Tech. Mission in Europe	United States Naval Technical Mission in Europe.
U. S. Naval Tech. Mission to Japan	United States Naval Technical Mission to Japan.
Ukrain. Khem. Zhur	Ukrains'kiĭ Khemichniĭ Zhurnal (Ukrainian (Chemical Journal).
Ullmann, Enzyk. Tech. Chem	Ullmann, F., Enzyklopädie des Technischen Chemie. Urban and Schwarzenberg, Berlin, 2d ed., 10 vols., 1928–1932.
Umschau	Umschau or Umschau in Wissenschaft und Technik.
Univ. Illinois Eng. Expt. Sta. Circ	University of Illinois Engineering Experiment Station Circular.
Uppsala	Uppsala Universitets.
Usine	L'Usine.

Abbreviations	*Journal titles*
Uspekhi Khim	Uspekhi Khimii (Progress of Chemistry).
Valve World	Valve World.
Vestnik Metallopromyshlennosti	Vestnik Metallopromyshlennosti (Metal Industry World).
Vierjahresplan	Vierjahresplan.
Vom Wasser	Vom Wasser.
Vsesoyuz. Nauch.-Issledovatel. Inst. Metrol., Kratkiĭ Obzor Vazheĭshikh Nauch.-Issledovatel., Rabot Lab.	Vsesoyuznyĭ Nauchno-Issledovatel'skiĭ Institut Metrologii, Kratkiĭ Obzor Vazhneĭshikh Nauchno-Issledovatel'skiĭ, Rabot Laboratorya
Vsesoyuz. Nauch.-Issledovatel. Inst. Metrol., Sbornik Trudov.	Vsesoyuznyĭ, Nauchno-Issledovatel'skiĭ Institut Metrologii, Sbornik Trudov.
Wärme	Die Wärme.
Westinghouse Eng	Westinghouse Engineer.
Wisconsin Eng	Wisconsin Engineer.
World Oil	World Oil.
World Petrol	World Petroleum.
	Zhurnal Fizicheskoĭ Khimii U.S.S.R. *See* Jour. Phys. Chem. U.S.S.R.
	Zhurnal Khimicheskoĭ Promyshlennosti, U.S.S.R. *See* Jour. Chem. Ind. (U.S.S.R.).
	Zhurnal Obshcheĭ Khimii. *See* Jour. Gen. Chem. (U.S.S.R.).
	Zhurnal Prikladnoĭ Khimii U.S.S.R. *See* Jour. Appl. Chem. U.S.S.R.
	Zhurnal Russkogo- Fiziko-Khimicheskogo Obshchestva U.S.S.R. *See* Jour. Russ. Phys.-Chem. Soc.
	Zhurnal Tekhnicheskoĭ Fiziki U.S.S.R. *See* Jour. Tech. Phys. (U.S.S.R.)
Zprávy Ústavu Vědecky Výzkum Uhli v Praze.	Zprávy Ústavu pro Vědecky Výzkum Uhlí v Praze. (*See* Mitt Kohlenforsch.-Inst. Prag.).
Ztschr. angew Chem	Zeitschrift für angewandte Chemie.
Ztschr. anorg. Chem	Zeitschrift für anorganische Chemie.
Ztschr. Elektrochem	Zeitschrift für Elektrochemie und angewandte physikalische Chemie.
Ztschr. ges. exptl. Med	Zeitschrift für die gesamte experimentelle Medizin.
Ztschr. kompr. flüss. Gase	Zeitschrift für komprimierte und flüssige Gase sowie für die Pressluft-Industrie.
Ztschr. Krist	Zeitschrift für Kristallographie.
Ztschr. Lebensm.-Untersuch. Forsch	Zeitschrift für Lebensmittel-Untersuchung und-Forschung.
Ztscyr. Physik	Zeitschrift für Physik.
Ztschr. physik. Chem	Zeitschrift für physikalische Chemie.
Ztschr. physiol. Chem	Zeitschrift fur physiologische Chemie.
Ztschr. tech. Physik	Zeitschrift fur technische Physik.
Ztschr. Ver. deut. Ing	Zeitschrift des Vereines deutscher Ingenieure.

LITERATURE ABSTRACTS

A

1. ABRAMOV, I. Underground Gasification of Coal. Gas World, vol. 123, 1945, pp. 130, 132.

Gives brief account of developments in Russia and the economic possibilities. Practical use of gas from an established experimental station has shown that its cost is about 2/5 of an equal amount of coal.

ACKERMANN, P. *See* abs. 1087, 1945, 1946, 1946a, 1948, 1950, 1955.

2. ADADUROV, I. E., AND DIDENKO, P. D. Catalysis by Fusions. Jour. Am. Chem. Soc., vol. 57, 1935, pp. 2718–2722; Chem. Abs., vol. 30, 1936, p. 1291.

Although orientation of a metal surface may be retained at the melting point, the decomposition of CH_3OH on Zn surfaces is now found to be catalyzed by ZnO; hence the constant rise in activity from solid to liquid Zn found by Steacie and Elkin (abs. 3264), is not conclusive proof of the nonexistence of active centers. Further evidence is that catalytic oxidation of NH_3 by Sn is due to the oxide; hence the rate increases upon fusion, but the activity of Ag falls abruptly at the melting point, and the nature of the reaction changes because the oxide is not formed. Mechanisms are cited for the formation of ZnO, and experiments show Zn chips to be coated with oxide.

ADAMS, N. G. *See* abs. 3595.

ADCOCK, W. A. *See* abs. 767.

ADKINS, H. *See* abs. 2073.

3. ADKINS, H., AND KRSEK, G. Preparation of Aldehydes From Alkenes by Addition of Carbon Monoxide and Hydrogen With Cobalt Carbonyls as Intermediates. Jour. Am. Chem. Soc., vol. 70, 1948, pp. 383–386; Chem. Abs., vol. 42, 1948, p. 2925.

Application of the Oxo process (U. S. Patent 2,327,066) to organic synthesis is presented. Several aldehydes have been prepared in an average yield of 50% by the addition of CO and H_2 to the alkene linkage in pentene-2, styrene, and other alkenes. The first step in the catalysis of the reaction appears to be formation of an ether-soluble Co compound, dicobalt octacarbonyl. Although the conversion of the alkene to the aldehyde may be brought about at 150° in the presence of Co on a support, it appears advantageous to use preformed dicobalt octacarbonyl in ether or other solvent for the catalysis of the synthetic reaction. The dicobalt octacarbonyl is readily made at 150° by the direct reaction of Co and CO and may be kept in ether for use as needed as a catalyst. The addition of CO and H_2 to an alkene goes very rapidly at 125° or lower in the presence of dicobalt octacarbonyl. The reactions may be carried out at 100–300 atm. pressure in the steel reaction vessels ordinarily used for hydrogenation. Warning is given as to the health hazards involved in the use of the Co carbonyls.

4. ———. Hydroformylation of Unsaturated Compounds With a Cobalt Carbonyl Catalyst. Jour. Am. Chem. Soc., vol. 71, 1949, pp. 3051–3055.

Hydroformylation of several unsaturated hydrocarbons, ethers, and esters, through the use of dicobalt octacarbonyl in benzene at 100–300 atm. of CO and H_2, has given good yields of aldehydes free of isomers (*see* Adkins and Krsek, abs. 3). The reaction of substituted ethylenes of the types $RCH{=}CH_2$ and $R_2C{=}CH_2$ have given in 6 cases aldehydes of the type RCH_2CH_2-CHO and R_2CHCH_2CHO; however, where R was phenyl, 1-naphthyl, n-butoxy, acetoxy, and ethoxymethyl, aldehydes of the type $RCH(CH_3)CHO$. Three alkenes of the type $RCH{=}CHR'$ have given good yields of a single aldehyde. Some limitations of the reaction, due to formation of mixtures of aldehydes or failure of the hydroformylation reaction to take place, are illustrated. The presence of a S-containing compound in the reaction mixture did not significantly poison the catalytic activity of the benzene-soluble cobalt carbonyl catalyst. This catalyst has proved to be effective for the hydrogenation of the carbon to carbon double bond in certain α–, β–unsaturated carbonyl compounds.

5. ADKINS, H., AND NISSEN, B. H. Selective Activation of Alumina, II. Reactions of Formic Acid at the Surface of Alumina. Jour. Am. Chem. Soc., vol. 45, 1923, pp. 809–815; Chem. Abs., vol. 17, 1923, p. 2104.

Effects of Al_2O_3 catalysts prepared in different ways on the decomposition of HCO_2H were studied. The amounts of H_2 and CO_2 formed agreed very closely, so that decomposition occurs almost entirely according to the reactions $HCO_2H{=}CO_2{+}H_2$ and $HCO_2H{=}CO{+}H_2O$ and to no considerable extent according to the equation $2\ HCO_2H{=}HCHO{+}CO_2{+}H_2O$. It is concluded that the distances separating the molecules of Al_2O_3, as determined by the method of preparation, were the important factors in defining the activity and selectivity of the catalyst.

6. ADKINS, H., AND PERKINS, P. D. Behavior of Methanol Over Aluminum and Zinc Oxides. Jour. Phys. Chem., vol. 32, 1928, pp. 221–224; Chem. Abs., vol. 22, 1928, p. 1521.

Fifty cc. of CH_3OH per hr. was passed over 1 gm. of catalyst at 300°–400°. CH_3OH was converted almost quantitatively over the Al_2O_3 catalyst into $(CH_3)_2O$ in increasing amounts at temperatures up to 350°. Further increase in temperature resulted in a rapid increase in products other than $(CH_3)_2O$ (CO_2, CO, C_2H_4, H_2, and CH_4). Formation of $(CH_3)_2O$ over the ZnO was almost negligible. Formation of gaseous decomposition products occurred, however, above 325°. Synthesis of CH_3OH by catalytic hydration of $(CH_3)_2O$ over Al_2O_3 was accomplished at 270°–430°. Optimum $H_2O : (CH_3)_2O$ ratio as constant flow varied with the amount of catalyst used.

7. ADKINS, H., BURGOYNE, E. E., AND SCHNEIDER, H. J. Copper-Chromium Catalyst for Hydrogenation. Jour. Am. Chem. Soc., vol. 72, 1950, pp. 2626–2629; Chem. Abs., vol. 44, 1950, p. 8564.

$CuCr_2O_4$ catalyst produced by thermal decomposition of basic Cu ammonium chromate (containing also Ba from $Ba(NO_3)_2$) contains CuO and $CuCr_2O_4$, but neither alone is the effective catalyst. By increasing the ratio Cr : Cu, the activity was enhanced in the reduction of Me laurate and Me palmitate at 600 p. s. i. and 175°. It is activated by adsorption of H_2 at 200 atm.

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and 100° and, thus activated, catalyzes the hydrogenation of aldehydes and ketones at room temperature and of certain esters at 80°.

8. **Agliardi, N., and Marelli, S.** [Activated Adsorption of Hydrogen and of Carbon Monoxide on Cobalt.] Gazz. chim. ital., vol. 78, 1948, pp. 707–717; Chem. Abs., vol. 43, 1949, p. 3686.

Co was prepared by decomposition of Co formate at 270° in vacuo and the adsorption apparatus was that used in previous experiments. With "cleaved" Co, adsorption of CO was at first more rapid than that of H_2, but subsequently adsorption of CO became less than that of H_2. When the Co was poisoned by CO, adsorption of H_2 was smaller; nevertheless adsorption was even then more rapid than by Co not poisoned by CO. Mixtures of CO and H_2 were adsorbed more rapidly than was pure H_2. CoC_2, traces of which are formed in the surface reactions with CO, tends to stabilize the adsorbing surface, and even with successive adsorptions of H_2, the surface does not revert to its original condition. Under the conditions of the experiments, not all of the C is reduced by H_2, and solution of the Co in dilute HNO_3 showed the presence of elemental C. The apparent energy of activation of adsorption of CO is greater than that of H_2 and decreases with increase in the amount of gas adsorbed.

9. **Aicher, A., Myddleton, W. W., and Walker, J.** Production of Hydrocarbon Oils From Industrial Gases. I. Jour. Soc. Chem. Ind., vol. 54, 1935, pp. 313–320 T; Chem. Abs., vol. 29, 1935, p. 8289.

In the production of hydrocarbon oils from CO and H_2, the total S content of the gas is reduced to approximately 0.1 grain per 100 cu. ft. Organic S compounds are removed by hydrogenation over a CuO–$PbCrO_4$–Et orthosilicate catalyst, and H_2S is then absorbed. The purified gas is passed over a Ni–Mn–Al catalyst supported on kieselguhr and cemented together by Et orthosilicate at 450°–480°. As the 1st few inches of the catalyst bed perform much more work than the succeeding layers, there is a tendency to produce a hot spot. Adsorption of the product on the surface of the catalyst exercises a retarding action, increasing with the partial pressure of the oil in the catalyst chamber. The preferred method of operation is to use the catalyst in 2 or 3 parts and to remove the products formed after each stage. This results in a grading of oil with definite variation in content of unsaturated hydrocarbons, increased throughput of gas per unit volume of catalyst and an increased yield of oil from a given volume of gas.

10. **Myddleton, W. W., and Walker, J.** Production of Hydrocarbon Oils From Industrial Gases. II. Jour. Soc. Chem. Ind., vol. 55, 1936, pp. 121–124T; Chem. Abs., vol. 30, 1936, p. 5393.

Dilution of the reactants does not lower the yield but decreases the rate when the diluents comprise reaction products that are adsorbed on the catalyst. The distillation characteristics of the products are independent of the contact time and the composition of the charge. A product of high olefin content, suitable for the preparation of motor fuel and oil, is favored by a short contact time, a CO : H_2 ratio greater than 0.5, and use of Co instead of Ni catalysts.

11. **Aita, A.** [New Developments in the Heavy Chemical Industry.] Notiz. chim.-ind., vol. 2, 1927, pp. 78–81; Chem. Abs., vol. 21, 1927, p. 1857.

Describes advances, since World War I, in the manufacture of fertilizers and synthetic fuels and in catalysis.

12. **Akamatsu, H., and Sato, K.** [Catalytic Decomposition of Carbon Monoxide by Iron.] Bull. Chem. Soc. Japan, vol. 22, 1949, pp. 127–131; Chem. Abs., vol. 44, 1950, p. 7637.

Pure CO was passed through a quartz reaction tube containing a piece of Kahlbaum's electrolytic Fe as catalyst. Gas flowing from the reaction tube passed through $Ba(OH)_2$ solution, which becomes turbid when the reaction proceeds as $2\ CO \rightarrow C + CO_2$. 5–10 hr. are necessary for decomposition to begin at 500° reaction temperature and CO flow of 400 cc. per hr. Once started, the reaction proceeds smoothly, and free C forms on the surface of the catalyst. Electron-diffraction patterns of the catalyst were taken just as decomposition had begun, as shown by turbidity of the $Ba(OH)_2$ solution, and after 15 hr. of decomposition. In case 1 no free C was found, but the Fe had lost its metallic luster, the pattern obtained was that of cementite. The 2d pattern was made when the surface was black or gray in parts but before C appeared in powder form; this pattern was principally of C, but some cementite spacings also appeared. Prolonged decomposition yielded a C-powder layer and the surface then gave only C spacings. Patterns of amorphus C ordinarily show only spacings corresponding to (*hk0*) and (*001*), but since the C resulting from decomposition of the CO showed spacings corresponding to (*101*) and probably (*112*) this deposit proved to be graphite. Since amorphus C must be heated above 2,500° to be graphitized, it is thought that in this case the C formed is not amorphus, but rather graphite formed by decomposition of cementite. Traces of O_2 in the CO prevented decomposition if an Fe plate was used as catalyst, but not if pulverized Fe was used.

13. **Akers, W. W., and White, R. R.** Kinetics of Methane Synthesis. Chem. Eng. Progress, vol. 44, No. 7, 1948, pp. 553–566; Chem. Abs., vol. 42, 1948, p. 6085.

When CO and H_2 mixtures are passed over a reduced Ni catalyst at 300°–350° and 1 atm., CH_4 is produced by the reaction $CO+3H_2=CH_4+H_2O$. CO_2 is formed by the side reaction $CO+H_2O=CO_2+H_2$. Carbon is not formed in appreciable amounts under the conditions studied. The rate of reaction between the adsorbed reactant molecules on the active centers of the catalyst is the rate-controlling step in the synthesis of CH_4. The rate of the CH_4-synthesis reaction is correlated by the equation:

$$r=\frac{p_{CO}p_{H_2}{}^3}{(A+Bp_{CO}+Dp_{CO_2}+Ep_{CH_4})^4}$$

The initial rate of formation of CO_2 can be expressed by the empirical equation:

$$r=A'\,(p_{CO}-B').$$

The rate remains almost constant until the rate of CH_4 formation equals the CO_2 rate. Thereafter both rates are equal, and the CH_4 rate equation can be used as the CO_2 rate equation.

14. **Akhmedli, M. K.** [Hydrogenation of Monocyclic Aromatic Hydrocarbons on a Cobalt Catalyst.] Jour. Gen. Chem. U. S. S. R., vol. 19, 1949, pp. 462–467 (in English, pp. 229–239); Chem. Abs., vol. 43, 1949, p. 6172.

Hydrogenation of C_6H_6, PhMe, and $C_6H_4Me_2$ is not catalyzed by either asbestos, Al_2O_3, or Cr_2O_3 at 220°. On pure Co, prepared by reduction of the formate, C_6H_6 is completely hydrogenated at 172°, PhMe at 208°, $C_6H_4Me_2$ at 228°. Co deposited on carriers is more active than pure Co. Thus, with Co (61.54%), reduced from the formate, on asbestos, the temperatures of complete hydrogenation were, respectively, 105°, 100°, and 92°, with Co (68.75%) on Al_2O_3, 85°, 82°, and 41°, with Co (61.54%) on Cr_2O_3, 42°, 94°, and 139°. For the hydrogenation of C_6H_6, the most active catalysts are Cr_2O_3 and Co, and Al_2O_3 and Co; for $C_6H_4Me_2$, Al_2O_3 and Co is very distinctly more active than Cr_2O_3 and Co. The rate of hydrogenation falls in the order C_6H_6, PhMe, $C_6H_4Me_2$. Hydrogenation of all 6 atoms takes place in 1 stage, in agreement with the multiplet theory of catalysis.

Al, J. *See* abs. 3043.

15. **Alberts, L.** [Iron Catalysts.] FIAT Reel K–29, 1938, frames 6932–6935; PB 70.218.

Special experiences with a Lurgi Fe catalyst are presented. A conclusive evaluation is not possible because the statements are contradictory. Continuation of the tests is recommended.

15a. **Alberts, L. W., Bardin, J. S., Beery, D. W., Jones, H. R., and Vidt, E. J.** Production of Methane From Coal. Chem. Eng. Progress, vol. 48, 1952, pp. 486, 493; Chem. Abs., vol. 46, 1952, p. 11,636.

It has been estimated that the investment of a plant designed to produce 100 million ft.^{3} per day of high-B. t. u. pipeline gas is approximately \$52.5 million. The cost of larger plants will be proportional to their size. The cost of producing the gas has been shown to be \$0.55 per 1,000 std. ft.^{3} when the charging stock is a noncaking coal or char having a heating value of 26 million B. t. u. per ton and containing no tar-forming materials, available at \$4.00 per ton. This study has shown that the cost of CH_4 from coal is closely related to the cost of coal. With fuel costing \$4.00 per ton, fuel represents 45% of the cost of gas, at \$8.00 per ton it is 60%. The overall thermal efficiency of this process compares favorably with other processes for converting coal into more readily available forms of energy. It has also shown that >90% of the cost of producing high-B. t. u. pipeline gas lies in the production of the purified synthesis gas. Therefore, efforts to reduce the cost must be directed toward reducing the cost of the synthesis gas. Proper selection and pretreatment of the coal to allow its introduction into the gas generator without prior removal of its tar and oil content will effectively reduce its cost, resulting in lowered gas cost.

Albrecht, W. H. *See* abs. 3620, 3621.

Albrecht, W. H., and Wedekind, E. [Distinguishing the Different Types of Ferric Oxides and Hydrated Oxides by Their Different Magnetic Properties. III. Hydrated Ferric Oxide From the Decomposition of Iron Pentacarbonyl.] *See* abs. 3622.

———. [Distinguishing the Different Types of Ferric Oxides and Hydrated Oxides by Their Different Magnetic Properties. IV.] *See* abs. 3623.

Albright, R. E. *See* abs. 1460.

16. **Alden, R. C.** Conversion of Dry Natural Gas to Liquid Fuels. World Petrol., vol. 17, No. 4, 1946, pp. 46–49; 70. Gas abs., vol. 2, No. 5, 1946, p. 118; Chem. Abs., vol. 40, 1946, p. 3248.

Reviews Fischer-Tropsch process development in Germany and its possible application in the United States. Either coal or natural gas can be utilized, but the latter is believed to be simpler and cheaper to operate. 3.5–5 gal. of gasoline are obtainable from 1,000 cu. ft. gas. One of the developments in this country is an Fe cataylst which gives a higher octane product and oxygenated materials.

17. ———. Conversion of Natural Gas to Liquid Fuels. Petrol. Refiner, vol. 25, No. 11, 1946, p. 194; Petrol. Processing, vol. 1, 1946, p. 246.

Abstract of a paper presented before the California Natural Gasoline Association. German developments in the conversion of coke and brown coal to liquid hydrocarbons, applied to natural gas, would result in a motor fuel costing about \$0.19 per gal. A number of developments in the several processes, however, including cheap O_2, large bed reactors, improved catalysts, and fluidized catalytic operations will probably reduce the cost to as low as \$0.05 per gal. These, with the larger scale of American operations, have already resulted in preliminary construction work on 2 commercial installations (Brownsville, Texas, and western Kansas) and several other installations, where natural-gas reserves and other conditions are favorable, are anticipated.

18. ———. Conversion of Natural Gas to Liquid Fuels. Petrol. Engineer, vol. 18, No. 4, 1947, pp. 148, 150, 152, 154, 156, 158; Oil Gas Jour., vol. 45, No. 27, 1946, pp. 79, 81, 82, 97, 98; California Oil World, vol 39, No. 20, 1946, pp. 5–16; Chem. Abs., vol. 41, 1947, p. 264.

German development of the Fischer-Tropsch process and the American refinements to use natural gas as raw material are reviewed. Natural gas is cheaper raw material and simpler to handle, and desulfurization is easier than with coal. In a conjectured commercial-scale operation at present, desulfurized natural gas and O_2 are preheated separately and passed into a combustion reactor, where synthesis gas consisting of 2 parts H_2 to 1 part CO is produced. The exit gas is cooled from about 2,100° F. to 600° F. in a waste-heat boiler, where a portion of the power requirements of the plant is produced. The gas is then passed into the synthesis reactor, where liquid hydrocarbon products are formed. A fluid, powdered Fe catalyst is employed. The temperature is controlled by water-cooled tubes extending into the reactor. By mild refining, the raw gasoline will have a 75–80 octane number and the Diesel fuel a cetane number >50. 5,000 bbl. of total refined hydrocarbon product, consisting of about 4,100 bbl. of motor fuel and 900 bbl. of Diesel fuel, are obtained from 60,000,000 cu. ft. of natural gas. In addition, there would be 360 bbl. of oxygenated products. With natural gas at \$0.05 per 1,000 cu. ft., the cost per gal. of liquid fuels would be approximately \$0.05.

———. *See* abs. 1399.

19. **Alden, R. C., and Clark, A.** Appraisal of Gas-Synthesis Operations. Petrol. Processing, vol. 3, 1948, pp. 425–430; Nat. Petrol. News, vol. 40, No. 14, 1948, p. 23.

Paper presented before the Western Petroleum Refiners Association, 36th annual meeting. Synthesis of liquid fuels from natural gas will require investments ranging from \$3,000.00 to \$4,000.00 per bbl. per day and cost \$0.0914 per gal. without credit for chemical products. The steel requirement is about 6 tons per bbl. per day. To make gasoline from coal would require approximately 2 times the investment and double the amount of steel, and it would cost \$0.114–\$0.164 per gal. To produce 650,000 bbl. per day of synthetic oil would require 10,000 cu. ft. of natural gas or 1,360 lb. of coal per gal. of motor fuel produced. Gas-synthesis plants would cost 2.6 billion dollars to build and require 3.96 million tons of steel. Coal-synthesis plants would cost 5.2 billion dollars and use 5.65 to 7.8 million tons of steel. Natural-gas reserves required for 20 yr. operation are 47.5 trillion cu. ft. and coal reserves required are 2.92 billion tons. Gas reserves are currently estimated at 165.9 trillion cu. ft. and reserves of total liquid hydrocarbons approximately 2.512 billion bbl. Since 50% of the energy in natural gas would be absorbed in the synthesis, the fuel-oil equivalent of the gas used for synthesis is 13.8 billion bbl. About 85% or 11.7 billion bbl. would be gasoline; and, at present estimated demand, our gas reserves would last about 13 yr. It is apparent that any significant long-range liquid-fuels program must be based on coal. Gas synthesis will be limited to those regions where enough gas reserves are available, 0.5 trillion cu. ft. being necessary to run one 7,000-bbl.-per-day plant for 20 yr. Future gas-synthesis, up to several hundred thousand bbl. per day, could be sustained by our natural-gas resources provided (a) the operation can compete economically with processing of crude oil and (b) can pay a high enough price for natural gas to stimulate new discoveries. Much will depend on the engineering and economic outcome of the 2 plants being built and on interim research and development programs. As things stand, with a marginal long-term profit prospect, a very large investment requirement, and most important, gas reserves committed otherwise, it is quite likely that new gas-synthesis operations will be undertaken slowly.

20. ———. Liquid Fuels From Natural Gas. Trans. Am. Soc. Mech. Eng. Paper 48–FET–13, 1948, 13 pp.; Oil Gas Jour., vol. 47, No. 24, 1948, p. 111.

Abstract of paper presented at American Society of Mechanical Engineers meeting, Amarillo, Texas. American research and development of the Fischer-Tropsch process have resulted in great improvements, which make the gas-synthesis operation appear in a favorable light as an economic source of liquid fuels. Plant investment is about $3,000–$4,000 per bbl. per day. Steel requirement is about 6 tons per bbl. per day for a capacity of 650,000 bbl. per day. A corresponding production of synthetic liquid fuels from coal would require about 2 times as much investment and nearly 2 times as much steel. Coal required would equal 28% of the 1945 production. Natural-gas reserves have been increasing at a faster rate than the marketed production of natural gas, which has been doubling every 11 yr. A producible natural-gas reserve of 0.5 trillion cu. ft. is required to sustain a 7,000-bbl.-per-day gas-synthesis operation for 20 yr. In only 10 States are there known gas reserves of over 1 trillion cu. ft., and only about 50 out of 426 gas-producing fields have reserves greater than 0.5 trillion cu. ft. A substantial gas-synthesis development must depend on new gas discoveries.

21. ALDRICH, R. C. Manufacture and Regeneration of Fischer-Tropsch Catalyst. Nat. Petrol. News, vol. 37, 1945, pp. R922–R924; CIOS Rept. VI–22, X–18–XV–5, 1944, 25 pp.; PB 373.

Operation of the Fischer-Tropsch unit of the Carrières-Kuhlmann plant at Harnes, France. Of the operating personnel of 120 men, 40 are employed in catalyst manufacture and regeneration. Capacity of the plant is 350 bbl. per day. The % composition by weight of the finished catalyst before hydrogenation is: Co 18.0, MgO 1.8, ThO_2 0.9, kieselguhr 79.3%, 40–50 kg. HNO_3 (36° B.), and 90 kg. of Na_2CO_3 per 100 kg. of catalyst. The Co must be 99% pure, the other 1% being Cu or Ni. ThO_2 must not contain even traces of Pb or P, and the CaO must be less than 0.2% by weight. The kieselguhr must not contain Fe or lime. The SiO_2 content must exceed 92%, but the sand content must not exceed a few %. All organic matter must be removed by roasting at 800° but not greatly above, as the structure of the particles will be destroyed. Kieselguhr from Kieselguhr-Industrie-Hannover No. 120 is one of the best both as to impurities and particle size; and Johns-Manville Filtracel is satisfactory. Describes manufacture of the catalyst and its regeneration in great detail, together with the accompanying chemical reactions.

22. ———. Synthetic Lubricating-Oil Production in France. Nat. Petrol. News, vol. 37, No. 45, 1945, pp. R859–R860; CIOS Rept. XVIII–5, 1945, 9 pp.; U. S. Naval Tech. Mission in Europe Rept. 80–45; TOM Reel 196; PB 365.

Two processes are described: The Standard Kuhlmann-Lestaque near Marseille and the Kuhlmann Co.-Harnes near Lille. The first process used Fischer-Tropsch gas oil, benzol, and dichlorethane as raw materials. The gas oil should be highly paraffinic and be produced by carrying out the $CO:H_2$ synthesis at a ratio of 2:1 and holding down the temperature of the reaction to 190° to produce as few olefins and as many paraffins as possible. The gas oil is first chlorinated, then mixed with the benzol-dichlorethane mixture in presence of $AlCl_3$, reacted for about 6 hr. at 70°–110°, the benzol stripped out, and the stripped oil settled and decanted and given a conventional refining treatment. The products are roughly 20% recycle gas oil, 30% transformer oil, 30% turbine oil, and 20% steam-cylinder oil. The viscosity index for the lubricating oils is about 100. The second process treats the Fischer-Tropsch gasoline with 3% of $AlCl_3$ for 5 hr. at room temperature, and the 2 layers are separated and treated for recovery of the oils. The quality of the lubricating oils is not good; their oiliness is poor, and they oxidize readily. Analyses are tabulated for the products of both processes.

———. *See* abs. 3038.

23. ALI, E. [Study of the Composition and Conversion Possibilities of Fischer-Tropsch Synthesis Hydrocarbons.] Thesis, Berlin, 1941. 64 pp.

24. ALLAN, D., COCKS, L. V., AND SUTCLIFFE, H. T. Production of Synthetic Fatty Acids and Their Conversion into Soaps and the Properties of the Products. Chem. Trade Jour., vol. 122, 1948, p. 89; BIOS Final Rept. 1560, 1947, 35 pp.; PB 91,672.

Soaps from the synthetic fatty acids, even when they form only 10–20% of the fat charge, have an unpleasant odor, which is imparted to the human skin when washed with the soap. The extent varies with different individuals. The odor is not found on cloth washed with the soap. Refractionation of the fatty acids and removal of the lowest molecular-weight acids give some improvement. The odor may be due in part to decomposition that takes place during heating of the anhydrous soap to 360° C., which is common to all German processes. Development of the process in England depends on finding enough raw materials.

25. ALLEN, C. F. H. The Oxo Process. Syn. Org. Chem., Eastman Kodak Co., vol. 18, No. 3, 1946; U. O. P. Co. Lib. Bull., vol. 22, No. 5, 1947, p. 20.

Oxo process developed in Germany produces straight-chain aldehydes and ketones from olefins and water gas, the former predominating. The use of hydrocarbons terminating in $=CH_2$ favors production of aldehydes. For example, if C_2H_4 is used, the products are propionaldehyde and diethyl ketone, the former being 70% of the total. The product from unsaturated hydrocarbons containing 11–17 C atoms has been the basic starting material. The reaction can be carried out in batches or continuously. Pressures used are about 150 atm. with temperatures up to 180°. After partial conversion and separation of the oxygenated fraction by distillation, the residue is made up with new gas and recirculated. The catalyst consists of Co, Th, and Mg carbonates on kieselguhr suspended in Diesel oil. The catalyst is not sensitive to S, so removal of S compounds from the water gas is not necessary. Possibilities of the process are great. The carbonyl compounds formed can be converted into other substances by known chemical processes. For example, reduction in presence of a Raney Ni catalyst gives the corresponding alcohols. These can be sulfated to produce the modern detergents. The development is only beginning, however, and many technical difficulties remain to be overcome.

ALLEN, J. G. *See* abs. 1477.

26. ALLGEMEINE OEL- UND FETT-ZEITUNG. [Properties of Synthetic Kogasin Lubricants.] Vol. 35, 1938, pp. 124–125.

After referring to the Fischer-Tropsch process and the advantages the product has over coal and natural oils owing to its greater uniformity, reference is made to the control that can be exercised over the product.

Viscosity-temperature curve of oil boiling 125°–250° C. is as good as that of a Pennsylvania oil. Winter-grade Kogasin oil corresponds very closely, both in viscosity and viscosity-temperature curve with a winter-grade natural oil. The specific gravity is very low due to the high H content, which is also important in giving a low C formation in an internal-combustion engine. Flash point of winter oil is rather low, but higher values can be obtained for summer and aircraft oils. Other points are: Very low setting point, complete freedom from S, and unlimited stability against the effect of O_2 and light. On these accounts the oil can be used for transformers and switchgear.

ALLISON, E. *See* abs. 890.

27. ALLNER, W. [Bunsen Flame.] Jour. Gasbeleucht., vol. 48, 1905, pp. 1035–1040; Jour. Chem. Soc., vol. 90, (2), 1906, pp. 441–442.

In the relatively cold flames formed by burning mixtures of CO_2 and H_2, or of CO and H_2, a state of equilibrium is not attained. In the flames of mixtures of CH_4 and H_2, CH_4, H_2, and CO_2, C_6H_6 and H_2, and C_6H_6, H_2, and CO_2, the equilibrium $K=[(H_2O)\ (CO)]/[(CO_2)\ (H_2)]$, corresponding with the temperature, is established. The effect of temperature on the equilibrium is discussed, and the values of the constant in the equation $\log K=-1/0.4343.R\int q/T^{2}.dt+\text{constant}$ are calculated from the different values of K and the effect of temperature on the specific heats of the gases.

28. ———. [Brown Coal Gas for City and Synthetic Purposes—The Kassel Parallel Current Chamber, Bubiag-Didier System.] Gas- u. Wasserfach, vol. 78, 1935, pp. 438–456; Tech. Blätter, vol. 25, 1935, p. 392; British Chem. Abs., 1935, B, p. 756; Chem. Abs., vol. 29, 1935, p. 6731.

Brown coal or brown-coal briquets are carbonized in vertical chambers heated externally to 1,000°–1,300°. The brown coal gradually passes down through the chamber, and the distillation products are cracked by passing down through the hot coke before being removed through outlets at various heights. The coke in the lower part of the chamber is steamed to generate water gas, which mixes with the gas produced by carbonization. Provision is made for the continuous removal of the coke, which is used to generate producer gas for heating the chambers. The yield and quality of the gas may be varied within wide limits by adjusting operating conditions, so as to produce a gas of 450 B. t. u. per cu. ft. or higher, or a gas containing less than 4% CH_4 suitable for synthetic purposes. Gas similar in composition to coal gas may be made if the excessive amount of CO_2 is washed out. This is accomplished by means of a 20%, K_2CO_3 solution, the regeneration of this solution requiring about 1 lb. of steam per 3 cu. ft. of CO_2. Possible uses for CO_2 are discussed, and costs for its removal are given. Losses of the wash solution are negligible, less than 20% per yr. The tar is similar to high-temperature tar, but the yield is much lower. The light-oil content is about 0.095–0.16 gal. per 1,000 cu. ft., but this may be increased by introducing petroleum oils or brown-coal tar into the chamber during carbonization. Gas manufactured by this process has been used successfully in ordinary gas-burning appliances both alone and mixed with the ordinary city gas and the experimental plant has been in continuous operation since October 1934, covering $\frac{1}{5}$–$\frac{1}{7}$ of the Kassel gas requirements. Cost data are given for German conditions. A laboratory apparatus for carbonizing brown coal is described, which permits comparison of various brown coals.

29. ———. [Direct-Current Degasification Process of the Kassel Oven of the Bubiag-Didier System.] Braunkohle, vol. 34, 1935, pp. 419–428; Chem. Abs., vol. 30, 1936, p. 7310.

Detailed description of process using various forms of brown coal for the production of domestic or synthesis gas. Coal drying, low-temperature carbonization, gas cracking, tar decomposition, coke gasification, and water-gas formation are involved in the operation. Excess CO_2 is removed by scrubbing. Economic aspects discussed.

30. ———. [Production of City Gas and Gas for Synthesis From Brown Coal by the Continuous-Current Gas Process.] Ztschr. Ver. deut. Ing., vol. 79, 1935, pp. 1487–1492; Coal Carbonisation, vol. 2, 1936, p. 18; Chem. Abs., vol. 30, 1936, p. 1542.

Kassel plant of the Braunkohlen und Brikett Industrie A.-G., Bubiag, for degasifying brown coal by parallel-flow process is described. The raw-gas yield for purposes of synthesis amounts to 1,100–1,800 $m.^3$ per ton at normal temperature and pressure. The CO : H_2 ratio can be adjusted exactly to 1 : 2 to suit the Fischer benzine-synthesis process without special preparation. An installation of 12 parallel-flow retorts 32 ft. 10 in. in height has been in continuous service in Hungary since 1932, making about 70,000 $m.^3$ of synthesis gas per day. Plants of any desired capacity can be supplied under guarantee for the manufacture of town gas or synthesis gas.

31. ———. [Brown Coal as Raw Material for City Gas and Synthesis Gas.] Braunkohle, vol. 35, 1936, pp. 495–511; Chem. Abs., vol. 31, 1937, p. 1584.

Comprehensive review of plants and processes for making water gas for synthesis purposes and a discussion of the correct conditions for producing synthesis gas are presented, with an analysis of costs.

32. ———. [Brown Coals as Raw Material for Town Gas and Synthesis Gas.] Braunkohle, vol. 35, 1936, p. 886; Chem. Eng. Cong., World Power Conf., vol. E1, 1936, 20 pp.; Chem. Abs., vol. 31, 1937, p. 8157.

An addendum is presented. The Pintsch-Hillebrand process yields a gas suitable for the Fischer synthesis in 1 stage. It contains 15% inerts (CO_2, CH_4, and N_2) and 85% of H_2 and CO in the ratio, H_2 : CO=2. After catalytically converting the CO into CO_2 and washing out the latter, the gas contains 97–98% of H_2. Data provided by J. Pintsch A.–G., are given for the cost of erecting and operating a plant yielding 80,000 $m.^3$ of synthesis gas/hr.

33. ———. [Manufacture of City Gas and Synthetic Gas From Brown Coal and Other Low-Rank Fuels.] Gas- u. Wasserfach, vol. 79, 1936, pp. 594–596; Chem. Abs., vol. 30, 1936, pp. 8572–8573.

Carbonization and gasification processes for brown coal are reviewed briefly. At Dessau a mixture of low-temperature brown-coal gas is mixed with coal gas. Successful experiments were made with brown coal in the Bube and Heinze gas producers at the Halle and Dresden gas works. Zittau has contracted for gas to be made from brown coal in the Lurgi high-pressure gas generators, with a mixture of O_2 and H_2O vapor. Several other processes have been or are now being operated on a semi-plant scale.

34. ———. Manufacture of Town Gas and Gas for Chemical Synthesis From Lignite. Trans. World Power Conf., Chem. Eng. Cong., 1936, E 6, 30 pp.; British Chem. Abs., 1936, B, p. 724.

It is emphasized that carbonization processes must be adapted to suit brown coals. Various processes are discussed from this viewpoint, and the correct conditions for producing town gas and synthesis gas are dealt with.

ALLOLIO, R. *See* abs. 337.

ALLUM, R. E. *See* abs. 291.

35. ALMQUIST, J. A. Catalytic Synthesis at High Pressures. Jour. Chem. Education, vol. 3, 1926, pp. 385–389; Chem. Abs., vol. 20, 1926, p. 1937.

Reviews NH_3 synthesis and reaction of CO with H_2 to form MeOH and other substances.

36. Almquist, J. A., and Crittenden, E. D. Study of Pure-Iron and Promoted-Iron Catalysts for Ammonia Synthesis. Ind. Eng. Chem., vol. 18, 1926, pp. 1307–1309; Chem. Abs., vol. 21, 1927, p. 802.

Several pure and promoted Fe catalysts are compared. The activity of pure Fe depends upon the state of oxidation of the fused oxide from which it is obtained by reduction. Fe_3O_4 gives the best results. The addition of K_2O alone lowers the activity of pure Fe, but when SiO_2 is added also there is a promoting action. It is shown that K_2O has a marked promoting action in the presence of difficultly reducible oxides of an acidic nature, for example, those of Mn, W, Si, and Al. It is also shown that its addition to Fe containing oxides of metals closely related to Fe, such as those of Ni and Co, lowers the activity.

Altmayer, V. *See* abs. 2217, 2218, 2219.

Altshuller, S. B. *See* abs. 784, 804.

Amero, R. C. *See* abs. 432.

37. Anders, H. [Individualities of Catalysts for the Fischer-Tropsch Synthesis as Regards the Composition and Properties of the Reaction Product.] Chem. Tech., vol. 2, 1950, pp. 27–29; Chem. Abs., vol. 44, 1950, p. 5566.

General discussion.

Anderson, H. C. *See* abs. 1217, 3297.

38. Anderson, J. A., and Seyfried, W. D. Determination of Oxygenated and Olefin Compound Types by Infrared Spectroscopy. Anal. Chem., vol. 20, No. 11, 1948, pp. 998–1006.

Laboratory investigation of relationship between molecular structure of organic compounds and their infrared-absorption spectra has resulted in development of procedures for the quantitative to semiquantitative determination of individual compound types in complex mixtures employing infrared-absorption spectroscopy in the liquid phase. At present, it is possible to make determinations for the functional groups of alcohols, aldehydes, carboxylic acids, esters, ketones, and 5 different olefin types in complex samples such as hydrocarbon-synthesis naphthas in about 4 hr. For oxygenated types, average accuracy (deviation from true composition) ranges from + or —10% to + or —20%, depending upon type and complexity of mixture. For olefin types, the average deviation is about + or — equivalent Br number units.

39. Anderson, R. B. Improved Adsorption Vessel. Ind. Eng. Chem., anal. ed., vol. 18, 1946, p. 156.

Description of adsorption vessel for measuring the weight loss upon reduction of metal oxide catalysts used in the Fischer-Tropsch process. The catalyst is reduced in a vessel that is small and light enough to be weighed in an analytical balance. It is also possible with this adsorption vessel to study the effects of treatment of the catalyst with gases other than H_2, such as synthesis gas or CO, on the surface area and pore structure, and to determine the weight loss of the adsorbent upon evacuation.

40. ———. Modifications of the Brunauer, Emmett, and Teller Equation. I. Jour. Am. Chem. Soc., vol. 68, 1946, pp. 686–691; Chem. Abs., vol. 40, 1946, p. 3322.

Brunauer-Emmett-Teller theory of multilayer adsorption has been applied extensively to physical-adsorption isotherms. While the simple Brunauer-Emmett-Teller equation provides an excellent method of estimating surface areas, it usually holds only for relative pressures of 0.05–0.40. In almost every case, the amount adsorbed at relative pressures higher than 0.40 is less than that predicted by the simple Brunauer-Emmett-Teller equation. This discrepancy has been explained in 3 ways: (1) By assuming the heat of adsorption in the second layer to be less than the heat of liquefaction of the adsorbate; (2) by assuming that the structure of the adsorbent is such that it will permit adsorption to only a finite number of layers; and (3) by considering the effects of capillary condensation. The author has observed that the simple Brunauer-Emmett-Teller equation can be fitted to many physical-adsorption isotherms in the range of relative pressures of 0.05–0.70 if the relative pressure is multiplied by a constant that is less than 1, usually varying between 0.6 and 0.7. This constant is interpreted to mean that the heat or free energy of adsorption in the 2d to 10th layers is less than the heat or free energy of liquefaction, or that the entropy of adsorption in these layers is more negative than the entropy of liquefaction. A similar equation containing an additional constant denoting the upper limit of the layers in which the heat, free energy, or entropy differ from those functions for the liquid has been fitted to isotherms in the range of relative pressures of 0.05–0.98. For porous solids, equations have been presented for adsorption on solids in which the area available to each succeeding layer is less than the previous one. A new-type equation has been developed for adsorptions limited to n-layers, which has better properties than the n-equation of Brunauer-Emmett-Teller.

41. Anderson, R. B., and Hall, W. K. Modifications of the Brunauer, Emmett, and Teller Equation. II. Jour. Am. Chem. Soc., vol. 70, 1948, pp. 1727–1734; Chem. Abs., vol. 42, 1948, p. 6198.

Modified Brunauer, Emmett, and Teller equation similar to that previously suggested has been derived and applied to physical-adsorption isotherms of types I and IV. With type I isotherms, this reaction can be satisfactorily applied if the free energy of adsorption in the second and subsequent layers is taken to be equal to the heat of liquefaction. For isotherms of type IV, which flatten below relative pressures of 0.85, the equation satisfactorily fits the data, if the free energy of adsorption was taken as less than that of liquefaction. For this kind of type IV isotherm, the equation was used to integrate the equation of Kistler, and the resulting expression gave surface areas of the same order of magnitude as the Brunauer, Emmett, and Teller areas. The equation is believed to be a simple method of characterizing isotherms with 4 constants.

Anderson, R. B. *See* abs. 51, 53a, 53b, 53c, 1090, 1449a, 1987, 2073a, 2227, 2227a, 2228, 3296, 3297, 3647.

42. Anderson, R. B., and Emmett, P. H. Surface Complexes on Charcoal. Gas Evolution as a Function of Vapor Adsorption and of High-Temperature Evacuation. Jour. Phys. and Colloid Chem., vol. 51, 1947, pp. 1308–1329; Chem. Abs., vol. 42, 1948, p. 1410.

Gases evolved, on evacuating charcoals for gas masks, to 1,200° were collected at 300° intervals and analyzed for CO, CO_2, H_2, H_2O, and CH_4. The O_2-containing gases were formed by decomposition of surface complexes and by reduction of the inorganic oxides present as ash. CO and CO_2 evolution reached a maximum at about 600° for charcoals prepared by the $ZnCl_2$ process and at 900°–1,200° for those prepared from coal. The total O_2-containing gases evolved were always equivalent to less than 50% of the charcoal surface. Extracting charcoals with HF and reexposing them to air resulted in about a 20-fold increase in the amount of CO evolved on heating the samples to 600°. H_2 evolution in the temperature range 600°–1,200° amounted to 25–147 cc. for the various charcoals. Activation of the charcoals by steam was shown to form very little O complex. The amount of CO and CO_2 displaced from the surface complex by the adsorption of CCl_4, H_2O, or chlorobenzene was found to be equivalent to less than 0.01 cc. per gm. NH_3 at 750°–900° formed a N complex on the charcoals that was more stable than the O complexes.

Anderson, R. B., and Hall, W. K. Modifications of the Brunauer, Emmett and Teller Equation. II. *See* abs. 41.

42a. Anderson, R. B., Feldman, J., and Storch, H. H. Synthesis of Alcohols by Hydrogenation of Carbon Monoxide. Ind. Eng. Chem., vol. 44, 1952, pp. 2418–2424; Chem. Abs., vol. 47, 1953, p. 291.

Processes involving the catalytic syntheses of alcohols from CO and H_2 may be divided into 2 classes: Alcohol syntheses in which alcohols are usually the predominant products, and variations of the Fischer-Tropsch process with Fe catalysts in which the product contains olefinic and paraffinic hydrocarbon, alcohols, acids, esters, aldehydes, and ketones. The alcohol syntheses include the MeOH, the higher alcohol, and the isosyntheses. The MeOH and higher alcohol syntheses employ mixed catalysts of active components such as Cu and oxides of Zn, Cr, and Mn, with alkali oxides added as promoter for the higher alcohol synthesis. Th is the active component of isocatalysts. Higher alcohols from these processes have branched C chains. Under some conditions the isosynthesis produces sizable yields of hydrocarbons. Alkali oxides seem to be the only important promoter for Fe Fischer-Tropsch catalysts. The nature of the Fe phase, oxide, carbide or nitride, is important. Processes producing sizable yields of alcohol include the fluidized, synol, and nitrided catalyst syntheses. Fischer-Tropsch alcohols are chiefly primary straight-chain alcohols. Available data indicate that the mechanism of chain growth in alcohol syntheses is different from that of the Fischer-Tropsch processes.

43. Anderson, R. B., Friedel, R. A., and Storch, H. H. Fischer-Tropsch Reaction Mechanism Involving Stepwise Growth of Carbon Chain. Jour. Chem. Phys., vol. 19, 1951, pp. 313–319.

Expressions are derived that predict satisfactorily the observed isomer and carbon-number distribution of products from Fe and Co catalysts in the Fischer-Tropsch synthesis. These expressions are based on 3 postulated schemes of stepwise addition of 1 C atom to the end or adjacent-to-end C atoms of the longest C chain: (A) Addition may occur at only 1 end of the growing chain on only 1 end C atom if 2 are present or on the adjacent-to-end carbon; (B) it may occur at only 1 end of the growing chain on any end or adjacent-to-end carbon; (C) it may occur at either end of the growing chain on any end or adjacent-to-end carbon. The implications of these schemes to some general aspects of the reaction mechanism are considered.

Anderson, R. B., Hall, W. K., and Hofer, L. J. E. Studies of the Fischer-Tropsch Synthesis. IV. Properties of Reduced Cobalt Catalysts. *See* abs. 47.

43a. Anderson, R. B., Krieg, A., and Friedel, R. A. Fischer-Tropsch Synthesis—Differential Reaction Rate Studies With Cobalt Catalyst. Ind. Eng. Chem., vol. 41, 1949, pp. 2,189–2,197; Chem. Abs., vol. 44, 1950, p. 2,358.

Synthesis was studied on a pelletted Co : ThO_2 : kieselguhr (100 : 18 : 100) catalyst in a fixed-bed reactor (90 cm. long bed) at atmospheric pressure and 186°–207°. The reactor contained a special tube for the removal of gas samples at 9 points along the length of the bed. About 5% A was added to the feed gas as a reference component. Synthesis gases containing H_2 : CO ratios of 3.5, 2, and 0.9 were used at space velocities ranging from 25–100 cc. of gas per cc. of total catalyst bed per hr. With all gas compositions the synthesis rate was high in the first 10% of the bed and lower and essentially constant in the remainder of the bed until the reactants were nearly completely consumed. The gas compositions in the bed in the region of constant synthesis rate varied considerably. CH_4 appears to be formed by primary reactions as well as by hydrocracking of higher hydrocarbons; the latter being favored by high H_2 and hydrocarbon partial pressures. CO_2 appears to be formed by primary reactions as well as by a secondary water-gas shift which latter was favored by high CO and H_2O partial pressures. CO_2 was reduced in the synthesis gas after CO had been completely consumed. Craxford's postulate (abs. 639) that the synthesis occurs on Co_2C with secondary reactions on Co atoms does not appear adequate to explain the data reported.

Anderson, R. B., Hall, W. K., Hewlett, H., and Seligman, B. Studies of the Fischer-Tropsch Synthesis. II. Properties of Unreduced Cobalt Catalysts. *See* abs. 45.

Anderson, R. B., Hall, W. K. Krieg, A., and Seligman, B. Studies of the Fischer-Tropsch Synthesis. V. Activities and Surface Area of Reduced and Carburized Cobalt Catalysts. *See* abs. 48.

Anderson, R. B., Hofer, L. J. E., Cohn, E. M., and Seligman, B. Studies of the Fischer-Tropsch Synthesis. IX. Phase Changes of Iron Catalysts in the Synthesis. *See* abs. 52.

Anderson, R. B., Krieg, A., Friedel, R. A., and Mason, L. S. Studies of the Fischer-Tropsch Synthesis. VI. Differential Reaction Rate Studies With Cobalt Catalyst. *See* abs. 49.

44. Anderson, R. B., Krieg, A., Seligman, B., and O'Neill, W. E. Studies of the Fischer-Tropsch Synthesis. I. Tests of Cobalt Catalysts at Atmospheric Pressure. Ind. Eng. Chem., vol. 39, 1947, pp. 1548–1554; Chem. Abs., vol. 42, 1948, p. 1039.

Methods of preparation and testing of a precipitated Co : ThO_2 : MgO : kieselguhr (100 : 6 : 12 : 200) catalyst are described. Usually tests with the same preparation of catalyst were quite reproducible, but tests with different catalysts prepared in the same manner showed very much wider deviations. Pelleted catalysts were shown to produce more light hydrocarbons and CO_2 than the granular catalysts. Liquid hydrocarbons containing less than 6% dissolved wax comprised about 75% of the total hydrocarbons formed in these tests at atmospheric pressure. Experiments were made in which the flow of synthesis gas was varied with the temperature adjusted to give the same degree of conversion. Under these conditions the degree of unsaturation increased with increase in flow. Except for the change in unsaturation, the product distribution was not significantly different up to temperatures of 207°. Overall activation energies of 24–26 kcal. per mol. were found for the synthesis. The reaction mechanism and rate law of the synthesis are discussed briefly.

45. Anderson, R. B., Hall, W. K., Hewlett, H., and Seligman, B. Studies of the Fischer-Tropsch Synthesis. II. Properties of Unreduced Cobalt Catalysts. Jour. Am. Chem. Soc., vol. 69, 1947, pp. 3114–3119; Chem. Abs., vol. 42, 1948, p. 2739.

Surface-area and pore-volume studies are reported for 2 types of unreduced Co Fischer-Tropsch catalysts and for similar preparations with promoters, kieselguhr, or both omitted. Properties of the catalysts are compared and related to properties of the kieselguhrs that they contain. Areas of unreduced precipitated Co Fischer-Tropsch catalysts were several times greater than those of the kieselguhr used as carriers. Catalysts prepared with natural kieselguhrs had larger areas than those prepared with calcined or flux-calcined kieselguhrs. Areas of unreduced catalysts varied from 60–150 m.² per gm. Average pore diameters of granular catalysts varied from 500 Å. to 770 Å. and for pelleted catalysts from 165Å. to 310Å. Surface areas of pelleted catalysts were 10–20% lower than the areas of the corresponding granules. It was shown that the Co basic carbonate-promoter complex was precipitated chiefly in the void space of the kieselguhr. Preparations without promoters, kieselguhr, or both had areas of the Co complex per gm. of complex that roughly equaled the area of the complex of the catalyst. Natural kieselguhr as a carrier considerably increased the area of the Co complex. Catalysts prepared in small batches were quite reproducible with respect to surface area, but the areas of catalysts prepared in large batches varied considerably.

46. Anderson, R. B., Krieg, A., Seligman, B., and Tarn, W. H. Studies of the Fischer-Tropsch Synthesis. III. Influence of Type of Kieselguhrs. Ind. Eng. Chem., vol. 40, No. 12, 1948, pp. 2347–2350; Chem. Abs., vol. 43, 1949, p. 3167.

Testing data are presented for a series, 89 in all, of Co : Th : Mg : kieselguhr (100 : 6 : 12 : 200) catalysts prepared with a number of commercially available American kieselguhrs. Catalysts containing calcined kieselguhrs had lower activity than similar catalysts with natural kieselguhrs. These results agree with those previously obtained by Craxford, who found that catalysts prepared with natural kieselguhr had surface areas and activities greater than those of a catalyst containing calcined kieselguhr. Acid-extracted natural kieselguhrs produced catalysts of the highest activity. The density of the catalyst varied directly with the density of the kieselguhr, and the distribution of products changed with density of the catalysts, the denser catalysts forming a greater % of light hydrocarbons and CO_2.

47. Anderson, R. B., Hall, W. K., and Hofer, L. J. E. Studies of the Fischer-Tropsch Synthesis. IV. Properties of Reduced Cobalt Catalysts. Jour. Am. Chem. Soc., vol. 70, 1948, pp. 2465–2472; Chem. Abs., vol. 42, 1948, p. 8058.

Reduced Co; ThO_2: MgO; kieselguhr (100: 6: 12: 200) and Co: ThO_2: kieselguhr (100: 18: 100) and similar preparations with one or more of the components omitted have been studied by N surface areas and CO chemisorptions at −195°, Hg and He densities, and X-ray diffraction. The experimental data show that the surface areas of all the catalysts studied decreased on reduction. The promoters were found to prevent excessive decreases; powdered MgO appears to be the most effective and ThO_2 the least. Kieselguhr as a carrier was somewhat effective in preventing the decrease of surface area and in increasing the pore volumes on reduction of all the catalysts. With unpromoted and unsupported Co large changes occurred in both surface area and bulk volume. The most important function of the kieselguhr was to prevent the decrease in bulk volume of the catalyst on reduction and at the same time inhibit sintering of the surface. The CO chemisorption studies showed that an appreciable fraction of the catalyst surface was occupied by promoter. The X-ray diffraction data were in qualitative agreement with the surface-area determinations but in addition indicated that the Co in supported and promoted catalysts had an anomalous structure.

48. Anderson, R. B., Hall, W. K., Krieg, A., and Seligman, B. Studies of the Fischer-Torpsch Synthesis. V. Activities and Surface Areas of Reduced and Carburized Cobalt Catalysts. Jour. Am. Chem. Soc., vol. 71, 1949, pp. 183–188; Chem. Abs., vol. 43, 1949, p. 3273.

This paper relates surface area and surface accessibility of the catalyst to activity and product distribution. Data reported previously on the effect of bulk carbide on the activity of Co catalysts have been extended to include surface areas and activities and distribution of products in the synthesis with catalysts carburized with CO under conditions that form carbide (Co_2C), free C, or both. The catalysts studied were Co : ThO_2 : MgO : kieselguhr (100 : 6 : 12 : 200) and Co : ThO_2 : kieselguhr (100 : 18 : 100). The surface of the catalyst was found to be heavily covered with hydrocarbon. Hydrogenation at 200° removed 90% of these adsorbed hydrocarbons, and reduction with H_2 at 400° restored the catalyst to the same condition as after the initial reduction. There was no evidence of sintering or of C deposition. Activity data for operation at 1 and 7.8 atm. are related to the adsorbed hydrocarbon film. Decrease in the accessibility of the surface of these catalysts either by deposition of excessive quantities of wax or by reduction of average pore diameter by pelleting caused an increase in the fraction of CH_4 and other light hydrocarbons and in some cases a decrease in activity. The presence of bulk-phase carbide in these catalysts caused a marked decrease in activity, but free C did not affect the activity very much. The presence of C in both forms shifted the product distribution toward light hydrocarbons. The surface area did not change appreciably when the Co was converted to carbide. Carburization at 275°, under conditions that form predominantly free C, increased the area considerably.

49. Anderson, R. B., Krieg, A., Friedel, R. A., and Mason, L. S. Studies of the Fischer-Tropsch Synthesis. VI. Differential Reaction-Rate Studies With Cobalt Catalyst. Ind. Eng. Chem., vol. 41, No. 10, 1949, pp. 2189–2197; Chem. Abs., vol. 44, 1950, p. 2358.

Differential reaction-rate data are presented for the Fischer-Tropsch synthesis with Co catalysts at atmospheric pressure. The synthesis rate was high in the initial part of the bed and lower in nearly constant throughout a large portion of the catalyst bed, until the reactants were fairly completely consumed. Over the range of relatively constant rate of synthesis, the gas composition varied considerably. CH_4 and CO_2 were formed by primary reactions; CH_4 was also formed by secondary hydrocracking of higher molecular-weight hydrocarbons and CO_2 by the water-gas reaction. These reactions occurred throughout the catalyst bed, and their extent depended upon the composition of the gas in contact with the catalyst. The assumptions of Craxford involving the synthesis occurring on Co carbide and the secondary reactions on Co atoms do not appear to be an adequate explanation of the author's data.

50. Anderson, R. B., Shultz, J. F., Seligman, B., Hall, W. K., and Storch, H. H. Studies of the Fischer-Tropsch Synthesis. VII. Nitrides of Iron as Catalysts. Jour. Am. Chem. Soc., vol. 72, 1950, pp. 3502–3508; Chem. Abs., vol. 44, 1950, p. 10299.

Conversion of Fe in reduced synthetic ammonia-type catalysts to nitrides by ammonia treatment greatly increased their activity in the Fischer-Tropsch synthesis. All tests described in the paper were performed with a catalyst prepared by the electrical-fusion method and having the composition: Total Fe 67.4%, ferrous Fe 21.7%, MgO, 4.61%, K_2O, 0.57%, SiO_2, 0.71%, and Cr_2O_3, 0.65%. Catalysts converted to ε-phase nitrides yielded a product of lower average molecular weight containing greater yields of gaseous hydrocarbons and oxygenated molecules than those products from corresponding reduced catalysts. In the synthesis, nitrided Fe catalysts appear to resist oxidation and deposition of free C and have a greater stability and longer life.

51. Hall, W. K., Tarn, W. H., and Anderson, R. B. Studies of the Fischer-Tropsch Synthesis. VIII. Surface-Area and Pore-Volume Studies of Iron Catalysts. Jour. Am. Chem. Soc., vol. 72, 1950, pp. 5436–5443.

Changes are reported in surface area and pore volume during the reduction of 2 widely different Fe catalysts, a precipitated Fe_2O_3–CuO–K_2CO_3 catalyst and a fused Fe_3O_4–MgO–K_2O catalyst. Information is presented as to the nature of Fe catalysts at the start of the Fischer-Tropsch synthesis, as well as data pertinent to the mechanism of reduction. The surface areas of raw precipitated Fe gel catalysts are high, and their pore diameters are small; conversely, unreduced Fe-synthetic NH_3-type catalysts have essentially no surface area and no pore volume. After reduction at 300° and 450°–550°, respectively, both types have moderate surface areas of about 8 m.² per gm. and reasonably large pore diameters of 350–900 Å. Thermal sintering of precipitated Fe gels causes drastic changes in structure, but removal of O_2 by reduction produces an even greater effect. The surface area and pore voume of an Fe-synthetic NH_3-type catalyst increased in a linear manner with extent of reduction, whereas the average pore diameter remained constant. It is shown that only surface-area measurements and complete chemical analysis of the raw catalyst are necessary to establish the pore structure of an Fe-synthetic NH_3-type catalyst as a function of the extent of reduction. Increasing the reduction temperature of an Fe-synthetic NH_3-type catalyst from 450° to 650° produced an 8-fold increase in the pore diameter.

52. Anderson, R. B., Hofer, L. J. E., Cohn, E. M., and Seligman, B. Studies of the Fischer-Tropsch Synthesis. IX. Phase Changes of Iron Catalysts in the Synthesis. Jour. Am. Chem. Soc., vol. 73, 1951, pp. 944–946; Chem. Abs., vol. 45, 1951, p. 6,032.

Phase changes in a reduced fused-iron catalyst have been studied during the Fischer-Tropsch synthesis with 1 : 1=CO : H_2 gas at 7.8 atm. In the 1st few days of the synthesis, α–iron was converted to Hägg carbide Fe_2C. The iron as Hägg carbide increased to a maximum of 29% at 200 hr. of synthesis and then decreased slowly throughout the remainder of the test. Magnetite was formed at a slower rate than Hägg carbide, apparently chiefly at the expense of the α–iron phase. The magnetite phase increased through the experiment.

53. Anderson, R. B., Seligman, B., Shultz, J. F., Kelly, R., and Elliott, M. A. Fischer-Tropsch Synthesis. X. Some Important Variables of the Synthesis on Iron Catalysts. Ind. Eng. Chem., vol. 44, 1952, pp. 391–397; Chem. Abs., vol. 46, 1952, p. 5,291.

Several important variables affecting the catalyst activity and selectivity in the Fischer-Tropsch synthesis include the operating temperature and pressure and the particle size and alkali content of the catalyst. Data are presented for fused, sintered, and precipitated Fe catalysts. The variation of synthesis rate with temperature may be characterized by an overall activation energy of 20 kcal. per mol. The synthesis rate increased with pressure. For a fused catalyst the rate increased linearly with pressure; however, for other catalysts the variation of rate with pressure was less than linear. The rate increased as the particle size decreased, probably indicating that only a fraction of the surface was accessible to the reactants. For precipitated catalysts, the rate increased only slightly with alkali content, whereas, for other types the rate increased sharply to a maximum at about 0.5 K_2O per 100 Fe.

53a. Shultz, J. F., Seligman, B., Shaw, L., and Anderson, R. B. Fischer-Tropsch Synthesis. XI. Effect of Nitriding on 3 Types of Iron Catalysts. Ind. Eng. Chem., vol. 44, 1952, pp. 397–401; Chem. Abs., vol. 46, 1952, p. 5,291.

Fe catalysts of the fused, sintered, and precipitated types were tested in the Fischer-Tropsch synthesis after reduction in H_2 and nitriding in NH_3 to an ε–phase nitride, and the selectivity and activity of the nitrides were compared with those of corresponding reduced or inducted catalysts. In all cases, the nitrided catalysts yielded products of lower average molecular weight than those from reduced or inducted catalysts. The activity of fused and sintered catalysts was increased by nitriding, whereas the average activity of the precipitated catalyst was relatively independent of the method of pretreatment.

53b. Shultz, J. F., Seligman, B., Lecky, J., and Anderson, R. B. Studies of the Fischer-Tropsch Synthesis. XII. Composition Changes of Nitrided Iron Catalysts During the Synthesis. Jour. Am. Chem. Soc., vol. 74, 1952, pp. 637–640; Chem. Abs., vol. 46, 1952, p. 5,290.

Changes in the composition of nitrided Fe catalysts during use in the Fischer-Tropsch synthesis at 7.8 and 21.4 atm. operating pressure are described. The ε–nitrides are slowly converted to ε–carbonitrides, the rate of replacement of N by C being somewhat more rapid at 21.4 than at 7.8 atm. At the lower operating pressure, oxidation and deposition of elemental C proceed at a very slow rate, whereas at 21.4 atm. these reactions are considerably more rapid in some catalysts. At the higher pressure, the type of structural promoter appears to be important in determining the rates of oxidation and of deposition of free C. When used, nitrided catalysts are treated with H_2, the N is almost completely removed, whereas the C content is not greatly changed. A part of the C appears either as Hägg carbide or cementite, depending upon the temperature of hydrogenation.

53c. Hall, W. K., Tarn, W. H., and Anderson, R. B. Studies of the Fischer-Tropsch Synthesis. XIII. Structural Changes of a Reduced Iron Catalyst on Reoxidation and on Formation of Interstitial Phases. Jour. Phys. Chem., vol. 56, 1952, pp. 688–691; Chem. Abs., vol. 46, 1952, p. 10,582.

Upon complete reduction at 450° or 550°, a fused Fe synthetic NH_3 catalyst develops an extensive pore structure corresponding to about 45% porosity. On reoxidation, the volumes of the individual particles remain constant, while the surface areas and pore volumes decrease. Reoxidation proceeds at an initially rapid rate, which becomes very slow after a few hours. The reoxidized catalyst is reduced much more easily than the raw catalyst. Formation of the interstitial nitrides and carbides causes the catalyst particles to expand and the pore volume and average pore diameters to increase. The % porosity, however, remains about constant.

Anderson, R. B., Krieg, A., Seligman, B., and Tarn, W. H. Studies of the Fischer-Tropsch Synthesis. III. Influence of Type of Kieselguhrs. *See* abs. 46.

54. Anderson, R. B., McCartney, J. T., Hall, W. K., and Hofer, L. J. E. Kieselguhrs—Suitability as Carriers in Catalysts. Ind. Eng. Chem., vol. 39, 1947, pp. 1618–1628; Chem. Abs., vol. 42, 1948, p. 1031.

Properties of a number of kieselguhrs used as supports in Co Fischer-Tropsch catalysts have been studied. Data on chemical analysis, X-ray diffraction, surface areas, pore volumes, together with electron micrographs at magnifications of 2.000 and 20.000 diam. are presented and correlated. The comparative suitabilities of various kieselguhrs as carriers for catalysts are not discussed.

Anderson, R. B., Seligman, B., Shultz, J. F., Kelly, R., and Elliott, M. A. Fischer-Tropsch Synthesis. X. Some Important Variables of the Synthesis on Iron Catalysts. *See* abs. 53.

Anderson, R. B., Shultz, J. F., Seligman, B., Hall, W. K., and Storch, H. H. Studies of the Fischer-Tropsch Synthesis. VII. Nitrides of Iron as Catalysts. *See* abs. 50.

Ando, T. *See* abs. 2198, 2199, 2200, 2201, 2202, 2203, 2204.

Andrews, A. *See* abs. 574.

55. Andrews, G. W. Water-Gas Equilibrium in Hydrocarbon Flames. Jour. Chem. Soc., vol. 105, 1914, pp. 444–456; Jour. Soc. Chem. Ind. (London), vol. 33, 1914, p. 303; Chem. Abs., vol. 8, 1914, p. 1659.

Andrews concludes that the explosive combustion of numerous hydrocarbon–O_2 mixtures under widely differing conditions of incomplete combustion give rise to products that at least approximately conform to the requirements of the water-gas equilibrium with a value of 4 for the thermodynamic constant, and the value is not greatly altered even when large quantities of C are separated or considerable % of CH_4 is found in the ultimate products.

56. Andrews, R. S., and Bennie, R. S. High-Pressure Gasification of Brown Coal. BIOS Final Rept. 722, 1946, 13 pp.; PB 52,856.

Some discussion relating to the use of Australian brown coals in a Lurgi high-pressure generator and whether this type of plant would be suitable for gas production in Australia. The Lurgi high-pressure gasification process is the only one of the many processes developed in Germany that has been established for a gas supply. 2 plants at Bohlen and Brüx have been operating in connection with the development of processes using brown coal for liquid-fuel production that are considered economical under the economic conditions prevailing in Germany. A detailed study is needed to determine whether the process can be operated in Australia economically simply on the basis of gas production without the production of liquid fuel.

57. Andrieux, J. L. [Making Metallic Powders by Electrolysis of Fused Salts.] Rev. mét., vol. 45, 1948, pp. 49–59; Jour. four élec., vol. 57, No. 3, 1948, p. 54; Chem. Abs., vol. 42, 1948, p. 8089.

Mixture of $Na_2B_2O_4+Na_2CO_3+3$ LiF$+1/12$ Fe_2O_3 heated to 780° and electrolyzed with 20 amp. at 2.5 v. produces Fe_3C. With electrolytic baths of slightly different composition the product is another carbide of Fe more rich in C than cementite whose Curie Point is 245° C.

58. Angli, J. [Composition, Origin and Synthesis of Petroleum—The Argentine Problem.] Anales asoc. quim. Argentina, vol. 14, 1926, pp. 39–61; Chem. Abs., vol. 20, 1926, p. 2906.

An address.

59. Antheaume, J. [Contribution to the Study of the Iron Catalyst in the Synthesis of Hydrocarbons From Carbon Monoxide.] Thesis, Univ. Lille, I. Special No. 1934, 69 pp; Brennstoff-Chem., vol. 15, 1934, p. 436.

After a discussion of heterogeneous catalysis and the benzine synthesis of Fischer-Tropsch, a study was made of precipitated Fe-Cu catalysts (4 : 1) and their efficiency. The effect on the yield of the method of preparation, the space velocity of the synthesis gas, and the composition and regeneration of the catalyst by oxidation were determined. An increased efficiency was shown by catalysts that had all alkali electrolytically removed. A reduction in the Cu content by $\frac{9}{10}$ resulted in a 5-fold increase in the yield. Catalysts without a carrier were more efficient than those with one. Optimal yield: 65 gm. of hydrocarbons per $m.^3$ of raw gas. Some physical-chemical investigations of the state of the Fe during the synthesis were made. X-ray as well as thermomagnetic analyses, relation between the temperature and magnetic properties, showed the complete absence of metallic Fe. In every active catalyst the Fe_2O_3 and Fe_3O_4 were present as solid solutions. By complete exclusion of alkali the solubility of both oxides and the activity of the catalyst were increased. The extraction of the gas from used catalysts on kieselguhr showed that the quantity of absorbed gases increased with the rise in activity. In catalysts without kieselguhr, the amount of adsorbed gas increased with increasing age and decreasing efficiency. By extracting used catalysts salvelike and high-melting paraffins were obtained; they were not alone answerable for the deterioration of the catalyst. Likewise, synthesis gas carbureted with hexane caused only a slight decrease in the activity.

60. ———. [Hydrogenation of Carbon Monoxide.] Ann. combust. liquides, May–June 1935; Tech. moderne, vol. 27, 1935, p. 594; Coal Carbonisation, vol. 1, 1935, p. 151.

The author has investigated the structure and function of Fe-base catalysts in the preparation, at atmospheric pressure, of liquid hydrocarbons from CO. He concludes: (1) It is not necessary to add K_2CO_3 to catalysts prepared by precipitation of a solution of Fe and Cu nitrates—the most active preparations do not contain it. (2) Cu plays a triple part in these catalysts, that is, permitting the reduction of ferric oxide by H_2 at a relatively low temperature, activating, and stabilizing. A certain minimum of Cu is essential to obtain a durable catalyst. (3) Catalytic hydrogenation of CO at atmospheric pressure yields CO_2, H_2O, gaseous hydrocarbons, and a mixture of liquid hydrocarbons more or less rich in paraffins. (4) The hydrocarbon yield with Fe-Cu catalyst washed electrolytically is lower than with Fischer's Ni or Co catalyst but higher than hitherto obtained from Fe and Cu. (5) Structural examination reveals the presence of magnetic Fe oxide rhombohedral Fe_2O_3 in the active substance, also the absence of free Fe. In the most active catalysts the magnetite is in a state of solid solution, the formation of which is facilitated by the electrolytic washing. Precipitated magnetite used alone gives no condensation of higher hydrocarbons.

61. ———. [Iron Oxide Catalysts for the Hydrogenation of Carbon Monoxide Under Atmospheric Pressure.] Ann. combust. liquides, vol. 10, 1935, pp. 472–507; Chem. Abs., vol. 29, 1935, p. 6396.

Catalysts are prepared by coprecipitating equimolar mixtures of Fe and Ca nitrates with NaOH, washing until $pH=7.4$, mixing with 2% K_2CO_3, granulating, drying, and reducing with H_2 at 250°. Hydrogenation is carried out at 250° under 1 atm. on the mixture $CO+1.75$ H_2. The weight of liquid hydrocarbons formed decreases rapidly as the rate of flow is increased. Oxidation of the catalyst, followed by H_2 reduction, does not affect its activity. A powdered catalyst, 1 precipitated by NH_3 instead of NaOH and 1 precipitated on kieselguhr, showed very poor activity. Omitting the K_2CO_3 or washing the catalyst electrolytically increases its activity materially. Catalysts containing less Cu are more active but lose their activity after a few days. Samples of catalyst are withdrawn without contact with air, and their powder X-ray diagrams and magnetic properties are determined. These indicate the absence of Fe and the presence of Fe_2O_3 and Fe_3O_4, probably in solid solution. In the abence of Cu, no Fe_3O_4 is present in catalysts

reduced at 250°. The catalysts adsorb an appreciable amount of hydrocarbons, but this does not seem to affect their activity.

———. *See* abs. 678.

62. Antheaume, J., Decarrière, E., and Réant, R. [Physicochemical Study of the Iron Catalyst Used in the Synthesis of Liquid Hydrocarbons.] Chim. et ind., Special No., April 1934, pp. 421–423; Compt. rend., vol. 196, 1933, pp. 1889–1890; Brennstoff-Chem., vol. 15, 1934, p. 413; Chem. Abs., vol. 28, 1934, p. 5935.

From investigations by the thermomagnetic-analysis method of Chaudron and coworkers for the study of metallic oxides (Forestier and Chaudron, abs. 1054), it is concluded that catalytic conversion does not take place in presence of either Fe_2O_3 alone or of Fe_3O_4 alone. In every case in which catalytic activity is manifested, Fe_3O_4 is present, and the activity increases with the fineness of the crystalline structure. The authors admit that, with their catalysts, the production of higher hydrocarbons by hydrogenation takes place in the presence of complex solid solutions.

63. Anthracite Institute Bulletin. Refuse Anthracite Source of Synthetic Fuels. No. 1513, 1948, p. 1.

It is estimated that there are 200 million tons of anthracite silt above ground and over 5 million tons are produced annually. In the plant and process now under construction by the institute at Wilkes-Barre, Pa., silt, air, and steam will be fed into a refractory-lined cylinder where combustion takes place. The fluidized-bed principle is used, and the silt is either intermittently blown with air and steam or continuously with O_2 and steam. A producer gas is made containing CO_2, CO, H_2, and N_2. This is passed through a second bed of silt where the CO_2 reacts with the C to give additional CO, which increases the heat content of the producer gas. If a gas of still higher heat value is desired, steam is introduced into the producer gas at the top of the fluidized bed to give water gas. A logical use of the process is to produce synthesis gas and to convert this into liquid fuels.

64. Antonena, C. M. [Synthetic Naphtha.] Rev. quim. ind. (Buenos Aires), vol. 2, No. 16, 1949, pp. 15–18, 30; British Abs., 1950, B, I, p. 35.

Short description of the Fischer-Tropsch process for producing naphtha by the hydrogenation of CO.

Antonov, V. K. *See* abs. 3327.

Antonova, M. F. *See* abs. 563.

65. Apin, A., Leipunskii, O., and Reinov, N. [Decomposition of Methanol Under High Pressures.] Jour. Gen. Chem. (U. S. S. R.), vol. 10, 1940, pp. 863–865; Chem. Abs., vol. 35, 1941, p. 2469.

With the aim to investigate the influence of high pressures on simple reactions of organic compounds, the behavior of MeOH has been investigated. The decomposition of MeOH was studied at 350° under pressures of 600, 2,000, 6,000, and 8,000 atm. The reaction products were Me_2O, CH_4, CO_2, CO, and H_2. Unsaturated hydrocarbons could not be detected. The amount of Me_2O increased with increasing pressure and decreased at a given pressure with prolonged reaction time. CO and H_2 were formed in small amounts and CH_4 in large amounts when high pressures were applied. The amount of CO and H_2 decreased with prolonged reaction time while the amount of CH_4 increased. The reaction vessel used consisted of nonrusting steel containing about 8% CrO_3 which possibly acts as a catalyst. A series of reactions is given that the decomposition reaction is assumed to follow.

Appel, E. G. *See* abs. 99.

Appel, H. *See* abs. 1710.

Appel, H., Böhm, H., Keil, W., and Schiller, G. Fat From Fat Acids With Odd Numbers of Carbon Atoms. IV. *See* abs. 1713.

———. Fat From Fat Acids With Odd Numbers of Carbon Atoms. VII. Preliminary Communication Concerning Properties, Stability, Physiology, and Toxicology of Synthetic Fats From Paraffin Fat Acids. *See* abs. 1717.

Appel, H., Berger, G., Böhm, H., Keil, W., and Schiller, G. Fats From Fat Acids With Uneven Numbers of Carbon Atoms. II. *See* abs. 1711.

66. Appleyard, K. C. Production of Oil From Coal by the Fischer-Tropsch Process. Gas World, vol. 111, 1939, Coke Sec., pp. 79–91; Colliery Guard., vol. 158, 1939, pp. 865–868, 968–970; British Chem. Abs., 1939, B, p. 799; Chem. Age, vol. 41, 1939, pp. 64–67; Chem. Abs., vol. 33, 1939, p. 5155.

Production of the $CO+2H_2$ mixture from coke or coke-oven gas, its purification, and the types of catalysts used for the actual synthesis of hydrocarbons, which may be carried out at atmospheric or at medium (10 atm.) pressure, are outlined. The yield of liquid products is about 79% of theory. Their nature depends on the conditions: Using a Co catalyst, they contained 8% of light hydrocarbons, b. p. $<30°$; 50% of motor spirit, b. p. 30°–200°, octane no. after redistributing 55; 39% of Diesel oil, b. p. $>200°$; and 3% of soft paraffin, m. p. $>50°$. The Diesel oil has a H_2 : C ratio of 2.17, which is more than that of other liquid fuels, and a low ignition temperature of about 240°, it has proved satisfactory in engine tests. The byproducts are hard paraffin, m. p. $>100°$, deposited on the catalyst and C_3H_8–C_4H_{10} mixtures. Good lubricants can be produced by polymerization over $AlCl_3$ of olefin fractions or of paraffin fractions after chlorination.

67. ———. Chemistry of Fischer-Tropsch Oil Production. South African Min. and Eng. Jour., vol. 50, 1940, pp. 585–587, 615–617; Chem. Abs., vol. 34, 1940, p. 5619.

Suitable catalysts and careful control of reaction temperature are of utmost importance in the reaction for the synthesis of liquid fuels. The primary reaction on which the synthesis is based may be indicated by $CO+2H_2=(CH_2)_x+H_2O+48{,}000$ cal. where $(CH_2)_x$ designates a light hydrocarbon. The operating conditions have the following effects upon the products: (1) Increasing pressure favors formation of alcohols; (2) increase of H_2 in reaction gases favors formation of CH_4 because of increasing saturation, unless the temperature is lowered; (3) decrease of H_2 in reaction gases favors formation of olefins; (4) increasing temperature favors formation of CH_4 and C; (5) catalyst metals in the order Fe, Co, Ni favor increasing saturation therefore lower olefin content; (6) presence of CO_2 has no influence; (7) increase in age of catalyst increases the light-oil fraction yield at the expense of heavy oil. As shown above, the gas used for the production of liquid fuel by this process consists essentially of a mixture of 1 vol. of CO with 2 vol. of H_2. This gas can be produced in a number of ways from a variety of fuels. Variations in production of this synthesis gas, depending upon economic factors, availability of raw materials, and market for byproducts are discussed. The importance of complete removal of all forms of S is emphasized. Consideration is given to the most suitable catalysts—Fe, Co, and Ni—and the physical form in which they should be used. The flexibility of raw materials and wide variety of products that this process permits are pointed out.

68. Aranda, V. G. [Artificial Fats.] Ion, Madrid, vol. 1, No. 2, 1941, pp. 18–23; Chem. Abs., vol. 36, 1942, p. 3377.

Brief discussion of German practice in the oxidation of Fischer gatsch paraffins.

69. Arbuzov, M. [Crystal Structure and Particle Size of the Carbide Phase in Tempered Steel.] Doklady Akad. Nauk S. S. S. R., vol. 73, 1950, pp. 83–86; Chem. Abs., vol. 45, 1951, p. 3217.

X-ray line widths were measured photometrically for carbide residues from 1% C steels tempered at 50° intervals from 100° to 700°. The calculated size and shape of the carbide particles showed that in the range 200°–350° the *c* dimension of the carbide is only about 10 lattice spacings and is about ⅓ as large as the *a* or *b* dimension. Growth in all dimensions occurred above 350°, and the difference between *c* and *a* or *b* decreased. Some X-ray lines present above 400° disappeared below this temperature. No lines were present in the pattern of carbides from the steel tempered at 150°. Even in steels tempered at low temperatures the carbide phase, Fe_xC, has the lattice of Fe_3C. The difference in diffraction patterns between Fe_xC and Fe_3C is caused by the platelet form and the small dimensions of Fe_xC. The change that occurs in the range 300°–400° is partly caused by changes in the interaction of the carbide and the solid solution.

70. Arbuzov, M., and Kurdyumov, G. [State of Carbon in Tempered Steel.] Jour. Tech. Phys. (U. S. S. R.), vol. 10, 1940, pp. 1093–1100; Chem. Abs., vol. 35, 1941, p. 2456.

Monocrystals of austenite (1.4% C) that, after tempering, were in the process of transformation into the regularly oriented martensite crystals were examined by X-rays. There was found in samples tempered at 130°–300°, a phase produced by the decay of martensite and the remaining austenite. This phase represents a carbide of Fe, different from Fe_3C. The lack of sharpness of the interference picture indicates the high degree of dispersion of the low-temperature carbide crystals. At 300° the low-temperature carbide is transformed very slowly into Fe_3C; this transformation is much accelerated at 350°–380°.

Argue, G. H. *See* abs. 302.

71. Aries, R. S. The Changing Industrial Alcohol Picture. Chem. and Eng. News, vol. 25, 1947, pp. 1792–1796; Petrol. Processing, vol. 2, 1947, p. 409.

Two sources are expected to satisfy the major part of the demand for industrial alcohol in the next decade, which may arise to over 200 million gal. per yr., chiefly for chemical use. The 1st and most important source is that from C_2H_4 from petroleum as the raw material, which even now is producing 70 million gal. per yr. with many new plants in prospect. The second source is that by synthesis from natural gas, and 3 plants now are planned each to produce 8–10 million gal. per yr. as a byproduct. Doubt is expressed that the industry will depend again upon molasses as the chief raw material, or that serious competition will arise from alcohol derived from waste wood or sulfite liquors or from grain alcohol because of the economic factors involved. Alcohol is now selling at a high price ($0.80 or more per gal. compared with prewar price of $0.20–$0.25), which will be maintained only until more petroleum alcohol plants can come into production. Present costs from C_2H_4 are even now below $0.15 per gal. at present economic levels.

72. Armbruster, M. H. Solubility of Hydrogen at Low Pressure in Iron, Nickel and Certain Steels at 400°–600°. Jour. Am. Chem. Soc., vol. 65, 1943, pp. 1043–1054; Chem. Abs., vol. 37, 1943, p. 4283.

The solubility (*s*, in micromoles per 100 gm.) of H_2 was measured over a range of pressure (*p*) from 0.001 to 1.5 mm. in carefully pretreated samples of α–Fe (initially carbonyl Fe), Ni, and certain steels at 400°, 500°, 600° and at pressures up to 350 mm. in the Fe at 600°. The results are reproducible and in all cases are in accord at each temperature, within the precision of the measurements, with the linear relation $s=ap^{1/2}$. The measurements on Fe and Ni at all 3 temperatures are accurately reproduced by the respective equations (*T* is absolute temperature): log $(s/p^{1/2})=-1454/T+1.946$ and log $(s/p^{1/2}=-645/T+1.732$. A similar equation holds for each of the several steels, which fall into 3 groups, according as each is (1) ferritic with low alloy content, (2) ferritic with high alloy content, (3) austenitic. The solubility in the low alloy steels differs little from that in pure Fe, but the small individual differences for different compositions are quite reproducible. A method is presented of calculating the amount of residual H, independent of any blank measurement to determine its effective volume (or effective pressure), from a suitable plot of the actual measurements; the result, so calculated, is identical with that obtained through the use of a blank with A in the presence of the sample. Comparison by extrapolation of the new results with data in the literature shows a general accord, particularly at temperatures of 600° and higher; at lower temperatures the values obtained in this investigation are, because of their consistency with the foregoing linear relations, believed to be of superior accuracy. After the pretreatments, reproducible equilibrium was obtained within a few min., except in the case of the 13%–Cr steel in which the unreducible, barely visible, oxide film slowed down the rate.

73. Armitage, G. E. Chemical Conversions of Lighter Hydrocarbons. Refiner and Nat. Gasoline Mfr., vol. 20, 1941, pp. 327–336; Chem. Abs., vol. 36, 1942, p. 1472.

Detailed discussion of the commercial processes for converting light hydrocarbons into usable products. The processes include catalytic and thermal polymerization and alkylation, gas reversion, isomerization, dehydrogenation, Fischer-Tropsch synthesis, aromatization and hydroforming, and synthetic-rubber production. 47 refs.

74. Armstrong, E. F., and Hilditch, T. P. Study of Catalytic Actions at Surfaces. I. Hydrogenation of Unsaturated Fats in the Liquid State in Presence of Nickel. Proc. Roy. Soc. (London), vol. 96–A, 1919, pp. 137–146; Chem. Abs., vol. 14, 1920, p. 142.

75. ———. Study of Catalytic Actions at Surfaces. II. Transference of Hydrogen From Saturated to Unsaturated Organic Compounds in the Liquid State in Presence of Metallic Nickel. Proc. Roy. Soc. (London), vol. 96–A, 1919, pp. 322–329; Chem. Abs., vol. 14, 1920, pp. 884–885.

76. ———. Study of Catalytic Actions at Surfaces. III. Hydrogenation of Acetaldehyde and the Dehydrogenation of Ethyl Alcohol in Presence of Finely Divided Metals. Proc. Roy. Soc. (London), vol. 97–A, 1920, pp. 259–264; Chem. Abs., vol. 14, 1920, p. 2439.

77. ———. Catalytic Actions at Solid Surfaces. IV. Interaction of Carbon Monoxide and Steam as Conditioned by Iron Oxide and by Copper. Proc. Roy. Soc. (London), vol. 97–A, 1920, pp. 265–273; Chem. Abs., vol. 14, 1920, p. 2439.

Amount of change $CO+H_2O \rightleftharpoons CO_2+H_2$ at temperatures from 200° to 500° with Cu and Fe oxide catalyst is examined. The former is much less complete in its action than the oxide at higher temperatures but predominates over the range 200°–300°, though it never effects more than 50–70% of the possible amount of chemical change. The results illustrate beautifully the specific action of 2 different types of catalyst. Cu decomposes HCOOH from 190° up, according to: (1) $CO+H_2O \rightleftharpoons HCOOH$; (2) $HCOOH \rightarrow CO_2+H_2$, in presence of Cu. On the other hand, the Fe oxide process is dependent on the temperature ranges at which oxidation of CO and decomposition of steam by Fe or FeO occur rapidly. That H_2O enters into active association with Cu is indicated, (1) by its protective action on aldehyde by preferential adsorption at Cu surfaces; and (2) by its actual part in a chemaction when associated with Cu.

78. ———. Study of Catalytic Actions at Surfaces. V. Rate of Change Conditioned by a Nickel Catalyst and its Bearing on the Law of Mass Action. Proc. Roy. Soc. (London), vol. 98–A, 1920, pp. 27–40; Chem. Abs., vol. 14, 1920, p. 3182.

79. ———. Study of Catalytic Actions at Surfaces. VI. Surface Area and Specific Nature of a Catalyst—Two Independent Factors Controlling the Resultant Activity. Proc. Roy. Soc. (London), vol. 99–A, 1921, pp. 490–495; Chem. Abs., vol. 16, 1922, pp. 188–189.

80. ———. Study of Catalytic Actions at Surfaces. VII. Influence of Pressure on the Rate of Hydrogenation of Liquids in Presence of Nickel. Proc. Roy. Soc. (London), vol. 100–A, 1921, pp. 240–252; Chem. Abs., vol. 16, 1922, p. 1348.

81. ———. Study of Catalytic Actions at Surfaces. VIII. Action of Sodium Carbonate in Promoting the Hydrogenation of Phenol. Proc. Roy. Soc. (London), vol. 102–A, 1922, pp. 21–27; Chem. Abs., vol. 17, 1923, p. 233.

82. ———. Study of Catalytic Actions at Surfaces. IX. Action of Copper in Promoting the Activity of Nickel Catalyst. Proc. Roy. Soc. (London), vol. 102–A, 1922, pp. 27–32; Chem. Abs., vol. 17, 1923, pp. 233–234.

83. ———. Study of Catalytic Actions at Solid Surfaces. X. The Interaction of Carbon Monoxide and Hydrogen as Conditioned by Nickel at Relatively Low Temperatures. A Practical Synthesis of Methane. Proc. Roy. Soc. (London), vol. 103A, 1923, pp. 25–34; Chem. Abs., vol. 17, 1923, p. 2220.

The action between CO and H_2 in the presence of Ni or a similar catalyst at temperatures below 300° is mainly $2CO+2H_2=CO_2+CH_4$. The reaction is considered to go in 2 stages; (1) $CO + H_2O = CO_2 + H_2$; (2) the H_2 so formed with that already present causes the formation of $CH_4CO+3H_2=CH_4+H_2O$. No evidence was found for the intermediate formation of CH_2O or MeOH. CO is quite active also, and the change commences at a lower temperature than with Ni. By this method the large amount of CO in municipal gas supplies may be reduced and the content of CH_4 increased. Pure CH_4 may also be prepared by passing water gas over Ni several times, removing CO_2 from the gas each time, and fractionating the product at low temperatures.

84. ———. Study of Catalytic Actions at Surfaces. XI. Action of Alumina and Other Oxides in Promoting the Activity of Ni Catalyst. Proc. Roy. Soc. (London), vol. 103–A, 1923, pp. 586–597; Chem. Abs., vol. 17, 1923, p. 3443.

85. ———. Study of Catalytic Actions at Surfaces. XII. Some Observations Relative to Those Particles of a Catalyst Which Participate in Chemical Change. Proc. Roy. Soc. (London), vol. 108–A, 1925, pp. 111–120; Chem. Abs., vol. 19, 1925, p. 2443.

86. ———. Study of Catalytic Actions at Surfaces. XIII. Some Factors Controlling Selective Hydrogenation, With Particular Reference to Certain Terpene Derivatives. Proc. Roy. Soc. (London), vol. 108–A, 1925, pp. 121–131; Chem. Abs., vol. 19, 1925, pp. 3054–3055.

87. Armstrong, E. F., and Williams, K. A. [Development of the Technical Applications of Hydrogenation.] Chim. et ind., vol. 42, 1939, pp. 234–242. Chem. and Ind., vol. 59, 1940, pp. 3–9; Chem. Age, vol. 41, 1939, pp. 271–272, 285–288.

Discusses hydrogenation of fats, the Fischer and synthetic-oil processes, and the possibility of directly hydrogenating coal under pressure with H_2 obtained by the Lurgi process.

87a. Arnold, J. H. Synthesis of Liquid Fuels From Natural Gas. Advances Chem. Ser. No. 5, 1951, pp. 120–137; Chem. Abs., vol. 45, 1951, p. 10,558.

In developing a commercial process to produce liquid fuels from natural gas, reliable large-scale techniques were evolved for producing O_2 and synthesis gas. To convert synthesis gas to hydrocarbons the use of Fe catalysts in a fluidized bed was required; the method of preparation of the catalyst proved to be much less important than the conditions of its environment during synthesis. The resultant integrated process (Hydrocol process) is striking in its simplicity and, from the indicated supply of gas, can contribute an appreciable fraction of American liquid-fuel requirements along with large quantities of oxygenated aliphatic chemicals. By utilizing still more recent developments, huge amounts of C_2H_2 may be obtained.

88. Arnold, J. O., and Read, A. A. Conditions in Which Carbon Exists in Steel. Proc. Chem. Soc., 1894, pp. 105–106; Jour. Soc. Chem. Ind., 1894, p. 740.

Existence is confirmed of a carbide of Fe having the formula Fe_3C. The normal carbide exists in 2 different forms identical in chemical composition—a diffused carbide consisting of granules or very small plates and a crystalline carbide arranged as plates and consisting of pure Fe_3C. The % of total C obtained as carbide is greater in hard than in soft steels. This loss is due to the presence of a readily decomposed subcarbide of Fe existing to the extent of about 25% in mild steel and capable of existing to the same amount in cold, hard steel after the latter has been heated for sometime at a white heat.

89. ———. Chemical Relations of Carbon and Iron. Jour. Chem. Soc., vol. 65, 1895, p. 788.

Arnold, M. R. *See* abs. 99.

90. Arwell, J. C. and Barss, W. M. Comparison of the X-Ray Diffraction and Nitrogen Adsorption Surface Areas of Carbon Blacks and Charcoals. Canadian Jour. Research, vol. 26, sec. A, 1948, pp. 236–242.

Surface areas, as determined from X-ray diffraction and low-temperature N adsorption data, were compared for a number of C-blacks and activated charcoals. Comparative data were obtained also on samples of charcoal at various stages of activation and after calcination. The X-ray diffraction data indicated that all the samples examined were composed of small, graphite-like crystallites of the same order of magnitude, which had specific surfaces of about 2,500–3,000 m.^{2} per cc. The N adsorption surface of a highly activated charcoal was found to be about equal to the X-ray surface. It is suggested that the crystallite surface represents the potential-adsorption surface of a carbonaceous material; and, providing that crystal growth does not occur during activation, the activation process makes these surfaces available to external adsorbate.

Asche, W. *See* abs. 1610.

91. Ashworth, J. R. Simple Characteristic Relationships Among the Ferromagnetics. Nature, vol. 116, 1925, p. 397; Chem. Abs., vol. 20, 1926, p. 2781.

Ratio of the critical temperature (θ° abs.) to the maximum intensity of magnetization (I_o) for Fe, Co, Ni, and magnetite is, respectively, 0.58, 0.95, 1.19, and 1.83, or 2 x 8/27, 3 x 8/27, 4 x 8/27, and 6 x 8/27. Heusler's alloy fits this scale, the ratio θ I_o being 1.50

or 5 x 8/27. The 2 to 6 are exactly integral within the accuracy with which θ and I_0 are known. The ration of I_0 for Fe to I_0 for Ni, and that of the values for Co and magnetite, are both 3.3, the respective ratios of the critical temperatures being 1.60 and 1.67.

92. Askew, H. O. Report on Fischer-Tropsch Process. New Zealand Dept. Sci. Ind. Research, Bull. 6, 1928, 28 pp.

Excellent review of development work up to and including 1927. Special emphasis is placed on the work of Patart. Discussion includes the thermodynamics and the mechanism of the reactions, reduction of CO at atmospheric and high pressures with consideration of the catalysts employed, analysis of the products obtained, together with data on plant and raw-material requirements and costs. Annotated bibliography of 51 refs.

93. Atwell, H. V. Koppers Powdered-Coal Gasification Process. FIAT Final Rept. 1303, 1947, 51 pp., 16 figs.

Experimental work on the gasification of powdered coal was conducted from 1938 to 1944. The first unit was set up at Brabag-Schwarzheide in 1938 and subsequent units at Rheinpreussen Shaft IV near Homberg. In all cases the reactor was a horizontal drum with powdered coal introduced at one or both ends, and the gasifying agent (air or O_2 mixed with steam) was introduced at spaced points along the length of the drum so as to insure turbulent flow of the dust between inlet and outlet. Preheating of the gasifying medium to about 1,200° was found to be essential, and Cowper stoves were used for this purpose. Operation was at atmospheric pressure. By this method a very rapid ignition of the coal dust took place and a temperature of more than 2,000° was obtained. This accelerated the gasification process so that the coal was gasified to the extent of about 95%. The final Rheinpreussen unit was estimated to have a capacity of 10 tons of coal per day, but it never operated successfully because of excessive cooling by the water jacket. Previous units were somewhat smaller, and no runs longer than 5 or 6 hr. had been made. No commercial units were built, but several proposals were made on the basis of about 0.5 m.^{3} O_2 consumption and 2 m.^{3} synthesis-gas production per kg. of coal. No original experimental records were available to support the claims made for the process.

94. ———. Gumz Powdered-Coal Gasification Process. FIAT Final Rept. 1304, 1947, 53 pp.; PB 85,163.

Cooperative experimental work on powdered-coal gasification was conducted by Demag, Bergbau, Verein, and Ruhrgas during 1940–43. The design of the plant was based largely on theoretical considerations developed by Dr. W. Gumz. The plant comprised 2 vertical reaction chambers, each having an inside diameter of 1.2 m. and a height of approximately 14 m. The mixture of powdered coal and gasifying agent was passed upward through the 1st chamber and down through the 2d. Most runs were made with air-steam mixtures as the gasifying agent. A few runs were made with air enriched with O_2 but none with air replaced by O_2. Only moderate preheating of the gasifying agent was used, maximum 600°, and conversion of C was relatively incomplete in all runs. A single unit with minor modifications was used throughout the program, and trouble always was experienced owing to accumulation of slag in the first reactor. The process was not regarded as ready for commercial use.

95. ———. The Schmalfeldt Process for Making Synthesis Gas From Methane. FIAT Final Rept. 1305, 1947, 23 pp.; PB 85,164.

Translation of a document by H. Schmalfeldt in 1947, describing work done in the plant of Klöcknerwerke A.-G., Castrop-Rauxel, on the production of synthesis gas from CH_4-containing gases by noncatalytic reaction with steam and O_2. In a pilot plant built in 1931, coke-oven gas was converted under a pressure of 23–24 atm. abs. with air enriched to 33% O_2. CH_4 in the exit gas was less than 1%, and formation of soot was observed. The maintenance of the refractory lining proved quite difficult. A larger plant started in 1938 could not be operated until 1941 because of difficulties in getting materials, particularly refractory brick. Results were not entirely satisfactory because of inadequate heat recovery and lack of facilities for purging unreacted gas between cycles. Fischer-Tropsch residue gas and coke-oven gas were converted at a pressure of 8–9 atm. abs., with an O_2 consumption 30–40% above theoretical and only slight formation of soot. The process can be recommended for large-scale commercial use. O_2 consumption per m.^{3} of converted CH_4 will range 0.55–0.65 m.^{3} O_2 depending on conditions and quality of the plant. At pressures of 20 atms. and above, C formation is more or less completely avoided. If the apparatus is suitably constructed conversions of 90–95% can be obtained.

———. *See* abs. 451, 452, 453.

96. Atwell, H. V., and Schroeder, W. C. Synthetic Lubricating-Oil Plant, Rheinpreussen, Homberg. CIOS XXIV–9, 1945, 17 pp.; TOM Reel 196; PB 283.

Describes plant and process of manufacture. Lubricating-oil synthesis consists broadly in chlorinating a Fischer-Tropsch middle oil, reacting this with naphthalene in the presence of Al chloride as catalyst, separating the sludge, neutralizing, and fractionally distilling the lube-oil product. Includes photographs.

97. ———. Steinkohlen-Bergwerk Rheinpreussen, Moers-Meerbeck. British Coal Utilization and Research Assoc., Monthly Bull., vol. 10, 1946, abs. 1045; CIOS Rept. XXV–6, XXVI–80; TOM Rept. 8, TOM Reel 196; TAC Rept. SnMC–2; PB 367,412.

Detailed account of the operation of a large Fischer-Tropsch plant from 1939 until October 1944. The layout of the plant is described. Includes plans and photographs. The synthesis gas consisted of a mixture of water gas treated catalytically to increase the H_2:CO ratio, and coke-oven gas cracked in the presence of steam. It was purified by passing it over Luxmasse and a catalyst consisting largely of Fe_2O_3 and Na_2CO_3. Special attention was paid to the composition of all catalysts used at this plant, analyses being checked with information obtained from the Ruhrchemie A.-G. Extracts have been made from record books and data sheets to show plant performance at different stages of the process. The effect of catalyst regeneration is discussed, and an account is given of methods, production figures, distribution of products to associated companies, manufacture and distribution of synthetic Diesel fuel, and recovery of hard paraffin wax. An outline of the research program is pieced together from miscellaneous documents and reproduced. Gives list of abstracts of patent applications filed up to July 1939 by the various companies collaborating in the Fischer-Tropsch process.

98. Atwell, H. V., Powell, A. R., and Storch, H. H. United States Government Technical Oil Mission Fischer-Tropsch Report 1. TOM Rept. 5, July 1945, 66 pp.; TAC Rept. SnMC–1; PB Rept. 2051, 1945, 45 pp.

This is a preliminary summary report, and much of the information contained is copied directly from the preliminary CIOS reports prepared by United States and British investigators from personal interrogations of German industrial officials or from captured German documents. Issue of a supplementary report is planned when the final CIOS reports are completed and when all pertinent German documents have been examined and studied. A list of 17 CIOS reports reviewed is attached. The report includes synthesis-gas manufacture; detailed information with flow sheets on the preparation, reduction, reworking, and regeneration of Co catalysts and the manner of conducting the synthesis operation at Hoesch Benzin, Sterkrade-Holten, Moers-Meerbeck, and Castrop-Rauxel; the gas-recycle operation of Lurgi and Ruhrchemie; the products and byproducts from Fischer-Tropsch operations; the experimental work with sintered, precipitated, and fused Fe catalysts by the I. G. Farbenindustrie A.-G., Kaiser-Wilhelm Institut, and Ruhrchemie A.-G.; the Ru catalyst; the isoparaffin synthesis; and synthesis of aromatic hydrocarbons at the Kaiser-Wilhelm Institut.

Atwood, K. *See* abs. 2804.

99. Atwood, K., Arnold, M. R., and Appel, E. G. Water-Gas Shift Reaction. Effect of Pressure on Rate Over an Iron Oxide-Chromium Oxide Catalyst. Ind. Eng. Chem., vol. 42, 1950, pp. 1600–1602; Chem. Abs., vol. 44, 1950, p. 9137.

Influence of pressure on the rate of the water-gas shift reaction over a commercial Fe oxide-Cr oxide catalyst was studied in the pressure range 1–30 atm. at 346° and 404°. The activity of the catalyst approximately doubled as the pressure was raised to 10 atm. and increased only slightly as the pressure was increased further. Plots of catalyst activity versus pressure gave curves similar in shape to Langmuir isotherms.

100. Audas, F. G. Continuous Dry Process for the Removal of Hydrogen Sulfide From Industrial Gases. Coke and Gas, vol. 13, 1951, pp. 229–234; Chem. Abs., vol. 46, 1952, p. 11,638.

This is a new process in the pilot-plant stage of removal of H_2S from industrial gases. According to the following reaction: $2H_2S+SO_2 \rightleftharpoons 2H_2O+3S$, H_2S is removed by adding SO_2 in small excess of the above reaction and passing the mixture through a bed of alumina at 60°–90° at such a rate that it emerges from the chamber containing the bed completely free of H_2S. The spent alumina is continuously withdrawn from the bottom of the reaction chamber for regenerative treatment, while regenerated material is continuously added at the top. Regeneration of spent alumina consists of heating at 500° by passing hot gases through the bed of alumina in the regenerating vessel. The process can be readily adapted for simultaneous recovery of C_6H_6, which is absorbed on the alumina in the purifier and can be recovered by heating to 140° in a steam-coil-heated chamber. This C_6H_6 recovery required the introduction of a desorption vessel between the purifier and the regenerator. A detailed approximate evaluation of costs is given.

101. Audibert, E. [Manufacture of Synthetic Liquid Fuels From Mixtures of Carbon and Hydrogen.] Chim. et ind., vol. 13, 1925, pp. 186–194; Brennstoff-Chem., vol. 6, 1925, p. 244; Fuel, vol. 5, 1926, pp. 170–177; Chem. Abs., vol. 19, 1925, p. 1487.

The results obtained and conclusions drawn by Fischer and Tropsch in the preparation of Synthol (*see* abs. 1014 and 1015) have in the main been confirmed by work carried out by the Société Nationale de Recherches sur le Traitement des Combustibles, and interesting results were obtained by using suboxides as catalyzers. These are defined as oxides that cannot be isolated as such because they oxidize spontaneously in air, for example, CrO, V_2O, VO, MoO, WO, U_2O_3, Pb_2O, BiO, etc. They must be prepared directly in the catalyst chamber by reduction of a higher oxide in the presence of a secondary catalyzer consisting of a reduced metal, which must be either inert toward CO (for example Cu) or easily eliminated after reduction of the principal catalyzer (for example, Ni, removed as Ni carbonyl at 60°–80°). When a 2 : 1 mixture of H_2 and CO under a pressure of 200 atm. is passed over the catalyzer there is no reaction below 225°; between 225° and 275°–300° (the upper limit depending on the nature of the catalyzer) practically pure MeOH is formed in 8–10% yield according to $CO+2H_2=MeOH$, not over 2% CO_2 according to $CO+H_2O=CO_2+H_2$, and traces of CH_4; above 300° H_2O, CH_4, MeOH and other organic compounds are formed.

102. ———. [Methanol. Its Synthesis.] Tech. moderne, vol. 20, 1928, pp. 861–866; Chem. Abs., vol. 23, 1929, p. 1385.

The catalysts in use are CuO and ZnO. CuO is the more active but is easily affected by the formation on its surface of substances of higher molecular weight. To prevent this, H_2 is increased to $CO+5H_2$. A long exposure to high temperature decreases the activity of catalysts. The activity is also affected favorably or adversely by the presence of other metallic oxides. Yields are roughly proportional to the square of the pressure. ZnO requires higher pressures than CuO. Maximum yields are obtained when the mixture of gases is equal to $CO+2H_2$. Since MeOH is an intermediate product, greater yields of MeOH, to the exclusion of other products, are obtained when the speed of the gases through the catalyst chamber is increased. Secondary reactions are increased with higher temperature. CuO permits the use of lower temperature. Both oxides are subject to poisoning.

103. ———. [Synthesis of Methyl Alcohol.] Chim. et ind., vol. 20, 1928, pp. 1015–1022; British Chem. Abs., 1929, B, p. 162.

Résumé of the work carried out on the synthesis of MeOH from CO and H_2 under high pressure and reported at the 2d Conference on Bituminous Coal, Pittsburgh, 1928. The conditions throughout the experiment were: Pressure 150 atm., rate of circulation of gases over catalysts 5,000 cu. m. (n. t. p.) per m.^{3} of catalyst volume, and gas mixtures containing H_2 and CO in the ratio 5 : 1 (with catalysts having Cu as the chief constituent) and 2 : 1 (with those of which ZnO is the basis); yields of MeOH are expressed in gm. per l. of catalyst vol. per hr. It was found that, in addition to the physical changes that occur in a catalyst as a result of prolonged use even with carefully purified gases, in the case of Cu catalysts a fouling of the solid took place owing to the deposition of C compounds of high molecular weight. The rapidity of fouling is a function of the partial pressure of CO in the gas, and it is reduced to an unimportant value when the proportion does not exceed 1/6. ZnO catalysts do not foul with gases containing 33% CO; such a proportion, in fact, gives the optimum yields of MeOH. When ZnO and Cu catalysts are heated in H_2 at 550° for a number of hrs., each suffers a loss of activity, that of the ZnO catalyst being the greater. The activity of a Cu catalyst is completely removed by the addition of small amounts of the oxides of Sn and Bi; those of B, Ti, and V have no immediate effect, although they accelerate the rate at which prolonged heating reduces the activity. Al and Ce oxides, on the other hand, increase the activity. The addition of Be and Cr oxides to a Zn oxide catalyst increases the activity, the presence of W oxide affects it adversely, while U oxide is without effect. The yields of MeOH obtained with each catalyst under the conditions specified above at temperatures corresponding to the optimum amounts are compared in the cases of Cu and ZnO catalysts. With Cu at temperatures not exceeding 275°, the yield was 1,100–1,150 gm. and with Zn oxide at 375°, 300–325 gm. The effect of the pressure (p in atmosphere) on the yield. R, for a Cu catalyst is represented approximately by $R=0.050p^2$, and for ZnO by $R=0.014p^2$. When the rate of flow over a ZnO catalyst is increased 5,000–10,000, the yield rises by 55% and 10,000–20,000 by 35%. Small amounts of S present as CS_2 or thiophen in an otherwise pure gas mixture poison the Cu but are without effect on the activity of the ZnO catalysts. Beside the desired reaction, which produces MeOH, a number of side reactions occur which result in the formation of H_2O, CO_2, and CH_4. From a study of the relative rates of the main and side reactions, it is shown that the useful conversion of CO is much greater with a Cu catalyst than is the case with 1 of ZnO. In deciding the relative value of the 2 types of catalyst, the poor yields from ZnO have to be considered in conjunction with the robustness and indifference to small traces of poisons, while the extra yields from Cu catalysts have to be offset against the much greater sensitiveness to poisoning.

104. ———. Synthesis of Methyl Alcohol. Proc. Internat. Conf. Bituminous Coal, 2d Conf., vol. 2, 1928, pp. 508–522.

Fouling of catalysts (Cu and Zn oxides), action of heat on catalysts, promoters, effect of pressure, composition of the gas, and rate of flow and parasitic reactions are discussed.

105. ———. [Synthetic Manufacture of Methanol.] Conférences-rapports sur les combustibles, Sec. tchécoslovaque soc. chim. ind., vol. 24, 1930, pp. 27–41; Chem. Zentralb., 1930, II, p. 3223; Ann. combust. liquides, vol. 5, 1930, pp. 239–272; Chem. Abs., vol. 24, 1930, pp. 4505, 5718.

An address describing the work carried out on the synthesis of MeOH by the Société Nationale de Recherches sur le Traitement des Combustibles, comprising laboratory experiments, semicommercial work on the verification of the results, and their application in the design and operation of the 5-ton commercial unit now under construction.

106. ———. [Synthesis of Methanol.] Ann. combust. liquides, vol. 6, 1931, pp. 655–709; Brennstoff-Chem., vol. 13, 1932, pp. 92–93; Chem. Abs., vol. 26, 1932, p. 1235.

Commercial synthesis of MeOH, particularly with regard to the heat of reaction, the use of pressure and low temperatures and the influence of the catalyst, and the H_2 : CO ratio and the temperature upon the speed of the reaction, is discussed. The economy of the process depends upon the extent of the side reactions. Beside increasing the consumption of synthesis gas they add to the difficulties of converter regulation since they give rise to excessive temperature increases. They are of 2 types: A primary, in which only the H_2 and the CO take part, and a secondary, in which the reaction products undergo further conversion. The primary reaction is exemplified in formation of CH_4 ($2CO+2H_2=CO_2+CH_4+61$kcal.). The quotient y/x (y is that portion converted into CO_2 and CH_4, x that converted into MeOH) is independent of the space velocity but depends on the chemical composition of the catalyst and the operating temperature. A rise in temperature of about 100° increases the extent of this side reaction with a Cu-Th catalyst about 60-fold and with a Zn-Cr catalyst about fourfold. Certain measures to be taken against the occurence of these side reactions are offered. Formation of high-molecular substances can be curtailed by avoiding the presence of alkali and by correctly choosing the H_2 : CO ratio. The MeOH must be removed before its concentration becomes too great. Ch_4 formation and overheating must be opposed by the efficient removal of heat through a cooling system or by addition of inert constituents to the reaction gas. Catalysts prepared the wet way are very susceptible to overheating. The injury produced thereby depends upon the chemical composition. The best catalysts are Cu and Zn oxides. As promoter for ZnO, Cr_2O_3 is suitable and for Cu a large number of additives are available. The activity with Cu-containing catalysts at 300° and 100 atm. is about 8-fold greater than with Cu-free catalysts and with at least equal resistivity toward overheating. With Cu-free catalysts the temperature must be at least 400° and the pressure 400 atm. to attain the same space-time yield. The Cu-containing catalysts require a thorough purification of the raw gas from S compounds, particularly COS. Even with this, the advantage is with them since the cost of gas purification per kg. of MeOH and down to 1.25 mg. S per m.³ is only 10–12 centimes. Extreme care is necessary in preparing the catalysts. The precipitation factors, such as concentration of the solutions, excess of alkali, precipitation temperature, etc., greatly influence the activity. The volume shrinkage during the operation, amounting after 600 hr. to 60%, could be reduced to 20% by means of previous compression.

107. ———. [Obtaining Liquid Organic Compounds from Technical Gases.] Ann. combust. liquides, vol. 8, 1933, pp. 757–869; Rev. ind. minérale, No. 307, 1933, pp. 447–464, 469–488, 501–508; Chem. Zentralb. 1934, I, p. 978; Chem. Abs., vol. 28, 1934, p. 462.

Thermodynamic conditions for the hydrogenation of CO to CH_4, C_2H_6, C_3H_6, and C_6H_{14} are discussed. Equilibria for 1 and 100 atm. are recorded. The formation of MeOH from CO and H_2 is exhaustively considered.

108. ———. [Principles of Thermal Decomposition and Hydrogenation of Organic Compounds.] Ann. combust. liquides, vol. 8, 1933, pp. 565–605; Chem. Abs., vol. 28, 1934, p. 463.

The article deals with primary reactions of paraffins, cyclic hydrocarbons, hydroaromatics, olefins, and aromatics, with superimposed reactions and catalytic cracking. Berthelot's hydrogenation method and Sabatier's discoveries and their applications are also discussed.

109. ———. [Mechanism of the Oxidation of Methane.] Compt. rend., vol. 216, 1943, pp. 348–350, 449–451; Chem. Abs., vol. 38, 1944, p. 2257.

Mechanism and the kinetics of the reaction taking place between CH_4 and O_2 at temperatures 300°–650° were studied by use of quartz or Pyrex tubes. Reaction products are H_2O, CO, CO_2, H_2, and HCHO (1); the amounts of (1) and H_2 formed are small, sometimes none of the latter. Even under equal conditions the results sometimes vary considerably and depend upon the diameter of the tube and the state of its inner surface. With a quartz tube of 10 mm. inside diameter, the inner surface of which is covered with a NaCl or KCl layer, the reaction isotherm remains constantly slow at 650° with a mixture of 1 molecule CH_4 and 2 O_2. With NaCl-lined quartz tubes of greater diameter the reaction may be accelerated to such an extent that the gas mixture ignites at 550° or higher. With unlined quartz tubes, the reaction may become violent at 550°, even if the diameter of the tube is 10 mm. To study the transformation isotherm further, the oxidation of CH_4 at 300°–700° was accomplished by passing the mixture at atmospheric pressure through a ring-like tube formed by inserting 1 quartz tube within another 4 mm. wider. The latter was coated on its inner surface, the former on its outer, with NaCl. With such an apparatus CH_4 and O_2 react at all temperatures between 300° and 700° with formation of H_2O, CO, CO_2, H_2, and (1). The amounts of H_2 and (1) are very small; the amount of CO_2 increases with the duration of heating, whereas the amount of CO increases to a maximum and then decreases. The ratio of consumption of $CH_4 : O_2$ is about 1 : 2 as long as the heating time is short and the temperature low. Based upon the CH_4 consumption, the reaction follows the law of Arrhenius, and the heat of activation is about 40,000 cal.; based upon the O_2 consumption, it does not follow this law, and the activation heat is 40,000 cal. at 650° or higher and 50,000 cal. at 625°. The results indicate that under the conditions used, the reaction is heterogeneous and that its course is influenced by the state of the surface of the reaction tube.

110. Audibert, E., and Raineau, A. [Study of the Action of Iron Catalyzers on Mixtures of Carbon Monoxide and Hydrogen.] Rev. ind. min., 1928, No. 182, pp. 286–314; Ann. combust. liquides, vol. 3, 1928, pp. 367–428; Ind. Eng. Chem., vol. 21, 1929, pp. 880–885; British Chem. Abs., 1929, B, p. 840; Chem. Abs., vol. 23, 1929, pp. 2094, 3620, 5091.

Fe, Ni, and Co exert a catalytic action on mixtures of CO and H_2, and this study was to determine if these metals when in contact with gaseous mixtures would give liquid-organic products. A study was made of different mixtures with a hydrated Fe_2O_3 base consisting of 98 parts anhydrous Fe_2O_3 and 2 parts of the following: Na_2CO_3, Li_2CO_3, $CaCO_3$, $SrCO_3$, $BaCO_3$, $MgCO_3$, $ZnCO_3$, $MnCO_3$, $CuCO_3$, Ag_2CO_3, Al_2O_3, Mo_2O_3, WO_2, or SiO_2. Of these 15 mixtures, those containing an alkali carbonate (Na_2CO_3 or Li_2CO_3) formed organic liquids with gas of composition $CO+5H_2$ under 150 atm. pressure and a flow of 3,000 m.³ All the others gave CH_4, CO_2, slightly acid H_2O, and finally C. Five mixtures with a ferric hydrate base were then studied consisting of 98 parts Fe_2O_3 and 2 parts of the following: K_2SO_4, K_3PO_4, KNO_3, and K_2S. No oil was formed by the K_2S catalyzer, but the other catalyzers produced 11 cm.³ per m.³ of gas from the sulfate, 9 cm.³ per m.³ of gas from the phosphate, 13 cm.³ per m.³ of gas from the borate, and 19 cm.³ per m.³ of gas from the nitrate, with gas ($CO+5H_2$) under 150 atm. pressure and a flow of 3,000 m.³. Mixtures were then prepared by precipitating a mixture of Cu nitrate and Fe nitrate with an alkali, adding to the precipitant K_2CO_3 in proportion to the Fe content, and, after drying, submitting the compound to the action of H_2 under atmospheric pressure at 200° for 4 hr. and at 300° for 14 hr. in such a manner as to reduce only the CuO but not the Fe_2O_3. It was shown that the presence of Cu increased the catalytic action of the Fe_2O_3–K_2CO_3 couple; the composition of the catalyzer after reduction at 300° was Fe_2O_3, 49.5%, Cu 49.5%, K_2CO_3, 1.0%. With this compound a mixture of H_2O and different organic liquid products was extracted from the $CO+5H_2$ mixture in the following proportions: (1) Light carburetants (55°–180° fractions of oil) 28.8%, light oil from activated charcoal 5.0%, alcohol in solution 29.0%, or a total of 62.8%; and (2) clear oil, 180°–250°, 14.0%; (3) heavy oil, 250°–330°, 10.0%; (4) paraffin 7.1%; (5) tar, 2.7%; and (6) fatty acids, distilling at 110°–140° (weak acetic, propionic, and butyric), 3.1%. With the Cu–Fe_2O_3–K_2CO_3 catalyzer, it is not possible to lower the temperature and still be assured of regularity of the phenomena of transformation of the mixture of CO and H_2.

111. ———. Synthesis of Methanol. Ind. Eng. Chem., vol. 20, 1928, pp. 1105–1110; British Chem. Abs., 1928, B, p. 920; Chem. Abs., vol. 22, 1928, p. 4461.

Results of the action of various substances in catalyzing the reaction $CO+2H_2=CH_3OH+27{,}000$ gm.-cal. are given. The following oxides were inactive: Al_2O_3, SiO_2, Mo_2O_5, V_2O_5, W_2O_5, ThO_2, TiO, MgO, CuO, BaO, and SrO. Ce_2O_3, UO_2, BeO, and ZrO_2 gave less than 2% of MeOH at 150 atm. MnO, Cr_2O_3, and ZnO, prepared by precipitation from the corresponding nitrates, converted 2–17.5% of CO into MeOH, the highest conversion being for ZnO at 350°. Metallic Cu was found to be a good catalyst if prepared at a low temperature by reduction of Cu oxides obtained by precipitation of the nitrate or by the thermal decomposition of Cu salts of organic acids. Cu catalysts prepared from the fused oxide or from Cu oxide obtained by precipitation of solutions of the chloride or sulfate were inactive. Ni and Fe catalysts favored the production of CO_2. Single-component catalysts were sensitive to heat, high temperatures impairing their activity. Mixed catalysts were more effective than single-component catalysts. A mixture of Ce_2O_3 and Cu was very effective, and the activity reached a maximum at a Ce : Cu ratio of 30 : 100 with a 92% conversion of CO. A mixture of BeO and Cu with a Be : Cu ratio of 6 : 100 was almost as good and showed the greatest heat resistance of the whole series studied.

112. ———. [Chemical Equilibrium Between Methanol, Carbon Monoxide and Hydrogen.] Ann. combust. liquides, vol. 5, 1930, pp. 454–461; Chem. Abs., vol. 25, 1931, p. 635.

With enough time of contact the following reactions take place: $CO+2H_2=CH_3OH$; $2CO+2H_2=CO_2+CH_4$; and $CO+3H_2=CH_4+H_2O$. The reaction constant for the first reaction under the above conditions can be determined, and from the experiments the following relation is found:

$$\log K=-35.38+\frac{6806}{T}+7.22\log T.$$

Averbukh, B. D. *See* abs. 564, 566.

113. Ayre, A. L. Report of the Hydrocarbon Oil Duties Committee. Coke Smokeless-Fuel Age., vol. 7, 1945, pp. 88–90; Chem. Trade Jour., vol. 116, 1945, pp. 423–426; Chem. Age, vol. 52, 1945, pp. 343–345; Petrol. Times, vol. 49, 1945, pp. 304–309.

This is a report with comments indicating the importance of developing chemical manufactures based on coal byproducts. The committee recommends that imported hydrocarbon oil used for chemical synthesis should be free of duty and for indigenous oil similarly used, allowances should be paid equal to the respective duties. An interesting feature of the Fischer-Tropsch process is that the products are aliphatic, not aromatic in character and, thus, resemble petroleum rather than coal oils produced by other processes. Many of the more important chemicals that can be produced from petroleum could, therefore, be derived with equal, and in some cases greater, facility from the primary products of hydrocarbon synthesis.

114. Ayres, E. Synthine Process—a Composite of Research. World Petrol., vol. 15, No. 11, 1944, pp. 56, 99.

Importance of the chemical development of the synthine process is discussed, and its economic possibilities are emphasized. The magnitude of the technical effort already expended upon the process is indicated by the 2,000 patents that have been issued.

115. ———. Comment on Synthetic Liquid Fuels Program. Petrol. Processing, vol. 2, July 1947, p. 558.

Commenting on criticism of the Bureau of Mines synthetic liquid fuels program (abs. 2641), Ayres says that such criticism comes from a misunderstanding of the way in which the work is conducted and that the program of the Bureau has satisfied the specification as set forth by the Advisory Committee.

116. ———. The Fuel Problem. Sci. American, vol. 181, No. 6, 1949, pp. 32–39.

As our petroleum resources decline (the peak of production is expected to be reached between 1955 and 1960) the 2 most abundant solid fuels, oil shale and coal, must be utilized. The major problem in their utilization is their conversion into the liquid state. Technological research has already developed methods to accomplish this, and it is quite possible that in a reasonably short period further development of these methods will bring these fuels into a favorable competitive position with petroleum fuels. General discussion is given of the methods for converting the solid fuels into liquid fuels: Oil-shale retorting, direct coal hydrogenation by the Bergius process, and indirect coal hydrogenation by the Fischer-Tropsch method. The cost problem is surveyed, and the economic evaluation of each method is discussed. The Fischer-Tropsch method of conversion appears to have the best possibilities as an economic producer of liquid fuel.

116a. ———. Synthetic Liquid Fuels—When and How? Petrol. Processing, vol. 7, 1952, pp. 41–44.

Production of liquid fuel from coal and oil shale is an inevitable part of the future industrial picture. From our present knowledge of synthetic fuels, oil shale shows the best immediate promise; exploitation can take place today with only nominal operating loss and by 1965 on a profit basis in direct competition with natural petroleum. But the future fuel economy depends upon coal and its wide-scale utilization by 1980 and as the main source of fuel energy by the year 2000. This position, however, will not come about by hydrogenation; unless radically new ideas are born coal hydrogenation as a whole is dead and will remain so, only parts of the process will remain applicable. If coal were to be converted to liquid fuel without regard to other aspects of the energy problem, use would probably be made of a modified Fischer-Tropsch synthesis since this appears to be cheaper and more flexible than hydrogenation. Most favorable economics should come from a highly integrated energy industry which would supply not only increasing amounts of liquid fuel but also even more rapidly increasing amounts of electric power. Coal would be mechanically mined at low cost, crushed, cleaned and transported by pipeline to locations of adequate water supplies, and there continuously distilled to yield a maximum amount of tar, some aromatic chemical intermediates, and fine char. The tar would be hydrogenated to liquid fuels, the char converted to liquid fuels and aliphatic intermediates by the Fischer-Tropsch synthesis or burned under boilers for generation of electric power. The course of production of petroleum is estimated and the general shape of the world's future annual production curve is predicted. On the basis of ultimate producible reserves of 1,000 billion bbl., it is estimated that the peak of world production is likely to come about in 1985.

117. Ayres, E., Montgomery, C. W., and Hirsch, J. H. Some Problems Associated With the Fischer-Tropsch Process. Oil Gas Jour., vol. 47, No. 25, 1948, pp. 112, 115; Petrol. Refiner, vol. 27, No. 11, 1948, pp. 583–585.

Abs. of a paper presented at a meeting of the Am. Soc. Mech. Eng. at Amarillo, Texas. Due to the fact that about 2,000 vol. of synthesis gas plus recycle gas must be processed to make 1 vol. of liquid motor-fuel product, the latter has to bear a disproportionate part of the cost of amortizing and maintaining the plant and equipment. Because of this characteristic and to obtain greater economic space-time yields, more severe operating conditions have been imposed, with the result that the catalyst has become overloaded and undesirable side reactions have been set up, which have greatly aggravated the catalyst problem. The problem of C deterioration of the catalyst is also a serious one. In the formation of carbides (which by the way are no longer regarded as essential intermediates in the synthesis of hydrocarbons) at synthesis temperatures and above, CO will deposit C on the transition metals of the catalyst far in excess of the stoichiometric amounts indicated by the formulas for the carbides M_2C or M_3C. As the rates of decomposition of the carbides increase, the C, which was uniformly distributed through the metal lattice in the carbide form, tends to diffuse and accumulate in inclusions, thus freeing lattice sites for the addition of more C. As this excess C accumulates, the lattices are forced to expand, with the result that the catalyst structure is broken down, and excessive pressure drops through the catalyst ensue. The formation of high-molecular-weight wax in the synthesis is another serious problem, particularly in fluid operation. A study of product distribution suggests that certain thermodynamic equilibria are operative and determine the relative amounts of *n*-paraffins of each molecular-weight range, the relative amounts of the different *n*-1-olefins, the degree of branching, etc. Operation of these equilibria impose certain limitations on the flexibility of the process. Generally speaking, the modern Fischer-Tropsch process yields a disproportionately large amount of gaseous hydrocarbons, while, at the other end of the product range, relatively small amounts of extremely high molecular weight wax paraffins are found. On account of the equilibria involved, it is impossible to reduce the gas yield without simultaneously increasing the wax yield. Likewise, the ratio of diesel fuel to gasoline, normally about 1:6, cannot be increased without a corresponding increase in wax. Only relatively small amounts of wax deposited on the catalyst in fluid operation are enough to cause catalyst agglomeration and incomplete fluidization with consequent localized overheating and C deposition. The Fischer-Tropsch process is peculiar not only in its abnormal volume shrinkage but also in its loss of heat value. The power requirements are also considerable. Economically, it is essential that synthesis processes be developed that do not depend upon credits for byproducts that have limited markets. The oxygenated compounds offer attractive possibilities as chemicals on a relatively small scale, but while synthesis plants of 70,000 bbl./day capacity would produce less than 3% of the country's motor fuel, the byproduct EtOH would amount to almost 100 million gal./yr., or about half the estimated demand for this material.

B

118. Baccaredda, M. [Decomposition of Methanol With Catalysts Used in Its Synthesis.] Ann. chim. applicata, vol. 27, 1937, pp. 413–422; Chem. Zentralb., 1938, I, p. 866; Chem. Abs., vol. 32, 1938, p. 2083.

Decomposition of MeOH at 356° and atmospheric pressure in the presence of catalysts used in its synthesis at high pressure is investigated. All simple ZnO-base products show similar results, while catalysts consisting of ZnO with other metallic oxides affect the reaction differently. Smithsonite calcined at 400°, which is very active in the synthesis of MeOH, was also found very active in promoting the decomposition. The formation of HCO_2Me does not appear to be due to condensation of 2 moles of CH_2O but rather to a secondary reaction between MeOH and CO.

119. Bach, A. [Reduction, Electrolysis, and Photolysis of Carbonic Anhydride.] Compt. rend., vol. 126, 1898, pp. 479–481; Jour. Chem. Soc., vol. 2, 1898, p. 332.

It is found that when CO_2 in aqueous solution is reduced by means of H_2 occluded in Pd, some CH_2O is also produced.

120. Bacqueyrisse, L. [French Fuels: Their Conservation and Replacement.] Mem. soc. ing. civils France, vol. 92, 1939, pp. 241–286; Chem. Abs., vol. 34, 1940, p. 7573.

A review of possible sources of gasoline substitutes: Hydrogenation products of coal and CO, low-temperature tar, benzene, coal gas, wood charcoal, alcohol (from beets, molasses, wine, maize).

Badami, G. N. *See* abs. 1187, 1188.

121. Badische Anilin und Soda-Fabrik. [Review of the Industrial Synthesis of MeOH.] Ztschr. angew. Chem., vol. 38, 1925, pp. 546–547.

Explanation of the dispute between the company and Patart as to the priority of the process.

122. Badische Anilin und Soda Fabrik, and Patart, G. Synthetic Methanol Controversy. Ind. Eng. Chem., vol. 17, 1925, p. 859; Chem. Ztg., vol. 59, 1925, p. 463; Chem. Trade Jour., June 5, 19, 1925.

Discussion between Badische and Patart as to the validity of patents by both parties on the pressure synthesis of MeOH from CO and H_2.

Badstübner, W. *See* abs. 3433.

123. Bahr, —. Medium Pressure Synthesis of Paraffins. FIAT Reel L5, frames 151–155, 1939; PB 70,159.

Observations are made on various phases of the operation of medium pressure synthesis as follows: Homogeneous filling of the furnace, putting a new catalyst into operation, furnace control, behavior of the catalyst during stoppages, charging of the paraffin catalyst, behavior of the paraffin catalyst under hydrogen action, and favorable conditions for emptying the furnace.

124. ———. [Comparative Gas Conversion of Synthesis Gas and Water Gas on Cobalt and Iron Catalysts.] FIAT Reel L5, frames 148–150, 1940; PB 70,159.

Results of comparative tests at a pressure of 7 atm. are presented in a numerical table. Decisive factors for the selection of the base gas and the type of catalyst are their cost, their availability, and the kind of products desired, with special reference to their olefin contents and their composition.

125. Bahr, H. [Influence of Sulfur in the Water Gas and in the Catalyst on the Action of the Contact Material in the Synthesis of Petroleum.] Ges. Abhandl. Kenntnis Kohle, vol. 9, 1930, pp. 514–516; Chem. Abs., vol. 25, 1931, p. 3806.

In the synthesis of paraffins from water gas at 270° over an Fe-Cu catalyst, the same result was obtained whether a synthetic water gas was made from pure H_2 and CO or a normally purified water gas was used. The S content of the latter had no appreciable effect. Of 2 Cu-Co catalysts differing in S content, the one with the lower S content was the more readily deactivated.

126. ———. [Occurrence of Hydroaromatic Constituents in Synthetic Benzine.] Ges. Abhandl. Kenntnis Kohle, vol. 9, 1930, pp. 521–523; Chem. Abs., vol. 25, 1931, p. 3807.

The action of $Ni\text{-}Al_2O_3$ catalysts on aliphatic and hydroaromatic compounds in presence of H_2 depends on the composition of the catalyst. One containing 75% Ni was found to be without action on *n*-hexane, but decomposed the corresponding cyclo compound, thus providing a means for separating the 2. The treatment of synthetic benzine with such a catalyst gave a small condensate of a characteristic aromatic odor, indicative of the presence of cycloaromatic compounds.

127. ———. [Reutilization of the Exit Gas From Petroleum Catalysts and Its Conversion Into Methane.] Ges. Abhandl. Kenntnis Kohle, vol. 9, 1930, pp. 519–521; Chem. Abs., vol. 25, 1931, p. 3806.

Exit gas from catalysts used for petroleum syntheses was passed over Fe at 850°. H_2 and hydrocarbons reduced the CO_2 to CO. This gas could be reused for petroleum synthesis. The gas can also be converted into CH_4 by passing over Ni at 240°. The calorific value of the gas after extraction of CO_2 was 6400 kg.-cal. per m³.

———. *See* abs. 973, 974, 975, 976.

128. Bahr, H. A. [Behavior of Water Gas on Various Catalysts; Contribution to the Equilibrium $6CO_2+C_6H_6 \rightleftharpoons 12CO+3H_2$] Ges. Abhandl. Kenntnis Kohle, vol. 8, 1929, pp. 217–219; Chem. Zentralb., 1929, II, p. 3263; Chem. Abs., vol. 24, 1930, p. 5207.

Heating a mixture of CO_2 and C_6H_6 vapor with various metallic catalysts to 550°–750° led only to the formation of traces of CO in the final gas. The gas mixture of $4CO+H_2$ heated on the same catalysts to 200°–800° did not show a reaction; only when $ZnO+0.5\%\ Fe_2O_3$ was employed as a catalyst, the formation of 24% CO_2 produced by decomposition of CO on Fe was observed.

129. ———. [Reduction of Carbonic Acid.] Ges. Abhandl. Kenntnis Kohle, vol. 8, 1929, pp. 219–224; Chem. Zentralb., 1930, I, p. 185; Chem. Abs., vol. 24, 1930, p. 5207.

Reduction of CO_2 according to $CO_2+H_2=CO+H_2O$, which up to the present has been investigated only at relatively high temperatures, can be carried out also at moderate temperature if the proper catalysts are employed. With metallic Cu the reaction is noticeable at 200°. With the employment of $Cu\cdot Cr_2O_3$ Fe·Cu, Fe·CO, and Co·Cu·Zn as contact materials with temperatures between 200° and 450° and with mixtures of CO_2 and H_2 in the ratio 1:1 and 1:3, respectively, the CO quantities obtained were up to 16%. With a slow current of the gas mixture, reduction of CO to CH_4 occurred, especially when contacts containing Co were employed.

130. Bahr, H. A., and Bahr, T. [Decomposition of Carbon Monoxide on Nickel.] Ber. deut. chem. Gesell., vol. 61B, 1928, pp. 2177–2183; Chem. Abs., vol. 23, 1929, p. 756.

Metallic Ni or NiO catalyzes the reaction $2CO=C+CO_2+38.9$ cal. by first forming Ni_3C. Below 270°, the decomposition of CO continues until the Ni is completely transformed into Ni_3C; then the reaction stops. Between 270° and 380°–420°, the CO decomposition continues, the catalyst being Ni_3C, which is free from metallic Ni. This is proved by analysis, which shows that the amount of C bound chemically by the catalyst corresponds to Ni_3C, excess C being present as the free element. (To determine the ratio of bound C to free C, H_2 is passed over the catalyst. The amount of CH_4 formed indicates the quantity of bound C. Free C remains inert.) Above 380°–420°, free Ni again appears in the catalyst because Ni_3C dissociates at such temperatures. Ni_3C_2 is probably an intermediary step in the decomposition of Ni_3C. It is believed that Ni_3G formed in the catalysis process is identical with that isolated from fusions of Ni in the presence of C.

131. ———. [Synthesis of Methane From Carbon Monoxide and Hydrogen by Nickel.] Ber. deut. chem. Gesell., vol. 61B, 1928, pp. 2465–2469; Chem. Abs., vol. 23, 1929, p. 1106.

Mixture of $CO\text{-}H_2$ in a ratio of 1:3 is passed over a Ni_3C catalyst at 250°. This catalyst is much less sensitive than Sabatier's Ni catalyst for the same reaction. The Ni_3C catalyst is pyrophoric and, therefore, must be handled in an atmosphere of inert gas as N_2. The reactions occurring are: $2CO+2H_2=$

CH_4+CO_2; $CO+3H_2=CH_4+H_2O$; $Ni_3C+2H_2=CH_4+Ni_3$; and $2CO=C+CO_2$. After a short period of operation the initial catalyst Ni_3C is reduced to Ni but again reacts to give Ni_3C. The main reactions are (1) $Ni_3+CO=Ni_3C+O$ (2) $Ni_3C+2H_2=CH_4+Ni_3$.

132. ———. [Reactions of Nickel Carbide (Ni_3C) Prepared at Low Temperatures.] Ber. deut. chem. Gesell., vol. 63B, 1930, pp. 99–102; Chem. Abs., vol. 24, 1930, p. 1812.

Finely powdered Ni_3C, resulting from the action of CO on Ni at low temperatures, is pyrophoric. This property is destroyed by displacing the adsorbed CO with pure N_2 at 250°. The stabilized carbide may be heated to 110° without oxidation. The activity toward CO and H_2 is also decreased by the stabilization. Ni_3C absorbs moisture from the air. It has a specific gravity of 7.97 and is slightly magnetic. Its heat of formation is—9.2=0.8 kcal. It begins to decompose into its elements when heated to about 400°. With H_2 at 180°–250°, CH_4 and C_2H_6 are formed in the ratio of 10:1. In gaseous-hydrogenation reactions with Ni as a catalyst, the primary hydrogenation is evidently much faster than the secondary polymerization reaction. An increase in pressure increases the latter. At 300° H_2O vapor acts on the carbide with the production of H_2 and CH_4. Similarly, NH_3 at 420° gives H_2, CH_4 and some C_2H_6. H_2S yields heavy hydrocarbons as low as 240°. HCl gas acts similarly. Contrary to the action of Fe_3C, Ni_3C usually dissolves in acids without the liberation of free C and produces hydrocarbons of lower molecular weight than the former carbide. In 3 *N* HCl, 67% of the C is converted to gaseous hydrocarbons and 33% to liquid. In dilute HNO_3 nitro compounds of the hydrocarbons are formed. Some free C results from the action of dilute H_2SO_4 on the carbide.

133. BAHR, H. A., AND JESSEN, V. [Dissociation of Carbon Monoxide on Cobalt.] Ber. deut. chem. Gesell., vol. 63B, 1930, pp. 2226–2237; Chem. Abs., vol. 25, 1931, p. 22.

Finely divided metallic Co does not dissociate CO at 225°. The dissociation of CO takes place on the Co combined with 9.24% C as Co_2C. At temperatures above 225°, Co_2C decomposes, giving free C. No evidence of other Co carbides than Co_2C is found. Co carbide prepared from CO dissociation on finely divided Co gives up its carbide C as CH_4 on treatment with H_2 at temperatures as low as 240°–250°, while the carbide prepared from free C + finely divided Co forms CH_4 on reacting with H_2 above 400°.

134. ———. [Fission of Carbon Monoxide on Iron Oxide and Iron.] Ber. deut. chem. Gesell., vol. 66B, 1933, pp. 1238–1247; Chem. Abs., vol. 28, 1934, p. 984.

Pure Fe_2C (9.7% C) can very probably be prepared from Fe and CO at 225° or lower; at 230°–400°, a mixture of Fe_2C, Fe_3C, with free C probably results; while above 400° only Fe_3C (6.68% C) is formed. Carbonized products obtained by means of Fe oxide always contain O; detection of combined C by hydrogenation with H_2 is not quite trustworthy in this case and must be performed at 255°–260°. The products obtained with Fe up to 330° are free from O; at higher temperatures, the oxidizing action of the liberated CO_2 is observed. The hydrogenation of combined C with H_2 can take place at 280°–290°. Carbide formation occurs relatively rapidly; subsequently, the main reaction is the separation of free C.

135. BAHR, T. [Reduction of Carbon Monoxide and Carbon Dioxide on Oxide Catalysts.] Ges. Abhandl. Kenntnis Kohle. vol. 12, 1937, pp. 292–297; Chem. Zentralb., vol. II, 1937, p. 3990; Chem. Abs., vol. 32, 1938, p. 6435.

CO was reduced at 250°–495° over S-resistant catalysts. Over MoO_3–ThO_2 (1 : 1) with 10% BaO and at 1 atm. and 350°–495°, 10–17% of CH_4 was obtained. In reduction at higher temperatures the hydrocarbon showed a somewhat higher C number. The reaction occurred as follows: $2\ CO+H_2=CH_4+CO_2$. Results were similar with a catalyst of Cr_2O_3–MoO_3 (1 : 1) with 10% BaO, but with a catalyst of ThO_2–MnO (1 : 1) with K_2CO_3 precipitated on kieselguhr, the results were entirely ineffectual. In the tests at increased pressure, Al_2O_3–MoO_3 (7 : 3) was used as catalyst, and beside CO_2 some H_2O and a small amount of low boiling hydrocarbons were obtained. From CO_2 at 20–30 atm. and 450°, CO and only a small amount of hydrocarbons were obtained.

———. *See* abs. 130, 131, 132, 1030, 1031.

136. BAIKOFF, A. A. [Reduction and Oxidation of Metals.] Metallurg (U. S. S. R.), No. 3, 1926; Rev. mét., vol. 25, 1928, pp. 47–54; Chem. Abs., vol. 22, 1928, p. 2129.

General discussion and review, dealing particularly with reduction of Fe oxides by H_2 and by CO and with the oxidation of Fe.

BAILEY, R. W. *See* abs. 3184.

137. BAILLEUL, G., HERBERT, W., AND REISEMANN, E. Aktive Kohle und ihre Verwendung in der chemischen Industrie. Ferdinand Enke. Stuttgart. 1937. 2d Ed., 114 pp.

One chapter describes the technical use of active C with special reference to benzine recovery from natural gas and obtaining gasol and benzine by the Fischer-Tropsch-Ruhrchemie process.

138. BAIN, E. C. Rates of Reactions in Solid Steel. Trans. Am. Inst. Min. and Met. Eng., vol. 100, 1932, pp. 13–46; Chem. Abs., vol. 27, 1933, p. 4509.

Basis for evaluating the contribution of any alloy addition toward the development of deep-hardening or air-hardening quality in steel is suggested, dependent on the effect of the addition to retard transformation in the 600°–500° range. This is the only fundamental property involved in securing the final quality of hardening without drastic quench. Mn, contributing greatly to this effect, is contrasted with Ni, which shows only a little retarding effect. In a series of similar steels, differing substantially only in Mn, the range in transformation velocity is 1–1,000,000. Graphite is the stable form in C in a 0.50 C–3.5 Ni steel free from significant amounts of other elements. Cementite, because of its high speed of formation, forms in large proportion, even though less stable than graphite. The relative velocities of the reaction producing carbide and that producing graphite are considered to be the cause of the presence of carbide alone in Ni steels in common use. A stable condition of ferrite, austenite, and carbide in equilibrium exists in certain Mn steels and results after long heating at a proper temperature regardless of whether the original metal is austenite or pearlite, but it is reached much more quickly when the starting material is austenite. Since white martensite is converted into coarse ferrite-carbide aggregate thousands of times faster than is austenite of the same composition, it is concluded that martensite cannot be an intermediate state in the austenite-pearlite reaction. Almost all of these reactions show a velocity pattern very nearly that of simple first-order chemical reactions. Certain reactions in steel begin at very high velocity and then slow up until it is barely possible to find any further change. The solution of carbide in austenite at temperatures above A_{cm} and the coalescence of carbide during tempering are 2 such reactions.

BAKSHI, J. B. *See* abs. 1190, 1191.

BALANDIN, A. A. *See* abs. 2092.

139. BALANDIN, A. A., AND MARUSHKIN, M. N. [Formation of Olefins From Higher Paraffinic Hydrocarbons.] Compt. rend. acad. sci., U. R. S. S., vol. 40, 1943, pp. 226–228, 254–257; Chem. Abs., vol. 39, 1945, p. 271.

Solid paraffin, m. p. 50°, av. mol. wt. 554, was exposed, at 450°–550°, to the action of a dehydrogenating catalyst containing Cr (*see* Chem. Abs., vol. 37, 1943, p. 867). Tabulated analyses of the reaction products indicate that 4 different reactions occurred: (1) Dehydrogenation to form olefins without cracking; (2) formation of aromatic compounds without cracking, but with splitting off of H_2; (3) simple fission to form olefin and saturated hydrocarbons; (4) complete cracking to CH_4, C, and H_2. Extent of these reactions was as follows: At 450°, (1) 20%, (2) 2%, (3) 20%, (4) 4%; at 500°, (1) 36%, (3) 21%, (4) 5%. At 550° the total yield of olefin was larger yet, but cracking also increased as indicated by the liquid character of the condensate and by halving the latter's average molecular weight.

140. BALDESCHWIELER, E. L. Production of Synthetic Fatty Acids and Edible Fats and Deutsche Fettsäurewerke, Witten. British Coal Utilisation and Research Assoc., Monthly Bull. 10, No. 1, 1946, abs. 943; Chim. et ind., vol. 55, 1946, pp. 329–330; CIOS Rept. XXVI–50; TAC Rept. SnMC–7; TOM Rept. 21; Chem. Abs., vol. 40, 1946, p. 7662; PB 225.

Wax from various Fischer-Tropsch plants was oxidized in Al vessels, the oxidation reaction being exothermic. A certain proportion of the fatty acids produced was used in the manufacture of edible fats similar to oleomargarine.

141. BALY, E. C. C., PEPPER, W. P., AND VERNON, C. E. Adsorption of Hydrous Metallic Oxides by Kieselguhr. Trans. Faraday Soc., vol. 35, 1939, pp. 1165–1175; Chem. Abs., vol. 33, 1939, p. 9084.

Method is described for purifying kieselguhr: The clay and part of the organic matter were removed by repeated extraction with hot 4 *N* HCl, the last traces of organic matter being oxidized by heating the extracted kieselguhr at 600° in a current of air for 8 hr. The purified kieselguhr was remarkably constant in its properties. It showed a surface area of 2.869×10^6 $cm.^2$ per 100 gm. It adsorbs the anhydrous oxides of Al, Th, Ni, and Co. The adsorbate in each case is activated (shown by enhancement of the ζ-potential) as the result of the formation of adsorption complexes. Al_2O_3 and ThO_2 form a single unimolecular layer; with Ni and Co oxides, 3 unimolecular layers are adsorbed together, forming 1 layer of crystal unit cells. When a mixture of Ni and Th oxides (1 ThO_2 : 24 NiO) is adsorbed, 1 out of every 7 groups of 4 Ni and 4 O in each of the 3 layers of the crystal lattice is replaced by a molecule of ThO_2. This is also true when CoO is substituted for NiO. The effect of the adsorbed layer of metallic oxide was determined by measuring the surface potential by cataphoresis methods.

BANDEL, G. *See* abs. 3323.

142. BANDTE, G. [Manufacture of Motor Fuel From Carbon Monoxide and Hydrogen.] Naturwissenschaften, vol. 14, 1926, pp. 732–735; Chem. Abs., vol. 20, 1926, p. 3225.

Review dealing with new processes for complete gasification and oleofication of coal. Synthesis of the Badische process (German Patents 293,787, 295,202, 295,203), transforms water gas by means of metal-oxide catalysts into oily and aqueous products. One example of this process is the MeOH synthesis (ZnO catalysts, temperature 200°–600°, 50–150 atm. pressure); iron carbonyl $Fe(CO)_5$, antiknock (motalin), is a byproduct. Franz Fischer prepares synthol by catalysis at 400°–450° up to 150 atm. pressure with an alkali-Fe mixture and obtains a motor fuel from the water-insoluble fraction. This synthesis is possible also (see abs. 1021) without high pressure if a Fe–Zn oxide catalyst is used (or Co–Cr oxide) and yields higher CH_4 homologs at temperatures around 270°; metal carbides are intermediary products (at higher temperatures CH_4 is the only product formed). Yield of useful hydrocarbons is about 55%. The product gasol, is mainly C_2H_6, C_3H_8, and C_4H_{10}, little unsaturated, nonresinifying, clear, and not sensitive to light. Refining appears unnecessary for use as motor fuel, $d_{15}=0.6718$, distillation 75.3% up to 100°, 96.4% up to 180°; the rest is kerosinelike, $d_{20}=0.7804$. Occasionally solid paraffin, melting at 61°, was formed. The importance of the absence of high-pressure installations for this synthesis is emphasized.

BANGERT, F. *See* abs. 977.

BANGERT, W. M. *See* abs. 1729.

143. BANGHAM, D. H., AND BENNETT, J. G. Chemistry of Gasification With Reference to Small Producers. Fuel, vol. 19, 1940, pp. 95–101; Chem. Abs., vol. 34, 1940, p. 7581.

Present knowledge of steam-C and water-gas reactions is summarized and applied to several theories of gasification. 34 refs.

BARCLAY, K. M. *See* abs. 3744.

BARDGETT, H. *See* abs. 2731.

BARDIN, J. S. *See* abs. 15a.

144. BARKER, K. R., SEBASTIAN, J. J. S., SCHMIDT, L. D., AND SIMONS, H. P. Pressure Feeder for Powdered Coal or Other Finely Divided Solids. Ind. Eng. Chem., vol. 43, No. 5, 1951, pp. 1204–1209.

High cost of compression of the synthesis gas before purification and synthesis to liquid fuels favor gasification at elevated pressures of powdered coal with superheated steam and O_2. Thus, it was necessary to develop a method of continuous charging of finely powdered coal into a pressurized gas generator. Experimental work under pressures up to 150 p. s. i. proved that powdered coal can be conveyed pneumatically, in a dense phase (26 lb./cu. ft.), from a fluidized bed and discharged at constant rate. With other conditions equal, the discharge rate is solely a function of the pressure differential across a conveying line of given dimensions. The differential pressure across the fluidized coal bed is a direct function of the amount of coal fluidized and, to a lesser extent, of the fluidization rate, but it is not influenced by the operating pressure. For a given rate of fluidization, the amount of coal in the fluidized bed is conveniently gaged by the pressure drop between the bottom and the top of the column. Regardless of the operating pressure, the amount of coal conveyed per unit volume of gas, measured at the existing pressure, is virtually constant, but the weight of coal carried per unit weight of gas rapidly decreases with increasing operating pressures. Further work should be done to determine the effects of using various fluidizing gases, such as synthesis gas, air, CO_2, and steam at various pressures and temperatures up to 500° F.

144a. BARKLEY, L. W., CORRIGAN, T. E., WAINWRIGHT, H. W. AND SANDS, A. E. Catalytic Reverse Shift Reaction. A Kinetic Study. Ind. Eng. Chem., vol. 44, 1952, pp. 1,066–1,071.

It is possible to make adjustments in the H_2:CO ratio of synthesis gas using the reverse shift reaction $CO_2(g)+H_2(g)\rightleftharpoons CO(g)+H_2O(g)$ over a standard Fe–Cu shift catalyst at 1,000° F. The kinetics of the reaction were studied, a rate equation was obtained, and a probable mechanism for the reaction is postulated: (a) A molecule of CO_2 is adsorbed on a single active center; (b) the adsorbed CO_2 reacts with H_2

to form a molecule of adsorbed CO plus a molecule of H_2O in the gas phase; (c) the molecule of CO is desorbed; (d) step (b) controls the rate of the reaction. The results of the investigation show that this method of adjusting the synthesis gas composition is feasible, but that its use would depend upon the economic advantage of employing a large excess of superheated steam in the coal gasification step.

Barnes, D. K. *See* abs. 3273a.

145. Barr, W. E. Glass-Blowing Art in Petroleum Research. Petrol. Refiner, vol. 26, No. 2, 1947, pp. 103–106.

This discussion, originating in the laboratory of the Gulf Research & Development Co., has been undertaken with the view of clarifying, in general terms, the operation of a glass-blowing shop and its relation to petroleum research. Its application to the fabrication of Fischer-Tropsch apparatus is shown.

146. Barral, J. [Total Gasification of Fuels by the Koppers Process.] Chim. et ind., vol. 57, 1947. pp. 441–443; Jour. Inst. Petrol., vol. 33, 1947, p. 308 A; Chem. Abs., vol. 41, 1947, p. 6385.

The Koppers process is designed to convert low-grade solid fuels into a synthesis gas suitable as feed to a Fischer-Tropsch plant. A simplified flow diagram of the process is given, as well as an analysis of the fuel and gas and of the costs involved. The process is applicable to fuels having an ash content as high as 20%. The plant and the operation at Schwarzheide are described. With this installation, it appears that Koppers prepared directly, by partial combustion and reduction of steam at high temperatures, not only gases for the synthesis of motor fuel and of MeOH but also heating gas, without using O_2 but only air mixed with steam.

147. ———. [Use of Oxygen in the Gasification of Fuels.] Génie civil, vol. 124. 1947, pp. 333–335; Chem. Abs., vol. 42, 1948, p. 9120.

Descriptions with diagrams are given of the Lurgi process utilizing O_2 and pressure for the direct gasification of lignite for city gas, and the Koppers process using O_2 and steam and atmospheric pressure to gasify a wide range of fuels. Synthesis gas is produced by the latter process by modifying the proportions of O_2 and steam.

148. Barrer, R. M. [Intercrystalline Sorption.] Jour. chim. phys., vol. 47, 1950, pp. 82–94; Chem. Abs., vol. 44, 1950, p. 6701.

Comprehensive summary is presented of work published on the sorption of gases in silicate and ionic crystals. The relative accessibilities of the interstitial adsorption sites increase in the order: beryl< silicate glasses<silica glass<harmotome<levynite< mordenite<gmelinite, chabazite, and a synthetic crystalline zeolite $BaAlSi_2O_6.2$–3 H_2O. Special attention is given to a summary for analcite and for the last 6 of the zeolites listed above—of their sieve action in adsorption, their thermodynamics of adsorption, and their kinetics of adsorption.

———. *See* abs. 895.

Barss, W. M. *See* abs. 90.

149. Bartholemé, E., and Sachsse, H. [Catalytic Phenomena With Aerosols.] Ztschr. Elektrochem. vol. 53, 1949, pp. 326–331; Chem. Abs., vol. 44, 1950, p. 2355.

The synthesis-gas generator consists of a burner for coal gas to form $CO+H_2$ with Ni–MgO catalyst to convert residual CH_4 with steam into $CO+H_2$. Soot particles (diameters of frequency maximum about 2 microns) in the flame are nearly completely removed by reaction with steam catalyzed by Ni vapor originating from the catalyst bed or from Ni-salt solutions injected into the generator. Injection of solutions of alkali and alkaline-earth salts likewise suppresses the formation of soot. Since these catalysts are present as colloidal particles, they facilitate the reaction between soot and steam by preventing coagulation of the primary soot particles.

150. Bartlett, E. P., Hetherington, H. C., Kvalnes, H. M., and Tremearne, T. H. Compressibility Isotherms of Carbon Monoxide at Temperatures From 70°–200° and Pressures to 1,000 Atmospheres. Jour. Am. Chem. Soc., vol. 52, 1930, pp. 1374–1381; Chem. Abs., vol. 24, 1930, p. 2925.

CO is shown to be similar to N_2 in physical properties at high pressure. In the low-pressure range, CO is slightly more compressible than N_2 and in the high-pressure range slightly less compressible. At about 375 atm. pressure, the deviation of CO from the law of the ideal gas is approximately constant (1.217) through 270°. At this pressure, the volume of a given mass of CO is a linear function of the absolute temperature.

Basak, N. G. *See* abs. 1182, 1187, 1188, 1189, 1771a.

151. Bashkirov, A. N., and Chertkov, I. B. [Oxidation of High-Molecular-Weight Synthetic Paraffin.] Bull. acad. sci. U. R. S. S., Sec. Tech. Sci., 1947, pp. 817–824.

Paraffin obtained by the Fischer-Tropsch reaction (molecular weight, about 1,000) was oxidized with air in the liquid phase to obtain fatty acids. Results of investigation of various factors are charted and tabulated. They show a maximum yield (55%) at 115°–120° with 0.2 permanganate and 8-hr. reaction time. The various acids separated and identified, ranged from CH_2O to the C_{20} acid, distribution being fairly uniform.

152. Bashkirov, A. N., Kryukov, Y. B., and Kagan, Y. B. [Mechanism of the Synthesis of Hydrocarbons From Carbon Monoxide and Hydrogen.] Compt. rend. acad. sci. U. R. S. S., vol. 67. 1949, pp. 1029–1031; Assoc. Tech. Services, Transl. RJ–21, March 1950; Chem. Abs., vol. 43, 1949, p. 9415.

The reaction observed on Fe catalysts, $2CO+H_2\rightarrow CH_2+CO_2$ (I), in contrast to the reaction $CO+2H_2\rightarrow CH_2+H_2O$ (II) occurring on Ni and Co, is interpreted as the sum of the primary reaction (II) and the subsequent secondary reaction $CO+H_2O\rightarrow CO_2+H_2$ (III). This point of view is corroborated by analyses of the gaseous products obtained, on precipitated Fe catalyst, with mixtures of $CO:H_2=1:1$ in the presence of added H_2O vapor, at 220°–250°, under atmospheric pressure, at space velocity~100 per hr. The balance, by reaction I, is expressed by $CO+mH_2\rightarrow 1/2xCH_2:+1/2xCO_2+(1-x)CO+(m-1/2x)H_2$, where x=mole fraction CO reacted, m=moles H_2 per mole CO. With reaction III occurring simultaneously with II, the balance is $CO+mH_2+pH_2O\rightarrow 1/2xCH_2:+(1/2x+z)CO_2+(p-z)H_2O+(1-x-z)CO+(m-1/2x+z)H_2$, where z=mole fraction CO reacted according to equation III, and p=moles H_2O per mole CO in the initial gas. The contraction k, in the first case, is $k=2a/(1+2a/(1+2a)$ (where $a=CO_2$ content in the product), in the second case, $k'=[2a/(1+2a)]-[3z/(1+2a)(1+m)]$. The difference $\Delta=k-k'$ is termed the contraction depression. Experimentally, Δ attains high values, up to 60–70%. H_2O added in amounts up to 20% of the reacting gas mixture is found to have reacted completely according to III; for example, with an initial mixture $CO:H_2:H_2O=44.5:44.5:11$, on an Fe–Cu–Zn–K_2CO_3–kieselguhr catalyst, at 240°, $a=36.6\%$, Δ experimental=22.3%, calculated=21.4%. A gas mixture $CO:H_2:H_2O=33:34:33$ on an Fe–Cu–Mn–K_2CO_3–kieselguhr catalyst, at 230°, gave a negative contraction of −32.5%, $a=29.7\%$, $\Delta=72.4\%$; the yield of hydrocarbons is depressed by H_2O but is restored when H_2O is eliminated. The ratio

of the rates of reactions III and I, on the 1st catalyst, at 240°, is 3.4, on the 2d catalyst, at 230°, it is 13.6. The primary reaction on Ni, Co, and Fe is reaction II, and CO_2 is a secondary product.

152a. ———. [Mechanism of the Synthesis of Hydrocarbons From Carbon Monoxide and Hydrogen.] Doklady Akad. Nauk S. S. S. R., vol. 78, 1951, pp. 275–276; Chem. Abs., vol. 45, 1951, p. 7,861.

Assumption (abs. 152) that the primary act in the Fischer-Tropsch synthesis is $CO+2H_2\rightarrow CH_2+H_2O$, and not $2CO+H_2\rightarrow CH_2+CO_2$, and that CO_2 is formed only as a result of the secondary reaction $CO+H_2O\rightarrow CO_2+H_2$, was confirmed directly by flow experiments in which a very short contact time prevented the secondary reaction from taking place to any appreciable extent in 1 single pass, and the H_2O formed in each pass was removed by condensation between passes in repeated recirculation. The experiments were conducted with a $CO:H_2=1:2$ mixture at 300° under 20 atm., at a gaseous space velocity of 150,000 l. per l. catalyst per hr., practically complete conversion was ensured by repeated recycling, with the fresh gas admitted at the rate of 44 l. per hr. Under these conditions, 290 l. gas gave, after several hr., liquid hydrocarbons 22.5 gm. per m.^{3}; gaseous hydrocarbons (C_3+C_4) 44.2, CH_4 100.0, H_2O 252.2 gm. per m.^{3}, and no CO_2. This result excludes the direct reaction $2CO+H_2\rightarrow CH_2+CO_2$ and demonstrates that on Co, Ni, and Fe catalysts alike, CO_2 is formed only through a secondary reaction between CO and H_2.

153. Basore, C. A. Research and the Coal Industry. Mfrs. Record, vol. 100, No. 12, 1931, pp. 29–30.

Discusses briefly production of synthetic MeOH and homologous alcohols from CO and H_2. Possibilities are emphasized.

Batchelder, H. R. *See* abs. 1431, 2455, 3311.

154. Batchelder, H. R., and Sternberg, J. C. Thermodynamic Study of Coal Gasification, Applicable to Suspension Gasification of Pulverized Coal. Ind. Eng. Chem., vol. 42, No. 5, 1950, pp. 877–882.

Thermodynamic studies of the continuous gasification of suspended powdered coal with superheated steam and O_2 have been undertaken. A method of calculation has been devised and will be presented in detail in a later paper. Through systematic application of the method of calculation, series of curves have been obtained for the probable ranges of operation in the gasification of a typical Rock Springs, Wyo., coal and a Union County, western Kentucky, coal with O_2 and superheated steam. These curves indicate certain trends that may be expected to hold even if the assumptions underlying the calculations are subsequently found to be not strictly valid, and at least 2 economic studies of much importance in reducing the cost of the gasification step are indicated.

155. Batchelder, H. R., Dressler, R. G., Tenney, R. F., Skinner, L. C., and Hirst, L. L. Role of Oxygen in the production of Synthetic Liquid Fuels From Coal. Bureau of Mines Rept. of Investigations 4775, 1951, 15 pp.

Steps in the production of O_2 by the liquefaction and fractionation of air are discussed. All commercial designs involve the following basic steps: (1) Supply of air into the plant apparatus; (2) refrigeration of the apparatus; (3) heat transfer between ingoing air and outgoing products; (4) removal of impurities from the air supply; (5) fractionation of liquefied air into components N_2 and O_2 and delivery of both as product gases; (6) removal of C_2H_2. Characteristics of 4 commercial-size plants in this country for the production of O_2 are presented, and the type and size of 4 other plants under construction are listed. The relationship of O_2-plant size to plant cost and to O_2 cost is discussed. Increases in O_2 cost are quite rapid as the size of the plant is reduced: $7.00 for a 100-ton plant; $4.80 for 300 tons; and $3.50 for 1,000 tons. The function of O_2 in the production of synthetic liquid fuels is primarily the gasification of coal with O_2 to produce mixtures of $CO+H_2$, which then may be used directly, in the case of the Fischer-Tropsch synthesis, or as a source of H_2 for coal hydrogenation. Among the potential advantages of the substitution of O_2 for air in the coal-gasification step are the following: (1) Fuel economy; (2) increased capacity of equipment; (3) wider range of possible fuels; (4) greater adaptability to pressure operation; and (5) higher range of attainable temperatures. The amount of O_2 necessary to produce synthetic fuel by Fischer-Tropsch is about 690 lb. per bbl. of liquid fuel. This amount of O_2 at $5.00 per ton would amount to $1.72 per bbl. and at $3.00 to $1.03. Each change of $1.00 per ton for O_2 will change the cost per bbl. of synthetic fuel from this process by about $0.35. In the coal-hydrogenation process, a relatively large part of the required H_2 is to be recovered from the tail gases by low-temperature separation and produced by reforming the product CH_4 with steam. Thus, the O_2 requirement for coal gasification is only a fraction of that for Fischer-Tropsch. About 90 lb. of O_2 will be required to make 1 bbl. of synthetic fuel by coal hydrogenation. At $5.00 per ton, the O_2 cost would amount to about $0.22 per bbl. of oil and at $3.00 to about $0.14. Each change of $1.00 per bbl. in O_2 cost will change the cost per bbl. by about $0.04.

156. Batchelder, H. R., Tenney, R. F., Skinner, L. C., Dressler, R. G., and Hirst, L. L. Role of Oxygen in Production of Synthetic Liquid Fuels From Coal. Trans. Am. Soc. Mech. Eng., Process Ind. Div. Conf., Paper 50–PRI–7, 1950.

Use of O_2 in place of air or of external heating in the gasification of coal for the production of H_2 for coal hydrogenation or of CO–H_2 mixtures for Fischer-Tropsch synthesis may have 1 or more of the following advantages: (1) Fuel economy; (2) increased capacity of equipment; (3) wider range of possible fuels; (4) greater adaptability to pressure operation; and (5) a higher range of attainable temperature. As to the relation of O_2 cost to that of synthetic fuel, it is well established that for the Fischer-Tropsch process about 690 lb. O_2 are needed to make 1 bbl. of synthetic liquid fuel. This amount of O_2 at $5.00 per ton would amount to $1.72 per bbl. and at $3.00 to $1.03. Each change of $1.00 per ton in the cost of O_2 will change the bbl. cost of synthetic fuel by about $0.35. For comparison, similar calculations made on coal would show that a change of $1.00 per ton in price would result in a change of about $0.40 per bbl. The O_2 requirement for coal hydrogenation is only a fraction of that for the Fischer-Tropsch process due to the fact that in the former process a relatively large part of the required H_2 is to be recovered from the tail gases by low-temperature separation or by reforming the product CH_4 with steam. It is estimated that about 90 lb. O_2 will be required to make 1 bbl. of synthetic fuel by coal hydrogenation. At $5.00 per ton the O_2 cost would be $0.22 per bbl. of oil and at $3.00 about $0.14. Each change of $1.00 per ton in the cost of O_2 will change the bbl. cost of oil by about $0.04.

157. Bates, L. F. Curie Points. Proc. Phys. Soc. (London), vol. 43, 1931, I, pp. 87–95; Chem. Abs., vol. 25, 1931, p. 1715.

Description of the magnetic behavior of a ferromagnetic substance may require 3 temperatures, (1) the ferromagnetic critical point, at which the rate of change of the square of the intrinsic magnetic moment per unit volume with temperature is a maximum; (2) the ferromagnetic Curie point, at which the intrinsic magnetization may be considered zero; and (3) the paramagnetic Curie point, given by θ in the Curie-Weiss law

$\chi=C/(T-\theta)$. The significance of the ferromagnetic and paramagnetic Curie points is discussed in the light of the results of a number of investigators on Fe, Ni, Co, the ferrocobalts, magnetite, and manganese arsenide. The paramagnetic behavior of these substances can be accounted for by a slight extension of the idea that ferromagnetism is due to a magnetic particle consisting of a group of associated atoms.

BATUEV, M. I. *See* abs. 802, 802a, 802b.

BATZ, W. *See* abs. 3649.

158. BAUER, W. [Mersol.] Seifensieder-Ztg., vol. 68, 1941, pp. 524–526; Chem. Zentralb., 1942, I, p. 1571; Chem. Abs., vol. 37, 1943, p. 6370.

Mersol is a sulfonyl chloride of an alphatic hydrocarbon of the formula RSO_2Cl, which is made by the action of SO_2Cl or chlorosulfonic acid on paraffin gatsch. It smells strongly of HCl and SO_2 and contains about 17–20% of unsaponification residues of hydrocarbons. Its saponification number is approximately 390. The saponification to Mersolate is carried out by pouring Mersol into alkali that is not warmer than 60°. The concentration of the alkali plays an important role in the formation of the final product. If the Mersolate glue is thick, a large part of the salt precipitates. If it is thin, the unsaponified part can be removed as a thin oil a few days later. In practical operations a thick liquid is prepared first, and after the removal of the salt, it is diluted. Contrary to soap glue, the Mersolate glue always remains fluid. Numerical data are given for a saponification, and the processing of Mersolate to soaps and soap powders is described.

BAUGH, H. M. *See* abs. 2804.

159. BAUKLOH, W. [Destruction of Cast Iron by Carbon Monoxide Gas Mixtures at High Temperature.] Metallwirtschaft, vol. 18, No. 3, 1939, pp. 57–59; Chem. Abs., vol. 33, 1939, p. 2864.

A cast Fe vessel was destroyed by a hot CO–gas mixture after 1½ yr. The gas penetrated along pores and graphite particles, leaving deposited C. At 550° the following reaction, catalyzed by Fe, takes place: $2CO \rightarrow C+CO_2$. Steel is not affected.

160. ———. [Destructive Action of Carbon Monoxide and of Gases Containing It.] Chem. Fabrik, vol. 13, 1940, pp. 101–104; Chem. Abs., vol. 34, 1940, p. 6559.

Decomposition of CO into C and CO_2 is accelerated by metals and by some oxides of metals. Deposition of C occurs within the structure of the metal, weakening or even destroying it. The temperature regions in which this action is appreciable are plotted for Fe, Fe_2O_3, Ni, NiO, Ni_2O_3, Cr, Mn, Co, and Co_3O_4. The effect is smallest for Cr and Mn.

161. BAUKLOH, W., AND EDWIN, B. [Effect of Temperature and Pressure on the Disintegration of CO.] Arch. Eisenhüttenw., vol. 16, 1942, pp. 197–200; Chem. Abs., vol. 37, 1943, p. 5903.

It is shown theoretically that the CO disintegration $2CO \rightleftharpoons C+CO_2$ is a special case of adsorption catalysis, which under normal conditions progresses only very slowly but assumes technical importance in the presence of suitable catalyzers such as Fe, Ni, or Co. The adsorption of CO molecules by the metallic surface is connected with an increase in their activity. The theory for the calculation of amount and concentration of disintegration and of disintegration velocity is developed, and the respective formulas are given. A maximum of disintegration exists, which depends on temperature; with increasing temperature the chemical reaction velocity increases, the adsorption possibility of Fe, and thus its capacity to influence the process catalytically, decreases. The C disintegration increases with increasing pressure (at constant temperature) to an asymptotic maximum value.

162. BAUKLOH, W., AND FOROUD, A. K. [Decarburization of Cast and Malleable Iron in Hydrogen and in Mixtures of Hydrogen and Water Vapor.] Arch. Eisenhüttenw., vol. 16, 1943, pp. 355–362; Chem. Abs., vol. 37, 1943, p. 6619.

Addition of about 2% by volume of H_2O vapor to H_2 decreases the time required for decarburization. Low contents of Mn have but little effect on H_2 decarburization; 80% ferromanganese could not be decarburized with pure H_2. The decarburization in gases with oxidizing components is determined mainly by the diffusion velocity of C in the Fe; in annealing in pure H_2 at higher temperatures, the purely chemical reaction between H_2 and C is the slower one and thus determines the decarburization velocity.

163. BAUKLOH, W., AND HELLBRÜGGE, J. [Effect of Some Substances on the Decomposition of Carbon Monoxide and Methane.] Arch. Eisenhüttenw., vol. 15, 1941, pp. 163–166; Brennstoff-Chem., vol. 23, 1942, p. 7; Chem. Abs., vol. 36, 1942, p. 7268.

In the presence of catalysts, such as metallic Fe, and at certain temperatures, CO disintegrates forming free C. The velocity of decomposition depends on the nature of the catalysts and is greatest at temperatures between 500°–600°. Fe_2O_3 mixed with SiO_2, CaO, Al_2O_3 or Cr_2O_3 caused a lowering in the catalytic decomposition of CO. Cr_2O_3 is the most effective. CH_4 has no critical-decomposition region; at higher temperatures, however, it is more unstable than CO and decomposes with greater velocity. Mixtures of Fe_2O_3 with $CdSO_4$, $HgCl_2$ or B_2O_3 are equally good.

164. BAUKLOH, W., AND HENKE, G. [Effect of Metals and Metal Oxides on the Decomposition of Carbon Monoxide and Its Technical Significance.] Metallwirtschaft, vol. 19, 1940, pp. 463–470; Chem. Abs., vol. 36, 1942, p. 317.

At 500°–600°, Fe oxides and cast Fe cause decomposition of CO accompanied by deposition of C according to $2CO=CO_2+C$, by strong loss of Fe from the oxides, and by destructive action on cast Fe. Fe-containing ceramic materials are also destroyed. The harmful effects occur only in the temperature and pressure range in which Fe, Fe oxides, C, CO, and CO_2 coexist. The maximum effect on decomposition of CO is shown at 500°. The oxides have virtually no effect on the decomposition; Fe metal itself is the catalytic agent. Decomposition occurs in the adsorption layer and is proportional to the amount of CO adsorbed. H_2O vapors retard CO decomposition by preventing formation of metallic-Fe surfaces. When CO is passed over Fe_2O_3 at 550°, the maximum rate of decomposition is reached at a streaming velocity of about 1 cm. or 2 cc./sec.; a marked maximum rate of decomposition at 1 atm. pressure occurs around 500°; below 400° and above 800°, virtually no deposition of C was observed. The maximums are eventually the same whether Fe, Fe_2O_3, FeO, or Fe_3O_4 is used; the initial activity is greater the lower the temperature at which reduction to Fe took place. Sintering is rapid above 600°. Addition of 1% $(CN)_2$, NH_3, or H_2S reduces the deposition of C by as much as 95%. Near 500° the oxides of Fe, Co, and Ni cause deposition of C; the maximum effects are at 500° for Fe_2O_3 and at 700° for NiO and CoO. Mg, Ca and Ba oxides and Fe_2SiO_4 are weak catalysts; the oxides of Cu, Ag, Zn, Al, Ti, Si, V, Cr, Mo, W, U, Mn, C, SiC, and $FePO_4$ are inert. Of the free metals, only Fe, Co, and Ni are strongly active; Mg, Al, Ce alloys, and Ti, Cr, and Mn react with CO and cause deposition of C. Ag, Cu, Zn, Si, Mo, W, Pd, and Pt are inert. The destructive action of CO on various materials as firebricks can be prevented by avoiding the harmful temperature and pressure limits, by removal of Fe, Co, and Ni, by conversion of the oxides of Fe, Co, and Ni to compounds such as the silicates or phosphates, which

are not reduced to the metal, or by protective glazes. Experiments on the destructive action show that it is due to very strong mechanical forces of crystallization of the deposited C.

165. BAUKLOH, W., AND HIEBER, G. [Influence of Various Metals and Metallic Oxides Upon Carbon Monoxide Decomposition.] Ztschr. anorg. Chem., vol. 226, 1936, pp. 321–332; Chem. Abs., vol. 30, 1936, p. 5139.

Reaction $2CO=CO_2+C$ was studied by passing CO gas over Fe_2O_3, Fe_3O_4, Fe, Co_3O_4, Co, Ni_2O_3, NiO, Ni, Cr_2O_3, Cr, Mn_3O_4, Mn, Al_2O_3, Al, ZnO, Zn, and Cu at 350° to 850°. The extent of the reaction is measured by weighing the C produced. The quantity of C separated rises to a maximum and then decreases, the maximum being at 550° for Fe and Fe oxides, at 650° for Co and Co oxides, at 450° for Ni oxides but at 750° for Ni, at 650° for Cr, and at 850° for Mn. No C separates with Mn_3O_4, Al_2O_3, Zn or ZnO, nor with CuO. It is concluded that not the oxides but metals produced from them cause the CO decomposition.

166. BAUKLOH, W., AND KNAPP, B. [Progress of the Reaction Between Hydrogen and Carbon in Iron.] Arch. Eisenhüttenw., vol. 12, 1939, pp. 405–411; Iron and Steel Inst. (London); Carnegie Schol. Mem., vol. 27, 1938, pp. 149–164; Chem. Abs., vol. 33, 1939, p. 3732.

Basic reaction $Fe_3C+2H_2 \rightleftharpoons 3Fe+CH_4$ is theoretically discussed. At first, independently of temperature and C content, H dissolves C present on the Fe surface in cementite or γ-solid solution. The Fe formed in this stage obstructs further direct access of H to C, so the reaction can continue only after diffusion of H. As long as diffusion is the slower process, the progress of the reaction is determined by the diffusion and, thus, depends on temperature, C content, and H_2 pressure. The CH_4 equilibrium is another factor. Beginning at 850° the migration velocity of C is higher than the reaction velocity of H and C, so the reaction becomes the slower process and is determined by the equilibrium conditions. Three types of marginal decarburization zones are distinguished: (1) Purely ferritic, up to 850°; (2) transition; and (3) hypereutectoid, above 850° within the 2-phase range of austentite + cementite. Experiments, which corroborate the theoretical deduction, are described in detail. 10 refs.

166a. BAUKLOH, W., CHATTERJEE, B., AND DAS, P. P. Decomposition of Carbon Monoxide in the Presence of Iron, Cobalt and Nickel as Catalysts. Trans. Indian Inst. Metals, vol. 4, 1950, pp. 271–278; Chem. Abs., vol. 46, 1952, p. 7415.

Maximum decomposition of CO by Fe, Co and Ni as catalysts takes place at 550°, 700°, and 350°, respectively. The speed of the decomposition reaction increases up to an hour and then decreases. The decrease in reaction speed is due to the formation of metal carbides which have a lower activity than the pure metal. Decomposition of the metal carbide by H_2 restores the activity of the metal. If the metal is heated in H_2 the metallic activity is lower, owing to a sintering process. C decreases this sintering.

167. BAUKLOH, W., SCHULTE, F., AND FRIEDERICHS, H. [Decarburizing Annealing of Plain and Alloyed Malleable Cast Iron in Carbon Monoxide–Carbon Dioxide Mixtures.] Arch. Eisenhüttenw., vol. 16, 1943, pp. 341–354; Chem. Abs., vol. 37, 1943, p. 6619.

Effects of wall thickness, duration of annealing, temperature, gas composition, and contents in the casting of Mn, Ni, Cr, V, Mo, and S on decarburization velocity were investigated on white-cast Fe in $CO–CO_2$ mixtures at 950°–1050°. The diffusion constant for C in Fe was determined. The decarburization velocity increases with increasing temperature and decreases with time approximately hyperbolically. The gasification of C takes place virtually only at the surface of the specimen. The velocity of diffusion of C from the interior to the edges determines the decarburization velocity. The quantity of C gasified in unit time does not increase proportionally with the original C content in hypoeutectoid white-cast Fe, as it does in steel. For short annealing times, the primary cementite inclusions seem to decrease the diffusion velocity and thus the decarburization velocity, but for longer annealing times this is hardly noticeable. Low contents of Mn, Ni, Cr, and V have hardly any effect on decarburization velocity. Mo at 1050° increases decarburization velocity. S seems to hinder decarburization. The highest decarburization velocity is obtained, for low-flow velocity, with a gas mixture of about 28% of CO_2 and 72% CO. CO_2 contents above 28% at 1050° cause scaling of the Fe and decrease of decarburization velocity. The results obtained with pure $CO–CO_2$ mixtures can be applied also to the tempering in N_2-containing $CO–CO_2$ mixtures.

168. BAUR, E., AND GLAESSNER, A. [Equilibrium Between Iron Oxides and Carbon Monoxide and Dioxide.] Ztschr. physik. Chem., vol. 43, 1903, pp. 354–368; Jour. Chem. Soc., vol. 84, 1903, (2) p. 423.

Equilibria, which may be established by passing CO or CO_2 over Fe, are represented by the equations: $Fe+CO=FeO+C$; $FeO+CO=Fe+CO_2$; and $C+CO_2=2CO$. The reaction $Fe_3O_4+CO=3FeO+CO_2$ is also one of equilibrium. The equilibrium relationships were determined by heating the solid in an atmosphere of CO or CO_2 in a boat contained in a porcelain tube connected with a gas burette. After equilibrium had been established the gas was drawn off and analyzed. The solids examined were ferrosoferric oxide and ferrous oxide and ferrous oxide and Fe. The equilibrium curve in the 1st case exhibits a maximum at 490°, when the gas phase contains 47% CO. This indicates the temperature at which ferrosoferric oxide is reduced most difficultly. In the 2d case, the curve shows a minimum point at 680° when 59% CO is present; this corresponds to the temperature at which ferrous oxide is most easily reduced to Fe. The results are plotted along with Boudouard's values for the equilibrium between C and CO_2, and from points where the curves cut, it is deduced that at atmospheric pressure, CO, CO_2, ferrous oxide, ferrosoferric oxide, and C can exist side by side at 647°, and the 3 solids are in equilibrium at 685°. Above 685°, C and Fe can exist together, and below 647°, C and ferrosoferric oxide. When applied to the blast furnace, the results show that the reductions of ferrosoferric oxide and ferrous oxide must take place at different zones, which are characterized by different contents of CO. Fe in contact with a gas rich in CO at temperatures below 647° is oxidized and C is deposited, but no C can be deposited from the gas at a temperature higher than 680°. The heat of formation of ferrosoferric oxide at 490° under constant pressure is calculated to be 267,380 cal., and that of ferrous oxide at 680° is 67,350 cal.

169. BAUSCHINGER, C. [Utilization in the Soap Industry of Carboxylic Acids Made from Paraffin.] Fette u. Seifen, vol. 45, 1938, pp. 629–630; Chem. Abs., vol. 33, 1939, p. 9695.

Synthetic fatty acids for use in the soap industry should contain the least possible amounts of hydroxy acids, lactones, lactides, keto acids, dicarboxylic acids, and unsaponifiable matter. The insufficient plasticity of soaps from synthetic fatty acids is ascribed to absence of unsaturated acids. Peculiar phenomena observed in the soap kettle in preparing soap from synthetic fatty acids are discussed briefly.

BAYAN, S. *See* abs. 2553.

170. BAYER, O. [Newer Large-Scale Technical Developments in the Chemistry of the Aliphatic Com-

pounds.] Angew. Chem., vol. 54, 1941, pp. 353–356; Chem. Abs., vol. 35, 1941, p. 6923.

Technical production of aliphatic compounds is a much later development than that of aromatic compounds but has already surpassed the latter and promises to surpass the production of inorganic chemicals. Unlike the countries with large supplies of petroleum and carbohydrates, Germany is forced to use coal, CO, and H_2 as raw materials. Among several most important developments mentioned are paraffin oxidation to fatty acids and MeOH and higher alcohols.

171. Beamer, C. M. Production of Synthetic Alcohol from Ethylene. Chem. Eng. Progress, vol. 43, 1947, pp. 92–96.

Alcohol manufacture from grain, molasses, and C_2H_4 is briefly reviewed. The properties are charted and the prewar and war uses of industrial EtOH are shown. 1 bu. of grain will yield about 2.5 gal. of alcohol. About 2.5 gal. of molasses is required to produce 1 gal. of 190 proof alcohol, and theoretically about 3.9 lb. of C_2H_4 will make 1 gal. of alcohol. The price of alcohol at present depends largely upon supply and demand and on the fluctuation in the cost of grain and molasses. Expansion in the synthesis method will tend to relieve the situation. Other possible sources of alcohol within the next few years are: Waste sulfite liquors, sawdust, and hydrocarbon synthesis. In the next 5–10 years, the production of industrial EtOH by the Fischer–Tropsch synthesis process may have to be reckoned with and will become an important producer.

Bean, E. H. *See* abs. 1442.

Beati, E. *See* abs. 2401.

172. Beck, R. A. Evaluation of Fluid Catalyst—Development of Laboratory-Scale Units. Ind. Eng. Chem., vol. 41, No. 6, 1949, pp. 1242–1243.

Two types of laboratory scale units for evaluation of fluidized catalyst have been developed. A mechanically stirred unit with helically finned rotor makes it possible to simulate fluidization independently of the gas velocity below 1 ft. per sec. A steel-stirred reactor is used in research where great flexibility in regard to reactant flow rates is desired. A baffled nonstirred unit is less subject to mechanical difficulties than the stirred type. Both types have proved to be effective laboratory units for the testing of small batches of experimental catalysts with moderate amounts of charge gases. For example, the use of a superficial linear velocity of 1 ft. per sec. in the 0.75-in. baffled reactor at 400 p. s. i. g. and 600° F., requires approximately 140 standard cu. ft. per hr. of total charge gas as contrasted with over 1,000 required for the open 2-in. reactor originally cited. With the stirred reactor the feed rate can be reduced to any desired level without decreasing the effectiveness of catalyst fluidization.

173. Becker, M. L. Carburizing and Graphitizing Reactions Between Iron-Carbon Alloys, Carbon Monoxide and Carbon Dioxide. Jour. Iron Steel Inst. (London), Adv. Copy 3, 1930, pp. 1–25; Chem. Abs., vol. 24, 1930, p. 3203.

Description of work carried out in an investigation to determine the quantitative influence of the temperature and C content of solid solutions upon the composition of a gas consisting of CO and CO_2.

Beckett, C. W. *See* abs. 654a.

174. Beckley, J. S. Chemicals From Coal—New Developments. Coal-Heat, vol. 47, No. 1, 1945, pp. 26–27, 30; Fuel Abs., No. 2079.

Coal is utilized as a raw material for the chemical industry in 3 ways: By carbonization, yielding valuable byproducts; directly as a reactant in a chemical reaction, yielding a finished product for commerce or an intermediate product, other than water gas, which serves as a raw material for subsequent processing; using the coke to make water gas, a starting material for many important synthesis. The production of some of these chemicals is discussed, in particular the synthesis of MeOH and the production of nylon.

Beebe, R. A. *See* abs. 1771.

175. Beebe, R. A., and Stevens, N. P. Heats of Adsorption of Gases on Iron-Synthetic Ammonia Catalysts at Low Temperatures. Jour. Am. Chem. Soc., vol. 62, 1940, pp. 2134–2140; Chem. Abs., vol. 34, 1940, p. 6515.

Data are given for the adsorption isotherms of the following gases on doubly promoted Fe catalyst containing 1.59% K_2O and 1.3% Al_2O_3, O_2, CO, N_2, A, and H_2 at −183°, CO_2 and CO at −78°, and CO at 0°. The heats of adsorption are given for these gases on this catalyst and on an unpromoted pure Fe catalyst containing 0.15% Al_2O_3 impurity. These measurements indicate that the adsorption of N and of A at −183° is exclusively of the van der Waals type; that the adsorption of H at −183° and of CO at −183°, −78° and 0° is in part chemisorption; and that CO is chemisorbed on the alkali-promoted catalyst at −78°, although the adsorption of this gas on the pure catalyst is exclusively van der Waal's. These conclusions are in general agreement with those of Emmett and Brunauer (see abs. 388) on an analysis of the low-temperature isotherms. The heat evolved in the irreversible adsorption of O at −183° approaches, in order of magnitude, that of Fe oxide formation. The form of the time-temperature curves with O at −183° indicates that the adsorption process involved is complex.

Beeby, G. H. *See* abs. 327.

176. Beeck, O. Catalysis—a Challenge to the Physicist. Rev. Modern Phys., vol. 17, 1945, pp. 61–71; Chem. Abs., vol. 40, 1946, p. 4593.

A review.

177. ———. Surface Catalysis. Rev. Modern Phys., vol. 20, 1948, pp. 127–130; Chem. Abs., vol. 42, 1948, p. 4435.

Review of work of Beeck and associates. The discovery of the effect of traces of H_2O and H_2S in lowering the decomposition temperature of hydrocarbons is discussed. The molecular-ray experiments also seem to indicate the decomposition of CH_4 into CH_3 and H and C_2H_6 into 2 CH radicals. There is evidence that the CH radical is formed in the decomposition of acetylene. The adsorption step is the crucial step in surface catalysis, and the reaction of ethylene and H_2 is cited as an example. Finally the tracer technique is discussed in connection with the isomerization of butane to isobutane.

177a. ———. Catalysis and the Adsorption of Hydrogen on Metal Catalysts. Advances in Catalysis, Academic Press, Inc., New York, vol. 2, 1950, pp. 151–195.

Review includes a discussion on adsorption, surface of metal catalysts, H_2 adsorption isobars and the effect of sintering, heat of adsorption of H_2 on Ni, Fe, W metal films partially covered with other adsorbed gases, sintered films and the criterion for mobility as well as Frankenburg's experiments and the experiments of Roberts. The following conclusions are reached: The adsorption (chemisorption) of H_2 on clean metal surfaces is almost always accompanied by absorption of H_2 into the interior of the structure. This absorption is a slow activated process and has in the past been mistaken for activated adsorption of H_2 on the surface. The heat of absorption of H_2 is considerably lower than the heat of chemisorption. The heats of chemisorption of H_2 on Ni and Fe are nearly identical and decrease from about 30,000 cal. for the sparsely covered surface to about 18,000 cal. for the completely covered surface. The heat of chemisorption on W decreases from 45,000 cal. to about 13,000 cal. as a function of surface coverage. The lower values of Frankenburg for higher surface coverage can be satisfactorily explained on the basis of surface impurities on Frankenburg's W powders. The heat of adsorption of H_2 on metals has been found to be constant over wide temperature ranges (for Ni by Beeck and coworkers from −183° to 23° C., by Frankenburg on W for temperatures up to over 500°). The activation energy for the chemisorption of H_2 on all metals studied is extremely low. Chemisorbed H_2 atoms on Ni are mobile. They are able to migrate from one crystallographic site to another site even at −183° C. On Fe, H_2 atoms are mobile at room temperature but are not mobile at −183° C. The decrease of heat of adsorption as a function of surface coverage can be explained satisfactorily by interaction of the adsorbed atoms with each other. While the surface of clean metal films appears to be homogeneous with regard to heat of adsorption and surface coverage (the latter within the limits of size of different crystallographic sites), the rate of hydrogenation of ethylene is markedly dependent on the crystal parameter. On Ni, chemisorption of H_2 is still taking place at 20° K. The true extent of metal surfaces cannot be measured by the B. E. T. method using N, since N is chemisorbed at −196° C. The H_2 adsorption at this temperature measures the surface more accurately and is in close agreement with the chemisorption of CO at both liquid N and room temperature and with the van der Waal's adsorption of krypton. 18 references are given.

———. *See* abs. 3712.

178. Beeck, O., and Wheeler, A. Activated Adsorption of Nitrogen on Iron at 23° and 100°, and Ammonia Synthesis. Jour. Chem. Phys., vol. 7, 1939, pp. 631–632; Chem. Abs., vol. 33, 1939, p. 8363.

178a. Beeck, O., Cole, W. A., and Wheeler, A. Determination of Heats of Adsorption Using Metal Films. Disc., Faraday Soc., 1950, No. 8, pp. 314–321; Chem. Abs., vol. 45, 1951, p. 9990.

A calorimeter is described for heats of adsorption of H_2 as a function of fraction of surface covered for Ni and Fe films at room and liquid-air temperatures. A criterion for mobility of adsorbed layers is presented.

Beeck, O., Givens, J. W., and Ritchie, A. W. Adsorption of Hydrogen on Nickel Catalysts. II. Sorption Isobars from 20° K. to Room Temperature. See abs. 180.

179. Beeck, O., Ritchie, A. W., and Wheeler, A. Adsorption of Hydrogen on Nickel Catalysts. I. Effect of Sintering. Jour. Colloid Sci., vol. 3, 1948, pp. 505–510; Chem. Abs., vol 43, 1949, p. 2079.

High-vacuum-evaporated Ni films prepared at 23° the method previously described adsorb H_2 virtually instantaneously. There is little difference in the amount adsorbed at −196° and at room temperature. This is in marked contrast to the results obtained with Ni catalysts prepared from NiO by H_2 reduction, which sorb H_2 slowly at room temperature in amounts [illegible] times the amounts adsorbed at −196°. If the vacuum-evaporated films are sintered at 100°–400°, slow sorption of H_2 is observed. The ratio of slowly sorbed H_2 to rapidly adsorbed H_2 increases with increasing sintering temperature. The so-called "activated adsorption" of H_2 on Ni is not adsorption on the metal surface but is slow sorption of H_2 into the interior of the metal structure. The adsorptive capacity of Ni indicated by chemisorption of CO or physical adsorption of Kr corresponds to the capacity for rapid H_2 sorption, chemisorption, and for catalytic reactions such as C_2H_4 hydrogenation but does not correspond to the capacity for slow sorption.

180. Beeck, O., Givens, J. W., and Ritchie, A. W. Adsorption of Hydrogen on Nickel Catalysts. II. Sorption Isobars From 20° K. to Room Temperature. Jour. Colloid Sci., vol. 5, 1950, pp. 141–147; Chem. Abs., vol. 44, 1950, p. 6228.

Sorption isobars were determined for H_2 at 0.1 mm. Hg pressure on evaporated Ni films, over the temperature range −253°–25°. Slow activated sorption, interpreted as absorption of H_2 into the interior of the metal structure, was observed in agreement with previous results. The process is exothermic and, after initiation by raising the temperature to approximately −150°, will continue at much lower temperatures.

181. Beeck, O., Smith, A. E., and Wheeler, A. Catalytic Activity, Crystal Structure and Adsorptive Properties of Evaporated Metal Films. Proc. Roy. Soc. (London), vol. 177. 1940. A, pp. 62–90; Chem. Abs., vol. 35, 1941, p. 2061.

Metal films of high reproducible catalytic activity were obtained by condensation of their vapors on glass at any desired temperature. The catalytic activity was measured by the hydrogenation of C_2H_4. The crystal structure of these films was investigated by electron diffraction. By controlling the pressure of an inert gas, N_2, A, and others, during evaporation of the metals, unoriented and oriented films could be produced at will, and their catalytic activities were compared. Completely oriented Ni films were obtained with an inert-gas pressure of 1 mm., the (110) plane, the least dense of the planes, lying parallel to the backing and the 2 remaining axes showing random distribution. Fe films were oriented with their (111) plane parallel to the backing, again the least dense plane thus oriented. Low-pressure adsorption of H_2 at room temperature and of CO at liquid-air temperature revealed that the oriented gas-evaporated Ni films have 2 times the available surface/gm. of randomly oriented high-vacuum films, but 10 times the activity. The oriented films have therefore 5 times the activity of unoriented films. Oriented films of an available surface equal to unoriented but of 5 times the activity could also be obtained in high vacuum by evaporation onto oriented films previously produced by evaporation in an inert gas. The activity/unit weight of the films was constant; this indicates ready accessibility to the interior of the film by the reacting gases. Adsorption of H_2 was found to be immeasurably fast in all cases. Adsorption isotherms on Ni films were obtained for C_2H_4, CO, N_2, H_2, and O_2; and the effect of catalyst poisoning by CO and O_2, as well as the effect of sintering, was studied. Loss of activity, decrease of H_2 adsorption, and amount of poison were found to be proportional. The most extensive studies were made on Ni films, but films of Fe, Co, Pd, Pt, and Cu were also investigated, and with the exception of Cu similar results were obtained. The enhanced activity of oriented films appears to be associated with the larger distances in the (110) plane of Ni or the (111) plane of Fe. The bearing of the results on the definition of active centers and on the general problem of adsorption is discussed.

Beery, D. W. *See* abs 15a.

Bégui, Z. E. *See* abs. 550.

Beletskii, M. S. *See* abs. 3371.

182. Bel'kevich, P. I. [Sorption of Hydrogen by Metals of the Platinum Group. I. Character of the Sorption Isotherms of the Iridium–Hydrogen, Rhodium–Hydrogen, Osmium–Hydrogen and Ruthenium–

Hydrogen Systems.] Jour. Gen. Chem. (U. S. S. R.), vol. 9, 1939, pp. 944–954; Chem. Abs., vol. 33, 1939, p. 8468.

Sorption isotherms for 20° and 50° for the Ir–H_2, Rh–H_2, and Os–H_2 systems are analogous to that of the Pt–H_2 system. The metals were used in the finely dispersed form (Ir, Os, Rh, and Ru blacks), prepared by the reduction of their chloride salts with hydrazine–HCl in weakly alkaline solution. By strict control of thermal conditions of treatment of blacks (temperature of sorption 20° and 50° and that of desorption for Ir 120° and for Rh and Os 150°), reproducible isotherms can be obtained. An increase in temperature of sorption and desorption causes decrease in the sorptive power of the blacks. Data are tabulated and plotted. 44 references covering the period from 1866–1926.

183. Bell, E. A. Synthetic fuel and Chemical Plants in France. Petrol. Times, vol. 46, 1942, p. 180; Chem. Abs., vol. 36, 1942, p. 4312.

Review.

184. Bell, H. S. Costs of Oil From Coal and Shale. Am. Petrol. Refining, chap. 36, rev. ed.; Nat. Petrol. News, vol. 37, No. 10, 1945, pp. R 205–206; Chem. Abs., vol. 39, 1945, p. 2190.

Three methods for the production of oil as a substitute for petroleum are compared from an economic standpoint: (1) Bergius coal hydrogenation; (2) Fischer-Tropsch gas synthesis; and (3) recovery of oil from shale. (1) Yield about 100 gal. of gasoline/long ton of coal, capital cost $0.90, operating cost $0.17–$0.22/gal. (2) 36 gal. of synthetic crude/ton of coke, capital cost $1.18, operating costs are believed to be comparable. (3) average of 43 gal. of gasoline/ton of shale, with a recovery of oil from the shale varying from 75–90%, capital cost $0.39, operating cost $3.20/bbl. of crude oil, assuming 60% yield of gasoline. $0.14–$0.15/gal. It is concluded that none of the methods is commercially attractive and none, with the possible exception of extraction of rich shale, could compete with petroleum. Adaptation of the second method to natural gas probably will precede commercial hydrogenation of coal in the United States.

185. Bell, I. L. Chemistry of the Blast Furnace. Jour. Chem. Soc., vol. 22, 1869, pp. 203–254.

Catalyzing effect of Ni, Co, and Fe upon the velocity of the reaction $2CO = CO_2 + C$ is investigated. Higher temperatures of 500°–800° were unfavorable for the decomposition of CO to C in the case of metallic Fe. At the temperatures investigated, the oxides were as effective as the metals themselves in determining the decomposition of CO.

186. Bellamy, L. J., and Nillson, K. T. German Chemical Industries—Synthetic Fatty Acids. Chem. and Met. Eng., vol. 52, No. 12, 1945, pp. 178, 182, 184. PB Rept. 6, 1945, 3 pp.; Chim. et ind., vol. 56, 1946, p. 18; Chem. Abs., vol. 40, 1946, p. 7662.

Synthetic fatty acids have been produced on a large scale in Germany at a number of plants. They have all used a similar method; that of oxidation of paraffins (normally from the Tief Temperatur-Hydrierung process on lignite) by air, using the same method as that worked by the Pasco Co. of America, which holds licenses from I. G. The Tief Temperatur-Hydrierung process is a new single-step hydrogenation process in which brown-coal tar is treated in the liquid phase with a catalyst of Florida clay + Cr and Mo oxides, yielding a low-quality gasoline, 50-cetane number diesel oil, and wax. The first fraction consisting of C_1–C_4 acids is recovered, fractionated, and used for various purposes. The C_5–C_{20} acids, which are insoluble in H_2O, are obtained as the first fraction of vacuum distillation and separated into the C_5–C_7, C_7–C_9 and C_9–C_{11} fractions. The first 2 are hydrogenated to the corresponding alcohols, the C_7–C_9 fraction finds application in fire extinguishers of the foamite type, and the C_9–C_{11} fraction is used in the flotation of minerals. The C_{10}–C_{18} fraction, isolated by vacuum distillation at 3 mm. pressure, is used directly for the production of soaps and edible fats, the latter of which appear to be of excellent quality. The C_{18}–C_{24} acids are used in greases as Na, Ca, and Li soaps and in combination with triethanolamine as softening agents for leather. The Zn, Mg, and Ca soaps have also been used as lubricants for plastic molding. The pitch residue is used in lacquer production and as a molding agent for foundry cores and in the manufacture of vaseline.

Beltz, J. C. *See* abs. 927.

Bemmann, R. *See* abs. 205, 206.

187. Bénard, J. [Role of Diffusion in Surface Oxidation of Iron.] Métaux, corrosion, usure, vol. 18, No. 2, 1943, pp. 20–29; Chem. Abs., vol. 44, 1950, p. 9781.

Rate of oxidation of pure Fe at 250°–900° was investigated. The chemical nature of the films formed and the mechanism of the diffusion of metal through the oxide film are discussed.

188. ———. [Variation of the Composition of Ferrous Oxide.] Bull. soc. chim. France, 1949, D, pp. 109–116; Chem. Abs., vol. 43, 1949, p. 6901.

Composition of FeO corresponds exactly to the theoretical for FeO (77.7% Fe) above 750°. Fe_3O_4 attains 75.9% Fe at 1,100° and does not change with increase in temperature. At 580°, an equilibrium exists between the 3 phases FeO, Fe, and Fe_3O_4 corresponding to 76.9% Fe. The apparatus is described, together with experimental technique. Reviews literature.

———. *See* abs. 478, 1279, 2275.

189. Bénard, J., and Coquelle, O. [Oxidation of Iron at High Temperatures Determined Metallographically.] Rev. mét., vol. 43, 1946, pp. 113–124; Chem. Abs., vol. 41, 1947, p. 3418.

Sheets of Armco Fe 3 mm. thick were heated in an open electric-resistance furnace provided with a free circulation of air for 5 hr. at temperatures from 570°, at which no perceptible oxide is formed, to 1,050°, cooled, sectioned, and examined under a microscope for the nature and distribution of scale constituents. These experiments were supplemented by isothermal heating at 700°–960° for up to 20 hr. Oxidic film produced on heating Fe is a result of Fe diffusion outward and of O_2 diffusion inward into the metal. These rates of diffusion, which vary with temperature, specify the character of the scale. Structure of scale produced at or above 910°, the A_3 point of the steel, is greatly different from the scale formed under this temperature, because there is a crystallographic continuity between α–Fe and scale, that is absent in case of γ–Fe. The formation of the scale as a whole follows a parabolic function. Individual constituents of it form according to other curves, Fe_2O_3 and Fe_3O_4 following a straight line and FeO a parabolic function. The influence of temperature on total scaling up to 900° can be presented by the well-known exponential equation.

190. Bénard, J., and Moreau, J. [Kinetic Study of Reduction of Peroxide With Hydrogen.] Compt. rend., vol. 231, 1950, pp. 904–906.

At 500° the curve shows an induction period of 20 min., a period of accelerating reaction 10 min., a period of steady reaction rate 23 min., and a period of decelerating reaction. At 450° the induction period is >2.5 hr., at 550° the induction period is suppressed; at 700° the period of accelerating reaction and period of steady reaction rate are suppressed.

191. Bender, R. J. German Wartime Diesel Fuels Were Blends of Natural and Synthetic Products. Nat. Petrol. News, Tech. Sec., vol. 38, No. 6, 1946, pp. R–104, R–106; BIOS Miscell. Rept. 71, 30 pp.; U. S. Naval Tech. Mission in Europe, Rept. 187–45, 1945, 42 pp.; TOM Reel 200; PB 1,675 and 2,529.

Principal sources of German diesel fuel were the following: (a) Natural-petroleum distillates; (b) synthetic distillate known as Kogasin II, the high-boiling fractions distilled from Fischer-Tropsch low-pressure, low-temperature catalytic process, having a high cetane No., 90–100, but as compared with petroleum diesel fuel of 47-cetane rating, not suitable when used alone because of its higher consumption and the increase of 25% in the exhaust-gas temperature. It was, therefore, used mainly to upgrade the ignitibility of other fuels such as petroleum–gas oil or coal or lignite-tar oil, in which case the mixture is purified by selective extraction; (c) Kogasin I, the lighter fraction distilled in the Fischer–Tropsch process boiling below 430° F. with a cetane number of 35–60; (d) distillates from the low-temperature carbonization of coal and lignite; (e) distillates from the hydrogenation process containing 38–49% aromatics and unsaturates good for blending with Kogasin II; (f) shale oil.

192. Benedicks, C. [Dissertation.] Upsala, 1904, p. 215.

A physical and physicochemical study of carburized steel.

193. Benedicks, C., and Löfquist, H. [Solubility of Oxygen in Iron of Ferrous Oxide (Oxoferrite, Wüstite).] Ztschr. anorg. Chem., vol. 171, 1928, pp. 231–238; Chem. Abs., vol. 22, 1928, p. 3612.

Diagram given for the system Fe–O (abs. 3053) contradicts the fact claimed by Schenck and Dingman (abs. 3052) that the solubility of O is as high as 2.8% (oxoferrite). It is only 0.05%. It has been suggested that traces of Al_2O_3 picked up from the container by Fe_2O_3 would explain the discrepancies. The solubility of O in a pure Fe–O system is so low that it is difficult to admit that this solubility is increased by the presence of foreign matter, MgO for instance.

Benedict, W. S. *See* abs. 2321, 2322.

194. Benesch, F. [Stability of Complex Iron-Manganese Carbides.] Anyagvizsgálók Közlönye, vol. 19, 1941, pp. 1–30; Chem. Zentralb, 1942, I, pp. 1180–1181; Chem. Abs., vol. 37, 1943, p. 2322.

Investigates the stability of complex Fe–Mn carbides in the austenitic 12 and 20% Mn steels (1.1% C). Annealed for a long time at 650°–850°, the free Fe–Mn carbides lose their homogeneity and change their structures similar to the hypereutectoid-carbon steels at corresponding temperatures. In the cases investigated, the hardness and, therefore, the number of precipitated double carbides are a direct function of time and temperature. In the range of carbide precipitation hardness increases steadily; at 650°–850° the double carbides decompose, and in spite of water quenching, hardness decreases and ductility increases. The magnetic properties missing in austenitic steels are also absent in the pearlitelike arrangements of the Fe–Mn carbides despite the fact that pearlite of straight carbon steel is magnetic.

195. Benke, R. [Transfer of Heat From Widely Spaced Tubes to a Transverse Current of Air.] Arch. Wärmewirt., vol. 19, 1938, pp. 287–291.

Question of whether a staggered or a line arrangement of tubes in a system gives better conditions for heat transfer has been discussed often but not definitely answered. Experimental investigations are described from which it is concluded that within the range examined the heat transfer is independent of the arrangement and spacing of the tubes in the system.

Bennett, H. A. *See* abs. 2804.

196. Bennett, J. G. Coal and the Chemical Industry. Jour. Inst. Fuel Wartime Bull., vol. 17, 1944, pp. 185–192.

First J. Arthur Reavell lecture. Discusses existing processes for coal utilization—carbonization, fractionation by solvent extraction, and synthesis of hydrocarbons. The principal defect of the latter process is its wastefulness; only about 30–40% of the coal substance is recovered in the products.

———. *See* abs. 143.

196a. Bennett, M. T. [Industrial Significance of Natural Gas.] Metano, vol. 5, No. 2, 1951, pp. 17–28; Chem. Abs., vol. 45, 1951, p. 4,427.

Review is given describing uses of natural gas followed by a discussion of methods of production of synthesis gas from CH_4 with diagram, description and composition of the gas for production of NH_3.

Bennie, R. S. *See* abs. 56.

197. Benoit, J. [Ten Years Progress in the Chemical Industries, III. Synthetic Organic Chemicals.] Ind. chim., vol. 36, No. 11, 1949, pp. 237–249.

Summary of progress in the fields of synthetic-coal chemistry as exemplified by the Fischer-Tropsch and the Bergius processes, benzene, and acetylene; petroleum chemistry—methane, ethylene, butylene, propylene; oxygenated products—methanol, ethanol, formaldehyde, acetaldehyde, acetone, acetic anhydride, ethylene oxide, and phenols.

198. Benoit, R. [Thermomagnetic Study of Boroferrites.] Compt. rend., vol. 231, 1950, pp. 1216–1218; Chem. Abs., vol. 45, 1951, p. 2355.

Magnetic susceptibilities were determined in the range 0°–1,100° for boroferrites, $B_2O_3 \cdot Fe_2O_3 \cdot xMO$, in which M=Mg, Cu, Co, Ni, and Fe; $x=2$ in the Mg compound and 4 in the others. The Curie constants were, respectively, 8.66, 10.5, 19.8, 16.9, and 20.6. (I) decomposed above 1,100°. Cu (II) changed to Cu (I) at 890°.

Bensmann, C. H. N. *See* abs. 3393.

Benson, H. E. *See* abs. 646, 647, 648.

Benton, A. F. *See* abs. 3681.

199. Benton, A. F., and White, T. A. Adsorption of Hydrogen by Nickel at Low Temperatures. Jour. Am. Chem. Soc., vol. 52, 1930, pp. 2325–2336; Chem. Abs., vol. 24, 1930, p. 3937.

Adsorption of H_2 on Ni was studied at pressures 0–1 atm. and at 11 temperatures between —210° and 110°. At a given pressure the adsorption is relatively large at the lowest temperature, decreasing to a minimum at between —200° and —175°, then rising to a maximum in the neighborhood of —100°, and finally decreasing again at higher temperatures. At 600 mm. the adsorption is constant between —100° and 0°, presumably indicating the formation of a monomolecular layer of adsorbed gas in this region. All adsorption values are easily reversible with respect to pressure. However, on cooling to about —190° a sample previously brought to equilibrium at 0°, the adsorption does not decrease to the value obtained isothermally at —190° but reaches a new reversible equilibrium at which larger quantities of gas are adsorbed than at 0°. For some unexplained reason, at —191° and —183° the adsorption increases in a discontinuous manner with increase of pressure.

200. ———. Sorption of Gases by Iron. Jour. Am. Chem. Soc., vol. 54, 1932, pp. 1820–1830; Chem. Abs., vol. 26, 1932, p. 3712.

Sorption of N_2, CO, and H_2 was studied on reduced Fe at temperatures 195°–400°. At the low temperatures sorption consists solely of physical adsorption. Activated adsorption takes place at higher temperatures. The rate of this process is greatest for CO and least for N_2. With H_2 at 110° and above, a probable solution of the gas occurs. A stepwise increase in the adsorption at low temperatures suggests the accumulation of definite layers of molecules.

Berg, A. *See* abs. 1389.

201. Berg, C. Hypersorption Process for Separation of Light Gases. Trans. Am. Inst. Chem. Eng., vol. 42, 1946, pp. 665–680.

Hypersorption is a light hydrocarbon recovery process developed by the Union Oil Co. of California to permit processing and recovery of hydrocarbons from streams that cannot be handled economically by the conventional recovery processes. The process employs a moving bed of activated C to adsorb hydrocarbons out of lean gas streams. Its applications include the recovery of C_2H_4 from gases produced in thermal and catalytic cracking operations, the recovery of C_3H_8 and heavier components from natural gas, the separation of CH_4 from H_2 and many other separations. Essential operation involves contacting the gas stream with a moving bed of active C that has been previously stripped and cooled to the desired temperature. Separation of the components of the feed takes place in the contacting bed by controlled selective adsorption of the heavier constituents. These are subsequently stripped from the C at an elevated temperature by steam. The stripped C is returned to the top of the unit where it is dehydrated and cooled, and the cycle of operation is repeated.

202. Berg, C., Fairfield, R. G., Imhoff, D. H., and Multer, H. J. Hypersorption. Oil Gas Jour., vol. 47, No. 52, 1949, pp. 95, 97, 130, 132, 135; Petrol. Refiner, vol. 28, No. 11, 1949, pp. 113–120.

The hypersorption process for the separation and recovery of light gases is operating in 2 commercial units, with others under construction. A moving bed of activated carbon absorbs hydrocarbons out of lean gas streams at low pressure. The general construction of a typical plant is described and its operation outlined. It can be utilized for recovering C_2H_4 from refinery gas or coke-oven gas at an efficiency of 98%, recovering C_3H_8 and butanes from natural gas, purifying hydrogenation gases, and separating CO_2 and S compounds from synthesis gas.

203. Bergbau. [Motor Fuel From Fischer-Tropsch Process.] 1937, pp. 2–10.

It is estimated that German production of motor fuel by the Fischer-Tropsch process is 150,000 tons per yr.

Berger, G. *See* abs. 1710,1711.

Bergo, G. Y. *See* abs. 2088, 2089.

204. Berkman, S., Morrell, J. C., and Egloff, G. Catalysis. Reinhold Pub. Co., New York, 1940, pp. 685–689, 813–814.

Catalytic synthesis of MeOH, industrial process, and catalytic hydrogenation of CO are covered.

205. Berl, E., and Bemmann, R. [Catalytic Experiments With High-Pressure Circulation Apparatus.] Ztschr. angew. Chem., vol. 44, 1931, pp. 34–39; Chem. Abs., vol. 25, 1931, p. 1432.

Water gas was subjected to catalytic high-pressure synthesis in a circulation apparatus in which the liquid-reaction product is separated from the gas mixture. A sketch of the apparatus and details of the design of the high-pressure bomb, separating vessel, fittings, and device for measuring gas velocity are given. The results, in general, confirmed data reported in the literature. Alkali-free ZnO catalyst forms MeOH chiefly. In contrast, higher alcohols, acids, and aldehydes are formed by using an alkali-containing ZnO. S has an injurious effect on the catalyst. The preparation and reduction of the catalyst are very important. The gas velocity over the catalyst has considerable influence on the reaction. With increasing velocity more unstable intermediate compounds are obtained, while at low velocities the stable end products predominate.

206. ———. [Effect of Hydrogen on Charcoal and Active Carbon and the Methane Synthesis.] Ztschr. physik. Chem., vol. A162, 1932, pp 71–93; Chem. Abs., vol. 27, 1933, p. 223.

Pressure hydrogenation of charcoal and activated C gives CH_4 almost entirely. The thermodynamic equilibrium leads to certain conclusions on free energy of para-crystalline C. Natural C gives liquid hydrocarbons, but since charcoal and activated C give none of them, their structure must be fundamentally different. Presents views of the structure and reaction mechanism.

207. Berl, E., and Jüngling, K. [Synthesis of Higher Hydrocarbons From Water Gas at Atmospheric Pressure.] Ztschr. angew. Chem., vol. 43, 1930, pp. 435–440; Chem. Abs., vol. 24, 1930, p. 3984.

In the Fischer and Tropsch water-gas reaction (*see* abs. 1018), an Fe catalyst gives a different course of reaction than a Co catalyst; Fe reacts with CO, Co with H_2. In the preparation of catalysts, it is best to start with metal nitrates and convert them to oxides or metals. The presence of Cu in a catalyst is advantageous. Co catalysts are more active than Fe catalysts, the former converting O_2 to H_2O the latter O_2 to CO_2. The method of reduction is important in catalyst preparation. It must be done slowly at low temperature, preferably not above the operating temperature. The same precautions are needed in catalyst regeneration. With Co, heating in H_2 to about 330° is best. With Fe, heating in pure H_2 is not satisfactory; air regeneration at about 400° and reduction by water gas at the operating temperature is preferable. Catalysts can operate for weeks or months without regeneration.

208. Bernier, R. [Thermomagnetic Study of Iron and Nickel Carbides. I. Nickel Carbides. II. Nickel Nitrides. III. Cementite. IV. Iron-Nickel Carbides.] Ann. chim., vol. 6, No. 12, 1951, pp. 104–161.

I. Dispersion of Ni in ThO_2 makes carburization easier. In $2:1=H_2:CO$, carburization took place at 150°–200°. No hexagonal carbide was obtained for unsupported Ni. Only with 10–30% ThO_2 was the cubic phase eliminated by carburization. In pure CO the carburization conditions differ from those for synthesis gas. Chemical analyses were inconclusive but reported in detail. X-ray diffraction pattern for hexagonal Ni_3C is given; $a=2.646$ Å, $c=4.320$ Å, $c/a=1.633$ Å. Thermomagnetic study showed decomposition starting at 210°, and Curie point of product at 314°. Product is face-centered cubic with $a=3.529$ Å (Ni, $a=3.516$ Å). On further and higher-temperature heating, the Curie point gradually goes up to normal, and a goes down to normal, showing that a face-centered cubic carbide had been transformed homogeneously to Ni+C. H_2 starts attack at 206° and leads to Ni with Curie point=359° and normal a. The face-centered cubic carbide is believed to be Ni_4C and is assumed to be intermediate in the Ni_3C formation. No real proof is given for the formula Ni_4C. In N_2, decomposition of Ni_3C starts at 276°; in H_2 at 171°; and in CO at 440°. In all cases the product went through a lower face-centered cubic carbide stage. 19 refs.

II. NH_3 passed over reduced Ni supported on ThO_2 at 170° leads to hexagonal close-packed Ni_3N, which is always contaminated by face-centered cubic Ni_4N. Thermomagnetic analysis seems to indicate that the hexagonal close-packed product is paramagnetic. It starts to decompose near 190° C into the face-centered cubic ferromagnetic nitride with Curie point=342°. X-ray diffraction data fit hexagonal close-packed phase with $a=2.668$ Å, $c=5.294$ Å, $c/a=1.609$ Å. For the face-centered cubic phase, $a=3.521$ Å. It is concluded that nitriding goes by way of face-centered nitride to hexagonal close-packed nitride. The latter reacts with H_2 at 155°, decomposes in N_2 near 450°. 8 refs. III. Gives discussion and bibliography on the thermal stability of Fe_3C. Fe_2O_3 and reduced Fe powder were treated with $2\ H_2+CO$ at 560°–1,000°. Heating at 800° for 24 hr. of mixtures of carbonyl Fe with acetylenic C or C from CO produced Fe_3C. Fe_3C made with $2\ H_2+O_2$ at 560° had a Curie point of 210° and at 1,000°, a Curie point of 216°. This spread is believed to be due to slight differences in composition, the former being richer in C than the latter. Stepwise destruction of the former gave higher Curie points with each step and partial reduction with H_2 at 500°. At 900°, 28.3% was destroyed after 4 hr., 29.9% after 19 hr.; at 1,050°, 48% was destroyed after 2 hr., 71% after 17 hr., and 79% after 37 hr. Partial destruction at these 2 temperatures and subsequent heating at 800° showed reformation and new formation of Fe_3C in the former case but no change in the latter. The difference is attributed to differences in crystallinity of the C. Fe_3C reacts with H_2 at 590° and with N_2 at 690°. 23 refs. IV. Fe–Ni–C alloys were prepared from Fe and Ni salts (with about 20% ThO_2 added for >30% Ni) in solution, precipitated with boiling K_2CO_3 solution, washed, dried, granulated, and reduced at 450°–600°, depending on the Fe content. Ferronickels were studied. Temperature of carburization varied between 170° and 560°. From 0–40% Ni, substituted cementite was formed (I); from 40–70% Ni, a mixture of (I) and substituted hexagonal close-packed Ni_3C (II) was formed; from 70–100%, Ni only (II) was formed. The Curie point of (I) varies with composition from 210° (0% Ni) to 234.5° (23.5% Ni) to 231° (30% Ni), and the recalescence decreases from 770° and 682° (0% Ni) to 572° (30% Ni). (II) decomposes on heating to form ferromagnetic face-centered cubic carbide, starting at about 210°. In a mixture of (I) and (II) a Curie point of 150° was found for (I), showing that the Curie point drops sharply when >30% Ni is added. A graph of Curie point of (I) versus % Ni is given. (I) was stable up to 600° (II) was stable up to 480° in vacuum. (I) is less stable than pure Fe_3C. 150° is the Curie point limit of (I) for about 40% Ni. 16 refs.

———. *See* abs. 2271, 2276.

209. Bernier, R., and Michel, A. [Hexagonal Phase Appearing in Evolution of Fischer Nickel Catalyst.] Bull. soc. chim., France, 1948, p. 1073.

Ni dispersed on ThO_2 forms a hexagonal carbide during the synthesis with 6–7% C. The hexagonal close-packed structure has $a=2.64$ Å, $c=4.32$ Å, $c/a=1.63$. The paramagnetic carbide is destroyed in vacuo at 210° and forms a ferromagnetic face-centered cubic phase with Curie point=314°.

210. Berr, R. [Recent Developments in Chemical Industry.] Chim. et ind., vol. 17, 1927, pp. 3–20; Brennstoff-Chem., vol. 8, 1927, pp. 205–211; Chem. Zentralb., 1927, II, p. 1497; Chem. Abs., vol. 22, 1928, p. 648.

Discussion is given of progress in the manufacture of synthetic NH_3, hydrocarbons, and MeOH, also the Bergius process, the Fischer-Tropsch process, industrial H_2, and synthesis in organic chemistry.

211. ———. [Progress of Industrial Chemistry From F. Kuhlmann to Berthelot.] Bull. soc. encour. ind. nat., vol. 138, 1939, pp. 152–174; Ind. chim., vol. 26, 1939, pp. 89–96; Génie civil, vol. 114, 1939, pp. 104–109.

Discusses ammonia and synthetic nitrates, synthetic MeOH, the hydrogenation of coal, the Fischer synthesis, the chemistry of C_2H_4 and C_2H_2, artificial rubber, the chemistry of petroleum, and antiknock agents.

212. ———. [Progress of Industrial Chemistry With Respect to Hydrocarbon Synthesis.] Rev. pétrolifère, No. 829, 1939, pp. 370–372.

Reviews the hydrogenation of coal and the Fischer synthesis. Stresses economic and military aspect of the problem of synthetic fuels.

213. ———. [Water Gas and Commercial Synthesis.] Ind. chim. belge, vol. 32, 1945, pp. 153–170; Chaleur et ind., vol. 26, No. 244, 1946, p. 68 D; Chem. Abs., vol. 40, 1946, p. 7566.

Contents of a paper presented in May 1943 before L'École Superieure des Mines. Discusses manufacture of water gas and the thermal balance of its production, the utilization of water gas for the production of H_2 and NH_3, proportions of CO and H_2 necessary, and utilization for the synthesis of alcohols and fuels. The following systems are described: Didier with external heating; Pintsch and Koppers with circulation of hot air; Winkler with the use of O_2; and the Lurgi pressure system.

214. Bertaut, F. [Coercive Force and Crystallite Size.] Compt. rend., vol. 229, 1949, pp. 417–419.

Coercive force of Fe powders prepared at different temperatures by H_2 reduction of the formate show marked peak (~1,000 gauss) for size, about 200 Å. This is generally in accord with Néel's views on shape anisotropy and the results suggest a critical size below which the Fe crystallites behave paramagnetically, but traces of Fe_2O_3 may complicate the interpretation.

215. Bertaut, F., Bochirol, L., and Blum, P. [Synthesis and Space Groups of the Boroferrites.] Compt. rend., vol. 230, 1950, pp. 764–765; Chem. Abs., vol. 44, 1950, p. 5749.

Boroferrites of the composition A.4MO, where $A=Fe_2O_3$ or B_2O_3 and M=Ni, Co, or Cu, were prepared by dissolving the oxides in alkali borates and slowly cooling the solutions. Acidification with HNO_3 gave long, crystalline needles. The unit crystal contains 2 mol. of A.4MO; the lattice parameters are given. Boroferrites of the composition A.2MO (M=Mg, Fe, Co, or Ni) are all paramagnetic at ordinary temperature.

216. Berthelot, C. [Composition of Coal and Its Utilization in the Chemical Industry.] Bull. soc. encour. ind. nat., vol. 126, 1927, pp. 485–511; Chem. Abs., vol. 22, 1928, p. 152.

Address reviewing present-day knowledge of the chemical composition and constitution of coal and its possible applications in the manufacture of MeOH, EtOH, petroleum hydrocarbons, and NH_3, more particularly from the standpoint of supplying the French market with products prepared from domestic raw materials.

217. ———. [New Views on the Chemical Utilization of Coal.] Bull. soc. encour, ind. nat., vol. 127, 1928, pp. 822–854; Bull. soc. ing. civ. France, vol. 81, 1928, pp. 1105–1181; British Chem. Abs., 1929, B, p. 344; Chem. Abs., vol. 23, 1929, p. 2012.

General review of the coal question, the following being briefly considered: (a) General methods for the chemical utilization of coal including high- and low-temperature carbonization, hydrogenation, reduction of CO with Badische Anilin- und Soda-Fabrik patents of 1913–1914, synthesis of MeOH. Patart's patent, Fischer's synthol, Fischer's and Tropsch's hydrocarbons, Kling and Florentin's process, and Bergius process; (b) N_2 question including preparation of $(NH_4)_2SO_4$ from gypsum, mixed fertilizers, $(NH_4)_2HPO_4$, and Claude's "potazote;" (c) the general organization for fuel and synthetic NH_3 manufacture, with some Norwegian, Italian, German, and French financial data.

218. ———. Chemical Utilization of Coal—Its Methods of Realization. Proc. World Eng. Cong., Tokyo, 1929, vol. 32, 1931, pp. 309–338. Chem. Abs., vol. 26, 1932, p. 578.

Review of synthetic-chemical industries that depend directly on coal: Coal-hydrogenation, synthetic-MeOH, and N-fixation industries are included.

219. ———. [Cost of Hydrogen Necessary for Manufacture of Synthetic Gasoline.] Chim. et ind., vol. 34, 1935, p. 815.

Average cost of H_2 from water gas used in the synthesis of gasoline amounts. at 30 centimes/m.^{3}, to 600 or 1,200 francs/ton of gasoline, depending upon the process used—Bergius or Fischer-Tropsch. Thus, the cost of the necessary H_2 is more than the cost of natural gasoline. By carbonizing coal at 900°–920°, 300 m.^{3} of a gas containing 72–74% H_2 can be recovered/ton treated. The cost of a 95% H_2 from this source is much less than that from water gas. Abstract of a paper presented at the XVth Congres de Chimie Industrielle.

220. ———. [Evolution of Semicarbonization and the Manufacture of Synthetic Carburants.] Génie civil, vol. 106, 1935, pp. 353–357, 384–387; Chem. Abs., vol. 29, 1935, p. 8293.

Comparison, with drawings, of modern practice in France, England, and Germany is presented. Germany will be able to make 500,000 tons of motor fuel annually by the Bergius process at Oppau, and 100.000 tons by the Fischer-Tropsch process. State experimental hydrogenation plants are to be laid down in France. The present trend in the synthetic preparation of motor fuels is outlined, the heavy capital investment required by the Bergius process is mentioned, and the need for subsidies to cover the difference between the cost of natural and synthetic fuels is emphasized. Attention is drawn to the attractive features of the Fischer process, particularly its operation at atmospheric pressure and relatively low temperatures, its moderate capital cost, and its utilization of existing coke ovens. On the other hand, the octane number of the fuel produced is from 47 to 62, requiring antiknock additions.

221. ———. [New Sources of Production of Hydrogen.] Ind. chim., vol. 22, 1935, pp. 406–407; Chem. Abs., vol. 29, 1935, p. 6370.

Attention is drawn to the possibility of producing cheap H_2, suitable for the synthesis of NH_3 or for the manufacture of gasoline by the Fischer-Tropsch process, by the carbonization of anthracite agglomerates (manufacture of artificial anthracites) and by injection of steam in coke ovens.

222. ———. [Synthetic Gasoline.] La Nature, No. 2958, 1935, pp. 121–124; Chem. Zentralb., 1936, I, p. 689; Chem. Abs., vol. 29, 1935, p. 8304.

Commercial application of various processes by I. G. Farbenindustrie, A.-G. at Leuna and at Oppau, Germany, is described. Hydrogenation is conducted at 425° under 200 atm. pressure in the presence of $Sn(OH)_2$, Ni, Co, or Fe as catalysts. Improvement in the Fischer-Tropsch synthesis is reported, especially the heat exchange, better catalysts, and a more valuable, more knock-resistant Kogasin fuel. Kogasin II lubricating oil has a constant viscosity between +25° and −25°. a pour point about 26° lower and a specific gravity about ⅙ less than the corresponding winter oil from Pennsylvania crude.

223. ———. [Large Gas Generators for the Production of Water Gas.] Génie civil, vol. 109, 1936, pp. 103–106; Chem. Abs., vol. 30, 1936, p. 7308.

Drawings and description of the Winkler and Didier systems are given. The thermal efficiency of the latter plant is about 75% and the total cost about $0.15/1,000 cu. ft. of gas using lignite briquettes at $4.00/ton.

224. ———. [Lubricants From Coal and Lignites.] Chim. et ind., vol. 36, 1936. pp. 270–280; Chem. Age, vol. 35, 1936. p. 139; British Chem. Abs., 1937, B, p. 864.

Fischer and Bergius processes are described. The former embodies non-catalytic polymerization of hydrocarbons, catalytic polymerization of olefins, dechlorination of chlorinated hydrocarbons and condensation of these with olefins, and condensation of chlorinated products with aromatic hydrocarbons. It is shown that ethylene and paraffins, byproducts of the Fischer process, constitute an important source for the production of lubricants.

225. ———. [Manufacture of Synthetic Gasoline.] La Nature. 1936, pp. 155–162; Chem. Abs., vol. 30, 1936, p. 4647.

Detailed discussion is presented with flow sheets and illustrations to show the methods used for commercial production of gasoline from charcoal in France, Germany, and England.

226. ———. [Metallurgical Problems Presented in Making Hydrogenation Tubes and Cracking Chambers.] Rev. mét., vol. 33, 1936, pp. 566–573, 619–626, 677–690, 727–746; Chem. Abs., vol. 31, 1937, p. 1738.

Phenomena taking place during working of the equipment used for hydrogenation and cracking are described and methods for meeting them suggested. The qualities required in metals for the above uses are summarized. A survey of published data is given.

227. ———. [Respective Advantages and Disadvantages of the Bergius and Fischer Processes for Production of Synthetic Liquid Fuels.] Chim. et ind., vol. 35. 1936, pp. 768–791; Coal Carbonisation, vol. 2. 1936, p. 222; Chem. Abs., vol. 30, 1936, p. 4647.

From an extensive comparison it is concluded that the 2 processes are complementary rather than competitive. The great distinction is that in one case the coal molecule is reduced from about 2,000 to the molecular weight of gasoline, about 100, by reconstitution with the addition of H_2, while in the other case it is completely destroyed and the hydrocarbon is built up synthetically from CO. The Fischer process is incomparably simpler than high-pressure hydrogenation in the choice of raw material, since any fuel is satisfactory that gasifies with a suitable yield of CO and H_2. Choice of fuels for hydrogenation is relatively narrow. Equipment required for the synthesis of gasoline is very simple and comparatively inexpensive. On the other hand, the hydrogenation process has a higher thermal efficiency, 43% of the heat content of the coal being available in the motor fuel, compared with 35% of the heat input recovered in synthetic gasoline. In the hydrogenation process, 4 ton of coal yields 1 ton of gasoline, 24% aromatics, 28% naphthenes, 7% olefins, sp. gr. 0.78, octane number 70–85. The Fischer-Tropsch process yields 195 lb. gasoline, octane number 50–60, from 1,000 lb. of coal of 12,600 B. t. u./lb. net calorific value. On the basis of stated capital costs for plant of 50,000 ton annual output, the cost/gal. of gasoline is about 7.9–8.6 d. by the Fischer-Tropsch process and 9.6–10.6 d. by hydrogenation.

228. ———. [Sources of Hydrogen for Production of Liquid Fuels.] Cong. chim. ind., 15th Cong., Brussels, 1936. pp. 833–846; Brennstoff–Chem., vol. 16, 1935, p. 430; Chem. Abs., vol. 30, 1936, p. 5756.

Assuming 2,000 and 4,000 m.^{3} of H_2 is required, respectively, for the Bergius and Fischer processes and that H_2 from water-gas costs 30 centimes/m.^{2}, it is estimated that the cost of H_2 required for 1 metric ton of gasoline would be 600 francs for the Bergius process and 1,200 francs for the Fischer process. Much cheaper H_2 could be obtained from the carbonization at 900°–920° of anthracite agglomerates, which can give 300 m.^{3}/ton of gas containing 72–74% of H_2.

229. ———. [Synthetic Motor Fuels in Belgium and France.] Génie civil, vol. 108, 1936, pp. 59–62; Mech. Eng., vol. 58, 1936, pp. 377–378.

There are enough sources of coke-oven gas in Belgium to provide 20% of the gasoline requirements in the form of MeOH. Technically and commercially the Bergius and Fischer-Tropsch processes are capable of producing fuels suitable for any admixture with natural gasoline or for replacement of natural gasoline. The choice between these 2 methods depends on the nature of the coal available and the means of producing H_2. Operating conditions in these 2 processes and some recent developments are noted.

230. ———. [Economic Problems Raised by Production of Synthetic Fuels for Internal-Combustion Engines.] Compt. rend., Cong. chim. ind., 17me, Paris, September-October 1937, pp. 424–429; Chem. Abs., vol. 32, 1938, p. 6429.

General discussion. The possibilities of existing synthetic processes and of substitutes for liquid motor fuels are discussed from the viewpoint of French national policy.

231. ———. [Extraction of Hydrogen From Coke-Oven Gas for use in the Manufacture of Synthetic Gasoline.] Génie civil, vol. 110, 1937, pp. 459–461; Chem. Abs., vol. 31, 1937, p. 7626.

Messer process is described with a drawing showing the operation. A gas containing 98–99% H_2 is obtained.

232. ———. [High-grade Fuels and Lubricants for Internal-Combustion Engines.] Chim. et ind., vol. 37, 1937, pp. 1043–1055; British Chem. Abs., 1937, B, p. 869.

Specifications for various grades of petrol are discussed. Aviation spirit for use at high altitudes should have high octane number and relatively close distillation range. Gum formation is also a greater hazard than in automobile use and this constitutes a difficulty for petrols prepared by the Fischer process or from shale oil. Lubrication requires an oil stable at 150°. Specifications for lubricants are discussed and the advantages of refining with solvents are pointed out. Satisfactory synthetic lubricants can be produced by hydrogenation or by $AlCl_3$ treatment of oils produced by the Fischer synthesis; chlorination of this material and condensation with an aromatic hydrocarbon gives Paraflow, which depresses the setting point of paraffin lubricants.

233. ———. [Production of Fuels by Catalytic Hydrogenation of Carbon Monoxide.] Génie civil, vol. 110, 1937, pp. 497–501; Chem. Abs., vol. 31, 1937, p. 7621.

Details are given of the manufacture of MeOH at the Mines de Béthune. Operating at pressures of 50–600 atm. and temperatures of 275°–600° C., according to the purity of the gas, the product is MeOH, whereas at atmospheric pressure and a temperature of 175°–200° gasoline is produced. Examples are given of the catalysts used in the respective cases and the production of MeOH and gasoline in various countries is reviewed. Process for making EtOH from the C_2H_4 in coke-oven gas is also described. Discusses also the synthesis of gasoline by the Fischer and Robinson–Bindley processes, the elimination of organic S from industrial gases, and the composition and preparation of catalysts.

234. ———. [Realizable Progress in Hydrogenation.] Génie civil, vol. 110, 1937, pp. 53–60, 86–90; Chem. Abs., vol. 31, 1937, p. 4082.

Deals mainly with researches in progress with a view to reducing the cost of gasoline made by direct hydrogenation of coal or lignite. Description is given with illustration of an intermittent conversion plant used at a Pas-de-Calais colliery to produce the gas mixture required by the Fischer process.

235. ———. [Synthetic Liquid Fuels Resulting From Reduction of Carbon Monoxide by Hydrogen: Methanol, Fischer Gasoline.] Chim. et ind., vol. 37, 1937, pp. 211–223; Chem. Abs., vol. 31, 1937, p. 4083.

General description, discussion, and comparison of the relative merits of the production of MeOH and of Fischer gasoline, respectively, by the action of H_2 on CO under various conditions. The choice between hydrogenation and these synthetic processes for the production of motor fuel depends largely on the nature and quality of the raw material available. The position in France is briefly discussed.

236. ———. [Synthetic Motor Fuels.] Mines, carrières, No. 172, 1937, pp. 5–6; Coal Carbonisation, vol. 3, 1937, p. 150.

An outline is given of papers relating to the production of MeOH and Kogasin by catalytic reduction of CO with H_2, and the hydrogenation processes of Bergius, Vallettee. Audibert, and Pott-Broche. The work of successive investigators is summarized, especially as regards the temperatures and pressures used. In October 1936, 11 plants, including those of the Béthune and Liévin mines, were using stepwise hydrogenation in liquid and gaseous phases successively. The 2d type of hydrogenation process, depending on preliminary extraction by solvents and subsequent direct hydrogenation in the gaseous phase, is being applied by the Mathias Stinnes concern in Essen. The author emphasizes the serious cost of large, high-pressure, high-temperature catalytic tubes of special steel and commends from this standpoint the Vallette and Audibert processes.

237. ———. [Economics of Synthetic Fuels Industry.] Génie civil, vol. 112, 1938, pp. 409–413.

A discussion of the reports by Lord Falmouth of Great Britain and Sir David Rivett of Australia.

238. ———. [Evolution of Processes for Production of Motor Spirit by Catalytic Reduction of Carbon Monoxide by Hydrogen.] Chim. et ind., vol. 40, 1938, pp. 434–460; Chem. Abs., vol. 33, 1939, p. 3106.

Critical review and discussion from which it is concluded that the most satisfactory economical procedures would be to combine hydrogenation of liquid products with a catalytic-reduction process of CO by H_2.

239. ———. [Conversion of Methane Into Carbon Monoxide and Hydrogen.] Rev. chim. ind. (Paris), vol. 48, 1939, pp. 194–198; Chem. Abs., vol. 33, 1939, p. 8562.

Review of various processes for the conversion of OH_4 into H_2 and C, CO, or CO_2 with special emphasis on a process involving the reaction of CH_4 with a mixture of O_2 and steam in the presence of active Ni, whereby CO (with some CO_2) and H_2 are formed. In this latter process the CH_4 reacts mainly with the O_2.

240. ———. [Conversion of Methane into Hydrogen and Carbon Monoxide. Process of the Société belge de l'azote at Renory.] Génie civil, vol. 115, 1939, pp. 461–464; Chem. Abs., vol. 34, 1940, p. 2541.

Continuous catalytic process recently developed. which works under atmospheric pressure, is reviewed with 2 diagrams.