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BIBLIOGRAPHY OF PROCESSES FOR REMOVING HYDROGEN SULFIDE FROM INDUSTRIAL GASES

JANUARY 1950—DECEMBER 1957

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United States Department of the Interior — 1959

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BIBLIOGRAPHY OF PROCESSES FOR REMOVING HYDROGEN SULFIDE FROM INDUSTRIAL GASES

January 1950–December 1957[1]

by

Sidney Katell[2] and Liang-tseng Fan[3]

SUMMARY AND INTRODUCTION

The reaction of coal, oil, or natural gas with air and oxygen and/or steam yields a gas containing varying amounts of impurities. Depending on the raw material and the end use of the product, these impurities include solids, such as dust or slag, and gases, such as hydrogen sulfide, carbon dioxide, and nitrogen.

Considerable effort has been expended in developing and operating purification systems, and the literature is replete with equipment data and operating results. The research problems, the design, and the operation of the various systems have been the subjects of patent applications, journal articles, and textbooks.

The Bureau of Mines is developing processes using synthesis gas from coal for producing liquid and gaseous fuels. Removal of sulfur compounds from the gas is an integral part of the program; consequently, the literature has been searched to facilitate the Bureau's work. This report is a compilation of references, with abstracts of the information dealing with one phase of the subject. It is concerned with removal of hydrogen sulfide gas from a gas stream and covers the literature from January 1, 1950, through December 1957 and should be helpful to other investigators.

ACKNOWLEDGMENTS

The authors wish to acknowledge the guidence of Dr. L. L. Hirst, Chief, Branch of Coal Gasification, and the assistance of the members of the Process Economics Evaluation Staff of the Branch of Coal Gasification during the preparation of the bibliography.

Chemical Abstracts, published by the American Chemical Society, was used extensively as a source for the information in this bibliography.

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LITERATURE ABSTRACTS[4]

A

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Corrosion was the principal problem in removing H_2S and CO_2 in glycol-amine gas-treating plants. Other problems were reduction of contactor capacity due to accumulation of corrosion products and to deterioration and loss of solution.

2. AUDAS, F. G. A Continuous Dry Process for the Removal of Hydrogen Sulfide From Industrial Gases. Coke and Gas, vol. 13, 1951, pp. 229-234; Chem. Abs., vol. 46, 1952, p. 11638i.

The catalytic reaction, $2H_2S + SO_2 \rightleftharpoons 2H_2O + 3S$, is employed to remove H_2S at 60-90° C. Alumine is used as a catalyst.

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3. BABIN, E. P., AND PLYUSIN, V. G. (Desulfurization Reactions Catalyzed by HF.) Jour. Appl. Chem., (U.S.S.R.), vol. 29, 1956, pp. 753-758; Chem. Abs., vol. 51, 1957, p. 6131i.

Catalytic desulfurization process using hydrogen fluoride.

4. BAHR, J. (Gas Desulfurization by Ammonia Wash and Conversion of Hydrogen Sulfide to Sulfur or Ammonium Sulfate.) Brennstoff-Chem., vol. 36, 1955, p. 129; Chem. Abs., vol. 50, 1956, p. 5275a.

Ammonia wash was used for purifying a gas stream. Through a short contact time, H_2S and a small amount of CO_2 were removed.

5. BENNETT, B. B. Possible Improvements in Oxide-Purification Practice. Gas Times, vol. 72, 1952, pp. 285-286, 291-293; Chem. Abs., vol. 47, 1953, p. 1357h.

Current processes for removing H_2S from gas.

6. BLOHM, C. L., AND CHAPIN, W. F. Purification and Dehydration of Gases. World Oil, vol. 130, No. 7, 1950, pp. 253-256, 258, 260, 262.

Use of glycol-amine solutions in removing H_2S and H_2O.

7. BOEHM, J. C. Conditioning of Natural Gas. Mech. Eng., vol. 74, 1952, pp. 563-567; Chem. Abs., vol. 46, 1952, p. 7736g.

H_2S is absorbed with an amine base, usually monoethanolamine.

8. BRAMSLEV, E. (The Principles of Dry Purification of Gases.) Compt. rend. 69th Cong. ind. gaz., 1952, pp. 551-601; discussion, pp. 601-606; Chem. Abs., vol. 48, 1954, p. 3663g.

Results of kinetic studies of H_2S absorption on various solids containing iron oxide.

9. _____. (Research on the Principles of Dry Purification of Gas. II. The Simultaneous Reaction of Fe_2O_3 With H_2S and O_2.) Compt. rend. 71e cong. ind. gaz., Paris,

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[4] Titles in parentheses are translations from the language in which the item was published.

1954, pp. 552-562; discussion, 1955, pp. 563-565; Chem. Abs., vol. 50, 1956, p. 12561b.

Tests were made in laboratory apparatus in which absorption of H_2S and O was determined by pressure drop and residual-gas analysis.

10. BRAMSLEV, E. Some Applications of Chemical Kinetics on Problems in the Gas Industry. 6th Internat. Gas Conf., New York, IGU/15-55, 17 pp. (in English); Chem. Abs., vol. 50, 1956, p. 10377c.

Rate of H_2S absorption is determined by diffusion through surface layer.

11. BRANDT, R. (Intensification of Dry Purification of Gas.) Gas-u. Wasserfach, vol. 92, 1951, pp. 321-326; Chem. Abs., vol. 46, 1952, p. 2267b.

Results of investigation have shown that capacity of dry purifier for H_2S and others can be increased 2-3 times by use of screened Luxmass of 1-2 mm.

12. BROMMER, H., AND LUHR, W. (The Perox Plant for Removal of Hydrogen Sulfide From Coke-Oven Gas.) Stahl u. Eisen, vol. 76, 1956, pp. 402-406; Chem. Abs., vol. 50, 1956, p. 17383i.

Washing process is used for complete removal of sulfur. Cost is discussed.

13. BRUCKNER, H. (Modern Practices in Gas Purification and Hydrocarbon Recovery.) Gas, Wasser, Warme, vol. 9, 1955, pp. 203-211; Chem. Abs., vol. 50, 1956, p. 5274h.

A modern NH_3 scrubber and dry purifier are used to remove H_2S.

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Factors that affect absorption of H_2S by peat from gases containing NH_3 were investigated. Efficiency of operation and mechanism of reaction involved were determined.

15. CRAXFORD, S. R., POLL, A., AND WALKER, W. J. S. Recovery of Sulfur From Flue Gas by the Use of Ammonia. Jour. Inst. Fuel, vol. 25, 1952, pp. 13-14; Chem. Abs., vol. 46, 1952, p. 2267d.

Describes practices using NH_3 to recover sulfur from flue gases.

16. CROTOGINO, H. (Recent Experiences in the Waste-Water Treatment of Coal-Hydrogenation Plant.) Vom Wasser, vol. 17, 1949, pp. 49-61; Chem. Abs., vol. 44, 1950, p. 8089i.

Discusses various purification processes, including that of H_2S.

17. CROUZET, J. (An Evaluation of Purifying Materials.) Compt. rend. cong. ind. gaz., Lyon, vol. 66, 1949, pp. 508-528; Chem. Abs., vol. 46, 1952, p. 6808h.

Compares effectiveness of various iron oxide mixtures to absorb H_2S.

18. CULBERTSON, L., AND CONNORS, J. S. How to Rid Natural Gas of Undesirable Sulfur Compounds. Oil Gas Jour., vol. 51, No. 14, 1952, pp. 114-115; Chem. Abs., vol. 46, 1952, p. 10586b.

Briefly reviews methods for removing H_2S and CO_2 from gas. They include the NaOH, iron oxide, Na_2CO_3, 2-stage phenolate, phosphate gas, and aqueous amine treatment.

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19. DAVIES, R. G., AND HARTMANN, H. F. The Use of Pyrite Cinders in Town-Gas Purification. Nat. Gas Bull., Australia, vol. 2, No. 19, 1955, pp. 8-15; Chem. Abs., vol. 49, 1955, p. 11261f.

H_2S absorption capacity of mixtures of pyrite cinders and a natural iron oxide from Nowa Nowa (Victoria) were tested for gas purification. Cinders from cyclones were most satisfactory.

20. DIXON, T. E. New Process Washes Coke-Oven Gas With Waste Pickle Liquor. Iron Age, vol. 175, No. 12, 1955, pp. 91-93; Chem. Abs., vol. 49, 1955, p. 7838i.

New process using waste pickle liquor for removing H_2S and other acid gases. Pure $(NH_4)_2 SO_4$ crystals, $Fe(OH)_2$ and ferric cyanides are recovered from solution after a 6-stage treatment. H_2SO_4 or sulfur is recovered in another step.

21. DOUCE, WILLIAM C., AND WORD, J. A Good Waste-Disposal Program Makes Sense - and Profits. Oil Gas Jour., vol. 51, No. 18, 1952, pp. 100, 103-104; Chem. Abs., vol. 46, 1952, p. 11524a.

Brief survey, including H_2S removal.

22. DRABKIN, A. E. (The Purification of Gases by Removal of Hydrogen Sulfide With Amino Alcohol Solution.) Trudy Vsesoyuz. Nauch.-Issledovatel. Inst. Pererabotke Slantsev, No. 2, 1954, pp. 207-215; Referat. Zhur., Khim. Abs. No. 26566, 1956; Chem. Abs., vol. 52, 1958, p. 3308c.

Wet process using amino alcohol solution to remove hydrogen sulfide.

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23. ERMOLENKO, N. F., AND OTHERS. (Desulfurization of Petroleum Fraction by Vapor-Phase Treating With Active Clays.) Uchenye Zapiski Beloruss. Gsudarst. Univ. im. V. I. Lenina, Ser. Khim., vol. 24, 1955, pp. 77-95; Chem. Abs., vol. 51, 1957, p. 6132e.

Bentonitic and kaolinitic clays, bauxite and apatite (particle size, 1.25-2.5 mm.) were used as desulfurizing agents at 300°-400° F.

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Additional data on H_2S absorption by H_2O and NH_3 and rate of absorption. Uses simple experiment.

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25. FEAGAN, R. A., LOWLER, H. L., AND RAHMES, M. H. Operating Experiences With Amine Units for Hydrogen Sulfide Removel. Petrol. Eng., vol. 27, No. 11, 1955, pp. C48-50; Chem. Abs., vol. 49, 1955, p. 16404i.

Corrosion, one of most serious problems, can be reduced by maintaining a low solution concentration, avoiding high reboiler temperatures, and using slipstream filters.

26. FORCH, J. H. (Extracted Blue Earth as a Filling for Gas Purifiers.) Chem. Weekblad, vol. 48, 1952, pp. 88-90; Chem. Abs., vol. 46, 1952, p. 6363i.

Extracted blue earth made from exhausted iron oxide can be used for purifiers.

27. FRAZIER, H. D., AND KOHL, A. L. Selective Absorption of Hydrogen Sulfide From Gas Streams. Ind. Eng. Chem., vol. 42, 1950, pp. 2288-2292; Chem. Abs., vol. 45, 1951, p. 831f.

Results of investigation at laboratory and pilot-plant level have indicated that methyldiethanolamine solutions have high selectivity for removing H_2S from gases containing CO_2.

28. FREITAG, R. (Purification of Gas by the Glycol-Amine Process.) Neue Deliwa Ztschr., 1951, p. 54; Chem. Zentralb., 1951, I, p. 3286; Chem. Abs., vol. 48, 1954, p. 9652i.

Scrubbing solution contains 10-30 percent $EtNH_2$, 45-85 percent ethylene glycol, and 5-25 percent water. H_2S, CO_2, and water vapor are removed almost completely by countercurrent scrubbing. Process is especially suitable for natural gas.

29. FUJIMURA, K., AND KAWASUMI, A. (Desulfurization of Carbon Dioxide by Ammonium Bisulfite Solution.) Jour. Chem. Soc., Japan, Ind. Chem. Sec., vol. 52, 1949, pp. 5-7; Chem. Abs., vol. 45, 1951, p. 1737g.

Aqueous NH_4HSO_3 solution was employed to absorb H_2S selectively from the impure CO_2 gas. With countercurrent packed column, H_2S content was decreased from 2 to 0.01-0.001 grain per cubic meter under certain experimental conditions.

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Method of determining quality of Na_2HAsS_3O solution used for H_2S scrubbing.

31. GOL'DINOV, L. I. (Purifying Gases of Sulfur by Using Waste Products From Acetylene Manufacture.) Gazovaya Prom., vol. 4, 1956, pp. 11-12; Chem. Abs., vol. 50, 1956, p. 15048h.

Raw producer gas containing H_2S and SO_2 is cooled and scrubbed with a saturated aqueous solution of $Ca(OH)_2$. Some CO_2 is also removed from the feed gas.

32. GRAFF, R. A. Sulfur-Recovery Practices in the Oil Industry. Petrol. Eng., vol. 25, No. 4, 1953, pp. C19-24; Chem. Abs., vol. 47, 1953, p. 7757g.

Absorption process is used to separate H_2S from natural gas. Liquid organic sulfur compounds are transformed into H_2S catalytically. H_2S is then partly oxidized to separate sulfur. Claus process for oxidation is described.

33. GREGOR, M., GAZO, J., AND PLSKO, E. (The Problem of Desulfuration of Waste Gas in a Viscose Plant by Ferric Absorbents.) Chem. Prumysl, vol. 5, 1955, pp. 159-162; Chem. Abs., vol. 50, 1956, p. 3756i.

Experiments with 2 absorption systems were made: (1) A suspension of Fe_2O_3 hydrate prepared by alkalizing a $FeCl_3$ solution by soda; (2) a colloidal solution of Prussian blue. Maximum absorption of H_2S was 96 percent.

34. GUNTERMANN, W. (Hydrogen Sulfide Absorption and Sulfur Recovery From Natural Carbon Dioxide Gases.) Gas-u. Wasserfach, vol. 97, 1956, pp. 896-899; Chem. Abs., vol. 51, 1957, p. 4663h.

CO_2 gas containing about 2 percent H_2S by volume is mixed with about twice as much air and passed through prepared iron oxide purifying materials in trays. CO_2 not recovered.

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Alkali consumption and life of solution depended primarily on O_2 content of gas in pilot-scale desulfurization of a Swedish shale gas (H_2S 20 and O_2 1 percent) by absorption with an alkaline amino acid solution.

36. HENRY, M. S., AND GRENNERT, M. How to Analyze Diethanolamine Solutions. Petrol. Refiner, vol. 34, No. 6, 1955, pp. 177-181; Chem. Abs., vol. 49, 1955, p. 11265d.

By means of synthetic mixtures, it was illustrated that the methods used for determining organic acids and other acidic constituents in diethanolamine for removing H_2S from refinery streams give reliable results.

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Current research and development of processes for remaining H_2S gas from manufactured gases.

38. HOPTON, G. V., AND HUBBARD, W. S. A Review of Some Carbonization Problems - III. Gas Purification. Gas World, vol. 132, 1950, pp. 76-80; Chem. Abs., vol. 44, 1950, p. 8618c.

Methods for removing H_2S and other impurities.

39. HUGHES, E. C., STINE, H. M., AND FARIS, R. B. Hydrodesulfurization of Heavy Petroleum Oils. Ind. Eng. Chem., vol. 42, 1950, pp. 1879-1882; Chem. Abs., vol. 45, 1951, p. 337g.

Mild desulfurization using a cobalt oxide - molybdenum oxide - aluminum oxide catalyst is employed to free heavy petroleum oils from sulfur.

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40. IVANOVSKII, F. P., DONISOVA, V. A., AND SEMENOVA, T. A. (Utilization of the Alumina-Production By-Product, Red Mud, in the Removal of H_2S From Gas.) Khim. Prom., 1955, pp. 218-222; Chem. Abs., vol. 50, 1956, p. 542i.

Elimination of H_2S from gas by red mud is not due to formation of FeS but to direct oxidation of H_2S with O_2, mud acting as a catalyst. A method of regenerating red mud is suggested. No wood shavings are used with mud.

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Operation of a plant to remove hydrogen cyanide and hydrogen sulfide from coke-oven gas.

42. KLEMPT, W., AND HUCK, G. (Removal of H_2S From Coke-Oven Gas by a Pressure-Recirculating Method.) Glückauf, vol. 91, August 1955, pp. 215-220; Chem. Abs., vol. 50, 1956, p. 3737c.

An H_2S washer (where H_2S is removed by 4 to 6 percent NH_3 liquor) is used.

43. KOHL, A. L. Selective Hydrogen Sulfide Absorption - A Review of Available Processes. Petrol. Processing, vol. 6, 1951, pp. 26-31; Chem. Abs., vol. 45, 1951, p. 2605a.

The Fe_2O_3 dry box, $Fe(OH)_3$-Na_2CO_3 and thylox processes give essentially complete selectivity of H_2S from gases containing CO_2. Other processes are partly selective.

44. KOHL, A. L., AND BLOHM, C. L. Technical Aspects of Glycol-Amine Gas Treating. Petrol. Eng., vol. 22c, No. 6, 1950, pp. 37-44; Chem. Abs., vol. 44, 1950, p. 7513a.

By means of absorption with an ethylene glycol solution containing 10-30 percent $HO - CH_2$-CH_2NH_2 and 5-10 percent H_2O, the H_2S content of natural gas can be reduced below 0.00016 mol percent.

45. KRISTENSEN, H. (Cleaning and Purification of Gas by Ethanolamines.) Chim. et ind., vol. 73, 1955, pp. 69-77; Chem. Abs., vol. 49, 1955, p. 7224d.

Review of acid-gas-removal processes. Twenty-nine references are included.

46. KRAMARZ, W. (Activation of Polish Bog Iron Ores for the Preparation of Purifying Material Used in Desulfurization of Manufactured Gas.) Przemysl Chem., vol. 13, 1957, pp. 332-338; Chem. Abs., vol. 52, 1958, p. 3310a.

Treatment of ores with alkalies under pressure gave a substitute for the Luxmass (used for desulfurizing manufactured gas). Ores contain Fe_2O_3 32-52, SiO_2 7.6-12.5, Al_2O_3 5.9-8.9, and CaO 6.0-14.

47. KROPP, E. P., AND SIMONSEN, R. N. How Sohio Fights Air Pollution. Oil Gas Jour., vol. 51, No. 11, 1952, pp. 84-85, 87; Chem. Abs., vol. 46, 1952, p. 9833h.

H_2S and other acidic substances in air streams can be removed by passing the air through a fog-filter-type scrubber. Scrubbing solutions used are 3-8 percent solutions of Na_2CO_3 or NaOH in atomized form.

48. ______. Scrubbing Devices for Air-Pollution Control. Proc. Air Pollution Smoke Prevention Assoc., vol. 45, 1952, pp. 48-53; Chem. Abs., vol. 47, 1953, p. 5044c.

Experimental work with a fog-filter-type scrubber to absorb H_2S and CO_2 is presented.

49. KUZNETSOV, M. D., AND SAGALOVSKII, A. E. (Kinetics of the Process of Absorption of Hydrogen Sulfide by Iron Hydroxide.) Zhur. Priklad. Khim., vol. 27, 1954, pp. 5-11; Chem. Abs., vol. 48, 1954, p. 6793i.

Effects of several factors on rate of H_2S adsorption were studied by suspension method. It was discovered that rate controls surface reaction.

L

50. LEIBUSH, A. G., AND SHNEERSON, A. L. (Absorption of Hydrogen Sulfide and of Its Mixtures With Carbon Dioxide by Ethanolamine.) Jour. Appl. Chem. (U.S.S.R.), vol. 23, 1950, pp. 149-157; Chem. Abs., vol. 45, 1951, p. 3223a.

Solubility of H_2S in ethanolamine solutions increases with increase of partial pressure and decreases with increase of temperature. Presence of CO_2 reduces the solubility of H_2S.

51. _____. (Rate of Absorption of Hydrogen Sulfide and Mixtures With Carbon Dioxide by Ethanolamine Solution.) Jour. Appl. Chem. (U.S.S.R.), vol. 23, 1950, pp. 1253-1263; Chem. Abs., vol. 46, 1952, p. 9389g.

Effects of pressure, temperature, and presence of CO_2 on rate of absorption of H_2S by ethanolamine have been studied in detail.

52. LINDSTROM, R. H. (Australian Gas Light Co., Sydney). Burnt Oxide in Purification. Nat. Gas Bull., Australia, vol. 20, No. 3, 1956, pp. 38-41; Chem. Abs., vol. 50, 1956, p. 15049e.

Laboratory and work tests were made on burnt ferric oxide. This was undertaken to investigate properties and potentialities of oxide as a substitute for natural oxide in gas purification. A 1:2 (by volume) mixture of ferric oxide and sawdust was selected as the standard.

53. LITVINENKO, M. S. Rate of Absorption of Hydrogen Sulfide by Aqueous Solutions of Sodium or Potassium Carbonate. Jour. Appl. Chem. (U.S.S.R.), vol. 25, 1952, pp. 775-794 (in English); Zhur. Priklad. Khim., vol. 25, 1952, pp. 696-717; Chem. Abs., vol. 48, 1954, p. 9795e.

Kinetics of H_2S absorption with Na or K carbonate solutions discussed in detail.

54. LITVINENKO, M. S., AND LUNDIN, S. P. (Classification of Industrial Hydrogen Sulfide-Absorbing Media by Thermodynamic Properties.) Zhur. Priklad. Khim., vol. 29, 1956, pp. 543-548; Chem. Abs., vol. 50, 1956, p. 14277h.

Free energy, ΔF_{298}, of reactions of the following with H_2S is tabulated as: Triethanolamine, +15.60; monoethanolamine, +9.32; PhONa, +2.95; K dimethylaminoacetate, -0.40; Na_2CO_3, -3.42; K_2CO_3, -3.42; K_3PO_4, -5.48. Correlation of these free energies with vapor pressure and dissociation constants and difference in solubilities in a temperature range suitable for absorption and stripping lead to conclusion that free energies of an economic absorber must be between +15.60 and -1.00 and preferably at 0.

55. LYON, L. R., AND FEAGAN, R. A., JR. Elk Basin (Wyo.) Plant Termed Real Conservation Project. Petrol. Refiner, vol. 28, No. 10, 1949, pp. 116-120; Chem. Abs., vol. 44, 1950, p. 1680h.

Removal of H_2S is accomplished by a modified two-stage Claus process.

56. MAI, K. L., AND BABB, A. L. Vapor-Liquid Equilibria by Radioactive Tracer Techniques. Ind. Eng. Chem., vol. 47, 1955, pp. 1749-1757; Chem. Abs., vol. 50, 1956, p. 45h.

Vapor-liquid equilibrium data is given for the system - carbon dioxide-hydrogen sulfide-water. The equipment used in obtaining this data is described.

57. MARCU, L. (Conversion of Hydrocarbons by Oxygen, Water, and Carbon Dioxide to Form Hydrogen.) Chim. et ind., vol. 70, 1953, pp. 677-693; Chem. Abs., vol. 48, 1954, p. 8499a.

H_2S is removed from a raw gas with a mixture of Fe_2O_3 and zinc oxide or by alkaline or oxidative scrubbing.

58. MATSUYAMA, T. (The Rate of Gas Absorption by Liquid. E. II.) Mem. Fac. Eng. Kyoto Univ., vol. 15, 1953, pp. 142-162; Chem. Abs., vol. 48, 1954, p. 4943d.

Mechanism of absorption of H_2S and other acid gases by H_2O and the alkaline solutions was studied. It was proved the equilibrium is existing or is rapidly developed at liquid-gas interface.

59. McCULLOUGH, O. F. Sweetening Small Volumes of Gas. Petrol. Eng., vol. 21D, No. 12, 1949, pp. 25-26; Chem. Abs., vol. 44, 1950, p. 820a.

A small commercial unit of H_2S absorption by H_2NCH_2-CH_2OH is described.

60. MILLER, F. E., AND KOHL, A. L. Here's a New Solution for Selective Absorption of Hydrogen Sulfide. Oil Gas Jour., vol. 51, No. 51, 1953, pp. 175-176, 178, 180, 183; Chem. Abs., vol. 47, 1953, p. 7699b.

Extensive laboratory research indicated that methyldiethanolamine has considerable selectivity for H_2S in presence of CO_2.

61. MINCHIN, L. T. Liquid Purification - Some British and Continental Developments. Coke and Gas, vol. 13, 1951, pp. 27-29; Chem. Abs., vol. 45, 1951, p. 3579i.

Recent processes and plants for removing H_2S from town gas and coke-oven gas by liquid reagents.

62. MIZE, W. W. El Paso Natural's San Juan River Plant Gets Gas From Two Sources. Oil Gas Jour., vol. 51, No. 51, 1953, pp. 258, 260-261; Chem. Abs., vol. 47, 1953, p. 7759c.

H_2S, CO_2, and much of the water vapor are removed with monoethanolamine-diethylene glycol solution.

63. MONKHOUSE, A. C., AND NEWALL, H. E. Industrial Gases - Recovery of SO_2. Disposal Ind. Waste Materials Conf., Sheffield Univ., 1956, pp. 103-106; Chem. Abs., vol. 51, 1957, p. 9104e.

Review, with 17 references.

64. MOORE, D. B. Recent Developments in Gas Purification. Gas World, vol. 143, 1856, pp. 153-155; discussion, pp. 155-156, 173; Chem. Abs., vol. 50, 1956, p. 7426g.

Gas purification for H_2S removal by using iron oxide in boxes is being supplanted by special porous oxide pellets.

65. MORRIS, H. B., AND GILBERSTON, D. L. Experimental Shale-Oil Refinery. Petrol. Eng., vol. 21C,

No. 9, 1949, pp. 26-32; Chem. Abs., vol. 44, 1950, p. 2733i.

Products from shale oil are washed with caustic to remove H_2S and other impurities.

66. MULL, W. (New Processes for the Purification of Natural Gas. Material Exchange and Heat Transmission.) Erdol u. Kohle, vol. 7, 1954, pp. 275-281; Chem. Abs., vol. 48, 1954, p. 12392g.

Absorbents for removing H_2S, CO_2, and H_2O are sprayed at high relative velocity and excess pressure against the direction of gas flow.

67. MUSATOV, K. A. (Desulfurization of Gases and Petroleum Distillates by Aluminum Sulfate.) Trudy Inst. Nefti, Akad. Nauk, S.S.S.R., vol. 1, No. 2, 1950, pp. 334-338; Chem. Abs., vol. 48, 1954, p. 3019a.

Description of catalytic oxidation process for removing H_2S and mercaptans by means of $Al_2 (SO_4)_3$. Removal of the two is complete.

N

68. NEAL, E. J. Liquid Purification. Nat. Gas Bull., vol. 6, No. 16, 1953, pp. 21-26; Chem. Abs., vol. 48, 1954, p. 979g.

Processes are discussed for removing H_2S from town gas by liquid means and their application to small works.

69. NORRIS, W. E., AND CLEGG, F. R. Investigation of a Girbotol Unit Charging Cracked Refinery Gases Containing Organic Acids. Petrol. Refiner, vol. 26, No. 11, 1947, pp. 107-109; Chem. Abs., vol. 44, 1950, p. 5572c.

Investigation revealed that the inactivating agents of diethanolamine solution in H_2S purifying system were HCOOH and AcOH. Scrubbing with aqueous NaOH effectively removed these acids.

70. NOVAK, E., AND LIEBICH, H. G. (Hydrogenation - Refining of Crude Light Oil With Coke-Oven Gas at the Nurnberg Gas Works.) Brennstoff-Chem., vol. 35, 1954, pp. 308-310; Chem. Abs., vol. 49, 1955, p. 1309a.

Light oil is treated with NaOH solution to separate H_2S.

P

71. PALTRIDGE, R. M. Possible Improvements in Oxide Purification Practice. Nat. Gas Bull. (Australia), vol. 15, November-December 1951, pp. 5-9; Chem. Abs., vol. 46, 1952, p. 7736b.

Suggests several schemes for improving iron oxide processes.

72. PANTONY, D. A., AND WILSON, C. L. Aids to Semimicroqualitative Analysis. Jour. Chem. Education, vol. 31, 1954, pp. 648-650; Chem. Abs., vol. 49, 1955, p. 5037d.

Illustrates new type of H_2S absorption apparatus for laboratory.

73. PIPPIG, R. (The Perox Liquid Purification Process for Sulfur Removal.) Gas-u. Wasserfach, vol. 94, 1953, pp. 62-63; Chem. Abs., vol. 47, 1953, p. 5096e.

H_2S is absorbed with an aqueous solution containing 0.3 gram of water-soluble organic catalyzer countercurrently through a hurdle-filled tower.

H_2S is recovered as sulfur by oxidation.

74. PORTER, S. C. Gas Purification. Gas World, vol. 143, 1956, p. 528; Chem. Abs., vol. 50, 1956, p. 6994c.

Effects of H+ concentration on process of removing H_2S from gases by means of iron oxide.

75. PRATT, D. C. F., AND RUTHERFORD, A. Removal of Hydrogen Sulfide From Exhaust Air From a Viscose Staple Fiber Factory. Chem. Ind., 1955, pp. 1281-1286; Chem. Abs., vol. 50, 1956, p. 5296g.

Ferrox process consists essentially of scrubbing contaminated air with an alkaline liquor containing a suspension of hydrated Fe_2O_3.

76. PROHLIK, J., AND NOVOTNY, J. (Dry Purification of Illuminating Gas.) Paliva, vol. 34, 1954, pp. 29-33; Chem. Abs., vol. 49, 1955, p. 7837e.

It is reported that sulfur content (either as elementary sulfur or H_2S) of raw gas is steadily increasing owing to higher sulfur content of coal, lower Fe_2O_3 content in purification material, and poor and varied quality of purification material.

Q

77. QUERET AND GUILLET. (Chemical Purification of Gas and Sulfur Recovery Progress and New Applications.) 6th Internat. Gas Conf., New York, N. Y., 1955, IGU/22-25, 44 pp. (in French); Chem. Abs., vol. 50, 1956, p. 9713i.

Review of methods of purification used at several French installations. The dry and wet methods are discussed, as well as advantages and disadvantages of each method. The H_2S removed by newer, wet methods are of interest today because it is readily transformed to sulfur or H_2SO_4.

R

78. RAHMES, M. H. Sour Gas - New Plant Operating Monoethanolamine, Dehydration, Caustic, and Copper Chloride Units. Petrol. Refiner, vol. 29, No. 8, 1950, pp. 118-122; Chem. Abs., vol. 45, 1951, p. 850g.

New plant employs monoethanolamine scrubbing to remove H_2S to less than 0.25 grain per 100 cubic feet.

79. RAIMONDO, E. (Modern Systems for Gas Purification.) Riv. Combustibili, vol. 4, 1950, pp. 474-492; Chem. Abs., vol. 45, 1951, p. 5908h.

Modern processes for removing H_2S are generally reviewed and discussed from viewpoint of economics and sulfur recovery.

80. REED, R. M. Improved Design and Operating Techniques for Girbotol Absorption (Gas Purification) Processes. Petrol. Processing, vol. 20, 1940, pp. 907-912; Chem. Abs., vol. 44, 1950, p. 5079e.

Oleyl alcohol and others are used to control foaming of liquid absorbent. Filtration and periodic cleaning are employed to remove FeS or sulfur sludge. Organic acid is removed by means of caustic treatment.

81. REED, R. M., AND UPDEGRAFF, N. C. Removal of Hydrogen Sulfide From Industrial Gases. Ind. Eng. Chem., vol. 42, 1950, pp. 2269-2277; Chem. Abs., vol. 45, 1951, p. 831h.

Industrial processes of H_2S removal are generally reviewed.

82. REED, R. M., UPDEGRAFF, N. C., AND PARKER, J. L. Processes for Removal of Hydrogen Sulfide From Industrial Gases. Oil Gas Jour., vol. 49, No. 35, 1951, pp. 48, 51-52, 58, 61; Chem. Abs., vol. 45, 1951, p. 2604i.

Review of processes.

83. REINHARDT, K. (Wet Processes for Sulfur Removal From Coal Gas.) Energie Tech., Berlin, vol. 6, 1956, pp. 454-463; Chem. Abs., vol. 51, 1957, p. 4629i.

Review of 4 oxidation processes (Thylox, Perox, Manchester, and Stassmijnen-Otto), 3 neutralization processes (Vacuum Carbonate, Ammonia, and Alkazid-Girbotol), and 1 physical process (Rectisol). Includes discussion of quality of available purification masses.

84. RIESENFELD, F. C., AND CODY, K. E. Simultaneous Desulfurization and Dehydration of Natural Gas at Coalinga, Calif. Petrol. Eng., vol. 22C, No. 1, 1950, p. 3104; Chem. Abs., vol. 44, 1950, p. 6101i.

Sour natural gas was purified by means of absorbing solution containing 20 percent $NH_2CH_2CH_2OH$, 75 percent diethylene glycol, and 5 percent H_2O, which removed all the CO_2 and essentially all the H_2S and H_2O.

85. RUHL, GERHARD. (Use of Water Gas. I. Practicability of Producing Coke-Oven Nitrogen and Sulfur by Indirect Processes.) Brennstoff-Chem., vol. 38, 1957, pp. 27-32; Chem. Abs., vol. 51, 1957, p. 5386g.

Production of nitrogen and sulfur from water gas by indirect processes.

S

86. SANDS, A. E., AND SCHMIDT, L. D. Recovery of Sulfur From Synthesis Gas. Ind. Eng. Chem., vol. 42, 1950, pp. 2277-2287; Chem. Abs., vol. 45, 1951, p. 332c.

Removal of H_2S from synthesis gas.

87. SAUNDERS, J. J. The Composition and Activity of Manchester Process Plant Liquor. Gas World, vol. 135, 1952, pp. 200-201; Chem. Abs., vol. 46, 1952, p. 4197c.

Removing H_2S to very low limit from coal gas can be accomplished by Manchester liquid-purification process. Alkaline ferric oxide suspension is used as absorbent.

88. SAVILL, A. H. Developments in Gas Production Practice. Gas World, vol. 132, 1950, pp. 126-130; Chem. Abs., vol. 44, 1950, p. 9137g.

Postwar development of H_2S removal process is included.

89. SCHMIDT, K. H. (Use of Water-Works Mass in Dry (Sulfur) Purification.) Gas-u. Wasserfach, vol. 98, 1957, pp. 207-211; Chem. Abs., vol. 51, 1957, p. 6978g.

Precipitation secured in removing Fe at water works has been found very effective for removing H_2S from manufactured gas. Its activity is greater than that of most other material. It is best dried to a moist content of 50 percent before mixing with materials to increase gas permeability.

In plant tests sulfur content of mass reached 42 percent (dry basis) when the test had to be interrupted after 9 months for operating reasons.

90. SCHUSTER, F. (Purification of Fuel Gases.) Gas-u. Wasserfach, vol. 53, 1951, pp. 1-3; Chem. Zentralb., 1952, p. 467; Chem. Abs., vol. 49, 1955, p. 11261e.

H_2S and other impurities in fuel gases cause trouble by formation of deposits and by corrosion. Experimental results of catalytic processes for converting those impurities into nontroublesome products are reported.

91. SEN, B. L., AND BANERJEE, T. Removal of Sulfuretted Hydrogen From Coal Gas. Jour. Proc. Inst. Chemists, India, vol. 24, 1952, pp. 77-95; Chem. Abs., vol. 47, 1953, p. 4062c.

Both dry and wet processes for removing H_2S from coal gases are briefly reviewed.

92. SHERWOOD, P. W. (Selective Separation of Hydrogen Sulfide From Gaseous Hydrocarbons.) Riv. ital. petrolio., vol. 22, No. 253, 1954, pp. 43-45; Chem. Abs., vol. 49, 1955, p. 9267g.

Various processes are generally reviewed.

93. ______. The Selective Removal of Hydrogen Sulfide From Hydrocarbon Gases. Petrol., London, vol. 17, 1954, pp. 21-23; Chem. Abs., vol. 48, 1954, p. 3670f.

Current American practice and recent developments are reviewed.

94. SHINOZAKI, HEIMA, AND ITO, KIHACHIRO. (The Removal of Hydrogen Sulfide From Coal Gas by the Ferrox Process.) Chem. Eng., Japan, vol. 18, 1954, pp. 461-466; Chem. Abs., vol. 49, 1955, p. 592h.

The mechanism of reaction of desulfurization in Ferrox process, one of wet processes for removing H_2S, is proposed as follows: $2Fe(OH)_3 + 3H_2S = Fe_2S_3 + 6H_2O$.

95. SIMON, A., AND MARCHAND, M. (The Problem of Dry-Gas Purification. I. Lux Mass (Lanta Mass) as an Active Skeleton Catalyst.) Ztschr. anorg. u. allgem. Chem., vol. 277, 1954, pp. 1-16; Chem. Abs., vol. 49, 1955, p. 7224e.

Hydrated Fe_2O_3 prepared by fusing bauxite with Na_2CO_3 and leaching with NaOH solution is stated to be much more active adsorbent for removing H_2S from gases.

96. SPAETH, W. (The Stuttgart Coke-Oven Plant.) Gas-u. Wasserfach, vol. 94, 1953, pp. 230-235; Chem. Abs., vol. 47, 1953, p. 8347i.

Part of H_2S is absorbed in NH_3 scrubber, and remainder is absorbed in dry purifiers.

97. SPICHAL, W. (Sulfur Removal From Synthesis Blue Gas by Active Charcoal.) Gas-u. Wasserfach, vol. 94, 1953, pp. 679-684; Chem. Abs., vol. 48, 1954, p. 3012d.

Two-stage removal of S compounds by charcoal is described. Sulfur compounds in blue gas are removed in 2 stages: The inorganic sulfur by means of catalytic oxidation to sulfur by F-charcoal and the organic sulfur by conversion to NH_4 compounds on M-charcoal.

98. STÖBER, W. (Adsorption Properties and Surface Structure of Quartz Powders.) Kolloid-Ztschr., vol. 145, 1956, pp. 17-46; Chem. Abs., vol. 50, 1956, p. 16259c.

Adsorption of H_2S and CO_2 is completely reversible.

99. STRIZHEVSKII, I. I. (Purification of Acetylene by "Geratol.") Zavodskaya Lab., vol. 15, 1949, p. 1133; Chem. Abs., vol. 44, 1950, p. 1245g.

Infusorial earth (2 to 3 mm. grains) saturated with $K_2Cr_2O_7$ solution completely removes PH_3 and H_2S from C_2H_2.

100. SWINARSKI, ANTONI, AND OTHERS. (Hydrogen Sulfide Binding Power of Natural Bog Ores.) Gas, Woda i Tech. Sanit., vol. 29, 1955, pp. 377-378; Chem. Abs., vol. 50, 1956, p. 10378f.

Hydrogen sulfide binding capacity of natural bog ores was determined as function of α FeOOH concentrations in the ores.

T

101. TAUBERT, L., AND MORLET, J. (A Comparison of Two Types of Gas Purification With Liquid Media.) Chim. et ind., vol. 71, 1954, pp. 273-276; Chem. Abs., vol. 48, 1954, p. 6100a.

Advantages and disadvantages of wet purification processes compared.

102. _____. (Semi-Industrial Study of the Wilputte Liquid-Purification Process.) Compt. rend. 69th cong. ind. gaz., 1952, pp. 607-616; discussion, pp. 616-617; Chem. Abs., vol. 48, 1954, p. 3664d.

A wet process that employs 4 percent Na_2CO_3 solution and a Raschig ring tower.

103. TERRES, E. (The Liquid Purification of Coal Gas.) Gas-u. Wasserfach, vol. 94, 1953, pp. 260-265, 311-317; Chem. Abs., vol. 47, 1953, p. 8348b.

Wet processes for absorbing H_2S are critically reviewed. The recovery of NH_3 is achieved as a mixture of NH_4HCO_3 and $(NH_4)_2CO_3$ from the gas freed from H_2S. This is then converted to urea.

104. TERRES, E., BUSCHER, H., AND MATROFF, G. (The Reactions Involved and Reaction Velocities for Regenerating the Scrubbing Solutions in the Metal Thionate Processes for Purifying Coal Gas From Ammonia and Hydrogen Sulfide. A Manganese Sulfate Process.) Brennstoff-Chem., vol. 35, 1954, pp. 65-74; 113-120; Chem. Abs., vol. 49, 1955, p. 11260i.

Various aspects of reactions of SO_2 and H_2S with aqueous suspensions of metallic sulfides of Fe, Zn, and Mn are examined and discussed.

105. _____. (The Reactions Involved and the Reaction Velocities for Regenerating the Scrubbing Solutions in the Metal Thionate Processes for Purifying Coal Gas From Ammonia and Hydrogen Sulfide. A Manganese Sulfate Process.) Brennstoff-Chem., vol. 35, 1954, pp. 144-151; Chem. Abs., vol. 48, 1954, p. 9042c.

Further studies of conversion of ammonium sulfite to sulfate in manganese thionate process indicate that process should operate satisfactorily in plant operation.

106. THOMPSON, R. J. S. Continental Practice in the Treatment of Coal

Gas. Gas World, vol. 135, No. 3529, 1952, Coking sec., pp. 37-41; Chem. Abs., vol. 46, 1952, p. 5292d.

Continental practice of gas treatment, including H_2S removal, is reviewed. Dry purification is used widely in comparison with wet process.

107. TOROPOV, S. A., AND PYLAEV, A. V. (Adsorptive Properties of Oxidized Carbon for Hydrogen Sulfide and Benzene Vapor.) Zhur. Priklad. Khim., vol. 22, 1949, pp. 568-571; Chem. Abs., vol. 44, 1950, p. 18i.

Activated carbon prepared by oxidation with boiling HNO_3 showed high adsorption for H_2S. (1.8 mg. per liter air flowing at 1.57 liter per min.)

108 TOWNSEND, L. G. Operation of the "Manchester" Liquid-Purification Plant at Linacre, Liverpool. Inst. Gas Eng., Copyright Pub., No. 429, 1953, 52 pp.; Gas Jour., vol. 275, pp. 159-160, 163-165; Gas World, vol. 137, pp. 1396-1397, 1797-1801; Chem. Abs., vol. 47, 1953, p. 9594i.

Manchester process, a modification of Ferrox process to remove H_2S.

109. TOYNBEE, P. A. Operation of the Thylox Process With Coal Gas Containing Hydrogen Cyanide. Jour. Appl. Chem., London, vol. 5, 1955, pp. 19-27; Chem. Abs., vol. 50, 1956, p. 553h.

H_2S in coal gas can be reduced to 1 grain per 100 cubic feet with the Thylox process, providing HCN concentration in gas is held below 10 grains per 100 cubic foot. The process consists of scrubbing the coal gas with thioarsenate.

$$Na_4As_2S_5O_2 + H_2S \longrightarrow Na_4As_2S_6O + H_2O$$

On regeneration:

$$Na_4As_2S_6O + O \longrightarrow Na_4As_2S_5O_2 + S$$

Constant bleeding of liquor from the system is necessary to control the buildup of thiosulfate formed by a side reaction.

U

110. UPDEGRAFF, N. C., AND REED, R. M. 25 Years of Progress in Gas Purification. Petrol. Eng., vol. 26, No. 10, 1954, pp. C57-63; Chem. Abs., vol. 48, 1954, p. 12392h.

Amine process to remove H_2S and CO_2 from natural and refinery gases.

V

111. VAJNA, S. Removal of Hydrogen Sulfide From Industrial Gases by a Purifying Mass Containing Iron Hydroxide. Acta Chim. Acad. Sci. Hung., vol. 2, 1952, pp. 163-174 (in English); Chem. Abs., vol. 47, 1953, p. 7759f.

A kinetic study of rate of H_2S adsorption by a synthetic mass of $Fe(OH)_2$ and gypsum.

112. ______. Removal of Hydrogen Sulfide From Industrial Gases by a Purifying Mass Containing Iron Hydroxide. Acta Chim. Acad. Sci. Hung., vol. 6, 1955, pp. 45-76 (in English); Chem. Abs., vol. 50, 1956, p. 2954c.

Equations are derived to predict rate of reaction of H_2S with $Fe(OH)_2$ and for desulfurization reaction in presence of air. Time of breakthrough for H_2S is calculated for mixed gases, and results are experimentally confirmed.

113. VANDAVEER, F. E. A Natural-Gas Purification and Gasoline Plant. Proc. Am. Gas Assoc., vol. 33, 1951, pp. 514-526; Chem. Abs., vol. 47, 1953, p. 2458f.

Girbotol monoethanolamine, iron oxide, and activated charcoal are employed to reduce sulfur content of sour natural gas.

W

114. WAINWRIGHT, H. W., EGLESON, G. C., BROCK, C. M., FISHER, J., AND SANDS, A. E. Removal of Hydrogen Sulfide and Carbon Dioxide From Synthesis Gas Using Di- and Triethanolamine. Bureau of Mines Rept. of Investigations 4891, 1952, 19 pp.; Chem. Abs., vol. 47, 1953, p. 1357h.

Operating data of a wet purification pilot plant with aqueous solutions of di- and tri-ethanolamine solutions are reported.

115. ______. Selective Absorption of Hydrogen Sulfide From Synthesis Gas. Ind. Eng. Chem., vol. 45, 1953, pp. 1378-1384; Chem. Abs., vol. 47, 1953, p. 8347g.

Results of pilot-plant studies on selective absorption of H_2S in presence of CO_2 and other inert gases by means of K_3PO_4 and glycerin solutions.

116. WENZELL, L. P., JR., DRESSLER, R. G., AND BATCHELDER, H. R. Plant Purification of Synthesis Gas. Ind. Eng. Chem., vol. 46, 1954, pp. 858-862; Chem. Abs., vol. 48, 1954, p. 8517f.

Diethanolamine scrubbing and iron oxide processes are used consecutively to remove H_2S and CO_2 from the synthesis gas from producer at 350-370 p.s.i.g.

117. WEYTH, WILHELM. (Dry Purification Plant in a Medium-Size Gas Works.) Gas-u. Wasserfach, vol. 98, 1957, pp. 1228-1234; Chem. Abs., vol. 52, 1958, p. 4960i.

Use was made of 2 Gastechik tower purifiers, with iron oxide in 10 mm. spherical form.

118. WHITING, R. The Case of the Deep Purifier. Gas Times, vol. 75, 1953, pp. 551-553, 556; Chem. Abs., vol. 47, 1953, p. 10199h.

A deep purifier is economical compared to the conventional form of box purifiers. Cost data of other purifiers are also presented.

119. WILLIAMSON, R. H., AND GARDSIDE, J. E. Application of Fluidized-Solids Technique to Coal-Gas Purification. II. Gas World, vol. 130, 1949, pp. 1999-2001; Chem. Abs., vol. 44, 1950, p. 3237h.

Laboratory development of two processes of fluidized H_2S purifier is described. Iron oxide is used for both processes.

Z

120. ZAHNSTECHER, L. W. Liquid-Phase Hydrogen Sulfide Removal. Ind. Eng. Chem., vol. 42, 1950, pp. 1879-1882; Chem. Abs., vol. 45, 1951, p. 337i.

H_2S content is reduced from 300 grains per 100 standard cubic feet to 1.7 grains per 100 standard cubic feet by the Shell regenerative K_3PO_4 process.

121. ZANKL, W. (Possibilities and Limits of Hydrogen Sulfide Removal by Ammonia Scrubbing.) Gas-u. Wasserfach, vol. 94, 1953, pp. 178-180; Chem. Abs., vol. 47, 1953, p. 6118e.

Effects of various factors on hydrogen sulfide removal.

LITERATURE SUBJECT INDEX

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PATENT ABSTRACTS

A

122. ADAMS, C. F. Apparatus for Gas Separation. U. S. Patent 2,742,103, Apr. 17, 1956. Chem. Abs., vol. 50, 1956, p. 11066i.

H, H_2S, and C_1 and C_2 hydrocarbons are separated from C_3 and C_4 hydrocarbons.

123. AMMONIA CASALE SOCIETA ANON., AND JEQUIER, L. Gas Desulfurization. British Patent 708,972, May 12, 1954. Chem. Abs., vol. 48, 1954, p. 11764f.

H_2S is adsorbed in a dense-phase fluidized bed.

124. ARITOMI, I. (Acetylene-Gas Purifier and Its Generation.) Japanese Patent 177,988, Feb. 25, 1949. Chem. Abs., vol. 45, 1951, p. 5984e.

0.014 percent H_2S is removed from C_2H_2 gas by passing through a mixture containing $FeCl_3$ 34, $HgCl_2$ 0.6, $(AcO)_2Cu$ 2.2, $(AcO)_2Fe$ 6.3, and kieselguhr 56 parts. Mixture is regenerated by passing through Cl gas.

B

125. BADISCHE ANILIN AND SODA-FABRIK A. G. (Purification of Hydrogen-Containing Synthesis Gases.) German Patent 908,013, Apr. 1, 1954. Chem. Abs., vol. 51, 1957, p. 696a.

Process of purifying a synthesis gas containing hydrogen.

126. BASAK, N. G., AND OTHERS. (Removal of Inorganic Sulfur Compounds From Industrial Gases.) Indian Patent 55,816, July 31, 1957. Chem. Abs., vol. 52, 1958, p. 701e.

Industrial gases are purified by passing over a catalyst prepared by the reaction of $FeSO_4$ and lime and atmospheric oxidation of the product to form Fe_2O_3 and $CaSO_4$. Optimum temperature is 110° F. Space velocity for coal gas is 50-150 l/hr. and for producer gas is 150-250 l/hr.

127. ______. (Removal of Organic Sulfur Compounds From Industrial Gases.) Indian Patent 55,817, July 31, 1957. Chem. Abs., vol. 52, 1958, p. 701f.

Gases are passed over a catalyst consisting of Cu chromite or Cu chromate supported on Al_2O_3.

128. BECHTOLD, I. C., AND KOHL, A. L. Extraction of Acidic Constituents From Gases. U. S. Patent 2,607,657, Aug. 19, 1952. Chem. Abs., vol. 46, 1952, p. 10589b.

Two-stage separation of H_2S and CO_2 by means of a liquid amine or amine glycol solutions.

129. BENSON, H. E., AND FIELD, J. H. Separation of Carbon Dioxide and Hydrogen Sulfide From Gas Mixtures. British Patent 725,000, March 2, 1955. Chem. Abs., vol. 49, 1955, p. 11990b.

Hot K_2CO_3 solution process to remove CO_2 and H_2S under high pressure.

130. BERG, C. H. O. Adsorption Process. U. S. Patent 2,603,553, July 15, 1952. Chem. Abs., vol. 47, 1953, p. 1924b.

H_2S, other inorganic constituents such as He, H, N, CO, CO_2, and H_2S, and hydrocarbons are separated in substantially pure form by means of 2 continuous selective adsorption and 2 extraction columns. Charcoal is preferred as an adsorbent; but other substances, such as silica, Al_2O_3, activated Fe oxide, or Cr oxide may be used. A 30-percent aqueous solution of diethanolamine is preferred extraction medium. Other alkaline solution may also be used.

131. BERGWERKS-VERBAND ZUR VERWERTUNG VON SCHUTZRECHTEN DER KOHLENTECHNIK G. m. b. H. Removal of Hydrogen Sulfide From Gases. British Patent 772,905, Apr. 17, 1957. Chem. Abs., vol. 51, 1957, p. 10878i.

Larger part of H_2S is removed selectively by spraying with ammoniacal liquor, with a retention time of the scrubbing fluid in the gas of below 1.0 second, preferably 0.1 second or less, and the velocity of the gas flow of at least 3 meters per second. The rest of the H_2S is removed by dry purification.

In an experiment the gas is brought into contact with a spray of ammoniacal liquor in a second unpacked stage, and then in a packed first stage with the liquor from the second stage.

132. _____. (Sulfur Removal From Industrial Gases.) German Patent 928,486, June 2, 1955. Chem. Abs., vol. 52, 1958, p. 2383g.

H_2S can be selectively removed from gas mixtures containing other acidic gases, such as CO_2, by washing with ammoniacal solutions at optimum gas velocity. Various concentrations of NH_3 and various pressures can be used. Gas is washed first in a chamber with baffles and then in a spray chamber. Wash solution can be recirculated. Removal of up to 90 percent S from 1,000 m.^{3} of gas at high pressure requires only 0.2 m.^{3} of 8-percent NH_3 solution.

133. BIRKS, F. M. Removal of Hydrogen Sulfide From Fuel Gases. British Patent 735,467, Aug. 24, 1955. Chem. Abs., vol. 50, 1956, p. 2957d.

H_2S is removed from fuel gas by treatment with iron oxide by passage through a stationary cylindrical vessel. Vessel can be rotated about its axis, which is horizontal or slightly inclined.

134. BLOCH, H. S., AND MAMMEN, H. E. Gas Purification. U. S. Patent 2,781,863, Feb. 19, 1957. Chem. Abs., vol. 51, 1957, p. 6982c.

Water and acidic gases, such as H_2S, are scrubbed from gas streams by essentially dry mixtures of water miscible glycols, glycol ethers, or glycol esters with a miscible liquid hydrocarbon such as xylene.

135. BLOHM, C. L., AND RIESENFELD, F. C. Removal of Hydrogen Sulfide and Carbon Dioxide From Hydrocarbon Gases. U. S. Patent 2,712,978, July 12, 1955. Chem. Abs., vol. 49, 1955, p. 14300e.

Compounds of hydroxy amino alkyl ether class are used to remove acid gases and moisture. It has been found that BB'-hydroxy amino ethyl ether would require only 60 percent of the liquid circulation of a comparable plant using monoethanolamine as acid gas absorbent and diethylene glycol as moisture absorbents.

136. BROWN, J. T. Removal of Hydrogen Sulfide From Gases. British Patent 666,055, Feb. 6, 1952. Chem. Abs., vol. 46, 1952, p. 6366g.

H_2S-rich gas is pretreated by passing through an empty tower of special design, countercurrent to an aqueous suspension of hydrated iron oxide.

C

137\. CHAPIN, W. F. Purification and Dehydration of Gases. U. S. Patent 2,518,752, Aug. 15, 1950. Chem. Abs., vol. 44, 1950, p. 10303c.

By using solutions of monoethanolamine and diethylene glycol, continuous, simultaneous removal of H_2S, CO_2, and H_2O is achieved.

138\. COLLIN, F. J., A. G. De-Acidification of Ammonia Liquor by Distillation. British Patent 701,986, Jan. 6, 1954. Chem. Abs., vol. 48, 1954, p. 7884b.

H_2S and CO_2 are removed from NH_3 in a liquor obtained from scrubbing coal gas in the bubble-cap tower with special cup arrangement. The volatile constituents of gases are expelled in the preheating (60°-70° C.) and deacidification (95°-90° C.) zones. NH_3 is reabsorbed in nonheated part of the system.

139\. _____. Gas Purification. British Patent 695,214, Aug. 5, 1953. Chem. Abs., vol. 48, 1954, p. 348h.

H_2S and NH_3 are washed by means of fresh water or gas condensate from a gas, especially a coal-distillation gas that also contains CO_2. First the gas is passed through a tower containing no packing, in which the washing medium is introduced as a mist. Second stage is a submersion water.

140\. _____. Extraction of Sulfur From Fumes Containing Hydrogen Sulfide. British Patent 748,037, Apr. 18, 1956. Chem. Abs., vol. 51, 1957, p. 9108g.

Cyclic process, whereby H_2S and oxygen are allowed to react with $(NH_4)_2S$ to produce the polysulfide, which at 125° C. and 2-6 atmospheres is reduced to sulfide and S.

D

141\. DAS GUPTA, N. N. (Solid Adsorbent.) Indian Patent 39,855, Nov. 9, 1949. Chem. Abs., vol. 44, 1950, p. 8022i.

Dust removed from blast furnaces is used as H_2S adsorbent. Porous substances, such as wood shavings and sawdust, may be added to this dust in 50:50 ratio.

142\. DIDER-KOGAG-HINSELMANN KOKSOFENBAU UND GASVERWERTUNG, A. G. Desulfurizing Coal Gas. British Patent 673,211, June 4, 1952. Chem. Abs., vol. 46, 1952, p. 10588e.

H_2S is absorbed from gases with ammoniacal liquor, which is regenerated with aid of CO_2 from gas.

143\. DIRECTIE VAN DE STAATSMIJNEN IN LIMBURG. Removal of Hydrogen Sulfide From Gases. British Patent 650,843, Mar. 7, 1951. Chem. Abs., vol. 45, 1951, p. 6825h.

Ammonia-solution process for removing H_2S from gases. Solution contains ferrocyanide in suspension, with such an amount of NH_4 salt that iron ferrocyanide compounds are stabilized in the wash water.

144\. _____. Removal of Hydrogen Sulfide From Gases. British Patent 653,817, May 23, 1951. Chem. Abs., vol. 46, 1952, p. 242a.

Addition of alkali ferric ferrocyanide in the process of removing H_2S by ferric ferrocyanide in presence of NH_3 to make up loss can be avoided with gases containing HCN by adding just enough $FeSO_4$ to react with HCN to form the ferrocyanide.

145. DOUMANI, T. F. Separation of Acid Gases From Gaseous Mixtures. U. S. Patent 2,486,778, Nov. 1, 1949. Chem. Abs., vol. 44, 1950, p. 2207h.

Absorption of weakly acidic gases, such as H_2S, can preferably be accomplished by a mixture of crude nitrogen bases that have been hydrogenated at low temperatures and high pressure.

E

146. EMA, G., AND MURATA, M. (Removing Sulfur From Industrial Gases Containing Carbon Dioxide.) Japanese Patent 436 (1955), Jan. 27, 1955. Chem. Abs., vol. 50, 1956, p. 11648e.

Soda solution with a concentration of 1 percent Na_2CO_3 and $NaHCO_3$ equivalent to 2 percent Na_2CO_3 is used.

F

147. FRAZIER, H. D. Dehydration and Amine Treatment of Gases. U. S. Patent 2,638,405, May 12, 1953. Chem. Abs., vol. 47, 1953, p. 7202c.

An aqueous amine solution is used both for removing H_2S and dehydrating gases.

148. FRAZIER, H. D., AND RIESENFELD, F. C. Removal of Hydrogen Sulfide and Carbon Dioxide From Gases by Absorption With Amines. U. S. Patent 2,608,462, Aug. 26, 1952. Chem. Abs., vol. 47, 1953, p. 2462i.

A countercurrent amine absorption process is used. Amine entrainment is recovered by absorption in a portion of absorbent saturated with CO_2.

149. FUJIOKA, ETSURO, AND OTHERS. (Removing Organic Sulfur Compounds From Water Gas.) Japanese Patent 435 (1955), Jan. 27, 1955. Chem. Abs., vol. 50, 1956, p. 11688c.

Pyrite slug ground to 2-5-mm. particles is calcined for 4-5 hours at 500°-600° C. The residue (100 parts) is heated 30 minutes at 80°-90° C. with 60 parts of CrO_3 in 90 parts of water. The solution is removed and the residue heated for 2 hours at 100°-200° C. and 2-3 hours at 200°-450° C. to obtain the sulfur-removing agent.

G

150. GAIN, W. C. Removal of Organic Sulfur Compounds From Hydrocarbon Gases. U. S. Patent 2,762,452, Sept. 11, 1956. Chem. Abs., vol. 51, 1957, p. 1590c.

SiO_2 gel is used to remove organic sulfur compounds.

151. GAS LIGHT & COKE CO., AND GRIFFITH, R. H. Iron Oxide Reagent. British Patent 636,560, May 3, 1950. Chem. Abs., vol. 44, 1950, p. 7516f.

Preparation of mechanically strong nodules of hydrated iron oxide for removing H_2S in fuel gases.

152. GASTECHNIK, G. m. b. H. Hydrogen Sulfide Removal From Gases. British Patent 683,432, Nov. 26, 1952. Chem. Abs., vol. 47, 1953, p. 4585f.

Moving bed of pelleted hydrated iron oxide is used to remove H_2S from a gas in tower purifiers.

153. GASTECHNIK, G. m. b. H. Hydrogen Sulfide Removal From Gases. British Patent 740,662, Nov. 16, 1955. Chem. Abs., vol. 50, 1956, p. 9721g.

Use of a second tower in an H_2S-removal system is described in which fresh oxide is used as the absorbent.

154. GESELLSCHAFT FÜR LINDE'S EISMASCHINEN A. G. (Washing Out CO_2 and H_2S From Raw Gases.) German Patent 929,808, July 4, 1955. Chem. Abs., vol. 52, 1958, p. 2383e.

CO_2 and H_2S are absorbed by organic solution, such as acetone, MeCOEt, and MeCOPr. Halides of Al, Be, Sn, Ti, and bivalent Hg (in MeOH) can be used as the metal salts (promoter).

155. GESELLSCHAFT FÜR LINDE'S EISMASCHINEN A. G., AND LURGI GESSELLSCHAFT FÜR WARMETECHNIK, m. b. H. Purification of Synthesis and Fuel Gases. British Patent 692,804, June 17, 1953. Chem. Abs., vol. 48, 1954, p. 1657f.

H_2S and other constituents such as CO_2, organic sulfur compounds, and hydrocarbons are absorbed with a polar washing agent, for example MeOH, at < 0° C. and under a pressure of at least 2 atmospheres.

156. GILMORE, F. E. Control of Gas Treatment. U. S. Patent 2,695,836, Nov. 30, 1954. Chem. Abs., vol. 49, 1955, p. 2712h.

In wet process for removing H_2S and other acidic constituents, undertreatment due to restricted flow or failure of the absorption medium is avoided by continuous measurement of volume of absorption medium.

157. GOLLMAR, H. A. Gas Desulfurization. U. S. Patent 2,490,799, Dec. 13, 1949. Chem. Abs., vol. 44, 1950, p. 1679a.

Absorption process for removing H_2S by means of an alkali metal carbonate solution is modified by reactivating the spent solution by aeration at 20°-30° C. and under a vacuum in excess of 9 pounds per square inch.

158. _____. Gas Purification. U. S. Patent 2,675,296, Apr. 13, 1954. Chem. Abs., vol. 48, 1954, p. 8522b.

NH_3 spraying is used to remove tar and moisture first. Gas is then scrubbed with an aqueous alkaline solution, such as Na_2CO_3, to remove virtually all the H_2S, HCN, and ammonia.

159. _____. Purification of Gases From the Hot Vacuum-Actification Process. U. S. Patent 2,671,008, Mar. 2, 1954. Chem. Abs., vol. 48, 1954, p. 6102d.

Hot vacuum-actification process is improved by freeing the gases stripped in the actification stage from $C_{10}H_8$ and NH_3 by scrubbing with some absorbents.

160. GOTTFRIED BISCHOFF G. m. b. H. Purification of Gases. British Patent 700,249, Nov. 25, 1953. Chem. Abs., vol. 48, 1954, p. 5469e.

Improved scheme of arranging gas-purifying apparatus, particularly for removing H_2 from industrial gases, is presented.

161. GROSOKINSKY, O., AND KLEMPT, W. Purification of Industrial Gases. British Patent 750,275, June 13, 1956. Chem. Abs., vol. 50, 1956, p. 14213c.

Scrubbing with an 8-percent aqueous NH_3 is used to remove H_2S and CO_2.

162. GUINOT, H. M., AND OTHERS. Removal of H_2S From Gases. British Patent 769,854, Mar. 13, 1957. Chem. Abs., vol. 51, 1957, p. 10878f.

The H_2S in coal gas is easily removed by oxidation to sulfur by scrubbing with $Fe(OAc)_3$ solution and oxygen.

<u>H</u>

163. HAENSEL, V. Removal of Hydrogen Sulfide From Gas Streams. U. S. Patent 2,733,979, Feb. 7, 1956. Chem. Abs., vol. 50, 1956, p. 8179e.

A suspension of Fe_2O_3 in a polyhydric alcohol (for example, ethylene or diethylene glycol).

164. HAMBURGER GASWERKE G. m. b. H. Removal of Nitric Oxide, Hydrogen Cyanide, and Hydrogen Sulfide From Gases. British Patent 670,028, Apr. 9, 1952. Chem. Abs., vol. 46, 1952, p. 8353c.

Three-stage iron oxide box process is used to remove the acid gases.

165. HARPENER, BERGBOU A. G. (Purification of Coke-Oven Gas.) German Patent 927,649, May 15, 1955. Chem. Abs., vol. 52, 1958, p. 2383d.

Conventional countercurrent washing technique is modified by fractional distillation of ammoniated solutions, thus raising their NH_3 concentration to 7-20 percent which deacidifies them in same process. Improved yields and better grain size of $(NH_4)_2SO_4$ are obtained.

166. HANKES, C. T. Removal of Hydrogen Sulfide From Gases. U. S. Patent 2,689,164, Sept. 14, 1954. Chem. Abs., vol. 48, 1954, p. 14137h.

Hydrogen sulfide and cyanide are absorbed with an aqueous alkaline suspension of hydrated iron oxide and carbonate. Solution is regenerated by oxidation with air or oxygen.

167. HIDAKA, TSUYOSHI. (Removal of Sulfur From Gases by Use of Carbon-Containing Ash From Producer.) Japanese Patent 3128 (1956), Apr. 26, 1956. Chem. Abs., vol. 51, 1957, p. 10036a.

A gas containing CO_2 16, CO 32, H 33, N 17.4, CH_4 1.6 percent, H_2S 1.8 grains per cubic meter and organic gaseous sulfur compounds 0.109 grain per cubic meter is passed through an ash obtainable from Winkler gas producers, containing C 42, volatile substances 1.4, ash 55.1, and water 1.5 percent, for 15 days at a rate of 80 volumes per volume of the ash. This removes 100 percent of the H_2S and 94 percent of the sulfur. Ash containing 6 percent H_2O or moistened with 1-11 percent $ZnCl_2$ gave still better efficiency.

168. HIDAKA, TSUYOSHI, AND OTHERS. (Recovery of Hydrogen Sulfide in the Gaseous Mixture as Free Sulfur.) Japanese Patent 4338 (1952), Oct. 22, 1952. Chem. Abs., vol. 47, 1953, p. 8997d.

Dry $Fe_2O_3.3H_2O$ with 2 percent NaOH is used as an adsorbent of H_2S. Sulfur is freed by means of oxidation process.

169. HOGG, H., AND ENGEL, W. R. Removal of Sulfur and Hydrogen Sulfide From Gases. British Patent 733,004, July 6, 1955. Chem. Abs., vol. 49, 1955, p. 16402e.

Catalytic combustion process to remove H_2S from gaseous effluent.

170. HOLMES, W. C., & CO., LTD., AND PRIESTLEY, J. J. Crude Sulfur Sludge. British Patent 653,304, May 9, 1951. Chem. Abs., vol. 45, 1951, p. 8745c.

Sulfur is recovered from a crude sludge, produced in a wet process for removal of H_2S from fuel gas.

171. HUMPHREYS & GLASGOW, LTD., AND PHILLIPS, I. E. Removing Hydrogen Sulfide From a Gas Mixture With a Purification Material and Then Revivifying That Material. British Patent 681,551, Oct. 29, 1952. Chem. Abs., vol. 47, 1953, p. 5667e.

A material containing $Fe(OH)_3$ is employed to remove H_2S from gas. Reactivation of material is achieved by oxidation with air or other oxygen-containing material.

172. HUMPHREYS AND GLASGOW, LTD., HOLMES, W. C., & CO., LTD., AND THORNE, W. F. Removal of Hydrogen Sulfide From Gases. British Patent 670,654, Apr. 23, 1952. Chem. Abs., vol. 46, 1952, p. 8352i.

Vertical panels are inserted in iron oxide boxes to promote uniform distribution of packing and to facilitate withdrawal of oxide.

J

173. JAHNIG, C. E., AND GORNOWSKI, E. J. Gas Desulfurization. U. S. Patent 2,671,723, Mar. 9, 1954. Chem. Abs., vol. 48, 1954, p. 6676c.

H_2S contained in a gas from a gasifier can be oxidized to sulfur by intimate contact with fresh spent char at about 204°-538° F. The weight ratio of char to sulfur in gas for most effective desulfurization is of the order 6 : 50.

174. JOHANNSEN, A., DAKZ, W., AND OTHERS. Gas-Purification Masses Containing Sulfur. U. S. Patent 2,768,959, Oct. 30, 1956. Chem. Abs., vol. 51, 1957, p. 696b.

Recovery of valuable catalytic substances from sulfur-containing catalysts or for regeneration of catalysts that have been poisoned by absorption of sulfur. Roasting furnaces are employed within a temperature range of 400°-1,100° C.

175. JORDAN, J. T. Absorbing Gases, Including Hydrogen Sulfide. U. S. Patent 2,594,557, Apr. 29, 1952. Chem. Abs., vol. 46, 1952, p. 7316f.

Two-stage operation of gas absorption by oil in a gasoline plant.

K

176. KAWASUMI, S., AND YASUHARA, K. (Removal of Sulfur Compounds From Gases.) Japanese Patent 1518 (1956), Mar. 3, 1956. Chem. Abs., vol. 51, 1957, p. 6128f.

Coke-oven gas (500 $m.^3$) containing 14-15 grains sulfur per 100 $m.^3$ is passed through a catalyst tower filled with 8 l. kieselguhr-V_2O_5-K_2O-P catalyst (5 percent V_2O_5) heated at 250° C. to decrease content of sulfur to 0.5-0.8 grain per 100 $m.^3$

177. KOPPERS, H., G. m. b. H. Recovery of Hydrogen Sulfide. British Patent 676,396, July 23, 1952. Chem. Abs., vol. 46, 1952, p. 11646i.

H_2S and other acidic gases are separated from coke-oven gas or illuminating gas by NH_3 scrubbing.

178. _____. (Removal of Acidic Constituents From Gases.) German Patent 929,986, July 7, 1955. Chem. Abs., vol. 52, 1958, p. 2383f.

HCN, H_2S, and No can be removed from coke-oven gases by passing through absorbing material containing hydrated FeO and alkali obtained from the processing of Al.

179. KOPPERS CO., INC. Separation of Acid Gases From Coal Gases. British Patent 675,348, July 9, 1952. Chem. Abs., vol. 46, 1952, p. 10589b.

Vapors from reactivator of hot vacuum process are treated to prevent stoppages in lines and equipment.

180. KREBS & CO. (The Removal of the Hydrogen Sulfide From Waste Gases.) Swiss Patent 289,062, June 16, 1953. Chem. Abs., vol. 48, 1954, p. 6102f.

A slight excess of Cl on basis of H_2S content is added to the waste gas and passed through two scrubbers. The HCl formed is removed in the first scrubber by H_2O. The excess Cl is removed by conversion to NaOH in the second scrubber, which is packed with rings and sprayed with diluted NaOH. The H_2S, unreacted, is oxidized to sulfur or H_2SO_4 by NaOCl.

L

181. LEUTZ, K. E. Gas Desulfurization. U. S. Patent 2,641,526, June 9, 1953. Chem. Abs., vol. 47, 1953, p. 8358i.

H_2S is absorbed selectively in presence of CO_2 from a gas with an aqueous suspension of $Fe(OH)_2$. Suspension is reactivated by oxidation.

182. _____. Gas Desulfurization. U. S. Patent 2,641,527, June 9, 1953. Chem. Abs., vol. 47, 1953, p. 8359a.

Selective removal process of H_2S by means of $Fe(OH)_2$ suspension and consequent regeneration of suspension by air oxidation.

183. _____. Desulfurizing Mineral-Oil Distillates. U. S. Patent 2,641,571, June 9, 1953. Chem. Abs., vol. 48, 1953, p. 8359d.

$Fe(OH)_2$ suspension is employed to remove H_2S from a light mineral oil distillate.

184. _____. Removal of Objectionable Sulfur Compounds From Mineral-Oil Distillates. U. S. Patent 2,616,834, Nov. 4, 1952. Chem. Abs., vol. 47, 1953, p. 1927c.

An aqueous suspension of iron oxide (0.05-0.8 mole per liter) is used to remove H_2S from a light mineral distillate. Solution is regenerated by oxidation.

185. LUEG-ALTHOFF, R. Gas Desulfurization. British Patent 711,008, June 23, 1954. Chem. Abs., vol. 48, 1954, p. 14166c.

H_2S is absorbed selectively in presence of CO_2 with an aqueous solution of ammonia using short contact time.

186. LUNDSTED, L. G., AND SCHULZ, W. F. Totally Hydroxypropylated Alkylenediamines. U. S. Patent 2,697,118, Dec. 14, 1954. Chem. Abs., vol. 49, 1955, p. 15951c.

Compounds can be used as absorbents for acidic gases such as H_2S and CO_2.

M

187. MARSH, J. D., AND NEWLING, WILLIAM, B. S. Recovery of Sulfur From Gases Containing Hydrogen Sulfide. British Patent 769,995, Mar. 13, 1957. Chem. Abs., vol. 51, 1957, p. 11675f.

Catalytic oxidation of H_2S and SO_2 to sulfur is performed as a continuous process. An activated Al_2O_3 is used as a catalyst.

188. McCARTNEY, E. R. Extraction of Acidic Impurities and Moisture From Gases. U. S. Patent 2,547,278, Apr. 3, 1951. Chem. Abs., vol. 45, 1951, p. 5912c.

An acid gas absorption process with amine and glycol solutions is improved by returning the condensate from the first heating zone to second for use as reflux.

189. McCLENDON, E. A. Portable Gas Purifier. U. S. Patent 2,616,513, Nov. 4, 1952. Chem. Abs., vol. 47, 1953, p. 849b.

An aqueous monoethanolamine solution (15-20 percent) is employed to remove H_2S and other acid gases from small volumes of gases.

190. METALLGESELLSCHAFT, A. G. Removal of Hydrogen Sulfide From Hydrogenation Product. British Patent 769,510, Mar. 6, 1957. Chem. Abs., vol. 51, 1957, p. 10878d.

H_2S dissolved in liquid product of catalytic hydrogenation is stripped by gas.

191. MILLER, B. E. Recovery of Sulfur From Natural Gas Containing Hydrogen Sulfide. U. S. Patent 2,771,964, Nov. 27, 1956. Chem. Abs., vol. 51, 1957, p. 11675d.

H_2S is adsorbed by SiO_2 gel. H_2S is desorped by heating.

192. MIYAKE, K., AND ITO, G. (Separation of Gases.) Japanese Patent 178,497 (1949), Apr. 16, 1949. Chem. Abs., vol. 45, 1951, p. 8730a.

An adsorbent for H_2S and other acidic gases such as SO_2, HK, and NO is made by treating aromatic or aliphatic amines, heterocyclic N compounds, or peat with NH_3 and mixing with an aldehyde condensate.

N

193. NEWTON, A. S. Purifying Inert Gases. U. S. Patent 2,521,937, Sept. 12, 1950. Chem. Abs., vol. 44, 1950, p. 11047a.

An inert gas that contains an H-nonmetal compound, such as H_2S or H_2O is purified by heating the gas with U at a high temperature (200°-1,000° C.).

O

194. ODELL, W. WILLIAM. Removal of Oxidizable Sulfur Compounds From

Gas. U. S. Patent 2,581,135, Jan. 1, 1952. Chem. Abs., vol. 46, 1952, p. 3245b.

Removal of H_2S or organic sulfur from a natural gas by two-stage heating and reacting process is described. Kaolin, Al_2O_3, iron oxide, or their mixtures are mentioned as suitable catalytic solids.

195. OTTO, C., & CO. G. m. b. H. Fuel-Gas Purification. British Patent 694,773, July 29, 1953. Chem. Abs., vol. 48, 1954, p. 9657a.

H_2S is removed from a gas obtained from dry distillation of coal by scrubbing with concentrated NH_4OH at the bottom of a scrubber and with liquor from the NH_3 removal plus recycled, cooled, and deacidified liquor from the H_2S removal step.

P

196. PAULING, H. Gas Purification. British Patent 765,673, Jan. 9, 1957. Chem. Abs., vol. 51, 1957, p. 9131i.

In a process for removing H_2S from gas by scrubbing with a solution of a weak alkali carbonate, NH_3 is added to the liquid product to produce NH_4 salts which are steam distilled from the solution.

197. PAULSEN, H. C. Regeneration of Ethanolamine Solutions From Gas Purification. U. S. Patent 2,716,136, Aug. 23, 1955. Chem. Abs., vol. 49, 1955, p. 15215d.

Steam stripping and alkaline treatment with $Ba(OH)_2$, $Sr(OH)_2$, or $Ca(OH)_2$ are used to regenerate ethanolamine solution completely.

198. PAULSEN, H. C., HOLTZCLAW, J. B., AND McNAMARA, T. P. Recovery of Diethanolamine and Salts. U. S. Patent 2,701,750, Feb. 8, 1955. Chem. Abs., vol. 49, 1955, p. 5817b.

Steam stripping of H_2S, caustic washing, and distillation to remove H_2O are used in order.

199. PHILLIPS, I. H. Removing Hydrogen Sulfide From a Gas Mixture With a Purification Material and Then Revivifying That Material. U. S. Patent 2,682,444, June 29, 1954. Chem. Abs., vol. 48, 1954, p. 9657b.

Continuous sulfur removal by passing gas through a packed bed of hydrated iron oxide-containing material that moves progressively downward through a chamber. Iron oxide is continuously purified and returned to process.

200. PHILLIPS, I. H., AND HUMPHREYS & GLASGOW, LTD. Gas Purification. British Patent 672,546, May 21, 1952. Chem. Abs., vol. 46, 1952, p. 9289b.

A moving-bed iron oxide process is described.

201. PIPPIG, H. Sulfur From Gases Containing Hydrogen Sulfide. U. S. Patent 2,772,146, Nov. 27, 1956, Chem. Abs., vol. 51, 1957, 1558g.

Sulfur recovery from a gas containing H_2S by a process involving the steps of absorbing H_2S from the gas in an alkaline washing liquid including a free-oxygen-containing oxidizing agent at 20°-25° C.

202. PORTER, F. W. B., AND NORTHCOTT, R. P. Hydrogen Sulfide Removal. U. S. Patent 2,757,127, July 31, 1956. Chem. Abs., vol. 50, 1956, p. 17413g.

Catalytic process to remove hydrogen sulfide from petroleum hydrocarbon.

R

203. RANDLETT, H. E. Purification and Separation of Gaseous Mixtures. U. S. Patent 2,615,787, Oct. 28, 1952. Chem. Abs., vol. 47, 1953, p. 1361f.

Steam is saved in regenerating alkaline solution used for H_2S and CO_2 absorption by simultaneously concentrating solution with enough steam and returning the excess condensate to lower part of tower.

204. REEVES, L. Removal of Hydrogen Sulfide From Industrial Gases. British Patent 719,056, Nov. 24, 1954. Chem. Abs., vol. 49, 1955, p. 7228a.

Process employs fluidized iron or manganese oxide at 150°-700° C. to remove H_2S. Oxides are regenerated by heating under oxidizing condition.

205. ROBINSON, S. P. Desulfurization of Gases. U. S. Patent 2,551,905, May 6, 1951. Chem. Abs., vol. 45, 1951, p. 6825e.

A continuous process for removing organic sulfur and H_2S in which the gases are heated and desulfurized by contact with a stream of pebbles entering at about 1,000° F. The pebbles are 1/4 to 1/2 inch in diameter and consist of a catalytic material such as bauxite and a metallic oxide acceptor for the sulfur.

206. ROYER, L. W. Gas Purification (Hydrogen Sulfide Removal). U. S. Patent 2,614,904, Oct. 21, 1952. Chem. Abs., vol. 47, 1953, p. 1361h.

Solvents, such as kerosine, diethybenzene, and especially aniline, have the selective absorptivity for H_2S from mixtures containing CO_2.

207. RUHRCHEMIE A. G. Desulfurization of Gases. British Patent 697,204, Sept. 16, 1953. Chem. Abs., vol. 48, 1954, p. 5469e.

An iron oxide is used in a vessel in which gas flow is upward at a rate which minimizes catalyst particle movement.

208. _____. Desulfurization of Gases. British Patent 772,917, Apr. 17, 1957. Chem. Abs., vol. 51, 1957, p. 10879a.

Organic sulfur is converted catalytically to H_2S and removed.

209. RUHRCHEMIE A. G., and GOTTFRIED BISCHOFF, G. m. b. H. Removal of Organic Sulfur Compounds From Gases by Conversion Into H_2S. British Patent 769,664, March 13, 1957. Chem. Abs., vol. 51, 1957, p. 10878e.

Organic sulfur compounds are converted to H_2S catalytically by means of 5 percent Ni on kieselguhr or dolomite.

S

210. SAILORS, H. R. Removal of Hydrogen Sulfide From Gases and Liquids. U. S. Patent 2,624,694, Jan. 6, 1953. Chem. Abs., vol. 47, 1953, p. 7772f.

H_2S is removed from natural gas and other hydrocarbon gases with $CaSO_4$ in H_2SO_4.

211. SCHAUB, F. Desulfurization of Gases. U. S. Patent 2,780,310, Feb. 5, 1957. Chem. Abs., vol. 51, 1957, p. 5390h.

Sulfur recovery by passing foul gas up through a molded desulfurization material at 25° C. Solid material may be regenerated and reused.

212. SHIRE, WILLIAM A., JR. Processing Dilute Hydrogen Sulfide Streams. U. S. Patent 2,726,932, Dec. 13, 1955. Chem. Abs., vol. 50, 1956, p. 8180a.

A gas is brought into contact with an excess of free oxygen in presence of a platinum catalyst to convert H_2S to SO_2 and SO_3 which are than absorbed by H_2SO_4. CO_2 is not absorbed.

213. SILVER, L. Treatment of Gases Rich in Hydrogen Sulfide. U. S. Patent 2,784,055, Mar. 5, 1957. Chem. Abs., vol. 51, 1957, p. 6982d.

Ammonia is removed from hydrogen sulfide rich gas by a two-stage aqueous washing with introduction of air.

214. STALHED, J. L. Desulfurization of Carbureter Gas. U. S. Patent 2,755,179, July 17, 1956. Chem. Abs., vol. 51, 1957, p. 6128g.

Carbureter or producer gas is desulfurized in a continuous process in which lumps of limestone or dolomite descend gravitationally in a column through which the sulfur-containing gas is rising countercurrently.

215. SZOMBATHY, KALMAN V. (Removal of Hydrogen Sulfide, Ammonia, and Hydrocyanic Acid From Gases and Recovery of Ammonium Sulfate and Sulfur.) German Patent 923,156, Feb. 3, 1955. Chem. Abs., vol. 52, 1958, p. 701c.

Scrubber uses a $(NH_4)_2S_2O_3$ solution containing 0.01-0.02 percent of a M-quinone (M = Mg, V, Cr, or Ce.). Gases are absorbed at 25°-30° C. and a pH of 8-9. Part of wash liquid is subsequently treated at 80° C. to convert the $(NH_4)_2S_2O_3$ to sulfur and $(NH_4)_2SO_4$, while other part is recycled.

T

216. TAKATA, NAOZO, AND OTHERS. (Purification of Carbon Dioxide.) Japanese Patent 8669 (1954), Dec. 28, 1954. Chem. Abs., vol. 50, 1956, p. 10356g.

Gas was passed into an absorption tower containing 30 kg. per m.^{3} NH_3 and 300 kg. per m.^{3} NH_4NO_3 at 10° C.

217. THIOSAN-GESELLSCHAFT WEIGEL & CO., G. m. b. H. Wet Purification of Gas. British Patent 709,772, June 2, 1954. Chem. Abs., vol. 48, 1954, p. 12395b.

H_2S and other acidic constituents can be removed from coal gas by scrubbing it in a packed tower with an alkaline, preferably ammoniacal solution. Air is also introduced from bottom of tower to oxidize H_2S.

218. THUMM, W., AND OTHERS. Sulfur From Hydrogen Sulfide and Sulfur Dioxide or Oxygen-Containing Gases. U. S. Patent 2,785,056, Mar. 12, 1957. Chem. Abs., vol. 51, 1957, p. 9108e.

Sulfur is obtained from H_2S and SO_2 or oxygen-containing gases by passing them through a series of catalysts.

219. TIERNEY, J. W. Selective Absorption of Hydrogen Sulfide in Methanol. U. S. Patent 2,813,126, Nov. 12, 1957. Chem. Abs., vol. 52, 1958, p. 4964b.

H_2S is absorbed from gaseous mixtures by MeOH. The H_2S-MeOH mixture is heated to recover H_2S, MeOH being regenerated for further use as an absorbent. Process is also used to prepare H_2S-MeOH stock solutions for manufacture of methanethiol.

V

220. VETROCOKE SOCIETA PER AZIONI. (Absorbing Carbon Dioxide and Hydrogen Sulfide From Gaseous Mixtures.) Italian Patent 470,758, Apr. 23, 1952. Chem. Abs., vol. 47, 1953, p. 10286a.

Na or K carbonate solution at 70°-75° C. and 10-13 atmospheres is used as absorbent. Absorbent is regenerated with waste vapors.

221. _____. Removal of Carbon Dioxide and Hydrogen Sulfide From Gaseous Mixtures. British Patent 728,738, Apr. 27, 1955. Chem. Abs., vol. 49, 1955, p. 15297e.

Wet removal of H_2S and CO_2 by alkaline solution of Na_2CO_3 or K_2CO_3 at 10-20 atmospheres and 60°-85° C. is described.

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222. WALKER, R., WILKIN, C. R., COOPER, H. G., AND BROWN, J. T. Hydrogen Sulfide Removal From Gases. U. S. Patent 2,503,528, Apr. 11, 1950. Chem. Abs., vol. 44, 1950, p. 5570a.

H_2S is absorbed at a room temperature with a single aqueous carbonated alkaline suspension of a hydrated iron oxide, iron carbonate, and basic iron carbonate in series.

223. WYLIE, R. Removal of Carbon Dioxide and Hydrogen Sulfide From Gaseous Hydrocarbons. U. S. Patent 2,718,454, Sept. 20, 1955. Chem. Abs., vol. 49, 1955, p. 16415i.

Formation of emulsion in amine absorption process can be prevented by adding 0.5 percent or more of an alkaline salt or hydroxide solution.

PATENT SUBJECT INDEX

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