

Synthesis of benzene was carried out using gas containing CO and H₂ in the ratio 1:2 and a catalyst of the composition of CO:Cu:ThO₂=9:1:1 at 197° under pressure of 7-369 mm. It was found that the relation $r = ap^b$ holds between the reaction pressure, p , and r , which represents the yield of oil, contraction of gas volume, or consumption of CO, with a and b as constants. As the above formula is of the same form as that of Freundlich's adsorption isotherm, $y = ap^b$, it is observed that there is a direct relation between the consumption of CO and the adsorption of CO. The formula $r = ap^b$ holds only when p is 30-200 mm. Below 30 mm. b increases gradually to 1 at a very low value of p , whereas, above 200 mm. b gradually decreases to zero at a large value of p . When the feed gas passes through the catalyst layer, the relation between the distance traversed L and the partial pressure P , can be expressed by a general formula $1/bp_1^b - 1/bp_2^b = aL$. Since this is a hyperbola, the rate of reaction in the catalyst layer can be represented by a hyperbola.

3613. WATANABE, T. Poisoning Effect of Certain Substances on the Iron Catalyst in the Decomposition of Carbon Monoxide. Bull. Inst. Phys. Chem. Research (Tokyo), vol. 7, 1928, pp. 1073-1087 (abs. I, 102-103); Chem. Abs., vol. 23, 1929, p. 1560.

CO from formic acid is decomposed in an Fe pipe on Fe gauze, and the gas is analyzed. The effects of H₂O, N₂, H₂, CH₄, C₂H₆, C₂H₄, C₂H₂, H₂S and C₂H₆S on the catalyst are investigated. N₂, CH₄, C₂H₆ and C₂H₄ have no effect, except that C₂H₆ liberates C. H₂O gives some CO₂, H₂ and CH₄. H₂ gives CH₄. Naphthalene causes a progressive drop in the catalytic efficiency, but the fall is temporary; by passing pure CO over the poisoned catalyst, the initial efficiency is recovered. S compounds kill the catalyst.

3614. WATASE, T. Heat of Formation of Cementite. Sci. Repts. Tohoku Imp. Univ., vol. 17, 1928, pp. 1091-1109; Chem. Abs., vol. 23, 1929, p. 1046.

Cementite prepared by subjecting plates of C steel (2% C) to electrolysis with N HCl and a current density of 0.075 amp. per cm.² was burned in a Berthelot-Mahler bomb calorimeter, and its heat of combustion was determined. From the observed amount of heat evolved and the composition of the combustion residue, the heat of the reaction Fe₃C+3 O₂=Fe₃O₄+CO₂ was found to be 366.3 kcal. From this figure and those found in the literature for the formation of Fe₃O₄ and for CO₂, the heat of formation of cementite is calculated to be -4.8 kcal. at 20°.

3615. [Heat of Formation of Cementite.] Ztschr. physik. Chem., vol. 147 A, 1930, pp. 390-395; Chem. Abs., vol. 24, 1930, p. 3702.

Previous value (abs. 3614) for the heat of combustion of Fe₃C was recalculated as 362.5±0.1 cal. and the heat of formation as -2.5 cal., by using the latest thermochemical data of Roth (abs. 2908).

3616. Studies on the Equilibrium: Fe₃C+2 H₂=3 Fe+CH₄. Jour. Chem. Soc. Japan, vol. 54, 1933, pp. 110-132; Chem. Abs., vol. 27, 1933, p. 2368. Equilibrium Fe₃C+2 H₂=3 Fe+CH₄ was studied at 450°-603°. The values ΔF₂₉₈°=-15,803 cal. and ΔH₂₉₈°=-21,822 cal. were obtained.

WATSON, K. M. See abs. 1498a.

3617. WEBER, G. Carthage Hydrocol Project. Oil Gas Jour., vol. 47, No. 47, 1949, pp. 248-250.

First commercial application of the Hydrocol process for converting natural gas to liquid hydrocarbons is slated for initial operation late this year. It was ½ completed at the end of March. The plant location is described, and the company stockholders and officers are listed. Some details of plant operation are presented. Flowsheet outlines process.

WECK, H. I. See abs. 3153a.

3618. WECK, H. I., MEYERSON, S., AND SEELIG, H. S. Hydrocarbon Synthesis-Catalyst Studies. Use of Deuteriochloric Acid. Jour. Am. Chem. Soc., vol. 73, 1951, pp. 2331-2333.

Fe catalysts that have been used in hydrocarbon-synthesis studies liberate H₂ and hydrocarbons when dissolved in HCl. By the use of DCl instead of HCl, it has been proved that these hydrocarbons are derived from Fe₃C and the acid and are not adsorbed synthesis products that were liberated when the catalyst dissolved. From an examination of the methane formed, it has been concluded that stable Fe alkyls do not exist on the catalyst. No exchange was observed between the H₂ in a sample of n-pentane adsorbed on metallic Fe and the D in the acid used to dissolve the Fe.

3619. WEDEKIND, E. [Magnetic Microbalance.] Ztschr. angew. Chem., vol. 41, 1928, pp. 771-774; Chem. Abs., vol. 23, 1929, p. 3.

Modification of the well-known Pascal set-up for measuring the properties of weakly diamagnetic or paramagnetic compounds. The balance is replaced by a microbalance, and the magnet is improved. The principle of the Pascal method remains unchanged. Gives details and diagrams needed for practical use. See abs. 2238, 3622, 3623.

3620. WEDEKIND, E., AND ALBRECHT, W. H. [Distinguishing the Different Types of Ferric Oxides and Hydrated Oxides by Their Different Magnetic Properties. I.] Ber. deut. chem. Gesell., vol. 59, 1926, pp. 1726-1730; Chem. Abs., vol. 21, 1927, p. 526.

3621. [Distinguishing the Different Types of Ferric Oxides and Hydrated Oxides by Their Different Magnetic Properties. II.] Ber. deut. chem. Gesell., vol. 60, B, 1927, pp. 2230-2243; Chem. Abs., vol. 22, 1928, p. 8090.

3622. 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.] Ztschr. anorg. Chem., vol. 202, 1931, pp. 205-208; Chem. Abs., vol. 26, 1932, p. 1535.

3623. [Distinguishing the Different Types of Ferric Oxides and Hydrated Oxides by Their Different Magnetic Properties. IV.] Ztschr. anorg. Chem., vol. 202, 1931, pp. 200-226; Chem. Abs., vol. 26, 1932, pp. 2630-2631.

Data previously reported are correlated and explained. Both natural and pure synthetic oxide hydrates exhibit low magnetic susceptibilities. Although these are normal, they do not always show well-defined X-ray interference patterns. Some preparations with poor X-ray interference patterns are normal, whereas others with characteristic patterns exhibit magnetic abnormality.

3624. WEGHOFFER, H. [Addition of N₂O to Olefinic Double Bonds.] Erdöl u. Kohle, vol. 4, 1951, pp. 1-3; Brennstoff-Chem., vol. 30, 1949, p. 440.

Addition of N₂O to 2-methylbutene-2 was investigated to clarify the structure of the reaction products. In connection therewith, Fischer-Tropsch olefins were converted, and the composition of the reaction products as well as several of the reactions were described. By adding N₂O to olefins, such as 2-methylbutene-2, there are formed, besides crystallized nitrosulfonate, an oily fraction, which, like the nitrous ester of 3-nitro-2-methylbutanol-2, is changed by treatment with NaOH into 3-nitro-2-methylbutanol-2 (nitronitrite). In performing the reaction, saponification with NaOH takes place at once, the nitrosulfonate yielding oximes and the nitronitrite nitroalcohols. The % division of the reaction products depends

largely upon the reaction temperature, furthermore very definite effect of peroxide addition exists. For example, the division at 0° without peroxide gives 7% oxime and 27% nitroalcohol; with 1% benzoyl peroxide, 40% oxime and 60% nitroalcohol. The addition of N₂O to a Fischer-Tropsch heptene in butanol solution yields, among other compounds, a dinitro compound. There are, thus, 3 reaction products available: A nitrosulfonate, a nitronitrite and a dinitro compound, the proportion of each depending upon the chosen reaction conditions (temperature and additives), the solvent agents, and the structure of the olefins.

3625. WEIBERG, M. [Reduction of Iron Ores with Carbon Monoxide, Hydrogen and Methane.] Jernkontors Ann., vol. 124, 1940, pp. 179-212; Chem. Zentralb., 1940, II, p. 3315; Chem. Abs., vol. 34, 1940, p. 6903; vol. 36, 1942, p. 6968.

Review of the equilibrium conditions in reductive Fe oxides with CO, H₂, and CH₄. The approximate relation between the O content of the wüstite and the gas composition at equilibrium in the wüstite region was calculated. On the basis of these calculations, the equilibrium diagram for the systems Fe-C-O and Fe-H-O were extended to include the O curves and the limits of the wüstite region in the phase diagram for the system FeO were corrected. Further, the relation between the equilibrium constants and the temperature was calculated for the reaction H₂O+CO=H₂+CO; for temperatures up to 2,000° and for the reaction C+2H₂=CH₄ for temperatures up to 1,200°, as well as for the formation of CH₄ by reduction with a mixture of CO and H₂. In the reduction with pure CO, the temperature increases about 100°-150°; in the reduction with pure H₂, it drops about 350°. There is no change in temperature with a mixture of 64% CO and 36% H₂. Reduction with CH₄ or coke-oven gas requires addition of so much heat that it can only be carried out in a retort furnace or other equipment with special provision for supplying heat, unless the CH₄ is first converted into a CO-H₂ mixture by oxidation with O₂, H₂O, or CO₂. Because of its greater rate of diffusion, H₂ reduces more vigorously at 1,000° than CO until about 75% of the O contained in the ore has been removed. Beyond this point the reduction velocity with H₂ drops considerably more rapidly than that with CO. Reduction time is shortest with a mixture of CO and H₂. Microscopic investigations showed that the greater reduction velocity of CO toward the end of the reduction probably is due to its carbonizing action on the reduced Fe, which surrounds the remaining small grains of wüstite as a thin scale. As a result of the reaction between the C in the austenite and the O in the wüstite, a gas is formed under high pressure in the boundary region, which ruptures the Fe scale and permits further reduction by the CO. In reduction with H₂, a similar condition may develop, except that only H₂ and not H₂O vapor is able to diffuse through the Fe scale, so that less excess pressure is developed in this case. In the reduction with pure CO at 1,000°, the Fe can be carbonized up to cementite, which does not show the constant composition Fe₃C but rather possesses a certain solvent power for C or Fe so that it forms a homogeneous region in the phase diagram. Upon longer carbonization of reduced Fe at 1,000° with CO, the cementite disintegrates with the separation of C; a heavy deposition of C from the gas phase also takes place. Reduction of a pure magnetite crystal at 1,000° results in the formation of 3 layers: a nucleus of Fe₃O₄, an intermediate layer of wüstite, and a surface layer of pure Fe. This shows that the O₂ passes through the wüstite layer by diffusion in solid solution; no porosity develops in the wüstite layer, only large fissures.

3626. WEIL, B. H. Shale Oil and Other Substitutes for Petroleum. Nat. Petrol. News, vol. 35, No. 31, 1943, p. R-343; U. O. P. Co. Lib. Bull., No. 33, 1943.

Approximate costs of motor fuels from sources, other than petroleum, are as follows: Fischer-Tropsch gasoline from coal, \$0.18 per gal.; from natural gas, \$0.09-\$0.12 per gal.; coal-hydrogenation gasoline, \$0.16, with the possibility that this will be lowered to \$0.12 at some future time; 10% alcohol blend gasoline, \$0.10. This involves alcohol at over \$0.40 per gal. and moreover only 10% of the fuel would be a substitute. These figures represent costs without profit and correspond to about \$0.05 per gal. for petroleum gasoline.

3627. Shale Oil, Other Petroleum Substitutes, and Oil Shortage. Interstate Oil Compact Commission, Quart. Bull., July 1943; Gas Age, vol. 92, No. 13, 1943, pp. 36, 62, 64; Gas, vol. 20, No. 1, 1944, pp. 36, 38.

Approaching depletion of petroleum reserves makes it desirable to supplement United States petroleum production with the production of oil from shale, the Fischer-Tropsch synthesis, the hydrogenation of coal, or the blending of hydrocarbon fuels with alcohol. Discussion deals chiefly with shale oil.

3628. Economic Factors to Determine Fuels of the Future. World Petrol., vol. 16, No. 2, 1945, p. 49.

At present rates of production, United States known reserves of petroleum would last 14 yr., coal 3,000, and natural gas 30. Synthesis of gasoline is at present uneconomic, but fundamental research should be carried on in case of future emergencies. Processes discussed are the Fischer-Tropsch, pyrolysis of oil shale and oil sands, carbonization and hydrogenation of coal, of which the first seems the most attractive. No future shortage of gaseous fuels is expected. Gasolines of 85-90 octane no. will be produced, and car design will undergo relative improvement. Diesel fuels are becoming more important, but it is difficult to predict the future of heavy fuel oil and natural gas.

3629. Fuels of the Future. Petrol. Eng., vol. 16, No. 5, 1945, pp. 156, 158, 160, 162, 164, 166.

Review of our present fuel resources and their possible future development. The Fischer-Tropsch, using natural gas, is almost competitive with crude petroleum. Even with the eventual use of coal as the raw material, this process appears attractive as it may be possible to bring down the cost of synthetic gasoline to as low as \$0.09 per gal., which would be competitive with petroleum at \$2.00 per bbl. A combination of coal carbonization with this process appears possible. Although coal constitutes the best raw material for use in any process for the long-term synthesis of petroleum-like oils, its hydrogenation is so complex and requires such expensive and elaborate equipment that it appears likely to be less attractive than the Fischer-Tropsch process using the same raw material.

3630. Synthetic Lubricating Oils. Nat. Petrol. News, vol. 37, No. 27, July 4, 1945, pp. R-512, 513, 516, 518, 520, 522.

Review containing 204 literature and 376 patent refs. Included are many refs. to the hydrogenation of coal and tar and to the Fischer-Tropsch process.

See abs. 2054, 2055, 2056, 2057.

WEINBERGER, E. B. See abs. 2309, 2310.

3631. WEINGÄRTNER, —. [Regeneration of Cobalt Catalysts of the Gasoline Synthesis by Hydrogenation.] FIAT Reel K25, frames 3,913-3,924, Mar. 21, 1938; PB 70,216.

On the basis of laboratory tests and working experiences, chemical and physical reactions in hydrogenation are explained. From that are developed the conditions for hydrogenation in the plant. It is stated

that 1,000 m³ per hr. for the furnace brings an efficient regeneration and prolongation of the life of the catalyst affected by the paraffin. An increase of production in furnaces with hydrogenation and with more than 2,000 working hours is reported. The disadvantage is that the paraffin is not completely removed and a part is destroyed by catalytic splitting.

See abs. 3270.

WEINIG, R. See abs. 1931.

3632. WEINROTTER, F. Investigation of the Reaction Water Obtained From Middle-Pressure-Synthesis Experiments With Iron Catalysts and Hydrogen-Rich Starting Gas. TOM Reel 101, Doc. PG-21579-NID; transl. of German documents on the Development of Iron Catalysts for the Fischer-Tropsch Synthesis, part II, 1946, pp. 24-26.

Analysis of the saponification fraction of the reaction water boiling below 100° revealed the presence of ketones and the absence of aldehydes. The % of pure alcohol was calculated and expressed in wt. % as follows: MeOH, 0.6, EtOH, 3.2, *n*-PrOH, 1.3, *n*-BuOH, 0.5. Analysis of the fraction boiling above 100° showed 1.7 gm. residue of pure fatty acid, or 0.23 wt. % of the total quantity of reaction water examined. For further identification, the fatty acids were esterified with MeOH in the presence of H₂SO₄. The only fraction obtained was 1.3 cc. of methyl acetate. Methyl formate was not present. The fatty acid mixture contained approximately 80% by wt. of acetic acid. The remainder was made up of the higher homologs of the fatty acid series. Formic acid was not present or at least only in very small traces. In the original reaction water, fatty acids were present in free form up to approximately 80%. (See abs. 936.)

See abs. 1029, 2239a.

WEINTRAUB, M. See abs. 2099, 2100, 2101, 2102, 2103, 2103a.

3633. WEIR, H. M. Oxo Process for Alcohol Manufacture From Olefins. TOM Rept. 6, 1945, 30 pp.; PB 2,047; T. A. C. A.I.M.I.-1.

Report covers the essential features of the Oxo process for producing alcohols from olefins as compiled mostly from seized German documents and interviews with personnel. The 1st stage of the process is operated at 150 atm. and 140°, the 2d at 150-200 atm. and 180°. The standard Fischer-Tropsch catalyst (100 Co-5 ThO-8 MgO-130-200 Kieselguhr) is used generally. The Co of the catalyst is converted partly to Co(CO)₄ in the 1st stage, and this dissolves in the liquid product. Subsequent hydrogenation breaks up the carbonyl leaving the Co in a catalytically active form. Apparently, almost any type of olefins may be used for the feed, but the sources mainly considered were the primary aliphatic olefins produced by the Fischer-Tropsch process and the olefins with double bond at the end of the straight chain obtained by mild cracking of Fischer-Tropsch paraffin gatsch. When diolefins are present, reaction occurs at only one of the double bonds with poor yields. Practically olefin mixtures from C₄-C₁₁ were desired, mainly, since these gave C₄-C₁₁ alcohols, which, after sulfonation, were most effective as detergents. The chemistry of the process is reviewed, and the practical operating conditions are outlined, with some attention being given to the engineering standpoint with flow sheet of the continuous process. The overall cost of alcohol product is calculated at 71 pf. per kg. for the batch process and 60 pf. per kg. for the continuous process or \$0.05-\$0.09 per lb.

3634. High-Pressure Gasification of Coal in Germany. Ind. Eng. Chem., vol. 39, 1947, pp. 48-54; Chem. Abs., vol. 41, 1947, p. 1079.

Details of the construction of equipment, typical operation, and costs for the continuous production of city

gas directly from solid fuel and at high pressure in Böhlen, the first commercial installation in Germany to operate under the conditions described. The fuel used was in the form of a 3-10 mm. brown-coal coke and local brown coal itself. The plant had a capacity equivalent to 15,000,000 cu. ft. of gas at normal temperature and pressure per day. The fuel bed, 1-2 m. deep, in the generator was continuously blasted with a mixture of steam and O₂. The crude gas produced contained some 30% CO₂ and was under some 13 atm. pressure. Suitable cooling, removal of tar and distillate, and other purification under pressure produced a gas with the following typical analysis: H₂, 48-49, CO, 22-24; CH₄, 25-29%; the remainder being higher hydrocarbons, N₂ and CO₂. It had a normal heating value of 470-490 B. t. u. per cu. ft.

WEISCHER, A. See abs. 1930.

3635. WEISER, H. B., AND MILLIGAN, W. O. Constitution of Colloidal Systems of the Hydrrous Oxides. Chem. Rev., vol. 25, 1939, pp. 1-30; Chem. Abs., vol. 33, 1939, p. 9088.

3636. Electron-Diffraction Study of Hydrrous Oxides Amorphous to X-Rays. Jour. Phys. Chem., vol. 44, 1940, pp. 1081-1094; Chem. Abs., vol. 35, 1941, p. 951.

Hydrrous oxides that give X-ray-diffraction patterns of the amorphous type may be grouped in 2 classes: (a) Oxides that give relatively sharp ring electron-diffraction patterns and (b) oxides that give electron-diffraction patterns of the amorphous type. The oxides of the 1st class are crystalline, but the primary crystal size is so small that the X-ray-diffraction pattern consists of broad bands. The precipitated oxides of the following metals belong in this class: Fe^{II}, Al (from sulfate), Ga, Ti^{IV}, and probably Be. The oxide gels of the 2d class are amorphous in the sense that glasses are amorphous, the atoms arranging themselves in the form of a network lacking the periodicity and symmetry that characterize a crystal lattice. The following precipitated oxides belong in this class: Cr, Si, Cb^V, and Ta^V. Fe₂O₃ gel thrown down at room temperature consists of minute crystals of α -Fe₂O₃. The oxide gel from Al₂(SO₄)₃ like that from AlCl₃ and Al(NO₃)₃ is γ -Al₂O₃·H₂O. Gallia gel precipitated at room temperature is made up of minute crystals of α -Ga₂O₃.

3637. WEISS, —, AND HAASE, —. [Analysis of the Fatty Acids for Soaps Made From Riebeck Paraffin and Fischer Gatsch.] FIAT Reel R-19, frames 6,333-6,566, May 6, 1940; PB 73,504; TOM Reel 300.

Fatty acids obtained from the above sources were decomposed into their individual components. The method, therefore, is described fully. The content of monocarboxylic acids (straight chain, branched, unsaturated) and their quantitative distribution on the basis of the chain length are determined. The examination is made by fractional distillation of the methyl esters in vacuum after adsorption on silica gel of all other acids that are not included in the examination. Results presented in 17 graphs and figs.

WEISS, B. See abs. 2234.

3638. WEISS, P. [Equation of Magnetic State and Variation of Atomic Moment.] Compt. rend., vol. 180, 1925, pp. 358-361; Chem. Abs., vol. 19, 1925, p. 1653.

By using data previously obtained for Ni, curves are given that establish a relation between the magnetization σ , the field H , and the absolute temperature T . Systematic divergences from the relation $H_m = n\sigma$, where n is a constant, are ascribed to an intra-atomic change by which Ni passes from 3 to 8 magnetons.

3639. WEISS, P., AND FORRER, R. [Magnetic Heat Phenomenon and the Specific Heat of Nickel.] Compt. rend., vol. 178, 1924, pp. 1347-1351; Chem. Abs., vol. 18, 1924, p. 1941.

Magnetic heat phenomenon is defined as the reversible emission of heat that accompanies magnetization. It is here considered as a function of the magnetic field that produces it, leaving to a later date its study as a function of the intensity of magnetization. The elevation of temperature ΔT as a function of the variation of the field ΔH is given by the magnetic analog of the Clapeyron formula: $C_H \Delta T = T(d\sigma/dT)\Delta H$, where C_H is the specific heat in a constant field and σ is the specific magnetization. Data and 2 graphs of ΔT versus H , and 1 graph of C_H versus T are given.

3640. [Magnetic Isotherms of Nickel.] Compt. rend., vol. 178, 1924, pp. 1046-1049; Chem. Abs., vol. 18, 1924, p. 1941.

Magnetic isothermal diagrams for Ni are given and discussed for the range 20°-405° and $H=0-21,000$ gauss.

3641. [Magnetization and the Magnetocaloric Phenomena of Nickel.] Ann. Physik, vol. 5, 1926, pp. 153-213; Chem. Abs., vol. 20, 1926, p. 1941.

Discussion of the experimental data relevant to the establishment of the equation of state of a magnetic substance. The following topics, in particular, are discussed: (1) Magnetization of Ni as a function of field and temperature in the range 20°-630°; (2) reversible temperature variations in relation to specific heat; (3) determinations of spontaneous magnetization; (4) the impossibility of a ferromagnetic equation of state. Interpretations of experimental data recently obtained (abs. 3638) given.

3642. [Absolute Saturation of Ferromagnetic Substances and the Law of Approach as a Function of the Field and of the Temperature.] Ann. Physik, vol. 12, No. 10, 1929, pp. 279-374; Chem. Abs., vol. 24, 1930, p. 2345.

Question of ferromagnetism is discussed in detail. The mathematical theory and the experimental work on Fe, Ni, magnetite, ferromagnetic sesquioxide of Fe, Fe₂B, cementite, pyrrhotine, and a series of ferrocobalts are described. Conclusions: The atomic moments of Fe and Ni are, respectively, 11 and 3 times 1125.6 c. g. s., with a precision of about 1 in 1,000. This value of the experimental magneton is approximately 0.19% higher than the older value (1,123.5) and 0.63% less than $\frac{1}{2}$ of the Bohr magneton. It is very close to the value, 1,126, which was deduced in 1924 from the moments of the ions of the Fe family, calculated from the Curie constant by the classical Langevin formula. This is regarded as an experimental justification of that formula. For ferric Fe in magnetite, the moment is 10.10 magnetons. A part of this excess over an integer is attributed to the paramagnetism that accompanies ferromagnetism in a molecule containing both ferric and ferrous Fe. It is very difficult to obtain C. P. ferromagnetic sesquioxide, cementite, Fe₂B, and pyrrhotine, and the last 3 are extremely hard, magnetically. The experimental values found for the magnetic moments are 8.88, 0.10, 8.84, and 1.83, respectively, which, considering the difficulties just mentioned, are compatible with the integral moments 9, 9, 9, and 2, respectively. The frequency with which the moment 9 occurs here, as well as in α -Co in the ferrocobalts and γ -Co of the Ni-Co series, is remarkable. The value 2 for pyrrhotine is the smallest moment known. In the Fe-Co and Ni-Co alloys, the atomic moment varies linearly with the concentration in certain intervals, thus confirming the law of mixtures. The results also indicate that the metals exist in different states, characterized by different magnetic moments. Thus in α -Fe-Co rich in Fe, the moment of Co is 17, whereas in α -Fe-Co rich in Co, the Fe has a moment of 15 and the Co 9 magnetons. In γ -Fe-Co, the moment of Co is 8 $\frac{1}{2}$. In γ -Ni-Co, the Co moment is 9 magnetons, whereas in H-Ni-Co it is 8 $\frac{1}{2}$. In the Fe-Co alloys containing 13-50% Co, there is indication of at least

3 different atomic moments. For 35-45% Co, the saturation value at ordinary temperatures is about 12.4% higher than for pure Fe. The law of approach to saturation as a function of the field is given by the equation $\sigma_H = \sigma_{00} \tau [1 - (a/H)]$. The constant a measures the magnetic hardness in strong fields and is sensibly independent of the temperature in the interval investigated. It differs from one specimen to another and is small for pure metals that crystallize in the cubic system. It is large for noncubic substances such as Fe₂B, cementite, and pyrrhotine. This law is valid for Fe and Ni at ordinary temperatures down to about 1,000 gauss, and this limit is displaced toward higher values as the temperature is lowered. The law of approach to saturation toward the limit of 0 abs. is given by the equation $\sigma_{00} \tau = \sigma_{000} \tau (1 - AT - BT^2 - \dots)$. Certain conditions that these 2 laws impose on the atomic model are not yet satisfactorily explained. The maximum magnetization at saturation of pyrrhotine is at 160° K., as already obtained by Zeigler. 2 new phenomena were observed. In most of the specimens of Ni, a feeble magnetization, proportional to the field, was found superimposed upon the regular phenomenon of approach to saturation. This parasitic magnetization is zero at 0° K. At 120° K., magnetite has a singular change in state. This does not affect its magnetic moment or the law of thermal variation of saturation but manifests itself at increasing temperatures by a discontinuous variation in magnetization, owing to an abrupt decrease in the coefficient of magnetic hardness, a .

WEISSBERGER, E. See abs. 1525.

WEITKAMP, A. W. See abs. 420a, 420b, 3767, 3768.

3642a. WEITKAMP, A. W., AND FRYE, C. G. Products of the Hydrogenation of Carbon Monoxide Over an Iron Catalyst. Relation of Product Composition to Reaction Mechanism. Am. Chem. Soc., 121st Meeting abs., March-April 1952, p. 11-M.

Evaluation of proposed reaction mechanisms for the hydrocarbon synthesis process was prompted by the availability of new product composition data and a knowledge of the effects of certain operating variables on product composition. The hydrocarbon synthesis process consists of several competing and concurrent reactions. The chemical steps in the formation of primary-product molecules are: initiation, chain extension, and termination. The initiator of chain growth may be adsorbed radical, possibly formed by hydrogenation on surface carbide. The adsorbed radical is enlarged by repeated addition and hydrogenation of adsorbed CO molecules. The termination reaction produces mainly alcohols or aldehydes and olefins. Competition between growth and termination is responsible for the exponential decrease in yields of successive C-number fractions. Distributions of normal and branched isomers are explained on the assumption of a statistical distribution of growth on the 2 C atoms last added to the adsorbed radicals. Secondary reactions convert part of the original olefins to paraffins and may convert part of the alcohols or aldehydes to acids and ketones.

3642b. WEITKAMP, A. W., SEELIG, H. S., BOWMAN, N. J., AND CADY, W. E. Products of the Hydrogenation of Carbon Monoxide Over an Iron Catalyst. Am. Chem. Soc., 121st Meeting abs., March-April, 1952, p. 9-M.

The general nature of the product from the hydrogenation of CO over an Fe catalyst has been investigated but not the detailed composition. In the present work the hydrocarbons were analyzed by distillation, chromatography, spectrometric methods, and other means. The wt. % yield reaches a maximum at 3 C's and then declines almost exponentially with increasing C number. In the aliphatic and alicyclic hydrocarbons,

olefins predominate and straight-chain structures are prevalent. The straight-chain content decreases exponentially with increasing C number. The branched isomers and the alicyclic hydrocarbons occur in increasing proportions in higher C-number fractions. Simple relationships among the structures and distributions of the open-chain and ring compounds reflect the mechanism of formation. Significant deviations from thermodynamic equilibria indicate that competing reaction rates control product composition. Knowledge of the composition not only aids in the efficient utilization of the product but also permits a better understanding of the process.

3643. WELLS, S. Kinetics of Carbiding and Hydrocarbon Synthesis With Cobalt Fischer-Tropsch Catalysts. *Jour. Am. Chem. Soc.*, vol. 69, 1947, pp. 2432-2436; *Chem. Abs.* vol. 42, 1948, p. 1433.

Rates of carbiding, of hydrogenation of carbide, and of hydrocarbon synthesis from CO-H₂ mixtures have been measured for a Co-ThO₂-kieselguhr catalyst (100 : 18 : 100) with the use of a circulating gas system. The initial carbiding rate is comparable with the synthesis rate, but the steady rate of bulk carbiding is about 10 times lower. The apparent activation energies for bulk carbiding and for the synthesis are 31 and 27 kcal. per mol., respectively. Within the pressure range 8-45 cm. Hg, the pressure dependence of the carbiding rate can be expressed as Rate = k_p^n , where n is 0.20-0.25. Some of the implications of these results for the mechanism of the carbiding and synthesis are discussed.

3644. ———. Effect of Operating Variables Upon the Fischer-Tropsch Synthesis. Bureau of Mines Rept. of Investigations 4405, 1949, 8 pp.

Paper consists of 2 parts: First is a discussion, based chiefly on previously published information, of the probable effect of space velocity, temperature, pressure, and gas composition on the course of synthesis and the type and properties of the products. Some remarks are made also on the role that Co carbide, particularly bulk carbide, plays in the synthesis.

3645. WELLS, S., AND FRIEDEL, R. A. Isomer Distribution in Hydrocarbons from the Fischer-Tropsch Process. *Jour. Chem. Phys.*, vol. 17, 1949, pp. 801-803; *Chem. Abs.*, vol. 44, 1950, p. 1314.

Isomer distribution found experimentally for the saturated hydrocarbon products (pentane to octane range) from a Co Fischer-Tropsch catalyst has been deduced from probability considerations. With certain restrictions, it is assumed that the C skeleton is built up by addition to any terminal C atom (for which the priori probability has a constant value a) or to any penultimate C atom (with a priori probability b). Values of a and b , determined from experimental data, led to deduced isomer concentrations in each molecular-weight cut agreeing with experimental concentrations with an average deviation of 0.7%. Peculiarities in the observed isomer distribution were reproduced also. If the same general mechanism described for Co catalysts holds for Fe catalysts, it should be possible to deduce the isomer distribution in the products from Fe catalysts also, when these data have been obtained. Furthermore, it may be anticipated that data for the skeleton isomerism of the olefinic products also will be describable in similar terms. In case of general agreement in enough cases, the validity of the assumed chain build-up mechanism for the Fischer-Tropsch reaction might be established and other schemes ruled out.

3646. ———. Isomer Distribution in Fischer-Tropsch Hydrocarbons. *Jour. Chem. Phys.*, vol. 18, 1950, pp. 157-158; *Chem. Abs.*, vol. 44, 1950, p. 4631.

An isomer distribution can be calculated by assuming that the various isomers of a given molecular-weight

fraction add C atoms in proportion to their concentrations. (See also abs. 3645.) It also can be calculated by assuming that the C-atom addition is proportional to the number of ways in which addition to the individual isomers can occur. An application of this calculation is given. Both schemes of calculation give results that agree well with experiment.

3647. WELLS, S., HOFER, L. J. E., AND ANDERSON, R. B. Role of Bulk Cobalt Carbide in the Fischer-Tropsch Synthesis. *Jour. Am. Chem. Soc.*, vol. 70, 1948, pp. 799-801; *Chem. Abs.*, vol. 42, 1948, p. 3550.

Evidence is presented that for Co catalysts, bulk Co carbide is neither an intermediate in the Fischer-Tropsch synthesis nor a catalytically active substrate for the synthesis: (1) The presence of extensive amounts of carbide in Co catalysts severely inhibits the Fischer-Tropsch synthesis; (2) used catalysts show no carbide by X-ray analysis, but samples carbided before synthesis show carbide to be present after synthesis; (3) the low-temperature unstable cubic Co produced by reduction of Co catalysts is not converted to hexagonal Co during the synthesis, although carbiding and subsequent hydrogenation of a reduced catalyst always result in this conversion.

WELLS, C. See abs. 3158.

3648. WELLS, C., AND MEHL, R. F. Rate of Diffusion of Carbon in Austenite in Plain Carbon, in Nickel, and in Manganese Steels. *Am. Inst. Min. and Met. Eng., Tech. Pub.* 1180, 1940, 28 pp.; *Chem. Abs.*, vol. 34, 1940, p. 7241.

Concentration-penetration curves for the diffusion of C in γ Fe were determined by diffusing C from high-C into low-C alloys. From chemical analysis of layers, diffusion coefficients (D) were calculated for 0.1-1.0 wt. % C and 750°-1,250°. At 0.7% C, D is accurate to $\pm 5\%$ and at 0.1% and 1.0%, to $\pm 10\%$. From the variation of D with temperature, the activation heat of diffusion (Q) was determined graphically. At 0.7% C, $Q = 32,000 \pm 500$ cal. per gm. atomic weight; at 0.1 and 1.0%, $Q = 32,000 \pm 1,000$ cal. For the range 0.1-1.0% C, $D \cdot \gamma \text{ Fe} = 0.12 \pm 0.07 \times e^{-32,000/RT} - 1,000/RT$; this is an average equation that does not give variation in D with concentration. At 0.7% C, $D \cdot \gamma \text{ Fe} = 0.12 \pm 0.03 \cdot e^{-32,000/RT}$; this is more precise. The rate of diffusion increases with increasing C concentration by approximately 30%, 0.1-1.0% C; this is approximately independent of temperature. For an accuracy of $\pm 10\%$, $D \cdot \gamma \text{ Fe} = (0.07 + 0.06 \times \% C) \cdot e^{-32,000/RT}$. Rate of diffusion does not vary with grain size in the range of A. S. T. M. Nos. -3 to 8 within the experimental error given nor with impurities ordinarily present in commercial steels: O as high as 0.19% has no effect on D . Mn and Ni up to 20% increase the rate of diffusion, but the increase is inappreciable for the amounts of these elements ordinarily present in heat-treating or carburizing steels. The significance of these results for the study of carburizing and formation of pearlite from austenite is discussed.

3649. WELLS, C., BATZ, W., AND MEHL, R. F. Diffusion Coefficient of Carbon in Austenite. *Jour. Metals*, vol. 188, No. 3, Trans., 1950, pp. 353-360; *Chem. Abs.*, vol. 44, 1950, p. 3421.

Diffusion-coefficient values for C in austenite covering a wide range of temperature and composition have been determined by employing statistical methods. In addition, the relation between concentration and each of the following, D (diffusion coefficient), Q (activation heat of diffusion), and d (the constant in the diffusion equation), has been obtained.

WELLS, C. See abs. 468.

WENDEL, I. See abs. 3275a, 3656b, 3656c.

3650. WENDEL, I., AND ORCHIN, M. Critical Review of the Chemistry of the Oxo Synthesis for Production

of Alcohols From Olefins, Carbon Monoxide, and Hydrogen. Bureau of Mines Rept. Investigations 4270, 1948, 26 pp.

Reviews the developments that have taken place in the synthesis of the higher alcohols and discusses the chemistry of the process, the reaction mechanism, the nature and analysis of the products, and their uses. The practical importance of the Oxo reaction is clearly outlined. The industrial production of long-chain alcohols, aldehydes, and fatty acids from olefin fractions of Fischer-Tropsch products or of petroleum products appears now to be a matter of careful cost estimating and engineering design.

3651. WENDEL, I., FRIEDEL, R. A., AND ORCHIN, M. Ethanol From Methanol. *Science*, vol. 113, 1951, pp. 206-207.

It has been found that, contrary to the usual order of reactivity of alcohols (tertiary > secondary > primary) MeOH reacts with synthesis gas (CO:H₂) more rapidly than secondary alcohols with EtOH as the chief product. The conversion was achieved by treating the alcohol with synthesis gas at 180°-185° in the presence of a Co catalyst such as dicobalt octacarbonyl [Co(CO)₈]. Pressures of 3,500-5,100 p. s. i. were employed. Analysis of the product mixture showed that 76.4% of the MeOH had reacted to yield a total of 70.3% of products (based on the converted MeOH) of which 38.8% was EtOH.

WENDEL, I., GREENFIELD, H., AND ORCHIN, M. Chemistry of the Oxo and Related Reactions. IV. Reductions in the Aromatic Series. See abs. 3655.

3652. WENDEL, I., LEVINE, R., AND ORCHIN, M. Chemistry of the Oxo and Related Reactions. I. Homologation of Alcohols. *Jour. Am. Chem. Soc.*, vol. 71, 1949, pp. 4160-4161; *Chem. Abs.*, vol. 44, 1950, p. 2430.

Investigations at the Bureau of Mines have revealed that an alcohol can be converted to the homologous alcohol containing 1 C atom more than the original one by the Oxo or hydroformylation reaction without proceeding via an olefin intermediate followed by a 1-step hydroformylation-hydrogenation. The process is to treat the alcohol with synthesis gas, 1H₂:1CO, at 160°-180° and 3,200 p. s. i. for 1-1.5 hr. in the presence of a Co catalyst, cobaltous acetate, or cobaltous oxide. By this means, benzyl alcohol is converted to β -phenylethyl alcohol, isopropyl alcohol to n -butyl and isobutyl alcohol, and t -butyl alcohol to isomyl alcohol. It is believed that the homologation reaction is an acid, HCoCO, catalyzed reaction that proceeds via a carbonium ion according to a mechanism that will be discussed later.

3653. ———. Chemistry of the Oxo and Related Reactions. II. Hydrogenation. *Jour. Am. Chem. Soc.*, vol. 72, 1950, pp. 4375-4378.

Aldehydes and ketones can be reduced to alcohols by H₂ and CO in the presence of a Co catalyst, and the reaction can be applied to the reduction of compounds containing S. A free radical mechanism is proposed for the hydrogenation. When olefins are treated with 150-300 atm. of synthesis gas and a Co catalyst at 180°-185°, alcohols containing 1 C atom more than the olefin are the principal products. Double bonds in some compounds, when treated under these conditions, are hydrogenated rather than hydroformylated. (See abs. 3652.)

3654. WENDEL, I., ORCHIN, M., AND STORCH, H. H. Mechanism of the Oxo and Related Reactions. III. Evidence for Homogeneous Hydrogenation. *Jour. Am. Chem. Soc.*, vol. 72, 1950, pp. 4842-4843.

It has been shown that the hydroformylation reaction is often accompanied by hydrogenation; indeed, in some instances, hydrogenation proceeds to the exclusion of hydroformylation. Evidence is presented that

strongly indicates that the great variety of hydrogenations that occur in the presence of Co and a high partial pressure of CO probably proceed by homogeneous catalysis in which [Co(CO)₄] or HCo(CO)₃ functions as the catalyst.

3655. WENDEL, I., GREENFIELD, H., AND ORCHIN, M. Chemistry of the Oxo and Related Reactions. IV. Reductions in the Aromatic Series. *Jour. Am. Chem. Soc.*, vol. 73, 1951, pp. 2656-2658.

Previous work has shown that certain aliphatic alcohols react with H₂ and CO in the presence of a Co catalyst to give an homologous alcohol; only in the case of MeOH is any of the alcohol reduced to a hydrocarbon. The present study is concerned with the reaction of alcohols and ketones in the aromatic series under the same conditions and shows that in all cases hydrocarbons are the principal products. Benzyl alcohol gives both 2-phenylethanol and toluene, but substituted benzyl alcohols of the type C₆H₄CR₂OH, where R₁ and R₂ may be H, alkyl, or aryl groups, react to give hydrocarbons in excellent yields. The mechanism of hydrocarbon formation is discussed. A simple, convenient procedure for the preparation of dicobalt octacarbonyl is given.

3655a. WENDEL, I., METLIN, S., AND ORCHIN, M. Chemistry of the Oxo and Related Reactions. V. Acid Catalysis With Pinacol. *Jour. Am. Chem. Soc.*, vol. 73, 1951, pp. 5704-5706.

Reaction of pinacol with CO and H₂ at 185° in the presence of a Co catalyst gives a complex mixture of products. 4 compounds more volatile than the starting material were identified; these were pinacolone, pinacolyl alcohol, 3,4-dimethylpentanol-1 and 2,2,3-trimethyltetrahydrofuran. The origin of these compounds is consistent with the formation and further reaction of a common carbonium-ion intermediate formed from pinacol under acidic conditions. The acid catalyst is probably Co hydrocarbonyl, HCo(CO)₃.

3655b. WENDEL, I., GREENFIELD, H., METLIN, S., AND ORCHIN, M. Chemistry of the Oxo and Related Reactions. VI. Experiments With Meta- and Para-Substituted Benzyl Alcohols. *Jour. Am. Chem. Soc.*, vol. 74, 1952, pp. 4079-4083.

Nuclear-substituted benzyl alcohols react with synthesis gas (2H₂:1CO) in the presence of a Co catalyst (dicobalt octacarbonyl) to give a mixture containing a substituted toluene derived from the hydrogenolysis of the hydroxyl group (reduction) in addition to a substituted 2-phenylethanol (homologation). The effect of the substituent on the overall rate of the reaction and on the product distribution was studied in a series of semiquantitative experiments. The rate of reaction decreased in the following order: $p\text{-OCH}_3 \gg p\text{-Cl} > m\text{-CH}_3 > p\text{-t-butyl} > H > p\text{-Cl} > m\text{-OCH}_3 > m\text{-CF}_3$. The proportion of homologation product as compared to reduction product also increased in the order in which the substituent is capable of releasing electrons but this effect was not nearly as pronounced as the effect on the reaction rate.

WENDEL, I., LEVINE, R., AND ORCHIN, M. Chemistry of the Oxo and Related Reactions. II. Hydrogenation. See abs. 3653.

WENDEL, I., METLIN, S., AND ORCHIN, M. Chemistry of the Oxo and Related Reactions. V. Acid Catalysis With Pinacol. See abs. 3655a.

3656. WENDEL, I., ORCHIN, M., AND STORCH, H. H. New Modifications of the Oxo Process. *Armed Forces Chem. Jour.*, vol. 4, October 1950, pp. 4-9.

It is pointed out, with reference to the work of Keulemans, Kwanten, and Van Bavel (abs. 1739), that it is possible by the hydroformylation of olefins to predict the structure of the aldehydes or alcohols obtained from a given olefin. It also has been found that under regu-

lated conditions of pressure and temperature it is entirely feasible to produce alcohols from olefins by a 1-step synthesis or to isolate the aldehyde as the major product. It is indicated quite strongly as the result of experiments that hydrogenation reactions that occur in the presence of Co and a high partial pressure of CO proceed by homogeneous catalysis in which dicobalt octacarbonyl functions as the catalyst. It also is possible that the reductions that occur under Oxo conditions proceed via a free radical mechanism. If this is so, hydrogenation under such conditions should not be adversely affected by S compounds, as is the heterogeneous catalysis of hydrogenation over a solid catalyst. Under the conditions of the Oxo reaction, some types of unsaturated linkages are hydrogenated, whereas others react by hydroformylation. Several such reactions are described, and the yields of products obtainable are summarized. Of particular interest is the reaction of furan and its derivatives. The homologation of aliphatic alcohols and the hydrogenation and homologation of aromatic aldehydes, ketones, and alcohols are discussed. It is not yet proved, but it is assumed, that the Oxo reaction with olefins proceeds via a carbonium ion, and evidence is mounting that homologation may proceed through such an intermediate. Two recently discovered reactions are found to take place under Oxo conditions: EtCHO reacts with synthesis gas to yield ethylene glycol and methylal with synthesis gas, and a Co catalyst yields methyl cellosolve. The synthesis of EtOH from coal or natural gas via synthesis gas and MeOH now is possible. Recent work indicates that EtOH may be an intermediate in the Fischer-Tropsch synthesis. Further assumptions have been made as to the possible mechanism of the Fischer-Tropsch hydrocarbon synthesis: The C skeleton is built up by the stepwise addition of 1 C atom at a time, and addition of the C atom occurs only at the terminal or next to the terminal C atom of the chain and does not occur at a tertiary C atom to form a product containing a quaternary C atom. As regards the Oxo synthesis these assumptions are already accepted as facts.

WENDER, I., ORCHIN, M., AND STORCH, H. H. Mechanism of the Oxo and Related Reactions. III. Evidence for Homogeneous Hydrogenation. *See abs.* 3654.

3656a. WENDER, I., STERNBERG, H. W., AND ORCHIN, M. Chemistry of the Metal Carbonyls. I. New Concepts Applied to Carbonyls of Cobalt. *Jour. Am. Chem. Soc.*, vol. 74, 1952, pp. 1216-1219.

Reactions of a variety of organic compounds with dicobalt octacarbonyl, previously assumed to proceed by displacement of 1 or more moles of CO by the entering organic molecule, are explicable on a common basis: The entering organic group, which always has an available pair of electrons, effects a homomolecular disproportionation of the dicobalt octacarbonyl into catalyst (II) ion and Co carbonyl anion according to the generalized equation: $12 B + 3[Co(CO)_4]_2 \rightarrow 2[Co(B)] [Co(CO)_4] + 8 CO$, where B is a base, in the Lewis sense. The electrons necessary for the formation of the anion are secured at the expense of some of the Co. Situations are also described in which these electrons are furnished by an external source. The tendency to form the stable (rare-gas structure) Co carbonyl anion is probably the driving force for the reactions.

3656b. STERNBERG, H. W., WENDER, I., FRIEDEL, R. A., AND ORCHIN, M. Chemistry of the Metal Carbonyls. II. Preparation and Properties of Cobalt Hydrocarbons. *Jour. Am. Chem. Soc.*, vol. 75, 1953, pp. 2717-2720.

New method for the preparation of Co hydrocarbonyl is based on the reaction between dicobalt octacarbonyl and pyridine whereby a Co salt of Co hydrocarbonyl is obtained readily and quantitatively:

$3 [Co(CO)_4]_2 + 12 Pyr \rightarrow 2 [Co(Pyr)_2] [Co(CO)_4]_2 + 8 CO$
Addition of salt to excess dilute H_2SO_4 in a stream of inert gas over a period of about 45 min. gave pure Co hydrocarbonyl in a yield of 95%. Co hydrocarbonyl is stable in aqueous solution and behaves like a strong mineral acid. The half life in the gas phase and in hexane solution is dependent upon its concentration. The infrared spectra of Co hydrocarbonyl in the gas phase and in hexane solution were determined in the 2-15 μ region. Neither of these spectra showed the presence of a conventional hydroxyl band. In addition the deuterocarbonyl was prepared to check for the expected shift of spectral bands, but the spectrum was identical to that of the hydrocarbonyl. Mass spectrometric analysis of Co hydrocarbonyl gave peaks for $Co(CO)$, $Co(CO)_2$, $Co(CO)_3$, and $Co(CO)_4$, and H. The latter was not found as part of any other fragment.

3656c. Chemistry of the Metal Carbonyls. III. Reaction Between Dicobalt Octacarbonyl and Dimethylamine. *Jour. Am. Chem. Soc.*, vol. 75, 1953, pp. 3148-3152.

It has been shown that many Lewis bases react with dicobalt octacarbonyl: $3[Co(CO)_4]_2 + 12B \rightarrow 2[Co(B)]_2 [Co(CO)_4]_2 + 8 CO$. When excess dimethylamine is condensed onto dicobalt octacarbonyl at -80° and the solution is warmed to room temperature, no CO is evolved and equimolar amounts of Co cation and Co carbonyl anion are formed. Infrared and mass spectrometric analysis of the reaction product indicated the presence of dimethylamine, dimethylformamide and small amounts of tetramethyl urea. It appears from these data that the CO usually given off in the disproportionation of dicobalt octacarbonyl in this instance reacted with the amine: $3[Co(CO)_4]_2 + 20(CH_3)_2NH \rightarrow 2[Co[(CH_3)_2NH]_2] [Co(CO)_4]_2 + 8(CH_3)_2NCHO$. According to this equation, stoichiometric quantities of dicobalt octacarbonyl would be required to convert dimethylamine to dimethylformamide. However, if it were possible to reverse the first equation employing the proper conditions, only catalytic quantities of dicobalt carbonyl might be required to convert dimethylamine to dimethylformamide, especially since the latter can coordinate the cation in the form $[Co[(CH_3)_2NCHO]_2]^{+}$. Treatment of dimethylamine with 1 mole % of dicobalt octacarbonyl at $200^\circ-210^\circ$ and an initial pressure of 3000 p. s. i. of CO gave dimethylformamide smoothly and in good yield; no tetramethyl urea was formed. A possible mechanism for the formation of dimethylformamide from dimethylamine and dicobalt octacarbonyl is discussed.

WENDER, I., GREENFIELD, H., METLIN, S., AND ORCHIN, M. Chemistry of the Oxo and Related Reactions. VI. Experiments With Meta- and Para-Substituted Benzyl Alcohols. *See abs.* 3655b.

3657. WENDT, G. L., AND EVANS, G. M. Equilibrium Between Hydrogen-Carbon Monoxide and Methane-Carbon Dioxide in the Corona Discharge. *Jour. Am. Chem. Soc.*, vol. 50, 1928, pp. 2610-2621; *Chem. Abs.*, vol. 22, 1928, p. 4335.

Gaseous phase in the reaction $2CC + 2H_2 = CO + CH_4$ reaches an equilibrium at a composition of 37.1% CO, 37.6% H₂, 13.3% CO₂, and 8.7% CH₄, corresponding thermodynamically to 900°-950° K. Contraction continues, however, and the end products are C and H₂O.

3658. WENNER, R. R. Prediction of Reaction Equilibria. *Chem. Eng. Progress*, vol. 45, 1949, pp. 194-207; *British Abs.*, 1949, B, I, p. 546.

All predictions are ultimately based on heats of formation and reaction, and these are best determined experimentally. For example, methods of calculation from bond energies are only a substitute for rigid determination. A number of methods are listed both for these heats and for entropy determination. The

methods are applied to the reaction of $C_2H_4 + CO + H_2 \rightarrow$ propionaldehyde. This, the Oxo reaction, is shown to go virtually to completion at 1 atm. The industrial use of higher pressures is presumably directed toward faster reaction rates by alteration of surface conditions. Other reactions discussed.

WENZEL, K. *See abs.* 2881.

3659. WENZEL, —. [State of the Synol Problem.] *TOM Reel 134, sec. II, No. 10; Rept. 326, Apr. 10, 1942, 33 pp.*

Since the Synol process was devised for producing high-molecular alcohols from CO and H₂, the problem has been to place it on an operating, commercial basis, 10,000 tons per yr., find the proper conditions for the synthesis, discover usable and economical methods for separating the hydrocarbons and alcohols in a pure enough state, and find applications for the products. These problems appear to have been solved. Alcohols can be obtained from synthesis or water gas of composition CO : H₂ = 1 : 0.75 or 1 : 1. For best results, overheating of the catalyst should be avoided. Pressures above 25 atm. are inadvisable. Four stages of gas conversion are best, care being taken that the formation of CO₂ does not exceed 10% in order to produce the best yield of alcohol. Temperature of conversion is about 190°-195° in the 1st stage, and not exceeding 210°-225° in the other stages. The layout for a Synol-synthesis plant with provision for a change over to diesel oil and gasoline production is described. A plate converter was the most efficient for heat removal. The best catalyst for the process appears to be the Leuna NH₃ fused Fe catalyst WK 17 of grain size 1-2 mm. reduced at 450° for 48 hr., with a H₂-load of 1:3,000 per hr. It was found that this catalyst during the conversion forms hexagonal Fe carbide, Fe₃C, which at temperatures above 200° is transformed into inactive Hagg Fe₃C. The 2d choice is a precipitation catalyst, No. 2643, with 3.7% Al₂O₃, 1% K₂O, and the remainder Fe. Recently an Fe catalyst of high activity has been developed at Leuna containing small additions, 0.1% Sb, Ni, which may surpass the precipitation catalyst previously obtained. The working up of the products is discussed at length to remove undesired impurities as acids, esters, aldehydes, and ketones. Alcohols up to C₆ are separated by washing with water or MeOH solutions, the higher alcohols by the boric acid method. Alcohols up to C₆ have been obtained. The alcohols are thought to be mainly straight-chain and primary alcohols with the double bond at the end of the chain. The products are believed to be suitable for making detergents, solvents, softeners for plastics, and varnish solvents. Several patent applications listed.

3660. WENZEL, W. [Synol Process. New Synthesis of Aliphatic Alcohols.] *Angew. Chem.*, vol. 20, 1948, B, pp. 225-230; *Bureau of Mines Transl. K-S, 1949, 26 pp; Chem. Abs.*, vol. 43, 1949, p. 994.

Predominant production of alcohols from CO and H₂ was developed by using fused Fe catalysts permitting operating temperatures as low as 180°. This development with all of its attending variations in synthesis is summarized, and some general information is presented on material balances and separation of alcohols.

See abs. 1999, 2000, 2001, 2002.

3661. WERNER, G. [Synthesis of Hydrocarbons by the Process of Fischer and Tropsch.] *Ztschr. kompr. füss. Gase*, vol. 36, 1941, pp. 77-80, 89-94; *Chem. Zentralbl.*, 1942, I, p. 823; *Chem. Abs.*, vol. 37, 1943, p. 3243.

Comprehensive presentation of the process of Fischer-Tropsch in its chemical principles and technique, with recent literature.

3662. WERT, C. A. Precipitation From Solid Solutions of Carbon and Nitrogen in Alpha-Iron. *Jour. Appl.*

Phys., vol. 20, 1949, pp. 943-949; *Chem. Abs.*, vol. 44, 1950, p. 503.

Formation of precipitates from the solid solutions of C and N in α -Fe was studied by means of the internal friction peak associated with the stress-induced interstitial diffusion of the solute atoms. A transformation law fits the experimental data. The data show the following: (1) Fe₃C precipitates in the shape of spheres; (2) an intermediate phase in the precipitation of N forms in the shape of disks; and (3) within the experimental error no continuous nucleation is indicated. From the results of a derivation made by Zener, the mean distance between nuclei is calculated for Fe₃C. For C concentrations of about 0.016 wt. %, this distance is about 800, 2,000, and 7,000 Å. at 27°, 102°, and 312°, respectively. With appropriate experimental conditions, the temperature dependence of the precipitation rate is about the same as the temperature dependence of the diffusion rate of the solute atoms.

3663. —. Diffusion Coefficient of Carbon in Alpha-Iron. *Phys. Rev.*, vol. 79, 1950, pp. 601-605; *Chem. Abs.*, vol. 44, 1950, p. 9760.

Equation of the form $D = D_0 e^{-\Delta H/RT}$ is developed for interstitial diffusion in cubic lattices. This development uses a classical statistical mechanical treatment. Measurements of D for C in α -Fe were made, -35° to 200° . Combined with earlier data they extend the knowledge of D in this system from $D=10^{-10}$ to $D=10^{-6}$ cm.² per sec. The values of D₀ and ΔH obtained by fitting this equation to the experimental points give $D_0 = 0.02$ cm.² per sec. and $\Delta H = 20,100$ cal. per mol.

3664. —. Measurements on the Diffusion of Interstitial Atoms in Body-Centered Cubic Lattices. *Jour. Appl. Phys.*, vol. 21, 1950, pp. 1196-1197; *Chem. Abs.*, vol. 45, 1951, p. 1835.

Rate of diffusion of C in Ta and Nb and of N in α -Fe was measured by effects on internal friction and an elastic aftereffect. Data covering a range of 10⁴ in rate are reported.

3665. —. Solid Solubility of Cementite in Alpha-Iron. *Jour. Metals*, vol. 188, Trans., 1950, pp. 1242-1244; *Chem. Abs.*, vol. 44, 1950, p. 10,631.

By using the internal friction of C in α -Fe, the solubility of cementite in α -Fe has been measured down to a temperature of 150°. The yield strength of ingot Fe containing small amounts of cementite also has been determined as a function of C concentration.

WESSELKOCK, H. *See abs.* 3057, 3066, 3067, 3069.

3666. WEST, E. L. Major Developments in Synthetic Lubricants and Additives in Germany. *Jour. Inst. Petrol.*, vol. 34, 1948, pp. 774-820; *BIOS Final Rept. 1611, February 1948, 128 pp.; PB 93,668.*

By the end of the war, Germany had a well-developed synthetic-lubricating oil industry, which was rapidly expanding. On a quantity basis the products obtained from natural petroleum resources predominated, but from a quality standpoint the synthetic production was of more importance. The total production of lubricants in January 1944 was 70,000 tons per mo., of which about 12% were synthetic oils. The I. G. Farbenindustrie was obtaining 1,250 tons per mo. from the polymerization of C₂H₄ with AlCl₃, while they, together with Rhenania Ossag, were producing 2,100 tons from olefins obtained from the cracking of petroleum and Fischer-Tropsch waxes. In addition to these developments, Ruhrchemie was producing 1,500 tons from olefins obtained from Fischer-Tropsch gas oils and sweater oil from the manufacture of wax derived from the process. Rheinpreussen was obtaining 300 tons by a method analogous to that for Paraffin production with chlorinated Kogasin from the Fischer-Tropsch process as the main raw material. In addition, there

were about 3,000 tons of lubricating oils being produced by brown-coal hydrogenation. A very promising development, which had not come into production, was the use of the esters of fatty acids, particularly sebacic and adipic acids. Extensive bibliography.

See abs. 873, 874, 875, 876, 877, 878, 3729.

3667. WESTGREN, A. [Crystal Structure of Cementite.] *Jernkontorets Ann.*, vol. 114, 1932, pp. 457-463; *Chem. Abs.*, vol. 27, 1933, p. 1301.

Grouping of Fe atoms suggested by Hendricks (abs. 1400) is verified, but the parameters have been slightly adjusted as follows: $x=0.333$, $y=0.175$, $z=0.065$, $u=-0.167$, and $v=0.04$. The C atoms are surrounded by 6 Fe atoms at the distance 2.01 Å, which define a regular prism on a triangular isosceles base. 11 refs.

See abs. 1801.

3668. WESTGREN, A., AND LINGE, A. E. [Crystal Structure of Iron and Steel.] *Ztschr. physik. Chem.*, vol. 98, 1921, pp. 181-210; *Chem. Abs.*, vol. 15, 1921, p. 3812.

Deals with an X-ray spectrographic investigation of the crystal structure of Fe and steel. The results of Hull (abs. 1516) that the atoms of pure Fe at ordinary temperature (α -Fe) are arranged on a centered cubic lattice, have been confirmed. At 800°-830° that is, within the so-called β -Fe interval, the atoms are grouped in the same way as in α -Fe. Since allotropy of crystalline solids is synonymous with polymorphism, β -Fe cannot be regarded as a special modification of Fe. In both austenite and pure Fe, which is stable at 1,000°, the crystals have a plane-centered cubic lattice. This is also characteristic of γ -Fe, and constitutes a fundamental difference between α - and γ -Fe. In martensite the Fe appears in the form of the α modification. This is likewise the case in rapid-drawn steel of ordinary composition that has been hardened at 1,275°.

3669. WESTGREN, A., AND PHRAGMÉN, G. [X-Ray Studies on the Crystal Structure of Steel.] *Ztschr. physik. Chem.*, vol. 102, 1922, pp. 1-25; *Jour. Iron Steel Inst. (London)*, vol. 105, 1922, pp. 105, 241-273; *Engineering*, vol. 113, 1922, pp. 630-634; *Chem. Abs.*, vol. 16, 1922, p. 2291.

X-ray photographs (according to Debye and Scherrer) of an Fe wire, heated to 800°, 1,100°, and 1,425°, have shown that the wire within the so-called β - and δ -ranges has a body-centered cubic structure and within the γ -range a face-centered structure. It is thus proved that the transformation that takes place at 900° (A_1) is reversed at 1,400° (A_2). The γ -Fe lattice of austenite steels is enlarged by the dissolved C. A steel with 1.98% C has a somewhat larger lattice when quenched from 1,100° than when quenched from 1,000°. Also, the α -Fe lattice in martensite seems to be influenced by the C present. The ranges of homogeneous α -Fe lattice in martensite are extremely small. A steel with 0.80% C, quenched in H₂O from 760°, is on the verge of being totally amorphous. Debye photographs of cementite and of the well-known crystal tablets of spiegel Fe are identical. A Laue photograph and investigations of an orientated rotating crystal of the latter type have made it possible to find out the crystal data of cementite. It belongs to the orthorhombic system, its ratio of axis is 0.670:0.755:1, and the dimensions of its elementary parallelepiped are 4.53, 5.11, and 6.77 Å. The base group consists of 4 mol. FeC, which corresponds to a specific weight of 7.62 for the cementite.

WESTRIK, R. See abs. 677.

3670. WETZEL, L. A., MCKEEVER, C. H., AND LEVESQUE, C.-L. Structures of the Oxo Aldehydes From Styrene. *Jour. Am. Chem. Soc.*, vol. 72, 1950, pp. 4939-4940.

Previous work (abs. 3 and 4) reported the preparation of 2-phenylpropionaldehyde in 30% yield by the application of the Oxo reaction to styrene. There was no evidence, however, of the formation of 3-phenylpropionaldehyde. Additional evidence is now obtained that the primary product of the Oxo reaction on styrene is actually a mixture of the 2- and 3-phenylpropionaldehydes. The data indicate that at least 23% is the 2-isomer, at least 29% is the 3-isomer, while the remaining 47% cannot be assigned to either at present. Oxidation of the phenylpropionaldehyde produced by the Oxo reaction with styrene (46% yield) gives a mixture of acetophenone and 3-phenylpropionic acid. This indicates that both 2- and 3-phenylpropionaldehydes are formed in the Oxo reaction.

3671. WEYER, F. [Iron Carbide.] *Mitt. Kaiser Wilhelm Inst. Eisenforsch. Düsseldorf*, vol. 4, 1922, pp. 67-80; *Chem. Abs.*, vol. 18, 1924, p. 1460.

By X-ray analysis, it is proved that the forms of cementite shown in the Fe-C thermal diagram are not distinguishable by their lattice structure. FeC crystallizes in a rhombic lattice denoted by the quadratic form $\sin^2\theta/2=0.0464x^2+0.0367y^2+0.0208z^2$. The edge lengths are $a=4.81$ Å, $b=5.034$ Å, $c=6.708$ Å. The density is calculated therefrom as 7.82. Data by the Debye-Scherrer method above 210° show that the magnetic transformation is not associated with a change in the type of lattice. The quadratic form is expressed by $\sin^2\theta/2=0.0456x^2+0.0362y^2+0.0203z^2$. The edge lengths are $a=4.52$ Å, $b=5.08$ Å, $c=6.77$ Å.

3672. [Nature of the Magnetic Transformation of Iron.] *Ztschr. anorg. Chem.*, vol. 162, 1927, pp. 193-202; *Chem. Abs.*, vol. 21, 1927, p. 3871.

A_1 and A_2 transformations of Fe are shown to be both polymorphic and phase transformations. In the magnetic A_1 transformation, neither the space group, the crystal structure, nor the space lattice orientation within the individual crystals is changed. Hence the magnetic transformation is not polymorphic. Further, the cooling curve for very pure Fe is interpreted as failing to establish the A_1 as a phase transformation.

3673. [Thermodynamics of the Transformations of Iron.] *Mitt. Kaiser Wilhelm Inst. Eisenforsch. Düsseldorf*, vol. 9, 1927, pp. 151-155; *Chem. Abs.*, vol. 21, 1927, p. 2245.

Discussion of polymorphic and phase transformations. The A_1 and A_2 transformations of Fe are clearly both polymorphic and phase transformations, whereas the magnetic A_1 transformation comes under neither class.

3674. WEYER, F., AND MÜLLER, A. [Binary Systems: Iron-Boron, Iron-Beryllium and Iron-Aluminum.] *Mitt. Kaiser Wilhelm Inst. Eisenforsch. Düsseldorf*, vol. 11, 1929, pp. 193-223; *Chem. Abs.*, vol. 23, 1929, p. 5458.

Equilibrium diagram of Fe-B was studied thermally, microscopically, and by means of X-rays and was found to belong to that group of binary Fe alloy having a narrowly limited γ -phase. As a result of insufficient solubility, a closed γ -field was not obtained. Mixed crystals of α -Fe-B as well as the solid solution γ -Fe-B are formed by ordinary atomic substitution. The boride Fe₃B has a tetragonal space lattice with 2 mol. per unit, while the boride FeB also exhibits tetragonal symmetry with 16 mol. per unit. The Fe side of the equilibrium diagrams of Fe-B and Fe-Al was studied, and both systems were found to have completely closed γ -fields. Mixed crystals of α -Fe and γ -Fe with both Be and Al are formed by atomic substitution.

3675. WEYER, F., AND NAEGER, G. [Manner in Which Carbon Is Bound in Hardened and Tempered Steels.] *Mitt. Kaiser Wilhelm Inst. Eisenforsch., Düsseldorf*,

vol. 16, 1934, pp. 201-206; *Chem. Abs.*, vol. 29, 1935, p. 2491.

Object was to determine, by analyzing the residues of tempered steels obtained by electrolysis in FeCl₃ solutions, the manner in which C is bound in steel at different temperatures. The residues are separated magnetically into 2 parts, one essentially highly dispersed C with H₂O and the other a gray-black powder, which, in dry state, ignites in air. The C content of the unseparated residues decreases with increasing tempering temperatures from very high values in untempered steels to that of the composition FeC at 700°, whereas the C content of the purified residues is mostly FeC up to about 300° and Fe₃C between 300° and 600°-700°. The composition of cementite is reached above 700°. Residues of steels transformed directly from the austenite state have lower C contents than tempered steels and correspond to FeC for transformation temperatures of 400°-500°. The existence of the carbides FeC and Fe₃C in tempered steels is considered to be established. 23 references.

3676. WETGAND, C. [Modern Method of Manufacture of Gasoline.] *Farbe u. Lack*, 1926, pp. 599-600; *Chem. Abs.*, vol. 21, 1927, p. 1004.

Synthetic process method of F. Fischer: CO, purified water gas, is hydrogenated in the presence of Co or Co-Cr₂O₃, Co-ZnO, Co-BeO, at 270° under atmospheric pressure, giving a reaction product of the following composition: (1) Gasol, C₂H₆, C₃H₈, C₄H₁₀; (2) gasoline, water-clear, not discoloring, boiling at 20°-180°; (3) petroleum boiling at 180°-330°; (4) paraffin wax.

3676a. WHEELER, A. Reaction Rates and Selectivity in Catalyst Pores. *Advances in Catalysis*, Academic Press, Inc., New York, vol. 3, 1951, pp. 249-327.

The review covers the physical picture of pore structure, mechanism of transport in catalyst pores, physical factors determining reaction rates on porous catalysts, reaction rates in single pores, reaction rates on practical catalyst pellets, reaction rates on poisoned catalysts and effect of pore structure on catalyst selectivity. 34 refs.

See abs. 178, 178a, 179, 181.

WHEELER, R. Y. See abs. 2813, 2814.

3677. WHEELER, R. Y., AND WOOD, W. L. Pyrolysis of Methane. *Fuel*, vol. 7, 1928, pp. 535-539; *Chem. Abs.*, vol. 23, 1929, p. 3212.

Study of the thermal decomposition of CH₄ has been made. The results obtained agree, in general, with those of Fischer (abs. 954). C₂H₄ is formed at 875°-1,100°, the optimum temperature (for the apparatus used) being about 1,050° with a yield of 0.2 gal. per 1,000 cu. ft. Quartz, porcelain, and Cu reaction tubes were all without catalytic effect on the decomposition. With an Fe tube only C and H₂ are formed. Dilution of the CH₄ with N₂ has little effect on the yield of aromatic hydrocarbons obtained at 1,000°, but dilution with H₂ rapidly decreases the yields. The apparatus is described and illustrated.

3678. WHITTAKER, J. W. Fuel Research in India. *Jour. Indian Chem. Soc., Ind. News Ed.*, vol. 12, 1949, pp. 9-17; *British Abs.*, 1950, B, I, p. 396.

Program of the Indian Fuel Research Institute; includes a physical and chemical survey of the Indian coal fields and studies of the efficient burning of powdered high-ash coals, of the Fischer-Tropsch process, and of high- and low-temperature carbonization.

3679. WHITE, E. C., AND SCHULTZ, J. F. Fused Cobalt Oxide as a Water-Gas Catalyst. *Ind. Eng. Chem.*, vol. 26, 1934, pp. 95-97; *Chem. Abs.*, vol. 28, 1934, p. 1505.

Catalysts made by the proper fusion and partial reduction with H₂ of Co oxide effectively catalyze the

water gas reaction to equilibrium at temperatures as low as 283° and space velocities of 1,800 vol. of water gas per vol. of catalyst per hr. Adding suitable promoters, such as Fe up to 3% or Cr oxide, suppressed the simultaneous formation of CH₄. A Co catalyst containing 38% Cu was particularly active as a water-gas catalyst without significant synthesis of CH₄.

3680. WHITE, J. Equilibrium at High Temperatures in Systems Containing Iron Oxides. *Iron and Steel Inst. (London)*, Carnegie Schol. Mem., vol. 27, 1938, pp. 1-75; *Chem. Abs.*, vol. 33, 1939, p. 4496.

Dissociation of Fe₂O₃ into O₂ and other Fe oxides was studied up to 1,650° under O₂ pressures 2-76 mm. Hg. The reaction was followed by measuring the change in O₂ pressure in a sealed tube, by air quenching from the equilibrium temperature and determining the weight loss, or by measuring the weight change with a special balance while the sample was at high temperature. Dissociation increases with rising temperature and decreasing O₂ pressure. Addition of lime increases dissociation and addition of silica decreases it. In mixtures each acts independently of the other. Equilibrium constants were calculated and dissociation calculated from them was found to be in approximate agreement with the observed dissociation. Additional work was done on the mutual solid solubility of Fe₂O₃ and Fe₃O₄. 23 refs.

WHITE, R. R. See abs. 13, 258.

WHITE, T. A. See abs. 199, 200.

3681. WHITE, T. A., AND BENTON, A. F. Adsorption of Hydrogen by Nickel Poisoned With Carbon Monoxide. *Jour. Phys. Chem.*, vol. 35, 1931, pp. 1784-1789. *Chem. Abs.*, vol. 25, 1931, p. 3895.

H₂ adsorption at 0° on about 23 gm. of Ni is increased considerably by 0.038 cc. of CO at all pressures up to 1 atm.; larger amounts of CO seem to have little effect on the amount of H₂ adsorbed but decrease the rate of adsorption.

3682. WHITELEY, J. H. Observation on Martensite and Troostite. *Jour. Iron Steel Inst. (London)*, vol. 111, 1925, pp. 315-349; *Chem. Abs.*, vol. 19, 1925, p. 3462.

An investigation was made of the different structures of quenched and tempered steels, grouped under the terms martensite and troostite. The facts recorded indicate that martensite, like austenite, is a solid solution of carbon in a transitory form of Fe intermediate between γ -Fe and α -Fe of strong twinning tendency. A series of photomicrographs (mostly X 850) accompanies the paper.

3683. Solution of Cementite in α -Iron and Its Precipitation. *Jour. Iron Steel Inst.*, No. 14, 1927, 11 pp.; *Engineering*, vol. 124, 1927, pp. 472-473; *Chem. Abs.*, vol. 21, 1927, p. 3872.

Basic steel of the Armco type, acid-steel plate heated to 1,000° and air-cooled, and acid-steel plate heated to about 1,400° and cooled very slowly were the specimens examined. The results indicate that above 630° α -Fe dissolves an appreciable amount of cementite, which is retained in solid solution on quenching. On tempering at or below 250° precipitation of this cementite occurs in the ferrite grains; and on further heating, the cementite particles travel to the grain boundaries at high velocity. The solubility of cementite increases above 630°, being above 0.03% at 720°. Decrease in purity of the ferrite slightly raises the initial temperature of solution, the acid-steel samples showing no solubility below 750°. Photomicrographic examination shows that the carbide precipitated at lower temperatures was always uniformly distributed in the ferrite grains in parts well away from pearlite areas, indicating a very rapid rate of diffusion. During slow cooling, the dissolved carbide is deposited on existing crystals. The presence of dissolved C has a distinct

hardening effect. Thus the sample of basic steel untreated showed a Brinell number of 89, whereas heated to 680°, quenched, and reheated to 550° the Brinell number was 91, and quenched from 680° it was 105.

3684. WHITMAN, W. G. Liquid-Fuel Supplies and National Security. *Petrol. Processing*, vol. 4, No. 11, 1949, pp. 1222-1232; *Petrol. Refiner*, vol. 28, No. 11, 1949, pp. 97-107.

Paper presented at the annual American Petroleum Institute meeting, November 1949. Five measures are put forward to ensure adequate liquid-fuel supplies for national security. The 1st is to foster the continuing existence of reserve capacity to produce crude oil in an emergency. The 2d is to accumulate a reserve of refinery products by stockpiling, but not in such large volume as to offer exorbitant and unnecessary insurance premiums for short-range security. The 3d suggestion is to import as much oil as can be accepted without serious prejudice to domestic exploratory activity. The 4th is to develop synthetic liquid fuels by private enterprise, assisted by basic Government research. The 5th is to develop refinery flexibility to permit higher yields of distilled products and to reduce the output of residual fuels.

3685. WHITNER, T. C. Review of Hydrogenation. *Oil and Soap*, vol. 16, 1939, pp. 39-44; *Chem. Abs.*, vol. 33, 1939, p. 2747.

Brief review of hydrogenation as applied to hardening of vegetable oils, conversion of glycerides or other esters of fat acids into alcohols of high molecular weights, reduction of CO to hydrocarbons or to alcohols and hydrogenolysis of petroleum. Some mention also is made of the types of catalysts, as well as of the operating conditions employed in each instance. A short outline of various methods for the commercial production of H₂ and its purification is included.

3686. WICKLE, E. [Theoretical and Practical Investigation of the Adsorption Velocity of Gases on Porous Substances.] *Ztschr. Elektrochem.*, vol. 44, 1938, pp. 587-590; *Chem. Abs.*, vol. 33, 1939, p. 1200.

For the velocity of adsorption and desorption of gases on porous solids, formulas are obtained, based on the following assumptions: Porous solids have a pile of spheres structure, the spaces between the solid fragments being the macropores; the micropores extend fjordlike into the solid particles and fill relatively rapidly, so that the velocity of sorption is determined solely by the transport of gases in the macropores. The effective diffusion coefficient for CO₂ calculated from the sorption velocity has the same order of magnitude as that calculated from the resistance to the flow of the gas through the solid absorbents.

3687. WIDEMANN, M. [Solubility of Hydrogen in Iron.] *Anz. Maschinenwes.*, vol. 64, No. 11, suppl., 1942, pp. 17-19; *Chem. Zentralb.*, 1942, II, p. 2194; *Chem. Abs.*, vol. 33, 1944, p. 2603.

Absorption of H₂ by liquid Fe, by Fe products during heat treatment in H₂-containing atmospheres, and by Fe during pickling is explained. Dissolved and absorbed H₂ are partly lost during hot and cold working or by exposure of metal to the atmosphere. H₂ causes decarburization in Fe-C alloys and decreased watt loss in transformer steel sheets. X-ray examination shows H₂ is dissolved in the α - and γ -lattices, produces an increase in lattice constant, and acts especially on the intercrystalline material.

WIDEMANN, K. See abs. 1032, 1033.

3688. WIELAND, H. [Combustion of Carbon Monoxide.] *Ber. deut. chem. Gesell.*, vol. 45, 1912, pp. 679-683; *Chem. Abs.*, vol. 6, 1912, p. 1409.

Combustion of CO in O₂ or air, in presence of Pd and H₂O, has been explained by assuming the formation of H₂O₂ and the simultaneous formation of CO₂

and H₂O from CO, H₂O, and O₂. This oxidation is not dependent upon O₂ of air, but takes place thus: CO + H₂O = CO₂ + H₂. The 1st product is HCOOH, which decomposes into CO₂ and H₂, the latter once more forming H₂O and O₂ of air. The presence of HCOOH may be shown by directing a CO flame upon ice, neutralizing the water formed with Ba(OH)₂, filtering, and testing with AgNO₃.

3689. ———. [Mechanism of Oxidation Process. III. Process of Combustion.] *Ber. deut. chem. Gesell.*, vol. 45, 1912, pp. 2606-2615; *Chem. Abs.*, vol. 7, 1913, p. 347.

Just as in the oxidation of CO to CO₂, HCOOH is an intermediate product, so, if the nonluminous Bunsen flame is allowed to burn on distilled H₂O, HCOOH can be detected. HCOOH also can be detected in the CH₄ flame; its formation probably is due to the decomposition of the CH₄ into C and H₂, and C with H₂O at once gives CO, the source of the HCOOH. (See abs. 2217.)

WIEMER, H. See abs. 1966.

WIENER, F. See abs. 2909.

3690. WITZEL, G. [Preparation of Synthetic Fatty Acids for the Manufacture of Soap.] *Kleptzig's Textil-Ztschr.*, vol. 41, 1938, pp. 528-529; *Chem. Abs.*, vol. 32, 1938, p. 9537.

Air is passed for 10-30 hr. through liquid paraffin at 90°-160° in the presence of suitable catalysts. The oxidized product is washed first with an aqueous solvent and later with a base. Any ingredients that cannot be saponified are removed either by extraction with a solvent or by distillation. The crude soap is treated with a diluted acid to liberate the fatty acid, which is then fractionally distilled. Soft soap, soap powder, household soap, and toilet soap can be obtained in this way.

3691. ———. [Synthesis of Fatty Acids by Oxidation of Hydrocarbons.] *Angew. Chem.*, vol. 51, 1938, pp. 531-537; *Brennstoff-Chem.*, vol. 20, 1939, p. 130; *Chem. Age*, vol. 39, 1938, pp. 278-280; *Chem. Abs.*, vol. 33, 1939, p. 420.

General discussion with graphs and figures. The oxidation of synthetic paraffin from the Fischer-Tropsch process is carried out with air at temperatures of 80°-120° under pressure and with catalysts. Overoxidation should be avoided by careful control of the temperature and the time of operation. The choice of catalysts is important also, since they may promote the oxidation at lower temperatures and prevent overoxidation. Oxidation takes place after the material has been suitably prepared, therefore, by saponification with caustic and separation of the unsaponified constituents either by selective solution or by distillation at 300°-400°. This treatment also clarifies and deodorizes the saponified portion of the fatty acids. The unsaponified portion is mixed with fresh paraffin and recycled. The crude soap does not yet meet the requirements for use but must be split by means of mineral acids into fatty acids and be subjected to vacuum distillation, whereby about 50-80% of the original raw material is preserved in a form pure enough for soapmaking. Some remarks are made also on the food fats made from synthetic fatty acids by esterifying with glycerin. The results thus far obtained have some appearance of success even though the work has not yet gone beyond the experimental stage.

3692. ———. [Preparation of Fatty Acids by the Oxidation of Paraffin.] *Fette u. Seifen*, vol. 46, 1939, pp. 21-25; *Chem. Abs.*, vol. 33, 1939, p. 9024.

Fatty acid mixtures obtained by the commercial oxidation of paraffin contain, as a rule, all the products obtainable by breaking the C to C linkage between each adjacent pair of CH₂ groups and oxidizing them

to COOH groups. The composition of such fatty acid mixtures suggests that the CH₂ groups nearer the center of the paraffin chain are the ones most prone to oxidation. Usual analytical methods are suitable for determining the I, OH, ester, and carbonyl numbers of the fatty acid mixtures.

3693. WIGGINTON, R. Notes on Recent Developments in Fuel Technology. *Fuel*, vol. 7, 1928, pp. 1-3, 49-51; *Chem. Abs.*, vol. 22, 1928, p. 2254.

Brief reviews of the following subjects: The Pittsburgh explosion, the Bergius method; calorific values of H₂ and C; chamber ovens for gas manufacture; synthetic gasoline; natural steam power; submerged combustion; the Benson boiler; pulverized fuel on ships; Smith tar extractor, water gas from vertical retorts.

WILEY, J. W. See abs. 2700.

3694. WILFORD, A. T. Recent Fuel Developments. *Bus and Coach*, vol. 11, 1939, pp. 4-8, 34, 49-51.

Survey of British requirements with particular reference to production from domestic sources. The possibilities of obtaining fuels from the hydrogenation of coal and synthesis of gas are discussed.

WILHELM, R. H. See abs. 3749.

3695. WILKE, G. [Production of Water Gas From Semicoke.] *Techn. Mitt. Krupp*, vol. 5, 1937, pp. 44-49; *Chem. Abs.*, vol. 31, 1937, p. 8883.

Semicoke containing 8-10% of volatile matter yielded by the back-run process as gas containing H₂, 53 and CO, 36%, suitable for the Fischer-Tropsch synthesis.

3696. ———. [Production and Purification of Gas for the Synthesis of Benzene.] *Chem. Fabrik*, vol. 11, 1933, pp. 563-568; *Chem. Abs.*, vol. 33, 1939, p. 1911.

For about 2 yr. 4 plants with a total yearly capacity of 300,000 tons of benzene have been operating the Fischer-Ruhrchemie process, and 5 more with a yearly capacity of 225,000 tons are under construction. Automobile and airplane lubricants of high quality have been made recently from the crude products of the process, and the paraffin fraction has been converted into fatty acids on a commercial scale for over a year. The ratio CO:H₂ must be held close to 1:2, and the gas be almost dust-free, contain not over 0.2 gm. H₂S or organic S per 100 m³, and contain no resin-forming substances. There is now no producer for the direct gasification of coking coal, but Krupp-Lurgi has recently developed a process for producing strong lump coke suitable for this synthesis. Producers for non-coking coals, brown coals, and others, by the Viag, Koppers, Pintsch-Hillebrand, Wintershall-Schmalfeldt, Bubiag-Didier, and Lurgi processes are described.

3697. WILKE, W. [Present Position of Synthetic Fuels and Their Importance to the World Oil Economy.] *Schweiz. Bauztg.*, vol. 66, 1948, pp. 587-591; *British Abs.*, 1949, B, I, p. 336.

Hydrogenation of coal (Bergius-Pier process) and direct synthesis (Fischer-Tropsch process) are discussed in detail and their merits compared. Elements of groups 5 and 6 make the best catalysts for the Bergius-Pier process. Economy in H₂ consumption is effected by using not only coal but also coal tar and petroleum residues. The specific gravity and octane number of the gasoline product are increased if the initial H₂ content of the hydrogenated tar is low. The Co-Th Fischer-Tropsch catalyst now has been substituted by cheaper Fe catalysts. The chief advantage of the process lies in the initial gasification of coal to CO, making possible the use of low-grade coals and coke. Care must be taken to remove S compounds. Recent improvements to the process in America are described. Natural gas is used as the raw material there instead of coal. This is oxidized by O₂ over Ni catalysts under

controlled conditions to give CO and H₂. Flowsheets, diagrams, and graphs are shown, and special reference is made to the economy and heat economy of the various processes.

3698. WILKINS, E. T. Underground Gasification of Coal. *Fuel Econ. Rev.*, vol. 23, 1944, pp. 14-18, 58; *Gas World*, vol. 121, 1944, pp. 545-550; *Am. Gas Assoc. Monthly*, March 1945, pp. 119-123.

Review of Russian prewar proposals. 3 methods of gasification are given: Stream method applicable only to steeply dipping seams and requiring some preliminary hand labor; percolation method intended for use with horizontal seams, eliminates all underground labor and depends on the development of shrinkage cracks and fissures in the coal when heated, so that part of the seam becomes readily permeable to gas; and borehole-producer method, a combination of the 2 preceding methods. A supply of O₂ for air enrichment is desirable for satisfactory gasification and would appear to add an appreciable, but not a prohibitive, amount to the cost of gasification. 3 different gases have been generated: Producer gas obtained by continuous blowing with air; water gas generated by alternate 20 min. blasts of air and steam; and H₂-rich gas. It is proposed to use the gas of lower calorific value as power gas for electricity generation and H₂-rich gas for chemical processes such as NH₃ synthesis and Fischer-Tropsch process. Available details are given of trials carried out on 5 different coal seams. No definite data have been obtained so far on the % of coal gasified. The cost of producing gas by this method is said to be about 1/2 of that with normal producers—1-2 d. per therm as against 4-6 d. Capital expenditure is about 60-70% of that of normal gas-producer plants, the principal costs being those of the blast- and power-supply installations.

See abs. 304.

3699. WILKINS, E. T., AND JOLLEY, L. J. Catalytic Production of Methane. *Coke and Gas*, vol. 9, 1947, p. 245.

Paper presented at the 11th International Congress of Pure and Applied Chemistry, London, July 1947. The work of the British Fuel Research Station is reviewed. The process has reached such a perfected stage that no obstacle appears to stand in the way of building a full-scale plant whenever desired. The cost of synthetic CH₄ production is made up largely of the cost of making the necessary water gas. Catalysts of Ni, ThO₂, MgO, all supported on kieselguhr, have been used to promote the reaction. 4 primary difficulties have been met. (1) C deposition on the catalyst. Methods for prevention are: To add steam to the reaction gases; to increase the H₂:CO ratio of the gases; to select a catalyst least susceptible to C deposition; and to study the correct design of the reaction vessel. (2) Sintering of the catalyst. This can be avoided by keeping the actual temperature of the catalyst below 600° C. The actual temperature is found to be about 150° below that of the temperature as measured. (3) Poisoning by S. This is the greatest single cause of catalyst deterioration and occurs when the Ni has absorbed 2-3% of S by weight. It can be avoided by using a gas of extreme purity, but it is preferred to use a cheaper method of using a gas of moderate purity (below 0.03 grain S per 100 cu. ft.) and secure a moderate catalyst life of 3 months. The above purity is secured by use of the well-known Fe₂O₃-Na₂CO₃ mixture at 200°. (4) Dissipation of the heat of reaction. This is secured by watercooling the shell of the reaction vessel to 200°. The catalyst is arranged to line the wall of the vertical tube, the outside of which is water cooled.

3700. WILLCOX, O. W. Cheap Oxygen Is Major Factor in United States Fischer-Tropsch Adaptation.

World Petrol., vol. 18, 1947, 7th Ann. Refinery Issue, pp. 78-79, 104.

Value of cheap O_2 to the coal, steel, and oil industries is noted, and particular mention is made of the changes that have been effected by it in the Fischer-Tropsch synthesis technique. The development of the Linde, Fränkl-Linde, and M-7 (National Defense Research Committee and M. W. Kellogg Co.) processes for the manufacture of O_2 from air is outlined, and the advantages of the latter process are emphasized. A brief description of the Stanolind plant in Kansas is given, and the estimated costs of O_2 produced at this plant and at the Hydrocol plant in Texas are compared with recent estimates of costs at small O_2 plants.

WILLEKE, H. See abs. 3058.

3701. WILLELMART, A. [Use of Carbon Monoxide in Organic Syntheses: Oxo Reaction.] Bull. soc. chim., 1947, pp. 152-157; Chem. Abs., vol. 41, 1947, p. 6527.

Review, especially of information obtained from the I. G. Farbenindustrie plant at Ludwigshafen-Opau, concerning the reaction of an equimolecular mixture of CO and H_2 with olefins in the presence of a Co catalyst with primary formation of aldehydes. Primarily a review of patents.

3702. [Use of Carbon Monoxide in Chemical Synthesis.] La Nature, No. 3156, April 1948, pp. 90-102.

Review of the Fischer-Tropsch process and its commercial development.

3703. WILLEBROTH, —, AND GIESEN, —. [Improvement of Consistency and Durability of Catalyst Used in Methanol Synthesis.] Board of Trade, German Division, Technical Information and Documents Unit, F. D. 1030/47, Jan. 5, 1928, 9 pp.; Fuel Abs., 1948, No. 2388.

Experiments are described aiming at improving the consistency and durability of ZnO-base catalyst by adding Mg salts. Shows process for the manufacture of various types of improved catalysts, as well as their effects in the catalytic hydrogenation of CO and of other C compounds. Further research on ZnO-Mg-Cr catalysts is intimated.

3704. [Use of Zinc and Chromium Minerals as Catalysts for Synthesis of Methanol.] Board of Trade, German Div., Tech. Information and Documents Unit, FD 1029/47, January 1928, 28 pp.; Fuel Abs., No. 2389, 1948.

Effect of various Zn- and Cr-containing catalysts is described in connection with operational data. ZnO was confirmed as the best basic substance for the catalytic hydrogenation of CO to O-containing C compounds.

3705. WILLIAMS, A. E. Food From Coal. Coke Smokeless-Fuel Age, vol. 3, 1941, pp. 187-189; Chem. Abs., vol. 35, 1941, p. 7682.

Coke is converted into water gas. The reaction gases are purified and separated and caused to react in presence of catalyst under pressure and at temperatures of 250°-420° to form hydrocarbons. The hydrocarbons are oxidized to form fatty acids. Glycerol is synthesized from acetylene and CH_4 . Synthetic lard and butter are produced by combining the proper mixtures of fatty acids and glycerol.

3706. Hydrogenation and War. Engineer., vol. 171, 1941, pp. 58-60; Chem. Abs., vol. 36, 1942, p. 5582.

Hydrogenation of fatty oils, the production and hydrogenation of water gas, synthesis of CH_3OH and fatty acids, and hydrogenation of coal and tar are reviewed.

3707. Synthetic Food Fats. Food Manuf., vol. 16, 1941, pp. 161-163; Chem. Abs., vol. 35, 1941, p. 7048.

Synthetic fats are produced from the hydrogenation of water gas (equal vols. CO and H_2) at 300° with metallic Pt and CrO_2 as catalysts, resulting in 10% CH_4 and 90% higher paraffin hydrocarbons. The latter are oxidized to solid fat acids at 140°-160° for 6-8 hr. in presence of oxides of Fe, Mn, or V. Esterification is carried out under vacuum at 200°-220° by use of glycerol with a sulfonic acid as catalyst. The synthetic product is not identical with the natural products, but is satisfactory as nutriment. Synthetic lard compares favorably in cost with the wartime price of true lard. Glycerol is hard to obtain in wartime, so in Germany it is synthesized by (1) Hydrogenation of water gas, chlorination resulting in trichloropropane, which, when treated with caustic alkali, produces glycerol or (2) fermentation of glucose with yeast and Na_2SO_4 , then addition of lime and $CaCl_2$ and activated C, filtration, distillation of alcohol, leaving weak glycerol in the still, which is then concentrated and refined. Sometimes substitutes for glycerol are used, such as glycol or mannitol. Certain molds and yeasts synthesize fats.

3708. Synthetic Hydrocarbons. Engineering, vol. 151, 1943, pp. 394-395; Chem. Abs., vol. 35, 1941, p. 6023.

Fischer-Tropsch process for synthesizing hydrocarbons from CO and H_2 in presence of a Co-Th-kieselguhr catalyst is described. The composition of the products depends on the H_2 :CO ratio, the proportion of gases to catalyst, and the pressure. The yields of gaseous, liquid, and solid products at various pressures are tabulated. Waxes formed during the synthesis and impurities in the gases, especially S, reduce the activity of the catalyst. The synthesizing plant is described briefly, and the application of the products is discussed, with special reference to motor fuel and lubricating oil.

3709. Synthetic Hydrocarbons From Water Gas. Paint Manuf., vol. 15, 1943, pp. 348-355; Chem. Abs., 40, 1946, p. 1005.

Hydrocarbon oils and alcohols produced synthetically from water-gas are of value to the paint and varnish industry in several ways. As alternatives to the volatile oils of paint, the higher flash point and lower price of the synthetic products give them an advantage. Synthetic oils are valuable as substitutes for glycerides in paints and sealing solutions for application to chemically active surfaces, for the synthetic product is inert to such surfaces.

3710. Synthetic Lubricating Oils. Sci. Lubrication, vol. 2, 1950, pp. 2-3; Fuel Abs., vol. 5, No. 2, 1950, abs. 1082.

Processes used in production of synthetic oils from coal are noted, and the Fischer-Tropsch process is described in some detail. Olefins provide suitable raw material for lubricating oil manufacture. The catalysts and operations employed in the polymerization of olefins are noted, and the properties of the lubricants so obtained are enumerated. Details of the hydrogenation process, suggested as the most promising refinery treatment, are presented also.

3711. WILLIAMS, C. R. Gas Development and Trends in South Texas. Oil Gas. Jour., vol. 45, No. 36, 1947, pp. 68, 71; Petrol. Eng., vol. 18, No. 4, 1947, pp. 174, 176.

Abridged version of a paper presented before the Texas Section, American Institute of Mining and Metallurgical Engineers. Of the estimated natural-gas reserves of the United States of approximately 150 trillion cu. ft. South Texas alone has 25-30 trillion cu. ft. and the State of Texas about 58% of the total reserves. The potential supply is increasing annually through new discoveries, and it is probable that gas will continue to maintain a reserve ratio substantially in excess of consumption, which averaged approxi-

mately 2½ trillion cu. ft. before the war and 4½ trillion cu. ft. at the close. Technical development and expansion of the Fischer-Tropsch process into actual commercial operation in Brownsville, Tex., indicate that natural gas may be worth \$0.09-\$0.12 per 1,000 cu. ft. for the manufacture of liquid fuels, although the ultimate realization of such a price will require accessibility to adequate gas reserves to afford a long-time operation and will depend largely on the duplication of small-scale results in larger commercial plants. Another factor influencing the value of natural gas is the proposed conversion of coal at the mines into synthetic natural gas having a heat value of approximately 1,000 B. t. u. per cu. ft. at a cost of \$0.16-\$0.20 per 1,000 cu. ft. Completion of such developments and the resulting competition in the transportation of gas from the Texas area will not justify a very high price at the wells, therefore, it would appear that the ultimate future price of natural gas will depend on its successful utilization by the Fischer-Tropsch synthesis of gasoline rather than by its export for industrial fuel.

3712. WILLIAMS, E. C., AND BECK, O. Hydrogenation of Hydrocarbons. National Research Council Committee on Catalysis, 12th Rept., 1940, pp. 107-119.

A table of hydrogenation catalysts, including remarks on their preparation, properties, and uses, is of special interest. Nearly 50 compounds are listed suitable or used for destructive hydrogenation of coal, oils, and tars, MeOH synthesis, NH_3 synthesis, and hydrogenation of oils. Literature refs. appended.

3713. WILLIAMS, J. P. Manufacture of Motor Fuels and Synthetic Petroleum, Especially From Coal. Synthetic Liquid Fuels Hearings Before a Subcommittee of the Committee on Public Lands and Surveys, U. S. Senate, 78th Cong., 1st sess., on S. 1243, 1943, pp. 238-247.

Brief survey of motor-fuel sources: Byproduct coking, shale oil agricultural products, solid fuel engines, high-pressure hydrogenation, and Fischer-Tropsch synthesis. The cost of synthetic gasoline by the Fischer-Tropsch process is calculated from German data of 1938 and adapted to American prewar conditions. The estimated costs are as follows from 3 raw materials:

Cost estimates on Rubricheemie process if operated in the United States in 1940

Raw material	Cost of synthesis gas per gal. of primary product	Cost of 1 gal. primary product	Cost of 1 gal. finished synthetic gasoline
Coke	\$0.122	\$0.186	\$0.244
Subbituminous coal	.073	.138	.182
Natural gas	.066	.13	.174

The conversion cost of the primary product from synthesis gas is put at \$0.0635 per gal. The estimates are for a plant making 2,424 bbl. of primary product per day. The total steel required is considered equivalent to 14 tons per bbl. of gasoline per day.

WILLIAMS, K. A. See abs. 87.

WILLIAMS, N. H. See abs. 691.

3714. WILLIAMS, P. N. Synthetic Fats. Chem. and Ind., No. 19, 1947, pp. 251-255.

Historical review of the process for producing synthetic fats by the oxidation of hydrocarbons to fatty acids; the method developed by the Deutsche Fettsäure Werke, Witten, Germany, for the manufacture of synthetic fatty acids from the Fischer-Tropsch wax (gatsch) is described in some detail. The total yield of crude fatty acids by this process is said to be 80% on the hydrocarbon oxidized. The margarine product

obtained by the esterification of the fatty acids with glycerin is described and analyzed. The product was found to be palatable and suitable for human consumption, although its nutritional value is still considered doubtful. From information available it appears that not only was the cost of producing the acids considerably greater than the cost of natural fatty acids; namely, \$65-\$77 per ton at 10 RM to the £, but the synthetic fat was even more expensive, £177 per ton. It is further stated that if paraffin wax at £44 per ton could be obtained as raw material, the production of synthetic fatty acid in England would cost £91-£96 per ton and the synthetic fat £205 per ton.

3715. WILLEN, L. J. Proposed Process for the Complete Gasification of Coal by the Use of Oxygen. Proc. Am. Gas Assoc., 1923, pp. 969-974; Chem. Abs., vol. 19, 1925, p. 1485.

Review of the possibilities of continuous blast gasification with 85-90% O_2 . The process should be economically feasible if, as estimated, 90% O_2 can be produced for \$0.45 per 1,000 cu. ft., with a plant investment of \$1.00 per 1,000 cu. ft. per yr.

WILSON, D. W. See abs. 1723.

WILSON, E. See abs. 1410.

3716. WILSON, H. Production of Formalin From Digester Gas. Surveyor, vol. 105, 1946, pp. 27-28; Chem. Abs., vol. 40, 1946, p. 5861.

All S compounds are removed from the gas (70% CH_4 and 30% CO_2), H_2O vapor is added, and the mixture is passed over granular Ni catalyst at 950°. The CO and H_2 produced are converted to MeOH at 2,500 lb. pressure over a granular Zn chromite catalyst. The MeOH is dehydrogenated to give CH_2O , which is dissolved in H_2O .

WILSON, M. W. See abs. 3025.

3717. WILSON, R. E. Technical and Economic Status of Liquid-Fuel Production From Nonpetroleum Sources. Nat. Petrol. News, vol. 36, 1944, pp. R 596-602; Chem. and Eng. News, vol. 22, 1944, pp. 1244-1250; Chem. Abs., vol. 38, 1944, pp. 5057, 6065.

Discussion of oil-from-coal law recently authorized by Congress.

3718. Oil for America's Future. Petrol. Eng., vol. 17, No. 1, 1945, pp. 166, 171, 172, 174.

Digest of testimony presented October 3 before a special congressional committee investigating petroleum resources. Severe possibilities, which eliminate even a remote danger of a petroleum shortage, are discussed. One important possibility is the production of gasoline from natural gas by the Fischer or Synthol process at costs similar to the present costs of production from crude petroleum. By devoting only ½ of the present calculated reserves of natural gas to this process, about 500,000 bbl. per day over a period of 25 years could be produced; this amounts to about 30% of our prewar gasoline consumption. Another possibility is that of hydrogenation of our low-grade coals, the reserves of which are virtually inexhaustible. The cost of gasoline on a large-scale operation would be about \$0.10-\$0.15 per gal. above present gasoline costs. A 3d possibility is the application of the Fischer process to subbituminous and lignite coals. Recent research development enables this indirect method to produce good quality gasoline and diesel fuels at costs not more than \$0.05-\$0.06 per gal. above present costs. In addition to these methods, there are still the oil shales and oil sands of the United States and Canada to be considered. It is believed, however, that the accessibility and extent of our coal and lignite deposits will make them the most logical major source of petroleum, if and when crude petroleum becomes scarce. The industry regards the use of the above processes as a rather long-range alternative and is, therefore, not

likely to spend the large sums required for extensive research nor for building large-scale pilot plants or semicommercial units. The Bureau of Mines program of research and development seems, therefore, to be sound, though the opinion of the industry is somewhat divided on this point. It is urged that the building of semicommercial units should be postponed until much more research and pilot-plant work has been done and until commercialization of the process appears reasonably imminent.

3719. ———. Government Synthetic Fuel Program. Nat. Petrol. News, vol. 41, No. 23, 1949, p. 22.

It is felt that erection now of commercial-size synthetic liquid fuel plants would be premature. The wisest course at the present time would be to confine expenditures only to research and pilot-plant work to obtain the technical information essential as a sound basis for commercial-plant design and operation, if and when such plants are needed.

3720. WILSON, R. E., AND ROBERTS, J. K. Petroleum and Natural Gas—Uses and Possible Replacements. Nat. Petrol. News, vol. 39, No. 14, 1947, pp. 9-10.

Paper presented at a meeting of the American Institute of Mining and Metallurgical Engineers and the Western Petroleum Refiners' Association. The authors foresee a considerable expansion in the present main uses of liquid fuels. By 1970 the demand for crude oil or its equivalent will be 56% greater than in 1945. As a supplementary, or possibly as a replacement fuel, that produced by the Synthol or Hydrocol process appears to be the most promising. Gasoline made by this process will cost \$0.06-\$0.065 per gal. when made from natural gas, \$0.09-\$0.04 more when made from coal. Another process that may help extend crude supplies is the hydrogenation of cracked cycle stocks and residue. It appears more expensive than the Synthol process when using natural gas as the raw material, but it will become economically desirable as the price of crude rises. Alternatively, residue could be used as starting material for the Synthol process by converting it to CO and H₂. It is estimated that these processes will be in commercial operation as follows: Synthol using natural gas in 1948; Synthol using coal in 1970; and hydrogenation of heavy oil residue in 1965. Gasoline from coal hydrogenation and from oil shale will cost much more, but neither of these sources should be overlooked and investigation of them should be continued.

WILSON, S. P. See abs. 633.

3721. WINDFELD-HANSEN, I. [Production of Motor Alcohol from Coal, More Particularly from the Standpoint of the Possibility of Creating a Synthetic Motor Alcohol Industry in Denmark.] Ingeniøren, vol. 49, No. 6, 1940, A, pp. 17-25; Chim. et ind., vol. 48, p. 646; Chem. Abs., vol. 34, 1940, p. 5623.

3721a. WINFIELD, M. E. Adsorption and Hydrogenation of Gases on Transition Metals. Australian Jour. Sci. Research, vol. A 4, 1951, pp. 385-405; Chem. Abs., vol. 46, 1952, p. 1939.

Behavior of gases chemisorbed at the surface of face-centered cubic crystals of transition metals is discussed by considering simple models of the surface and the possible arrangements of the gas molecules on them. Molecular, atomic and ionic adsorbates are considered. In using such bond energies and lattice parameters as are available, models are suggested for the structures of the adsorbates of O₂, H₂, C₂H₄, C₂H₂, and CO on Cu, Ni and Fischer-Tropsch catalysts. From the properties of these models, mechanisms are suggested for the hydrogenation of C₂H₄ on Ni and for the Fischer-Tropsch hydrocarbon synthesis.

WINKELMANN, ———. See abs. 3581.

WINKELMANN, H. See abs. 1606.

3722. WINKLER, ———. [Synthesis of Ethyl Alcohol—Preparation of Ethyl Alcohol from Carbon Monoxide and Hydrogen Under Pressure.] Ind. agr. Aliment., vol. 66, 1949, pp. 159-160; British Abs., 1950, B, II, p. 2.

Mixture of CO and H₂ (3 : 1) is passed through a reaction tube at 300°-320° and 180-200 atm. in contact with a catalyst containing Fe₂O₃, K₂CO₃, and ZrO₂. Fractionation of the product yields an alcohol fraction equal to 25 gm. per m.³ of gas and containing 60-70% of EtOH. The reaction tube of 120 mm. diameter produces 1,500 kg. of EtOH per month.

3723. WINKLER, H., AND JACQUE, L. [Synthetic Petroleum and the National Fuel.] La Nature, vol. 53, i, 1925, pp. 325-327, 346-347; Chem. Zentrabl., 1925, II, p. 1002; Chem. Abs., vol. 19, 1925, p. 2734.

Review from the chemical standpoint of the liquid-fuel problem, including a discussion of cracking and hydrogenation of petroleum, carbonization of oils, and the possibilities of EtOH and MeOH as fuels.

3724. WINKLER, L. [Place of Gas in German Energy Supply.] Gas- u. Wasserfach, vol. 78, 1935, pp. 845-848, 876-880; Chem. Abs., vol. 30, 1936, p. 1208.

Discussion of competition of gas with electricity and with solid fuels. A gas of higher heating value than the present 430-450 B. t. u. gas is advocated, as offering a lower unit cost. Low temperature distillation is advocated to produce larger volumes of liquid fuel and a gas of higher heating value, which may be scrubbed to remove heavy hydrocarbons. Motor-fuel synthesis from manufactured gas by the Fischer process also is advocated, and attention is called to yield of gas of higher heating value from this process in addition to motor fuel.

WINSAVER, W. O. See abs. 1269.

3724a. WINTER, E. [Catalytic Decomposition of Ammonia Over Iron.] Ztschr. physik. Chem., vol. 13, Abt. B, 1931, pp. 401-424; Chem. Abs., vol. 26, 1932, p. 364.

Catalytic decomposition of NH₃ in NH₃-H₂ or NH₃-H₂-N₂ mixtures was studied over Fe catalysts at 500°-700° by a flow system. On supported Fe catalysts the rate of decomposition was approximately proportional to the partial pressure of NH₃ and inversely proportional to the 3/2 power of the partial pressure of H₂. H₂ was without effect on the decomposition. One series of runs over a roll of Fe gauze indicated that the rate of decomposition was proportional to the first power of NH₃ partial pressure and inversely to the first power of H₂. The energy of activation over the temperature range studied is about 51,000-54,000 cal. The relation between catalytic activity and formation of Fe nitride is discussed. The results indicate that the reaction rate depends upon the concentration of atomic N on the surface of the catalyst.

3725. WINTER, H. [Catalysts and Materials of Hydrogenation.] Glückeuf, vol. 73, 1937, pp. 420-424; Coal Carbonisation, vol. 3, 1937, p. 114.

Importance of catalytic research and investigations on hydrogenation reaction vessels in relation to the German 4-year plan is emphasized. The limitations of light metals (sp. gr. below 5) and their applications in binary catalysts are noted. For economic reasons, special interest attaches to the less expensive of the heavy metals. The degree of activity of catalysts is important in securing the desired product (for example, motor fuels and not CH₄). The stability, freedom from poisoning, and ready regeneration of catalysts are important factors. The present state of knowledge on these matters is reviewed with reference to original sources, and the various mechanical forms in which catalysts are used, ranging from sheets to colloidal sus-

pensions, are discussed. Methods of increasing the activity of catalysts and the various theories of catalytic action are considered. The special requirements of constructional materials for reaction chambers and the like are noted. Plain C steels are not satisfactory; instead, low-C special steels (Ni-Cr, W, and other alloys) are used. Many data relating to specified materials and reactions incorporated.

WINZER, K. See abs. 1035, 2624, 2625.

3726. WIRGES, M. F., AND PALM, J. W. Production of Chemicals by Oxidation of Natural-Gas Hydrocarbons. Oil Gas Jour., vol. 48, No. 1, 1949, pp. 90, 92, 114; Petrol. Processing, vol. 4, No. 6, 1949, pp. 677-678.

Paper presented at the American Institute of Chemical Engineers meeting at Tulsa. Direct oxidation of natural-gas hydrocarbons is used for the commercial production of substantial quantities of formaldehyde, acetaldehyde, methanol, acetone, and other chemicals. The methods used in carrying out the various steps in the oxidation process are discussed by help of a flow sheet. The important variables in the process are temperature, pressure, makeup composition, recycle, catalyst and reaction time. These variables are discussed and data concerning their effects on the reaction are presented. Use of a recycle system with commercial O₂ at elevated pressures instead of atmospheric induces increased yields (102% increase) of CH₂O. The preferred temperature range is 840°-880° F. Natural gas added as makeup in the recycle system gives optimum chemical yields within the range of 5-20% makeup. The reaction time is usually from 0.25-2 sec. Catalysts must be selected carefully.

3727. WIRTE, G. [Evaluation of Converters for Exothermic and Endothermic Catalytic Reactions Occurring Within Narrow Temperature Limits.] Tom Reel 134, sec. I-B, item 37, July 4, 1952; Bureau of Mines Inf. Circ. 7,587, 1950, 13 pp.

In exothermic and endothermic catalytic reactions, control of the temperature is of utmost importance. Basic calculations are developed for determining catalytic volumes of various types of reactors that give particular temperature distributions. With the help of the formulas evolved, the individual types of construction are compared with regard to cooling surface and space utilization. To select a converter of the proper size, it is necessary to consider still other factors that do not appear in the calculations; for example, height of the catalyst bed, linear gas velocity, ease of discharging, construction costs, and maintenance and operating costs. It is believed that the information contained in this paper may prove of value to workers in the field of catalytic reactor design.

3728. WIRTH, H. R., AND ETH, ———. [Benzine and Oil.] Schweiz. Aero-Rev., vol. 17, 1942, pp. 139, 141, 226-228; Chem. Zentrabl., 1942, II, p. 971; 1943, I, p. 116.

Brief review of the production of motor fuels from petroleum by cracking and polymerization, as well as by the benzene synthesis process of Fischer-Tropsch and high-pressure hydrogenation.

WITHERS, J. G. See abs. 259.

3729. WITHERS, J. G., AND WEST, H. L. Interrogation of Dr. O. Roelen at Wimbledon. BIOS Final Rept. 511, 1946, 26 pp.; PB 28,883; TOM Reel 227.

Translation of 3 documents prepared by Dr. Roelen: (1) The Fischer-Tropsch Synthesis and Its Products; (2) Synthetic Lubricants Made by Ruhrchemie A.-G.; (3) Town Gas and Methanized Gas for Automotive Propulsion. (See also abs. 1334 and 1335.)

3730. WITTKA, F. [Recent Advances in the Field of Paraffin Oxidation.] Seifensieder-Ztg., vol. 66, 1939, pp. 666-668, 699-700; Chem. Abs., vol. 33, 1939, p. 9603.

Review of patents.

3731. ———. Manufacture of Synthetic Fatty Acids by Oxidation of Paraffins Obtained from Water Gas by the Fischer-Tropsch Process. Soap Sanit. Chemicals, vol. 16, 1940, p. 28.

3732. ———. Moderne Fettchemische Technologie. Heft II. Gewinnung der höheren Fettsäuren durch Oxidation der Kohlenwasserstoffe, 1940, 167 pp. Lithoprint by Edwards Bros., Ann Arbor, Mich., 1945.

3733. ———. Synthetic Aliphatic Acids. Soap Sanit. Chemicals, vol. 16, 1940, No. 8, pp. 28-32, 73; No. 9, pp. 34-37, 73; Chem. Abs., vol. 34, 1940, pp. 7636-7637.

Raw materials used in the German process are synthetic paraffins prepared from water gas by the Fischer-Tropsch process, yielding up to 50%. The paraffins are distilled, and those having a b. p. above 350° are used. They are mixed with 0.1% of powdered KMnO₄ and heated to 150° for 10 min. By adding catalysts and blowing air through porous plates made of sintered metal, the temperature can be reduced to 100° and the time of oxidation shortened to about 20 hr. Various salts of Mn including KMnO₄, Mn stearate, and Mn soaps of unsaturated acids are used in quantities from 0.5-1%, depending on the quality of the soaps. The products of oxidation are gaseous, as well as volatile and nonvolatile liquids. The gases formed are CO and rarely CO₂. The volatile liquid products are H₂O and low aliphatic acids of all kinds. Acetic acid is the main constituent of the soluble acids. The insoluble low-aliphatic acids make up 10-12% of the original weight of the paraffins and have an acid value of about 272 and a saponification number of about 370. The acids of low molecular weight have little value and are used in small amounts only industrially. The non-volatile liquid products of the oxidation are used for making soaps after being separated from the large quantities of unsaponifiable substances with which they are mixed. If light-colored acids are desired, the oxidation is stopped when only 30-40% of the paraffins have been oxidized. Naphtha is used as the solvent in the continuous process for the removal of the unsaponified materials, and the soap solutions are first mixed with Et or isopropyl alcohol to prevent the formation of emulsions. Two solvent-extraction plants are described, both processes requiring 2 treatments for producing usable acids. Another process, the high-temperature and pressure method, consists in heating the soap solution at high temperature under pressure and dispersing the hot soap solution without a drop in temperature. The oxidized acids are dehydrated to form unsaturated acids, and the acid products are changed into neutral ones. The soap remains as a yellow liquid, which when cooled over rollers gives an odorless yellow powder. Approximately 0.1% of unsaponifiable remains in the soap. Aliphatic acids made from the Fischer-Gantsch paraffins have the following constants: Acid value, 261.5; I number, 7.0; oxidized acids, 0.2%; average molecular weight, 214. Separation of the acids in this mixture shows that virtually all from C₆ to C₂₂ are present. For soap making all under C₁₀ and over C₁₈ are eliminated by fractional distillation. The fraction that can be used for soaps has the following properties: Solidification point, 26.2°-30°; acid value, 241.2-239; saponification number, 247.2; average molecular weight, 229.8=C₁₈H₃₆COOH; I number, 4.9; hydroxyl value, 3.7; unsaponifiable, 0.29%. Through esterification, the lower acids can be converted into a form that can be used in the perfume industry, but no use has been found for the higher acids, which are sent back to the oxidation tower.

3734. ———. [Modern Fatty Acid Synthesis.] Seifensieder-Ztg., vol. 40, 1943, pp. 50-51, 68-69; Chem. Zentrabl., 1944, I, p. 717; Chem. Abs., vol. 39, 1945, p. 2211.

Production of fatty acids from CO, hydrocarbons, alcohols, aldehydes, ketones, nitro compounds, and

metal alkyls is discussed. The problem of fat acid synthesis by oxidation of paraffins has already been solved. The following 3 processes should be considered for commercial production: (a) Potash fusion of chlorinated hydrocarbons; (b) high-pressure hydrogenation of CO; and (c) saponification of aliphatic nitro compounds. The advantage of these is that the raw materials are of the gas-oil type and are byproducts, which are cheaper than paraffins.

3735. ———. [Production of Fatty Alcohols.] *Allgem. Oel- u. Fett-Ztg.*, vol. 40, 1943, pp. 103-110; *Chem. Zentralbl.*, 1943, II, p. 74; *Chem. Abs.*, vol. 38, 1944, p. 4461.

Patent literature on production of fatty alcohols by splitting sperm oil, by high-pressure hydrogenation of fat acids, and by oxidation of hydrocarbons is reviewed.

3736. WOLFF, B. [Synthetic Fatty Acids.] *Przeglad Chem.*, vol. 3, 1939, pp. 45-51; *Chem. Abs.*, vol. 33, 1939, p. 3759.

Concise description of the technical synthesis of fatty acids by oxidation of higher paraffins with air at higher temperatures, 140°-160°.

WOLFF, L. K. See abs. 3222, 3223.

WOLLAN, E. O. See abs. 3182.

WOOD, W. H. See abs. 432.

3736a. WOOD, W. L. Production of Gaseous Hydrocarbons From Coals and Their Tars. *Oil Shale Cannel Coal Conf.*, vol. 2, 1951, pp. 690-709; *Chem. Abs.*, vol. 46, 1952, p. 11,630.

Cannel coals were studied as a possible source of olefinic gases to be used by the chemical industries in England. Low-temperature assays were conducted on samples from most of the major seams, and semi-commercial tests were run on a high and a low oil-yield cannel. The light oils and tars were cracked at high temperatures and the carbonization and cracking gases analyzed. Some properties of the liquid products and the analyses and yields of gases are given. It is concluded that, even with simplified equipment charging high-grade cannel coals, the process could not produce olefins at a cost competitive with those available from petroleum cracking.

See abs. 2208, 2209, 3677.

WOODRILL, J. S. See abs. 1049.

3737. WOODRUFF, J. C. Synthetic Methanol and Ammonia From Butyl Fermentation Gases. *Ind. Eng. Chem.*, vol. 19, 1927, pp. 1147-1150; *Chem. Abs.*, vol. 21, 1927, p. 3702.

High-pressure NH₃ plant at Peoria has been adapted to the production of MeOH, for which purpose it is necessary to remove only a portion of the CO₂ content of the fermenter gas, the reaction employed being CO₂ + 3H₂ = CH₃OH + H₂O. Investigations are in progress for the development of a suitable process for converting the CO₂ into CO in order to make use of the reaction CO + 2H₂ = CH₃OH whereby the MeOH output for a given compressor capacity may be increased 33%.

WOODS, H. L. See abs. 1390.

WOODWARD, L. A. See abs. 448, 449, 1409.

3738. WORLD PETROLEUM. Humble Considers Erecting Gas-Conversion Plant on Gulf Coast. *Vol. 17, No. 1, 1946, p. 63.*

In addition to the Hydrocol plant now being built in Brownsville, Tex., 2 plants are being considered for construction in the Hugoton gas field extending from western Kansas to the Texas panhandle. Humble has not indicated the proposed location. In common with other operators of cycling plants in the Gulf coastal areas of Oklahoma and Texas, Humble is carefully conserving gas as a reserve of motor fuel raw material. At current prices, natural gas at the wellhead in Texas

is bringing only about 10% of its B. t. u. value when compared with liquid fuel. In common with most other large companies in the oil industry, Standard Oil is devoting a considerable portion of its research and development work to gas- and coal-conversion processes. An extensive abstract of Murphree's recent talk before the American Gas Association (abs. 2344) is included.

3739. ———. Centrifugal Compressors Completed for Carthage Hydrocol Plant. *Vol. 20, 1949, pp. 58-59.*

Two mammoth centrifugal compressors for the Hydrocol plant have been built by Clark Bros., Olean, N. Y. Each of the compressor units consists of 3 cases to be installed in tandem for drive through by a single steam turbine. Designed capacity is to compress 110,000 cu. ft. of air per minute to 100 p. s. i. g.

The 1st 2 cases operate in parallel, the 3d acting as a 2d stage. Power requirement is 23,000 b. hp. A total of 24 units with an installed hp. of over 80,000 will be used to compress 6 different gases involved in the Fischer-Tropsch synthesis. Some special nonferrous metals have been adopted in order to guard against O₂ and to provide adequate intercooling between the various compressor cases. Internal parts of the O₂ compressors are made of bronze alloy and are water-cooled, a special bronze diaphragm being used to obtain a high rate of cooling. 2 photographs given.

WORTHINGTON, H. See abs. 607.

3740. WRIGHT, C. C. Liquid Fuels From Coal. *Canadian Min. Jour.*, vol. 64, 1943, pp. 792-794; *Pennsylvania State Coll. Mineral Industries*, vol. 13, 1943, No. 2, pp. 1, 3; *Chem. Abs.*, vol. 38, 1944, p. 847.

Brief review of methods of obtaining liquid motor fuel from coal.

3741. ———. Liquid Fuels From Coal. *Mineral Industries*, vol. 13, No. 2, 1944, pp. 1, 3; *Coke*, vol. 6, 1944, pp. 59-60.

Review of the various methods of producing motor fuel from coal, indicating the present state of commercial operation of the Bergius process, the Fischer-Tropsch synthesis process, and extraction processes such as the Pott-Broche and Ulde. In current Fischer-Tropsch synthesis, the refined liquid products consist of 62% gasoline of low octane number and low lead susceptibility, 26% Diesel oil of very high cetane number, 10% gas, and 2% paraffin wax. The theoretical yield of liquid products is 13 lb. per 1,000 cu. ft. of gas treated; the actual yield is 7.5 lb. (1.2 gal.) but the modified Fischer-Pichter process yields 9.4 lb. In 1938 Germany was operating 14 Fischer-Tropsch plants with a capacity of 7,000,000 bbl. per yr.

3742. ———. Hydrogen or Synthesis Gas by the Oxygen Gasification of Solid Fuels. *Mineral Industries*, vol. 17, No. 3, December 1947, pp. 1, 3.

Basic processes for the conversion of coal to synthesis gas are: Gasification of lump or sized fuel in a fixed bed with steam and O₂ or air; gasification of fine coal in a fluidized bed using steam and O₂; and gasification of finely pulverized coal carried in a gas stream with steam alone or with steam and O₂. Economic consideration will be the deciding factor. The fixed-bed process developed by the Consolidated Mining & Smelting Co. of Canada has been investigated for the production of raw synthesis gas and of H₂ from both coke and anthracite. The process has probable interest for use in the United States. O₂ produced by the Claude process, is saturated with H₂O and then passes with steam through the fuel bed. The raw synthesis gas produced is scrubbed and passed through a converter where it reacts with steam in the presence of a catalyst to form H₂ and CO; the CO₂ being removed by scrubbing with H₂O at 225 lb. pressure. In terms of generator volume, the gasification rates for

coke exceed those of the conventional water gas process and compare favorably with most of the fluidized- and pulverized-coal processes. With small sizes of anthracite, gasification rates were only about 50% of those for large sizes. The efficiency of the fixed bed O₂ producer compares favorably with that of any other process yet developed as regards C, O₂, and steam consumption. The over-all economics depend largely upon the cost of O₂ and fuel suitable for the process. See abs. 1163.

3743. WRIGHT, C. C., AND NEWMAN, L. L. Oxygen Gasification of Anthracite in the Wellman-Galusha Producer. *Chem. Eng.*, vol. 54, No. 6, 1947, pp. 114-115; *Pennsylvania State Coll. Mineral Ind. Exper. Sta.*, *Tech. Paper 122, 1947, 12 pp.*; *Proc. Am. Gas Assoc.*, vol. 29, 1947, pp. 701-712.

Rice and Barley anthracites were gasified in the Wellman-Galusha producers used for the manufacture of synthesis gas from coke by O₂ gasification at Trail, B. C. Both sizes were satisfactorily gasified using O₂ and steam and at gasification rates considerably above 100% increase in capacity over that obtained with air and steam. The gas produced from the Rice anthracite was close to the composition desired for synthesis gas; that from the Barley size was not so good. The coal consumption per 1,000 cu. ft. of raw gas was, respectively, 23.2 and 25.9 lb. The O₂ consumption per lb. of fuel gasified was appreciably lower for Rice coal and slightly lower for Barley coal than for large coke. Steam consumption per 1,000 cu. ft. of raw gas and per lb. of fuel gasified was higher for both Rice and Barley coal than for coke. Operating results are tabulated, a heat balance is shown, and a flowsheet is given.

3744. WRIGHT, C. C., BARCLAY, K. M., AND MITCHELL, R. F. Production of Hydrogen and Synthesis Gas by the Oxygen Gasification of Solid Fuels. *Ind. Eng. Chem.*, vol. 40, 1938, pp. 592-600; *Chem. Abs.*, vol. 42, 1943, p. 4329.

Information in this paper is additional to that reported recently by Mitchell and by Wright and Newman. The oxygen gasification of solid fuels in fixed-bed producer-gas equipment has been demonstrated as a practical commercial success. The construction and operation of the equipment is simple, its performance well known, and its cost relatively low. The results of plant-scale operations indicate that the overall C, O₂, and steam consumption for synthesis-gas production compare favorably with any fixed-bed, fluid-bed, or coal-suspension process thus far developed. Gasification efficiencies for synthesis-gas production are high. The gasification rates per unit of generator area are appreciably higher than those normally attained in air-blown producer operations and higher than those attained in the standard water-gas generator when using the same size fuel, but appreciably lower than the rates attained for the pulverized-fuel processes. The gasification rates per unit of generator volume are, however, comparable to those of the pulverized-fuel processes. The quality of the raw gas from O₂ gasification of anthracite was such that with a slight reduction in CO₂ content it could be used directly for the isosynthesis process. Raw gas from the coke at the highest steam : O₂ ratio approached this composition. For conversion to a gas of 2 : 1 = H₂ : CO ratio, the shift reaction must be used. Removal of CO₂ from the gas by pressure scrubbing with water results in a substantial loss of CO and H₂. This loss may be reduced appreciably by 2-stage pressure letdown and by recycling part of the gas. Material and heat balances over the producer and over the converter system are shown for the production of H₂, and a calculated material balance is shown for the production of synthesis gas of 2 : 1 = H₂ : CO ratio. These balances indicate some of the factors involved

in the overall problem of synthesis-gas production from solid fuels. The economics of the O₂ gasification of solid fuels in fixed beds hinges largely upon the cost of the solid fuel suitable for the process and upon the cost of O₂, the relative efficiency, as compared with other processes, and the capital charges.

3745. WRIGHT, C. W. Germany's Capacity to Produce Petroleum. *Survey of the Substitute Fuel Industry*. *Petrol. Times*, vol. 37, 1937, pp. 46-50.

Statistical report on the German crude petroleum production and byproducts, the production of synthetic hydrocarbons from lignite in 1934 and 1935, and the total production, consumption, imports, and exports of oil products from all sources for 1913 and 1932-35.

3746. WRIGHT, M. M., AND TAYLOR, H. S. Interaction of Methane and Methane-d₂ on Nickel and the State of the Catalyst Surface. *Canadian Jour. Research*, vol. 27, 1949, B, pp. 303-317; *Chem. Abs.*, vol. 43, 1949, p. 7802.

Mass spectrometer studies of the exchange reaction and the reaction of H₂ with catalyst surface residues support the concept of dissociative adsorption. Evidence of fragments, such as CX_n, CX, C (X=H or D), was obtained. The first order disappearance of CD₂ has an activation energy of 20.9 kcal. at 100°-255°. Temperature increases the concentration of the more hydrogenated fragments (larger *i* for CD_i and CH_i), and equilibrium between the fragments depends on the heats of adsorption of the fragments and H on the surface and, therefore, on the nature of the catalyst and on the strength of OH bonds formed. Experimental details, tables, and graphs.

3747. WRIGHT, S. R., DIMOCK, W. R., AND DAVIS, S. G. Evaluation of Catalysts Used in the Synthesis of Hydrocarbons. *Canadian Chem. Process Ind.*, vol. 32, No. 1, 1948, pp. 33-54, 57; *British Abs.*, 1948, B, I, p. 280.

Preliminary report on the methods used in evaluating Fischer-Tropsch catalysts at the University of Alberta. The evaluation is being done on a semiplant scale with synthesis gas prepared from natural gas and O₂ using a catalyst chamber of design similar to that used at the Bureau of Mines in Pittsburgh. Operating data are presented, activity tests of 3 Co catalysts tabulated, and optimum operating conditions indicated.

3748. WYCKOFF, R. W. G. R., AND CRITTENDEN, E. D. X-Ray Examination of Some Ammonia Catalysts. *Jour. Am. Chem. Soc.* vol. 47, 1925, pp. 2866-2876; *Chem. Abs.* vol. 20, 1926, p. 526.

The effect of promoters in activated catalysts is studied by means of X-rays to show that certain additions produce their activating effects by favoring the formation of numerous active points and by stabilizing these specifically active metal particles. X-ray photographs, prepared in the usual way for powder photographs, were obtained (1) from various fused Fe oxides having compositions near to Fe₂O₃, and others richer in ferrous Fe than Fe₂O₃, (2) from artificial magnetites containing various amounts of Al₂O₃ and K₂AlO₄ as promoters, and (3) from the Fe catalysts obtained by reducing these fused oxides. One function of the promoters of Al₂O₃ and K₂AlO₄ in reduced Fe oxide catalysts for the synthesis of NH₃ is suggested. The length of the edge of the unit cube of magnetite was found to be $a_0 = 3.37 \pm 0.010$ Å. U. In magnetites containing an excess of FeO this substance occurs as a separate phase. This phase disappears when the equivalent amount of the promoter, Al₂O₃, is added. The composition of the oxide is thus adjusted toward Fe₂O₃ with the formation of FeAl₂O₄, which is apparently in solid solution in the magnetite. The value of

A. for magnetite containing $K_2Al_2O_4$, differs so little from A. for pure Fe_3O_4 , that it is impossible to decide whether or not there is solid solution of one in the other. A. for the α -iron obtained by the reduction of Fe_2O_3 is 2.850 ± 0.004 Å. U. The size of the unit cell of Fe in the reduced material containing the promoters differs from that of pure Fe by less than 0.1%. The presence of the composite promoter, K and Al oxides, in the reduced catalysts has been found to maintain a large surface of Fe by preventing the rapid growth of the Fe crystals.

3749. WINKOOP, R., AND WILHELM, R. H. Kinetics in Tubular Flow Reactor. Hydrogenation of Ethylene Over Copper-Magnesia Catalyst. *Chem. Eng. Progress*, vol. 46, No. 6, 1950, pp. 300-310. *Chem. Abs.*, vol. 44, 1950, p. 6713.

Catalytic hydrogenation of ethylene over Cu-magnesia catalyst was studied experimentally and theoretically as an example of the application of chemical kinetics to a continuous-flow tubular reactor. Most experiments were isothermal; a few experiments were permitted to assume modest temperature variations. Experimental conditions were varied over the following ranges: H_2 concentration, 32.6-95.2%; temperature, $9^\circ-79^\circ$; space velocity, $0.20 \times 10^3-32.0 \times 10^4$ total mol. per cc. sec.; catalyst particle size, 0.108-0.279

YANIMKIN, N. A. See abs. 3536.

YAMADA, H. See abs. 1893.

YAMADA, T. See abs. 1890, 1891, 1909.

YAMAMOTO, K. See abs. 1801, 1802, 1803.

3751. YAP, C. P. Influence of Dissolved Carbide on the Equilibria of the System: Iron-Carbon. *Am. Inst. Min. and Met. Eng., Tech. Pub.* 382, 1931, 19 pp.; *Chem. Abs.*, vol. 25, 1931, p. 1148.

Previously published data on the Fe-C diagram are used to discuss the shape of the solidus. The straight solidus is obtained by cooling a sample from the melt, whereas the curved solidus is obtained by heating samples that have already reached room temperature. Fe₃C exists as a structurally stable phase that the austenite must redissolve. This leads to the conclusion that within a certain range of temperature the C in solution in austenite must be in the form of a carbide.

3752. ———. Thermodynamic Study of the Phase Equilibria in the System: Iron-Carbon. *Am. Inst. Min. and Met. Eng., Tech. Pub.* 381, 1931, 26 pp.; *Chem. Abs.*, vol. 25, 1931, p. 1148.

Previously published Fe-C diagrams are reviewed and the disagreements regarding the shapes of the liquidus and solidus are pointed out. The Fe-C diagrams were replotted and C was calculated as mol. % and as mol. % Fe-C. Thermodynamic laws of solutions that apply to a diagram of this type were calculated and values taken from the various Fe-C diagrams were substituted to determine which was the more nearly correct. The results indicated that in the liquid state C exists mainly as Fe₃C, but in the solid γ -Fe it is dissolved as C. The correct liquidus bounding the field Δ -melt is probably that of Ruer and Goerens (*Chem. Abs.*, vol. 12, 1918, p. 2524), which is slightly convex. In the Δ -field, C is dissolved as such in the melt. Heat of transition of γ - to Δ -Fe is about 2.0 cal. per gm. and accordingly the heat of fusion of γ -Fe is about 64.4 cal. per gm.

3753. YAP, C. P., AND LIU, C. L. Free Energy, Entropy, and Heat of Formation of Fe_3C . *Trans. Faraday Soc.*, vol. 28, 1932, pp. 788-797; *Chem. Abs.*, vol. 27, 1933, p. 462.

Following values are calculated from existing equilibrium data on CH_4-H_2 and $CO-CO_2$ mixtures over

cm. diam.* Kinetic equations for the flow system were developed and the experimental data were found to correspond to a first order reaction with respect to H_2 . The precision of measurement of the rate constant is discussed. Because of small conversions, a high precision analysis for H_2 by means of thermal conductivity cells was developed. An effect of reversible poisoning of the catalyst by water vapor was encountered. Flow equations and precautions that must be used in their development are discussed. A mechanism for the hydrogenation reaction is proposed.

3750. WYSOCKI, J. [One-Step Conversion of Carbon Monoxide for Rendering Illuminating Gas Nonpoisonous.] *Plyn, Voda zdravotni Technika*, vol. 17, 1937, p. 184; *Chem. Zentrabl.*, 1937, II, p. 1487; *Chem. Abs.*, vol. 33, 1939, p. 4763.

Furnace, constructed by Eskreis, is described; it is suitable for the conversion $CO+H_2O=CO_2+H_2$, as well as the 2-step conversion according to this reaction and the reaction $CO+3H_2=CH_4+H_2O$. It operates on the principle of the successive carrying off of the excess heat along the whole length of the furnace with the progress of the reaction so that the products of the reaction leave the furnace with a final temperature of $400^\circ-350^\circ$.

austenite and Fe_3C : $3\alpha-Fe+C=Fe_3C$; $\Delta F_{298}^\circ=-9,300$ cal., $\Delta H_{298}^\circ=12,300$ cal., $\Delta S_{298}^\circ=0.9$ cal., $S_{298}^\circ=3.8$ cal. per degree. From its free energy of formation, Fe_3C is stable above 750° . Austenite behaves as an ideal solution and follows Raoult's law.

YASHIRO, R. See abs. 1896.

YASUDA, M. See abs. 1895, 1916, 1917, 2210.

YATSKOVSKAYA, N. S. See abs. 281.

3754. YENSEN, T. D. Evidence Obtained by X-Ray Analysis of Films of Iron in Magnetic Fields as to the Ultimate Nature of Magnetism. *Phys. Rev.*, vol. 32, 1923, pp. 114-123; *Chem. Abs.*, vol. 22, 1923, p. 3580.

Results of other workers showed that there is no change in crystal structure of single crystals of magnetite and hematite when placed in strong magnetic fields. In the present investigation, films of electrolytic Fe were analyzed by X-rays to determine whether there is any change in the random orientation of the minute crystals, of the order of 150 Å., found in these films when placed in strong magnetic fields up to 2,600 gauss. If so, the uniform circular diffraction patterns resulting from the randomly oriented crystals should, because of the preferred orientation, be changed to show greater or less density along a diameter parallel to the applied magnetic force than along the other perpendicular to it. The circles were analyzed microphotometrically and the results indicate no change in the orientation. The average of all the measurements is a ratio of the intensities along the 2 diagrams of 1.00 ± 0.08 , the variation being attributed to incidental sources arising from the developing and handling of the film. Conclusion: The most minute crystal aggregates in Fe are not oriented in a magnetic field. This lends strength to the previous conclusion in regard to the ultimate nature of magnetism, namely, that the magneton is an atomic property.

YONE, G. R. See abs. 930.

YOKOMAKI, Y. See abs. 1918, 1919, 1920, 1921, 1922, 1923, 1924, 1925, 1926.

3755. YOKOYAMA, T. [Gas-Producer Furnace With Oxygen Blast.] *Jour. Fuel Soc. Japan*, vol. 20, 1941, pp. 9-11; *Chem. Zentrabl.*, 1941, II, p. 294.

Discusses production of synthesis gas for NH₃ and motor-fuel catalysis, operating constants and gas prop-

erties, gasification process, and properties of coke used as raw material.

3756. YOSHIKAWA, K. [Oxidation of Methane to Carbon Monoxide and Hydrogen.] *Bull. Chem. Soc. Japan*, vol. 6, 1931, pp. 106-110; *Sci. Papers Inst. Phys. Chem. Research*, (Tokyo), vol. 25, 1934, pp. 295-301; *Chem. Abs.*, vol. 25, 1931, p. 3956.

Experiments were made by a flow method at $800^\circ-1,000^\circ$ with and without catalysts on CH_4 -air and CH_4-O_2 mixtures. Ni and Co were efficient catalysts and their activity was promoted by adding various oxides. The most efficient catalysts of those studied were Ni-ThO₂ and Ni-SiO₂. In the presence of these catalysts the reaction, $2CH_4+O_2=2CO+4H_2$, proceeds almost quantitatively at $850^\circ-900^\circ$. Without catalysts most of the CH_4 remains unchanged at $1,000^\circ$.

YOSHIMORI, K. See abs. 2200, 2201, 2202, 2203, 2204, 2205.

YOSHIOKA, Y. See abs. 1897, 1898, 1899.

ZABOLOTSKIĬ, T. V. See abs. 2913.

3757. ZABOLOTSKIĬ, T. V., AND SINGUROVSKA, Y. O. [Determination of the Surface of Iron Catalyst in Ammonia Synthesis.] *Ber. Pissarjewsky Inst. physik. Chem., Akad. Wiss. Ukr. S. S. R.*, vol. 12, 1940, pp. 23-30 (in German, p. 31); *Chem. Abs.*, vol. 35, 1941, p. 2685.

About 1 gm. of the Fe catalyst used in NH₃ synthesis was placed in a tube kept at 23° and containing a benzene solution of the dye. At definite time intervals, samples of solution were withdrawn and the dye concentration was determined with a photocolormeter. The areas were calculated by the method of Emmett and Brunauer (abs. 922). The areas also were determined by the method of Gaukman and Roifer (abs. 1164) with N₂ and A at temperatures close to their condensation points. Definite relationship was established between both methods.

ZARNSTECHEK, L. W. See abs. 1708.

3758a. ZAIĐENMAN, I. A., AND KHOZYAKOV, K. G. [Initial Stages of the Interaction of Carbon Monoxide and Hydrogen With Nickel Catalyst at the Temperatures of Synthesis of Gasoline.] *Doklady Akad. Nauk S. S. R.*, vol. 78, 1951, pp. 901-904; *Chem. Abs.*, vol. 45, 1951, p. 8336.

Heat evolved on contact between CO or a mixture $1CO:1H_2$ and a skeleton Ni catalyst, by leaching Ni-Al, reduced by H₂ 2-4 hr. at $190^\circ-200^\circ$ was determined in an Al calorimeter with a Pt resistance thermometer, accuracy $0.0005^\circ-0.001^\circ$, in experiments at $180^\circ-185^\circ$ in both flow and circulation systems. With the aid of simultaneous measurements of the change of pressure, the heat was referred to 1 mole gas disappeared. First contact of CO with a freshly prepared Ni catalyst evolved over 85 kcal. per mole gas disappeared. This is considerably higher than the heat effects, per 1 mole gas disappearing, of any of the 5 possible reactions: (I) $2CO+C+CO_2$, 42.9; (II) $2CO+3Ni \rightarrow Ni_3C+CO_2$, 31.7; (III) $2CO+2H_2 \rightarrow CH_4+CO_2$, 30.15; (IV) $CO+3H_2 \rightarrow CH_4+H_2O$, 16.9; (V) $3Ni+CO+H_2 \rightarrow Ni_3C+H_2O$, 11.1 kcal. The abnormally high initial heat effect of 85 kcal. can be attributed only to a change within the catalyst itself, specifically to partial recalescence. On consecutive admissions of CO, each time after reduction of the catalyst with H₂, the heat effect drops to and remains constant at about 34 kcal. per mole gas disappeared. This corresponds to the carbide-formation reaction (II); reaction (V) is excluded, as there is no H₂O formation with CO alone. The rate of reaction (II) passes through a maximum within the 1st few

3757. YOSHISAKI, H. [Velocity of Decomposition of Cementite.] *Sci. Repts. Tohoku Imp. Univ., Ser. A*, vol. 1, No. 1, 1949, pp. 63-70; *Chem. Abs.*, vol. 44, 1950, p. 9887.

In the conversion of white cast Fe to gray, namely, decomposition of cementite to Fe and graphite, it is assumed that: (1) The reaction occurs selectively at the surfaces of a number of singular points, as reaction nuclei; (2) the number of reaction nuclei diminishes as the reaction continues; and (3) the velocity of movement of a reaction zone in a fixed direction in a homogeneous crystal grain of the reactant does not vary at constant temperature. On the basis of these assumptions, the following empirical equation was derived for the reaction velocity constant as a function of temperature, C, and Si contents: $K=5.8 \times 10^{-10} C^{0.4} Si^{0.4} e^{-10000/T}$.

YOUNG, D. W. See abs. 3238.

YUCUCHI, M. See abs. 1119, 1120.

YUKIO, U. See abs. 2019.

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minutes. Its activation energy in the range $165^\circ-195^\circ$ is 15.8 kcal. per mole. The same heat effect, 34 kcal. per mole gas disappeared, is found in contact with a $1CO:1H_2$ mixture, on a catalyst previously exposed to CO. This again is evidence for the occurrence of reaction (II); reaction (III) is out of the question, as in this instance one does observe formation of H₂O; furthermore, subsequent admission of H₂ alone produces hydrocarbons, which is proof that Ni carbide has been formed. On more prolonged contact with the gas mixture, the heat effect decreases gradually, which indicates beginning occurrence of reaction (IV). However, in the initial stage, the preponderance reaction is (II).

ZAMEZLA, E. See abs. 3187.

ZARAKOVSKAYA, A. I. See abs. 3763, 3764.

3759. ZEITSCHRIFT DES VEREINS DEUTSCHER INGENIEURE. [Diesel Fuels From Coal.] *Vol. 83*, No. 47, 1939, pp. 1240-1241; *Kohle u. Erz*, vol. 36, 1939, p. 278; *Coke Smokeless-Fuel Age*, vol. 2, 1940, pp. 70-71.

H. Köbel claims to have developed stable diesel fuels from coal-tar oil and Kogasin, utilizing the selective solvent action of the latter to remove constituents liable to cause coking. The process is said to be applicable also to low-temperature tar oils. The latter have inherently higher cetane nos. Synthetic hydrocarbons of the Kogasin type have a cetane no. of 120, and when about 38% is mixed with tar oil of 20 cetane no., a diesel fuel of 60 cetane no. is obtained, which is equal in ignition qualities to commercial diesel oil of petroleum origin. A 45:55 Kogasin-coal-tar-oil mixture shows better properties than an unnamed petroleum fuel.

3760. ZELINSKIĬ, N. D. [New Syntheses of Hydrocarbons From Carbon Monoxide.] *Doklady Akad. Nauk S. S. R.*, vol. 60, 1948, pp. 235-237; *Chem. Abs.*, vol. 42, 1948, p. 6510.

Occurrence of free CH₃ radicals in the Fischer-Tropsch synthesis is considered demonstrated by the methylation of C₆H₆, introduced into the reaction mixture, to PhMe, and the proof that these radicals actually originate from CO+H₂. Comparative kinetic studies of the rates of formation of hydrocarbons from CO+H₂, of formation of carbide in the reaction between CO and the catalyst, and of the reduction of the carbides by H₂, have demonstrated that intermediate carbide formation plays a role only on Fe catalysts, not on Co and on Ni. The Fischer-Tropsch reaction proceeds by way of the intermediate radical CHOH and CHOH+H₂→H₂O+CH₃. Closely related to this mecha-

nism is the catalytic hydrocondensation of CO with olefins (C_2H_4 , C_3H_6 , C_4H_8 , etc.) to saturated and unsaturated aliphatic hydrocarbons, and the catalytic hydrocondensation of olefins to saturated and unsaturated aliphatic hydrocarbons, occurring only in the presence of some (5-7%) CO. It is obvious that these reactions are determined by intermediate formation of CH_3 radicals. (See abs. 795, 792, 795, and 3761.)

See abs. 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 802b, 802c, 803, 1704, 1705, 2916, 3558.

3761. ZELINSKIĬ, N. D., AND SHUKIN, N. I. [Peculiar Conversion of Cyclohexane in the Presence of a Nickel Catalyst.] Compt. rend. acad. sci. U. R. S. S., vol. 3, 1934, pp. 255-257 (in German, p. 258); Chem. Abs., vol. 28, 1934, p. 7252.

In the presence of a Ni catalyst precipitated on $Al(OH)_3$, cyclohexane (I) in H_2 atmosphere at $330^\circ-350^\circ$ undergoes a peculiar conversion with the formation of complex hydrocarbons. Along with a dehydrogenation of (I) to C_6H_6 a deep-seated cleavage takes place with the formation of free CH_3 radicals. These are, in part, reduced to CH_4 , and in part combine with the C_6H_6 and the unaltered (I) to form toluene, xylene, methylcyclohexane, and dimethylcyclohexane.

ZELINSKIĬ, N. D., AND VERESHCHAGIN, L. F. [Chemical Reactions at Superhigh Pressures and High Temperatures. II. Reactions of Polymerization of Cyclohexene and Vinylcyclohexene.] See abs. 3559.

ZELINSKIĬ, N. D., EIDUS, Y. T., PUZITSKIĬ, K. V., AND BATEV, M. I. [Catalytic Hydrocondensation of Carbon Monoxide With Olefins. V. Hydrocondensation of Carbon Monoxide and Propylene.] See abs. 802a.

ZELYAKOV, N. V. See abs. 3267.

3762. ZERNER, E. [Catalytic Oxidation of Paraffin and Mineral Oil.] Chem.-Ztg., vol. 54, 1930, pp. 257-259, 279-281; Brennstoff-Chem., vol. 11, 1930, p. 291; Chem. Abs., vol. 24, 1930, p. 3635.

Experiments were made on the oxidation of paraffin and mineral oil in the presence of catalysts. Catalysts consisting of the stearates and oleates of Al, Ba, Cr, Pb, Fe, Mn, stearic, and oleic acids, as well as other organic substances such as fats, oils, turpentine oil, and sugar were used. A very efficient catalyst was Mn stearate; with this the reaction began at $110^\circ-115^\circ$, whereas, without a catalyst, an induction period and heating to 160° were necessary. The reaction products obtained were a salve-like neutral portion (103%), an oily, acid distillate (2.5%), an aqueous distillate (5.5%), and a volatile material absorbable on activated C. CO. was only 2% of the raw material. The neutral portion can be bleached with H_2O_2 and can be saponified (saponification No. 175) and yields thereby: 40% unsaponifiable material, 20% H_2O soluble, and 40% H_2O insoluble acids. The recovered acids are dark and semisolid. The oily distillate consists of only $\frac{1}{4}$ fatty acids; the rest is neutral substances. The aqueous distillate is 15-20% acetic acid contaminated with homologous substances. The volatile material yields up to 15% of a highly unsaturated oil. The oxidation of mineral oil in both an acid and alkaline medium was not satisfactory; the physical properties of the products were not nearly so good as with paraffin, and the odor was very unpleasant and persistent, making the products unsuitable for soap making.

ZETTEMAYER, A. C. See abs. 1372.

ZHADROVA, G. M. See abs. 814, 815.

ZHEMOCHKIN, M. N. [Utilization of the Permanent Gases From the Dry Distillation of Wood for Organic Synthesis. III.] See abs. 3765.

3763. ZHEMOCHKIN, M. N., LAPSHIN, S. I., AND ZARAKOVSKAYA, A. I. [Utilization of the Permanent Gases From the Dry Distillation of Wood for Organic

Synthesis. I. Sulfur Compounds in the Products of Thermal Decomposition of Wood.] Lesokhim. Prom., No. 4, 1939, pp. 22-26; Khim. Referat. Zhur., No. 8, 1939, p. 117; Chem. Abs., vol. 34, 1940, p. 5272.

3764. ZHEMOCHKIN, M. N., LAPSHIN, S. I., TROITSKAYA, F. B., AND ZARAKOVSKAYA, A. I. [Utilization of the Permanent Gases From the Dry Distillation of Wood for Organic Synthesis. II. Composition and Yield of Permanent Gases Produced During Dry Distillation.] Lesokhim. Prom., No. 5, 1939, pp. 32-40; Khim. Referat. Zhur., No. 12, 1939, p. 103; Chem. Abs., vol. 35, 1941, p. 878.

3765. ZHEMOCHKIN, M. N. [Utilization of the Permanent Gases From the Dry Distillation of Wood for Organic Synthesis. III.] Lesokhim. Prom., vol. 2, No. 9, 1939, pp. 12-14; Chem. Zentralb., 1940, I, p. 1106; Chem. Abs., vol. 35, 1941, p. 7152.

Permanent gases are now used for heating. This is uneconomical owing to the low heating value, 2,000-3,000 cal. per m^3 , and high CO_2 content, 50%. By passing the gases and steam over Ni catalysts at 800° , CH_4+CO_2 or H_2O giving CO and H_2 , and 500° , $CO+H_2O=CO_2+H_2$, a gas is obtained, which, after cooling and removal of CO_2 , can be used directly for MeOH synthesis.

3766. ZHEMOCHKIN, M. N., LAPSHIN, S. I., AND TROITSKAYA, F. B. [Utilization of the Permanent Gases From the Dry Distillation of Wood for Organic Synthesis. IV. Conversion of the Permanent Gases.] Lesokhim. Prom., vol. 2, No. 10, 1939, pp. 11-20; Chem. Zentralb., 1940, I, p. 1106; Chem. Abs., vol. 35, 1941, p. 7152.

Best conditions for the 1st conversion are: Ni catalyst, temperature of 800° , volume velocity of 200 and a H_2O content of 0.3 m^3 per m^3 . The product contained CO_2 , 27; CO , 35; H_2 , 33; and N_2 , 5%. For the 2d stage (formation of gas with a $CO:H_2$ ratio of $\frac{1}{2}$), a volume velocity of 200, temperature of 500° , and a H_2O content of 0.6 m^3 per m^3 is used.

ZHEMOCHKIN, M. N., LAPSHIN, S. I., TROITSKAYA, F. B., AND ZARAKOVSKAYA, A. I. [Utilization of the Permanent Gases From the Dry Distillation of Wood for Organic Synthesis. II. Composition and Yield of Permanent Gases Produced During Dry Distillation.] See abs. 3764.

ZIEGLER, —. See abs. 872.

ZIESECKE, K. H. See abs. 2688, 2689, 2690, 2691, 2692, 2693.

ZIMMERMANN, F. See abs. 3068.

3767. ZIMMERSCHIED, W. J., DINERSTEIN, R. A., WEITKAMP, A. W., AND MARSCHNER, R. F. Complexes of Urea With Linear Aliphatic Compounds. Jour. Am. Chem. Soc., vol. 71, 1949, p. 2047; Chem. Abs., vol. 44, 1950, p. 1033.

Work confirms the observation of Bengel (German Patent Application O. Z. 12,433, Mar. 18, 1940) that C_6H_{14} (0.1 mol.) in 9 vol. mixed decahydronaphthalenes, treated with 1.5 mol. $CO(NH_2)_2$ and 0.15 mol. MeOH and stirred 45 min. at 25° , gives a complex containing 11 mol. $CO(NH_2)_2$; the formation is accompanied by the evolution of 23 kcal. per mol. C_6H_{14} . Decomposition of the complex in 300 ml. H_2O gives 0.097 mol. C_6H_{14} . Halogen, S, and various O derivatives form entirely similar complexes if the linearity of the C skeleton is preserved. Compounds with a single Me branch form complexes when the linear chain approaches 20, the exact number depending upon the nature of the substituent and the position of the Me group.

3768. —. Crystalline Adducts of Urea With Linear Aliphatic Compounds. A New Separation Process. Ind. Eng. Chem., vol. 42, 1950, pp. 1300-1306; Chem. Abs., vol. 44, 1950, p. 9356.

With *n*-alkanes and their linear derivatives, urea forms crystalline complexes; with most branched and cyclic hydrocarbons and their derivatives, it does not. The effects of time, concentration of urea, concentration of urea solvent, concentration of *n*-alkane, and volume of wash liquid were studied, and optimum conditions were applied in the separation of unbranched hydrocarbons from complex petroleum fractions. Compounds such as 2-bromooctane, where substitution occurs at a point other than the end of a linear chain, often do not yield urea adducts. No simple molecular ratio of urea to C atoms was determined. An empirical value of 0.8 ± 0.1 for the ratio was found for chains 7-32 C atoms long. The heats of adduct formation were measured for straight chain paraffins, olefins, alcohols, bromides, mercaptans, and Me esters. From a comparison of this heat with the heats of crystal transition, fusion, vaporization, H bonding, adsorption, and gas hydrate formation, urea adduct formation resembles adsorption more closely than any other physical process. Petroleum fractions usually contain inhibitors to adduct formation. This was overcome by the use of an activator such as MeOH, or by seeding with freshly prepared adduct. Formation of the adduct at room temperature is reasonably rapid, and recovery of the components by heating or stirring with H_2O is virtually quantitative.

ZISSON, J. See abs. 3153a.

ZOLOTOV, M. N. See abs. 1107.

3769. ZOLOTOV, N. N., AND SHAPIRO, M. I. [Activity and Structure of Copper-Zinc Catalysts for the Decomposition of Methanol.] Jour. Gen. Chem. (U. S. S. R.), vol. 4, 1934, pp. 679-682; Chem. Abs., vol. 29, 1935, p. 2062.

ZnO-CuO catalyst used for the decomposition of MeOH undergoes reduction at not less than 220° , the

CuO being reduced completely and the ZnO partly. In consequence, α -brass is formed, the Zn content of which increases with duration of contact.

3770. ZOAN, H. [Carbon Monoxide-Hydrogen Synthesis at I. G. Farbenindustrie A.-G.] FIAT Final Rept. 1267, April 14, 1949, 173 pp; PB 97,368.

Part 1 of a 3-part report compiled by German technicians in the French occupation zone. It contains the following papers: (A) Researches on $CO-H_2$ Synthesis in the Badische Anilin und Soda Fabrik Laboratory in 1925-1945, Dr. F. Duftschmid; (1) Development of Fused Fe Catalysts According to Research by E. Linckh and R. Klemm; (2) Oil-Circulation Process, Dr. F. Duftschmid; (3) The High-Pressure Gas-Circulation Process for the Synthesis of EtOH From Waste Gases, E. Linckh and R. Klemm; (B) Hydrocarbon Synthesis From CO and H_2 , Researches of the Ammonia Laboratory, 1935-1944, A. Scheuermann; (C) Hydrocarbon Synthesis From CO and H_2 With Fe Catalysts, Gas-Circulation Process, and Foam Process, W. Michael.

See abs. 3143.

ZUEVA, V. P. See abs. 2754.

3771. ZWERGAL, A. [Role of Hydrocarbons in the Production of Synthetic Fats by Oxidation in Germany.] Kolloid-Ztschr., vol. 112, 1949, pp. 168-182; Chem. Zentralb., 1950, I, p. 238.

Describes Fischer-Tropsch process and discusses Fe catalyst, its preparation and reduction, the synthesis gas, and the effect of certain variables, such as space velocity and heat of reaction upon the synthesis. Normal, medium, and high pressures and the Synol and Oxo processes are considered. The physiological effect of the isocompounds is explained. It is shown how the synthesis of fuels can be suppressed in favor of the synthesis of solid paraffins.

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Berthelot, M. A., L'Industrie des combustibles liquides. Part 2. Les carburants de synthèse.	255
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Ellis, C., The Chemistry of Petroleum Derivatives	813
Ellis, C., Hydrogenation of Organic Substances	811
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Goldstein, R. F., The Petroleum Chemicals Industry	1213
Griffith, R. H., Geometrical Factor in Catalysis	1259
Kainer, F., Die Kohlenwasserstoff-Synthese nach Fischer-Tropsch	1654
Lohse, H. W., Products From Carbon Oxides and Water Gas	2133

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Quill, L. L., Chemistry and Metallurgy of Miscellaneous Materials. Thermodynamics	2761
Sachanen, A. N., Conversion of Petroleum	3008
Schenck, H., Einführung in die physikalische Chemie der Eisenhüttenprozesse. Die Grundstoffe und Grundreaktionen der Eisenhüttenprozesse	3046
Schmidt, J., Das Kohlenoxyd, seine Bedeutung und Verwendung in der technischen Chemie	3097
Storch, H. H., Fischer-Tropsch and Related Processes for Synthesis of Hydrocarbons by Hydrogenation of Carbon Monoxide	3291
Storch, H. H., Synthesis of Hydrocarbons from Water Gas. Chemistry of Coal Utilization	3287
Storch, H. H., Golumbic, N., and Anderson, R. B., The Fischer-Tropsch and Related Syntheses	3296
Thomson, G. H., and Given, P. H., Progress in Coal Science	3397
Tongue, H., Design and Construction of High-Pressure Chemical Plant	3411
Tongue, H., Practical Manual of Chemical Engineering	3412
Tropsch, H., Entstehung, Veredlung, und Verwertung der Kohle	3455
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